Mosaiq and IviewGT Software in Verification of Irradiation Set Up (Study of Conformal Radiotherapy in Nasopharyngeal Cancer Patients at Dr. Sardjito Hospital Yogyakarta)

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Abstract. Verification of the irradiation set up is a process to ensure that the position and volume of the irradiated tumor are the same as planned. It is conducted by comparing the radiographic image information of the Treatment Planning System (TPS) with radiation therapy to be provided on the Electronic Portal Imaging Device (EPID). Existing software s on the EPID modality device in this hospital are Mosaiq and IViewGT. This study was to describe the details of the verification process and the differences between two software s in conformal radiotherapy of nasopharyngeal cancer patients. This study was a quantitative analytic study. Samples were fifty-two portal images. Data was analyzed by statistical software. The results are descriptions of