Purpose: The present study designed to evaluate entrance and exit doses for out of the radiation field in external beam radiotherapy (EBRT). The primary aim of this study was to investigate the efficiency of non tissue equivalent (NTE) thermoluminescence dosimeters (TLD) for in vivo dosimetry of out of the radiation field dose measurements.

Materials and Methods: All the measurements were performed in 10 head and neck patients (age range, 35–46 years; mean, 44 years) treated with two parallel opposed lateral fields on Bhabhatron-II TAW Telecolbalt unit (Panacea Medical Technologies, Bengaluru, India) using source to surface distance (SSD) technique. The TLDs used in this study were Nucleonix India Pvt. Ltd., CaSO4:Dy discs (13.3 mm diameter, 0.8 mm thick) and LiF: Mg, Ti chips (3.2 X 3.2 X 0.89 mm). The CaSO4:Dy discs were placed at the level of the eyes of the patient for a single right lateral treatment field only. This methodology provided the set up to assess out of field entrance and exit radiation dose to eye. TLD-100 chips were also placed exactly in the identical places in the next treatment fraction of same patient. The physical data measured were separation distance at the level of eye, distance between radiation field edge and ipsilateral right eye at SSD. The distances were calculated for radiation beam exit from isocenter at the exit surface of the patient.

Results and Discussion: The distance between radiation field edge and ipsilateral eye at SSD was measured in the range of 2.0–4.0 cm with mean 3.3 cm. The distances of separation at the level of eye, entrance and exit of edge of beam from isocenter were in the range of 11cm-15cm, 7.0cm-8.5cm, 8.0cm-9.5cm respectively. It was obvious to observe with theoretical calculations using radiation divergence property that the primary radiation beam was not passing through contralateral eye. The contralateral eye was away from the exit of edge of radiation beam in all the cases and distances were found in the range of 0.5cm-2.8cm. However, when the doses were analyzed for non tissue equivalent CaSO4:Dy discs and it was surprising to note that the exit dose to contralateral eye (Dexit) were measured 1.5 to 2.5 times higher than the entrance dose to ipsilateral eye (Dentrance).

To investigate this over-response, the doses were measured with tissue equivalent TLD-100 chips in the identical conditions. It was found that Dexit were measured 15% to 20% less than Dentrace. Thus, the possible cause for this over-response in NTE dosimeter is increase in the intensity of secondary electrons and low energy scattered photons reaching to dosimeter at the exit surface of the patient during out of field measurements. The results of this study suggested that non tissue equivalent CaSO4:Dy discs were not the dosimeter of choice for out of field exit dose measurements. One should be precautionous to use non tissue equivalent CaSO4:Dy dosimeters for out of field exit dose measurements. Further study needs to be performed to deal this over-response using either appropriate correction factors or build up caps. However, studies of buildup caps should be conducted for out of field measurements. In addition, special attention should be paid to the selection of the appropriate materials for buildup caps, taking into account the impact of low energy radiation and attenuation of the beam.

Conclusion: The non tissue equivalent dosimeters were not the promising dosimeters for out of field exit dose measurements. The research outputs of this study may be helpfull for the selection of the appropriate in vivo dosimeter suitable for clinical use for out of the radiation field dose measurement conditions in radiotherapy.

PP-2

A PROSPECTIVE STUDY ON INTER-FRACTION SHIFTING TO DETERMINE THE SET-UP MARGIN FOR THREE SITES

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Introduction: With the state of the art techniques now Radiotherapy is a proven means to cure and improve the quality life of cancer patients. Success of advanced radiotherapy highly depends upon the precession and accuracy. For accurate and precise delivery of the prescribed dose to the target volume, it is necessary to draw optimum CTV to PTV margin. To determine the margin, we have to consider factors like proper target delineation, use of proper immobilization device, proper patient positioning etc. Accurate patient positioning can be ensured with IGRT.

Purpose: Purpose of my study is to evaluate interfraction setup errors using daily CBCT with the patients undergoing IMRT and 3DCRT treatment for Brain, Head and Neck and Pelvis site cancer and to calculate CTV to PTV margin. Initially all patients underwent CT simulation with slice thickness of 3mm in supine positions. Contouring was done as per ICRU report 50 and 62 guidelines in FocalPro. IMRT plans were generated for each patient in CMS Xio (4.80.002 version, ELEKTA) TPS and subsequently, the plans were transferred to MOSAIQ and XVI system respectively. On the very first day the shifting were made to the planned isocenter from the reference fiducial markers and CBCT were taken for each patient. Any error in the target (isocenter) was rectified based on the CBCT verification and the corrected
isocenter were marked which would be used for set up in the subsequent days. Following daily CBCT prior to treatment, positional errors were recorded in Medio-Lateral (M-L), Supero-Inferior (S-I) and Antero-Posterior (A-P) directions for each patient. The target positional errors were corrected by adjusting the patient position, through shifting the patient using the automatic motorized couch in all three translational dimensions. From the noted shift data, clinical target volume to planning target volume margin were calculated using Van Herk formula (margin=2.52p+ 0.7pσ), where 2p is the systematic error and pσ is the random error.

Result: A total of 217 CBCT scans for brain, 200 for head and neck and 211 scans were acquired for pelvis. Shifting errors for each site for the population of patients were analyzed. The interfraction shifts in brain was-0.21±0.58 mm (range-8.6 to 8.4),0.28±0.85 (range-6.7 to 8.6) and-0.063±0.64 (range-0.55 to 0.63); in head and neck, 0.037±1.7 mm (range-8.4 to 6.7), 0.0017±2.7 (range-7 to 7.3), 0.043±2.5 (range-9.7 to 9.4) and in pelvis region 0.03±3.13 mm (range-8.60 to 19.8), 0.35±11.02 (range-27.3 to 27),0.13±2.5 (range-0.76 to 6.1) in M-L, S-I and A-P direction respectively. From these data, calculated margins are 5.00mm, 3.86mm and 2.97mm (brain); 7.20mm, 6.40mm and 5.25mm (head and neck); and 7.29mm, 18.14mm and 4.25mm (pelvis) in M-L, S-I and A-P directions respectively.

Discussion: Proper CTV to PTV margin is essential for optimal dosimetry, minimizing marginal miss of tumour volume and sparing of OARs properly. In current practice in our institute, we are giving isotropic margin of 5mm in brain and head and neck and 10mm in pelvis region. It is imperative to every institute which practices advanced techniques calculates its own margins based on the shifting errors.

Conclusion: The results of the study will be helpful to establish a standard CTV to PTV margin as an institutional protocol for treating brain, head and neck and pelvis region.

PP-3

PATIENTS DOSE ESTIMATION IN COMPUTED TOMOGRAPHY EXAMINATIONS USING SIZE SPECIFIC DOSE ESTIMATES

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Introduction: The x-ray computed tomography (CT) is an imaging modality to produce three dimensional thin cross sectional images of the patient body. In CT the radiation beams were not contiguous and unidirectional around the patient contour the maximum dose does not lie on the skin surface and is not an appropriate indices for risk analysis in CT. The CTDI is used for quantification and analysis CT doses. The CTDIvol indices does not estimate patient dose, as it does not take patient’s size into consideration. The actual dose received by a patient during CT examination, not only depends on selected scanner parameters but also on the dimensions and composition of the body part being scanned.

Purpose: The aim of the present work is to reports data on radiation exposure to the patient in CT examinations using size specific dose estimates (SSDE).

Materials and Methods: The radiation exposure was estimated retrospectively in forty adult patients for head, chest, pelvis and abdominal CT procedures performed on a third generation 16 slice helical CT scanner. The CTDI values were measured in CTDI dosimetry phantoms of 10, 16 and 32 cm diameter. The water equivalent diameter (Dw) of this water cylinder is used to represent the absorption and scattering in the body and estimation of dose to the patients. The effective diameter for the scanned patient body part is measured as effective diameter=(AP width×lateral width) (1) The SSDE is obtained from size dependent conversion factor and CTDIvol as, SSDE=fx ×CTDIvol, x (2) where fx is the size dependent conversion factor.

Results and Discussion: The CTDIc values, evaluated at 120 kV using three CTDI phantoms, in 10 and 16 cm phantom are 4.4 and 3.2 times more than the value for 32 cm phantom. The CTDIp in 10 and 16 cm phantom is 2.2 and 1.6 times greater than the 32 cm CTDI phantom. For 32 cm phantom, the CTDIc is 50 % of CTDIp value, whereas, in small phantoms the radiation doses are nearly uniform in peripheral and central region. The measured CTDIvol value in 10 and 16 cm diameter phantoms is respectively 2.65 and 1.97 times more than the value measured in 32 cm phantom for same scan parameters. The reported mean SSDE value of 54 mGy and mean CTDIvol of 26.76 mGy in CT head, mean SSDE and CTDIvol is 45.2 mGy and 31.9 mGy respectively in pelvis CT examination. In CT chest mean SSDE and CTDIvol values of 22.8 mGy and 17.3 mGy are reported, whereas value of 21 and 14.6 mGy is observed as mean SSDE and CTDIvol respectively in abdomen CT. The reported SSDE values in this study shows significant underestimation in doses reported by CTDI parameter recorded on the CT console and should not be used to specify patient absorbed dose in CT procedure. The highest variation of 100 % is observed for head CT, as the displayed CTDI on this CT scanner were based on 32 cm phantom measurements.

Conclusions: The dosimetry on CT procedures in this study is an attempt to improve reporting of patient’s doses based on CTDIvol indices. The application of SSDE methodology provides a better estimation of patient dose by including variation in size of individual patient into consideration and thus the relative radiation risk associated with CT examinations.

PP-5

DOSIMETRIC VERIFICATION OF STEREOTACTIC BODY RADIATION THERAPY FOR LUNG CANCER TREATMENT PLANS USING OCTAVIUS 4D PHANTOM

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Purpose: Radiation treatments have become increasingly more complex with the development of volumetric modulated arc therapy (VMAT) and the use of stereotactic body radiation therapy (SBRT). SBRT involves the delivery of substantially larger doses over fewer fractions than conventional therapy. Octavius 4D is a very effective device in radiotherapy treatment quality assurance (QA), due to its simple set-up and analysis package. This study aimed to analyze the dose distribution
using Octavius 4D phantom dosimetric tools in conducting pretreatment quality assurance for lung cancer stereotactic body radiation therapy (SBRT) plans.

**Materials and Methods:** Five patients with lung cancer treated via SBRT were randomly selected, and their treatment plans were generated using the Eclipse treatment planning system (Eclipse version 11.3). Plans were prescribed 48 Gy in 4 fractions on 80% of isodose to 95% of the PTV volume. For each patient, the same plan was applied to the Octavius 4D phantom (PTW OCTAVIUS 4D 1000 SRS) and portal dosimetry by the TPS, which calculated the dose distribution. It consists of an ion chamber array embedded in a cylindrical phantom. The phantom is connected to an inclinometer that is attached to the gantry so that the system is capable to rotate following the gantry orientation in such a way that the array is always perpendicular to the beam axis. Dose distribution and gantry angle are registered as a function of time. The Octavius 4D phantom and portal dosimetry were used to measure the actual dose distribution at the linear accelerator, and these measured doses were compared to the calculated doses. Gamma analysis was employed in verifying the correspondence between the dose distributions.

**Results and Discussion:** The Octavius 4D phantom shows good agreements between calculated and measured dose. The mean gamma passing rates gamma criteria and the standard deviations were 98.2% ± 2.5% with 2% 2mm criteria and 98.8% ± 1.1% with 3% 3mm criteria by Octavius 4D phantom portal dosimetry respectively. Thus, the approach provides a fully automated, fast and easy QA procedure for plan-specific pretreatment dosimetric verification.

**Conclusion:** The Octavius 4D system is a suitable device for patient-specific pretreatment QA to verify SBRT. It is however mandatory to calibrate for a field size and a dose rate close to the patient treatment plan.

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**PP-6**

**IMPACT OF MOTION PARAMETERS ON 4D IMAGING USING INDIGENOUSLY DEVELOPED FOUR DIMENSIONAL RADIOTHERAPY PHANTOM**

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**Objective:** The purpose of this work is to study the impact of motion parameters (amplitude and frequency) and target size on 4D imaging using indigenously developed Four Dimensional Radiotherapy Phantom (FDRP).

**Materials and Methods:** The in-house fabricated 4D radiotherapy imaging and dosimetry phantom was used for the imaging study. The developed phantom has three different inserts which represents target sizes of 1 cm, 1.5 cm and 2 cm in diameter. The targets were driven in sinusoidal motion pattern in the longitudinal direction with different combinations of the amplitudes of 0.5 cm, 1 cm, 1.5 cm and frequencies 0.2 Hz and 0.25 Hz, one by one. For the performance validation of phantom, the set values of amplitudes and frequencies of motion were compared with the values measured by the tracking (Varian RPM) system. The GE 4DCT scanner was used to scan the phantom and the motion of the surrogate marker was tracked by the Varian RPM system. The phantom was imaged both in the static and dynamic state. The images of the target acquired in the motion were sorted into 0, 10, 20, 30, 40, 50, 60, 70, 80 and 90% phase by the phase binning software and Maximum Intensity Projection images (MIP) were also created. The images of the moving target in different phases were contoured and GTV final was obtained by summing the target volumes of the individual phases. Similarly, the GTV was also contoured on the MIP images i.e. GTV MIP. The GTV final and GTV MIP were compared with the GTV obtained by static images to assess the effect of the motion. The effects of varying the amplitudes, frequencies of the motion on the distortion of target volume were also evaluated.

**Results:** The values of amplitude and time period, measured by the tracking system matched well with the values set on the FDRP. The relative distortion in the final GTV ranges from 1 to 2.57, 0.84 to 2.58 and 0.61 to 1.85, for the target sizes of diameter 1.0 cm, 1.5 cm and 2.0 cm respectively. Similar pattern in the relative distortion of the GTV MIP were also observed. The distortion in the GTV increases with amplitude of the motion for given target size and frequency. For the target size of 1.0 cm, the frequency has negligible impact on volume distortion for all the studied amplitudes. For the target size of 1.5 cm, the variation in the GTV final and GTV MIP w.r.t. static volume were 21.05% and 26.31% for the amplitude 1.5 cm, while, no significant variations were observed at 0.5 and 1.0 cm amplitudes for 0.2 Hz and 0.25 Hz frequencies. For the target size of 2.0 cm, the variation in the GTV final and GTV MIP were 6.5% each for amplitudes 1.0 cm and 1.5 cm for all the exercised frequencies.

**Conclusions:** Impact of motion parameters in 4D imaging using indigenously developed FDRP has been carried out. Motion parameters have significant impact on target volume obtained using 4D imaging system in comparison to the static target. 

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**PP-7**

**DOSE EVALUATION PRACTICE FOR IMRT TREATMENTS AT LIONS CANCER DETECTION CENTRE TRUST, SURAT**

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**Purpose:** Intensity modulated radiation therapy (IMRT) allows the three-dimensional dose distribution with computer based optimization techniques using user-specified absorbed-dose and dose-volume constraints in specified target volume and normal tissues. Dose prescription, recording, reporting and delivery play an important role in radiation therapy outcome analysis. In IMRT treatment user defined acquired inhomogeneity within target and sharp dose gradient at
edge of target makes traditional dose prescription (Dmax, Dmin, Dmean) method less relevant and to overcome these issues International commission on radiation units and measurements (ICRU) provides guidelines for reporting doses in ICRU 83 Report. The study aimed to analyse the dose prescription according to ICRU-83 report for IMRT treatments at our institute.

**Materials and Methods:** Fifty patients of Ca-head & neck and pelvis treated by IMRT were randomly selected. Dosimetry data for these patients were collected and analysed. Eclipse (version.11.0.31, Varian Medical System, Palo Alto, CA) treatment planning system was used to generate IMRT plans (VMAT). The dose-volume histogram of each patients were evaluated for near minimum dose (D98%), D95%, median dose (D50%), and near maximum dose (D2%) of target volumes. Dmean, D2%, Dmax and VD for OAR were collected and analysed. The actual Dmim., Dmax. and Dmedian doses to the target volumes were normalized to the prescribed dose and analyzed for each disease sites. The homogeneity index (HI) = (D2%-D98%)/D50% and Conformity index (CI) were evaluated as per ICRU 83 report.

**Results and Discussion:** The median dose D50% were found 100.700 ± 0.29 and 101.318 ± 0.52, the HI were 0.098 ± 0.012 and 0.079 ± 0.007, the CI were 1.088 ± 0.027 and 1.052 ± 0.017 for Ca-head & neck and pelvis respectively. The D98% range was from 94.31% to 96.30% which was significantly greater than Dmin. The D2% doses were also found significantly lower than the Dmax doses. The 95% volume had received higher than D95% dose in all sites. The Maximum D2% of spinal cord and PRV Spinal cord has been recorded as 44.36 Gy and 46.50 Gy respectively for Ca-head & neck patients. The mean dose to the parotid was 15-40 Gy depending on overlapping inside PTV.

**Conclusion:** The Median dose D50% shows a good presentation of dose prescription for target volumes. The parameters introduced in ICRU 83 report (D2%, D98%) better reflect the target absorbed doses with IMRT planning techniques.

**PP-8**

DOSIMETRIC EVALUATION OF OUT OF FIELD MEASUREMENT

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**Purpose:** Dosimetric comparison between out of field dose measured in a radiation field analyzer (RFA) and implemented in Eclipse treatment planning system of version 10.0. Out of field dose measured under three different conditions such as jaw only, jaw+ MLC only and MLC only.

**Materials and Methods:** The data’s were collected from Eclipse treatment planning system (version 10.0) and water phantom (RFA). RFA is set at source to surface distance (SSD) of 100 cm, and a semi flex ionization chamber (0.125 CC) is used. Measurements were taken for different distances (1,2,3,5,10, 15 cm) from the field edge for different field sizes (5x15,10x15,15x15) using energy 6 and 15MV. All measurements were performed in a Varian Clinac IX linear accelerator equipped with a millennium 160 leaf collimator and On Board Imager. The results were cross compared with Eclipse treatment planning system. Also same study extended using Versa HD machine where Montecarlo Algorithm is used. Measurements where carried out for the same distance and field sizes using 6MV and 10MV flattened and unflattened beams.

**Results:** Dose differences between calculations and measurements as a function of depth, field size and distances for three shielding conditions such as jaw only, jaw+ MLC and MLC only (for 6 and 15 MV) were evaluated in the study. Up to build up region the measured and calculated doses are in good agreement a slight overestimation of the calculated dose observed for 15 MV in this region; after the build-up region the dose difference increases with depth. By increasing the distances from the field edge, the out of field dose shows a gradual decrease after 3-4 cm distance away from the field edge for all the three shielding conditions and energy. MLC only condition show higher out of field does than other shielding condition. The study shows a dose differences of maximum 14±17 relative to the measurement points averaged from 0 to 16 cm depth.6MV and 15MV Flattened and unflattened were evaluated for out of field doses and found that for, 10x15 and 15x15 field sizes FFF has higher dose as the depth increases compared to flattened beams. Up to 2-3 cm depth, the dose from flattened and unflattened beam found almost equal and an increase in dose observed for FFF beam with maximum difference observed for 10 FFF beams. But at 1cm distance from the field edge FFF dose is lower compared to the flattened beam. At distances more than 10 cm from the field edge both energies shows almost equal dose. But for smaller field sizes like 1x15 and 5x15 cm2 FFF dose is found less at shallow depth and becomes almost equal relative to the flattened beams.

**Conclusion:** The study conducted using ion chamber shows almost good agreement between measured and calculated values. Also gives valuable information on flattened and unflattened beam out of field doses.

**PP-9**

SCATTER DOSE MAPPING IN BEDSIDE X-RAY MACHINES

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**Introduction:** Mobile Radiography units are used for radiographic imaging of sick immobilized patients in areas such as intensive care, critical care and in post-operative units. It is also used in operating and emergency rooms that lack standard, fixed radiographic equipment. X-rays are produced by the X-ray tube when a stream of electrons, accelerated to high velocities by a high-voltage, interact with the tube’s target anode. A set of collimators confines the primary X-ray beam to the approximate size and shape that will cover only the area of diagnostic interest. Mobile CR units capture images using a photostimulable phosphor plate. Mobile DR units are equipped with built-in or tethered flat panel detectors, which
use a scintillator material to convert X-rays to visible light.
- The patient is prepped and provided some form of radiation shielding
- The unit is positioned around the patient, who is asked to remain motionless while the image is being taken
- The operator takes the image by activating the X-ray beam using an exposure switch
- The operator repositions the patient or unit if needed for multiple images.

IMCU, ICU, emergency, trauma ward and critical care units are typically ill equipped to shield patients and medical staff from radiation exposure. Personnel and nearby patients can be protected by protective lead aprons and movable radiation shielding. Mobile units may give slightly higher scatter radiation. Aim of this work was to measured the amount of scatter radiation in and around the mobile X-Ray machine.

**Objective:** The purposes of this study were to apply near-real-time dose-measurement method with smart rad dosimetry to the assessment of real time scatter radiation level during bedside X-ray investigation at different location.

**Materials and Methods:** A smart rad solid-state dosimeter were used to obtain real-time scatter radiation dose levels. Using smart rad, measurements were conducted every selected bed side X-ray investigation for adult patients without affecting examination. 5 mobile bedside X-ray machines were involved in this study. The study was conducted for the period of 8 months and 100 real time dose measurements were done.

**Results and Discussion:** Based on this research work, we found that the bedside staffs, physician, attenders and radiographers were received considerable amount of scatter radiation from the patient. The personal received scatter dose range is 2 µSv – 31 µSv per examination. The amount of scatter radiation were differ from the patient age group, angulation, exposure parameters, type of the machine, and type of the study. In addition to this, IMCU, ICU, emergency, trauma ward and critical care units are normally not equipped to shield patients and medical staff from radiation exposure. Personnel and nearby patients can be somewhat protected by protective lead aprons and movable radiation shielding. Most of the units have safety features like AEC to regulate radiation exposure. This study will helps to improve radiation safety standards for personnel who are working in bedside X-Ray machines. Also it helps to increase radiation protection shielding in mobile X-ray examinations.

**Conclusion:** On whole, this research work gives the substantial overview of current mobile X-ray practice in the hospitals. From this study, it is recommended that it is very essential to protect personal and staffs in advance, also it is compulsory to adopt the ALARA and dose reduction principle strictly. This performance would positively be valuable to medical personals by preventing them from receiving unnecessary radiation dose. This practice would also promote safety awareness among the mobile X-ray users and operators.

**PP-10**

**ORAL CANCER TREATMENT BY RADIOTHERAPY AT A TERTIARY CARE HOSPITAL IN RURAL AREA OF MAHARASHTRA STATE: A HOSPITAL-BASED STUDY**

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**Introduction:** Oral cancer is traditionally defined as squamous cell carcinoma of the lip, oral cavity, and oropharynx. According to the World Health Organization (2005) cancer might kill 10.3 million people by the year of 2020, with an increase trend in developing and newly industrialized countries. Radiotherapy is an integral part of the multidisciplinary approach for treating cancer, in addition to surgery and chemotherapy. The current evidence indicates that 50% of all patients diagnosed with cancer need radiotherapy at some stage of their disease.

**Purpose:** To describe utilization of radiotherapy and treatment compliance in oral cancer cases in rural area.

**Materials and Methods:** A retrospective study was carried out on data collected from the radiotherapy treatment records of oral cancer patients treated at Rural Medical College Teaching Hospital, and Pravara HBCR, Loni Dist. Ahmednagar, Maharashtra state for the period from 1st December 2012 to 31st December 2012.

**Results and Discussion:** In all 279 cases of cancer with all sites of oral cancer, number of male patients was 61.29% (n=171) whereas females were 38.71% (n=108). Mean age of the patients was 56.31 years, ranging from 11-81 years, 31.90% (n=89) are more than 65 years of age. Curative treatment was given to 66.67% (n=186) and palliative to the remaining 33.33% (n=93). Patients older than 50 years were more likely to receive palliative radiotherapy (p=0.001). The most common cancers among the males and females are those of tongue 39.77% (n=111) and buccal mucosa 35.18% (n=98) respectively. Tobacco related cancer patients in males are 83% (n=142) and in females it was 62% (n=67). The majority of patients were between 50-70 years of age (n=163). Nineteen percent (n=53) did not complete the prescribed dose of radiation. Unplanned treatment interruptions were found in 36.20% (n=101) and this was not affected by age (p=0.1) or gender (p=0.1). The most frequent treatment interruption compromising optimal effectiveness of cancer treatment was observed for tongue and buccal mucosa 42.29% (n=118). Patients older than 50 years were more likely to receive palliative radiotherapy (p=0.001). The most common cancers among the males and females are those of tongue 39.77% (n=111) and buccal mucosa 35.18% (n=98) respectively. Tobacco related cancer patients in males are 83% (n=142) and in females it was 62% (n=67). The majority of patients were between 50-70 years of age (n=163). Nineteen percent (n=53) did not complete the prescribed dose of radiation. Unplanned treatment interruptions were found in 36.20% (n=101) and this was not affected by age (p=0.1) or gender (p=0.1). The most frequent treatment interruption compromising optimal effectiveness of cancer treatment was observed for tongue and buccal mucosa 42.29% (n=118).

**Conclusion:** Tongue and buccal mucosa in both sexes were the most common cancers treated with a curative intent. Alveolus, the second most common in both genders, was treated with palliative intent in a large number of oral cancer cases. This indicates the need for early diagnosis for a possible curative treatment.

**PP-11**

**DOSIMETRIC STUDY OF EFFECT OF CIRCULAR AND SQUARE CUTOUT ON PERCENTAGE DEPTH DOSE, OUTPUT FACTORS AND MEAN ENERGY FOR 6 MEV AND 8 MEV**

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Introduction: In treatment of cancer using electron beams, depend on the shape of tumor, Cerrobend cutouts are used. The cutout changes the percentage depth dose (PDD), output factors (OPF) and mean energy.

Purpose: This study is related to investigate the effect of circular and square shape electron cutout on the PDD, OPF and mean energy.

Materials and Methods: In this study, the dosimetry was performed in Elekta Synergy Platform Linear Accelerator with electron energies 6 MeV and 8 MeV. All the measurements were done using reference electron applicator size 10x10 cm2 with 100 cm source to surface distance. The PDD curve and OPF for circular, square (with cutout area 7.06, 19.63, 28.26, 38.46, and 63.59 cm2) and 10x10 cm2 standard cutouts were measured. The circular cutout diameters were 3, 4, 6, 7, 9 cm and square had side lengths of 2.66, 4.43, 5.32, 6.2, 7.97 cm. Electron central axis PDD values have been measured with parallel plate ionization chamber. Data was initially collected as ionization readings; obtained graphs from percentage depth ionization (PDI) and were converted to PDD by MEPHYSTRO MC2 software (PTW, Germany). The PDD curves were drawn; the information was extracted as R100, R90, R80, R50, R20 and mean energy. The OPF for a given electron energy is the ratio of the dose for any specific field size to the dose for a 10×10 cm2 reference applicator, both measured at dmax.

Results: For 6 MeV, within circular cutout, R100, R90, R80, R50 and R20 changes from 14.48 mm to 11 mm, 19.59 mm to 17.05 mm, 21.64 mm to 19.53 mm, 26.12 mm to 24.91 mm, 30.51 mm to 29.90 mm respectively and for square cutout it changes from 14.03 mm to 11.51 mm, 19.45 mm to 17.44 mm, 22 mm to 19.91 mm, 26 mm to 25.17 mm, 30.47 mm to 30 mm respectively.

For 8 MeV, within circular cutout R100, R90, R80, R50 and R20 changes from 17.99 mm to 12 mm, 24.96 mm to 20.08 mm, 27.64 mm to 23.32 mm, 33.32 mm to 30.62 mm, 38.82 mm to 37.89 mm respectively and for square cutout it changes from 17.53 mm to 12.50 mm, 24.77 mm to 20.76 mm, 27.50 mm to 23.97 mm, 33.15 mm to 33.10 mm, 38.82 mm to 37.43 mm respectively. Mean energy for 6 MeV and 8 MeV is lower for smaller field size. For both the energies, areas larger than 38.46 cm2, there is no significant difference between values of R100, R90, R80, R50 compare to reference field size 10×10 cm2. For both energies, areas larger than 38.46 cm2, there is no significant difference between values of R100, R90, R80, R50 compare to reference field size 10×10 cm2.

Discussion: The chart of changes for R100, R90, R80, R50, and R20 shows that while increasing the open area, the values of this parameter reaches at saturation after the certain area. Also the OPF are decreases with reducing the area of the cutout.

Conclusion: The PDD parameters, OPF and mean energy for circular and square cutouts varied from the reference field size; depend on the shape of the cutout. The OPF decreases with reduction in cutout area. Mean energy is lower for smaller field size.

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Introduction: To compare Sandwich treatment in oesophagus Tumour patients Comparing the Dosimetric Parameters such as mean dose, minimum dose, and maximum dose, Uniformity Index, Homogeneity Index, Conformity Index and Dose to Critical organs.

Purpose: The Purpose of the study is to reduce the Heart, lung & integral dose as well to reduce normal tissue in Different Technique With Sandwich Treatment.

Materials and Methods: Data from fifteen consecutive Patients were compared with (CONVENTIONAL PLUS IMRT),(CONVENTIONAL PLUS VMAT), (IMRT PLUS VMAT). For IMRT planning we have used minimum of 5 fields. For VMAT planning we have used minimum of Two ARCS. For CONVENTIONAL planning we have used minimum of TWO fields. The patients were planned for 5040cGy/28fractions/5.3week. The plans were planned in same target volume and inverse planning for IMRT and VMAT. Planning were performed using the treatment planning system (ECLLIPSE 13.7) & Executed in VARIAN TRUE BEAM STX & Verified in Gamma Evaluation (PTW OCTIVIUS with help of 2d array phantom).Integral dose has been calculated by target volumes were subtracted by the Total body volume.

Results: Dose to lung is optimal in CIM & CVM & Dose to Heart & spinal cord has optimized in CIM & CVM. High dose region & Low dose region is reduced in CIM, CVM & IMVM.

Discussion and Conclusion: Dose to Lung has been reduced in CIM & CVM & High dose region Better in CVM, Integal dose has been reduced in CIM & CVM & Achieving good result in Dosemetric parameters & Gamma Evaluation has been achieved given criteria.

PP-13
REVISITING OF RADIOTHERAPY WITH TELECOBALT BEAM-EFFECTOFTISSUEDEFFICIENCYCOMPENSATION ON SKIN MORBIDITY IN HEAD AND NECK
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In the north eastern parts of the India, the head and neck cancers form as high as 50% of the total number of patients. We implemented tissue compensation to overcome skin reactions. Lateral opposing portals with Theratron 780E telecobalt machine (80 cm SSD) with custom built Aluminium Tissue Compensors were used for treatment of head and neck radiotherapy(RT) patients. The skin morbidity in these patients was evaluated in 178 patients treated with and without tissue compensator as a retrospective study (89 patients in each group). About 75% of the H & N patients were in Stage III/IV. 74% of all the patients had concurrent chemotherapy (Cisplatin, Carboplatin and Paclitaxel). It is observed that in Group A (Orfit uncut, No Tissue Compensation) 12 out of 38 (31%) have not completed dose

PP-12
PLAN ANALYSIS ON SANDWICH TREATMENT IN OESOPHAGUS WITH VERIFIED DOSEMETRIC PARAMETERS

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up to 60 Gy (more drop outs). In 26 patients who completed >60 Gy dose, 9/26 (35%) had absented >5 fractions; 4 patients, (4/38) 11% only received 70 Gy planned dose. In Group B (POP Immobilization, Tissue Compensated), 24 patients (24/29), 83% completed RT above 60 Gy. In these 24 patients, 3 (11%) only had interruptions >5 fractions. 7 patients (24%) could complete 70 Gy. Group B patients did not face more interruptions due to treatment morbidity. Also in Group B, there was no skin sequelae in 29 patients, 5 patients had only. In Group D (Orfit Cut, Tissue Compensated), 90% of the patients (54/60), could complete >60 Gy dose; whereas in Group C (Orfit Uncut, No Tissue Compensation) only 65% (33/51) could complete >60 Gy. In Group D, 28% completed a dose of 70 Gy compared to only 6% in Group C. In 33 patients (Group D) who completed >60 Gy, 89% of patients (48/54) completed treatments with minimal interruptions; whereas in Group C, only 73% of patients (24/33) completed >60 Gy with minimal interruptions. A careful review of all groups brings out an important observation that in ‘Uncompensated RT’ (A and C) 31% and 35% of the patients could not reach a dose upto 60 Gy; in ‘Compensated RT’ (B and D) 17% and 10% patients only did not complete 60 Gy. Grade IV Skin and Mucosal reactions which occurred in Group C reduced in Group D. Skin reaction appeared minimal or did not occur in most of the ‘tissue compensator treated’ patients, facilitating dose escalation up to 70 Gy. Two radiobiological end points shall be understandable in head and neck radiotherapy from this study. Without ‘Tissue Compensation’, 82% of patients receive 10% to 15% increased dose to tip of the neck. In 88% of patients, 6% to 13% increased dose to chin portion. The spots of increased radiation doses directly correlate the spots of radiation reactions. When the physical dose is more in some regions, it becomes larger fractionation, radio-biologically there are islands of higher effective dose (as high as 2.32 Gy/Fr), thereby inducing excess morbidity in normal tissues both in skin and mucosa.

Due to skin morbidity, when overall treatment time (OTT) is increased from 42 days, the Biologically effective dose (BED) and Equivalent total dose (ETD) for the total regimen reduce; effectively likelihood of local control. We calculated effect of 60 Gy total dose in 42, 45, 50, 55, 60 days giving effectively BED values 63.6Gy, 61.8Gy, 58.8Gy, 55.8Gy and 52.8Gy respectively; 2Gy/Fr ETD becomes 60Gy, 58.5Gy, 56Gy, 53.5Gy and 51.0Gy respectively; A reduction in Local Control from 100% to 95.8%, 88.8%, 81.8%, 74.8% due to increase in OTT expected. Therefore, it is strongly highlighted that Cobalt RT has a strong role in head and neck RT, if tissue compensation and build up preservation is practiced.

**PP-14**

**MEASUREMENT OF DOSE TO RECTUM DURING HDR INTRA-CAVITARY BRACHYTHERAPY FOR CANCER OF UTERINE CERVIX**

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**Objective:** Brachytherapy ensures good local tumor control and disease free survival. The dose prescription for the HDR application is restricted by the dose tolerance of the rectum and bladder. Hence accurate estimation of rectal and bladder doses are essential to decide upon the dose prescription for each fraction of HDR treatment.

**Materials and Methods:** At our institute, Carcinoma uterine cervix patients undergo a conventional EBRT followed by 3 fractions of HDR brachytherapy. Dose to rectum was measured using TLDs for twenty five cases where standard Fletcher tandem-ovoid applications were done under local anaesthesia. A total of 5LiF: Mg TL pellets were placed in small plastic tube at a regular spacing of 1 cm and inserted into the rectum and orthogonal radiographs were acquired on a C-arm for treatment planning. The doses measured using the TLD’s were compared with the rectal dose calculated on the TPS.

**Results and Conclusion:** The dose to rectum measured varied between 3.5-4.5 Gy for a prescription of 7 Gy to point A, (40-45%) and within tolerance. The patients were followed up for a month and no patient was presented with unmanageable early complications. It is also observed that the HDR ICBT applications were well tolerated by the patients while delivering dose for maximum tumor control. The variation between the physically measured and the TPS calculated doses were within 1% which gives us confidence in the accuracy of dose delivery in HDR brachytherapy of cancer uterine cervix.

**PP-15**

**DENTAL RADIATION SAFETY STATUS IN COIMBATORE REGION**

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**Introduction:** To diagnose the oral health, dental x-rays are essential. Dental x-ray machines vary from simple hand held radiographic machine to 3-D Cone Beam Computed Tomography (CBCT) machines. They have a wide range of exposure parameters varies from 60 kV and 2 mA to 90 kV and 20 mA. Ionization radiation can bring two main biological effects mainly stochastic and deterministic. A certain threshold dose is required for deterministic effect to occur and the chance for this effect to arise is very less in dental radiography. Several retake of dental x-ray, use of improper exposure parameters and room design, lack of quality of dental machine and knowledge about radiation are some of the reasons leads to increase the chance of stochastic effect. Estimating the accurate exposure parameters depending on patient size and position of teeth, opting right dental radiography method are some of the guidelines to ensure patient safety. In this research study, a questionnaire regarding dental radiation safety has been prepared and data were collected from several hospitals and clinics and further analyzed to implement safe dental radiography procedures in Coimbatore, Tamil Nadu. Purpose The purpose of this study was to analyze current dental radiation safety protocols and practices followed by dental hospitals and clinics and establish a safe method of practice for dental radiology.
Abstracts

Materials and Methods: This study was carried out in 15 clinics at Coimbatore in Tamil Nadu, where OPG and intraoral machines were installed. The selection of hospitals was done by considering the patient workload. A questionnaire enclosed of 15 questions was prepared to collect data regarding the dental practices and protocols followed by the hospitals and clinics in Coimbatore region. This data helped to record the dental radiation status in Coimbatore region.

Results and Discussion: Among 15 clinics enrolled in this study 5 were having OPG machines and 10 were having intraoral machines. It was observed that limited numbers of clinics were aware about radiation protection protocols. The result discloses that 73 % of the clinics don’t have TLD, 87 % of the clinics not registered under eLORA and properly not maintaining calibration as per AERB, 47 % of clinics don’t have lead apron and thyroid collar for patient and staff protection. Lack of knowledge about radiation and its consequences constrains dentist to avoid using lead aprons and thyroid collars. Addition to this, radiation dose can be reduced to an adequate level by using fast films or digital detectors instead of normal films. Also the study found that majority of hospitals weren’t keen in changing the exposure values by considering patient size, age and sensitivity of detectors. It is mandatory to adopt ALARA and dose reduction standards stringently.

Conclusion: Findings obtained in this research work imply the requirement of sudden attention from authorities towards all dental clinics. Hesitation of several dentists to support this research work points the idleness of authorities to implement stringent regulations. The radiograph can create risks to radiographers, dentists and patients. Knowledge about radiation and its consequences is necessary for everyone who is working in radiation field.

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PP-16

EFFECTS OF NONCONFORMAL RADIOTHERAPY TECHNIQUES IN BREAST CANCER PATIENTS

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Breast cancer is the most prevalent cancer type in women and global best practice in radiation treatment of cancer requires the use of conformal techniques. Inavailability of required equipment in some developing countries result in a deviation from standard practice. This study set out to estimate the ensuing risk.

Twenty (20) breast cancer patients (stages I – III) were planned on a Prowess Panthet TPS using a 1.25 MeV cobalt beam of 80 cm SSD. The patients were simulated using both the standard 3D two laterally opposed tangential fields with appropriate wedge angles and a 2D technique in which the field borders were determined using bony landmarks on the DRR images mimicking the scenario in a typical low resource radiotherapy centre. The beam was conformed to the target using cerrobend blocks for the standard 3D technique only. The two techniques were compared in terms of the doses to the PTV and the OARs; the lungs and the heart. The LKB NTCP model was used to assess the possibility of developing radiation pneumonitis and pericarditis in the OARs respectively.

The mean and maximum doses to the PTVs and OARs were significantly higher in the 3D technique for all patients. The NTCP values showed that there was no risk of pericarditis while the risk for pneumonitis was higher in the 3D technique. The doses to the OARs were lower in the 2D technique than the 3D technique however at the expense of the coverage to the PTV.

PP-17

EVALUATION OF PLAN QUALITY OF INTENSITY MODULATED RADIATION THERAPY FOR TWO DIFFERENT BEAM ORIENTATION FOR CARCINOMA CERVIX

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Introduction: Radiotherapy (RT) plays an important role in the adjuvant treatment of gynecologic malignancies, particularly in cervical and endometrial cancer. While RT has greatly improved local regional control of primary tumors, it has come at the cost of significant toxic effects to adjacent non-cancerous tissues. In the late 1990s, the technique of three-dimensional conformal radiation therapy (3D-CRT) emerged as a preferred treatment for gynecologic malignancies, since it gave better target coverage and significantly reduced the radiation exposure to the bladder. However, this technique did not appreciably reduce the amount of radiation exposure to the intestine or rectum. More recent advances in computer technology have led to improvements on the 3D-CRT technique; one, in particular, being the development of intensity modulated radiation therapy (IMRT). In contrast to 3D-CRT, which uses uniform fields, IMRT generates non-uniform fields to achieve better planning target volume coverage, while decreasing unnecessary radiation exposure to normal organs. Therefore, IMRT has become a common strategy for whole pelvic radiotherapy (WPRT), and has been shown to offer more accurate dose distributions and tighter dose gradients to targets and to reduce toxic risk and undesirable side effects to the rectum, bladder, small bowel, and pelvic bones.

Purpose: The aim of this study is to evaluate the effect of beam orientation in Intensity modulated radiation therapy and to evaluate the effect and the plan quality by using Eclipse treatment planning system.

Methods: For this study twenty patients of carcinoma cervix IIB were selected those treated in our institution from the period of Jan 2018 to June 2018. Clinical step and shoot IMRT treatment planning were done using nine beam orientation with Eclipse treatment planning system and was delivered on Siemens Oncor Expression with multi leaf collimators (82 leaf). To ensure the similarity or difference in the plans due to beams orientations, nine beams orientation were planned with certain optimization objectives to achieve the target and OARs dose and the
same objectives were used for the seven beam orientation plan and the plans were evaluated.

**Results:** The Plan analysis performed based on dose distribution and Dose Volume Histogram for Planning target volume (PTV), the organ at risk (OARs) as well as other physical indices like Mean dose (Dmean), Maximum dose (Dmax), 95% dose (D95), %5 dose (D5), total number of segments, monitor units, Dose homogeneity Index and Conformity Index for the PTV were also evaluated.

**Discussion:** For all twenty patients both nine beam IMRT and seven beam IMRT technique gave clinically acceptable plans while comparing target doses and dose to critical organs. Dose homogeneity index for 9beam and 7beam IMRT is 1.03 ± 0.01 and 1.03 ± 0.01 and significance difference P=0.02. Significance difference (P=0.002) exist only between the conformity index of PTV CI (1.03 and 1.03) for both plans. Similarly OAR doses for bladder, rectum, bowel, Right femoral head and Left femoral head were evaluated there is much variation in both plans for all twenty patients the significance difference for all critical organs (P<0.0001). Monitor units for 9beams and 7beams (750.84 and 738.11). There is little variation was observed in the segments (79 and 66).

**Conclusion:** We conclude that it is not necessary to select 9beam IMRT for the treatment of Ca. Cervix we can select 7beam IMRT were we can achieve the similar PTV coverage and OARs doses as achieved from 9beam IMRT and also as step and shoot IMRT it will help us to reduce the overall treatment time to the patients.

**PP-18**

**DOSIMETRIC EVALUATION OF FIELD IN FIELD INTENSITY MODULATED RADIATION THERAPY AND INVERSE PLANNING INTENSITY MODULATED RADIATION THERAPY FOR CARCINOMA LEFT BREAST**

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**Introduction:** Breast cancer is the most common cancer in women worldwide as it is also the main cause of cancer death among women globally. The use of radiotherapy in the adjuvant setting has shown to improve both local control and overall survival in early stage breast cancer patients. The most common and traditional whole breast radiotherapy technique uses two tangential fields due to its efficiency in terms of sparing nearby organs at risk (OARs) as well as technical simplicity in which wedge filters are used to compensate patients surface irregularity and reach a homogenous dose distribution. This technique has evolved over the last decade with introduction of multi leaf collimators (MLC) to deliver three dimensional conformal (3DCRT) or intensity modulated radiation therapy.

**Purpose:** This study is to evaluate the target coverage and Organ at risk (OARs) doses in both Field in Field Intensity modulated radiation therapy (FIF-IMRT) and Inverse planning Intensity modulated radiation therapy (IP-IMRT).

**Methods:** For this study twenty patients of left breast cancer cases were selected those treated in our institution from the period of Jan 2017 to June 2018. Treatment plans of 22 patients with left sided breast cancer, in which 10 post mastectomy treated to a prescribed dose of 50 Gy to chest wall with FIF-IMRT and 12 post breast conservative surgery treated to a prescribed dose of 50 Gy to the whole breast in 25 fractions, patients are treated with 8 beam IP-IMRT. For 10 post mastectomy patients 8beam IP-IMRT was planned and for other 12 patients FIF-IMRT monoisocentric plan were created by combining two fields with three to four segments in two tangential beam direction and these plans are compared and evaluated.

**Results:** The Plan analysis performed based on dose distribution and Dose Volume Histogram for Planning target volume (PTV), the organ at risk (OARs) as well as other physical indices like Mean dose (Dmean), Maximum dose (Dmax), 95% dose (D95), %5 dose (D5), the Dose Homogeneity and Conformity Index to Planning target volume (PTV) and dose received by OARs like both lungs, heart and Contralateral breast were compared in both technique for all 22 patients.

**Discussion:** All patients both FIF-IMRT and IP-IMRT technique achieved comparable radiation dose delivery to PTV-95% of the prescribed dose covering >95% of the breast PTV. The volume of PTV receiving 110%(V110) of the prescribed dose was 1.12±1.1% for FIF-IMRT and 0.75±1.2% for IP-IMRT. The dose homogeneity and Conformity indices (HI and CI) were similar for FIF-IMRT and IP-IMRT (1.02 and 0.9). In OARs Ipsilateral lung and heart V30, V20, V5 and Dmean were compared, the low dose volume V5Gy and Dmean in the heart and ipsilateral lung were larger in IP-IMRT than the FIF-IMRT (50.67% and 93%), (15.54Gy and 18.81Gy). In this study, the relative volume of contralateral breast and contralateral lung volumes V5,V2 and Dmean were analyzed. The contralateral lung in FIF-IMRT receive significantly low doses (1.31%±1.4%, 7.38%±4.9%, 1.02Gy±0.3Gy) than the IP-IMRT (66.16%±24.4%, 93.92%±14.7%, 6.96Gy±1.9Gy).

**Conclusion:** Comparison with IP-IMRT, FIF-IMRT proved to be simple and efficient planning technique for breast irradiation. It provided dosimetric advantage, significantly reducing the size of the hot spot and minimally improving the coverage of the target volume. In addition it was felt FIF-IMRT required less planning time, easy field placements and less time for treatment delivery.

**PP-19**

**COMPARING EUD BASED OPTIMIZATION AND PHYSICAL OPTIMIZATION IN BREAST CASE IMRT DOSE DISTRIBUTION**

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**Introduction:** In the advance radiotherapy technology such as 3D conformal radiation therapy, IMRT and VMAT technique, Breast cases need more involvement with understanding of anatomy. Radiobiological principles and treatment planning. The Main challenge of Breast treatment planning is to reduce the dose to life saving organs of Heart, Lung and Spinal cord is making feel difficult.
Abstracts

**Purpose:** The purpose of the study is to reduce the Heart, Lung, Cord & Contra lateral Breast in IMRT with EUD Based Optimization.

**Materials and Methods:** Fifteen consecutive Patients data were compared with EUD Based Optimization & Physical Optimization. For IMRT planning we have used 5 fields. For Conventional Planning we have used minimum Four fields. The patients were planned for 4005cGy/15fractions/3week. The plans were planned in same target volume(PTV) and Planning were performed using the Eclipse(V13.7) treatment planning system, Executed in VARIAN TRUE BEAM STX & Verified with Gamma Evaluation method (PTW OCTIVIUS with help of 2D array phantom). Integral dose has been calculated by subtracting target volumes from the Total body volume.

**Results:** Volume Lung dose (V20) is optimal in EUD Optimization, Dose to Heart & spinal cord has optimized in EUD Optimization.

**Discussion and Conclusion:** Dose to Lung, Heart & Cord has been reduced in EUD Optimization & Achieving good result in Dosimetric parameters & Gamma Evaluation has been achieved given criteria.

**PP-20**

**NEED OF PUBLIC PRIVATE PARTNERSHIP MODULE IN GOVERNMENT CANCER HOSPITALS**

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The Department of Radiotherapy in Shyam Shah Medical College, Rewa was started in the year 2003 but could not become functional due to non-availability of trained staff like Radiotherapy Technologist and Radiological Safety Officer. Dr. Gopa Ghosh was the Head of Department and Radiation Oncologist took lots of effort to make this unit functional but finally department gets closed. This unit was re-started under Public Private Partnership (PPP) Module by Honorable Minister Rajendra Shukla Ji. Mr. Yougesh Shukla took personnel interest and makes this unit functional after 13 years. Asha Cancer Care got Grand of Rs. 81 Lacs from Department of Atomic Energy (DAE), Government of India for radioactive source replacement. Now the department is working smoothly and got permission from Atomic Energy Regulatory Board (AERB), Mumbai. The PPP Module is very successful in Government radiotherapy departments. Now, almost all the cancer patients from Rewa and nearby districts getting radiotherapy treatment. The department of radiotherapy is totally different from other medical departments. Most of the time Dean/Head of Institution have less knowledge about the radiotherapy department. In this presentation, different types of challenges and advantages of PPP Modules we will discuss.

**PP-21**

**COMPARISION OF PRE-TREATMENT EPID BASED PATIENT SPECIFIC QA RESULTS WITH DURING-TREATMENT TRAJECTORY LOG FILES ANALYSIS OF TRUEBEAM LINEAR ACCELERATOR**

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**Introduction:** IMRT (Intensity Modulated Radiotherapy)/ VMAT(Volumetric Modulated Radiotherapy) is a complex process which requires a proper QA programme in place in order to ensure a accurate tumoricidal dose delivery. The accuracy of dose delivery must be documented for each course of treatment by irradiating a phantom that contains array of detectors to sample the dose distribution & to verify that the dose delivered is the dose planned.

**Aim:** To compare EPID based patient specific QA results with Trajectory log files analysis of trueBEAM linear Accelerator.

**Materials and Methods:** Patient specific dosimetric verification of an IMRT/VMAT plan is an important part of clinical implementation of IMRT/VMAT into any clinic. 10 patients comprising different clinical cases & undergoing IMRT/VMAT treatment on trueBEAM Linear Accelerator (Varian Medical System, Palo Alto, USA) were selected for this study. The pre treatment patient specific QA was performed with a-Si 1200 EPID (amorphous Silicon Electronic Portal Imaging Device). During treatment, the TrueBeam™ system records actual axis positions and MU delivered. After the treatment is completed, this information is stored to a trajectory log file. The truebeam control system generates the trajectory log files after the course of treatment by irradiating a phantom that contains array of detectors to sample the dose distribution & to verify that the dose delivered is the dose planned.

**Discussion and Conclusion:** The trajectory log files analysis QA studies were performed using Assurance QA Software.

**Results:** For portal dosimetry QA & Assurance QA, the predicted dose distribution and the acquired one are compared using the gamma evaluation criteria of dose to agreement of ± 3% & or distance to agreement of ±3mm. The dose threshold & pass minimum were set at 10% & 90% respectively. The gamma values obtained from Portal Dose Image Prediction (PDIP) software were compared with the Assurance QA software. The maximum % variation & (minimum) maximum standard deviation observed was (0.1) 6.15% & (0.07) 4.13 respectively for one patient. The maximum difference was found for one patient because the field size in YDirection was 38cm, so some portion of the fluence was out of the EPID active area which resulted in low gamma passing rate as compared to Assurance QA.

**Conclusion:** The trajectory log file analysis using Assurance QA tool was highly correlated with the Portal dose image prediction software. The trajectory log file analysis is helpful for the cases where treatment field size is more than the active area of phantom used for patient specific dosimetry.

**PP-22**

**ROLE OF SUPERPARAMAGNETIC NANOPARTICLE AS RADIATION THERAPY SENSITIZER**

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**Introduction:** The purpose of the study is to evaluate the role of superparamagnetic nanoparticle (SPMN) as a radiation therapy sensitiser. SPMN is a type of magnetic nanoparticle containing iron oxide. At present, the clinical use of SPMN is limited due to low efficiency of the magnetic field. This study was undertaken to compare the efficiency of the magnetic field between SPMN and conventional nanoparticles.

**Materials and Methods:** The study used two types of nanoparticles: SPMN and conventional nanoparticles. The efficiency of the magnetic field was measured using a magnetic field strength gauge. The results were then compared to determine the effectiveness of each type of nanoparticle.

**Results:** The study showed that SPMN had a significantly higher magnetic field strength compared to conventional nanoparticles. This indicates that SPMN could be a more effective radiation therapy sensitiser.

**Discussion:** The findings of this study suggest that SPMN could be a promising candidate for use in radiation therapy. Further research is needed to investigate the long-term effects and potential applications of SPMN in radiation therapy.

**Conclusion:** SPMN had a significantly higher magnetic field strength compared to conventional nanoparticles, indicating its potential as a radiation therapy sensitiser.
Introduction: Cancer is one of the leading causes of death worldwide and the number of cancer-diagnosed patients is rapidly increasing, in part due to an ageing population. Radiotherapy is a key treatment and is beneficial in the treatment of about 50% of all cancer patients. Such treatment relies on the deposition of energy (the dose) in tumour cells, typically by irradiation with either high-energy gamma rays or X-rays (photons), or energetic beams of ions, sufficient to damage the cancer cells or their vasculature and thus induce tumour death or nutrient starvation. Photon radiotherapy is non-specific, since a significant dose can be delivered to healthy tissue along the track of the photons, in front and behind the tumour. For radiotherapy, the central pathways to increase the therapeutic index, i.e. the ratio of treatment efficacy to side effects, are enhancement of radioresistance in healthy tissue, increasing radiosensitisation in tumour tissue, and better confinement of the deposited dose to the tumour volume. Increase in radiosensitization of tumor tissue can be done by the use of nanoparticles.

Purpose: Given that radiation therapy is not a selective antitumor treatment, the main challenge for radiation oncologists, medical physicists and radiobiologists is to increase its therapeutic efficacy without increasing damages dealt to the surrounding healthy tissues. Hence, by sensitizing tumor cells, it can be treated with less dose than required so that we can reduce normal tissue dose. To evaluate the efficacy increase in classical radiation biology, it is customary to use the Relative Biological Effectiveness (RBE) which is defined as the ratio of a dose of standard radiation (e.g. photons) to a dose of any other type of ionizing particles (i.e. protons, neutron, etc) to produce the same biological effect. E.g. Medical physicists and radiation oncologists would have to deliver 30 Gy with NPs instead of delivering 60 Gy, if the therapeutic strategy "X-rays with NPs" was characterized by a RBE of 2.

Materials and Methods: PEG coated superparamagnetic nanoparticles have been synthesized by chemical co-precipitation method and were characterized by X-ray powder diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), Transmission electron microscopy (TEM), Thermogravimetric analysis (TGA), Zeta-Potential Measurements, Dynamic Light Scattering (DLS) and Magnetization studies.

Results: The XRD pattern reveals the formation of single phase Fe3O4, inverse spinel structure with lattice constant, a=8.3578 A0, which is very close to reported value of magnetite (JCPDS Card No. 89-4319, a=8.3952 A0). The crystalline size of PEG coated MNP is estimated about 10.42nm from X-ray line broadening using the Scherrer formula. FT-IR spectra shows two characteristic absorption bands from the Fe-O in bare Fe3O4 at 586cm-1 and 626cm-1. 3399cm-1 band probably attributable to stretching vibration of O-H bond. The peak at 1643 cm-1 for PEG coated Fe3O4 and at 1632 cm-1 for bare Fe3O4, represents shifting of stretching vibration of C=O group which confirms the appearance of PEG molecule on surface of Fe3O4.

Conclusion: Size of nanoparticles is enough to penetrate cancer cell lines and PEG coated nanoparticles are hydrophilic and protein rejecting. With the use of nanoparticle as a radiotherapy sensitizer to tumor we can minimize dose to normal tissue.
comfort and reduces the risk of intra-fraction motion. It also increases the feasibility of breath hold and gating techniques in lung SBRT.

**PP-24**

**COMMISSIONING OF VOLUMETRIC DOSIMETER (DELTA 4) AND PRE TREATMENT QA FOR INTENSITY MODULATED RADIOTHERAPY**

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**Introduction:** The IMRT technique is widely used in clinical application to deliver the highly conformal dose to the target and spare the normal structures. To achieve that we need a more accuracy and high precision volumetric dosimeter.  
**Purpose:** The purpose of this study is to perform the commissioning of Delta 4 dosimeter QA system and evaluate the IMRT Pre treatment plans.  
**Materials and Methods:** Linear accelerator(ELEKTA COMPACT), 0.6cc Ion chamber, Polyethylene (PMMA) Phantom, Scandidos Delta4 Phantom, Solid Phantom, Oncentra Treatment Planning System (TPS) v4.3.  
The Delta 4 Phantom is a Diode based detector and that phantom measuring the absolute dose cylindrically. The measurement is synchronized with the linac by detecting the trigger pulse signal from the linac. We performed following tests to ensure the dose is measured accurately.  
1. Cross calibration with Ion chamber  
2. Relative Array Calibration  
3. Directional Response correction  
4. Temperature response check  
5. Box field plan verification and IMRT Plan verification.  
**Results and Discussions: Cross Calibration:** Absorbed dose was measured in Farmer chamber and PMMA Phantom of Delta4. The result of PMMA shows that 0.6% higher than the absorbed dose in water. This difference is due to mass absorption co-efficient and scatter condition of water and PMMA material.  
**Relative Array Calibration:** In this test shows, 93% of wing units detectors are within ±0.5% and 94% of Main unit detectors are within ±0.5%. The vendor acceptance tolerance was 90% of the detectors should have responses within ±0.5%. This Relative array calibration test was passed.  
**Directional Response Correction:** The directional calibration increases the accuracy of measurements by determining the detector-to-detector variations according the rotational direction-dependency of the detector. This measurements shows the result within ±5.0% as per vendor specification.  
**Temperature Response Check:** The Delta 4 device is diode based detector, it varies with temperature. So that, the temperature need to be entered into the Delta4 software prior to the every measurement and correction for the temperature calculated automatically by the software. For 20° C the dose was 0.9988 Gy and 21°C, the dose was 0.9689 Gy. It was found that dose increases with decrease in temperature.  
**Box Field Plan Verification:** The 2Gy prescription of Box field were planned in Oncentra TPS and executed in Delta 4 phantom. The result of Gamma value shows 99.2% of points pass the criteria of 3% Dose Deviation (DD) and 3mm of Distance to Agreement (DTA) with a dose threshold of 30% of the prescription dose.  
**IMRT Plan Verification:** The two IMRT Plan were implemented in Delta4 Phantom. The result of Gamma value shows 99.7% for prostate plan and 99.8% for esophagus plan. DTA results of both plan were also passed. The Pre treatment QA for two IMRT plans were performed with ion chamber(0.6cc) and solid phantom. The Maximum variation observed between the calculated dose (TPS) and measured dose was 1.30 % and 2.0 % for prostate and esophagus cases respectively.  
**Conclusion:** The Scandidos Delta4 Phantom for 3D dose verification were commissioned and met the criteria to be used clinically. The Pre IMRT Treatment plans were verified and results was passed.

**PP-25**

**DOSIMETRIC CHARACTERISTICS OF OPTICALLY STIMULATED LUMINESCENCE DOSIMETER IN PHOTON BEAMS**

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**Introduction:** Optically Stimulated Luminescence Dosimeter (OSLD), relatively a new dosimeter, recently introduced in medical dosimetry as a potential alternative to TLD. The properties and process that describe OSL are very similar to TLD but differ in read out technique and properties of dosimetric materials. TLDs contribute to transient signal immediately after irradiation and decay away in few minutes and also experiences fading with time. Therefore, it is essential to determine if the OSLD also have unstable traps that might contribute to transient signal immediately after irradiation. Due to the thermal stability of nanoDot OSLDs and the light tight casing, decreased fading is expected when compared to TLD.  
**Purpose:** The objective of the study was to determine the dosimetric characteristics of OSLD in photon beams. The precision and accuracy in measuring dose, field size, reproducibility, signal depletion, dose rate dependency, energy dependency and angular dependency of the detector have been investigated and compared with ion chamber measurements.  
**Materials and Methods:** Nanodot OSLD with MicroStar reader acquired from Landauer Pvt. Ltd., was used for this study. The nanoDots consist of plastic discs of Al2O3: C of 5mm diameter and 0.2mm thick. Irradiations were performed with LINAC and Cobalt machine photon beams. An element correction factor was determined for individual detector and applied to the raw readings of each dosimeter in all tests. Signal depletion per readout of OSL was investigated. The dose range selected for exposure to investigate the linearity of the OSLD was from 0.5 Gy to 10 Gy. In order to establish the field size dependency, the OSLDs were irradiated with field sizes from 3 x 3 to 40 x 40 cm2. The dose rate dependency of OSLD response was evaluated by varying the dose rate in the range 100 MU/min to 600 MU/min. To find the reproducibility, the OSL detectors were exposed to identical doses. The angular dependency was measured from 0° to 360° for 6MV photons.
**Discussion:** It was observed that the OSL response was linear for doses from 50cGy to 300 cGy and a supra linearity was observed for doses greater than 400cGy upto 10Gy. The experimental uncertainty (< 1.6%) found for field size variation with photon beams. For different dose rates, OSL dosimeters were found to have a maximum variation of 1.3% and 1.8% with ion chamber beams. For different dose rates, OSL dosimeters were found to have a maximum variation of 1.3% and 1.8% with ion chamber beams. For different dose rates, OSL dosimeters were found to have a maximum variation of 1.3% and 1.8% with ion chamber beams. For different dose rates, OSL dosimeters were found to have a maximum variation of 1.3% and 1.8% with ion chamber beams. For different dose rates, OSL dosimeters were found to have a maximum variation of 1.3% and 1.8% with ion chamber beams.

**Results:** The results shows that nanoDot OSL dosimeters are suitable for in-vivo dosimetry or continuous routine dosimetry in radiotherapy instead of TLDs or diodes, owing to its properties with regard to handling, small size and good dosimetric response with a relatively prompt read out.

**Conclusion:** The good reproducibility of OSLD system demonstrated that these nanoDots could be conveniently reused number of times provided optical bleaching in between the irradiations. Yet, OSLDs can be repeatedly used without an intermediate bleaching process by subtracting the previous exposure along with the background response. The measurements with photon beams carried out indicated that this newly introduced OSLD is suitable dosimeter for dosimetric measurements in clinical radiotherapy settings.

**PP-26**

**VOLUMETRIC MODULATED ARC THERAPY PRE-TREATMENT DOSE VALIDATION: A SECOND VERIFICATION OF MONITOR UNITS WITH A DIAMOND SOFTWARE**

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**Introduction:** At the moment it is recommended to perform an independent check of the MUs calculated by the treatment planning system (TPS). In modern complex treatment techniques, it is not feasible to perform these checks by hand, Diamond (PTW Freiburg version 6.2) is a secondary check software that allows independent MU and point dose verification for VMAT treatment.

**Materials and Methods:** As a part of our QC program all the dose calculations are independently checked, in particular our VMAT pre-treatment protocol establishes that prior to each treatment, calculations are verified at least with:
- Diamond software (PTW Freiburg version 6.2)
- Octavius 4D (PTW Freiburg verisoft version 7.0).

For the MU/point dose verificationDicom files exported from Monaco (version 5.10.02) (dose, plan and structure) are imported by Diamond which compares results against the TPS. The isocenter coordinates and dose are automatically read by Diamond to perform the comparison, but if it is not a representative dose point for all the arcs, extra points must be generated in MONACO and manually introduced in Diamond. We have analyzed the results of the comparisons as well the practical questions that have arisen.

**Results:** We have calculated more than 25Lung patients since June 2017. Two arcs are commonly used for majority of the plan. The average deviation is 1.53% with maximum deviation is 8% in diamond and the average passing rate is 98.9% in Octavius 4D. The standard deviation is 3.7 % in diamond and 0.97% in Octavius 4D.

**Conclusion:** Diamond has proven to be an efficient tool to perform independent verifications of TPS VMAT calculations. From our initial experience we have found that some minor changes in the program such as an improvement in the introduction of all the desired calculation points or the possibility of modification of the calculation slice (removing support structures, adding heterogeneities) would be very helpful to users.

**PP-27**

**EVALUATION OF TREATMENT PLANS FOR BRAIN TUMOUR (GLIOMA) WITH DIFFERENT TREATMENT METHODS**

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**Introduction:** The very basic aim of radiotherapy is to deliver a tumoricidal dose to the target and at the same time spare the normal structures in the vicinity. Intensity modulated radiotherapy (IMRT) in the recent past has established itself as a gold standard for organs at risk (OAR) sparing, target coverage and dose conformity. With the advent of volumetric modulated arc therapy VMAT and 3DCRT, an inter-comparison is needed to address the advantages and disadvantages of each technique.

**Purpose:** Radiotherapy plays a major role in treatment of brain tumours. The main purpose of the study is to optimize the treatment approach for the GBM. IMRT in the recent past has established itself as a gold standard for organs at risk (OAR) sparing, target coverage and dose conformity. This study attempts to evaluate the treatment plans for brain tumours in 20 patients with different radiotherapy treatment techniques by 3DCRT, IMRT and VMAT.

**Materials and Methods:** Computed Tomography (CT) images of 20 GBM patients with 3mm slice thickness were used in this study. The contouring and treatment planning was performed in the Monaco treatment planning system version with 6 MV photons (Elekta Infinity LA) available in our Department. The dose to 95% tumour volume, dose received by eye lens, eye ball, optic nerves, and optic chiasm were calculated using the DVH from Monaco treatment planning system. For all the selected patients,3DCRT, IMRT and VMAT treatment plans were generated. Plan comparison was done in terms of target coverage, dose homogeneity index (HI), dose conformity index (CI), OAR dose, monitor units (MUs) and Integral Dose (ID).

**Results:** The dose to 95% to the Planning Target Volume (PTV) were maintained for all three treatment techniques. PTV coverage is comparable in all three treatment techniques. However, VMAT give better sparing of critical structures such as optic nerve, optic chiasma and brainstem than IMRT and 3DCRT. whereas, 3DCRT technique gave better sparing in...
eye and eye lens but the PTV coverage is less than IMRT and VMAT. Monitor Units (MU) for VMAT is more when compare than IMRT and 3DCRT plans.

Discussion: Radiotherapy is usually delivered with 3D-conformal techniques but several improvements in the technologies led to more complex delivery technique (IMRT and VMAT) used to treat different types of solid tumours with a considerable outcome, allowing to deliver dose with excellent conformation around the tumour and a better sparing of normal structures. VMAT is an advanced radiation treatment modality. It has a potential to generate treatment plans which are comparable with the corresponding IMRT and 3DCRT plans in terms of OAR sparing, plan quality with better treatment efficiency.

Integral dose (ID) and the volume receiving low-dose radiation for non-target volume, represented by ID of low-dose regions, were compared between IMRT plan, VMAT plan and 3DCRT for all the 20 patients. The study also showed that 3DCRT scored less ID than IMRT and VMAT. However, the IDs for VMAT and IMRT showed not much difference, with VMAT plans showing very minimal decrease in IDs when compared with IMRT.

Conclusion: This study shows achievement of better treatment of GBM cases with IMRT and VMAT techniques (except increase in IDs) when compared with 3DCRT technique. VMAT had additional advantage of lesser treatment time when compared with IMRT.

PP-28

PLANNED VERSUS RECEIVED DOSE IN SBRT LUNG CASES: A STUDY ON DOSIMETRIC INFLUENCE OF DAILY IMAGE-GUIDED RADIOTHERAPY CORRECTIONS

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Purpose: To study the daily variations in delivered doses in Stereotactic body radiotherapy lung cancer patients, using Cone Beam Computed Tomography (CBCT) images acquired before treatment to correct for target position.

Materials and Methods: Ten patients treated with volumetric Modulated Arc Therapy (VMAT) to the Lung cancer patients were studied. CBCT performed on all patients before treatment for all fractions. Patients were localized after CBCT by fusing the CBCT with the planning CT to evaluate the corrections that closely matches the patient treatment position with the planning position using bony land marks. Then CTV was superimposed on both scans for final corrections or daily deviations. Initially lasers match with external fiducial markers; later localization point changes with respect to external fiducial markers due to inter-fraction variations. Patients received 50 Gy of SBRT using 6X unflattened beam in 5 fractions. Actual dose delivered were calculated on CT for contour after editing the normal structures and PTV according to the fused CBCT on that day in Treatment planning system. The mean, maximum and minimum doses received by the planning target volume and mean doses of oesophagus, trachea and maximum dose of spinal cord were evaluated.

Calculations were performed on each day on edited CT for contour. For this study 5 fractions for 5 patients (total 25 study sets) were created. Planning CT fused with daily CBCT for all 5 fractions to delineate and adjust the OAR contours.

Results: Localization was performed to optimize the target coverage. Over the whole treatment, most patients experienced Significant deviations in dose and displacement for Spinal cord, trachea and Oesophagus. Compared with the planning values, the mean dose for PTV was-5% % to-0.2 %, for trachea was-20 % vs +20 % and for Esophagus was 2% to >20 %. The dose maximum in spinal cord changes from 0.2 % to 10%. For PTV, deviations in maximum dose and minimum dose were observed; whereas mean dose variations observed less than 3%.

Discussion: In general, we have been concentrating on tumor localization and its position compared to other normal structures. Our aim is to deliver the maximum dose to the tumor and minimum dose the surrounding normal structures. As we are concentrating on only tumor the OARs are neglected. The dose planned versus the actual dose delivered were different due to its position with respect to the tumor or isocenter in most of the cases. If the Actual dose delivered to the OARs were near to the prescription or within the limits, then there will not be any issue. Problem comes only if the dose exceeds the limit to the OARs. To know this first we need to get the actual dose to the OARs. This method shows the solution for this task. This study can avoid hazards due to excess dose to normal structures or critical structures due to their mobility, Inter-fraction variation and Intrafraction variations.

Conclusions: This study shown the actual dose delivered to the PTV and normal structures while localization was performed to optimize the target coverage in daily IGRT corrections. A detailed study on few more number of patients yet to complete to give more meticulous results on doing daily shifts for tumor localization.

PP-29

DOSIMETRIC COMPARISON OF FIELD IN FIELD AND IMRT TECHNIQUES IN BREAST CANCER TREATMENT

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Introduction: The curative potential advantage of radiation therapy in the management of Breast cancer is greatly enhanced by the use of Intensity Modulated Radiotherapy (IMRT). The success of IMRT requires the high radiation dose delivery to the tumour, while sparing the surrounding normal tissues. The aim of this study is to compare the feasibility of 3DCRT, Field in Field (FiF) 3DCRT, IMRT plans to improve the treatment quality and optimize the treatment approach for the Breast cancer.

Purpose: The present study is aimed at comparing the planning and delivery efficiency of FiF 3DCRT and IMRT in radiotherapy of cancer of breast. Treatment planning using 3DCRT technique without any subfields was also performed for dosimetric comparison.

Materials and Methods: Treatment plans of 20 patients with left sided breast cancer and 5 right sided breast Cancer was used for this study. The 25 patients who had breast...
conservative surgery received a prescribed dose of 50Gy in 25 fractions to the whole breast. FIF, IMRT and 3DCRT plans were compared for doses in the planning target volume (PTV), the dose homogeneity index (HI), conformity index (CI), conformation number (CN), dose to the ipsilateral lung, dose to the left and right breast irradiation and the monitor unit counts (MU) required for treatment. In the 3DCRT technique, the beam arrangement consists of two parallel opposed tangential beams with dynamic wedges. The FIF plans were created by using two open tangential beams and four to five subfields. Five beam angles were chosen to create IMRT plans and were inversely optimized.

**Results:** The HI, CI and CN were similar for 3DCRT and FIF whereas IMRT plans had better CI and HI and CN. The low-dose volumes (V10) in the heart and lungs were lowest in FIF plans than in the other techniques. The mean dose to the heart and ipsilateral lung was higher with FIF and 3DCRT than with IMRT. The Heart dose in the case of right breast irradiation is negligible in all three techniques. In the current study, the relative volume of contralateral breast receiving low dose (1 Gy) was significantly lower with the FIF plans than in the other plans. Also, 3DCRT and FiF techniques required fewer monitor units (MU) to deliver a given dose compared to IMRT.

**Discussion:** Target is more efficiently covered in the IMRT plans, compared to 3DCRT and FIF plans. The doses to critical structures i.e., lung, heart and contralateral breast is higher with 3DCRT technique compared to the other techniques. The IMRT and FiF techniques significantly reduced the maximum dose and the volume receiving greater than 110% and 107% of the prescription dose. The volume of contra lateral breast receiving dose of 1 Gy (V1) is found to be high in IMRT plans compared to the 3DCRT and FIF plans.

**Conclusion:** The 3DCRT technique without field-in-field though is simple to plan results in higher maximum dose to the target. The IMRT technique for breast radiotherapy enables significantly better dose distribution in the PTV with reduction in the doses to the organs at risk. However, the FIF technique is simple and efficient planning technique for breast irradiation. It significantly reduces the doses in low dose regions and it requires lesser planning time. Data analysis based on the dose volume histogram (DVH) shows that both FiF and IMRT techniques provided good dosimetric results.

### PP-30

**TPS COMMISSIONING AND VALIDATION OF SRS CONES BY USING TECHNICAL REPORT SERIES 483 PROTOCOL**

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**Introduction:** Success of radiotherapy is not only depends on the planning, dosimetry also plays a vital role in modern radiotherapy, because of the complex treatment technique. It is very essential to take care in the small field dosimetry, because of these factors i.e. Lack of lateral charged particle equilibrium (LCPE), occlusion of the source and detector size.

**Purpose:** Aim of this study is to implement the Technical Report Series 483 protocol in the commissioning of SRS cones and its dosimetric impact.

**Materials and Methods:** This work was carried out in Clinac ix (Trilogy) which has 6MV, 15MV and 6SRS and five electron energies. It has equipped with radio surgical cones of diameter ranging from 5mm and 10mm to 30 mm in steps of 2mm for the SRS treatment technique. The beam data requirements for the commissioning of the cone are TMR, Total scatter factor and Off Axis ratio (OAR). The TMR for the 5mm and 10mm diameter cones were measured using Scantiditronix stereotactic diode. And for the larger cones 12 to 30mm Wellhofer CC01 ionization chamber. The OAR were measured at the depth of 5 cm for the cones 5, 10, 12, 14, 20 and 30mm at three different SSDs 90, 100, 110 cm. In this study we have taken 18mm cone as reference field as a MSR (machine specific reference field) as specified in the code of practice TRS 483. The total scatter factor was measured with SSD of 100 cm at the depth of 5 cm for the available cones and normalized to 18mm cone size. The reference dosimetry has been carried out using 18 mm cone as a reference field. Reference dose for 18mm cone was measured in water phantom with 10g/cm2. The correction factor for reference dosimetry for the machine specific reference field, KQmsr, Q0fmsr, fmsr has been applied.

The formula for the reference dosimetry using the MSR is and the Corrected output factor for the MSR has been calculated by a new beam data has been generated using these parameters. To evaluate the beam data, a plan has been created using cones. Same plan has been delivered and the dose measured using CC01 chamber.

**Results:** We have measured the dose for each cone and compared with the TPS calculated dose. The TPS calculated MU are compared with manually calculated MUs.

**Discussion and Conclusion:** We found there is a good agreement between the TPS calculated dose and the measured dose. And also the manually calculated MUs are matched with TPS calculated MUs. The commissioning of SRS cones in the TPS has successfully done by using Technical Report Series 483 protocol.

**PP-31**

**DOSSIMETRIC EVALUATION OF CARDIAC AND LUNG DOSES FOR LEFT SIDED POST BREAST CONSERVATIVE SURGERY PATIENTS UNDERGOING HYPOFRACTIONATED RADIOTHERAPY USING 3DCRT**

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**Purpose:** To evaluate cardiac and lung doses in left sided breast conservative surgery undergoing adjuvant radiotherapy with hypo fractionated 3DCRT.

**Materials and Methods:** Between January 2012 to December 2015, 61 patients of Left sided breast cancer undergoing adjuvant hypo fractionated radiotherapy were included in present analysis. Clinical target volume (CTV), heart and ipsilateral lung and total lung were delineated on plan CT scan. 3DCRT plans with field in field techniques were generated for all patients. All dose calculations were done.
using AAA algorithm in Eclipse planning system version 8.9. Heart, lung and CTV doses were evaluated using dose volume histogram (DVH).

**Results:** Sixty one patients were included in analysis. The median age of cohort was 55yrs (range 35-76 years). The prescribed dose was 40 Gy in 15 fractions over period of 3 weeks. The mean CTV D95 was 36.5 Gy (Range 34.8-39.5). For heart mean and V25 were 4.7 Gy and 5.6% respectively. For ipsilateral lung (left lung) Mean, V5, V20, V30 was 7.8%, 28.3%, 15.45%, 12.07% respectively. For total Lung mean, V5, V20 and V30 was 3.79%, 12.88%, 7.07%, 5.46% respectively.

**Conclusion:** Hypo fractionated 3DCRT with field in field technique for left sided post BCS radiotherapy provides adequate coverage of CTV keeping heart and lung doses within accepted tolerance limit.

**PP-32**

**DOSE VOLUME PARAMETERS OF BONE MARROW PREDICTING HAEMATOLOGICAL TOXICITIES IN PATIENTS WITH CARCINOMA CERVIX TREATED WITH VOLUMETRIC MODULATED ARC THERAPY TECHNIQUE**

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**Aim:** Purpose of this study is to predict haematological toxicities in patients with squamous cell carcinoma of the cervix from dose volume parameters undergoing concurrent chemoradiotherapy by volumetric modulated arc therapy (VMAT) technique.

**Materials and Methods:** patients diagnosed with carcinoma of the cervix presented to the hospital between Jan 2017 till Dec 2017 were prospectively analyzed in this study. All were treated with concurrent chemoradiation by VMAT technique. Patients were assessed at baseline and every week during treatment for acute haematological toxicities. Dose volume parameters of VMAT plans from treatment planning system were correlated with RTOG grade of haematological toxicities.

**Results and Discussion:** A total of 34 patients diagnosed to have carcinoma of cervix were treated by radical radiotherapy by VMAT technique and concurrent chemotherapy (weekly cisplatin 40mg/m2). Median age of presentation was 54 years (39-73 years). The most common stage of presentation was stage IIB (61.7%). Out of thirty-four patients twenty-nine (85.2%) completed five cycles whereas four received four cycles and one received three cycles of chemotherapy. Statistical analysis was performed using ROC curve to find sensitivity and specificity of dosimetric parameters. The t test was used to find the probability for bone marrow toxicity. Mean dose to the bone marrow more than or equal to 28.85Gy was significantly associated with bone marrow toxicity (sensitivity – 82.4%, specificity-70%). Incidence of grade 2 or higher toxicity was increased if mean dose to bone marrow exceeded 31.2Gy and was negligible if mean dose was less than 27.9Gy. Analysis of different dose volume parameters showed that volume of bone marrow receiving 20Gy, 30Gy and 40Gy (V20, V30 and V40) more than or equal to 71.75%, 49.75% and 25.7% respectively were significantly associated with increased bone marrow toxicity.

**Conclusion:** It is important to consider bone marrow as an organ at risk and limit its radiation absorbed dose to decrease haematological toxicities in pelvic malignancies.

**PP-33**

**PRETREATMENT VERIFICATION USING PORTAL DOSIMETRY AND ION CHAMBER ARRAY DETECTOR**

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**Introduction:** The complexity of intensity modulated radiotherapy (IMRT) demands through verification of the planned dose before treatment delivery. Traditional method of film dosimetry for pre-treatment verification of patient specific IMRT dose distribution is gradually being replaced by two-dimensional (2D) array detector and portal dosimetry system due to their ease of use and immediate readout of the result.

**Purpose:** to use the ion chamber array detector (I’MatriXX) and portal dosimetry for IMRT patient pre-treatment verification. To analysis the gamma scaling parameters like γ (γ max), γ (γ avg) γ % ≤1. To compare the gamma indices used in the dosimetry system. To analyse the effect of gamma indices with respect to gantry rotation.

**Materials and Methods:** Twenty five IMRT plans (10H&N,9 Brain and 6 Cx) were selected for this study, Eclipse TPS used for IMRT planning and UNIQUE Linear Accelerator was used to deliver the IMRT plans. The high resolution aSi-1000 EPID with Portal dose prediction (PDP) software and 2D ion chamber Array detector (ImatriXX) with OmniPro IMRT software was used in this study. For each IMRT plans, a portal dose verification plan was created in eclipse TPS using PDIP algorithm and same was exposed on EPID which is placed at SSD of 105cm. the images were acquired in integrated mode and processed to determine the photon fluence. This processed fluence was then compared with corresponding predicted fluence in eclipse TPS. The same plan was verified with I’MatriXX with OmniPro IMRT software. Fluence of every plan was projected separately at SSD 100cm.

**Results:** The PD predicted and EPID measured photon fluence are in well agreement with overall mean values of γ max, γ avg and γ % ≤1 with1.63, 0.24 and 99.4% respectively. Independent verification using MatriXX showed comparable overall mean values of γ avg and γ % ≤ 1 is 0.26 and 99.80%. However, in all plans, MatriXX showed significantly lower γ max with an overall mean value of 1.37. Both MatriXX 2D ion chamber array and portal dosimetry showed comparable results.

**Discussion:** The agreement of PD predicted and EPID measured photon fluence/dose distribution were evaluated using gamma (γ) index set at 3%/3 mm distance to point agreement (DTA). Three gamma scaling parameters, maximum γ (γ max), average γ (γ avg) and percentage of points with γ % ≤1 were estimated for each field. An independent measurement was carried out with the MatriXX 2D ion chamber array detector and γmax, γ avg and γ % ≤1 were estimated using the OmniPro IMRT analysing software. The effect of gantry rotation on PD was also investigated for 5 IMRT plans.
Conclusion: the overall result of patient specific IMRT fluence verification using portal dosimetry and MatrixXX 2D ion chamber array is comparable except for gamma max, which is higher in portal dosimetry. However, all parameters are well within the clinically acceptable values. Based on the result of range of the plans studied, portal dosimetry can be considered as an alternative method of 2D detector array or vice versa for pre-treatment verification IMRT plans.

PP-34

POSITRON EMISSION TOMOGRAPHY/COMPUTED TOMOGRAPHY IMAGING FOR RADIATION THERAPY: OUR EXPERIENCE IN QUALITY ASSURANCE PROGRAM

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Introduction: In the last few years, there has been significant advances in radiation treatment planning (RTP) software of the treatment planning system (TPS) calculation algorithms and it is able to combine the biologically guided Positron emission Tomography (PET) data or Magnetic Resonance imaging (MRI) data and anatomic Computed Tomography (CT) data with five registrations methods namely, Manual approach (MA), Landmark, Identity, Surface Matching, and Mutual Information (MI) for precise three dimensional (3D) computer based dose calculation. Combined PET/CT based treatment planning has an advantage over CT alone in the standardization of target volume delineation (Gross tumour volume (GTV), Clinical target volume (CTV), and Planning target volume (PTV) margins), in reduction of risk for geometric misses and in minimizing radiation dose to the non-target organs.

Purpose: To identify and minimize the sources of uncertainties and errors, a rigorous quality assurance (QA) protocol of these imaging tools is mandatory for its proper functioning and effective image integration and safe use for patients. In this paper, QA procedures necessary for the success of PET/CT imaging for radiation therapy will be discussed.

Materials and Methods: INHS Asvini, a premier Indian Naval Hospital has installed an integrated PET/CT unit (Discovery Elite VCT 690) of M/s Wipro GE Healthcare make in Apr 2014. Till now optimum number of patients have undergone whole body PET/CT scans successfully. Prior to the actual clinical use, various acceptance testing and Quality Assurance (QA) tests related to radiation safety and proper calibration of the unit were carried out using 200 mCi of radioactive 18F-fluorodeoxyglucose (FDG) (half life 110 minutes), scatter fraction, image quality, sensitivity and spatial resolution phantoms, Ge-68 VQC phantom (solid polyethylene cylinder with line sources) as per the Atomic Energy Regulatory Board (AERB) proforma and National Electrical Measurement Association (NEMA) protocol. The QA program is generally divided into daily, weekly, and quarterly checks. The PET/CT scanner has a radioactive rod Ge-68 pin (half life 270.8 days) source mounted in a shielded container behind the scanner and is used for daily calibration. It monitors the image quality of the scanner. Tests like single events, coincidence, dead time and peak energy spectrum of the detectors are measured. In weekly QA, all detectors are irradiated and corrections are made for the detector outputs. The quarterly calibration provides the system with a benchmark for counting variations and optimizes the system performance.

The type of measurements includes the position of single events, update gain, and energy. The detector coincidence timing characterization, 2D normalization, 3D geometric and 2D/3D well counter calibration checks are also done. The vendor performs QA of image acquisition and data transfer and a standard disease specific image acquisition protocol is developed, optimized, and used routinely, and is confirmed by routine inspection of clinical procedures. The standard uptake values (SUV) forms the basis for quantitative use of the imaging data and automated segmentation. The delineation of target volumes and contours in radiation therapy is usually done by: (a) Visual interpretation; (b) By using a threshold SUV; (c) Threshold percentage of the maximum uptake; and (d) The source-to-background ratio. A rigorous validation tests and procedures are followed in tumor volume definition, by ensuring the consistency of SUV.

Conclusions: PET/CT imaging plays an important role in oncology. To ensure safe and effective use of this latest technology, a comprehensive QA program should be followed for checking overall performance of the scanner, thereby minimizing uncertainties and errors during treatment planning of radiation therapy patients.
on location and size of the tumor, average dose prescribed was 20Gy. X-ray energy of 6 MV FFF and a dose rate of 1400 MU/min, were used for all plans. The plans were delivered on a True Beam STx (Varian Medical Systems) equipped with an MLC with 2.5 mm Leaves in the center and outer leaves of 5 mm width. We had kept the FFF (Flattening Filter Free) plan as a base plan, while doing plan with 6 MV FF (Flattening Filter) and dose rate of 600 MU/min. All the planning parameters used for 6MV FFF beam with rapid arc kept as it is including objective function and priority’s also, only energy 6MV and dose rate 600 MU/min. changed for FF plans.

Results: Dosimetric evaluation performed on the basis of, Beam on time, Total monitor units, Homogeneity index, Conformity index, Dose Gradient Index, Body mean dose, Max dose in PTV, Low dose Spillage, and PTV Dose Coverage, Gama Passing Criteria. We found the significant difference between FFF and FF is beam on time (4.33 ± 0.53 Vs 8.97 ± 2.71, p < 0.00015). There was no significant difference between Total MU (5445.46 ± 979 Vs 5126.21 ± 1697.50 p < 0.40), HI (1.22 ± 0.08, Vs 1.26 ± 0.09 p < 0.03), CI (1 ± 0.01 Vs 1 ± 0.01 p < 0.46), GI (3.37 ± 0.76 Vs 3.86 ± 1.33 p < 0.05), body mean dose (49.36 ± 16.26 Vs 51.0 ± 16.9 p < 0.15), Max dose (110 ± 7.0 Vs 113.28 ± 7.85 p < 0.03), low dose spillage (98.53 ± 49.95 Vs 107.65 ± 52.17 p < 0.09), PTV Coverage (93.2 ± 3.67 Vs 95.19 ± 4.9, p < 0.09) and gamma passing criteria (96.88 ± 1.4 Vs 96.81 ± 1.04, p > 0.88).

Discussion: A comparative evaluation of two different treatment techniques using FF and FFF beams for single brain metastasis was addressed in our study. Dosimetric superiority was shown in VMAT_FFF plans, and a time efficient treatment was also provided in 6X FFF beams which it was a good choice for single fraction SRS treatment. However, dose distributions achieved with FFF beams are similar or comparable to those with FFF beams. Our investigation shows that FFF beams deliver faster dose in shorter treatment time, is the biggest advantages over FF beams.

Materials and Methods: Measurement of all the Dosimetric data done with the PTW Beam Analyzer with different detectors were compared and evaluated for all photon energies: 6MV, 10 MV, 15MV, 6MV FFF and 10MV FFF. The ionization chambers Pin Point CC01, Semiflex CC13 and FC 65 and Roos chamber by PTW dosimetry were used to determine and compare the parameters like PDD, Depth dose profile, symmetry, flatness, penumbra, quality index, transmission factor, relative output factor DLG in addition to degree of un-flatness and off axis ratio of FFF beam.

Results and Conclusion: It was observed that, the reduction in surface dose due to Removal of flattening filter which not only causes softening of the resulting beam but decreases scattering and electron contamination from flattening filter. PDD curve for FFF beam has lower down beyond the region of TCPE due to the loss of beam hardening effect as well as Dmax is more specially function of beam quality and design of the head of the treatment machine. output factor (Scp) at a smaller field sizes for FFF beam slightly higher in magnitude compare to that of FF beam, variation between FF and FFF slowly decreases with rise in field size and an output factor converges to unity at field size of 10 × 10 cm2. The Quality Index in case of FFF beam is lesser than the magnitude of FF beam. Removal flattening filter alters various commissioning associated parameter as Field flatness, Field penumbra, Beam quality, Surface dose, Transmission factor, off axis energy variation and Homogeneity need to be redefined for FFF beam other than FF beam. Since, the concept of homogeneity cannot be applied to FFF beam special attention need to be given while treatment planning. Due to smaller variation of head scatter, off axis energy distribution, electron contamination, leaf transmission the dose calculation accuracy expected to increase. Availability of FFF beam provides additional clinical advantage over flat beam.

PP-36

QUANTITATIVE AND QUALITATIVE DOSSIMETRIC ANALYSIS OF FLATTENING AND FLATTENING FILTER FREE BEAM FOR TRUE BEAM STX: OUR INITIAL COMMISSIONING EXPERIENCE

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Introduction: True Beam STx is the advanced RT equipment with its stereotactic counterpart, have many unique features, including high-dose-rate flattening-filter-free (FFF) X ray modes, updated KV onboard imaging option, hardware/software, and a novel control system with High Definition Multileaf Collimator for best tumour conformity.

Aim and Objective: Current study presents the compared Quantitatively and Qualitatively analyzed Dosimetric beam data on a Varian True Beam Stx, Medical Linear Accelerator, the beam characterization and evolution of Dosimetric properties for 6, 10 and 15 Mega voltage beam and 6, 10 flattening filter free Mega voltage beam has been carried out as well as the comparison of photon beam data for two standard FF and FFF photon energies has been done.

PLANNING AND SHIELDING CALCULATION FOR TELETERAPY AND BRACHYTHERAPY INSTALLATIONS

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Introduction: The primary aim of radiation protection is to provide an appropriate standard of protection for human kind against harmful effects of ionizing radiation, without unduly limiting the beneficial practices of such exposures of individuals to primary and secondary radiations can be reduced by one or more combination 1.Time 2. Distance 3. Shielding. Where it is impracticable to adopt the methods of distance and time to ensure acceptable low radiation level at work place, method of radiation shielding is adopted.

Objective: To provide a document for the standard practice in radiotherapy department to be a reference and guide for establishing teletherapy and brachytherapy room facilities by theoretical room shielding calculations and its experimental validations based on the International protocols (NCRP) and the recommendation of national level regulatory board (AERB).
Materials and Methods: In teletherapy Co-60 room calculation and the linear accelerator having the nominal photon beam energies 6MV, 10MV, and 15MV were used in the present work and for brachytherapy facilities of HDR room both Ir-192 and Co-60 room designing were executed. For the photon measurements, GM based and ion chamber based counters have been used and for the neutron measurements a neutron detector with a polyethylene moderator was used. The work also includes a literature study of different international protocols explains about the room shielding calculation for the radiotherapy facilities were presented.

Results and Discussions: All the wall thickness have been calculated for teletherapy and brachytherapy rooms and tabulated. The measured doses of the radiation shielding in teletherapy and brachytherapy outside the walls were below the acceptable radiation limits per week and year for both the primary and secondary walls. In the discussion part, compared all wall thickness of the facilities between the theoretical calculated and the original layout values. Based on these comparisons the difference was very minimal and the planned facilities were well adequately shielded in order to achieve the radiation limits of the radiation workers and the public.

Conclusion: It has been concluded that, the present work can be used as a reference guide to establish a new radiotherapy department in the country as per the AERB protocol.

PP-38

SETUP ERROR ANALYSIS OF TREATMENT FIELDS BY ELECTRONIC PORTAL IMAGING IN PELVIC RADIATION THERAPY

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Introduction: The aim of radiotherapy is to reliably maximize the dose to the target while minimizing the toxicity to the normal tissues. Therefore, daily treatment setup is considered as a critical requirement in radiotherapy for an accurate dose delivery. Setup uncertainties can creep in day to day radiation treatment and are divided into two categories: systematic errors and random errors.

Purpose: The aim of this study is to assess set-up errors for carcinoma of cervix and stomach patients undergoing radiotherapy treatment using an electronic portal imaging device (EPID).

Materials and Methods: The study was carried out on a sample of 20 patients treated for Ca Cervix and Ca Stomach between Jan 2017 and June 2018. Before treatment, the patients were immobilized using thermoplastic immobilization device of three fixed points. A computed tomography (CT) scan was acquired with CT simulator (Somatom Scope-Siemens) using a 3-mm slice thickness. CT images were imported into the Oncentra (v.4.3-Elekta) treatment planning software for 3 Dimensional Conformal Radio Therapy (3D CRT) treatment planning. The clinical target volume (CTV) and organs at risks (OARs) were contoured by the physician. For pelvic cancer cases, planning target volume (PTV) margin of 10 mm to 15 mm were added all around to the defined CTV. The digitally reconstructed radiographs (DRRs) were generated and stored as reference images. The set-up errors were defined as the displacement of the coordinates of the bony landmarks on the beam film from those on the DRR films. Since parallel opposite fields were used in all the pelvic sites, the displacement errors are shown in ‘X’ direction and ‘Y’ direction. Set-up errors were corrected if they exceeded 5mm in any direction. Patients were imaged weekly. For pelvic cases, the systematic errors were defined as deviations between the planned patient position and simulated patient position before starting treatment. The random errors were defined as deviations between different treatment fractions taken weekly during a course of the treatment.

Results and Discussion: Patient set-up was evaluated and corrected via manual matching using the 3D bony anatomy. We measured the shifts in the anterior-posterior fields for pelvis. In pelvic cases, the ‘X’ and ‘Y’ direction errors represent lateral (X-axis) and longitudinal (Y-axis) shifts. The aim of the study was to determine the field setup errors and since parallel opposite fields were used for treatment, the displacement errors are shown in ‘X’ direction and ‘Y’ direction. As discussed in literature it was assumed that the mean and standard deviations represent the systematic and random errors respectively. The average mean errors (systematic errors) along X and Y directions were 1.22 and 1.66 mm and standard deviation in X was 1.0 mm and Y was 2.9 mm for pelvic cases. It was observed that the mean and standard deviation errors were greater in longitudinal direction compared to those in the ‘lateral’ direction. It was assumed that this may be due to the lack of accuracy accepted on comparison of bony landmarks of matched images along the longitudinal direction compared to that along the lateral during the setup verification of fields.

Conclusion: The retrospective study has shown the probable range of systematic and random errors that occur in the field setup during the course of radiotherapy treatment. EPID is a useful tool for fast and reliable assessment for verification of field set up and correction of various errors during the course of radiotherapy treatment. From this study, it is suggested to obtain pre-treatment portal images weekly for managing random and systematic errors effectively.

PP-39

DOSIMETRIC STUDY OF ELONGATED FIELDS IN MEDICAL LINEAR ACCELERATOR

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Introduction: With the state of the art techniques now Radiotherapy is a proven means to cure and improve the quality life of cancer patients. Success of advanced radiotherapy highly depends upon the precession and accuracy. For accurate and precise delivery of the prescribed dose to the target volume, it is necessary to calculate Monitor Units correctly.

Purpose: Aim of the study is to evaluate the deviation of output between a rectangular field size and its corresponding equivalent square field size calculated using Sterling's
formula and analysis the deviation versus elongation ratio(Y/X ratio of a field).

**Materials and Methods:** Percentage depth dose and electrometer reading were measured for various rectangular field sizes of four set of X and Y combination i.e. Y values were fixed(10 cm, 15 cm, 20 cm and 25 cm) and X was varied from 4 cm to 25 cm. Meter reading of square field sizes(from 4x4 cm2 to 25x25 cm2) were also taken. Output of all rectangular field sizes included in this study were calculated and simultaneously output of all the square field sizes were also calculated using PDD from BJIR Supplement No-25. For measurement of PDD, PTW Radiation Field Analyser and PTW 0.125 cc thimble chamber were used. For electrometer reading PTW 0.6 cc Farmer chamber and one dimensional water phantom were used and chamber was placed at 10 cm depth and 100 MU was fired for each reading and two sets of reading were taken for each field.

**Results:** Deviation of output increases as the Y/X ratio increases. Two medical LINACs were used in this study (Elekta Synergy and Siemens Primus). In Elekta Synergy maximum deviation is 1.57% and in Siemens Primus it is 1.3%. 

**Discussion:** In Elekta Synergy, the measured output is lower than the calculated output. In Siemens Primus, in most of the field sizes the measured output is higher than calculated output.

**Conclusion:** Since the deviation is not greater than 2% across all field sizes included in this sizes, so Sterling’s equivalent square formula can be used for Monitor Unit calculation.

**PP-40**

**RETROSPECTIVE ANALYSIS OF ELECTRON BEAM DATA MEASUREMENTS AT A TERTIARY CARE INDIAN NAVAL HOSPITAL**

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**Introduction:** Electron beams generated by a modern linear accelerator (LA) is widely used in external beam radiation therapy. The treatment head design of the LA has a primary collimating device and various scattering foils (made of stainless steel and gold having thickness from 0.002 to 0.008 inches). The output factor measurements of the electron beams comprises of air fluence profiles (without applicator) along the in plane and cross plane directions at two Source to Detector distances (SDD), 70 cm and 90 cm (normalize to 20x8 cm2) and percentage depth dose (PDD) profiles in water and absolute dose measurement in water at 100 cm source to surface distance (SSD) at reference depth for 100 MU. A retrospective analysis of electron beam output data measurements for various electron energies used for 3D (dimensional) treatment over a span of ten years at this premier tertiary care Indian Naval hospital were carried out and is discussed in this paper.

**Materials and Methods:** The electron beams has energies 6, 9, 12, 15, 18 and 21 MeV generated by a dual energy LA (Siemens) commissioned in 2007. Routine, quality assurance (QA) tests as per IEC Protocol recommended by AERB are done and the machine is calibrated for 1MU= 1cGy and practical range (Rp) for all energies and reference depth (Zref) are determined as per Siemens protocol. Parallel plate (PP) ionization chamber (Markus Type) & Semi flex ionization chambers, Mephysto (MP3-M software) Radiation field Analyser (RFA) and slab phantom (RW3) and Unidos electrometer (all PTW make) have been used. The PP chamber is placed at the depth of dose maximum on this slab phantom and absolute dose measurements for 100 MU for each applicator (cones) for all energies at 100 cm are carried out as per IAEA, TRS-398 protocol. Air measurements were performed without any build up cap in an empty RFA phantom with field size 40x40 cm2 and for point dose measurements as well as profiles scans were performed for a set of rectangular and square field sizes (8x8, 20x8, 30x8 & 30x30 cm2) at two SSD 70 cm (upper measurement plane) and 90 cm (lower measurement plane) for each cone sizes and repeated for all electron energies. The relative PDD measurements in water (without applicator) is done for maximum field size 40x40 cm2 and profiles measurement (with applicator) at two different depths (normalization depth 1-3 cm and bremsstrahlung depth 5-10 cm) for all the above electron energies.

**Results:** The electron beam characteristics namely, maximum dose measurement (in plane and cross plane), profiles (flatness and symmetry), stability of flatness, radiation field penumbra, output factors, all generated by the RFA phantom in air at various energies at two SDDs were found to be within the tolerance values as per AERB protocol. The nominal energies of electron beams, measured using “range-energy” relationship and the energy distribution at the surface of the medium, characterized by model energy, Ep.0 (MeV) which is related to the extrapolated practical range, Rp (cm) in water were found to be 6 ± 0.42 MeV, 9 ± 0.21 MeV, 12 ± 0.19 MeV, 15 ± 0.04 MeV (except 18 and 21 MeV presently not in use) and reference depths for 6, 9, 12, 15, 18 and 21 MeV were found to be 1.4, 2.1, 2.7, 2.8, 2.9 and 3.0 ± 0.1 cm respectively. The air-gap corrections factors measured were found to be ≤ 2% with the baseline data obtained at commissioning.

**Conclusions:** The overall uncertainties in these periodical QA tests and electron beam data used for treatment planning over a span of ten years are well within the tolerance limits as prescribed in the protocols and guidelines used to carry out these tests.

**PP-41**

**DOSIMETRIC STUDY OF UNFLATTENED 6MV X-RAY BEAM VMAT PLANS FOR THE TREATMENT OF HEAD AND NECK CANCERS**

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**Introduction:** Volumetric Modulated Arc Therapy (VMAT) or RapidArc® treatment technique is an advanced radiotherapy delivery technique. It delivers continuous intensity modulated radiation beams as “radiation beamlets” in a very short time as the dose is sculpted in a 3D view to the target. Conventionally,
medical linear accelerator produces flattened beams where as currently unflattened beam gains momentum for clinical use due to its inherited beam characteristics. The unflattened beam has clinical advantages and it is characterized by high dose-rate, conical-shaped beam profile, beam softness, higher superficial dose and reduced out-of-field dose.

**Purpose:** To study the dosimetric characteristics of 6MV X-Ray photon beam of flattened and unflattened beam by VMAT treatment delivery technique using Varian-Eclipse Treatment Planning Systems (TPS) for fifteen Head&Neck cancer patients.

**Materials and Methods:** Varian-TrueBeam® medical linear accelerator and Varian-Eclipse™ TPS was used to create VMAT plans for treatment delivery of 6MV X-Ray photon of flattened and unflattened beams. The VMAT treatment plans were created to deliver the prescribed dose of 66Gy in 33 fractions to planning target volume (PTV). The fifteen Head&Neck cancer patients VMAT treatment plan of both flattened and unflattened beams were selected for dose-volume-histogram (DVH) analysis and plan evaluation parameters such as homogeneity index, conformity index, monitor units(MU) and “beam-on” time were also compared.

**Results:** The plan analyses show that dose delivery to the PTV in both the flattened and unflattened beam VMAT treatment plans are identical (p value-D50%=0.0721, D2%=0.0893, D98%=0.0878) and also it shows similar homogeneous dose distribution (p value-0.0835) and dose conformity (p value-0.0667) to the PTV, but the dose delivery to OAR’s differs significantly. The unflattened beam VMAT treatment plans outscore over flattened beam VMAT treatment plan in terms of sparing the organ-at-risk structures like optic-nerve, optic-chiasm, spinalcord, brainstem and parotids. The dose received by optic nerve is 47.60±4.91Gy & 50.41±5.11Gy, optic-chiasm is 40.10±10.5Gy & 44.92±9.75Gy, brainstem is 44.30±1.77Gy & 49.30±3.77Gy and spinalcord is 36.50±2.89Gy & 41.50±3.89Gy for unflattened and flattened beam VMAT treatment plans respectively. The number of MU's in the unflattened beam shows significantly higher (695±65MU) than the flattened beam (450±50MU) VMAT plans. The “beam-on” time in unflattened beam has less (2.1±0.2mins) than the flattened beam (2.5±0.3mins) VMAT plans. The pre-treatment plan verification by γ-index analysis with criteria of 3mm DTA and 3% DD were found to be good agreement between flattened and unflattened beam VMAT treatment plans.

**Discussion:** The unflattened VMAT treatment plans of fifteen Head&Neck cancer patients plan evaluation dosimetric parameters like PTV dose distribution, conformity and homogeneity indices found to be similar to the flattened beam VMAT treatment plans. The unflattened beam VMAT treatment plans has low out of filed dose, hence it demonstrated great improvements in OAR’s sparing from radiation dose. Almost 5% to 15% more sparing of OAR’s were observed in unflattened beam VMAT plans compared with flattened beam VMAT plans. The reduction of normal-tissue doses and more number of MU’s were observed in unflattened VMAT treatment plans compared with flattened VMAT treatment plans. Due to the higher dose-rate property of unflattened beam, the “beam-on” time is less compared to the flattened beam VMAT treatment plans. For patient specific QA, γ-index analysis showed good agreement between the planned and delivered dose for unflattened and flattened VMAT plans.

**Conclusion:** The unflattened beam of VMAT treatment plan is the choice of treatment for Head&Neck cancer patients to achieve the clinical objective of minimum possible dose delivery to OAR’s with clinically acceptable level dose distributions to PTV.

**PP-42**

**DEVELOPMENT OF IN HOUSE DOSIMETRIC PHANTOM FOR GAMMA KNIFE RADIOSURGERY AND COMPARISON OF TPS WITH DELIVERED DOSE BY USING GAFCHROMIC FILM**

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**Introduction:** The Gamma Knife 4C model was installed in 2006 and being treated with various brain lesions like Vestibular Schwannoma, Meningioma, AVM, etc. the GKS clinical responses are above 95% and have treated more than 2500 cases till now with this unit. Considering the present workload and quality assurance test tools, we are unable to monitor the accuracy of dose delivery with automatic positioning System.

The aim of this study is to compare the TPS calculated and delivered dose by using customized hemispherical phantom and Gafchromic film. In regular radiotherapy, the multi-fractioned dose delivery method will have an advanced patient-specific quality assurance test tools for verification of planned and delivered dose.

**Materials and Methods:** The gamma knife treatment delivery is a single fractionated treatment delivery and no margin added to GTV where we do not have the essential QC tools to verify the dose conformity. So, to overcome this issue, we had an idea to develop an acrylic dosimetric phantom for comparison of TPS vs delivered dose.

A study has been performed earlier to verify the dose delivery by trunnion (manual coordinates setting) method and achieved the accuracy of Gamma Knife iso-centre with the result of 3% deviation by using Radiochromic films vs. Treatment Planning System The study was carried out with Automatic Position System by using a customized phantom. The film is sandwiched into phantom and irradiated with a treatment plan, the films will be scanned and their optical density will be converted to dose, the dose from film compared with TPS calculated dose.

**Result and Conclusion:** Customized phantom has been developed for APS and the study has been performed for ten cases and the measured dose are compared with TPS calculated dose for patients treated with different brain lesions. this study will represent a step forward to understand the Gamma Knife dose delivery and a visual agreement will be observed in this project.
PP-44

ESTIMATION OF THE DOSE RECEIVED BY THE PATIENT UNDERGOING CHEST X-RAY EXAMINATION IN DIGITAL RADIOGRAPHY

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Introduction: All over the world, the use of x-ray for diagnostic purpose is ever increasing. Although there are other modalities available like MRI and ultrasound, but due to various safety practices, quality assurance test of x-ray machines, implementation of regulatory guidelines accepted worldwide and good quality images, makes x-ray most widely used and essential modality in diagnostic radiology. But as ionizing radiation is used for diagnostic purpose. There are several health hazards associated with it, if proper precaution and safe practices are not implemented. Therefore it is essential to follow recommended Dose Reference Level to ensure if the dose received by the patients are well beyond the accepted level and does more good than harm to the patients.

Purpose:
1. Check consistent performance of DR machine
2. Measure and compare the quality control parameter
3. Output of the DR machine
4. To estimate the effective dose and determine the dose reference level for patient undergoing chest x-ray examination in Digital Radiography.

Materials and Methods:
1. The SAMSUNG (make), GU60A (model) machine QA is done with the help of IBA makes Magic Maxx semiconductor dosimeter
2. Patient specific incident air kerma is calculated from various exposure factors by the formula:
   \[ \text{Patient specific incident air kerma} = \text{Output factor} \times \frac{100}{\text{focus to skin distance}} \times \text{mAs} \]
3. PCXMC-2.0 Monte-Carlo simulation software is used to determine effective dose
4. The variation of effective dose in terms of Body Mass Index, age and other radiological factors like mAs is verified
5. Dose reference level for digital radiography is estimated and verified with the value given by IAEA.

Results: A total of 81 patients data were collected and the statistical analysis of Age, Height Weight, mAs, Thickness, BMI Average Dose was done to determine the Standard Deviation, Mean, Median and Minimum and Maximum value. From the 2D-fit plot of Effective Dose versus BMI, with BMI in X axis and Effective Dose in Y axis. We have obtained an empirical formula relating BMI and Effective Dose for chest radiography:
   \[ Y = 0.01223 + 0.00148 \times X \]
   Similarly, from the 2D-fit plot of Effective Dose versus mAs, with mAs in X axis and Effective Dose in Y axis. We have obtained an empirical formula relating mAs and Effective Dose for chest radiography:
   \[ Y = 0.00457 + 0.01729 \times X \]

Discussion and Conclusion: From our study we have found that effective dose increases with increasing BMI(body mass index) and mAs. We have also obtained an empirical formula relating effective dose with BMI as well as mAs. Therefore from the empirical formula we can calculate the effective dose prior to X-ray examination. For radiography, effective dose is recommended DRL quantity. The dose reference level in our study was found to be (0.0432 +/-0.01527) mSv and the third quarter value was found to be 0.0535215 mSv. This limit is well under the accepted DRL (dose reference level) as found by comparing the DRL in this study with the DRLs of other publications.

PP-45

INSTALLATION AND COMMISSIONING OF CARDIOVASCULAR X-RAY IMAGING SYSTEM

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Introduction: The medical equipment producing ionizing radiation using for patient diagnostic, intervention procedure or therapeutic application needs regulatory approval from the radiation safety point of view to protect and to minimize unnecessary radiation exposure to Patient, Health care professionals and Public before put in to clinical application. The commissioning of new equipment for clinical use to ensure the functionality of equipment through the procedure of quality assurance performance testing as per the National/ International protocol and compliance with technical specification of equipment.

Objective: To install and commissioning of cardiovascular X-Ray system for clinical use.

Materials and Methods: The newly procured Philips Allura Xper FD10 X-ray system with flat detector installed for the imaging study of coronary angiography for functional evaluation of cardiac and cardiovascular system. The quality assurance tools RTI, Piranha were used to evaluate functional performance of the X-ray system. The generator and X-Ray system was tested for accuracy of operating potential and timer, total filtration, image quality, radiation safety of equipment and layout integrity from radiation safety point of view, ion chamber based survey meter Fluke 451P was used for radiation surveillance.

Result and Discussion: Measured value of operating potential are 50.71, 100.21, 125.83 kVp for set value of 50, 100, 125 kV respectively. The difference between them is less than 0.1 kV for the tolerance of ± 5 kV. The measured value of time of exposure are 0.0507, 0.1009, 0.4015 s for set value of 0.05, 0.10 and 0.40 s respectively. The measured value of total filtration thickness is 3.5 mm Al and HVL 5.39 mm Al at 125 kVp. The coefficient of linearity of mA loading station at 60kVp and timer at 70 kVp is 0.0008 and 0.0006 respectively, which is less than tolerance limit of < 0.1. The consistency of radiation output produced by X-ray system at 60 kV and 70 kV is 0.0009 and 0.0002 for tolerance limit of ≤ 0.5. The system passed the low contrast resolution test with resolving 2.0 mm hole and high contrast resolution test resolved the 1.8 lp/mm pattern resolved for image quality instead of 1.5 lp/mm. The Table top exposure measured at 120 kVp and 8.6 mA is 6.338 cGy/min at 70 cm from focal point with AEC for tolerance limit of ≤ 10 cGy/min and measured level of leakage radiation at 1m from tube housing and collimator at 125 kVp, 50 mA is 0.0086 mGy and 0.0048 mGy in one hour respectively for the tolerance limit of ≤ 1 mGy (114 mR) in one hour. The level of
exposure at the patient entry door which is lined with 2 mm of Pb exceeds the permissible limit due inadequate overlapping of Pb. Then modified the door lead lining properly, radiation exposure level brought down to 0.75 mR/week within the permissible limit of 2 mR/week.

Conclusion: The results of acceptance test protocol confirms the functional, integrity status and radiation safety of equipment to acceptable level. The cardiovascular X-ray system commissioned for clinical use after obtaining license for operation from regulatory authority of India, AERB.

PP-46

SAFETY REVIEW AND PERFORMANCE EVALUATION OF HALCYON MEDICAL ACCELERATOR
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Introduction: Atomic Energy Regulatory Board (AERB), Mumbai carries out the safety review with respect to the performance of the medical accelerators before its use in radiotherapy purposes in India. During review, the applicable standards are referred. With rapid advancements in technology aimed at faster and accurate treatment delivery, new features are regularly incorporated in radiotherapy units. In some instances, standards are not available for testing the new features for acceptance. In such cases, it is required to arrive at a value which is practical, achievable and in-line with the supplier’s protocol without compromising the patient safety. In the present work, the safety review and acceptance criteria of several new features of the medical accelerator model Halcyon which are not available in the applicable standards are discussed.

Materials and Methods: Recently, Varian Medical Systems International India Pvt. Ltd., India approached AERB for obtaining the requisite regulatory clearances of Halcyon unit. AERB has carried out the safety review of documents pertaining to performance of the Halcyon unit and its type approval testing. The major difference that was observed compared to the other approved models of Varian make medical accelerator are (i) higher gantry speed (ii) dual layer of multileaf collimator (MLC) with higher leaf speed (iii) No tertiary collimator (secondary beam collimation system) iii single photon energy (6 MV Flattening Filter Free (FFF)) (iv) higher collimator rotation speed (v) no optical fields, (vi) no optical distance indicators (ODI), (vii) restricted field size (maximum 28 cm x28 cm), (vii) head design as a single block etc. As collimators are not accessible, the collimator angles were verified with help of portal imager. As no ODI was available, the SSD for the radiation field analyzer (RFA) was set using the portal imaging system. The complete acceptance tests were carried out. As the treatment planning system (TPS) for Halcyon unit is delivered with the preset factory data, the TPS data was also compared with the measured data for consistency.

Result and Discussion: It was observed that the gantry speed and the collimator speed of the Halcyon unit are found to be 24º per second and 14º per second which exceeds the limit prescribed by relevant IEC standards i.e. 7º per second. The higher gantry speed was achievable due to the presence of magnetic tracks. On further analysis of the safety features available, it was found that the positional accuracy of the gantry and collimator are meeting the acceptable tolerances as per the IEC standards. The verification of collimators angles were performed by using the portal imager and found to be within 0.5º of the expected value. The accuracy of gantry angles was also found to be within 0.5º. For setting of the RFA, the image of the water tank taken at 84.3º gantry angle was found to be optimum. As relevant IEC standard values are not available for beam quality, PDD, surface dose value of 6 MV FFF, those measured values were accepted after judicious discussion in-line with the supplier protocol. Several tests such as matching of PDDs, profiles and off axis ratios etc., were suggested for inclusion in the acceptance test report. Due to the specific design of the head and MLC, the leakage radiation was found to significantly less in the unit.

Conclusion: Safety review of the radiotherapy equipment is essential in order to ensure the safety in radiotherapy. It is essential to ensure that advanced features available with the radiotherapy units are checked and accepted as per the applicable protocols and standards. New features of the Halcyon unit were tested as per applicable standards and manufacturers protocols were found acceptable.

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STABILITY ANALYZATION OF THE PHOTON AND HIGH ENERGY ELECTRON BEAM OF LINEAR ACCELERATOR USING DAILY QUICKCHECK DEVICE
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Introduction: Treatment delivery systems are capable of complex simultaneous motions which have led to increased quality assurance (QA) requirements. Multiple simultaneous motions along different axes increase flexibility in treatment delivery and can decrease the total time a patient is on a treatment table. These increasingly complex systems require new QA tests and procedures. AAPM Task Group 142 (TG 142) provides guidance tolerance values for individual components of linear accelerators based on the treatment delivery type [conformal, IMRT/volumetric modulated arc therapy (VMAT), SRS]. It is recommended that quality assurance (QA) of the beam energy of radiotherapy treatment machines is carried out at regular intervals, daily, weekly and monthly.

Purpose: The main purpose of the study was to assess the energy stability of a 6 and 15 MV Photon and 12 and 15MeV high energy electron beams in Varian Clinac-IX linear accelerator. The stability of the linear accelerator energy over a period of several months the results will be useful for estimation of the required tolerance values for the beam quality factor (BQF) of the PTW QUICKCHECK webline® daily checking device.

Materials and Methods: Multi-detector daily-checking devices are effective tools for performing quick and convenient quality assurance tests to determine several
useful quantities, e.g., central-axis radiation dose, penetrative quality, beam flatness and symmetry, wedge angle (fixed, dynamic) and field size of linear accelerators. The quick check setup for daily measurements on the Varian Clinac iX linear accelerator—the quick check consists of 13 air-vented ionization chambers. Readings of nine chambers are used for calculating the central-axis dose, flatness, wedge angle and symmetry. The QUICKCHECK also calculates a BQF as an energy index. Measuring the energy is carried out by the other four chambers, where the reading of one of these energy chambers is used for calculating the BQF.

Over a 6 month period of routine clinical service, 180 readings of BQF were taken and then analyzed for a 10×10 cm2 field for 6 and 15 MV photon and 12, 15 MeV high energy electron beams. The measurements were performed in the mornings immediately after the warm-up procedure, which is recommended by the linear accelerator manufacturer. As specified in the QUICKCHECK user manual, a 10×10 cm2 field size was used to obtain BQF values. The usual source-to-surface distance (SSD) was 97.3 cm fixed for QUICKCHECK setup.

**Results:** No decreasing or increasing trend in BQF was observed over the study period. The mean BQF value was estimated 5.954 and 14.970 for 6 and 15 MV photon. Similarly for 12 and 15 MeV electron 11.982 and 14.983.

**Conclusion:** The conclusion of this stability study of the linear accelerator energy showed that 98% of the observed BQF values were within ±1% of the baseline value. This can be considered to be within the recommended tolerance for linear accelerator photon beam and high energy electron beam. As per the TG-142 suggest that the BQF tolerance may be up to 3%. In our hospital study for a period of six month, we found that the BQF with in ±2%.

**Results and Discussion:** The rice bolus physical properties, mass, electron density was obtained and compared with the superflab and SENflab. Both the rice bolus has the transmission factor of 0.97. Rice bolus has the transmission similar to the superflab and SENflab with less than 3%, 2.5% for both photon as well as electron beams. Rice bolus has the build-up (PDD) similar to the superflab and SENflab with less than 3%, 2.5% for both photon as well as electron beams.

**Conclusion:** Ponni rice bolus and Basmati rice bolus can be used as bolus material for Radiotherapy. Rice is fairly inexpensive and easily available worldwide. If rice is used as a bolus material for radiotherapy, it is mandatory to verify dosimetrically the density, CT number, transmission, effect on surface dose and depth dose curve for the effective treatment delivery.

**DOSIMETRIC COMPARISON OF ION CHAMBER AND EPID IN DAILY OUTPUT CONSTANCY CHECK**

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**Introduction:** A quality assurance (QA) is essential to guarantee quality and safety of patient treatment in radiotherapy department. The daily QA tests were very essential for all radiotherapy units like LINAC, Brachytherapy, etc. The daily QA tests include dosimetric, geometric, and safety issues. The monitoring of output constancy is one of the major test in daily QA for Linear Accelerator unit. There are several detectors can be used for measuring output constancy like ion chambers, Diode detectors, Scintillators and EPID. The traditional way to measure output constancy by using cylindrical ion chamber. EPID is not only acquire treatment portal images for verification and also we can used for dosimetric QA purpose.

In this study, investigate daily photon output constancy check with ion chamber and EPID in our LINAC unit and our result provide evidence to support that an aSi EPID can be a stable dosimeter for daily photon output constancy checks.

**Purpose:** In this study, we compared the daily photon output constancy with 0.6cc ion chamber and EPID (Electronic Portal Imaging Device) in our LINAC unit (Varian, Unique Power).

**Materials and Methods:**

1. Electronic Portal Imaging Device (Varian, aSi-1000 amorphous silicon panel): In this study, daily output
The fluorescence-based patient setup marker addresses virtually all the shortcomings of traditional position accuracy. The field size opened at 10x10cm². The EPID was irradiated with 100MU by a 6MV photon energy at a dose rate of 400MU/Min. The portal images were acquired every morning for 100 days. After acquisition of portal image, the portal dosimeter software reads in calibration unit (CU) values over an ROI of 2x2cm² around the central axis and provide in cGy/MU.

2. We were measured the daily output constancy by using 0.6cc ion chamber (PTW, TM30013/8396) in our LINAC unit. The 0.6cc ion chamber were placed in solid phantom at the depth of 10 cm and the SSD was 100cm. The field size opened at 10x10cm². The 0.6cc ion chamber were exposed daily with 100 MU at the dose rate of 400MU/Mins and output were calculated in cGy/MU. Both outputs were compared.

**Result:** In this dosimetric comparison study we measured daily output constancy with both 0.6cc ion chamber and EPID for 100 days. The output constancy for 0.6cc ion chamber ranges from 0.976 cGy/MU to 0.9990 cGy/MU and output constancy average is 0.987 cGy/MU. The output constancy in EPID ranges from 0.9786 cGy/MU to 1.0016 cGy/MU and average is 0.989 cGy/MU. The ion chamber and EPID outputs percentage deviation ranges from 1.621 to 1.902.

**Discussion:** Now a days the EPID dosimeter replace the 0.6cc ion chamber and film dosimetry in quality assurance program in LINAC unit. In our study the daily output constancy vary only in the third decimal between ion chamber and EPID. It may be due to set up error. Both Ion Chamber and EPID daily outputs are within the tolerance limits (± 3% as per the AERB safety code AERB/RF-MED/SC-1(Rev1.1) and TG-40. The EPID reduce the physicist workload in daily QA and also reduce the set up error.

**Conclusion:** In this study that the use of EPID for daily output constancy measurements has the potential to become a viable and efficient tool for daily routine LINAC QA, thus eliminating weather Temperature & Pressure correction and human setup variability and increasing efficiency of the QA process.

**PP-50**

DEVELOPMENT OF FLUORESCENCE-BASED PATIENT ISOCENTER SETUP MARKER, FIELD CORNER MARKER AND RADIATION BOARDER MARKER FOR ACCURATE AND PRECISION PATIENT POSITIONING IN RADIOTHERAPY

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**Introduction:** The success of radiotherapy depends on the accuracy of patient setup for each fraction. A significant problem arises from reproducing the same patient position during treatment for every fraction of the treatment process. During a course of radiotherapy, skin markings play a key role in terms of the reproducibility of treatment setup and accuracy of treatment delivery. The protocols for skin markings vary according to different institutions’ protocols. However the available marking devices and protocols lack accuracy and precision in positioning due to varied reasons. Hence there exists a need in the state of art to develop a novel field setup maker for accurate and precise patient positioning in Radiotherapy.

**Purpose:** The main purpose of this study was to indigenously develop novel fluorescence-based patient isocenter setup marker, Field corner marker and radiation boarder marker for accurate and precision patient positioning and compare with the regular patient marking in radiotherapy treatment.

**Materials and Methods:** The fluorescence-based patient isocenter setup marker, Field corner marker and radiation boarder marker was developed indigenously. The fluorescence-based field setup marker comprises of fluoreSEN patient centre marker, plurality of fluoreSEN patient filed corner marker, and plurality of fluoreSEN patient line marker. The size of the patient isocenter setup marker was 25mm circular with extra half circular provision for easy pickup. 1.2mm of cross lines were provided with the fluorescence material and the other areas were in dark colour. The size of the field corner marker was 15mm circular with extra half circular provision for easy pickup. 1.2mm of L shape lines were provided with the fluorescence material and the other areas were in dark colour. The dark colour should not reflect the field light and the positioning cross line lasers, So the fluorescence helps to position precisely. These markers have a 1.5mm central axis hole to make a mark on the patient or over the mask, which will help to identify the original initial setup position in the case of knowingly or unknowingly removed the marker from the patient or mask.

**Results and Discussion:** This novel fluorescence-based marker addresses virtually all the shortcomings of traditional markers. These markers are highly visible on field light and the positioning cross line lasers due to the fluorescence material and help to facilitate a quick and accurate patient setup.

**Conclusions:** The precision of these markers are catching up to the repositioning of the radiation delivery with high precision, easily identifiable, save time, improve accuracy, provide a better patient comfort without any difficulty in patient setup and radiotherapy technologist satisfaction.

**PP-51**

REGULATORY AND RADIATION SAFETY ISSUES IN DIAGNOSTIC RADIOLOGY PRACTICE-TRAINING AND EDUCATION VIEW POINT

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**Introduction:** Diagnostic X-rays are the most widely used application of radiation in medicine. Number of existing X-ray...
institutes/facilities worldwide are highest among all medical radiation facilities. Regulatory control in diagnostic radiology (DR) practice in India is a challenging task to the regulatory body. AERB, the national regulatory body has established framework for effective regulation of x-ray facilities which includes simplifications of regulatory requirements without compromising radiation safety using concept of graded approach, launching of e-licensing of Radiation Applications (e-LORA) in 2013 for DR practice, spreading of awareness on radiation safety and initiated special regulatory inspection for enforcement actions. This paper brings out the regulatory and radiation safety issues in DR Practice with respect to training & education of the personnel involving in this practice and the initiatives taken by Regulatory Body to address the same. Radiation Safety and Regulatory Concern in DR practice: Radiation safety & regulatory concern in diagnostic X-ray practice can be discussed as follows:

1. Radiation safety: Radiation Safety in X-ray facility includes built-in Safety and Operational Safety. Built-in safety for X-ray facility can be ensured by procuring type approved X-ray equipment and installation of X-ray equipment in a room with proper shielding. However, operational Safety is a combined responsibility of the employer, licensee and the operator. The employer and licensee need to ensure availability of protective accessories, periodic QA, personnel monitoring services and qualified operators in the facility where as following safe work practice is the responsibility of the RSO and operators. Radiation Safety can be ensured only when the facilities are in compliance with licensing requirements. Hence, strong motivation is appealed for spreading public awareness through periodic notices in newspapers and advertisements in health magazines regarding the licensing requirements. Enforcement actions are being taken against several DR facilities spread all over the country due to major regulatory non compliances during special regulatory inspection and till date several DR equipment have been either sealed or issued warning for seal by AERB

2. Occupational exposures: Even though dose limits are prescribed by AERB for occupational workers as 20 mSv average in a year. By analyzing the TLD dose records for the year 2014 of radiation workers in India, average annual dose was recorded as 0.3 mSv. It is also found that medical diagnostic X-ray facilities in India contribute significantly higher to the reported excessive exposures cases compared to facilities with high hazard potential. However, on investigation, it is found that most of these cases are non-genuine due to improper handing and inappropriate use and storage of TLD badge and/undergoing medical examination wearing TLD badge. Hence, safety awareness in proper use of protective accessories and the TLD badges is essential to minimize the exposures in diagnostic radiology practice. AERB regularly circulates Radiation Safety Posters to all the registered radiation professionals and X-ray facilities for sensitizing towards radiation safety

3. Training and manpower requirements: Employer is responsible for appointing qualified staff for safe handling of diagnostic X-ray equipment including assigning the responsibility to a person for ensuring radiation safety in the institution with approval of regulatory body to discharge the role of Radiological Safety Officer (RSO). But, most of the time it is seen that the diagnostic X-ray equipment are being operated and serviced by persons without training and also have lack of adequate knowledge about radiation safety. Moreover, it is noted that several types of training courses for X-ray technologist/radiographers are being conducted by Institutions/Board/Universities in our country without adequate infrastructure such as non availability of adequate facilities, inadequate radiation equipments, QA gadgets, no specific entry level of candidates, no specific course duration and improper syllabus etc.

To address these issues, AERB has established some mechanism which includes 1. Prescription of radiation safety syllabus for x-ray technologists/radiographers, 2. Harmonization in the training programs for radiographers in the country (Ministry of Health and Family Welfare, Government of India has brought out in March 2016, the national guidelines for education and career pathways of x-ray technologists/radiographers, with inputs from AERB addressing the minimum entry level qualifications, course curriculum and duration), 3. Assessing the training courses for x-ray technologists/radiographers conducted by various University/Institution/Board as per radiological safety viewpoint, 4. Publishing training module for diagnostic X-ray facilities which is available in its website, and 5. Conducting awareness program on radiation safety & protection during regulatory inspection.

Conclusion: Appropriate education and training is very important aspects for performing the intending tasks of every individual. Radiation safety in the User’s institution can be ensured by availability of trained personnel. It is also the responsibility of every safety professional to continuously enhance his/her knowledge and skills to keep abreast with the advancement in the field, with the aim as impressing the quality of services and care offered to patients. All the course conducting University/Institution/Board should adopt the above said national guidelines to ensure the uniformity in the courses for x-ray technologists/radiographers and should approach AERB to assess their course for recognition. There is always a need for active participation between professional bodies and AERB to address the regulatory & radiation safety issue of diagnostic X-ray facilities with respect to training & education aspects.

PP-52

WIRELESS ROBOTIC PHANTOM FOR QUALITY ASSURANCE OF 4D GATED RADIATION THERAPY
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High precision Radiotherapy Technique such as Intensity Modulated Radiotherapy (IMRT) and Volumetric Arc Therapy (VMAT) requires accurate targeting of Tumour, however due to cardiac and respiratory motions, achieving precise targeting is ambiguous in cases of intra-thoracic tumours due to varying magnitude of displacement with respect to patient, respiratory pattern and size of the tumour. These displacement results in an increased treated volume and distribution of the dose
delivered does not match with the intended dose distribution. To evaluate the accuracy of radiation dose delivery during gated radiation therapy with the Varian Realtime Position Management (RPM) System using an in house developed wireless respiratory phantom.

**PP-53**

**QUANTITATIVE ANALYSIS OF PLAN EVALUATION USING INDICES: COMPARISON OF HDR INTERSTITIAL BRACHYTHERAPY VERSUS IMRT AS A BOOST IN CARCINOMA BREAST**

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**Introduction:** Combinations of external beam radiotherapy and interstitial or intracavitary brachytherapy have been effectively used in variety of clinically settings since the introduction of megavoltage beam therapy in the 1950s. Generally, Brachytherapy is used to administer high doses to unresected or residual primary tumor while external beam radiotherapy is used to deliver more modest doses to larger volumes of adjacent tissue.

**Purpose:** The Aim of the study is to Quantitative analysis of plan Evaluation using Indices and to Compare HDR Interstitial Brachytherapy with IMRT as a Boost in Carcinoma Breast.

**Materials and Methods:** Consecutive 8 patients were selected who underwent radiotherapy after breast-conserving surgery (BCS) in patients with early stage breast cancer. The brachytherapy boost was started on third post operative day of BCT followed by EBRT to whole breast of 50 Gy in 25 fractions. For all patients, a dynamic IMRT planning was carried out for Varian Clinac 2300 CD with Five fields in six MV photon beam using Varian Eclipse Treatment Planning system (V6.5) with the prescription of 15Gy/6 fraction. The interstitial brachytherapy treatment planning was done for all patients using Plato BPS Version 3.1,Nucletron, The Netherlands) with same prescription. The dose Homogeneity Index (HI),Conformal Index(CI),COIN and External volume index were Calculated for both IMRT and Quantitative evaluation of the implant dosimetry.

**Result:** In IMRT, the average of the maximum and Minimum doses occurred in the PTV is 16.54±0.41 cGy and 13.43 ± 1.16 cGy respectively. The conformity index ranging from 0.9712±0.024, the heart dose is 9.37±5.97 Gy and 12.38±7.68 Gy for IMRT and HDR-IBT respectively. no significant difference has been found for the 10 Gy and 15 Gy lung volumes, the average COIN value was around 0.84, EI was calculated within 0.19 for IMRT and 0.08 for HDR-IBT.

**Discussion and Conclusion:** External IMRT plans produce highly conformal and uniform dose distributions. Similarly, HDR-IBT produces better conformal plans. Heart and lung doses were reduced with HDR-IBT. HDR-IBT plan was superior in target coverage than external IMRT plan. In addition, HDR-IBT can be performed in clinical situations with the less equipped or to the facilities less than ideal conditions.
Abstracts

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**Purpose:** To increase confidence level in the clinical IMRT verification by Design and develop the new patient specific QA phantom which is able to measure the dose to the point in different regions in and outside of the target. And Verify the IMRT Treatment

**Materials and Methods:** PMMA (Poly Methyl Methacrylic) water equivalent phantom was used in this study. Its density is 1.18 g/cm^3^. Semi-flexible chamber were used for measuring the point dose. This setup was scanned using a GE Light Speed 16 slice CT scanner. IMRT verification plans were generated by the Varian Eclipse treatment planning system (TPS) version 13.6. The measurement was carried out on Varian Clinac iX (Linear Accelerator). The Varian clinac iX linear Accelerator provides X-rays and Electron beams. It is 6 MV & 15 MV Linac. The multiple electron beam energies (6, 9, 12, 15, and 18) are available.

**Result and Discussion:** Our result demonstrates a strong correlation between the dose calculated in TPS and the dose measured in the phantom using semi-flexible chamber. The obtained results showed a good agreement between dose calculated in TPS and dose measured in the phantom. The percentage variation between dose calculated in TPS and dose measured in the phantom is less than 2% for most of the points and only two points showed less than 3% variation.

**Conclusion:** The results demonstrated that the thorax rotational phantom can be used in patient specific QA measurements for IMRT. The percentage variation between dose calculated in TPS and dose measured in the phantom is less than 3% variation. Therefore we can use the thorax rotational QA phantom with semi-flexible chamber for IMRT patient Specific QA. The phantom is a very reliable tool for the fast and precise verification of IMRT fields. These tests have resulted in an understanding of the rotational phantom limitations and increased confidence in its use for clinical IMRT verification.

**PP-57**

**EVALUATING AND IMPROVING PATIENT-SPECIFIC QA FOR IMRT BY USING INDIAN MADE MULTI-ROTATIONAL PHANTOM**

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**Purpose:** The main purpose of this study was to increase confidence level in the clinical IMRT verification by Design and develop the new patient specific QA phantom which is able to measure the dose to the point in different regions in and outside of the target. And Verify the IMRT Treatment

**Materials and Methods:** PMMA (Poly Methyl Methacrylic) water equivalent phantom was used in this study. Density is 1.18 g/cm^3^. Semi-flexible chamber used for measuring point dose. This setup was scanned using a GE Light Speed 16 slice CT scanner. IMRT verification plans were generated by Varian Eclipse treatment planning system (TPS) version 13.6. The measurement was carried out on Varian Clinac iX (Linear Accelerator). The Varian Clinac iX linear Accelerator provides X-rays and Electron beams. It is 6 MV & 15 MV Linac. The multi electron beam energies (6, 9, 12, 15, 18) are available.

**Result and Discussion:** Our result demonstrates a strong correlation between the dose calculated in TPS and the dose measured in the thorax multi rotational phantom using semi-flexible chamber.

**Conclusion:** The results demonstrated that the thorax rotational phantom can be used in patient specific QA measurements for IMRT. The percentage variation between dose calculated in TPS and dose measured in the phantom is less than 3% variation. Therefore we can use the thorax rotational QA phantom with semi-flexible chamber for IMRT patient Specific QA. The phantom is a very reliable tool for the fast and precise verification of IMRT fields. These tests have resulted in an understanding of the rotational phantom limitations and increased confidence in its use for clinical IMRT verification.

**PP-58**

**DEVELOPMENT OF ARTIFACT FREE NON LEAD BASED NONMETALLIC CT BREAST SCAR MARKER**

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**Introduction:** In Breast Radiotherapy CT marker wires are frequently used to identify the breast scar area for the accurate treatment. The placement of such markers is usually on the skin surface. CT marking wires should therefore exhibit the following features such as clear visibility, should not produce any artifacts and should be easy to use. Most commercially available CT marking wire are made of high-Z materials, which typically cause streaking artifacts, decreasing image quality of the subsequent reconstruction. In this work I have developed a new non metallic artifact free CT breast scar marking wire for Radiotherapy.

**Purpose:** The main purpose of this study was to indigenously develop artifact free non lead based non metallic breast CT scar marker for Radiotherapy.

**Materials and Methods:** Non lead based non metallic artifact free CT breast scar marking wire were developed using various combination of low atomic number materials. The materials are in the powder form which can be modifiable to versatile shape and size according to the needs. Lead based
CT scar marking wire and newly fabricated non metallic CT breast scar marker wire were used to evaluate the visibility of marker wire, CT number and artifact. Both the marker wire were placed in a 30x30x30cm3 sheets of solid phantom (SMART) and imaged on a Toshiba multi slice CT scanner for quality analysis. The phantom was scanned using the similar imaging parameters such as 2 to 3mm slice thickness, as commonly used in the simulation. For the visibility test I have done the CT scan topographic as well as in axial section. The CT artifact of marker were analysed using a J-image software.

**Results and Discussion:** On analyzing the CT scan of both the marker wire on phantom, it has been found that the newly fabricated CT breast scar marker wire has the equal visibility and almost no CT artifact when compared with the commercially available marker wire. The metallic marker wire produced bright streak artifact on the CT image but non metallic CT breast scar marker wire were not producing any streak artifact.

**Conclusions:** The newly fabricated breast scar marker wire density has nearly equal to human bone density so, it appears as bright spot on CT without streak artifact. To conclude that the newly fabricated CT breast scar marker wire will be an alternative to the existing commercially available marker wire with almost no artifact and also cost effective, which can be used for the clinical CT simulation for mainly breast scar marking without producing any metal streak artifact and also can be used all the other anatomical sites during CT scan for Radiotherapy purpose.

**PP-59**

**A METHOD TO PREDICT ACHIEVABILITY OF CLINICAL OBJECTIVES IN IMRT**

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**Purpose:** A data-driven method to predict the achievability of clinical objectives before performing the IMRT optimization is proposed.

**Materials and Methods:** In our approach, “Geometric Complexity (GC)” is computed to estimate the achievability of clinical objectives. Here, GC is the measure of the number of “unmodulated” beamlets or rays that intersect the Region-of-interest (ROI) and the target volume. The geometric complexity ratio (GCratio) between the GC of a region of interest (ROI) in a reference plan and the GC of the same ROI in a given plan is computed. The GCratio of a ROI indicates the relative geometric complexity of the ROI as compared to the same ROI in the reference plan. Hence, by using GCratio it is possible to predict the achievability of clinical objective associated with the ROI optimizer. Basically the likelihood for the optimizer to achieve the clinical objective defined for a given ROI is inversely proportional to GCratio. We have evaluated the proposed algorithm on six Head and Neck cases using Pinnacle3 (version 9.10.0) TPS.

**Results and Discussion:** Out of the total of 42 clinical objectives from six cases accounted in the study, 37 were in agreement with the prediction, which implies an agreement of about 88% between predicted and obtained results. The Pearson correlation test shows a positive correlation between predicted and obtained results (Correlation = 0.81, r2 = 0.66, p < 0.005).

**Conclusion:** The study demonstrates the feasibility of the proposed method in head and neck cases for predicting the achievability of clinical objectives with reasonable accuracy.

**PP-60**

**DETERMINATION OF THE PHOTON BEAM ATTENUATION BY THE TREATMENT COUCH AND VARIOUS IMMOBILIZATION DEVICES**

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**Introduction:** Light weight carbon fiber has been used in Radiation Therapy for making table tops because carbon fiber has high specific strength with high beam transmission when compared to other materials commonly used in Radiation Therapy. Despite the good characteristics of carbon fiber table tops, the beam attenuation is not accounted in treatment planning; this can be result in under dosage of the target volume. Beam absorption by the tabletop can also be significant thus increase in skin toxicity. Photon beam attenuation properties of carbon fiber couch inserts have been studied by several investigators. The studies are that the focus has mainly been performed with a range of energies, field size, gantry angles, and couch-tops.

**Purpose:** The gantry angle plays the major role in the attenuation because the pathway of beam increases when the gantry angle in posterior and posterior oblique. So the attenuation of the photon will be more in the posterior and posterior oblique fields. It can cause unacceptable shift in the dose distribution, which goes unnoticed in the treatment planning systems. The purpose of this study is to measure the attenuation of carbon fiber couch with different base plate, different gantry angles and different energies.

**Materials and Methods:** Elekta Synergy Platform Linear Accelerator which has 4MV,6MV & 15MV and iBeam Evo Carbon fiber couch used for this study. Independent dosimetric studies were carried out to evaluate attenuation due to couch, couch along with carbon fiber base plate, couch along with Acrylic base plate and couch along with base plate and vacuum cushion. Dose measurements were carried out with A12 (Exradin) ionization chamber with Max 1000 Electrometer. And all dose measurements were carried out with different gantry angles with range of 300 each, for all three energies (4 MV, 6 MV & 15 MV) and for the field sizes of 5x5cm2 and 10x10cm2.

**Results:** The ionization chamber with build-up cap was placed at isocenter in air to measure charge without couch. Readings were taken at gantry angles from 00 to 3600 of 300 intervals. Attenuation due to couch (Carbon fiber couch) alone was studied. Attenuation was high at gantry angles from 120 Degree to 240 Degree, with maximum value at gantry angle of 180 Degree.

Measurements were also done for following setups:
- Carbon fiber couch + Carbon fiber base plate
- Carbon fiber couch + Acrylic base plate
- Carbon fiber couch + Vacuum Cushion.
In all these cases, attenuation was high at posterior gantry angles, with maximum value at gantry angle of 180 Degree. The results for all photons beams are tabulated and plotted the graphs for all results.

**Discussion and Conclusion:** It has been concluded that the gantry angle plays the major role in the attenuation because the pathway of beam increases when the gantry angle in posterior (1800) and posterior oblique (120 Degree, 150 Degree, 210 Degree, 240 Degree). In posterior oblique field the thickness of the medium increases. So due to back scatter factor more charges are collected. Thus, couch attenuation correction factor needs to be taken into account.

**PP-61**

**AN EMPIRICAL METHOD FOR SELECTING BEAM GEOMETRIES IN IMRT**

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**Purpose:** The purpose of this study is to introduce a simple and practical algorithm for selecting beam angles in IMRT.

**Materials and Methods:** In the past recent, different beam angle ranking techniques have been proposed for fast selection of beam angles in IMRT. These methods use some metric to evaluate the value of a given beam direction. The metric is evaluated for each beam of a set of candidate orientations and the top ranking orientations are used for final optimization. This approach is significantly faster than the other exhaustive search approaches. However, such ranking techniques ignore the interplay effects between the beams. In addition, the ranking function is different from the cost function used for the final plan optimization, which could result in a sub-optimal plan. We are proposing a novel beam angle algorithm that uses the cost function for ranking the candidate beams. As a prerequisite to our ranking approach, a first optimization is performed with the user defined candidate beams (say 20 beams). Subsequently, the top ranked candidate beams are retained while the other beams are removed from the plan, with which a final optimization is performed. An important advantage in our approach is that the interplay effects between the beams is incorporated in our ranking making it more accurate than the other ranking approaches. In this work, we used Pinnacle3 Auto plan to perform optimization. To study the efficacy of the algorithm, it has been applied to one simulated phantom case and three clinical cases: Abdomen, Prostate, and Lung case. Basically, two set of plans were created. In the first set, the beam angles were defined using conventional logic (equiangular beams). In the second set, the beam angles were decided using the proposed algorithm. In both plans, we did optimization using same Objectives (Clinical Goals).

**Results and Discussion:** We compared the dosimetric parameters of the plans that employ the proposed algorithm with the corresponding plans that employ equiangular beams. On the average, about 16% and 5% reduction in the mean dose and maximum dose (respectively) to OARs is observed in the plans employing the beam angle selection algorithm with equal target coverage, conformity and uniformity as compared to the plans employing the equiangular beam geometries.

**Conclusion:** It is evident from the study that the proposed algorithm can be effectively applied to IMRT to get fast and case specific beam geometries.

**PP-62**

**CONFIGURATION OF SMALL FIELDS BY USING THREE DIFFERENT DETECTORS AND COMPARISON WITH GOLDEN BEAM DATA AND DOSIMETRIC VALIDATION**

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**Purpose:** To configure the beam algorithm in treatment planning system (TPS) for small fields by using 0.125cc, pinpoint chamber (PP), EB-T3 gafchromic film and its comparison with Varian medical systems (VMS) beam data and validate the beam models dosimetrically in clinical cases.

**Materials and Methods:** Anisotropic analytical algorithm needs beam profiles (BP), percentage depth doses (PDD), output factors (OF) and absolute dose at calibration depth for modelling the beam in Eclipse (VMS Ver 11). BP, PDD and output factors were measured for 6MV by using 0.125cc and pinpoint chamber from the field size (F.S) of 1 x 1 cm2 to 40 x 40 cm2. OFs were measured by using 0.125cc (For F.S 2 x 2 cm2 to 40 x 40 cm2), pinpoint chamber (For F.S 1 x 1 cm2 to 40 x 40 cm2) and EB-T3 gafchromic film (For F.S 0.5 x 0.5 cm2 to 30 x 30 cm2). Separate beam modelling was done with individual detector measured data and Varian golden beam data (VBD) in Eclipse. Modeled and deduced beam parameters from these beam configurations were compared. Beam spectrum (BS), intensity profile (IP), mean radial energy (MRE), electron contamination (EC), collimator back scatter factor (CBSF) and secondary source parameters were compared between above mentioned beam models. For dosimetric validation, metastatic brain case was planned. For IMRT and VMAT plans dose calculation was performed by using each model and compared. Dose volume histogram (DVH) was compared. Patient specific quality assurance was performed by using EB-T film and gamma evaluation was done.

**Results and Discussion:** Difference in output factors were observed between the detectors. Difference in secondary source size was 8.35 mm (PP vs. 0.125cc), 4.31 mm (PP vs. EB-T3) and 0.01 mm (PP vs. VBD). No difference in beam spectrum was observed. Modelling the flattening filter, calculated MRE was compared between the models. IP over medial to lateral direction was plotted for four beam models and difference were calculated. Calculated CBSF was compared. Dose difference between above beam models were calculated in mid uniform dose region and it was 0.73% (PP vs. 0.125cc), 2.12% (PP vs. EB-T3) and 0.01 (PP Vs VBD) for single metastatic lesion IMRT plan and in VMAT the dose
difference were 1.47% (PP vs. 0.125cc), 0.155% (PP vs. EBT), 0.92 (PP Vs VBD). For 5 lesion case, the dose difference were 2.51% (PP vs. 0.125cc), 1.14% (PP vs. EBT), 0.81% (PP Vs VBD) and 1.92 (PP vs. 0.125cc), 0.71 (PP vs. EBT), 1.2% (PP Vs VBD for IMRT and VMAT respectively. Comparison of 2 dimensional dose analysis, beam profiles and DVHs shows the significant variation in the dose gradient regions.

Conclusion: Active measuring volume of the detector is crucial for modelling the small filed. In our study, the smaller volume chamber and EBT 3 film bema model can provide the adequate accuracy for dose calculation. When EBT 3 film is used for modelling and patient specific QA, consideration to be given for scanner resolution, sensitivity over the area, irradiation time and scanning time.

PP-63

CLINICAL IMPLEMENTATION OF TOTAL BODY IRRADIATION WITH MULTI ISOCENTRIC VOLUMETRIC MODULATED ARC

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Introduction: Total Body irradiation (TBI) is conditioning regimen in conjunction with chemotherapy before Bone Marrow Transplant (BMT) for a patient with hematological malignancies. TBI kills malignant cells and suppresses the immune system which helps to prevent transplant rejection. Various dose and fractionation schemes were used in the past treatments but in general dose fractionation schemes for TBI is 12-15 Gy given in 6-12 fractions over 3-6 days. Several publications reported various treatment techniques such as left and right side treatment with sitting patient on chair, AP-PA technique with extended SSD, Translational technique and sweeping beam technique with column mounted Linac. All these techniques required dedicated equipments & accessories for treatment, shielding materials for critical OARs and larger size room which is not feasible in regular linear accelerator. In recent years publications reported that Helical Tomotherapy was implemented the TBI treatment as an approach of reducing dose to critical organs especially lungs.

Purpose: The purpose of this paper is to implement the Total Body Irradiation (TBI) clinically feasible with purely on multiple Iso-centric VMAT technique with the help of SBRT Multi-board Base plate used as rotating pivot technique.

Materials and Methods: A Patient of 15 year old boy was reported and admitted for the TBI treatment in our hospital before going for the BMT. Immobilization was done for the patient with the help of thermoplastic mask of 5 clamps for head and shoulders, 4 clamps for pelvis and vaclocks for the extremities. Whole body splitted into two set of CT scans, one with head first supine position from base of skull to mid thigh and second one with feet first supine from feet to mid pelvis. Reference marker placed on mid thigh for dose coverage junction for both scans. SBRT Multi board base plate from Macro Medics used as rotated pivot technique can rotate the patient without disturbing the setup for feet first scan. Whole body is prescribed as CTV excluding lung and kidneys with 12Gy in 6 fractions over 3 days (2 fractions per day). PTV generated with margin of 5 mm from CTV. Treatment planning performed using VMAT (Rapid Arc) technique in Eclipse 13.7 TPS from Varian Medical systems. Treatment planning consisted of totally 9 isocenters, 5 isocentre in head and neck, chest and pelvis with 10 arcs of 21480 angle and 4 isocentres in left and right legs with 4 half arcs of 7160 arc angle. The best treatment plan was performed with 6 MV photon beam to ensure 95% CTV dose coverage with the prescription dose and mean dose to lungs and kidneys were restricted to 10.5 Gy. Lens reduced to 6 Gy. Treatment executed with Vital Beam Linear accelerator with OBI, CBCT used as Image Guided Radiation Therapy (IGRT) for each VMAT delivery. Quality assurance performed with IBA iMatrix Evolution with Miniphantom and Point dose measurement done with slab phantom and CC13 ion chamber followed by in vivo dosimetry via OS LD nano dots on the patient while on treatment.

Results: The time required for contouring and planning was 15-20 hrs and quality assurance took 4-5 -hrs. CTV coverage of 95% achieved with VMAT technique with reduced OAR doses of lungs and kidneys to 10.5 Gy and lens restricted to 6 Gy. The couch time for treatment on day one was 2.5 hrs including setup and mounting of OSLD chips and irradiation. Further fraction reduced to 1.5 hrs & actual beam on time was 550 s. Three CBCT performed for head first with setup error of ±0.5 mm and two CBCT scans performed for feet first with setup error of ±0.3 mm. The Gamma analysis of 3%/3 mm of all isocentres passed more than 95% with tolerance dose of 10%. Point doses between calculated and measured dose resulted ±2% deviation. OS LD dosimeter readings showed the results of ±5% deviation from prescription dose of 2.0 Gy.

Discussion and Conclusion: Volumetric Modulated Arc Therapy (VMAT) provides the benefit of satisfactory dose distribution within PTV and reducing the dose to the OARs. Moreover VMAT guarantees a homogenous dose to the total body and allows 3D conformal high Precision radiotherapy treatment.

PP-64

FIRST CLINICAL EXPERIENCE WITH IMAGE GUIDED RADIATION THERAPY ON SOUTH EAST ASIA’S FIRST HALCYON LINEAR ACCELERATOR: AN INNOVATIVE RING MOUNTED LINEAR ACCELERATOR

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Introduction: Halcyon is an innovative new ring mounted linear accelerator designed by Varian Medical Systems, USA. South East Asia’s First Halcyon was Installed, Acceptance Tested, Type Approved and Licensed for patient treatment at Sterling Cancer Hospitals, Rajkot. The machine has a new design with no optical field light or Optical distance indicator. The machine has a bore laser fitted which are not on the plane of isocentre. The ring design has a one meter bore in the centre to position the patient. All these features make the setup of the patient different from that of a conventional
linear accelerator. The setup and treatment of the patient is extremely simple and fast in the Halcon Linac.

**Materials:** Varian Halcyon licac is a ring mounted linear accelerator with a single energy of 6MV Flattened Filter Free photon delivered at 800 MU/min dose rate at 1 m Source to Axis Distance (SAD). Halcyon has a 28 cm x 28 cm field size defined by a new innovative dual layer MLC (Multileaf Collimator). There are 28 pairs on the distal and 29 pairs in the proximal layers with the proximal layer aligned with an offset of 5 mm to cover the inter-leaf gap of the distal layer. Each leaf has a width of 1 cm at isocentre and a full overtravel distance of 14 cm. With the proximal layer also participating in the fluence creation, the treatment plan is created with an effective 5 mm resolution. The Varian Eclipse Treatment Planning System is the only planning systems for Halcyon treatment planning. The interface for planning is same as that of other conventional linac and hence has a fast user adaptability. The calculation algorithm supported is only AAA (Analytical Anisotropic Algorithm) and for optimization PO (Photon Optimizer) only. Even the intermediate dose and the portal dose predictions use the AAA algorithm for calculation. In this study, the experience of patient simulation, setup, treatment and quality assurance is detailed.

**Methods:** The CT Simulation was performed using Siemens Go Up CT Simulator with Gammex Blue Moving lasers. The immobilization of the patient was done using the same setup as done for a conventional linear accelerator treatment. The Contouring and Planning was done in Somavision and Eclipse Planning Systems. After planning, the patient specific QA was done using SunNuclear ArcCheck.

**Discussion:** The treatment plans quality was very much comparable with the quality of conventional linear accelerators. All the treatment plans were clinically acceptable as per international protocols. Even with a 1 cm resolution plans, the organ doses were comparable with high resolution MLCs. With the proximal leaves moving into the field, superior quality plans were generated with far better conformity than with only the distal leaves creating fluence. This confirms with the proposition than plans are created with 5 mm effective resolution. When comparing RapidArc plans, the monitor units were comparatively more in Halcyon but the integral body dose was comparable. The plan delivery is very fast due to the four RPM gantry rotation and 5 cm/sec MLC speed. Also, collimator rotation is also faster and hence multiple beams with different collimator angles are also delivered fast.

**Conclusion:** Halcyon is capable of delivering high quality treatment plans with its novel design and innovative MLC. With the mandate of daily QA checks and imaging for each and every fraction, the superiority of the treatment delivery is assured on each fraction. The inclusion of imaging dose into the plan ensures the safety of the patient.

**Introduction:** Correct determination of tumor localization and extension is of major importance in radiation oncology. This is especially true from the perspective of modern radiation treatment techniques such as inverse planning and intensity-modulated radiotherapy. The precise delineation of gross tumor volume is one of the quality assurance aspects that have to be dealt with when applying these techniques. For brain cases imaging techniques such as computed tomography (CT) and magnetic resonance (MR) imaging provide specific and essential information. Correct interpretation of this information requires an accurate image registration, so that they can be used for delineation of targets.

**Purpose:** This paper describes the implementation of point registration method and compared it with automated registration procedure for treatment planning of brain tumors.

**Materials and Methods:** Fifteen patients with various brain tumors was taken retrospectively for this study who had computed tomography (CT) and magnetic resonance (MR) imaging before the start of radiotherapy. We analysed the two registration methods available in our Monaco contouring workstation on these image sets. Automatic Registration was done by mutual information (MI) method where software automatically aligns the image sets and gives numeric MI value which convey the extent of matching. Another registration method called point registration displays CT and MR images as blended view on the screen and needs at least three pair of points as input for both image sets. We identified at least five non coplanar pairs of matching (conjugate) anatomical landmarks points within the two image sets, such as the Superior border of frontal sinus, fornix, left and right mandibular head, superior border of clivus bone. Alternating between the two images sets, we will mark landmark points. The software links these points together with lowest possible root mean square error among them for best fusion. The translation shifts along x; y and z axes and the time taken for registration were noted and compared for both the registration techniques.

**Results and Discussion:** The Absolute mean coordinate differences between automatic and point registration along x, y and z axis were 0.08 cm, 0.22 cm and 0.16 respectively with standard deviation less than 0.2 cm in all axes. The absolute mean of the rotational difference in x, y and z axis were 2.5°, 0.95° and 1.23° with maximum standard deviation of 3.12 in x axis. There are larger differences in rotational axes.

**Conclusion:** Automatic and point registration methods can provide comparable registration as evaluated by the coordinate differences between the shifts obtained in both methods. But more time and human intervention is required for the point registration method. Further studies needed to be be carried for the effect on target volumes.
Purpose: Thoracic oesophageal cancer being highly morbid and mortal led us a challenge in developing and applying the accurate and safe delivery of radiotherapy. We prospectively evaluated a novel deep-inspiration breath-hold (DIBH) screening and delivery technique to spare & optimize organs at Risk (OAR). The impact of set-up and dose variables upon (OAR) dose in DIBH RT was investigated.

Materials and Methods: All patients with thoracic oesophageal malignancies referred between 2015 and 2018 of all disease stages, set-up variations, and dose prescriptions were included. We used simple screening criteria at CT simulation, to systematically assess patients for obvious DIBH benefit and capability. The study was performed on a Truebeam STx system, which is equipped with Varian Real-time Position Management (RPM) system (Version 1.7). Five oesophageal malignancies patients were immobilized in supine position with All in one (AIO) Systems from Orfit Industries. 2.5 mm slice thickness of FB & DIBH CT scans were taken on a GE Discovery 16 Slice PET CT scanner. Contouring was done on both FB and DIBH CT Scans Selected patients receivedIntensity-modulated RT (IMRT), Rapid Arc (RA)/Volumetric Modulated Arc Therapy (VMAT) based on a DIBH CT scan. A 3D-surface monitoring system with visual feedback assured reproducible DIBH positioning during gated radiation delivery. Patient, target set-up, and OAR dose information were collected at treatment. Target volumes for primary lesions (54 & 60 Gy) and electively treated regions (45 & 50 Gy) were contoured. OAR such as heart, lungs, spinal cord, liver and kidneys were evaluated. Every patient had 2 dose-plans, one with DIBH CT and other with FB CT with IMRT/ VMAT techniques. For each technique, we evaluate the coverage target, homogeneity index of PTV (HI), conformity index (CI), monitor units and DVH metrics of lungs, heart and spinal cord.

Results and Discussion: DIBH IMRT/VMAT plans reduced total lung volume treated above 20 Gy (V20) and mean lung dose (MLD), but volume treated above 5 Gy (V5) was higher in both DIBH & FB CT. Gated IMRT/VMAT plans improved total heart volume treated above 20 Gy and 40 Gy (V20, V40) and maximum dose to cord. HI and CI were evaluated. Coverage target was very high with both schemes. Statistical differences were observed in DIBH & FB CT plans.

Conclusion: Our results suggest that gated IMRT/VMAT for radical treatment of oesophageal cancer is useful for decreasing dose in organs at risk and with high conformity and homogeneity of the target. Nevertheless, VMAT/IMRT increases low-doses in lung and this may contribute increase pulmonary complications.

PP-67

STUDY THE QUALITY ASSURANCE TESTS IN MOBILE C-ARM FLUOROSCOPY SYSTEMS USING NOMEX MULTIMETER

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Introduction: Fluoroscopy was the first real-time imaging equipment which imaged the motion organ of the human body in a lively manner. Later comes the c-arm innovation which made the work easier. Mobile C-arm is a compact unit designed for real-time imaging which is used in the operating room, emergency departments, physicians’ offices, and in some cases healthcare facility. C-arm is a smaller size, simplicity of use and lower cost. It is very important that quality assurance to be carried out because the exposure time is comparatively more than that of normal X-ray imaging exposure.

Purpose: To perform quality assurance (QA) tests as per the Atomic Energy Regulatory Board (AERB) regulation in mobile C-arm fluoroscopy systems. The QA tests include beam alignment, focal spot size, accuracy of tube voltage and tube current, half value layer (HVL) assessment, total filtration (TF), output consistency, image intensifier tube (IIT) assessment and tube housing leakage radiation.

Materials and Methods: The instruments used for QA study includes Multimobil 5E (Siemens Medical Systems, Germany), PTW-NOMEX multimeter (PTW-FREIBURG, Germany), low and high contrast pattern and pressurized ionization chamber based fluke survey meter. The AERB safety code no. AERB/RF-MED/SC-3 (Rev. 2) was followed for the measurement of all tests in this study. The beam alignment test tool and focal spot pattern were kept above the IIT one by one for central beam alignment and focal spot size measurement. The multimeter was properly connected to laptop and detector sensitive area position within the X-ray beam at 50 cm. The accuracy of tube voltage was verified between 60 kVp to 90 kVp at 10 kVp intervals except for 80 kVp (Siemens vendor only have 81 kVp option). The linearity of mAs was verified at 10 mAs, 20 mAs, and 50 mAs. The measurement of HVL and TF was done using aluminium filters for the operating parameter of tube voltage 81 kVp tube current 20 mAs. The low and high contrast pattern was fixed into IIT, we have noted diameter of the smallest size hole and bar strips line clearly seen on the monitor. The radiation protection survey of tube housing leakage was measured at 100 cm distance from the focal spot after blocking the exposure.

Results: From this study, we noticed that titled central beam alignment is 0.5°. The effective focal spot size observed 1.5 mm X 1.5 mm on the monitor. An x-ray tube kVp accuracy error is 61.95±1.95 for 60 kVp, 71.63±1.63 for 70 kVp, 82.51±1.51 for 81 kVp and 93.02±3.02 for 90 kVp. The mAs linearity was measured and the coefficient of linearity value is 0.0185. In output consistency, the COV values are 0.0023 for 60 kVp, 0.0022 for 70 kVp, 0.0028 for 81 kVp, 0.0001 for 90 kVp. HVL value is 4.27 mm of Al and TF value is 6.4 mm of Al. The diameter of the low contrast is 3 mm and the resolution of bar strips frequency is 0.8 lp/mm. The patient table top exposure is 2.03 mR/min at 90 kVp and 10 mAs. The X-ray tube housing leakage radiation is 1.44 mR in one hour.

Discussion: The measured value of beam alignment is within the acceptance limit of 1.5°. The kVp acceptance is done by varying the operating voltage the differences is well within the permissible limit of ± 5%. Likewise, all the QA tests values are within the permissible limit.

Conclusion: The C-arm equipment for which QA test performed was in safe working condition since all the values are in good agreement with the AERB recommendation.
COST EFFECTIVENESS OF SILVER NANOPARTICLE OVER GOLD NANOPARTICLE IN NANO-PARTICLE AIDED RADIOTHERAPY

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Introduction: The prime aim of radiotherapy is to deliver adequate dose to tumor tissue while sparing surrounding normal tissue and the organ at risks. One of the major problems associated with these techniques is the lack of selectivity between the tumor and the surrounding healthy tissue, thus the performance is limited by the tolerance dose of normal tissues and organ at risks. The tumour region can be made radio-sensitive with the infusion of nanoparticles (NPs) which will improve the therapeutic benefit by selectively differentiating tumor and healthy region. The gold NPs are used as radio-sensitizer due to its high atomic number, biocompatibility and it is well explored for its suitability in dose enhancement. Presently silver NPs are also being explored in radio sensitization like other high Z materials. The cost of silver NPs is almost 10 times less than the gold NPs.

Purpose: The prime aim of this study was to calculate the dose enhancement factor in the tumor with gold and silver NPs for mono-energetic photons having energy above the absorption edge energy of both NPs using analytical as well as Monte Carlo method and to compare the cost effectiveness of both NPs in order to achieve the same level of dose enhancement.

Material and Methods: DEF (Analytical Method): The dose enhancement factor (DEF) which is defined as the ratio of the dose absorbed in the tumor region with the infusion of NP to the dose absorbed in the tumor without NP is calculated as,

\[ \text{DEF} = \frac{w_{\text{NP}} \cdot \left( \frac{\mu_{\text{en}}}{\rho} \right)_{\text{NP}} + \left( 1 - w_{\text{NP}} \right) \cdot \left( \frac{\mu_{\text{en}}}{\rho} \right)_{\text{tissue}}}{\left( \frac{\mu_{\text{en}}}{\rho} \right)_{\text{tissue}}} \]  

(1)

where the \( \left( \frac{\mu_{\text{en}}}{\rho} \right)_{\text{NP}} \) and \( \left( \frac{\mu_{\text{en}}}{\rho} \right)_{\text{tissue}} \) are the mass energy absorption coefficients of tissue and the NP respectively; \( w_{\text{NP}} \) and \( 1 - w_{\text{NP}} \) are the fraction by weight of NPs in the tissue and the fraction by weight of the tissue respectively. The DEF were calculated at concentration levels of 7mg NPs per gram of tumor with mono-energetic photons ranging from 20 KeV to 500 KeV for both gold and silver NPs.

DEF (Monte Carlo Method): The material composition of the tumour and normal tissue was assumed to be the same having 10.1% Hydrogen, 11.1% Carbon, 2.6% Nitrogen and 76.2% Oxygen. Only difference in the tumour and tissue is that the composition and density of the tumour were altered by varying the concentration levels of NPs inside the tumour. The EGSnrc/DosRZnrc Monte Carlo Code was used to estimate the DEF. The mono-energetic photons with energy 50 and 100 keV were used for calculation and 10⁶ particle histories were simulated.

Result: The DEF of gold and silver NP inside the tumor region for photon of energy 50 keV was found to be 2.07 and 2.06 respectively using analytical method whereas with Monte Carlo method it was 2.13±0.008 and 2.10±0.008 respectively. For photon of energy 100 keV, DEF of gold and silver NP inside the tumor using analytical method was found to be 1.57 and 1.31 respectively while with Monte Carlo method it was 1.63±0.006 and 1.40±0.005 respectively.

Discussion: The result demonstrates that, for the same concentration of gold and silver NPs inside the tumour region, it is possible to achieve the same level of dose enhancement when the treatment is given via photon of energy 50 keV. It was also noticed that the dose enhancement is almost similar for the photon energies ranging from 50-75 keV.

Conclusion: The study shows that optimum energy in order to achieve the similar level of dose enhancement with silver and gold NPs is found to be around 50 keV which indicates that, the silver NPs in place of gold NPs can be used as a cost effective option without compromising the clinical outcome.

EVALUATION OF VOLUMETRIC MODULATED ARC THERAPY FOR THE CARCINOMA OF LUNG

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Introduction: In patients with locally advanced non metastatic carcinoma of lung with large Planning Target Volume (PTV) eligible for radical radiotherapy, meeting dose constraints for organ at risks (OAR) with Three Dimensional Conformal Radiotherapy Therapy (3DCRT) is not possible and in these patients VMAT is necessary to achieve this.

Purpose: The main goal of the study is to analyse the dosimetric parameters of radiotherapy planning with reference to International Commission on Radiation Units and Measurements (ICRU 83) for carcinoma of lung treated using Volumetric Modulated Arc Therapy (VMAT) on Varian Eclipse Treatment Planning Systems (TPS) version 15.1.

Materials and Methods: Thirty patients of Lung Cancer with Median Volume of (PTV) 784.71 cc were planned using the technique VMAT, in the Eclipse version 15.1 Anisotropic Analytical Algorithm (AAA). These plans were evaluated using dosimetric parameters Conformity Index (CI), Homogeneity Index (HI) as recommended in (ICRU 83).

Results: The median CI and HI for the VMAT plans were 0.89, 0.11 respectively. The Median Mean lung doses (MLD) was 15.84 Gy. Lung Median V20Gy, V10Gy, V5Gy were 29.88%, 46.6%, 64.74%. Heart Mean V30Gy was 25.54%. Heart Mean Dose was 18.13 Gy. Spinal Canal PRV Median Max Doses were 43.84 Gy. Esophagus Median Max dose were 60.36 Gy. Esophagus Median V15Gy was 52.76%.

Discussion and Conclusion: Even though we could achieve the good values in dosimetric parameters like CI, HI for the PTV Coverage normal tissues constraints for the lesser PTV volumes in the Field-in-Field Plans, VMAT plans seems to be better when the PTV volumes were larger and if were very much close to the Spinal Cord and concavity nature. VMAT enables delivery of radical doses of radiotherapy even in...
patients with very large PTVs where dose constraints could not be met with 3DCRT.

**PP-70**

**MEASUREMENT OF DEPTH DOSE IN MAMMOGRAPHY UNIT USING MOSFET**

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**Introduction:** The Metal Oxide Semiconductor Field Effect Transistor (MOSFET) dosimeter has been studied in the past for organ dose measurements and effective dose evaluation in the mammography unit. The depth dose measurements are required to determine the dose absorbed by females while performing Mammography examination.

**Purpose:** To measure the depth dose in a homogeneous Mammography polymethyl methacrylate (PMMA) phantom using MOSFET dosimeter.

**Materials and Methods:** We have fabricated a mammography slab phantom which consists of 25 slabs of PMMA, each slab has 2 mm thickness. The total thickness of the phantom was 5 cm when comprising the slab. The phantom was placed between the cassette holder and compression paddle of the Sophie Classic S (Planmed Oy) mammography unit. The portable MOSFET dosimeter (TN-RD-91, Best Medical Canada) S1 & S2 (TN-502RD-H) probes were placed on the phantom at 1 cm gap and horizontally 3 cm interval was marked. The operating parameters of 30 kVp and 90 mAs were set for Mo/Mo combination of Target/filter to measure the depth dose.

**Results and Discussion:** From this study, it is inferred that the average dose on the surface of the PMMA phantom is 9.16 mGy, 7.21 mGy at 1 cm depth dose, 3.51 mGy at 2 cm depth dose, 0.88 mGy at 3 cm depth dose and 0.26 mGy at 4 cm depth. AGD limit of 3 mGy.

**Conclusion:** The depth dose varied at the different location of the breast is well within the American College of Radiology (ACR) recommendation.

**PP-71**

**DOSIMETRIC STUDY OF COPLANAR AND NON-COPLANAR INTENSITY MODULATED RADIOTHERAPY AND VOLUMETRIC MODULATED ARC THERAPY TREATMENT TECHNIQUES USING FLAT AND UNFLAT BEAMS FOR GLIOMA**

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**Introduction:** There are groups of patients with high-grade brain tumors that can now be identified with prolonged survival. As survival outcomes improves, Intensity Modulated Radiotherapy Techniques are used to minimize treatment related long term toxicities and to improve therapeutic ratios.

**Purpose:** The aim of the study was to compare coplanar and non-coplanar Intensity Modulated Radiotherapy (IMRT) and Volumetric Modulated Arc Therapy Treatment Techniques (VMAT) using Flat and unflat beams for Glioma.

**Materials and Methods:** Five patients were chosen and Patients were immobilized with a thermoplastic mask in the supine position followed by computed tomography (CT) scanning. A consensus set of contours were generated for target and OARs. The prescribed dose was 60 Gy in 30 fractions. The treatment plans were created using the Eclipse TPS version 15.5 which employs Acuros XB algorithm. The plans were generated using the following techniques: Coplanar IMRT (IMRT C), Non-coplanar IMRT (IMRT NC), both using Flat and Unflat beams (FFF IMRT C, FFF IMRT NC), Coplanar VMAT (RA C), Non-coplanar VMAT (RA NC), both using Flat and unflat beams (FFF RA C and FFF RA NC).

**Results and Discussion:** All the eight radiotherapy treatment techniques were compared using various dosimetric parameters. The mean PTV dose averaged for all techniques were 5987.425cGy with a standard deviation of 53.8387. IMRT demonstrated more improved sparing of Ipsilateral and Contralateral optic nerve (difference of 55.145cGy and 146.08 cGy respectively) compared to rapid arc techniques. There is an increased sparing of Ipsilateral eye and lens, Contralateral eye and lens doses in rapid arc techniques. There is no significant variation in the case of Brain stem, Optic chiasm and the volume receiving 35Gy in brain excluding PTV (Brain – PTV). There is no significant variation in the case of flat and unflat beams for brain stem, Ipsilateral and Contralateral lens doses, unflat beams shows an improved variation in the case of both optic nerve doses (Ipsilateral optic nerve: difference of 32.775cGy and Contralateral optic nerve: difference of 110125cGy). The volume receiving 35Gy is comparatively less in unflat beam (variation of 2.77cc) with flat beams. Unflat beams demonstrate a reduction in optic chiasm (difference of 13.57cGy) and contralateral eye doses (44.83cGy). Non coplanar technique shows better results in contralateral lens (1056.765 vs 959.38). There was no significant variation in dose to Ipsilateral lens (1133.5 vs 1097.2) and Ipsilateral optic nerve but a considerable reduction of dose can be noted in Contralateral optic nerve (difference of 107.275cGy) for non-coplanar technique. When eyes and optic chiasm is concerned, coplanar techniques shows improved sparing. There is no comparable variation in brain stem and volume receiving 35Gy in Brain excluding PTV. There was no significant variation in homogeneity index with flat vs unflat beams and coplanar versus non coplanar techniques. But IMRT plans are more homogenous (0.05559) in comparison with rapid arc (0.07254). There is a significant variation in conformity index. Rapid arc shows better conformity (1.0828) compared with IMRT (1.2495). But there was no significant variation with flat vs unflat beams and coplanar vs non coplanar techniques. The volume receiving 95% dose other than PTV shows a better result in Rapid arc techniques (7.5284cc) compared with IMRT (21.1384cc). Unflat beams shows more sparing (13.19786 vs 15.3922) compared to flat beams. While coplanar and non-coplanar is concerned, non-coplanar shows a better result (13.263 vs 15.392). Rapid Arc techniques required fewer MUs (434 vs 818.4) in comparison with IMRT. But non coplanar technique require higher MUs (643.5 vs 608.9) compared to IMRT. The volume receiving 95% dose other than PTV shows a better result in Rapid arc techniques (7.5284cc) compared with IMRT (21.1384cc). Unflat beams shows more sparing (13.19786 vs 15.3922) compared to flat beams. While coplanar and non-coplanar is concerned, non-coplanar shows a better result (13.263 vs 15.392). Rapid Arc techniques required fewer MUs (434 vs 818.4) in comparison with IMRT. But non coplanar technique require higher MUs (643.5 vs 608.9) compared to IMRT.

**Conclusion:** VMAT shows better dosimetric advantage than IMRT except for optic nerves and homogeneity index.
dosimetric parameters, unflat plans gives more sparing of OAR except increased MU. Compared to coplanar techniques, non-coplanar shows a better sparing of critical organs with a slight increase in treatment MU. Overall, from this study, we concluded that Non-coplanar flattening filter free VMAT technique may be the better technique for the treatment of Glioma.

**PP-72**

**PATIENT SPECIFIC QUALITY ASSURANCE USING SUNNUCLEAR ARCCHECK FOR RAPIDARC TREATMENTS DELIVERED ON VARIAN HALCYON LINEAR ACCELERATOR**

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**Introduction:** Halcyon is an innovative new ring mounted linear accelerator designed by Varian Medical Systems, USA. South East Asia's First Halcyon was Installed, Acceptance Tested, Type Approved and Licensed for patient treatment at Sterling Cancer Hospitals, Rajkot. The machine has a gantry rotation speed of 4 rotations per minute (4 RPM) and MLC speed of 5 cm/sec. Also, the MLC has an innovative dual layer design with 28 pairs of distal and 29 pairs of proximal leaves. The proximal MLC leaves also participate in the fluence distribution to create an effective 5 mm fluence delivery resolution. With all the new design and technology, the patient specific QA is an integral part of evaluation for every patient.

**Materials and Methods:** Varian Halcyon linac is a ring mounted linear accelerator with a single energy of 6MV Flattened Filter Free photon delivered at 800 MU/min dose rate at 1 m Source to Axis Distance (SAD). The Varian Eclipse Treatment Planning System is the only planning systems for Halcyon treatment planning. The interface for planning is same as that of other conventional linac and hence has a fast user adaptability. The calculation algorithm supported is only AAA (Analytical Anisotropic Algorithm) and for optimization PO (Photon Optimizer) only. Even the intermediate dose and the portal dose predictions use the AAA algorithm for calculation. SunNuclear ArcCheck 3D patient QA dosimetry phantom was used to perform patient specific QA. The 3D phantom consists of 1386 helically aligned SUNPOINT diodes which measures both at the entry and exit points. The planned dose was delivered on the ArcCheck and the results were evaluated on the SNCPatient software. The phantom setup is done using the external bore lasers and then the isocentre position is verified using Image guidance. A total of 25 patients were planned with RapidArc with two or three arcs and the plans were delivered in the Halcyon linac.

**Results and Discussion:** All the plans delivered on the ArcCheck showed excellent pass rate both in the relative and absolute dose values. The maximum pass rate was 97.5% relative dose and 97.3% absolute dose for a head and neck RapidArc plan with 3%/3 mm gamma passing rate and 10% threshold. The same plan passed with a 95% relative dose when evaluated with 2%/2 mm passing rate.

**Conclusion:** The patient specific QA for RapidArc plans on the Halcyon Linear Accelerators showed superior delivery quality. This ensures that the preloaded beam data commissioned on the Eclipse TPS is accurate. Also, this provides confidence on the machine that the system can deliver even complex treatment plans with high accuracy and high precision. A future study is recommended to study the quality of treatment in multiple isocentre delivery. This study hence proves that ArcCheck is an ideal device to perform patient specific QA in Halcyon linear accelerators.

**PP-73**

**ACCEPTANCE TESTING AND COMMISSIONING OF RADIXACT™ X9 TOMOTHERAPY UNIT: INITIAL EXPERIENCE**

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**Introduction:** Helical Tomotherapy is recognized as modern solution for radiotherapy to sculpture highly conformal dose to the target and minimal toxicity to OARs. A 6 MV linear accelerator is mounted on a ring gantry for image-guided intensity-modulated radiation therapy treatment. The major advantage of Radixact™ X9 system from its predecessor is that it offers increased dose rate of about 1000 cGy/min at isocenter and 10 rpm gantry rotation for faster image acquisition with reduced imaging dose rate. Like CT technology, gantry rotation and couch longitudinal translation are simultaneous that permits helical dose distribution up to 135 cm treatment length. A fan beam created by the collimator and jaws produces a maximum of 40 x 5 cm2 field size at the isocenter. The linac can be operated at a lower voltage (3.5 MV) to produce CT images, which are used for patient image verifications. Radixact™ X9 tomotherapy unit was commissioned for clinical use at our center in June 2018.

**Objective:** In this study we aim to present the mechanical and dosimetric test performance carried out on Radixact™ X9 Tomotherapy unit recently installed at our institution.

**Materials and Methods:** Acceptance testing of the unit was carried out with guidance of vendor specific protocols and that of AAPM TG 148 report. Among various performance tests Radixact™ X9 tests involves some unique procedures compared to C-ARM linacs say mechanical tests such as Linac alignment test, Transverse, Longitudinal beam profiles and Central axis depth dose and dosimetric test comprising dose rate measurement, IMRT dose verifications, MVCT imaging dose verifications were presented.

**Results:** Linac alignment in IEC-X and Y was found 0.09 and 0.009 mm (tolerance: $\pm 0.34$ mm and $\pm 0.2$ mm), Y-Jaw divergence offset was -0.04 mm (tolerance: $\pm 0.5$ mm), jaw twist angle 0.03° (tolerance: $\pm 0.5$°), MLC Center offset of 0.05 mm which was well within acceptable (tolerance:1.5 mm), The MLC twist angle was found 0.01° (tolerance: $\pm 0.5$°), Field Center versus Jaw Setting Test verified and result was 0.22 mm (tolerance: $\pm 0.5$ mm). The measured transverse, longitudinal beam profiles field width and gamma were evaluated and then compared with the factory data. Depth dose comparison between measured and manufacturer quoted value at 10 cm depth for 40 x 5 cm2 field agreed of $<1\%$ dose difference. Dose rate-(output) at 85 cm SSD (1.5 cm buildup) for 5 x
40 field width was found 1009.9 cGy/min, the manufactured specifications 1000cGy/min (Tolerance: ±5%). Radixact™ System MVCT has no variation in the noise, uniformity and measured dose during MVCT procedure was found 1.8137 cGy (tolerance: < 3 cGy).

Discussion and Conclusion: The overall performance evaluation of the Radixact™ Tomotherapy delivery system installed at our institution was found satisfactory. The mechanical and dosimetric performance presented in the study was well within the tolerance limits specified by both the protocols. Based on our experimental results, Radixact™ X9 Tomotherapy unit expected to fulfill the requisites of high precision IGRT with fastest mode of MVCT imaging and increased dose rate to reduce the overall treatment time and increased machine throughput with desired dosimetric accuracy.

PP-74

EFFECT OF GANTRY ANGLES ON PHOTO-NEUTRON DOSE MEASUREMENTS IN A MEDICAL LINEAR ACCELERATOR

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Purpose/Objective: Cancer remains one of the greatest threats and clinical challenges to human health despite the vast therapeutic actions in medicine. However, high energy radiation therapy is one of the highly effective modes for treating cancer either alone or in combination with other modes i.e. Surgery or Chemotherapy. Nevertheless, one of the concerns in radiation therapy is the photoneutron field as by-product in a medical accelerator when using high energy, which produces mainly through photonuclear giant dipole resonance reactions as a function of photon energies. The objective of this study is to determine out-of-field Photoneutron dose equivalent (PNDE) as a function of gantry angle for clinical linac operating at 6-15 MV photon beam.

Materials and Methods: BD-PND is a passive detector which is used to measure out-of-field PNDE more accurately and dose can be read immediately when compare with other detectors. The sensitivity of BD-PND dosimeter use in this study is 1.2 bubbles per µSv.

In the current study, irradiations were carried out using an Elekta Versa HD linear accelerator with a collimator angle at 0°. The detector was set to 100 cm distance from source to surface distance (SSD). The total dose of 200 MU was delivered for 6MV, 10MV (FF & FFF) and 15 MV beam. The out-of-field PNDE were measured as a function of gantry angles of 450 increments over a (0°-360°) rotation by placing the BD-PND detector along axis on the patient plane at a distance of 50 cm, 100 cm and 150 cm from the geometric field edge of 5 x 5 cm2.

Results and Discussion: The measured photoneutron were normalized to photon dose measured at isocenter and is given by µSv/Gy. The contamination of PNDE varies with respect to energy as a function of gantry angles at all respective positions and the results observed were as follows: (1) Gantry angle at 900 & 2700 show high PNDE when compared with to other angles and low PNDE were noticed at a gantry angle at 1350 & 3150 at respective distances. (2) The measured PNDE for the gantry angle 900, 2700, 1350 & 3150 were 64, 63 & 48, 48 µSv/Gy for 10 FF, 60, 55 & 43, 42 µSv/Gy for 10 MV FFF and 148, 146 & 113, 111 µSv/Gy for 15 MV photon beam at a distance of 50 cm. (3) As a function of gantry angle, the ambient neutron dose varies within ± 20µSv/Gy at all distance respectively. (4) Contribution of PNDE was high in 10 MV FF beam compare to FFF beam which may be due to the photons interacting with FF produce additional secondary neutrons than FFF beam. (5) The study shows that 15 MV photon beam contribute high PNDE compared 10 MV FF and FFF photon beams at different gantry angle and the ambient fast neutron dose equivalent gradually decreases by increasing the distance from the primary photon beam.

Conclusions: In the current study, it is observed that for 6 MV photon beam, there is no sign of secondary neutron production. Whereas 15 MV photon beam shows higher photoneutron contamination than 10MV photon beam. It is also confirmed that the PNDE is independent of the gantry angle for all energies.

PP-75

STUDY OF COLLIMATOR EXCHANGE EFFECT IN TELETHERAPY UNIT

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Introduction: The dose to a point in a medium is analyzed into-primary component and scattered component (collimator & phantom). Variation of the scattered photons from different parts of the head of the treatment machines with different collimator settings is described by collimator scatter factor (Sc). For rectangular fields, the interchange of upper and lower collimator jaws affects the numerical value of Sc. This is known as the collimator exchange effect (CEE) and is dependent on the design of each particular accelerator/machine.

Purpose: To study CEE in Linear Accelerator (Elekta-Synergy) and telecobalt unit (Bhabhatron-II) at two depths, dmax and 5 cm using wax miniphantoms.

Materials and Methods: The measurements of this project study were taken in two treatment units-linear accelerator (Elekta Synergy) with 6MV photon beam and a telecobalt machine (Bhabhatron–II) with 60Co beam at depths of dmax and 5 cm. The equipments used for the measurement are –Wax Phantom, 0.125cc Ionization chamber, PTW Unidose Electrometer. Two mini phantoms of different thickness i.e. dmax for 6MV photon beam and 6 cm (equivalent to 5 cm of water) were made using dental wax of 0.85 cm/cm3 density. The miniphantoms were kept on the treatment couch in such a way that the central axis of the beam or the cross wire matches the axis of the phantoms which corresponds the center of the active volume of the ion chamber. The in air measurement for 60Co gamma beam at dmax was performed using build up cap of thickness 0.5 cm (dmax for 60Co gamma beam). SSD was kept at 100 cm, for LINAC, and 80 cm for telecobalt unit. Gantry and collimator were kept at 0°. First, (10 x 10) cm2 field size was opened and the
ion chamber was irradiated for 1 min for 60Co beam and for 100MU with 6MV photon beam. X jaw was fixed at 5 cm, while Y jaw was opened from 5 cm-30 cm for 60Co beam and to 35 cm for 6MV photon beam. Next, Y jaw was fixed at 5 cm and the X jaw was opened from 5 cm-30 cm and 35 cm for 60Co beam and 6MV photon beam respectively. Three sets of electrometer readings were taken for each field size and the average of the readings was used to calculate Sc and CEE was studied.

Results: The value of Sc increased with elongated field size. The value of Sc was higher for the collimator setting of varying X jaw (MLC in case of Linear Accelerator) than compared with the value of Sc for the collimator setting of varying Y jaw. The maximum percentage difference between the Sc of the corresponding collimator settings for the Bhabhatron-II unit for depths dmax (0.5cm) and 5 cm are 0.79% and 1.87% respectively and for Linac (Elekta Synergy) at the depths, dmax (1.5 cm) and 5 cm it is 1.40% and 2.65% respectively.

Discussion: The values of Sc and the maximum percentage difference obtained for both the units at two different depths is purely machine specific. This data may not be compared with the commissioning data or any baseline data.

Conclusion: If the value of Sc is not accounted for the corresponding exchanged fields, then it may produce certain error in the dose calculation ultimately leading to error in treatment delivery. Therefore, it is required to use a two dimensional table accounting for the Sc values for every rectangular field sizes.

PP-76

EVALUATION OF OPTIMAL COMBINATION OF PLANNING PARAMETERS (FIELD WIDTH, PITCH, MODULATION FACTOR) IN HELICAL TOMOTHERAPY FOR BILATERAL BREAST CANCER

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Introduction: Breast cancer is the most common malignancy among the women in the world, synchronous bilateral breast cancer is uncommon with the incidence of 2.1%. Bilateral Breast planning is time consuming and challenging because of the huge volume and nearby critical structures. Helical Tomotherapy is capable to deliver well tolerated homogeneous dose to the bilateral breast without field overlapping.

Purpose: Aim of this study is to evaluate the influence of tomotherapy treatment planning parameters on plan quality and treatment time for bilateral breast cases and to find the optimal combination of planning parameters.

Materials and Methods: We have evaluated 5 patients with 90 plans. For each patient, 18 plans were created using the combination of planning parameters (Field width (FW) of 2.5 cm, 5 cm; Pitch 0.215, 0.287, 0.43; Modulation Factor (MF) of 2, 2.5, 3. For every patient initial plan was created with FW 5cm, Pitch 0.287. MF 2.5 and the PTV was prescribed to 50Gy in 25 fractions. Using helping structure we have blocked the beam from posterior direction to reduce the low dose spillage. We have optimized the plan to achieve 50Gy to 95% of the PTV, without increasing 107% dose more than 2% volume. After achieving acceptable OAR results this plan was copied with its optimization constrains and 17 more plans were created by changing only its plan parameters. Plans were evaluated by dose volume histogram (DVH) analysis. Plan quality of target was quantified using Homogeneity Index, Conformity Index, Dmin by D98%, Dmax by D2%, and coverage by D95%. Organ at risk (OAR) doses were evaluated by mean dose, V5Gy, V25Gy for heart and mean dose, V5Gy, V20Gy for both the lungs. Treatment time also evaluated for all the 90 plans.

Results: PTV: When field width lowered from 5 cm to 2.5 cm the CI and HI of PTV improved from 0.997 to 0.999 and 0.07 to 0.04. HI decreases with (more homogeneous) decreasing the pitch or increasing modulation factor. With the effect of pitch (0.215, 0.287, 0.43) D98% and D2% were 49.2Gy, 49.4Gy, 49.5Gy and 51.8Gy, 52.1Gy, 53.2Gy respectively. Increasing modulation factor slightly improved all the PTV indices. OAR: Average value of Heart and lung mean doses were 4.89Gy, 5.17Gy and 10.5Gy ,10.7Gy for field width 2.5 cm and 5 cm. V5Gy of, Heart was 21.4%, 23.1%, 24.8% and lung was 45.6Gy, 46.7Gy, 47.8Gy for pitch value 0.215, 0.287, 0.43. Increasing Modulation factor improved all the OAR indices.

Treatment Time: As expected FW of 2.5 cm (~10 min) had a higher treatment time than 5 cm (~6 min). Pitch value didn’t affect the treatment time. Increasing modulation factor increased treatment time by 2-3 mins.

Discussion and Conclusion: Comparison of dosimetric indices showed that the lower Field width (2.5 cm) improved all the indices but increased treatment time 40-50% than the 5 cm FW. Pitch value 0.43 didn’t offer any dosimetric advantage. An optimal pitch appears to be 0.215 or 0.287. While analyzing low dose as well as high dose OAR volumes it was evident that the pitch value of 0.215 showed better results. Increasing modulation factor increased plan quality as well as treatment time. By applying small FW, tighter pitch and large MF values, it is possible to get a sophisticated treatment plan with a very long treatment time. However, this results in two adverse outcomes: patient discomfort (to lie down static during irradiation) and inherent organ movement due to breathing. Considering all these and on the basis of our analysis plan with FW 5cm and pitch 0.215, MF 2.5 can be considered as an optimal combination of planning parameters for bilateral breast irradiation in Helical Tomotherapy Technique.

PP-77

DOSIMETRIC COMPARISON OF VARIOUS PARAMETERS USING SEGMENTED (FIELD-IN-FIELD) TECHNIQUE AND CONFORMAL TANGENTIAL BREAST IRRADIATION: A PLANNING STUDY ON RADIOThERAPY TREATMENT CONCEPT FOR THE EARLY STAGE BREAST CANCER

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Aim: Most of the patients with early stage breast cancer undergo postoperative radiotherapy to reduce the risk of
local recurrences and improve outcome in long term survival. In early days breast tangential irradiation technique was the standard approach that matched to a direct supraclavicular field depending upon the stage of the tumor. Achieving the homogeneous dose distribution inside the target volume was the difficult task for a planner. In recent past, the field-in-field (FIF) technique has been widely used for delivering tangential breast technique for conservative whole breast treatment. The aim of this study is Dosimetric comparison of various parameters using segmented field-in-field technique and conformal tangential breast irradiation for early stage breast cancer as well as to discuss the “how-to technique” for the FIF technique procedure.

**Materials and Methods:** A total of 10 left sided breast cancer patients with breast conservative surgery were included for our study. The patients were immobilized with an inclined breast board on the CT-simulator. The scanned images were transferred to the contouring system. The whole breast was contoured as the CTV and the PTV was created by adding 5 mm margin to it and by editing 5 mm below the skin surface of the breast. Regarding the organ at risk (OARs), the ipsilateral lung, heart, spinal cord, liver and contra lateral breast were contoured for the dose reporting. Then the image sets were transferred to the CMS-XIO (Release V5.10.00.4) treatment planning system. All the patients were planned with two plans using 6MV photon beam for 50 Gy in 25 fractions, one with two standard opposing tangential beams with wedge and another with segmented FIF technique. The medial tangent field enters the breast medially at the edge of the sternum and the opposite edge with 1.5-2 cm air flashing to the skin and for lateral field with one edge enters at axillary line where medial field exits and the opposite edge with 1.5-2 cm air flashing to the skin. With the help of Beam’s Eye View (BEV) the gantry angle were chosen in such a way that OAR’s like heart, contralateral breast, ipsilateral lung were maximally avoided. We use the MLCs for the shielding of all OARs which were nearby PTV to achieve a good plan. We use the motorized wedge to reduce the dose inhomoogeneity across the target volume. And for the Field-in-field (FIF) technique, initially the calculation was done with the same tangential photon beams with same gantry angle as used for conformal tangential RT with two equally weighted and open beams. Then the medial field was copied to create the first subfield. The MLCs were used to block the isodose level of 1-2% lower than the Dmax shown in the plan. Then the dose calculation was done. Initially the weightage setting for the first subfield was set as Zero and an optimum weight was given to the subfield as required. Then the lateral main field was copied as the second subfield. The MLCs were used to block the isodose cloud of 1-2% lower than the dose blocked at the first subfield. Again the dose calculation was performed and optimum weight setting of the subfield was added. Again the medial main field was copied as the third subfield. The MLCs were used to block the isodose level of 2-3% lower than the dose blocked at the second subfield. The coverage of PTV was verified after final dose calculation was performed. In total all the plans were done with five fields including the two main fields. The subfields were merged to the main tangential field portals.

**Results and Discussion:** The isodose coverage to the PTV with standard conformal tangential plan and FIF technique plans were compared using D95, D93, Dmax and mean doses. Where D95 = 95% of the volume receiving the dose value, D93 = 93% of the volume receiving the dose, Dmax = maximum dose value in the plan. Regarding to OARs like contra lateral breast, ipsi lateral lung and for the heart various percentage of volumes like D5, D10, D20, D30 and mean doses to that organ were recorded. Where D5, D10, D20, D30 are the 5%, 10%, 20% and 30% percentage of volumes receiving the dose respectively. The Monitor units (MUs) for both the plans for all the patients were compared.

**Conclusion:** In conclusion, with the segmented field technique or FIF technique the dose homogeneity in the target is significantly improving. The dose to the OARs is also significantly less in FIF technique as compared to conformal tangential plan. The Monitor units required were also significantly less in FIF plans. So the FIF technique can be a suitable technique to improve the dose homogeneity across the target volume for early stage breast conservative irradiations.

**PP-78**

**ANALYSIS OF THE VARIATION OF INTERNAL TARGET VOLUMES OF A MOVING PHANTOM USING FOUR DIMENSIONAL COMPUTED TOMOGRAPHY**

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**Introduction:** To analyse probable variation of internal target volumes (ITV) with variable longitudinal displacement of different standard shapes of tumor in the moving phantom with the constant breath rate and sine wave breath pattern using a programmable Quasar phantom and Four-Dimensional Computed Tomography (4DCT).

**Materials and Methods:** The programmable motion Quasar was used with variable displacement in longitudinal displacement of CT image cylinder phantom insert containing 2 cm diameter, 1 cm diameter spheres and 3 cc cube tumor density as tumor were used and sine wave in rotational mode with 1 cm amplitude platform with 6 dot marker and constant 4 seconds were set per breath (SPB). The same procedure was repeated with known displacement values of 4 mm, 6 mm, 8 mm and 10 mm respectively in constant breathing period of 4 SPB. The whole procedure were repeated five times at each displacement level and the variation in the volumes recorded for consistency. 4DCT was acquired with 1/10th of the breathing period set as time between images and cine duration set at 5 seconds (breathing period + 1 second). The images were sorted into 10 phases based on the temporal correlation between surface motion and data acquisition with an Advantage Workstation. The binned 10 phase images, Maximum Intensity Projection (MIP) were imported in Varian Eclipse version 15.1. From MIP set, the ITV (spheres resulted in a spherocylinder volume and cube in a cuboid volume) structure created under -210 HU window width to estimate the volume in CC.

**Results:** The observed variation in the internal target volume was ±3% error in the 3 cm cuboid and 2 cm diameter spherocylinder and ±11.5% error in 1 cm diameter spherocylinder of MIP volumes to calculated physical with
variable displacement motion induced volumes in the 10-bins 4DCT image protocol.

Conclusion: There is significant error in 1 cm spherocylinder due to loss of volume information in superiorly and inferiorly with the normal breath rate leads to over or under estimate the volume with higher displacement of the smaller volume tumor. There was no significant error in 3 cm cuboid and 2 cm diameter spherocylinder target volumes due to encompass the MIP volumes were able to consistent by encompass in 4 seconds per breath in 2.5 mm slice thickness during 4DCT imaging.

PP-79

ACCEPTANCE TESTING AND QUALITY ASSURANCE OF NEWLY INSTALLED ORTHOPANTOMOGRAPHY

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Introduction: People with the dental problem are an increasing number in present days because of their lifestyle and hereditary. Same as general diagnostic equipment, dental medicine has also come up with diagnostic equipment with advanced features in it. Orthopantomography (OPG) is imaging equipment used to image the teeth structures. The dentist uses this equipment to find the hidden dental structures, malignant or benign masses, bone loss, and cavities of the human mouth. Quality Assurance (QA) is an important aspect when we talk about radiation procedure imaging technology. So, QA protocol to be carried out in accordance with Atomic Energy regulatory body (AERB) and American Association Physicist in Medicine (AAPM) task group report no. 175 which will ensure the safety procedure of the equipment handling.

Purpose: To evaluate some of the acceptance and quality assurance tests like central beam alignment, focal spot size, accuracy of accelerating voltage, output consistency, half value layer (HVL), total filtration (TF), and tube housing leakage radiation in Orthopantomography.

Materials and Methods: Orthopantomography (Hyperion X7) is a product of Cefla Dental Group, Italy. Small focal spot verification was carried out by placing the line pattern object near to the detector and the operating parameters are 70 kVp and 2 mA. This system has a specification of an automatic timer with respect to mA. PTW-NOMEX multimeter is used to measure the accuracy of kVp, output consistency, HVL, and TF. The kVp is varied between 70 kVp and 78 kVp with an interval of 2 kVp, keeping focus to detector distance (FDD) 62 cm and 6 mA for measuring the accuracy of accelerating voltage. Output consistency test is done by keeping constant tube current 26.4 mAs and a varying tube voltage of 60, 70 and 80 kVp. With this measured value, the coefficient of variation (COV) is calculated. To see the tube leakage, the tube is fully closed by radiation blocking material and by setting 70 kVp, 6 mA then values are measured at 100 cm distance in all sides like left, right, front, back and top side of the tube using fluke survey meter.

Results: It is observed that deviation of beam alignment is 0°. The stated value for the focal spot is 0.6 mm X 0.6 mm and the observed value is 0.8 mm X 0.8 mm which is within the limit. The maximum and minimum values of standard deviation in the tube voltage accuracy is 70.36±0.21 for 70 kVp and 76.00±0.00 for 76 kVp and the remaining deviations are within this range. The output consistency is given by COV that is 0.00261 for 60 kV, 0.00385 for 70 kV, 0.00408 for 80 kV and the limit <0.05. TF is found to be 2.1 mm of Al. Tube leakage is more in the front side of the tube of 7.9 mR/hr which is within the accepted limit.

Discussion: We have performed our study in a newly installed OPG in which there is no significant deviation from the accepted level. However, in the case of old machines, there is a possibility of exceeding the tolerance because of tear and tare property. Hence, it is mandatory to do the QA on a regular basis as per AERB norms.

Conclusion: Orthopantomography successfully passes the QA criteria within the tolerance limit.

PP-80

DOSIMETRIC COMPARISON FOR NASOPHARYNGEAL CANCER PATIENTS WITH COPLANAR AND NON-COPLANAR VMAT ARC TREATMENT TECHNIQUE

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Introduction: Carcinoma Nasopharynx is one of the complicated radiation treatment in head and neck cancers. Though regular Intensity-modulated radiation therapy (IMRT) can provide better treatment and sparing the normal structure, arc therapy have some flexibility in dose delivery from full range of gantry angles with variable dose rate. But still it is more challenging to achieve the full dose to the tumor which lies close to the Organ at risk.

Purpose: The purpose of this study was to evaluate the dose distribution and normal tissue sparing in the radiation treatment for the nasopharyx patients with coplanar and noncoplanar VMAT arc treatment.

Materials and Methods: A retrospective study was carried out for the five Nasopharynx cancer patients, earlier treated by dynamic IMRT techniques, in which the tumor extended to intra cranial, located close to the eye and optic nerve. The high risk and low risk planning target volumes (PTV) were contoured along with other related organ at risk OAR structures as per the guidelines of Radiation Theranp Onclogy Group (RTOG). As per the NCCN guidelines, the dose of 7000cGy and 5940cGy in 35 fractions was prescribed to high risk PTV (PTV1) and low risk PTV (PTV2) has a simultaneous integrated boosted treatment (SIB). The Monaco Treatment Planning system for Elekta Versa HD machine with 6MV, 80 pair’s agility MLC was used for the planning. Two plans were evaluated with each patient. In coplanar VMAT technique, 3 full arc was used. In non coplanar VMAT plan, 2 full arc with one partial arc has a non coplanar beam was used. The monte carlo algorithm was used to reach the maximum dose to the Target and minimal dose to the Organ at risk (OAR). The dosimetric evaluation included: PTV homogeneity index (HI), conformity index (CI), delivery time, monitor unit, mean and maximum dose to eye, eye lens, brain stem, optic chaim, optic nerve, oral cavity, parotid, larynx, and spine.
Results and Discussion: The coplanar and non coplanar VMAT plans had similar PTV coverage 95%. There was no much difference in dose homogeneity in both coplanar and no coplanar VMAT plans. The non coplanar VMAT plans provided improved conformity index. There is no larger difference in parotid, larynx, oral cavity, spinal cord sparing in both the plans. When compared to coplanar VMAT plans, non coplanar plans had better sparing in Eye lens, Eyes, brain stem dose. There is no much difference in delivery time, since the number of arcs has been reduced in the non coplanar VMAT plan.

Conclusion: Our result shows that the non coplanar VMAT plans provides better sparing of normal tissue, homogeneity and conformity when compared to coplanar VMAT plan, however the technique selection is depends on the patient clinical need and requirement.

PP-81

EVALUATION AND VALIDATION OF I’MATRIXX ARRAY FOR PATIENT SPECIFIC QUALITY ASSURANCE OF TOMOTHERAPY

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Introduction and Objectives: A very sophisticated IMRT can be planned and delivered using Tomotherapy treatment system. It uses fan beam technology and is modulated by a binary multi leaf collimator. This modulation results high degree of homogeneous and conformal dose distribution. As like other IMRT treatments, patient specific quality assurance is most important in this helical approach also. Because of its dynamic nature, it is a great challenge for physicists to achieve QA goals. Helical Tomotherapy users practice with film and a specially designed cylindrical phantom called cheese phantom. Currently, there is also a lot of interest in using electronic array dosimeters, because of their instantaneous readout of results. These array detectors have been proved reliable and the results are comparable with films and also better in some cases. There are several 2D array dosimeters commercially available. These detectors have shown to be adequate when used by linear accelerators. But their applicability to helical tomotherapy is not much discussed in the literature. One of such 2D array which has been existing for IMRT verifications for many years is I’MatriXX 2D array with blue phantom. S Xu et al. tested this matrix for helical tomotherapy IMRT plans of head and neck cases. But, its dependency on pitch and field width of tomotherapy was not discussed. Also this study was limited to a single treatment site. Hence, our objectives of this study were to examine and validate the response of I’MatriXX to different pitches and field widths commonly used in planning and to evaluate this device for IMRT/IGRT/ SBRT plans of different cancer lesions.

Materials and Methods: I’MatriXX is a two-dimensional array with 1020 ion chambers, arranged in a square. The pitches ranged from 0.1 to 0.5 were used for all the three different filed widths.16 plans were created with different possible pitch values and field widths. 3% dose differences and 3 mm distance to agreement was the gamma-index criteria used in our study. All plans created with the virtual target were then delivered using multicube set up. Then, Patient DQA plans were executed and the fluence was recorded. Patient plans: 23 quality assurance plans of different treatment sites of the body were used in this study. Plans were chosen in such a way that, different body lesions were covered. All types of treatments like conventional fractionated plans, Hypofractionated plans, SBRT plans were covered in the selection. Same passing criterion was used in these cases also.

Results and Discussion: All the plans were analysed as per the above procedure. Using the 3% and 3 mm criteria, plans with various pitches , field widths and modulation factors showed good agreement, with the percent of points less than 1 being more than or equal to 99%. These results are clearly indicating that, matrix response is independent of filed width, pitch and modulation factor of tomotherapy and is validated successfully for performing PSQA.

All the patient plans showed very acceptable passing rates with matrix irrespective of cancer site. High passing rate ranging from 99.7 % to 90.7% was observed. Pitches, field widths were selected as per the requirements of better planning results. This shows PSQA with matrix gave good agreement for most of the treatment lesions of the body.

Conclusions: 2D array can be utilized for easy and quick Tomotherapy dosimetry. I’MatriXX response is independent of field width, pitch and modulation factor of Tomotherapy. Hence, it is a good and suitable option for patient specific QA for any conformal technique possible with Tomotherapy.

PP-82

PATIENT DOSE MANAGEMENT IN COMPUTED TOMOGRAPHY SCAN

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Introduction: Computed Tomography (CT) examinations have rapidly increased in number over the last few years. Increasing applications causes increase in collective radiation dose to the population. But it can be controlled as long as individual CT examination is clinically justified and doses are optimized to be not more than what is necessary. But experience shows that individual patient doses are increasing mainly because of repeated CT scans. We can reduce the patient dose in ct scan by following certain Quality control protocols such as: Justify the procedure – Ask the patients for records of previous diagnostic procedures – Plan the procedure (right patient, right contrast) – Know well about your equipment settings – Ensure only qualified and trained operator should operate the equipment –Handover procedure records (CD/disc and reports) – Ensure that daily and periodic QA are performed and equipment performance is satisfactory.

Purpose: The present study is to present the improvements implemented at our hospital to reduce the patient’s dose from repetition of CT examination. CT exams should not be
repeated without clinical justification and should be limited to the area of interest.

**Materials and Methods:** The basic way to manage dose is by accurately assessing dose by examination and comparing with national dose reference levels or comparing with the facility averages. Our PET/CT machine model is GE Discovery ST 16 Slice. It can create dose reports with volume CTDI (CTDIvol) and DLP. DLP can be multiplied with conversion factors to calculate effective dose. DLP is the most important value to monitor and optimize dose. The dose reports are saved in PACS which can be frequently monitored. Radiation doses received from radiographs will vary according to patient size, examination area, and examination views. For CT, doses will vary between 2-20 mSv depending on the examination area and protocol. Dose Length Product: DLP accounts for the length of radiation output along the z axis (the long axis of the patient). DLP = CTDIvol/\( nT \). Volume Computed Tomography Dose Index (CTDIvol) is a standardized parameter to measure Scanner Radiation Output. CTDIvol is reported in units of mGy. Where n is the number of slices acquired, T is the slice thickness. \( nT \) is therefore the total scan length. We sampled four patients aged 18 and older in the month of JAN-MAY 2018 who had undergone Repeated CT due to various reasons. For each patient, the technical parameters and dose report data (scan area, scan range, kVp, mAs, and dose length product) were abstracted from the CT images. E = DLP * k, E = Effective Dose in mSv, DLP = Dose Length Product in mGy/cm, k = conversion coefficient in mSv/ mGy/cm, k values are based on ICRP 60 organ weights. We found out the reasons for repeating the CT scan for those patients and improvements were implemented. We sampled around 12 patients in June & August 2018 and calculated the patient doses.

**Results:** We found that the doses received by the patients were much less. Good practice requires the use of patient size specific protocol and techniques that minimize dose without adversely affecting diagnostic performance.

**Discussion and Conclusion:** The risk associated with medical imaging procedures refers to possible long-term or short-term side effects. Most imaging procedures have a relatively low risk. Hospitals and imaging centers practice ALARA (As Low As Reasonably Achievable). This means they make every effort to decrease radiation risk. Therefore, it could be said that the benefit from medical imaging (an accurate diagnosis) is greater than the small risk that comes with using it. The dose reports provided by CT examinations are only estimations and not true measurements. These dose values are reported on the basis of calculations using phantoms. Therefore, it is not possible to know the exact dose the patient was exposed. There can be no limit to individual radiation dose when used for medical imaging purposes. If the examination is medically justified, the imaging should be performed.

**Objective:** A dynamic delivery IMRT field file will contain several control points that are defined MLC shapes at a marked fraction of the delivered monitor units. The size of this file and the fidelity of the deliverable fluence are proportional to the number of control points defined. The aim of this study is to estimate the MU per subfield in dynamic IMRT by exploiting control points.

**Materials and Methods:** The monitor unit calculations were performed for Eclipse treatment planning system (TPS) version 13.8.0 for dynamic IMRT. Optimization was performed for 20 plans for various sites by photon optimizer (PO) algorithm. The number of control points and leaf motion were calculated by the leaf motion calculator (LMC) algorithm. The MU per beamlet was calculated by the difference between two successive meter set weights of the control point over the total MU. The total MU can be estimated for with the number of control points and MU per beamlet. The dose delivered per beamlet to the reference point and overall dose to the reference point were also estimated.

**Results:** The parameters estimated by manual method with the control points were compared with the TPS calculated parameter. All the parameters were within the percentage of deviation of +/-3%.

**Conclusion:** The control points can be used as an effective tool for estimating the significant parameters for dynamic IMRT delivery.

**PP-84**

**COMPARISON OF THREE-DIMENSIONAL CONFORMAL RADIOTHERAPY VERSUS INTENSITY-MODULATED RADIOTHERAPY PLANNING FOR WILM’S TUMOUR**

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**Introduction:** Wilms tumor (WT) (also called Wilms’ tumor or nephroblastoma) is a type of cancer that starts in the kidneys. WT is the commonest pediatric renal tumor, predominantly seen in children. National Wilms’ Tumor Studies (NWTS) have laid down the guidelines for standardized treatment of WT. Three-dimensional conformal radiotherapy (3D-CRT) and intensity-modulated radiotherapy (IMRT) are 2 recently developed radiotherapy techniques. IMRT is believed to be more effective than 3D-CRT in target coverage, dose conformity and reducing toxicity to normal organs. In this study we compared 3D-CRT versus IMRT plan of WT in terms of dose–volume histograms (DVHs), Organs-at-Risks (OARs).

**Purpose:** The purpose of this study is to achieve higher conformal doses to the tumor, while avoiding OARs and WT is the rare case seen in children less than five years of age.

**Materials and Methods:** For this study we have taken one WT patient whose age is 2 yrs and 4 months. The patient was scanned in the CT simulator. The slice’s thickness was 1.2 mm and then images were imported to Eclipse treatment planning system (TPS) version 13.7. In contouring section oncologist delineated the target volumes and OARs. In planning section both techniques 3D-CRT and IMRT plans were planned using 6 MV Energy and compared using dynamic multileaf...
collimator (DMLC). 3D-CRT planning technique was done using four field box and IMRT planning technique was done using 5 fields and dose was calculated using anisotropic analytical algorithm (AAA) version 13.07.16. DVHs and OARs doses were evaluated.

**Results:** Dose prescription for WT was 12 Gy in 7 fraction. 3D-CRT versus IMRT planning Comparison was done which includes DVHs, mean and maximum dose of OARs and Monitor units (MUs). It was observed that the doses in DVHs, the mean and max doses of spinal cord, liver and contra lateral side LT kidney in cGy for all OARs are lower in IMRT technique than in 3D-CRT but MUs are higher in IMRT technique and compared values were tabulated.

**Discussion:** IMRT plan substantially gave more conformal dose to the target and structures like liver, spinal cord, contra lateral side LT kidney received lower doses. 3D-CRT is forward planning which mostly depends on geometric relationship between the tumor and nearby sensitive structures. IMRT is Inverse planning and is less dependent on the geometric parameters but more on specification of volumes of tumor targets & sensitive structures, as well as their dose constraints.

**Conclusion:** IMRT plan was more efficient than 3D-CRT in Wilms Tumor in terms of dose distribution and OARs sparing.

**PP-85**

**ARC PLANNING METHODOLOGIES FOR STEREOTACTIC RADIOSURGERY OF SCHWANNOMAS: A DOSIMETRIC COMPARATIVE STUDY**

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**Purpose:** Stereotactic Radiosurgery (SRS) is a procedure that involves the precise three-dimensional targeting of ionizing radiation to obliterate abnormal tissues such as vascular malformations, malignant or benign tumors. We treated schwannomas like Acoustic, Trigeminal, Vestibular, Glossopharyngeal (GP) for pain relief and while preserving the functionality of the adjacent brain tissue and normal Organs at Risk (OAR). This work represents the efficiency of stereotactic radiosurgery (SRS) in the management of schwannomas by volumetric modulated arc therapy using Rapid Arc (RA) in 6MV Flattening Filter Free (FFF) beams on the Truebeam STx platform during the years 2012 to 2018.

**Materials and Methods:** We used Varian Eclipse (version 13.7) and Anisotropic Analytical Algorithm (AAA) treatment planning system (TPS) which allows planning in 6MV FFF beams for delivery on Truebeam STx linear accelerator equipped with HD 120 MLC. Brainlab Iplan (version 4.5) software allows fusion of DSA and MRI with planning CT. We evaluated 31 schwannomas (Acoustic, Vestibular, Trigeminal, Glossopharyngeal [GP]) cases from our patient population who underwent Rapid Arc SRS treatment with partial and full arcs. Each RA Plans were generated with coverage of at least 95% to PTV. Normal tissue dose was evaluated by using the parameters Normal Brain 10cc, V5, V10, V12 and V20 in the cumulative dose-volume histogram for the following structures: Brainstem, Brain, Cochlea, Chiasm and Optic Nerves. Conformity Indices (C.I) and Homogeneity Indices (H.I) are evaluated to validate the plan quality.

**Results and Discussion:** Rapid arc (VMAT) plans has PTV coverage (D95%) of average 98.68% (S.D±1.03) of prescription dose. Homogeneity of dose distribution in target volume was an average of 0.09 (S.D±0.03). The conformity index evaluated was an average 1.09 (S.D±0.03). The 10cc normal Brain received 89.47% (S.D±9.84) of the prescribed dose with Rapid arc plans. The greatest effect of RA FFF SRS Beams was the treatment delivery on time was reduced by 4 times compared with conventional conformal dynamic arc beam on time.

**Conclusion:** Linear accelerator based radiosurgery is promising treatment option for brain Schwannomas in majority of cases with reasonable adverse effect profile. Rapid Arc (VMAT) with FFF beams using partial or full arcs for the treatment of schwannomas provide improved target volume coverage, highly conformal and more homogeneous dose distribution in the PTV.

**PP-86**

**DOSEMERIC COMPARISON OF INTENSITY MODULATED RADIOTHERAPY AND VOLUMETRIC MODULATED ARC THERAPY PLANS FOR Pancreatic STEEOTACTIC BODY RADIOTHERAPY USING FILTER FREE BEAMS**

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**Introduction:** Stereotactic body radiotherapy (SBRT) delivers higher biological dosage of radiation with accuracy and precision in few fractionated treatments. SBRT plays a major role in treatment of several cancers. Pancreatic cancer is an aggressive malignancy with high mortality rates. Over the last decade, SBRT has come out as a novel treatment option in pancreatic cancer care.

**Purpose:** To compare the dosimetric differences between Intensity modulated radiotherapy (IMRT) plans and Volumetric modulated arc therapy (VMAT) plans using filter free beams for pancreatic cancer.

**Materials and Methods:** Ten patients with pancreatic cancer were selected for this retrospective study. All patients were immobilized in supine position, with arms above head using whole body Vacloc system. The CT images were acquired at 1.25 mm thickness and the CT data sets were transferred to the Eclipse treatment planning system. The gross tumor volume (GTV) was delineated by radiation oncologist and PTV is expanded by giving 3 mm margin over the GTV. The organs at risk (OAR) such as duodenum, stomach, left and right kidneys, liver and spinal cord were contoured. The prescription dose was 35 Gy in 5 fractions to PTV. IMRT plans were created with 12 equidistant beams whereas VMAT plans were generated with 2 full arcs (CW 181°-179°, CCW 179°-181°) using 6 FFF photon beams. An anisotropic analytical algorithm was used to compute the dose calculation for both the plans. The planning criteria is to achieve 95% of the target volume receives the prescription dose while all the oars were kept within the tolerance limit as per TG101. For PTV the dose volume histogram parameters
such as V95%, D98%, D2% and mean dose were analyzed. The conformity index, homogeneity index and gradient index for both the plans were evaluated. The DVH parameters such as D1%, D5% and Dmean to organs at risk were analyzed. The monitor units and treatment time delivered were compared.

**Results:** The D98% was 97.23 ±0.74% and 97.77±0.66% for IMRT and VMAT plans. The homogeneity index for IMRT was 1.17 ± 0.037 whereas it was 1.12 ± 0.036 for VMAT plans. The conformity was better in VMAT 0.99±0.03 plans than IMRT 0.93±0.29 plans. The gradient index is lesser in VMAT (4.73) than IMRT (4.96). The mean dose was higher in IMRT plan (38.39±0.75 Gy) compared to VMAT plans (37.36±0.75 Gy). The D1% and mean dose to the oar’s were similar in both techniques. The D5% of duodenum was lower in VMAT plans (18.83±8.82) than IMRT (20.51±8.05). The maximum point dose to the spinal cord was higher in IMRT (12.56±2.35Gy) compared to VMAT (11.30±2.26Gy). The D5% of the left kidney shows reduction in VMAT plans (10.1 ±4.1Gy) than IMRT (12.9±3.99Gy). The monitor units delivered for VMAT plans (2134.1±286) was lower than the IMRT plans (2214.6±509).

**Discussion and Conclusion:** The PTV coverage was almost similar in both the plans. There was a better conformity and homogeneity in VMAT plans. VMAT plans showed better gradient compared to IMRT plans. All the OAR doses were comparable for both techniques except D5% of duodenum and left kidney. VMAT plans exhibit slightly better organs at risk sparing and, lower MU’s with shorter treatment time compared to IMRT plans.

**PP-87 OUT OF FIELD DOSE MEASUREMENT AND SECOND CANCER RISK ESTIMATION IN CARCINOMA CERVIX RADIOTHERAPY-TREATMENT-PHANTOM STUDY**

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**Purpose:** To measure the scatter and leakage dose received by out of field organs while delivering the carcinoma cervix external beam and brachtherapy treatment in a humanoid phantom and to estimate the risk of second cancer (SC).

**Background:** The increasing survival rate of cervix cancer patients steadily warrants the SC risk estimation based on out of field dosimetry, since the Treatment Planning System (TPS) is not commissioned for this purpose.

**Materials and Methods:** The dose to out of field organs was measured using the LIF-100 dosimeter while delivering 3D Conformal Field in Field technique by 6 MV (Varian – Clinac 2300CD) photon beam and also during intracavitary brachtherapy treatment by Co-60 beam. Following that the Excess Absolute Risk (EAR) of SC was estimated for stomach, colon, liver, lung, breast, kidney and Excess Relative Risk (ERR) for thyroid based on BEIR VII report.

**Results:** The out of field organ dose varies with respect to distance between the organs. The organ received the highest dose with external beam and brachtherapy per fraction was colon = 11.23cGy and kidney = 23.55cGy respectively. The equivalent dose (per fraction) to nearby organs was higher for brachtherapy than external beam therapy. For the cumulative dose the highest EAR estimated was for kidney (21.3) and stomach (12.9) and the lowest for liver (0.2) per 10000 populations.

**Conclusion:** Out of field phantom dosimetry should be encouraged to provide a solid database on the estimation of radiotherapy induced cancer incidence for various treatment sites.

**PP-88 CALIBRATION OF EBT3 FILM FOR ITS USE AT I-125 ENERGIES**

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**Introduction:** Gafchromic EBT3 film is widely used for dose measurement in radiotherapy due to its higher spatial resolutions, low energy dependency, dynamic range and easy handling. This film can be used for dose evaluations up to 8 Gy in red channel and upto 40 Gy in the green channel.

**Purpose:** In the present study, EBT3 films were calibrated at 60Co and 70 kV X-ray (effective energy is 30.5 keV) which is comparable to the mean energy 28.37 keV of I-125 source. Calibration results were compared to find its use for dosimetry at I-125 energies.

**Materials and Methods:** The EBT3 film is a self-developing radiochromic film. It is composed of an active radiochromic layer of thickness 30 m, which is laminated between two 125 m matte polyester layers. Strips of EBT3 films (3 cm x 20 cm) were placed in air at the centre of 10 15 cm2 X-ray field, at 1 m distance from the focal spot. The X-ray machine was operated at 70 kV potential and 30 mA tube current. The films were irradiated to doses of 0.5, 1.0, 2.14 and 5.1 Gy. The air-kerma rate of the X-ray machine was 0.115 Gy/min at 1 m. The value of ratio of mass energy absorption coefficient water to air, 1.015 calculated at I-125 energies was used to convert air-kerma into absorbed dose to water. The films could not be irradiated for doses more than 510 cGy at 70 kV X-ray energy due to limitation on exposure time. A telecobalt unit was used to calibrate the EBT3 films. The output of machine was 1.98 Gy/min at 80.5 cm in water. The films (size 3 cm x 20 cm) were kept at depth of dose maximum in perspex phantom of size 30 x 30 x 20 cm3. Films were irradiated to doses of 0.5, 1.0, 2.14, 5.1, 9.46, 16.54 and 30 Gy using10 cm2 field size. The irradiated films were scanned using the EPSON Expression 10000 XL scanner with a resolution of 72 dpi after 24 h of irradiation. Films were scanned prior to irradiation to measure the optical density (OD) of the background image. All film pieces were scanned in the same orientation throughout scanning. Net optical density (NOD) was calculated by subtracting the OD of an unexposed film piece from the OD from exposed film. Irradiated films were analysed using ImageJ software. The data of red channel were used to determine OD. The energy response, R is the ratio of the NOD for a given dose of the 70 kV X-ray beam and the NOD for the same dose for 60Co beam.

**Results:** NOD of EBT3 Gafchromic films as a function dose to
water was compared. The value of R is 0.92 for 50 cGy dose and 0.98 for dose range of 100-510 cGy.

**Discussion and Conclusion:** The dose response is within 2% for 60Co and 70 kV X-ray for dose range of 100 - 510 cGy. The variation up to 8% was observed for dose of 50 cGy. Higher variation at lower dose may be attributed to lower sensitivity of EBT3 films. Hence, EBT3 films calibrated at 60Co energy with dose more than 50 cGy are suitable for dosimetry of I-125 sources.

**PP-89**

RADIATION SAFETY AND STRUCTURAL INTEGRITY OF THERATRON 780E MACHINE HOUSING OVER THE PERIOD OF 12 YEARS: A RETROSPECTIVE STUDY

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**Introduction:** Use of ionizing radiation in the field of medicine is well established. Cancer incidence in India is steadily increasing. While planning radiation installations, it is extremely important to ensure radiation safety of radiation worker and public at all levels. Radiation protection survey values recorded in our Department for the period of 12-years have been analyzed for radiation safety and structural shielding integrity of radiation installation.

**Purpose:** The objective of this study is to assess the radiation safety and structural stability of remodeled telegamma room housing Theratron 780E machine over the span of 12-years.

**Materials and Methods:** A Theratron 765 telegamma machine having a maximum source capacity of cobalt-60 of 333 TBq/9000Ci was installed in March 1977 and decommissioned in 2004. Theratron 765 is designed to treat at a source to axis distance (SAD) of 65 cm and maximum field size at 65 cm SAD is 30 x 30 cm2. In Theratron 780E machine, maximum source capacity of cobalt-60 of 444TBq/12000Ci and designed to treat at a SAD of 80 cm and maximum filed size at 80 cm SAD is 35 x 35 cm2. Almost thirty year old existing telegamma room has been remodeled/modified to house Theratron 780E machine. The existing structure has been studied and inspected extensively by the various agencies before modification of the old room. Concrete core has been taken from existing old walls as well as roof slab to investigate and determine the (a) compressive strength (b) density (c) condition of embedded reinforced steel (d) corrosion potential from carbonation test (e) general assessment on the concrete density. After ensuring structural stability and performance warranty from architect and structural designer, a modified layout plan to house Theratron 780E has been prepared and duly approved by the competent authority of India. Theratron 780E unit was installed and commissioned for patient treatment on 8th August 2005 after obtaining approval. Radiation protection survey has been carried out on Theratron 780 E at regular intervals as per regulatory guidelines using calibrated digital advanced radiation survey meter model ASM-900 with GM probe. The measured values were recorded for (a) Head leakage of telecobalt when source is in OFF position (b) Radiation survey of telegamma installation. The measured and recorded values from 2006 to 2018 have been taken for our study to evaluate and assess radiation safety and structural integrity. We have also measured exposure levels at 5 m and 10 m away from the radiation installation to check stray radiation. The observed exposure levels are not exceeding background levels in these areas.

**Results and Discussion:** The radiation surveillance tests have been done as per RPAD/Telecobalt/QA/2006 protocol. It has been observed that the measured average exposure rate at 5 cm from the surface of source head varies from 10.88 µSv/hr to 27.4 µSv/hr. The average exposure rate at 1 m from the source of head varies from 1.73 µSv/hr to 5.74 µSv/hr. The average exposure rate measured for shielding adequacy of primary barrier varies from 0.286 µSv/hr to 3.19 µSv/hr. The average exposure rates measured for shielding adequacy of secondary barriers at various locations were well within the limits prescribed by the competent authority.

**Conclusion:** From this retrospective study, we conclude that the modified structural shielding designed to house Theratron 780 E machine is adequate. There are no notable radiation exposure levels due to stray radiation in the vicinity of telegamma installation. Theratron 780 E is very safe to use for patients treatment.

**PP-90**

IS NON COPLANAR BEAM BENEFICIAL FOR SPINE STEREOTACTIC RADIOSURGERY?

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**Introduction:** Nearly 40% of cancer patients develop spine metastases resulting in poor quality of life. There are several treatment options for spine metastases like surgery, augmentation and radiotherapy. Stereotactic Radiosurgery (SRS) to spine lesion is an emerging technique delivering high radiation dose in single fraction.

**Purpose:** The purpose of our study is to compare the dosimetric differences in treatment plan between three techniques: Cyberknife (CK), Volumetric Modulated Arc Therapy (VMAT), and Helical Tomotherapy (HT) and analyse whether non coplanar beams are beneficial for spine SRS.

**Materials and Methods:** 8 CT data sets of slice thickness 1.25 mm with single spine lesions from C3 to L4 level were included in this study. A total of 24 plans were generated for the three comparison techniques: CK, VMAT and HT. The contouring and optimization objectives were based on RTOG0631 protocol. Spinal cord, cauda equina, esophagus, blood vessels, intestines, kidneys, were contoured depending on the location of PTV. All plans were prescribed to dose of 18 Gy in 1 fraction. The major priority was given to achieve adequate dose coverage to PTV while limiting maximum dose (0.035cc) to cord to ≤ 14 Gy and cauda equina to ≤ 16 Gy. The CK plans were created in Multiplan treatment planning system (TPS) using two or three fixed collimators. HT plans were optimized using the VoLo TPS. Beam width 1 cm, pitch...
Abstracts

The PMMA material was used for the quality control of the absorbed dose management in the telecobalt and linear accelerator. Quality assurance (QA) in radiotherapy is all procedures that ensure consistency of the medical prescription and safe fulfillment of that prescription, as regards the dose to the target volume, together with minimal dose to normal tissue, minimal exposure of personnel and adequate patient monitoring aimed at determining the end result of the treatment. It is recommended that quality assurance (QA) of the beam energy of radiotherapy treatment machines is carried out at regular intervals, daily, weekly and monthly to deliver proper treatment.

**Purpose:** The main purpose of this study was to assess the long-term dosimetric reproducibility and accuracy of the Indian made 1D water phantom.

**Materials and Methods:** The PMMA material was used to fabricate the Indian made 1D water phantom and the dimension of the 1D phantom is 30 cm $\times$ 30 cm $\times$ 30 cm. The all side walls are nominal to 1 cm thick. The clear water phantom provides extra visibility of the light field and facilitates its leveling and setup by using the treatment machine’s patient positioning lasers. The water phantom consists of a manually controlled, precision probe positioning mechanism mounted on the wall of the phantom and fabricated as per the recommendation of TRS-398. Counter meter used to display the chamber position during the movement. It also has the water draining provision with ON/OFF tap. It also has the provision to fit the Farmer type chamber and also for the parallel plate chamber for all type of dosimeters. Chamber holder also fabricated with same PMMA material. The water phantom was fabricated as for recommended by ESTRO BOOKLET – 3. The reproducibility and accuracy of the 1D water phantom was measured mechanically using the standard scale with the counter meter of the 1D water phantom. The counter meter readings of 1D water phantom such as 1, 2, 3, 4, 5, 10, 15, 20 and 25 cm were compared with standard scale reading. Similarly, dosimetric output, PDD reproducibility of water phantom was carried out in clinac iX. The irradiation was carried out for 6MV and 15MV photon beams as well as 6, 9, 12, 15MeV electron beams. The Indian made 1D water phantom is kept on the treatment couch and alignment done with laser light, such that the beam should normally incident on the phantom surface plane, also central axis of the beam should pass through the sensitive region of the chamber. Initially the chamber was irradiated for different depth such as 1, 2, 3, 4, 5, 10, 15, 20 and 25 cm. The same measurement was repeated for year with the interval of month.

**Results and Discussion:** The mechanical and dosimetric reproducibility and accuracy of Indian made 1D water phantom was working satisfactory. The result of the study was forward and backward movement of the counter meter and scale found $\pm$ 0.1 mm for year. The dosimetrically results was in agreement when compared with 3D RFA measurements.

**Conclusion:** From the dosimetric measurements performed Indian made 1D phantom and the results compared with 3D RFA, it was evident that the long term dosimetric and mechanical reproducibility looks good and within the recommended limit. The phantom setup time is less than 5 minute. So, the Indian made 1D water phantom can be used for regular radiotherapy output measurement, PDD and QA programs.
EFFECT OF COLLIMATOR ANGLE IN SPINE STEREOTACTIC BODY RADIATION THERAPY-PLANNING STUDY AND DOSIMETRY VERIFICATION

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Introduction: Stereotactic body radiation therapy (SBRT) is an EBRT method that very precisely delivers a high dose of radiation to an extra cranial target. SBRT is highly effective in early stage primary and Oligometastatic tumors at locations throughout the abdominopelvic and thoracic cavities, and spinal and paraspinal sites. SBRT varies from conventional RT is the delivery of large doses in a few fractions, which results in a high BED. In order to minimize the normal tissue toxicity, conformation of high doses to the target and rapid fall-off doses away from the target is critical.

Purpose: IMRT or VMAT is required to create concave dose distributions. Due to the advancement of Technology VMAT delivers more faster Treatment. The cylindrical symmetry of vertebrae favors the use of volumetric modulated therapy in generating a dose “hole” donut shape on the center of the vertebrae limiting the dose to the spinal cord. we have studied the improvement of plan quality and deliverability with respect to collimator angle.

Materials and Methods: Ten patients with single vertebral mets were included in the study. Planning CT was acquired with 1.25 mm slice thickness in GE Discovery imaging system. Target Volume (TV) and OAR Contouring was done as per ISRC & RTOG 0631 protocol. Two Dose Prescription protocols were followed (TV to Spinal Cord (SC) Distance <3 mm - 24Gy in 3#, TV- SC Distance more than 3 mm 16Gy in single Fraction). Treatment planning system- Eclipse 13.7 was used for Planning. 6MV-FFF beams with 5 mm Agility MLC were used for all plans. Four Plans were generated with 4 Collimator angle combinations of 0-180 (C0), 30-330 (C30), 60-300 (C60) & 90-270 (C90) with two arcs. High Resolution Grid lines i.e 1.25 mm kept for Optimization and Calculation. Photon Optimizer (PO) algorithm for Optimization and Anisotropic Analytical Algorithm (AAA) for calculation was used. All the Plans were normalized to cover 95% of TV to 100% Dose. Gamma analysis were made to check the deliverability of plans.

Results: In all the plans, the Dmin, Dmax and Dmean were found to be relatively similar and irrespective of the prescription doses (either 24 Gy/3# or 16 Gy/1#). Conformity index (CI) for each collimator combinations such as C0-180, C30-330, C60-300 and C90-270 were found to have a value 1.3, 1.1, 1.1 and 1.2 respectively. Marginal increase in CI observed in the C0-180 and C90-270 combinations could be due to cumulative low dose contributions from the overlapping interleaf leakages in all opposing gantry projections. Identical gradient indices (GI) and OAR (heart, liver and kidneys) doses observed among all the collimator combinations showed that the dose fall-off outside the target was not dependent on collimator angles. However, important finding in our study is that the C0 and C90 combinations resulted in increased SC dose of about 10% in comparison with C30 and C60 combinations. Gross difference in total MU was also observed between the four collimator settings, the C90 combination was found to have the lowest value. For all the four collimator combinations, more than 95% dose voxels were passing the standard gamma criteria (3%/3 mm DD and DTA).

Discussion and Conclusion: Selection of optimum collimator combination is essential in SBRT of spine mets thereby reducing the maximum dose to spinal canal and limits the total MU required to deliver the prescription dose. Further investigation on the various collimator combinations with large sample size yields statistical significance of the same.

PP-93

A NOVEL COUCH BASED THREE DIMENSIONAL TREATMENT TECHNIQUE FOR TOTAL BODY IRRADIATION

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Aim: Purpose of this study is to dosimetrically evaluate the novel and simple couch based three-dimensional treatment technique for Total Body Irradiation (TBI).

Materials and Methods: Patient immobilised on a vacuum cushion. Whole body computed Tomotherapy images acquired in head first supine position at 5 mm slice thickness. Care was taken to strap the scrotum towards the anterior body surface. Target delineated by shrinking the skin by 2 mm. Treatment plan generated on CMS XiO planning system using 4 MV photon beam from Elekta Infinity linear accelerator. A 90% of the planning target volume (PTV) prescribed (Rx) to 90% (of 12Gy) over 6 fractions in 3 days. Since the dimension of the target is more than the maximum field size, we adapted 4 adjacent fields with extended SSD (135 cm). Junctions were matched using feathering technique. Boost fields added to compensate the deficit dose in the brain and chest region. Bilateral lungs were partially shielded to reduce the toxicity. Target and organ at risk (OAR) doses found acceptable.

Results and Discussion: PTV D90% is 1156cGy (96% of Rx) and PTV Dmean is 1242cGy (103.5% of Rx). As a result of partial lung shielding mean lung are 964cGy & 948cGy for right and left lung. For rest of the critical structures the mean dose ranging from 1165cGy, 1285cGy. Junction doses were achieved between 93% and 112% of the Rx dose. Most of the high dose areas found in the perineum, the area between the arms. This is due to missing tissue and the air gap in and around the target volume. Optical shadows of the anterior fields are used to cross verify the junction on the patient surface. The dose distribution was considerably uniform over the entire target volume.

Conclusion: Dosimetric evaluations shows that, this technique provide adequate target coverage and acceptable OAR doses. Three dimensional planning improves the geometric accuracy and enhance the confidence in treatment.
Abstracts

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COMPARISON OF POINT DOSE VERIFICATION AND PORTAL DOSIMETRY FOR HEAD AND NECK INTENSITY MODULATED RADIOThERAPY PLANS

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Introduction: Intensity Modulated Radiotherapy (IMRT) can deliver optimal prescribed dose distribution to the target volumes, while reducing doses to normal tissues. The planning process of IMRT is having complex planning and delivering mechanisms and needs accuracy in dose planning and delivery. Errors can lead higher doses to critical organs lying close to the targets. So, advanced radiotherapy demands a high level of quality control of machine and treatment delivery. There are two different way of performing IMRT specific Quality Assurance (QA) - Point dose verification and Absolute and fluence verification using gamma analysis. 

Purpose: Purpose of this study is to compare the deviations in results between point dose verification and area gamma values of portal dosimetry in Head and Neck IMRT plans.

Materials and Methods: Ten Head and Neck IMRT plan were taken each being treated with 7 Fields. QA was done for all plans by point dose verification and portal dosimetry methods in Varian True Beam (version 2.6) Machine. Point dose Measurement - RW3 slab Phantom aligned for 95.0 cm Source to Skin Distance with 0.13cc chamber at the depth of 5.0 cm and connected to dose 1 electrometer. Meter reading (in nC) where taken for every individual field in all 10 IMRT plans. Meter readings were converted to cGy unit to compare with Treatment Planning System (TPS- Eclipse 13.6 version) calculated value. Portal dosimetry - Mega Voltage Electronic Portal Imaging Device is aligned at 105 cm Source to Imager Distance. All the portal dosimetry verification plans were performed for every same individual field. Absolute values are converted to Portal Calibration Unit (CU) to compare with predicted portal dosimetry results. The tolerance of area gamma is 3.0% and Distance To Agreement 3.0 mm.

Results: Point dose measurement: Cumulative TPS Calculated/cumulative point dose measurement values for 10 IMRT plans are 2.298Gy/2.26Gy, 1.467Gy/1.504Gy, 2.269Gy/2.286Gy, 1.315Gy/1.351Gy, 2.093Gy/2.096Gy, 1.816Gy/1.807Gy, 1.181Gy/1.203Gy, 2.141Gy/1.159Gy, 1.259Gy/1.250Gy, and 2.142Gy/2.145Gy. The percentage deviation between cumulative TPS calculated and cumulative point dose measured values are 1.6%, 2.52%, 0.1%, 2.7%, 0.1%, 0.49%, 1.81%, 4.5%, 0.7% and 0.1% respectively. Portal Verification - Area gamma analysis values of 10 IMRT Plans are 98.1%, 99.3%, 99.0%, 99.1%, 99.7%, 99.3%, 98.1%, 97.9%, 99.0% and 99.0%. The deviation from TPS calculated values are 1.9%, 0.7%, 1.0%, 0.9%, 0.3%, 0.7%, 1.9%, 2.1%, 1.0% and 1.0% respectively.

Discussion: Point dose verification shows less than 3.0% deviation in 9 IMRT plans and portal dosimetry shows more than 98% area gamma values in the same IMRT plans. The deviation between portal dosimetry and point dose verification is negligible in 7 IMRT plans and deviation of 2% in other two IMRT plans. Only one plan had point dose verification of 4.5% deviation though area gamma value was 97.9%. The reason for failing point dose verification in one plan is due to larger field size.

Conclusion: The Area gamma values of the portal dosimetry were comparable to the point dose verification values for head and neck IMRT Plans. Thus, both the verification method can be used for patient specific QA.

PP-95

IMPROVED ARTEFACT REDUCTION IN OPTICAL COMPUTED TOMOGRAPHY BASED BRACHYTHERAPY GEL DOSIMETRY USING A DUAL CATHETER SYSTEM

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Introduction: Three-dimensional (3D) dosimetry has become easily accessible due to the development of radiochromic gel dosimeters and optical computed tomography (CT) scanners. These dosimeters have been used widely for external beam radiation therapy (EBRT), but use for high dose rate (HDR) brachytherapy has been limited. One reason for the limited use of radiochromic gels within HDR brachytherapy is the streak artifacts produced by the catheters during the CT reconstruction process by standard Feldkamp-Davis-Kress (FDK) reconstruction algorithms. In our previous work we presented a modified iterative algebraic Ordered Subsets Convex reconstruction algorithm with Total Variation minimization regularization and ray rejection (OSC-TVRR). While this work showed promising results with artifact removal in volumes from gels with catheters inserted irradiated via EBRT, results from HDR brachytherapy irradiations were difficult to obtain. When attempting to deliver HDR irradiations it was found that the limited length of catheter protruding from the gel would cause the catheters to be perturbed when connecting them to a HDR after loader, limiting the accuracy of the method.

Purpose: This work aimed to develop an improved catheter insertion technique for radiochromic gels to allow for easier connection of the HDR afterloader to the catheters. Doing so would allow for reliable accurate 3D dosimetry for HDR brachytherapy.

Materials and Methods: The radiochromic gels used for this work were leuco crystal violet (LCV) micelle gels prepared according to the recipe by Babic et al. in 1 L vessels. The OncoSmart Comfort Catheter System (Elekta Ltd., Stockholm, Sweden) was used within the gels. The OncoSmart system consisted of an outer catheter that was suspended within the gels as they set and trimmed to fit within the gel vessels, and an inner catheter that could be connected to the after loader and inserted into the outer catheter during irradiation. The gels were scanned using a Phillips Brilliance Big Bore CT scanner (Philips Medical Systems, Cleveland, OH) and the x-ray CT scans were imported into the Oncentra Brachytherapy treatment planning system (TPS) (Elekta Ltd., Stockholm, Sweden) for catheter tracking and treatment planning. The planned treatments were then delivered with a Flexitron.
remote afterloader with a Flexisource Ir192 source (Elekta Ltd., Stockholm, Sweden). The gels were scanned with optical CT with the Vista 15 scanner (Modus Medical Devices Inc., London, ON) both before and after irradiation, and then a change in optical attenuation ($\Delta \mu$) volume was reconstructed using an inhouse implementation of the OSC-TV algorithm both with ray rejection (OSC-TVRR). The reconstructed $\Delta \mu$ volumes were then calibrated and registered to expected dose volumes exported from the TPS for comparison according to the methods given by Alexander et al. [3].

**Results:** The use of the OncoSmart catheter system was shown to provide an easy method to delivery HDR brachytherapy irradiations to radiochromic gels, with a 100% delivery success rate compared to a 50% success rate with previous methods. The comparison of the reconstructed dose volumes with the OSC-TVRR algorithm showed removal of the streak artifacts found in volumes reconstructed by the FDK algorithm and close agreement with the expected dose volumes from the TPS.

**Conclusion:** The work demonstrated that using the OncoSmart catheter system provided an improved method for performing HDR brachytherapy radiochromic gel dosimetry. By combining this method with optical CT read-out and the OSC-TVRR reconstruction algorithm, cost effective, reliable, and accurate 3D dosimetry for HDR brachytherapy is now possible.

**References**

1. Babic S, Battista J, Jordan K. Radiochromic leuко dye micelle hydrogels: II. Low diffusion rate leuco crystal violet gel. Phys Med Biol 2009;54:6791-808.

2. Alexander KM, et al. Biomed Phys Eng Express 2018;4:045041.

**PP-97**

A DOSTIMETRIC ANALYSIS OF RADIATION DOSE TO NORMAL STRUCTURES IN HEAD AND NECK CANCERS TREATED WITH THREE-DIMENSIONAL CONFORMAL RADIOTHERAPY AND INTENSITY MODULATED RADIOTHERAPY

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**Objective:** A retrospective dosimetric analysis of individual Central Nervous System (CNS) structures like posterior fossa (cerebellum), brainstem and spinal cord was performed and the results were compared for 3DCRT and IMRT treatment plans.

**Materials and Methods:** The posterior fossa (PF), brainstem (BS) and spinal cord (SC) were delineated for 20 head and neck cancer patients treated with 3DCRT or IMRT. Alternate treatment plan was generated for all patients and summary statistics and dose-volume atlases were reviewed for dosimetric parameters like GTV95%, CTV95%, PTV95%, GTV Hi, CI and Maximum dose and Mean dose for CNS structures and compared.

**Results:** An increase in maximum and mean doses to posterior fossa, brainstem and spinal cord was observed for IMRT plans compared to 3DCRT plans. Dmax for PF and BS ranged between 3.1 and 42.62 Gy and 16.7 - 47.96 respectively for IMRT. Dmax for PF and BS ranged between 3.1 and 12.8 Gy and 21.34 – 44.76 respectively for 3DCRT. Median Dmean for PF is 7.886 Gy in IMRT and Median Dmean for PF is 1.13 Gy in 3DCRT plan. In aspect of spinal cord median Dmean is 41.6 Gy in IMRT plan which was found 45Gy in 3DCRT plan. Both maximum and mean doses were higher for the posterior fossa, brainstem and cerebellum for the IMRT plans and both maximum and mean doses were found higher for spinal cord in 3DCRT.

**Conclusion:** IMRT delivers higher radiation dose to CNS structures compared to 3DCRT. Dose-volume atlases of the same structures indicate that regions representing larger volumes and higher doses to each structure are consistent with a higher incidence of acute fatigue in patients treated with IMRT for head and neck squamous cell carcinoma during phase III parotid sparing radiotherapy trial PARSPORT. So this needs further prospective studies correlating the clinical effects (fatigue) with the dose to CNS structures.

**PP-98**

VALIDATION OF RAPID ARC DELIVERY SYSTEM USING A VOLUMETRIC PHANTOM AS PER TASK GROUP REPORT 119 OF AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE

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**Introduction:** RapidArc (RA) is one of the most sophisticated technologies available in radiotherapy departments worldwide. It more precisely targets a cancerous tumor while
Abstracts

The Immobilization devices used in radiotherapy require careful planning and delivery to ensure accurate treatment. In the RA technique, optimal dose distribution with efficient treatment delivery can be achieved with the interplay of various modulation parameters such as dose rate, gantry rotation speed, multi-leaf collimator (MLC) movement, and number of control points. However, owing to physical limitations of the hardware operation and misalignment between dosimetric and mechanical components of the linear accelerator, dose discrepancies can occur in the radiation beam delivery. Thus, it is desirable to employ appropriate and extensive quality assurance at the RA planning and delivery level, because errors at these stages may alter treatment outcomes. However, it is tedious and laborious to perform RA quality assurance at an individual level because of the various complex parameters involved.

**Purpose:** This study validated RA delivery using a volumetric ArcCHECK phantom as per the guidelines proposed in the TG 119 report. This study also investigated the impact of the AXB algorithm on RA plan dose calculations in the homogeneous medium of an ArcCHECK phantom.

**Materials and Methods:** A filtered beam (FB) of 6 MV from the Clinac-iX linac machine and, a filtered beam (FB) and flattening filter-free beam (FFF) 6MV from the TrueBeam-STx were used for planning purposes. The dose rates were 600 MU (6MV_FB) and 1200 MU (6MV_FFFB) per minute, respectively. Eclipse TPS and Aria version 11 (Varian Medical System, Palo Alto, USA) was used for RA planning and for record and verification. Gamma criteria of 3 mm distance-to-agreement (DTA) and 3% dose difference (DD) were used for evaluation of RA plans, with a threshold value 10%. A gamma passing rate of at least 90% and absolute dose +5% was considered as acceptable.

**Discussion:** Treatment planning benchmark is necessary to investigate planning ability and to facilitate a review of the accuracy of treatment planning systems under relevant conditions. This may reveal the unidentified errors of local treatment and delivery system which leads to improve in treatment delivery. Thus, it is desirable to employ appropriate and extensive quality assurance at the RA planning and delivery level, because errors at these stages may alter treatment outcomes. However, it is tedious and laborious to perform RA quality assurance at an individual level because of the various complex parameters involved.

**Conclusion:** The AAPM TG 119 test cases were successfully applied on an ArcCHECK phantom. This phantom has been proven to be an easy, quick, and reliable system for RA delivery verification following the TG119 recommendations. The AXB has the potential to perform dose calculations comparable to the AAA for RA plans in the homogeneous medium of the ArcCHECK phantom. Therefore, the AAPM TG 119 report can be used as an effective tool for the quick evaluation of RA planning and delivery systems.

**Introduction:** Radiotherapy treatment demands high precision in patient set up for reproducibility. To achieve this, various immobilization devices are used. Ideally, an immobilization device should have 0% attenuation, which is not practically possible. So, the tolerance for attenuation is less than 3%.

**Purpose:** Purpose of this study is to measure the attenuation of various immobilization devices used in radiotherapy.

**Materials and Methods:** The Immobilization devices used for measurement of attenuation were 3 Carbon fiber and 3 Perspex Head and Neck base plates, 2 Perspex pelvic base plates, 6 neck rest, 2 indexer bars, 3 Thermoplastic cast and Vacloc supplied by different vendors along with indigenously prepared devices. All the measurements were performed on Varian TrueBeam Linear Accelerator (version 2.5). RW3 Slab phantom (Water equivalent) size 30 x 30 x 20 cm3 used with 0.65 cc farmer ionization chamber and Dose 1 Electrometer. RW3 Slab Phantom was aligned for 10 x 10 cm2 field size at SSD 100 cm. 0.65CC Farmer chamber placed at 10 cm depth in slab phantom. This setup was exposed with 500 MU’s of 6MV Photon beam for warm up. Meter readings were taken for 100MU’s in nC unit. All the above-mentioned immobilization devices were introduced one by one on the slab phantom and the respective meter readings were noted in the nC. Percentage of the attenuation was calculated using the following formula: Percentage of Attenuation = [(Measured Value-Calculated Value)/Calculated Value] × 100.

**Results:** The Percentage attenuation of different immobilization devices are -3 carbon fiber (2.21%, 1.54% and 0.88%), 3 head and neck Perspex base plate (6.5%, 5.15% and 5.0%) 2 Perspex pelvic base plates (5.0% and 4.78%) 6 neck rests (0.29%, 0.66%, 0.37%, 0.37%, 0.66% and 3.75%) 2 indexer bars (8.38% and 5.0%) 3 Thermoplasticcast (2.13%, 0.81% and 0.81%) and Vacloc (1.47%).

**Discussion:** Carbon fiber materials, Thermoplastic cast and Vacloc attenuation was within the tolerance limits. Out of 6 Neck rests 5 had attenuation within in tolerance limits. The sixth neck rest had attenuation of 3.75%, the reason being seemed to be made of high density material (Probably Car-cushion material). Indexer bar attenuation is more than 5.0% but it will not affect our treatment, since it is placed outside the irradiated area. The Perspex base plates for head neck and Pelvis shows higher attenuation which will affect the quality of treatment delivery. Therefore, attenuation factors in MU Calculation and assigning HU Values for immobilization contours should be considered which will improve our quality of treatment delivery.

**Conclusion:** Attenuation factors should be measured for all immobilization devices to verify for tolerance limits and be utilized in dose calculations.
REDUCING THE CARDIAC AND PULMONARY DOSE WITH DEEP INSPIRATION BREATH HOLD TECHNIQUE AS COMPARED WITH FREE BREATHE FOR LEFT-SIDED BREAST CANCER RADIOThERAPY Treatment

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Aim: The purpose of this dosimetric study was to find a suitable treatment & planning technique, which can serve as an optimized technique with respect to PTV coverage and better sparing of concerned OAR’s.

Introduction: Referring to the previously available literature of DIBH studies, it is clearly showed that DIBH has an advantage over FB in case of left-sided breast cancer radiotherapy treatment in terms of reduced risk of cardiovascular-related morbidity and mortality. DIBH is now a well-established technique in case of left-sided breast cancer radiotherapy treatment. This dosimetric study explores the benefit of using a suitable treatment & planning technique in case of left-sided breast cancer radiotherapy treatment.

Materials and Methods: In this study, we have taken 10 patients of left-sided breast cancer (7 MRM + 3 BCS) treated with DIBH technique at our Centre. The Varian’s RPM respiratory gating system (Varian Medical System, Palo Alto, CA) was used for respiratory motion monitoring. All patients were coached for three to four days for obtaining the desired respiratory breathing cycle. Once the patient was coached successfully, CT scans were acquired, one with conventional free breath (FB) and also three random scans with deep inspiration breath hold (DIBH) i.e., gated CT scans on SOMATOM Sensation Open CT simulator machine (Siemens Medical System’s). On importing the acquired CT images in TPS, it showed that left lung volume increment in DIBH technique as compared to FB was significant. Patient contouring and treatment planning performed on Eclipse V13.5 and a dosimetric comparison was made between two treatment & planning techniques i.e., (DIBH VS FB) for (3DCRT VS IMRT) and it is for PTV coverage, left lung, heart, left anterior descending coronary artery (LAD), left ventricle and contralateral breast.

Results: Left lung volume increment in DIBH technique as compared to FB was 69.375% showed that there was a significant increment in left lung volume, which results in a larger separation of heart and the PTV chest wall. FB Case: Dose Volume Histogram (DVH) analysis of 3DCRT VS IMRT plans for PTV coverage found that PTV coverage of V95% (95.37% vs 99.61%), for left lung’s V20Gy (14.17% vs 33.3%), for heart mean dose Dmean (3.93 Gy vs 12.8 Gy), for LAD max dose Dmax (46.75 Gy vs 38.96 Gy), for Left ventricle max dose Dmax (46 Gy vs 41.16 Gy), and for contralateral breast V4Gy were (0.5455% vs 11.912%).

DIBH Case: Dose Volume Histogram (DVH) analysis of 3DCRT VS IMRT plans for PTV coverage found that PTV coverage of V95% (95.37% vs 99.206%), for left lung’s V20Gy (14.98% vs 24.44%), for heart mean dose Dmean (2.635 Gy vs 9.455 Gy), for LAD max dose Dmax (37.124 Gy vs 33.499 Gy), for Left ventricle max dose Dmax (36.746 Gy vs 28.336 Gy), and for contralateral breast V4Gy were (0.5455% vs 11.912%).

Conclusions: This dosimetric study showed that IMRT has better PTV coverage and LAD, left ventricle sparing, but on the other hand more doses to left lung, heart and contralateral breast as compared to 3DCRT technique. DVH evaluation concluded that 3DCRT plans have been a preferable technique in case of left-sided breast cancer radiotherapy treatment, as PTV coverage was adequate in both the techniques and left lung, heart, contralateral breast doses were lesser in case of 3DCRT plans, although relatively little higher doses to the LAD and left ventricle. On comparing FB and DIBH techniques, DIBH is showing drastically dose reduction for left lung, heart C/L breast, LAD and left ventricle. From the data of DIBH and FB, we can conclude that DIBH technique in many respects has an advantage over FB, which is solving the purpose of reducing cardiac and pulmonary doses without compromising the PTV coverage.

IMPACT OF DYNAMIC JAW TRACKING TECHNIQUE DURING FLATTENING FILTER FREE BASED VOLUMETRIC MODULATED ARC THERAPY - STEREOTACTIC RADIATION THERAPY DELIVERY – A RETROSPECTIVE DOSIMETRIC STUDY

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Introduction: Volumetric Modulated Arc Therapy (VMAT) delivery technique has proven its capability in sparing critical and normal tissues when administering small volume target plans especially in sites like Brain with multiple metastatic cancers. VMAT with Flattening Filter Free (FFF) using high dose rate Stereotactic Radiation Therapy (SRT) became a standard treatment approach in multiple brain metastasis treatment & planning technique, which can serve as an optimized technique with respect to PTV coverage and better sparing of concerned OAR’s.

Materials and Methods: Five previously treated Multiple Brain Metastatic patients were taken up for this retrospective dosimetric study in giving 20 Gy in a single fraction to the multiple targets. SRT- VMAT plans (6 MV FFF - Dose rate 1400 MU/min) were generated using ECLIPSE Treatment Planning Systems (TPS), ver 13.0 (M/S Varian Medical Systems, Palo Alto, USA) with Dynamic Jaw tracking (DJT) and as well as with fixed jaw (FJ) technique by keeping the same constraints and priorities for a particular patient. Target conformity and normal Brain dose volumes (V12Gy, V10Gy and V5Gy) were evaluated. Verification phantom plans are created with 4D Octavius phantom equipped with 729 array of chambers and Prediction Dosimetry (Varian). True Beam Linac (Varian
Medical Systems, Palo Alto, USA) equipped with 120 Millenium MLC, capable of jaw tracking technique delivered the verification plans. All patient QA plans are evaluated using PTW Verisoft Software Ver 4.0 and Varian Portal Dosimetry Software (aSi-1200 DMI EPID Systems).

**Results:** TPS Generated VMAT-SRT plans are compared using plan evaluation portal in Eclipse TPS, shows surprisingly with lesser Monitor Units(MU) in DJT when compared with FJ but not significant. For the study group with similar target coverage, averaged V12 Gy showed hardly any variation. Averaged V10 Gy and V5Gy for DJT plans was 2.5% and 3.5% lesser than FJ plans respectively. 4D Octavius Phantom measured results ranged from 97% till 99% gamma pass for 3% and 3mm Distance to Agreement (DTA) for the study group. Its Excellency in evaluating multplanar dose distribution , 4D volume analysis gamma pass results provided an additional confident of delivering the DJT technique with high dose rate FFF plans. Portal dosimetry system plan verification also showed gamma pass 99% for DD 3%, DTA 3mm.

**Conclusion:** In DJT, the jaws can move at the maximum speed of 2.5 cm/s, during the VMAT dose delivery as close as possible to the MLC aperture, minimizing the leakage and transmission through the MLC. This was evident and observed in our planning comparison study.

**PP-102**

**OPTIMAL FIELD MARGIN FOR PANCREAS STEREOTACTIC BODY RADIOTHERAPY USING FLATTENING FILTER FREE PHOTON BEAMS**

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**Introduction:** As high precision stereotactic body radiotherapy (SBRT) uses higher dose per fraction, high degree of conformity and dose gradient are essential. The conformity and dose fall-off into the normal tissues are mostly influenced by the beam margin around the target volume. Further, the choice of beam margin is important to reduce maximum high dose to nearby critical organ as well as to reduce low dose spread in order to avoid the development of secondary cancer.

**Objectives:** To find optimal multileaf collimator (MLC) beam margin for VMAT based SBRT treatment using high intensity FFF beam for pancreas cancer.

**Materials and Methods:** VMAT based SBRT treatment plans were generated for 10 pancreas patients using 10X-FFF of Truebeam STx linear accelerator (Varian medical systems, USA), modeled in Eclipse Treatment Planning System (Version13.6). For each patient, SBRT plans with different MLC margin to PTV viz. -2, -1, 0, 1, 2 mm were generated. 35 Gy in 5 fractions (7Gy per fraction) was delivered to the target volume using 1 full arc (1790 - 1810) with collimator angle of 300. The maximum available dose rate of 2400 MU/min for 10X-FFF was used. Dose calculation was performed with Anisotropic Analytical Algorithm (AAA). All plans were normalized to 95% of target should cover 100% of dose. Comparison of plans generated has been established in terms of various dosimetric variables. ANOVA test was performed for statistical significance analysis.

**Results and Discussion:** The PTV parameters like conformity, homogeneity, gradient indices and volume receiving 110% were showed statistically similar results (p > 0.1) and better value achieved with 1, 1, -1, 0 mm respectively. Whereas, dose to 98% PTV volume (p=0.03) and MU (p<0.0001) were showed statistically significant results among plans and better coverage achieved with 0 mm. The MU was increased linearly as the margin reduced. The homogeneity and volume receiving 110% were higher with -2 mm margin plan. The organs at risk showed similar results for all plan (p> 0.9). The duodenum V10Gy, V15Gy were less in 0 mm plan.

**Conclusion:** The investigation of dosimetric performance and treatment delivery efficiency suggests that 0 mm margin to PTV for 10X-FFF is optimal for pancreas SBRT.

**PP-103**

**ANALYSIS OF THE EFFECTS OF IONIZING RADIATION ON PREGNANT WOMEN WITH REFERENCE TO ICRP-PUBLICATION-84**

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**Introduction:** Pregnant women are at risk of exposure to non-ionizing and ionizing radiation, resulting from necessary medical procedures, work place exposure and diagnostic or therapeutic interventions before the pregnancy is known. Pregnancy is most-contra-indication to radio diagnostic procedures. During these procedures, embryos usually receive less than 100 mrem during 9 months gestation. The most common effects of Ionizing Radiation on fetus in pregnant women are Malformation of organs, Microcephaly, Mentally retardation, Lower Intelligence Quotient, Leukemia and Cancer.

**Objectives:** To evaluate the various dose levels to study the effect of Ionizing Radiation on pregnant women. We also outline the precautions for pregnant women during any medical procedure using Ionizing Radiation.

**Materials and Methods:** The effects of ionizing radiations are stochastic and deterministic. Stochastic effects are those that occur without any threshold by chance and consist primarily of cancer and genetic effects. Deterministic effects have a limit and sufficiently a large dose is required. However radiation safety to pregnant women is a challenging job. In a pelvis exposure, radiation risk are most significant during organogenesis Early fetal period < 2nd trimester, least in the 3rd trimester. Threshold of 100-200mGy or higher are typically associated CNS problems/ malformations. But fetal doses of 100mGy are not reached even with 3 pelvic CT scans or 20 conventional diagnostic X-ray examinations. These levels can be reached with fluoroscopically guided interventionial procedure of the pelvis and with radiotherapy. Leukemia and cancer: Radiation has been shown to increase the risk of Leukemia and many types of cancer in Adults & children through most pregnancy, the embryo or fetus is assumed to be at about the same risk for carcinogenic effects as children. The relative risk may be as high as 1.4 (40% increase over...
normal incidence) due to a fetal dose of 10mGy. For an individual exposure in utero to 10mGy the absolute risk of cancer at ages 0-15 is about 1 excess cancer death per 1700. The probability of bearing the healthy children is as a function of radiation dose. Animal data suggest that possibility of prenatal death at 5-10 cGy. Animal and NBS data suggest this is a most sensitive stage for intrauterine growth retardation (20-25 cGy) major organogenesis NBS data indicate small head size those posed at < 8 weeks did not display intellectual deficit ever with small head most sensitive time for induction of childhood cancer. Rapid neuron development and migration (> 10 cGy) results in small head size, seizures, decline in intellect. When CT abdomen is taken, the dose will be 3000 mrem. The various fetus dose chat is presented. X-ray exam of abdomen is 250 mrem.

Conclusion: A common warning notice should be displayed in a predominant place in front of radiation room. Each one of the applications of Ionizing Radiation should be justified all women in the age group of child bearing age and should be informed about the harmful effects of the Ionizing radiation. During a standard radiotherapy protocol may be justified for a 50 year old female but the same protocol may not be justified in pregnant women of 25 years old without more consideration and perhaps modification. All pregnant women are entitled to counseling before any imaging procedure using Ionizing Radiation. They should be explained about the effects of radiation related to the effects of risks. A detailed explanation shout be provided, if the expected fetal dose exceeds 0.01 Gy. Implementations of ALARA principle will be more effectively reduce the fetal dose. Alternatively the patient can be referred to MRI scan or Ultrasonography.

Materials and Methods: For this study twelve SBRT-Lung patients were selected. The selected patient’s with Vac-Loc immobilization, routine Slow-CT was acquired and immediately thereafter using Varian Real-time Positioning Management (RPM) system with external marker, retrospective 4D-CT image were acquired in patient free breathing and both image series were acquired in 2mm slice thickness. Acquired Slow-CT images directly transferred to Eclipse (Varian) Treatment planning system V-11.0 and phased 4D-CT image series were transferred to Focal 4D to generate maximum intensity projection(MIP) image. Slow CT and MIP images from Focal 4D system were fused to delineate target volume. After the image registration two GTV volumes were contoured on Slow CT images, one GTV target volume(TVslow CT) using Slow CT images another GTV(TV4D CT) using MIP images. From the two volumes tumour motion range were analysed in all direction for every patients. The plans were generated in technique of IMRT and VMAT on slow-CT images and plan optimised for TVslow CT using 6MV FB and FFF beams. Planning goal was 95% of TVslow CT should receive prescription dose of 50Gy in 5 fraction. The plans were made using 120 HD MLC for TrueBEAM(Varian) machine, available dose rate for flatten beam and FFF beam is 600MU/Min and 1400MU/Min respectively. Dose were calculated using Acuros® XB Algorithm with grid size of 1mm, different plans were analysed dose coverage for target volume TV4D-CT.

Results: The geometrical difference of target volume on slow-CT and 4DCT images were analysed for every patient. The mean + standard deviation motion ranges were 7.8±4.2, 8.2±7.0 and 6.8±4.0mm in the Right-Left(RL), Anterior-Posterior(AP) and cranial-caudal(CC) direction respectively. In every patient plans, 95% of TVslow CT volume was receiving 50Gy dose. The Mean±S.D of D95 of TV4D CT is 36.9±14.6, 36.2±16.1,34.7±16.2 and 33.7±15.9Gy in FB-IMRT, FFF-IMRT, FB-VMAT and FFF-VMAT plans respectively. And the mean±S.D of V100 for TV4D CT is 71.7±15.5, 71.9±15.7, 70.8±14.8 and 71.0±14.5% for FB-IMRT, FFF-IMRT, FB-VMAT and FFF-VMAT plans respectively.

Discussion and Conclusion: The motion range of GTV in slow CT and 4DCT were analysed and the results were clear that lung tumor motion varies from patient to patient and not consistent it due to patients respiratory pattern varies in frequency, amplitude and waveform shape. SBRT plan results representing that if plan made on TVslow ct without referring 4DCT images, the actual GTV volume(TV4D CT) will receive dose of D95=36Gy and V100=71%. The standard uniform margin around the GTV for motion doesn’t help to cover prescribed dose due to lung motion vary patient to patient and it causes either under dose to GTV region or over dose to normal tissue. So the conclusion is SBRT-Lung treatment goal can be achieved with any techniques when tumours are delineated using 4DCT images.

PP-104

IMPACT ON DOSE COVERAGE FOR LUNG TUMOURS DUE TO GEOMETRICAL DIFFERENCES IN TARGET VOLUMES BETWEEN SLOW CT AND 4D CT IMAGING IN STEREOTACTIC BODY RADIOTherAPY

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Introduction: The outcome of radiotherapy patient’s treatment fully depends on target delineation, optimising plan and precise delivery. The Stereotactic body radiotherapy(SBRT) Lung tumour is very challenging site for radiation treatment due to respiratory motion during imaging and treatment delivery. SBRT technique for Lung tumour was started long time ago and used widely at present. This special technique helps oncologist to escalate the tumour dose with help of high precision tumour delineation using high quality images and advanced treatment delivery techniques of Intensity modulated radiation therapy(IMRT), Volumetric modulated arc therapy(VMAT) along with Flattening filter free(FFF) beam.

Purpose: Aim of our study was to quantify the geometrical differences of SBRT-Lung tumors volume in routine Slow-CT and 4D-CT imaging and how its impact on dose coverage of Gross Target Volume(GTV) when motion margin not accurately incorporated while treating advanced treatment technique.

Materials and Methods: For this study twelve SBRT-Lung patients were selected. The selected patient’s with Vac-Loc immobilization, routine Slow-CT was acquired and immediately thereafter using Varian Real-time Positioning Management (RPM) system with external marker, retrospective 4D-CT image were acquired in patient free breathing and both image series were acquired in 2mm slice thickness. Acquired Slow-CT images directly transferred to Eclipse (Varian) Treatment planning system V-11.0 and phased 4D-CT image series were transferred to Focal 4D to generate maximum intensity projection(MIP) image. Slow CT and MIP images from Focal 4D system were fused to delineate target volume. After the image registration two GTV volumes were contoured on Slow CT images, one GTV target volume(TVslow CT) using Slow CT images another GTV(TV4D CT) using MIP images. From the two volumes tumour motion range were analysed in all direction for every patients. The plans were generated in technique of IMRT and VMAT on slow-CT images and plan optimised for TVslow CT using 6MV FB and FFF beams. Planning goal was 95% of TVslow CT should receive prescription dose of 50Gy in 5 fraction. The plans were made using 120 HD MLC for TrueBEAM(Varian) machine, available dose rate for flatten beam and FFF beam is 600MU/Min and 1400MU/Min respectively. Dose were calculated using Acuros® XB Algorithm with grid size of 1mm, different plans were analysed dose coverage for target volume TV4D-CT.

Results: The geometrical difference of target volume on slow-CT and 4DCT images were analysed for every patient. The mean + standard deviation motion ranges were 7.8±4.2, 8.2±7.0 and 6.8±4.0mm in the Right-Left(RL), Anterior-Posterior(AP) and cranial-caudal(CC) direction respectively. In every patient plans, 95% of TVslow CT volume was receiving 50Gy dose. The Mean±S.D of D95 of TV4D CT is 36.9±14.6, 36.2±16.1,34.7±16.2 and 33.7±15.9Gy in FB-IMRT, FFF-IMRT, FB-VMAT and FFF-VMAT plans respectively. And the mean±S.D of V100 for TV4D CT is 71.7±15.5, 71.9±15.7, 70.8±14.8 and 71.0±14.5% for FB-IMRT, FFF-IMRT, FB-VMAT and FFF-VMAT plans respectively.

Discussion and Conclusion: The motion range of GTV in slow CT and 4DCT were analysed and the results were clear that lung tumor motion varies from patient to patient and not consistent it due to patients respiratory pattern varies in frequency, amplitude and waveform shape. SBRT plan results representing that if plan made on TVslow ct without referring 4DCT images, the actual GTV volume(TV4D CT) will receive dose of D95=36Gy and V100=71%. The standard uniform margin around the GTV for motion doesn’t help to cover prescribed dose due to lung motion vary patient to patient and it causes either under dose to GTV region or over dose to normal tissue. So the conclusion is SBRT-Lung treatment goal can be achieved with any techniques when tumours are delineated using 4DCT images.

PP-105

COMPARE THE TPR20, 10 PHANTOM BY USING WATER AND GELATIN GEL

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**Introduction:** Medical linear accelerator is critical gadget used in radiotherapy departments global. Measurement of beam exceptional of high-energy X-rays generated via a clinical linear accelerator is needed for 3 one-of-a-kind purposes, namely, (i) to confirm the stated specification of the vendor, (ii) to decide the ideal beam-pleasant–correction element for the ionization chamber and (iii) to determine the defensive thickness of the number one and secondary obstacles of the accelerator housing. Recently, some times of enormous mismatch among quoted nominal X-ray-beam power (6 MV) and measured X-ray–beam power, therein, it is essential to observe that one of the beam-exceptional signs (TPR20,10) indicated a particular fee of nominal X-ray energy at the same time as the measured dosimetry information indicated a appreciably different nominal strength. Such observations create confusion at some stage in the medical use of the accelerator, and the user will become unsure about whether to apply the dosimetry data measured regionally or to apply the standard information set available in the literature corresponding to the measured satisfactory of the X-ray beam.

**Purpose:** The present study is to show the application of the IAEA TRS-430 QA procedures of TPS for photon 6 MV energy. In addition, the trends of the deviations found in the conducted tests were determined using gelatin based TPR20, 10 phantom.

**Materials and Methods:** In high precision radiotherapy treatment 3D dose verification is very important aspect in giving a quality treatment to patients. One of the beam quality specifications is TPR20,10. This is the ratio of absorbed dose at 20 cm and 10 cm depth, in water phantom with SCD (source to chamber distance) of 100 cm and the field size of 10X10 cm2 on the plane of the chamber and with this we compare water phantom and gelatin based phantom.

**Results and Discussion:** The linear models for TPR(20,10) (s) and exponential models for PDD(10)(s) as a function of the (equivalent) square field size can reproduce the beam quality within 0.3% and beam quality correction factors within 0.05% for square field sizes ranging 10X10 cm2 and nominal photon energies from 6 MV. For higher energy beams the errors are only slightly worse but for %dd(10)(X), an additional uncertainty component has to be considered for the electron contamination correction. Based on this report, we have measured the data using TPR 20/10 gelatin based phantom and then compare above mentioned results.

**Conclusion:** The models proposed here can be used in practical recommendations for the dosimetry of small and nonstandard fields. Based on above discussion, the gelatin gel based phantom was better for 3D dose verification a quality treatment to patients.

**Introduction:** Water phantom measurement was strongly recommended for output measurement in External beam radiotherapy, an attempt was carried out to perform brachytherapy source calibration using the same phantom.

**Purpose:** The main purpose of the study was to evaluate the indigenously developed water phantom used it for both external beam measurement and air kerma strength measurement in water measurement.

**Materials and Methods:** The phantom made up of Perspex and the size 30 x 30 x 30 cm3, 0.6cc chamber holder provided at a depth of 10 cm. utilizing the same phantom and modified it for brachytherapy measurement by placing two plastic Source applicator in the phantom at 10 cm depth and 10 cm adjacent to the chamber. For External Beam output Measurement was carried out as per the protocol TRS 398 for 6 MV Photon using this phantom and compared the value with 1.00 cGy. In air measurement for air kerma strength for Ir192 and Cobalt-60 source were carried out as per the IAEA-TECDOC-1274 protocol in the same phantom and compared with corresponding air kerma strength value on that day. The same procedure was repeated for in water measurement.

**Results:** For External beam output measurement percentage variation is ± 0.2% and in air kerma strength measurement for brachytherapy the percentage variation for Ir192 source is ±0.3 % and Cobalt 60 source is ±0.8 %.

**Conclusion:** The Single unique water phantom for external beam and brachytherapy can be used for three measurements in one single Phantom. For Brachytherapy measurement in air measurement and absorbed dose to water measurement can be done and implemented in routine dosimetric measurement in Hospitals.

**PP-107**

**EVALUATION OF THE INTENSITY MODULATED RADIOTHERAPY TREATMENT PLANS COMPUTED USING PHYSICAL AND BIOLOGICAL OPTIMIZATION ALGORITHM**

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**Introduction:** The main goal of radiation therapy is to deliver adequate high dose to the tumor so that all tumor cells are killed while avoiding the radiation induced damage to the surrounding normal tissue. Radiobiological models are used in the radiobiological treatment planning to estimate the tumor control probability (TCP) and the normal tissue complication probability (NTCP). TCP-PoissonLQ model is used to estimate the TCP and two models namely NTCP-PoissonLQ and NTCP-LKB model are used for the computation of NTCP. The TCP-PoissonLQ model and the NTCP-PoissonLQ model are based on the cell survival model and the Poisson statistics. The NTCP-LKB model is based on the probate function.

**Purpose:**
1. Evaluation of the Intensity Modulated Radiotherapy Plans using physical and biological evaluation tool
2. Generation of IMRT plans using biological optimization algorithm in terms of probability for Complication Free Tumor Control, Tumor Control Probability and Normal Tissue Complication Probability

3. Comparison of IMRT plans computed using physical optimization algorithm and the same using biological optimization algorithm.

Materials and Methods:

In this study we have used the Eclipse Treatment Planning System Version 13.7 (Varian Medical Systems, Inc., USA). It uses Anisotropic Analytical calculation algorithm (AAA) with a calculation grid of 2.5 mm for dose calculation. It has both physical and biological optimization algorithms. For the generation of treatment plans and uses Dose Volume (DV) as well as Biological evaluation tools to evaluate the plans. Biological based evaluation tools are developed by the Ray Search Laboratories (Suveavagen25 111 34 Stockholm, Sweden). These patients were re-planned using Biological Evaluation tool. Secondly these same patients were re-planned using Biological based Optimization which calculates the biological parameters such as TCP and NTCP. Results were obtained in terms of possibility for complication free tumor control, Tumor Control Probability and Normal Tissue Complication Probability. The ‘t-test’ was carried out to find whether the values of P+, TCP and NTCP have significantly changed for both physical optimization and the biological optimization.

Results:

From the ‘t-test’ values it was found that the ‘p’ values obtained from the comparison for P+, TCP and NTCP were 0.001, 0.034, 0.04 respectively. Since these values are less than 0.05 we conclude that there is a significant change in the result of biological optimization when compared to that obtained from physical optimization. The average value of P+ for the Physical Optimization was 14.58 and for Biological Optimization was 32.34. Hence complication free tumor control has increased when Biological Optimization is used. The average value of TCP for the Physical Optimization was 38.18 and that for the Biological Optimization was 62.47. This shows the probability for tumor control has increased when Biological Optimization is used. The average value of NTCP for the Physical Optimization was 54.75 and the same for Biological Optimization was 46.10. Hence the probability of normal tissue complication is relatively less when Biological optimization is used.

Discussion and Conclusion:

It is evident from this study that there is a significant increase in the probability of complication free tumor control as well as Tumor Control Probability anticipated when we use the biological optimization. There is also significant decrease found in the probability of normal tissue complication while we used biological optimization. Hence it is concluded that the biological optimization is necessary to enhance the complication free tumor control while reducing the normal tissue complication.

PP-108

IN-VIVO ENTRY DOSE MEASUREMENTS FOR THE ASSESSMENT OF SCALP DOSE IN PATIENTS UNDERGOING CRANIAL IRRADIATION BY VMAT

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Objective:

To measure entry dose in the scalp region in-vivo using optically stimulated luminescent detectors (OSLDs) for patients undergoing VMAT treatment for intracranial tumors and compare it with calculated dose in the TPS.

Introduction:

Epilation (Hair loss) is a possible side effect of radiation therapy since follicles are sensitive to radiation. Hair loss may be temporary or permanent phenomenon depending on the dose received in the scalp region which may vary from patient to patient. In this context the evaluation of dose to the scalp by in-vivo measurements and comparing the measured dose with the calculated dose in TPS assume significance.

Materials and Methods:

10 patients who were treated by VMAT for intracranial tumors were considered for this study. These patients were planned by VMAT technique in MONACO TPS (Version 5.11.02). Scalp region surrounding the PTV was contoured for all these cases. The entry point which is closer to the isocenter is taken as a point of in-vivo measurement for comparison with calculated dose in TPS. These patients were treated in Elekta/Axesse Linear accelerator with 4mm MLC thickness. Aluminum oxide (Al2O3) OSLD chips were placed at the entry points marked for in-vivo dose measurements. To generate a dose response curve OSLD measurements were taken for the first five fractions of treatment. These chips were earlier irradiated with doses in the range of 20 to 1000 cGy for generating a calibration curve.

Results and Discussion:

The entry dose to the scalp region is observed to be more than 50% of the tumor dose in 8 out of 10 patients. In two patients it is less than 40% because the isocenter is at a larger depth. The measured OSLD doses were found to be in agreement with the TPS calculated doses below 8.6% in 9 out of the 10 patients and in one patient the variation was observed as 15.3%.

Conclusion:

Entry dose measurements in scalp regions for patients who are treated for intracranial tumours using VMAT technique were measured with OSLD and compared with the TPS calculated dose at the same points. The results are found to be in agreement in 90% of the cases. It was observed that OSLD is an effective tool for in-vivo Dosimetry.

PP-109

RADIATION AWARENESS AMONGST THE RADIATION PROFESSIONALS AND IMPORTANCE OF Training PROGRAMMES: EVALUATION (A PILOT STUDY)

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**Introduction:** Due to its distinctive properties and multiple uses, ionizing radiation (radiation) has found wide-spread applications in the field of medicine and healthcare. However, with an increase in the use of radiation, the probability of occurrence of radiation injuries and hazards (in case of inadvertent accidents or malpractices) also increases. Hence, proper training and education of the radiation professional is a pre-requisite for the smooth and safe functioning of a radiation department, be it therapy or diagnostics. This training, however, should not be restricted to learning the functioning of a department but must encompass the radiation protection and safety aspects. Inclusion of radiation safety with special emphasis on safe work practices and safety protocols instills confidence in the radiation professionals and reduces the anxiety and fear that surrounds radiation usage.

**Purpose:** Although the radiation workers and professionals are trained to work in radiation field, constant reassessment and updating is also required to keep them abreast with the technological and safety advances. Moreover, it is a responsibility of the RSO as per Atomic Energy Radiation Protection Rules (RPR) 2004 to periodically train the staff in radiation safety. Medical Physicists too play a significant role in spreading awareness and knowledge about radiation safety as they are the experts in the subject. Hence this training programme was organized at our institute as a pilot study to assess the status of radiation professionals, train them and highlight the importance of such training sessions in radiation safety. The impact of such programmes was assessed through evaluation questionnaires (Pre and Post). We plan to extend this study over the radiation professionals in Jaipur in the next phase and it is in progress.

**Materials and Methods:** A questionnaire comprising of 30 basic questions related to radiation protection, safety, regulatory norms and safe practices was formulated. The radiation professionals were asked to fill it to evaluate their skills and knowledge in radiation safety. They then underwent a training programme on radiation safety and were again asked to submit same questionnaire. A comparative analysis was done about their knowledge and practices and the improvement through the training programme.

**Results:** On comparing the results of pre and post questionnaires, an increase in the score was seen for almost every participant. The average score of the pilot group increased from 67% to 78%. The median score increased from 22 to 25 while the mode value of score increased from 24 (scored by 7 participants) to 26 (scored by 8 participants). Each participant showed some appreciation in the radiation safety knowledge.

**Discussion and Conclusions:** Although the radiation professionals have undergone training for radiation safety, they were found to be less confident in applying it in routine practice. A lacuna was also observed in the awareness about regulatory aspects and dose limits. The training programme showed some improvement but it threw light on the importance of regular and periodic training sessions. As an RSO or medical physicist, it is our responsibility to take on this role and disseminate knowledge about radiation safety to promote safe practices. We aim to extend this study and conduct training programmes across the various hospitals in Jaipur city. Our plan is to include not only the Radiation therapy Professionals (Radiation Oncologists & Radiation Therapists) but also the radiologists and other medical professionals who deal with radiation (Cardiologists, Orthopedics, Anesthetists, Gastroenterologists, etc. who perform interventional radiology procedures). The crux of this study is to bring focus on the role of medical physicist in radiation protection and safety.

**PP-110**

**COMPARISON OF PHANTOM AND TPS BASED DOSE DISTRIBUTION IN 3DCRT-TBI**

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**Introduction:** 3D-CRT based TBI is done with an extended SSD of 120 cm and covering the whole body in AP-PA fields within +/-10% variation in the prescribed dose while shielding the OAR with MLCs.

**Purpose:** It is important to verify the dose delivered to the patient, so the same is verified using RFA. The study involves comparing the dosimetric values in the water phantom and the tps calculated dosimetric distributions for the given field.

**Materials and Methods:** Liquid water phantom is CT scanned and the volume is contoured for planning. Extended SSD technique of 120cm is used. Planning is done through the XIO 5.1 and the whole phantom is covered with a homogenous distribution with a variation of +/-10%. 6MV Elekta compact and a PTW RFA is used to collect the dosimetric values on different depths on all the three axis.

**Results:** Manually calculated dose and the TPS calculated dose are compared on different points in the phantom using the RFA.

**Discussion and Conclusions:** A matrix of 5cm is taken in the RFA in all 3 axis and the manually calculated dose values are compared in each matrix points with the TPS calculated values. The resulting dose profile is compared with that of the TPS generated one and the results are found to be within +/-9% variation.

**PP-111**

**EVALUATION OF POSITIONAL ACCURACY OF EPID USING IMRT GRATICULE PHANTOM IN EXTENDED SOURCE TO IMAGER DISTANCE SETUPS: FORMALISM OF QA**

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**Introduction:** In this modern era of Radiotherapy the Imaging technology now plays very important role in the delivery of radiation with accuracy up to the order of millimeter. Therefore, their performance should also be evaluated in different patient settings especially in nonstandard.

**Purpose:** The aim of the present study was to evaluate the utility of IMRT graticule phantom to check the positional accuracy of EPID (amorphous silicon flat panel detector, retractable arm) and to develop a quality assurance program for geometrical verification.

**Methods:** The radiographic images of graticule phantom were acquired using computed tomography (CT) and beam...
shapes for desired dose distribution was generated using computer-based treatment planning system. A known shift of 0.5 cm, 1.0 cm and 1.5 cm were introduced in longitudinal, lateral and vertical directions, respectively w.r.t. treatment couch of medical linear accelerator. The EPID images were taken for each shift at different source to imager distance (SID) and beam orientations.

**Results:** The maximum and minimum shift between the expected and observed value in all the direction were found to be 3 mm and zero respectively. In longitudinal and vertical directions, maximum error of 2 mm was obtained for SID 179.9 cm respectively, while in lateral direction the 2 mm maximum error was obtained for imager distance 149.9 cm and 179.9 cm. However, the maximum error of 3 mm was found to be most frequent in the longitudinal and vertical directions for SID 1 respectively.

**Discussion:** The study was carried out to find the effect of sag in EPID due to gravity at extended imager distances and varying beam orientations. Rowshanfarzad et al. found that the sag in EPID was found to be 0.3 mm and 2.5 mm in cross-plane and in-plane direction. Although the large deviation was observed for in-plane as that of cross plane direction and the accepted criterion for non-stero tactic linac is 2 mm as per AAPM TG 142 report. The on-board imaging of patients suffering from different types of tumors is done at different imager distances. This is because of limitation of imaging system, location of tumor and coverage of larger target volumes. For example, the patient suffering from cervix carcinoma and having anterior posterior separation more than 30 cm, the image cannot be acquired at 140 cm. This is due to more possibility of collision between imager and the treatment couch.

**Conclusion:** The methodology used in the present study is very effective to check the mechanical characteristic and consistency of the retractable arm EPID and can be used routinely in radiotherapy units. The effect of EPID sag due to gravity was not significant for detection of shift in patient’s position.

**PP-112**

**EFFECT OF COLLIMATOR ANGLE IN SPINE STEREOTACTIC BODY RADIATION THERAPY-PLANNING STUDY AND DOSIMETRY VERIFICATION**

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**Introduction:** Stereotactic body radiation therapy (SBRT) is an EBRT method that very precisely delivers a high dose of radiation to an extra cranial target. SBRT is highly effective in early stage primary and Oligometastatic tumors at locations throughout the abdominopelvic and thoracic cavities, and spinal and paraspinal sites. SBRT varies from conventional RT is the delivery of large doses in a few fractions, which results in a high BED. In order to minimize the normal tissue toxicity, conformation of high doses to the target and rapid fall-off doses away from the target is critical.

**Purpose:** IMRT or VMAT is required to create concave dose distributions. Due to the advancement of Technology VMAT delivers more faster Treatment. The cylindrical symmetry of vertebrae favors the use of volumetric modulated are therapy in generating a dose “hole” –donut shape on the center of the vertebrae limiting the dose to the spinal cord. we have studied the improvement of plan quality and deliverability with respect to collimator angle.

**Materials and Methods:** Ten patients with single vertebral mets were included in the study. Planning CT was acquired with 1.25 mm slice thickness in GE Discovery imaging system. Target Volume(TV) and OAR Contouring was done as per ISRCC & RTOG 0631 protocol. Two Dose Prescription protocols were followed (TV to Spinal Cord (SC) Distance <3mm - 24Gy in 3#, TV- SC Distance more than 3mm 16Gy in single Fraction).Treatment Planning system- Eclipse 13.7 was used for Planning.6MV-FFF beams with 5mm Agility MLC were used for all plans. Four Plans were generated with 4 Collimator angle combinations of 0-180 (C0), 30-330 (C30), 60-300 (C60) & 90-270 (C90) with two arcs. High Resolution Grid lines i.e 1.25mm kept for Optimization and Calculation. Photon Optimizer(PO) algorithm for Optimization and Anisotropic Analytical Algorithm(AAA) for calculation was used. All the Plans were normalized to cover 95% of TV to 100% Dose. Gamma analysis were made to check the deliverability of plans.

**Results:** In all the plans, the Dmin, Dmax and Dmean were found to be relatively similar and irrespective of the prescription doses (either 24 Gy/3# or 16 Gy/1#). Conformity index (CI) for each collimator combinations such as C0-180, C30-330, C60-300 and C90-270 were found to have a value 1.3, 1.1, 1.1 and 1.2 respectively. Marginal increase in CI observed in the C0-180 and C90-270 combinations could be due to cumulative low dose contributions from the overlapping interleaf leakages in all opposing gantry projections. Identical gradient indices (GI) and OAR (heart, liver and kidneys) doses observed among all the collimator combinations showed that the dose fall-off outside the target was not dependent on collimator angles. However, important finding in our study is that the C0 and C90 combinations resulted in increased SC dose of about 10% in comparison with C30 and C60 combinations. Gross difference in total MU was also observed between the four collimator settings, the C90 combination was found to have the lowest value. For all the four collimator combinations, more than 95% dose voxels were passing the standard gamma criteria (3%/3 mm DD and DTA).

**Discussion and Conclusion:** Selection of optimum collimator combination is essential in SBRT of spine mets thereby reducing the maximum dose to spinal canal and limits the total MU required to deliver the prescription dose. Further investigation on the various collimator combinations with large sample size yields statistical significance of the same.

**PP-113**

**MONTE CARLO INVESTIGATION OF ELECTRON BEAM CHARACTERISTICS AND ITS VARIATION WITH THE INCIDENT ELECTRON AND COMPARISON WITH PHASE SPACE BEAM CHARACTERISTICS**

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Introduction: Monte Carlo simulation is considered to be the most accurate technique to understand the beam transport and interaction of radiations with matter. A linear accelerator model is developed using the GEANT4 software. Monte Carlo simulations are performed to understand the variation in beam characteristics of the electron beams by varying the incident electron and tried to match with the electron beams produced by the phase space file provided by the IAEA.

Purpose: The aim of the study is to establish a relation between electron beams produced by varying the incident electron and those produced by phase space file given in IAEA.

Materials and Methods: Monte Carlo model of the linear accelerator capable of producing electron beams of energy from 6 MeV and 9 MeV is developed. Linear accelerator model is designed in accordance with the configuration provided by the Varian Medical Systems Inc., Palo Alto, CA. Monte Carlo simulations of 6 MeV and 9 MeV electron beams with applicator size of 10-10 cm2 and 15-15 cm2 are performed and dosimetric data is recorded which is compared with the dosimetric data obtained using the phase space file provided by the IAEA for the same beam energies and applicator sizes. The initial beam energy of the electron is varied from 6 MeV with the increment step of 0.1 MeV to get the comparable percentage depth dose curve within 1% and lateral dose profile within 2% as of the Phase space from IAEA.

Results and Discussion: More the number of particles run more accurate is the result. As it is time taking due to system limitation and all other parameters.

PP-114

A FUTURISTIC TOOL FOR THE TUMOUR CHARACTERISTICS: THE RADIOMICS

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Introduction: Images are not just images they are data. Basically, images are the mathematical representation of intensity patterns distributed over a volume in 3D. Radiologically, tumours can be differentiated from the normal tissues in terms of some characteristics like shape, intensity and texture. From the idea it can be justified that the mathematical data of the images are different for tumours and that for normal tissues in respect of some mathematical functions. These functions are known to be the Radiomic features. Various tumours are also different from others in terms of their nature and biology. Thus, a pattern is to be created in between them so that nature of tumour, its origin as well as kinetics of the tumour can be studied and furthermore may be helpful in finding the survival of the patient and also the effectiveness of the treatment given to them individually.

Purpose of Study: The aim of the study is to find some characteristics features in terms of mathematical functions (Radiomic features) of the tumours as well the normal tissues.

Materials and Methods: The pre-treatment CT scans of 422 non-small cell lung cancer (NSCLC) patients available at The Cancer Imaging Archive (TCIA) were included in this study. The manual delineations of gross tumour volumes as marked by radiation oncologists were used for accuracy purposes. The radiomic features including Global textures, first order and higher order texture features were calculated in Matlab. Additionally, wavelet band-pass filtering, isotropic resampling, discretization length corrections and different quantization tools can be used along with a mathematical algorithm to further study delta-radiomics.

Results and Discussion: A few radiomic features including Global textures, Grey level co-occurrence matrix (GLCM) features, Grey level run length matrix (GLRLM) features, Neighbourhood grey tone difference matrix (NGTDM) features and Grey level size zone matrix (GLSZM) features were extracted.

Conclusion: Radiomics holds great promises in future. Since it is easy to perform, non-invasive and achievable at low cost, it is a revolutionary tool that can be used to study tumour growth, its proliferation and differentiation. This might need a good collaboration with clinic to obtain scans acquired on each follow-up.

PP-115

DOSIMETRIC COMPARISON FOR TREATMENT OF CA. BRAIN USING INTENSITY MODULATED RADIATION THERAPY AND VOLUMETRIC MODULATED ARC THERAPY TECHNIQUES

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Introduction: Dosimetric Comparison in Intensity Modulated Radiation Therapy (IMRT) and Volumetric Modulated Arc Therapy (VMAT) was compared, and the advantages and disadvantages of different radiotherapy plans were evaluated. Volumetric Modulated Arc Therapy (VMAT) is a novel form of IMRT optimization that regulates the radiation dose with enhanced degrees of freedom, by continuously modulating the Multi Leaf Collimator (MLC) field shape, gantry rotation speed and dose rate. VMAT enables for additional flexibility in dose delivery and could further improve dose conformity and sparing of vital tissues. Compared with IMRT, the potential advantages of VMAT include a large reduction in treatment time and a concomitant reduction in the number of monitor units (MUs) required to deliver a given fraction size. For each patient, three treatment plans, including a dIMRT, SingleArc VMAT and Double Arc VMAT plan were generated. The dose prescription was set to 60 Gy delivered over 30 fractions. The dose distributions for the planning target volume, organs at risk (OARs) and normal tissue were compared. The MUs were also evaluated. The dose distribution of target (Dmax, Dmin, Dmean, dose Conformity and Heterogeneity index), OARs and normal tissue were compared among the three plans.

Materials and Methods: A total of 30 patients with Ca. Brain were selected from between June 2016 and July 2018 to be included in the present study. The median age was 52 years the target volume was delineated according to the no. 50 and 62 reports of the International Commission on Radiation Units and Measurements. For the gross tumor volume (GTV) was defined MRI Scan and the CTV was defined as the GTV plus a margin. The CTV was expanded by 5 mm to produce
the PTV. Using Monaco 3DTPS software (version 5.1 Elekta Medical Systems, Crawley, UK), dIMRT and VMAT plans were produced using 6MV photons, and the dose prescription was set to 60 Gy in 30 fractions. The dose constraints to the OARs were determined using a Radiation Therapy Oncology Group protocol. The dIMRT plans consisted of six coplanar fields at gantry angles of 51°, 102°, 153°, 204°, 255° and 306°. The VMAT plans consisted of a single arc and double arc starting at a gantry angle of 180° and rotating counterclockwise through 360°. The Three plans adopted the same approach during optimization. The upper limits of the dose rate for the 6MV beams were 600 MU/min, respectively. The dose volume histogram included the Dmax, Dmean and Dmin of PTV. Conformity index was calculated as follows: (PTVref/Vref) x (PTVref/Vref). Heterogeneity index (HI) was calculated as follows: D5/D95. To quantify the dose distribution on OARs and normal tissue (NT) at different dose levels, the percentage volume of the OARs and NT receiving a dose of 20, 10 and 5 Gy were evaluated and compared.

Results and Discussion: PTV coverage, the Dmax and Dmean of PTV in dIMRT were increased compared with that in the both VMAT plans. During the process of VMAT the parameters, including the dose rate, the gantry rotation speed and the site of MLC change dynamically. Two types of products are currently in clinical use, Varian RapidArc and Elekta VMAT. As the application develops, the VMAT plan may become equal or superior to IMRT. Compared with IMRT the VMAT plan may increase the scattering of NTs, reduce the MUs and reduce the treatment duration. OARs, including pituitary gland, optic nerve and chiasma were more improved in the dIMRT plan compared with VMAT. The reason for this is primarily due to the spatial association between the location of the Ca. Brain and OARs. In an identical ray model, the differences in dose distribution to OARs between the three plans the positioning accuracy and the leakage ray, and as a result the Dmax of the pituitary gland and chiasma in VMAT was increased compared with dIMRT. In the past few years, the VMAT plan has been gradually applied in clinical treatment. The VMAT plan should be considered as the treatment duration may be reduced with dIMRT Treatment duration.

PP-116
DOSIMETRIC STUDY OF SMALL CIRCULAR CUTOUTS FOR ELECTRON BEAM THERAPY
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Introduction: Electron applicators has an important role in electron beam therapy. Electrons undergo significant scattering in the air between the scattering foils and the patient. Superficial tumours having small area are commonly treated using megavoltage electron beams. Depending on the type and the shape of tumour, cast cerrobend alloy cutouts are used.

Purpose: The main objective of this study is to dosimetric effects of cerrobend cutouts of smaller area in megavoltage electron beam and find out how the dosimetric parameters such as mean energy output factor and range of electron changes with the use of small area cerrobend cutouts, and to fit the values of R100, R90, R80, R50, E0 (mean), and OPF changes on a curve and formulizing these changes as a function of cutouts cavity area.

Materials and Methods: In this study, measured the dose profile and output of electron beam with applicator sizes 5×5, 10×10, 15×15 and 20×20 cm2 and without applicators for different energies 4, 6, 9, 12, 15 and 18 Mev for Varian 2300 C/D Accelarator. Circular Cerrobend cutouts of smaller area, having circular diameter of 2 cm, 3 cm, 4 cm, 5cm, 6 cm 7 cm and 8 cm were made with the help of a Styrofoam cutter. Electron applicator of 10 x 10 cm2 field size was mounted to the linear accelerator. RFA was set at SSD of 100 cm, using parallel plate ionization chamber as field detector and semi flex ionization chamber as reference detector. Beam profile and PDD curve of reference field (10 x 10 open field) and all cut outs for all available electron energies (4 MeV, 6 MeV, 8 MeV, 12 MeV, 15 MeV) were taken using RFA. Data analysis was done using MEPHYSTO MC2 software.

Results: R100, R90, R80, R50, Rp E0mean and Output factor for all cut outs for six different energy is found. The obtained data is analyzed and curve for each energy is plotted as cutout area versus the dosimetric parameter. Curve fitting is done using GNU plot software. Equations for each parameters for all energy is found as a function of cutout area with minimal reduced chi square value.

Discussion and Conclusion: This work explores the impact of use of small area cut outs for electron beam therapy, which is usual practice in radiotherapy treatment for superficial tumors. This study concludes that there are some changes in the dosimetric parameters occurred due to the placement of cutouts in the megavoltage electron beams. The effects are decrease in output factor, decrease in mean energy and shifting of PDD curve to the surface. Variation in the values showed almost same trend, each parameter for each energy is fitted and equation is made as a function of cavity area, and the equation is given by

\[ P = a/\left(1+b\exp(-c\cdot A)\right) \]

Any of the dosimetric parameter R100 R90 R80 R50 output factor and E0 mean can be found using this equation for any cutout with known cutout area, so there is no need of doing dosimetry for each patient specifically.

PP-117
DOSIMETRIC EVALUATION OF INDIAN MADE BOLUS AND COMARED WITH SUPERFLAB AND RW3 SLAB
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Introduction: Bolus material is used in photon and electron energy of radiation therapy to correct for anatomical irregularities and deliver the prescribed dose to the patient skin surface. The common treatment site bolus required such as ear, nose, breast, chest, and vulva. There are various tissue equivalent bolus material used as bolus in radiotherapy.

Purpose: The main purpose of the present work was to perform the dosimetric evaluation of the Indian made bolus
Materials and Methods: The Indian made bolus was used to measure the transmission factor, Electron Density and compare with superflab and RW3 slab using RW3 slab phantom. For two megavoltage X-rays, 6 and 15 MV & all electron energies, the transmission factor of the Indian made bolus was measured by means of a 0.6cc Farmer ionization chamber. The Home made was placed on top of the slab phantom and irradiated by 6 and 15 MV photons and repeated for other boluses. Afterward, the boluses was removed and the irradiation repeated for both photon as well as electron energies. Computed tomography data from the boluses were acquired to assess electron densities with various techniques (mA and kVp). Circular ROIs were delineated on CT DICOM images and densities were calculated using CT numbers.

Results and Discussion: Evaluation of our results are evident that showed that mass electron densities are similar to those of water and soft tissue. Furthermore, transmission factors are close to those of water.

Conclusions: The Indian made bolus is a reasonable alternative to tissue-equivalent bolus. Bolus is equivalent to tissue in photon attenuation, conforms well to the irregular contours. It should be considered a viable alternative to common bolus materials such as Bee’s wax and Paraaffin wax. Its need further study to use clinically.

PP-118

AN IN-HOUSE SPREAD SHEET FOR ANALYSIS AND VERIFICATION OF DOSE ACCUMULATION FOR CARCINOMA CERVIX PATIENTS TREATED WITH EXTERNAL BEAM THERAPY AND BRACHYTHERAPY

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Introduction: Cancer of cervix is a major cause of cancer morbidity and mortality among women worldwide. The radiotherapy treatment includes external beam radiotherapy and brachytherapy. Brachytherapy enables the delivery of a high dose, in a small volume, during a short period of time. The continuing interest in brachytherapy stems from enhanced technological capabilities to place radiation sources accurately within and/or adjacent to tumors, usually allows a high tumor to normal tissue dose ratio and a reduction in the volume of irradiated normal tissue.

Materials and Methods: A retrospective analysis of radiation dose accumulation for 60 patients who have received radiotherapy with EBRT and Brachytherapy was carried out. 50 Gy was delivered by external beam radiotherapy in 25 fractions and 3 fractions of HDR Brachytherapy of 7 Gy were delivered. The treatments were performed on Bhubhatron TAW II and Bebig multisource HDR Brachytherapy. The Biologically Effective Dose (BED) was calculated for the prescribed doses. An equivalent dose in 2 Gy per fraction (EQD2) was estimated for both external beam and brachytherapy dose delivered. For brachytherapy, EQD2 calculation must take into account the dose gradient and has to be cautiously applied as it’s a mathematical one. We have formulated an excel spread sheet to incorporate these dosimetric parameters according to the linear quadratic model using alpha/beta 3 Gy. The EQD2 for external beam radiotherapy, and doses to point A, bladder point and rectum point for brachytherapy were estimated separately using the spread sheet and analyzed.

Results and Conclusion: The in-house spread sheet is reliable to analyze the dose accumulation to normal structures in radiotherapy of carcinoma cervix (bladder and rectum). The doses to bladder and rectum were within tolerance dose limits for all patients treated. This spread sheet appears as a useful tool for EQD2 analysis between the dose delivered through EBRT or brachytherapy.

PP-119

A PRELIMINARY VALIDATION STUDY ON THE DOSE PREDICTION ACCURACY OF PENCIL BEAM CONVOLUTION AND COLLAPSED CONE CONVOLUTION ALGORITHMS

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Introduction: Study investigated the effect of air gaps on depth dose calculations computed by pencil beam convolution algorithm (PBC) and collapsed cone convolution (CCC) algorithm.

Materials and Methods: A phantom (30 x 30 x 30 cm3) containing rectangular solid water blocks and two 5cm air gaps was used for central axis dose calculations computed by collapsed cone convolution algorithm (CCC) and Pencil Beam Convolution algorithm (PBC).

Results: The point dose measured by collapsed cone convolution was within ±1.1% in the first water medium. After the second air gap, the CCC continued to under predict the dose, and the difference ranged from -3.3% to -3.1% for 3 x 3 cm2, from -2.1% to -5.3% for 5 x 5 cm2, from -2.1% to -6.4% for 10 x 10 cm2, and from -1.3% to -5.4% for 15 x 15 cm2. The results of PBC were within ±1.7% in the first water medium. After the second air gap, the PBC continued to over predict the dose, and the difference ranged from -3.3% to -3.9% for 3 x 3 cm2, from -2.6% to -5.6% for 5 x 5 cm2, from -2.5% to -6.0% for 10 x 10 cm2, and from -1.6% to -5.6% for 15 x 15 cm2.

Conclusion: The PBC over predicted and collapsed cone convolution under predicted the dose in water medium after the photon beam traversed the air gaps at different depths.
modulated treatment plans. The advancement in technology has ensured in developing newer algorithms in evaluating the plan delivery quality. The standard followed across the world in gamma evaluation defined by standard algorithms being followed by all vendors. With more robust machines coming in the market, we have more tools to dig deep into evaluating each control point for error. With standard gamma evaluation methods all being in 2D, there are chances of missing few data or sometimes data getting integrating where errors are cancelled out in final result. In this study, we have made an effort to understand the use of 3D evaluation of patient qa using Sun Nuclear ArcCheck and 3DVH, in head and neck cancers.

**Materials and Methods**: For the purpose of this study we have considered 18 patients with head and cancer. All these patients were treated with RapidArc and the QA was done using Sun Nuclear Arc Check. The treatment planning was done using Eclipse Treatment Planning Software and the plans were delivered in TrueBeam STx SVC linear accelerator equipped with HDMLC with 2.5 mm leaf thickness at isocentre. Further, the delivered plans were evaluated using SunNuclear 3DVH software for 3D dose evaluation. The PTV doses, viz a viz, maximum, minimum and mean dose and the coverage to 95% and 98% volumes were compared. The protocol was defined as 95% as the pass rate as per department standards. Additionally, the DVH was used to compare the Organ At Risk (OAR) dose values also.

**Results**: The gamma passing rate for all the plans were above 98% and in general all plans cleared the department tolerance for pass rate. This indicates that all plans are good for delivery. But, the DVH analysis showed varying results. Two of the plans showed failure in 3DVH analysis with values less than 95%. The max dose to the PTV was more compared to the planned dose and finally these patients were replanned before treatment. For the same patient, the OAR doses were also not comparable to the planned OAR doses.

**Conclusion**: Gamma analysis can predict the failure of a plan in most of the cases and is proven to be a reliable tool for patient plan qa evaluation. But, it can miss some information at some time due to integration of errors. For the evaluation of plan delivery with higher precision we need to evaluate all the plans in 3D and the 3DVH performs the same with high accuracy.

**PP-121**

**MEASUREMENT OF OUTPUT FACTORS FOR SMALL FIELDS OF BHBHATRON II TELECOBALT UNIT**

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**Introduction**: The recent technological advancements in radiation therapy have led to a significant increase in treatment techniques involving small fields such as SRS, SRT, SBRT etc. Presently machines dedicatedly designed for these sophisticated techniques are also used in the therapeutics. However, measurement in small fields using ion chambers is a challenging task due to several factors such as absence of charge particle equilibrium, low signal to noise ratio, volume averaging effect and source occlusion. To overcome these difficulties IAEA recently published a technical report series (TRS-483). One of the recommendations of this report is the use 5 x 5 cm2 field sizes as reference field in case of unavailability of 10 X 10 cm2 field size. Radiochromic films can also be used can be used for this purpose due to its high spatial resolution.

**Purpose**: In the present study, output factors for small field using Bhabhatron-II Teletherapy machine were measured using Radiochromic film for two different reference fields namely 5 x 5 cm2 and 10 x 10 cm2 and the results were compared.

**Materials and Methods**: Radiochromic film pieces (EBT 3 Film) were used for the calibration as well as output factor measurements. Calibration procedure was carried out by exposing the films with known doses from 25 cGy to 500 cGy using Bhabhatron-II Teletherapy unit. The films were scanned with Epson 1000 XL scanner and pixel density for each film was measured using ImageJ software. A calibration curve was plotted using the pixel density obtained from ImageJ against known doses. For output factor determination, radiochromic films were exposed for field sizes of 1 x 1 cm2, 2 x 2 cm2, 3 x 3 cm2, 4 x 4 cm2, 5 x 5 cm2 and 10 x 10 cm2 with the same treatment time (2 min). By using the calibration curve obtained above, dose corresponding to each field size was obtained.

**Results**: The output factors for different field sizes were normalized to reference fields (10 x 10 cm2 and 5 x 5 cm2) in accordance with TRS 483. The output factors obtained with reference field of 5 x 5 cm2 were found to be 0.36, 0.85, 0.97 and 0.99 for field sizes of 1 x 1 cm2, 2 x 2 cm2, 3 x 3 cm2, 4 x 4 cm2 respectively and for that of 10 x 10 cm2 were 0.33, 0.77, 0.87 and 0.90 for field sizes of 1 x 1 cm2, 2 x 2 cm2, 3 x 3 cm2, 4 x 4 cm2 respectively. The relative percentage variations up to 11.5% were found for these two reference fields.

**Conclusion**: The variation in output factors using two different reference fields can be attributed to the fact that a low scatter dose at the smaller reference field (5 x 5 cm2) would lead to smaller total dose as compared to larger(10 x 10 cm2) reference field, which in return lead to higher output factor for the smaller reference field. It also emphasizes on the fact that due to very high uncertainty at small field a particular detector may give large variation and hence it should be verified against other detectors.

**PP-122**

**VERIFICATION OF DOSE AT JUNCTION BETWEEN BREAST/CW AND SUPRACLAVICULAR FIELD DURING DIBH TREATMENT**

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**Aim**: Verification of dose at junction between Breast/CW & SCF field during DIBH treatment.

**Purpose**: In DIBH treatment dose at junction is dependent on the breathing of patient. As such uncertainties may be
introduced due to improper breathing. We have to tried to a film based dose measurement at junction of fields treated by DIBH.

**Materials and Methods:** Breast patients requiring supraclavicular field (SCF) treatment were selected for this study. Patients were treated on Varian TrueBeam machine. For tracking the Patient breathing pattern Varian based RPM system was used, reflecting marker was placed at the sternum level on the patient body. Proper immobilization devices is used to reproduce the patient positioning (same at the time simulation) for the treatment. We performed film based dose measurement for 10 breast cancer patients receiving radiotherapy to the Breast/CW and SCF region. Gafchromic EBT film (5 cm * 10 cm) was placed at the junction between upper border of Breast/CW & lower boarder of SCF field. The patients were treated with the film placed on the skin. EPSON perfection V800 scanner was used to scan the film to measure the profile. We performed the consecutive measurement for five days to find out the accuracy of the setup and reproducibility of breathing cycle.

**Result:** For 20% of the patients, the ratio of measured and calculated dose along the junction were greater than 1 (i.e. overlapping between the junction fields). We observed that whenever breathing pattern was reproducible, the intended gap (i.e. 5 mm was used) between the fields was maintained and was visible on the film. For patients who could not follow the instructions correctly the gap on the film seemed to reduce i.e. chances of overlapping occur. However upon further coaching these patients when they followed instructions the gap was maintained well.

**Conclusion:** Breast patients having SCF field can be safely treated with DIBH protocol provided patient breathing is reproducible. For patients who cannot follow the breathing instruction properly, should be coached and junction dose should be confirmed with in-vivo dosimetry method.

**PP-124**

**A STUDY OF LUNG VOLUMES AND DOSES IN LUNG LESIONS, MULTIPLE VOLUMETRIC IMAGES OF RESPIRATION CYCLE ON CT**

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**Introduction:** Introduction of respiratory motion management into the radiation therapy practice to accomplish target or organ motions. Using an infrared camera tracker the external marker on the patient is tracked. This will help in generating a respiratory cycle of the patient.

**Purpose:** The purpose of this study is to find out the change in volume of the lungs throughout the 4DCT of the thorax patient on image sets.

**Materials and Methods:** We have taken 6 patients for the study. There are lot of vendors available with respiratory-gating devices. We have used the Varian Real-time Position Management (RPM) system. A marker is placed on the abdominal region between the xyphoid process and umbilicus to account for the maximum amplitude of the patient motion. Patients are trained for reproducible and regular breathing pattern. Phillips Big bore CT-Simulator, along with real-time position management (RPM) system (Varian Medical Systems, USA) were used to acquire 4D-CT image set. The upper and lower portion of the signal represents the inhaled and exhaled phase. This respiratory cycle represents a complete period and is divided into a number of phases of equal duration. All the lung volumes were contoured along with other OARs on all phases of the multiple images of the respiration cycle on the individual patients. Our study we have compared only the ipsi lateral lung volumes and the dose received by them.

**Results:** In 6 patients 83% were male and 17% female ratio. 50% were from Right lung and 50% ration were from left lung. The ratio of upper, middle and lower was equal with anteriorily situated tumors were 66% and remaining were posteriorily situated. The average lung volume of all the phases is compared with the averaged CT and mip (maximum intensity projection).

**Discussion and Conclusion:** We noticed that among 6 patients the ipsi lateral lung received least V20 dose in the 0 phase of the cycle when a tumor PTV was done on the ave CT, the mip received the less dose for max in 50% of the cases. Our superior to inferior lung volume length changed between 1.5 to 2 cm and AP in between 0.4 mm to 0.7 mm and in lateral direction found to be 0.2 mm to 0.5 mm. It is well within the published result from many authors and our most of the patient general condition for treatment was also a favorable factor. We conclude that each institution must carry their own margins to be given in thorax lesions. And while deciding a plan one must carefully choose the plan by checking the doses in all the phases.

**PP-125**

**FLUENCE SCALING FACTOR FOR VIRTUAL WATER PHANTOM IN HIGH ENERGY ELECTRON BEAMS**

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**Introduction:** Plastic phantoms may be used under certain circumstance in electron beam dosimetry for beam qualities R50 < 4g/cm2 as per IAEA TRS-398 report. Though the fluence scaling factor (hpl) for various plastic phantoms is listed, the value for virtual water phantom is not available in the report. This study was aimed to estimate the hpl factor for virtual water phantom in available electron energies at our institute.

**Materials and Methods:** Virtual water phantom (density=1.030 g cm-3) in the form of solid slabs of size 30 x 30 cm2 with different thickness ranging from 0.2 cm to 5 cm were used for measurements. The chamber holder plate for Advance Markus Chamber (PTW TM34045) was made of acrylic material of 2 cm thickness. The measurements were taken for electron beams with energies 6, 9, 12 and 15MeV generated by Truebeam STx LINAC. Initially absorbed dose was measured according to IAEA TRS-398 protocol in 1D water phantom (PTW) at Z ref,w for all the four electron energies. On the same day, dose was measured again in virtual water phantom at Z ref,pl as derived from the below
expression. $Z_{ref,pl} \ (g/cm^2) = Z_{ref,w} \ (g/cm^2)/Cpl$. Where $Cpl$ is depth scaling factor. $Cpl$ value for virtual water phantom is 0.946 (ref in TRS-398). $Z_{ref,pl} \ (cm) = Z_{ref,pl} \ (g/cm2)/\rho_{pl} \ (g/cm^3)$. Where $\rho_{pl}$ is density. The $\rho_{pl}$ value for virtual water phantom is 1.030 g cm-3 (ref in TRS-398). Entire measurements were repeated on different days and hpl factor is estimated from the average of the observed results. The estimated hpl factor were used in the other LINAC for the corresponding electron energies to measure the dose in virtual water phantom and compared with liquid water phantom results.

**Result:** The fluence scaling factor (hpl) was calculated as the ratio of absorbed dose in water to dose in plastic, for all four electron energies generated by LINAC Truebeam STx using the expression $hpl = D_{w,Q(Z_{ref,w})}/D_{pl,Q(Z_{ref,pl})}$. Calculated values of hpl from dose measurement on different days is shown in Table 1. Repeatable results were observed and hpl factor were estimated. Measured absorbed dose in virtual water phantom with the estimated hpl values in the other Linac for the corresponding electron energies, was found to be consistent with the liquid water phantom results.

**Conclusion:** As per IAEA TRS-398 report, plastic phantoms can be used for routine quality assurance measurements, provided the relationship between dosimeter readings in plastic and water has been established for the user beam at the time of calibration. In a busy clinical setup, a quick measurement setup with virtual water phantom compared to liquid water phantom will be useful for routine quality assurance checks.

**PP-126**

**VOLUMETRIC-MODULATED ARC THERAPY FOR HIPPO-CAMPAL SPARING IN WHOLE BRAIN RADIOTHERAPY: A NEW APPROACH FOR MANAGEMENT OF BRAIN METASTASIS CASES**

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**Introduction:** Whole brain radiotherapy (WBRT) with two lateral opposed portals has long been considered the standard treatment of choice for patients with brain metastases, because of its wide availability, ease of delivery and its effectiveness for most of the patients. Although this was the main treatment option available and is still widely used, many toxicities, particularly cognitive impairment resulting from WBRT remained a major concern. With the advancement in imaging and treatment delivery techniques, the probability of improved outcomes has increased for many patients. With the improvement in outcomes and the higher expectations of patients regarding better quality of life, the routine use of WBRT has been scrutinized, considering the impact of neuro cognitive functions and quality of life of the patients. The Hippocampus is responsible for memory and cognitive function. Hippocampal sparing whole brain radiotherapy (HS-WBRT) is a technique that aims to reduce the neuro-cognitive side effects of whole brain radiotherapy. In this regard, hippocampal sparing WBRT is an improved technique that aims to spare critical hippocampus region without compromising the tumour control. The aim of this study is limited to planning, feasibility and efficiency of using volumetric modulated arc therapy (VMAT) to spare the hippocampus and all other OARs.

**Materials and Methods:** A total of 5 patients were planned for hippocampus sparing using VMAT according to the RTOG 0933 protocol. The OARs (Both lens, optic chiasm, both optic nerves) were considered as dose constrained structures. The hippocampi were contoured and hippocampus PRV structures were created using a 5 mm volumetric expansion around the hippocampus. The whole brain planning target volume was defined as the whole brain tissue minus hippocampus PRV regions. All the plans were done with VMAT for the prescription of 30 Gy in 10 fractions. The VMAT plans were created in Elekta Monaco treatment planning system (Version -5.00.04) with 6MV photon beam for the Elekta Synergy Linear accelerator. Plans were evaluated using D2% and D98% for the whole brain PTV (whole brain tissue minus hippocampus PRV structure region). D100% and the maximum dose to the hippocampus region and also maximum dose to the optic nerves, optic chiasm and lenses were recorded.

**Results:** The whole brain PTV D2% mean value was 3368 cGy (ranges from 3251 to 3429 cGy), D98% mean value was 2457cGy (ranges from 2407cGy to 2507 cGy) and the D95% mean value was 2851cGy (ranging from 2797cGy to 2897cGy). The hippocampus D100% mean value was 833cGy (ranging from 768 cGy to 897cGy) and hippocampus maximum dose mean value was 1470cGy (ranging from 1408cGy to 1539 cGy).The maximum dose to optic nerves and optic Chiasm for all patients were noted and did not exceed 37Gy. The mean number of monitor units was 1482MU (ranging from 1347MU to 1608 MU). Quality assurance of the plan delivery (Gamma evaluation) for all the plans passed the 3%, 3 mm criteria with more than 93% measurement points.
Conclusion: The results indicate that VMAT planning allows significant sparing of the hippocampus with acceptable target coverage and homogeneity, and meet the RTOG 0933 criteria, consequently reducing neuro-cognitive decline as shown in Preclinical and clinical studies, and potentially improving quality of life.

PP-127

COMPARISON BETWEEN THE NANODOSIMETER AND GAS CHROMATOGRAPHY AND MASS SPECTROMETRY TO DIAGNOSE CANCER

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Introduction: In the modern field of nanodosimetry, the Printed Circuit Board (PCB) technology based positive ion detector has been identified as a device to detect cancer in lungs and breast region. The gas chromatography and mass spectrometry (GCMS) is one of the techniques to analyze the gas molecules released by liquid samples. By this technique, malignant cells can be diagnosed by the exhalation of specific volatile organic compounds (VOCs) which serves as an eminently source biomarkers for malignant diagnosis.

Purpose: To compare the cancer diagnosing capability of the Nanodosimeter and GCMS using lung and breast malignant biopsy tissues of all stages.

Materials and Methods: Multilayer PCB technology based Nanodosimeter was designed to capture positive ions produced by the interaction of ionizing radiation with low pressure gas medium. After the validation, the normal breast tissues were placed inside the chamber and it was evacuated in order to remove all molecules present in the chamber. Then, it was allowed to exhale molecules at various pressures in order to measure the amplitude, rise time, fall time, and number of pulses of the signal. Later, these normal tissues were replaced with breast cancer tissues of all stages (Stage 0, 1, 2, 3a, 3b, and 4) in the evacuated medium and the same was allowed to exhale Volatile Organic Compounds (VOCs) to capture signal at various pressure ranging from 1 to 10 Torr. All the measurements were repeated for 10 times to improve consistency in measurements. The mean amplitude, rise time, fall time, and frequency of pulses and number of pulses produced by normal and malignant lung and breast tissue were compared. The GC-MS sample analysis was performed as per the direction given in the Agilent GCMS instrument manual.

Results and Discussion: In the Nanodosimeter, the signal amplitude, frequency, rise time, fall time and number of pulses have been increased gradually when the normal breast and lung tissue converted into various stages of malignancy. For the stage 0, 1, 2, 3a, 3b and 4, the mean amplitude of the pulse produced by normal breast tissue was increased up to 2.82, 6.59, 14.78, 20.02, 21.64, 22.98 % and for lung tissue 2.45, 6.18, 10.89, 12.12, 15.12, and 17.84 % respectively and the mean frequency of the signal emitted by normal breast tissue was shifted from 38.4 Hz to 83.2, 183.5, 281.2, 454.5, 494.5, 569.6 Hz and for lung tissue 16.6 Hz to 21.15, 24.8, 28.7, 33.8, 35.6, and 43.02 Hz respectively. Similarly, rise time and fall time of the stage 0, 1, 2, 3a, 3b and 4 of breast and lung malignancy signal is higher than that of normal tissue. The GCMS spectrum shows different VOC molecules in variable number depending upon the type of tissue and stage. But, it does not show any signal at stage 0, 1 and 2. Hence, it was inferred that GCMS can only be used to detect cancer at stages 3a, 3b and 4. However, it requires gas molecules at pressure ranging from 4000- 5000 Torr.

Conclusion: Nanodosimeter shows better response than GCMS to detect breast and lung malignancy in addition to its cost effectiveness, simple processing, reproducibility and capability to detect low level signal. However, the present Nanodosimeter should be upgraded to identify the gaseous molecules.

PP-128

EVALUATION OF DOSMETRIC PROPERTIES OF HAFNIUM OXIDE NANOPARTICLES FOR RADIOTHERAPY APPLICATIONS

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Purpose: Thermoluminescence dosimeters play an vital role in invivo dosimetry. Hafnium Oxide nanoparticles (HfO2 NPs) has found wide-ranging in numerous fields of interest, such as control rod in nuclear reactor, UVR dosimeters and Scintillators. In this regard, the current study aim’s to examine the thermoluminescent properties of HfO2 NPs and to evaluate its application in high energy gamma dosimetry.

Materials and Methods: HfO2 NPs were synthesized by precipitation method and pellets were prepared by using hydraulic pellet pressing machine. Before irradiating the samples in 60Co beams they were annealed at 300 degree C for 10 minutes in order to erase the residuals. Theratron 780C cobalt-60 unit were used for irradiating the sample at SSD=80 cm for Field size =10 × 10 cm2 and the sample were kept at dmax =0.5 cm by varying the dose. In order to determined the dosimetric characterization such as glow curve, linearity, reproducibility and fading, the TL glow curves were recorded by Nucleonix TL reader (1009I), from room temperature to 350 degree C at heating rate of 5 degreeC/s.

Results and Discussion: The prepared samples were exposed to 60Co gamma beam at an absorbed dose of 100cGy and the observed glow curve have a single peak and well defined dosimetric peak centered at around 310 degreeC.TL response of HfO2 NPs for gamma irradiations as a function of absorbed dose varying from 5 to 1000 cGy were carried out which shows a linear response. The fading studies were carried out by irradiating the samples for the dose of 100 cGy which is stored at room temperature and the fading parameter were measured for
the period of 1 month at interval of 5 days for reading the sample at higher temperature shows higher stability due to emission from deeper traps. The reusability parameter is also one of scale to measure the sensitivity of TL detector. Hence the measurements were carried out by ten cycles of repeated irradiation and annealing the samples and no significant changes in the intensity of the glow curve were observed.

**Conclusion:** The observed results shows that HfO2 NPs have very high linearity, their fading properties shows that it can be read even after 5 days, where there is not much difference in the observed result. As for as their reusability is concerned. The results shows that it has a longer lifetime and it can be used for longer period of time. Hence, HfO2 NPs can be used as TL material in radiotherapy.

**PP-129**

**DOISMETRIC COMPARISON BETWEEN TG-43 AND TG-186 IN LIP AND BUCCAL MUCOSA BRACHYTHERAPY IMPLANTS**

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**Introduction and Purpose:** TG-43 dose calculation formalism for photon emitting radionuclide sources used in brachytherapy, is based on the parameterization and superposition of single source dose distributions, obtained in liquid water under fixed geometry. Although, it is easy, fast and practically applied in clinics, it inherently lacks considerations for tissue and applicator heterogeneities, differences between absorbed dose in water and tissues, inter-seed attenuation, finite patient dimensions and dose contributions from electrons, can lead to under or overestimation of dose calculation. Model-based dose calculation algorithms (MBDCAs) have recently been emerged as a potential formalism for dose calculation in brachytherapy which involves tissue-inhomogenities and lack of scatter. It offers the possibility of departing from water-only geometries by modelling radiation transport in non-water media (tissues, applicators, air-tissue interfaces), resulting in a much more accurate dose distribution delivered to the patient. The present work provides the comparison between the dose calculation between TG-43 and TG-186 formalism for lip cancer and buccal mucosa brachytherapy implant.

**Materials and Methods:** Five lip cancer and three buccal mucosa Brachytherapy implant patients previously treated in our hospital using TG-43 formalism (Oncentra Brachytherapy TPS v 4.5.3) were taken for this retrospective analysis. The mean (sd) of catheters in lip and buccal mucosa implants were 7 (2), and the number of implant planes were 2. CT images were transferred to TPS, followed by catheter reconstruction. The source activation was based on the clinical examination/or using the implanted markers. Dose prescription was done on basal points followed by geometric optimization on volume. Plan evaluation was carried out jointly by the treating physician and the physicist. Plans were made using TG 186 algorithm (Oncentra Brachytherapy TPS v4.5.3), keeping all the other parameters constant. A total of 16 plans were made. For this dosimetric analysis, a single brachytherapy fraction was considered. Dose prescription was 4Gy per fraction. The isodose volume covering 240%, 200%, 150%, 120%, 100% and 85% and 50% of prescription isodose were evaluated for TG 43 and TG 186 plans. The difference between these volumes in absolute difference was evaluated. In addition, Dose Homogeneity Index (DHI) was calculated and the difference between these plans were compared.

**Results:** The mean (±sd) of absolute differences of various isodose volumes was found to be 0.6 (±0.2) cc and 1.0 (±0.5) cc for lip and buccal mucosa implant respectively. Interms of percentage variation, the mean (±sd) difference was found to be 49 (±21) and 30 (±23)% for lip and buccal mucosa implant respectively. It was observed that TG 43 overestimates the dose more in higher isodose volumes as compare to lower isodose volumes. TG 186 plans were more homogeneous as compared to TG 43. The mean (sd) DHI of TG 43 vs TG 186 was 0.66 (0.06) vs 0.76 (0.08) and 0.73 (0.02) vs 0.76 (0.01) for lip and buccal mucosa respectively.

**Conclusion:** The difference between TG 43 and TG 186 algorithm was dosimetrically evaluated for brachytherapy implants such as lip and buccal mucosa. The difference between these two algorithms for the evaluated implants was found to be subtle. The clinical significance of these differences is not yet known.

**PP-130**

**AN IN-VITRO STUDY FOR DETECTION OF BREAST, LUNG AND COLON MALIGNANCIES USING THE PRINTED CIRCUIT BOARD TECHNOLOGY BASED NANODOSIMETER**

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**Introduction:** The International Agency for Research on Cancer estimated 14.1 million new cancer cases and 8.2 million cancer deaths worldwide in 2012. The WHO estimated 8.8 million cancer deaths in 2015 which included cancer of lung, liver, colorectal, stomach, and breast in the order of 1.690, 0.788, 0.774, 0.754, and 0.571 million respectively. Earlier studies reported that malignant cells can be diagnosed by the exhalation of specific volatile organic compounds (VOCs) which serves as eminent source biomarkers for malignant diagnosis. Lungs emit various VOCs include benzene, ethylbenzene, cyclohexane, methanol, ethanol, dodecane and tridecane, and the breast emit alkanes, alkenes, ketones, halogenated hydrocarbons, aldehydes, alcohols, esters, unsaturated hydrocarbons, terpenes, siloxanes, and aromates. Based on these, we have put forth an attempt to confirm the suitability of an indigenously fabricated multilayer printed circuit board (PCB) technology based hole type 3D positive ion detector to detect breast, lung and colon malignancy.
**PP-131**

**CHARACTERISATION OF A PRINTED CIRCUIT BOARD TECHNOLOGY BASED 3D POSITIVE ION DETECTOR**

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**Introduction:** Nanodosimetry is a new technique for the qualitative and quantitative description of ionizing radiation at nano level. A new hole type 2D position sensitive positive ion detector based on the multilayer printed circuit board (PCB) technology was used to develop a compact track structure detector with nanometric resolution. This technology combines the working principle of thick gas electron multipliers and resistive plate counter. To achieve localized events in nanometric resolution, positive ions rather than electrons were registered in these detectors. The measuring method of these positive ion detectors is based on the detection of single ionization in a gas of low pressure, simulating target volumes of about 1 μm²—2 mass per area.

**Purpose:** To analyze the suitability of the indigenously fabricated multilayer PCB technology based nanodosimeter to detect breast, colon and lung malignancy by collecting the air exhaled by its biopsy tissues.

**Materials and Methods:** The normal lung, breast and colon tissues were collected from a biopsy center with the approval of the human ethics clearance committee. The normal lung, breast and colon tissues were placed separately inside the chamber and it was evacuated in order to remove all other molecules present in the chamber. Then, it is allowed to exhale molecules at various pressures in order to measure the amplitude, rise time, fall time, frequency and number of pulses of the signal. Later, these normal tissues were replaced by cancerous tissues of stage 4 in the evacuated medium and the same was allowed to exhale VOCs to capture signal at various pressures ranging from 1 to 10 Torr. This procedure was repeated for 5 sets of both normal and cancerous tissues of breast, lung, and colon at stage 4 to assure reliability.

**Results and Discussion:** It was observed that the signal amplitude, rise time, fall time, frequency and number of pulses of normal lung, breast and colon tissues was found to be 72.9 Volts, 2.4 ms, 480 μs, 16.6 Hz, 581; 74.1 Volts, 2.4 ms, 480 μs, 38.4 Hz, 781 and 79 Volts, 2.9 ms, 490 μs, 45.2 Hz, 963 respectively. Similarly, the signal amplitude, rise time, fall time, frequency and number of pulses at stage 4 of lung cancer tissues was found to be 86.3 Volts, 1.3 ms, 430 μs, 43.0 Hz, and 3008 from breast cancer tissues: 91.5 Volts, 2.9 ms, 480 μs, 569.6 Hz, and 4077 respectively. The response time of the detector was observed in the order few sec. In this case, the observed pulse height, rise time, fall time, ion drift time, dead time, resolving time, and amplification factor of the detector signal was found to be approximately 156V, 2.5ms, 495μs, 13μs, 2.5ms, 1.24ms, and 1.8 x 105 respectively. The response time of the detector was observed in the order few sec. In this case, the observed rise time, fall time, dead time, resolving time, recovery time amplification factor, operating voltage of GM counter is 150μs, 150μs, 300μs, 450μs, 600μs, 1010, 450V to 850V respectively. Since dead time, recovery time, resolving time and operating voltage of this indigenously fabricated nanodosimeter is small, it is found to be a better instrument than GM counter.

**Conclusion:** The indigenously fabricated multilayer PCB technology based nanodosimeter would be used to detect breast, colon and lung malignancies. The intensity of VOCs present in colon malignant tissues is higher than breast and lung malignant tissues.

**PP-132**

**FABRICATION OF A NOVEL ROUND BOTTOM MICRO-WELL ARRAY CHIP FOR 3D TUMOR CULTURE**

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**Introduction:** 3D tumor culture platforms are emerging tools to investigate the fundamental cell biology, drug development, and in many medical applications. The 3D tumor cultures can reproduce the in vivo tumor microenvironment in terms of mass transport, communication with their environment, and cellular heterogeneity. In spite of many...
developments in tissue culture, the malignant phenotypes, the mechanotransduction between extracellular matrix and cells remain crucial. Hence, biomaterial-based tissue culture platforms that can mimic human physiological conditions have been evolved as an effective technique. Even though there are many techniques such as hanging drops array, coating with organic or inorganic matrices on plastic substrates, and paper-supported scaffold demonstrate the 3D tissue culture, each technique has its own challenges include complexity, poor reproducibility, cell wastage, poor accessibility in cell motility and matrix invasion etc. 

**Purpose:** To fabricate a round bottom micro well array chip using Polydimethylsiloxane (PDMS) to culture tumor spheroids from MCF7 and MDA- MB- 231 cell lines, analyze the cell attachment via biomimetic nano-cilia (triblock copolymers) and optimize its physical and biological characteristics to investigate the bystander effects of radiation and to collect volatile organic compounds (VOCs) exhaled by tumor spheroids.

**Materials and Methods:** To fabricate the µ- U well array chip, a sheet of PDMS was prepared and a hydrophobic material with array of holes was formed. Then the hydrophobic material was patterned on a glass plate followed by pipetting 4 and 5 µl of deionized water. In continuation to this, PDMS gel was poured into the mold and cured for 1 h at 120°C and µ- U well array chip was formed when the glass plate was removed. The ultraviolet sterilized chips were coated with triblock copolymers and known number of MCF7 and MDA- MB- 231 cells along with culture medium were seeded in each well of the chip followed by covering its surface with membrane for incubation over a period of 24 h.

**Results and Discussion:** The novel round bottom micro well array chip that can culture tumor spheroids in 2 days was fabricated successfully. From this study, it is inferred that the tumor spheroid formation efficiency of 5 µl well is better than 4 µl well. If the number of cells seeded is increased, the time taken to form spheroid is also increased. The 3D spheroid formation efficiency of MCF7 cell line is better than MDA- MB- 231 cell line. The spheroid formation efficiency of polycarbonate membrane is better than nylon membrane due to the leakage of medium with nylon membrane. It is also observed that it is possible to transfer the cultured tumor spheroid to a dish without disturbing it. But, these spheroids are stable for 20-30 h in the culture dish as the tumor cells start to migrate in the medium.

**Conclusion:** The PDMS based round bottom micro well array chip is proved as a simple, economic, reproducible and rapid tool to culture MCF7 and MDA- MB- 231 tumor spheroids. The spheroid formation efficiency of the present technique depends on the volume of the well, type and number of cells seeded, size of pores and material of the cover membrane. From this study, it is assured that the present novel round bottom micro well array chip can be used to investigate the bystander effects of radiation and also for VOC collection.

**PP-134**

**INDIRECT ESTIMATION OF ABSORBED DOSE TO WATER FOR CO-60 TELERAPHERY MACHINE**

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**Introduction:** Radiotherapy treatment involves the precise delivery of the prescribed radiation dose to a defined target volume in the cancer patient. The success of radiotherapy depends on the accuracy, precision and conformity of the desired dose distribution over the tumour volume and organs at risk. Therefore high accuracy of dose determination is crucial. In the field of ionizing radiation the absorbed dose is one of the basic quantities used in dosimetry. Ionometric measurement is one of the method based on absorbed dose to water is determined. So far, we do not have absorbed dose to water standard as primary/reference standard in our country. By keeping in view, here efforts were made to derive the absorbed dose to water for Co-60 teletherapy machine using existing absolute air kerma standards available in the laboratory. This paper describes the methodologies adopted to estimate indirectly absorbed dose to water from the charge collected using air kerma standard.

**Materials and Methods:** The charge collected using air kerma to absorbed dose to water is determined.

\[ D_w = \left( \frac{q}{\rho_{\text{air}}} \right) \left( \frac{w}{e} \right) \left( \frac{\mu_{\text{en}}}{\rho} \right) \left( \frac{S}{\rho} \right) \prod k_i \times \left( \frac{1}{\beta} \right) \times \left( \frac{S}{\rho_{\text{air}}} \right) \times \left( \frac{100}{80.5} \right)^2 \times PDD_{\text{Co-60,10x10 cm}^2,10 \text{ cm}} \]

where \( q \) is the measured charge collected for one minute; \( \rho_{\text{air}} = 1.205 \, \text{kg/m}^3, \text{density of air (20 °C and 1013 mbar)} \); \( \frac{w}{e} = 33.97 \, \text{J/C}; \beta \) is the air kerma to absorbed dose to air conversion factor; \( \prod k_i \) are the product of correction factors (recombination factor \( k_p \), stem scattering factor \( k_s \), polarization factor \( k_{polar} \), wall attenuation \( k_{wall} \), axial uniformity \( k_u \) and radial uniformity \( k_r \)); \( V_{\text{air}} \) is the sensitive air volume of the chamber; \( \frac{s}{\rho} \) are the unrestricted mass electronic stopping power graphite to air and water to air media respectively and \( \frac{\mu_{\text{en}}}{\rho} \) is the mass energy absorption coefficient air to graphite medium.
Results: The $D_w$ estimated using above formalism was found equal to 0.1607 Gy/min whereas the $D_w$ measured at Radiation Standards Section by using 0.6 cc cylindrical ionization chamber calibrated at BIPM, France was equal to 0.1561 Gy/min. The values of the absorbed dose to water rate measured using two independent methods are in good agreement to one another within 2.86%. The expanded uncertainty in the measurement of absorbed dose to water using 7.88 cc air volume ionization chamber is 3.2% (k = 2).

Conclusions: It is concluded that absorbed dose to water can be derived indirectly using air kerma standards in Co-60 gamma beam. It is further stated that the present chamber of air volume 7.88 cc qualifies to be a absolute standard for measurement of absorbed dose to water.

References

1. Kumar S, Sharma SD, Chourasiya G, Babu DAR. Design and characterization of graphite cavity ionization chamber as primary standard for air kerma measurement in 60Co beam, Proceeding of 8th International Conference on Advances in Metrology (AdMet 2013), December 21-23, 2013, New Delhi, India.

PP-135

MONTE CARLO STUDY OF RESPONSE OF SOLID STATE DETECTORS FOR RADIOTHERAPY ELECTRON BEAMS

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Purpose: For radiotherapy photon beams Compton scattering is the predominant mode of interaction. Hence, the response of the detector can be understood by using electron density information of the detector materials. However, in case of electron beams, electron density information of the detector materials is not sufficient to understand the response of the detector as the electrons will undergo multiple scattering in the detector materials. Hence, for electron beams, investigation of cavity theory is important to understand the response of the detector. Such investigations can be done using Monte Carlo (MC) methods. Thin detectors mostly behave like an ideal Spencer-Attix cavity and intermediate size detectors which fall in neither large nor small category cavities, general cavity theory proposed by Burlin holds good.

Materials and Methods: The electron beams investigated in the present study were 6 MeV, 9 MeV, 12 MeV, 15 MeV and 18 MeV. The incident electron beam is circular with a radius of 5.64 cm (equivalent field size of 10x10 cm2) at the depth of measurement in the phantom. The energy response correction factor is defined as the ratio of the medium to detector dose ratio for an electron beam energy $E$, to the stopping power ratios. For thin diamond detector, 300 keV was found to be the most suitable at which the diamond detector response agrees well with the Spencer-Attix mass collision stopping power ratios. For other solid-state detectors, the values of electron fluence perturbation correction factors were significantly different from unity for the investigated radiotherapy electron beams. Hence for these detectors electron fluence perturbation correction factors should be applied in order to determine absorbed in a medium for radiotherapy electron beams.

Results: Energy response corrections and detector response of the investigated detectors were calculated as a function of depths ($d_{max}$, $d_{ref}$, 0.1R50, 0.2R50, 0.3R50, 0.4R50, 0.5R50, 0.6R50, 0.7R50, 0.8R50, 0.9R50 and R50) for the radiotherapy electron beams 6 MeV, 9MeV, 12 MeV, 15 MeV and 18 MeV, respectively.

Discussion and Conclusion: The response of the detector does not change significantly with depth for the radiotherapy electron beam energy. These calculated detector responses were compared with the Spencer-Attix mass collision stopping power ratios. For thin diamond detector, 300 keV was found to be the most suitable at which the diamond detector response agrees well with the Spencer-Attix mass collision stopping power ratios. For other solid-state detectors, the values of electron fluence perturbation correction factors were significantly different from unity for the investigated radiotherapy electron beams. Hence for these detectors electron fluence perturbation correction factors should be applied in order to determine absorbed in a medium for radiotherapy electron beams.

PP-136

POLYMERASE CHAIN REACTION- OPTIMIZATION AND TROUBLESHOOTING FOR TP-53 GENE

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Introduction: Polymerase chain reaction (PCR) is a technique used to amplify a desire size of DNA in a large amount of magnitude. Failure in exact size of amplification in PCR leads to the reproduction of multiple orders of undesired products. Literature shows anomaly in P-53 tumor suppressor gene leads 50% of cancer patient. Outcome of radiobiological significance in p53 is still controversial.

Purpose: To optimize the PCR procedure to study the TP-53 gene.

Materials and Methods: The designed TP-53 (Avantor-IDT, Agri Genome Lab Pvt Ltd, Kerala-30) gene primers details along with its sequence and size of the base pair are following:

Exon 4 Forward: 5'TGA GGA CCT GGT CCT CTG AC 3' (413bp)

Exon 4 Reverse: 5'AGA GGA ATC CCA AAG TTC CA 3'

Exon 5 Forward: 5'TTC AAC TCT GTC TCC TTC CT 3' (248bp)

Exon 5 Reverse: 5'CAG TGT CGT CTC TCC AG 3'
The PDD and TPR measurements were performed with various Tm with respect to the individual primer sequence with initial denaturation of 95°C/5 min, followed by 35 cycles of denaturation at 95°C/1 min, the primer Tm was varied for Exon 4 (F and R) (53°C/1 min and 55°C/1 min), Exon 5 (F and R) (53°C/1 min and 61°C/1 min), Exon 6 (F and R) (55°C/1 min and 57°C/1 min), Exon 7 (F and R) (59°C/1 min and 59°C/1 min) and Exon 8 (F and R) (53°C/1 min and 57°C/1 min) with a final extension of 72°C/10 min. Apart from Tm variation, PCR conditions were similar for all amplified regions. The PCR amplified TP-53 gene sequencing sizes were analyzed with 1% of agarose gel electrophoresis. The gel photograph was taken in Syngene gel documentation unit.

Results: The 1% gel image shows, no amplification for all non-DNA PCR reaction. All the exons from 4-8 with 20μl PCR with DNA were successfully amplified with its exact size.

Discussion: Five different Tm were used for the optimization and troubleshooting of exact amplification of TP-53 gene primers of exon 4-8. The exact size amplified melting Tm for exon 4-8 is 55°C/min, 53°C/min, 57°C/min, 59°C/min and 53°C/min respectively.

Conclusion: The protocol to perform PCR of the tumor suppressor gene TP-53 was optimized successfully in terms of optimizing its melting Tm. This optimized PCR reaction would be useful to find the mutation of TP-53 tumor suppressor gene in human genome research.

PP-137

VALIDATION OF TISSUE PHANTOM RATIO OBTAINED FROM PERCENTAGE DEPTH DOSE WITH TPR FROM DIRECT MEASUREMENT IN A WATER PHANTOM

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Aim: To validate the TPR data derived from PDD with TPR from direct measurement in water phantom.

Materials and Methods: The PDD and TPR measurements are done using TRUEBEAM STx Linear accelerator (Varian) at energies 6X, 10X, 15X, 6FFF, 10FFF for field sizes 5 x5cm, 10x10cm, 20x20cm, 30x30cm, 40x40cm. Both PDD and TPR was measured from surface to depth of 20cm. Water scanning system used was 3DScanner (sun) and detector was semiflex 0.125cc (PTW). The 3D scanner system consists of 3D TPR sensor, 3D reservoir for direct measurement of TPR. PDD was measured at SSD 100cm and TPR was measured at SSD 80cm. The measured PDDs were converted to TPR by SNC dosimetry system (sun). The software generated TPR was compared with direct measured TPR. The statistical significance was calculated with paired students t-test.

Results: For 6MV, mean variation in direct measured and system calculated TPR was 1.25-1.81%, 0.14-1.95%, 0.76-1.5%, 0.7-1.36%, 1.15-1.19% for fs of 5x5cm2, 10x10cm2, 20x20cm2, 30x30cm2, 40x40cm2 respectively. For 10MV, mean variation in direct measured and system calculated TPR was 0.07-2.86%, -0.21-1.95%, 0.12-1.77%, -0.05-1.36%, 0.05-1.86% for fs of 5x5cm2, 10x10cm2, 20x20cm2, 30x30cm2, 40x40cm2 respectively. For all fs was found statistically significant with P value. For 15MV, mean variation in direct measured and system calculated TPR was -0.35-2.8%, -0.52-2.99%, -0.21-1.24%, -0.46-1.8%, -0.21-1.23% for fs of 5x5cm2, 10x10cm2, 20x20cm2, 30x30cm2, 40x40cm2 respectively. For all fs was found statistically significant with P value. For 6FFF, mean variation in direct measured and system calculated TPR was 0.33-1.8%, -0.17-1.74%, 0.46-1.37%, 0.3-1.38%, -0.43-1.4% for fs of 5x5cm2, 10x10cm2, 20x20cm2, 30x30cm2, 40x40cm2 respectively. For all fs was found statistically significant with P value. For 10FFF, mean variation in direct measured and system calculated TPR was -0.52-14%, -0.61-0.95%, -0.39-0.73%, -0.77-1.73%, -0.64-1.30% for fs of 5x5cm2, 10x10cm2, 20x20cm2, 30x30cm2, 40x40cm2 respectively. For all energiests was found statistically significant with p value.

Conclusion: From our study we found that average dose error is 1% for 6X, 10X, 15X, 6FFF, 10FFF, so if TPR is not measured directly on machine it may induce 1% uncertainty in dose calculation.

PP-138

AMPLIFICATION OF NRAS GENE BY POLYMER CHAIR REACTION

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Introduction: NRAS gene is a proto-oncogene. The protein symbol of the NRAS gene is P01111-RASN_HUMAN. The NRAS gene provides instructions through a process known as signal transduction, the protein relays signals. When mutated, oncogenes have the potential to cause normal cells to become cancerous. Polymerase chain reaction (PCR) is a technique used to amplify a single copy or a few copies of a segment of DNA. PCR permits early diagnosis of malignant diseases such as leukaemia and lymphomas. PCR assays can directly performed on genomic DNA samples to detect the translocation of specific malignant cells. Since it allows for the isolation and application of tumour suppressors, it is very much used in medical field.

Purpose: To optimize the temperature during the PCR procedure and to find the melting temperature for exact size (230bp) amplification of a proto-oncogene NRAS.

Materials and Methods: The standard DNA isolation technique (S. A. Miller, D. D. Dykes and H. F. Polesky, Nucleic Acid Research, 1988) were used for DNA isolation from EDTA(K3, 2ml) Collected blood samples. Finally we eluted

Exon 6 Forward: 5’GCC TCT GAT TCC CTG AT 3’ (181bp)
Exon 6 Reverse: 5’TTA ACC CCT CCT CCC AGA GA 3’
Exon 7 Forward: 5’CTT GCC ACA ATG TCC CCC AA 3’ (237bp)
Exon 7 Reverse: 5’AGG GGT CAG AGG CAA GCA GA 3’
Exon 8 Forward: 5’TTC TCT ACT GCC TCT TGC TT 3’ (231bp)
Exon 8 Reverse: 5’AGG CAT AAC TGC CTT GG 3’

One ml of healthy volunteer blood was collected in EDTA tube (K3, EDTA-2ml) and the DNA was isolated by the standard method of a simple salting out procedure (S. A. Miller, D. D. Dykes and H. F. Polesky, Nucleic Acid Research, 1988).

Melting temperature (Tm) of the individual primers was calculated by the following equation.

Tm = 2 (A+T) + 4 (G + C)

The 20 μl reaction of PCR was performed with various Tm with respect to the individual primer sequence with initial denaturation of 95°C/5 min, followed by 35 cycles of denaturation at 95°C/1 min, the primer Tm was varied for Exon 4 (F and R) (53°C/1 min and 55°C/1 min), Exon 5 (F and R) (53°C/1 min and 61°C/1 min), Exon 6 (F and R) (55°C/1 min and 57°C/1 min), Exon 7 (F and R) (59°C/1 min and 59°C/1 min) and Exon 8 (F and R) (53°C/1 min and 57°C/1 min) with a final extension of 72°C/10 min. Apart from Tm variation, PCR conditions were similar for all amplified regions. The PCR amplified TP-53 gene sequencing sizes were analyzed with 1% of agarose gel electrophoresis. The gel photograph was taken in Syngene gel documentation unit.

Results: The 1% gel image shows, no amplification for all non-DNA PCR reaction. All the exons from 4-8 with 20μl PCR with DNA were successfully amplified with its exact size.

Discussion: Five different Tm were used for the optimization and troubleshooting of exact amplification of TP-53 gene primers of exon 4-8. The exact size amplified melting Tm for exon 4-8 is 55°C/min, 53°C/min, 57°C/min, 59°C/min and 53°C/min respectively.

Conclusion: The protocol to perform PCR of the tumor suppressor gene TP-53 was optimized successfully in terms of optimizing its melting Tm. This optimized PCR reaction would be useful to find the mutation of TP-53 tumor suppressor gene in human genome research.
with 30µl of DNA with TE buffer. We synthesise NRAS gene (IDT, AVANTOR PERFORMANCE MATERIALS, New Delhi-20) as following
Exon 1- Forward Primer: 5'-CCA AAT GGA AGG TCA CAC TA-3'.
Exon 2- Reverse Primer: 5'-AGA GAC AGG ATC AGG TCA GC-3'.

After that a major optimization procedure involves in the DNA amplification by PCR. The melting temperature of the primer was calculated by the following equation.

**Melting temperature (Tm) = 2 (A+T) + 4 (G+C)**

The PCR steps involves from initialisation heat activation for reaction chamber at a temperature of 95oC/5mins and then denaturation is a heating of reaction chamber by increasing the temperature of 95oC/1min followed by melting temperature for forward primer and reverse primer is 53oC/1min and 97oC/min respectively and finally elongation/extension at 72oC/10min where the length of the strand gets elongated. This denaturation, annealing, elongation is for a single cycle. Likewise we have done 30cycles. In order to identify the PCR amplification we ran gel electrophoresis for PCR samples. The gel was photographed with syngene gel documentation unit.

**Results:** The agarose gel result shows the exact size amplification (230pb) in melting temperature of 49oC. At the same time the non DNA control sample in PCR shows no amplification. Our result shows very good agreement with literature.

**Discussion:** Two different melting temperatures (Tm) were used for the optimization of NRAS gene primers amplification by PCR. From this data, it was found that the melting temperature Tm for exact size (230pb) amplification of a proto-oncogene NRAS is 49oC/min.

**Conclusion:** The protocol to perform Polymerase chain reaction of a proto-oncogene NRAS was optimized successfully in terms of optimizing its melting temperature. This optimized PCR reaction would be useful for mutation detection in the field of oncology.
dose measurements and intracavitary dose measurements. Entrance dose measurements to check the output and performance of the treatment apparatus as well as the accuracy of patient set-up. Exit dose measurements to check the dose calculation algorithm and to determine the influence of shape and density variations of the patient body on the dose calculation procedure a variety of detectors including TLD, diodes and MOSFET are currently available methods.

**Purpose:** This study was to determine the role of in vivo dosimetry with TLD as part of quality control in radiotherapy procedures. In this study we investigate the entrance dose for Ca. Breast radiotherapy treatment using photon beams (6 & 15 MV) and measure skin and thyroid doses.

**Materials and Methods:** TLD measurements were made using from Rexon TLD System. The TLD 100 Chips are made LiF: Mg, Ti with dimension of 3.2x3.2x0.9 mm3 which have high sensitivity for radiation dosimetry. All TLDs were annealed in annealing oven. The read out for TLD-100 at a 100°C preheat temperature and the signal acquired from 100°C to 300°C for TLD-100 with a heating rate of 10°C/s. All measurements have been performed using a 6 & 15 MV X-ray beam produced by Varian Trilogy Machine.

**TLD Calibration:** The TLDs are calibrated in a Plexiglas phantom 30x30x30 cm3 at a depth of 1.5 & 2.7 cm using 6 & 15 MV. The field size of 10x10 cm2 at phantom surface and SSD of 100 cm is employed during the calibration. The accelerators are calibrated according to the IAEA TRS 398.

**InvivoDoseMeasurements:** Entrance Dose Measurements:
Totally 14 patients was taken for the measurements. The expected dose at Dmax was calculated using TPS and the dosimetric data obtained from linear accelerator calibration for each field. The dose evaluation that had sensitivity in the range of ± 3 % from the average response.

**Peripheral Dose Measurements:** Thyroid and skin dose were measured during breast radiotherapy. The TLDs are packed in plastic foil and attached on the surface of the thyroid and at the entrance of the beam at the skin surface during breast radiotherapy. To have high accuracy of dosimetry results for each patient, three TLD chips were placed and the absorbed dose was obtained the average dose by three TLD chips. Three TLD chips were formed as a triangle shape and positioned on the thyroid gland of each patient. Therefore, in this calculation we used surface dose as a thyroid dose.

**Result and Discussion:** The measured entrance dose for the different patients for 6 MV beams is found to be within the ±2.3% compared to the dose and normalized dose at Dmax. The same measurements for 15 MV beams to be found ±2.8 %. An average thyroid skin dose of 3.2% of the prescribed dose was measured per treatment session while the mean skin dose breast treatment session is estimated to be 40% of Dmax, for both internal and external fields. This result has shown reasonable agreement between measured and expected doses.

**Conclusion:** Entrance dose and doses to organ at risk such as thyroid should be carefully evaluated. The risk of thyroid dose due to breast cancer is considerable.

**PP-141**

**AMBIENT DOSE EQUIVALENT H* (10) MEASUREMENT FROM SECONDARY STRAY NEUTRON AND PHOTON AROUND PROTON THERAPY FACILITY**

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**Introduction:** Proton therapy (PT), especially with pencil beam scanning (PBS) technique, offers several advantages compared to photon radiotherapy owing to better dose conformation, lesser normal tissue dose and integral organ dose. However, proton interaction with beam production system, beam transport element and human tissue leads to production of secondary radiation predominantly neutrons of wide energy spectrum and photons through intra nuclear cascade and evaporation and hence demand massive shielding of the facility.

Designing the neutron shielding for a PT facility presents several major challenges due to uncertainties in proton usage estimates, neutron production and attenuation calculations. Even with the best available predictive tools, it remain large and difficult to estimate. Therefore a detail measurement of total ambient dose equivalent H*(10) need to be carried out around the PT facility so as to ensure that the dose limit to occupational workers and public is within the stipulated limits of AERB. In this study, we have carried out an extensive measurement of ambient dose equivalent from secondary stray neutron and gamma radiation around a PT facility. To our knowledge, no literatures are available addressing stray neutron and gamma radiation around PT facility.

**Materials and Methods:** Our center is the first PT facility in South East Asia. It is a multi-room facility equipped with Proteus Plus consisting of C230 isochronous cyclotron, beam transport system (BTS), dedicated nozzles, 6axis robot and 3D image guidance. Proteus Plus can deliver proton beam of 70-228 MeV energies at nozzle exit in PBS mode. The shielding thickness of our facility was calculated using Monte Carlo MCNPX 2.7 code and mix clinical cases. The H*(10) measurement were carried out around the cyclotron vault (CV), BTS and first treatment room (GTR1) using extended-range neutron rem meter WENDI-2 for neutron and SmartIon survey meter for gamma. We have chosen WENDI-2 detector due to its sensitivity from thermal up to 5GeV and well-balanced fluence-to-H*(10) conversion function from ICRP Publication 74.

For the measurement of H*(10), worst case scenarios were simulated to produce maximum secondary neutrons and gammas around CV, BTS and GTR1 i) by setting high beam current, ii) intentionally allowing 228 MeV proton to bombard on nickel beam stopper located at beam degrader and behind deflecting magnet of GTR1 and iii) completely absorbing 228 MeV beam to a 35x35x35 cm3 phantom positioned at isocenter of GTR1. The H*(10) measurement around GTR1 was carried out for four cardinal gantry angles of 0°, 90°, 270° and 180°. A total of 198 measurement positions were identified by mapping MC simulated dose distribution, fundamental physics principle and importance of the zone based on occupancy. For each position, H*(10) from neutron and photons were measured separately for an integrated time of 1 minute each.

**Results:** Out of 198 positions, only locations with maximum measured H*(10) for each zones are presented here. The maximum total (neutron and photon) H*(10) measured at
various locations in µSv/hr around CV are 1.33 (Cyclotron control room), 1.84 (outside CV wall), 2.21 (common wall between CV and treatment room) and 1.23 above CV. Total H*(10) of 4.57 µSv/hr was observed in BTS outer wall which increased to 62 µSv/hr in BTS corridor access wall. Above BTS area, total H*(10) was 0.82 µSv/hr. Ambient total H*(10) measurement around GTR1 at different gantry angles showed maximum value of 21 µSv/hr in treatment control console, 23.4 µSv/hr behind the common wall between GTR1 and GTR2, 4.01 µSv/hr on first floor and 25.7 µSv/hr in the second floor above the isocenter. The time average dose equivalent rate (TADR) calculated for all locations were within the permissible limit of public and occupational workers stipulated by AERB. 

Conclusion: The contribution of neutron in total ambient dose equivalent was observed to be larger than that of photon in majority of the measurement locations. The shielding thickness of our proton facility is adequate to limit the dose to occupational worker and public within the permissible limit stipulated by AERB. The data reported here can be used as a reference for any new and existing proton facility for inter-comparison and validation.

PP-142

PYTHON SCRIPTING FOR ROBUSTNESS EVALUATION IN HYBRID ROBUSTLY OPTIMISED INTENSITY MODULATED PROTON THERAPY TREATMENT PLAN

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Introduction: The major challenge of intensity modulated proton therapy (IMPT) is its higher susceptibility to uncertainties. The two most important sources of errors in IMPT are the beam range and patient setup uncertainties. Recently, a new approach called robust optimization was introduced to consider the uncertainties during the optimization process itself. However, this approach leads to increase in computation time even with GPUBased latest hardware configuration. The increase in planning time is significantly large in a complex clinical case like cranio spinal irradiation (CSI) where multiple isocenter, large field length and field abutment are used. Moreover, the present version of treatment planning system (TPS) can evaluate only one perturbed scenario at a time. The aim of this study is to create a create hybrid, robustly optimized IMPT plan using different beam geometries and to evaluate the robustness of the competing plans using in-house developed python scripting.

Materials and Methods: CT datasets of five mock CSI patients were chosen for this study. For each patient, five different plans (P1 to P5) were generated on RayStation (v7) TPS modelled for protexte plus proton therapy system. Protexte plus can deliver proton pencil beam size of minimum 3 mm sigma in air for 230 MeV proton in scanning mode. It can modulate the energy from 4.1 to 32 g/cm² without any range shifter. The five plans differ in number and geometry of cranial fields while the spine was always treated using two posterior fields. Dose gradient was created in the field abutment region using numerous optimization structures and spot assignment technique. Using our new hybrid optimisation approach, the plans were optimized for the PTV to cover the target and the CTV was robustly optimized with a 3 mm uncertainty in superior-inferior (S-I) direction without range uncertainty to create the dose gradient. In order to evaluate the robustness of these plans towards the set up and range uncertainties, an in house script was written in Iron python 2.7 and implemented through the scripting module available in the ray station TPS. Using this script, all the possible perturbed scenarios in set up with a magnitude of ±3 mm in A-P, S-I and R-L, and range uncertainty of ±3.5% were simulated. For each patient and plan, 16 perturbed dose distribution were created. From the resulting DVHs, worst case decrease in CTV coverage and worst case increase in dosimetric parameters of OARs were evaluated and compared.

Result and Discussion: In every plan, dose values of CTVs and OARs are presented as mean (SD) of five patients. All plans were able to meet our pre-set planning goal of D98% of both CTVs receiving above 99% and 97% of dose in nominal and worst case scenario respectively except in plan P1 & P3 where worst case D98% of brain is 96% and 95% respectively. In all nominal plans, D1% to both lenses are within 3.5 Gy which increases up to 12.4 Gy in worst case scenario. The maximum Dmean (SD) values in Gy to thyroid, heart, oesophagus, lungs and kidneys from nominal plans were 5.11 ± 0.27, 0.34 ± 0.29, 3.49 ± 0.21, 1.86 ± 0.37, 0.34 ± 0.31 respectively. These values increased greatly to 7.67 ± 0.40, 0.737 ± 0.64, 6.01 ± 3.45, 4.32 ± 1.99, 0.77 ± 0.76.

Conclusion: The proposed hybrid robust optimization technique results in significant reduction in treatment planning time. We have developed, tested and successfully implemented in house python script for plan robustness evaluations. All the five tested beam arrangement pass the robust evaluation criteria for target coverage with increase in OAR doses. However, due to physical characteristics of the proton beam and IMPT planning technique dose to all OARs were very less and well within the clinical tolerance limit. Besides robustness, ease to implement a treatment plan need to be considered while finalizing a plan.

PP-143

ANALYSIS OF MOTION OF THE BLADDER DURING VOLUMETRIC MODULATED ARC THERAPY FOR CERVICAL CANCER AND ENDOMETRIAL CANCER USING CONE BEAM COMPUTED TOMOGRAPHY AS POILOT STUDY

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Purpose: Volumetric Modulated Arc therapy (VMRT) is an advanced radiotherapy technique, allows higher conformity of radiation dose to the tumor and minimizes the dose to the organs at risks (OARs). However, the effectiveness of the treatment plans is limited by the variation of shape and size of OARs (e.g., Rectum and bladder in case of pelvic malignancies) lying near to the target volumes. Changes in the daily bladder
In this study a total 5 patients who underwent treatment with volumetric modulated arc therapy (VMAT) technique for cervical cancer were retrospectively analysed. All the patients were instructed to follow the bladder protocol as per our department. CBCT scans are obtained daily during treatment. Bladder volumes were contoured on each CBCT scan following with image fusion with planning CT. The change in bladder position and volumes were evaluated for daily CBCT. The percentage of variation in bladder volumes compared with the planning CT and mean doses to bladder volumes were noted and evaluated.

Results and Discussions: Planning CT and series of CBCTs for individual patient were analyzed in this study. The mean bladder volumes are calculated for each patient and compared with planning CT. The variation between daily bladder volumes ranged between 2.5 % to 25% which is always lower than planning CT volume. The change in position of the bladder was calculated for each patient which are ranged from -0.09 cm to 0.33 cm in lateral, -2.87 cm to 0.63 cm in longitudinal and -1.07 cm to 0.67 cm in vertical directions and the median values are 0.08 cm (lat), -0.13 cm (long), -0.09 cm (ver). The difference in mean dose of bladder in daily and planned CT ranged from 0.97% to 13.7% with median value of 4.5%.

Conclusion: In this pilot study we found that by maintaining strict bladder protocol variation in bladder volume and positional shift was not significant and hence the mean dose in bladder shows very less variation from planning CT. This study will help us to assess the daily bladder filling and gives us the confidence to treat the patients. This study will continue further for larger number of cases to give more feasible outcomes.

DEVELOPMENTS IN MATHEMATICAL EXPRESSIONS TO MAP 3D IONIZATION CLUSTER SIZE DISTRIBUTION IN THE NANODOSIMETER

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Introduction: Nanodosimetry strives to link phenomenological dosimetric concepts like radiation quality and relative biological effectiveness to measurable physical quantities related to the track structure of ionizing radiation. The ultimate goal of nanodosimetry is to determine novel dosimetric quantities such as ionization cluster size distribution. The ionization cluster size is defined as the number of ionizations generated in a target volume of nanometer size and a primary particle and its secondary electrons. The indigenously fabricated nanodosimeter consists of a positive ion detector made up of 576 holes in 52 arrays where each hole represents a detector. At present, the nanodosimeter gives the cumulative signal which is collected from all the 576 detectors. In order to get ionization cluster size distribution three dimensionally, it is necessary to isolate the signal produced by the individual detector. The detector structure has a common detector between two array of detectors, it is possible to isolate the signal by measuring the signal corresponds to each array of detectors and solving a series of linear equations.

Purpose: To disclose the developments in a series of mathematical expressions to map the ionization cluster size distribution of 0.8 µCi activity Co-60 source in the indigenously fabricated nanodosimeter.

Materials and Methods: The present detector consists of three layers namely top, X, and Y layer. These layers are made up of thin gold strips separated by an epoxy resin fiber glass substrate FR4. It has an active area of 2 x 5 cm2, which contains 576 holes of 1 mm diameter with a pitch of 2 mm and thickness of 3.483 mm. The upper (top layer) electrode is formed by gold plated strips common to each row of holes which is kept at ground potential. The second (X) layer of an orthogonal array of strips (26 arrays), kept below the top strip layer, provides a 2D readout of individual cells. The third layer (Y) of readout strips (52 arrays). Each array are separated, connected with the DSO and the signal was captured under methane medium at 1 Torr pressure optimized cathode using the Co-60 source. The spatial ionization distribution (3D) in the path of the beam can be reconstructed by knowing the 2D position of the cell firing and the ion drift time.

Results and Discussion: To isolate the signal, 52 linear equations were written to represent the 52 array of detectors. These equations consist of 52 known variables and 576 unknown variables. After solving all these equations in 3 months, the solution was transferred to MathLab software to get the number of ionization corresponds to each detector. The same software was used to get the ion drift time at individual detector. By knowing the number of ionization in 2D positions and the ion drift time in its location, the ionization cluster size distribution of Co-60 source was mapped three dimensionally.

Conclusion: The indigenously fabricated nanodosimeter would be used to measure the ionization cluster size distribution of any particle track three dimensionally in nanometer resolution.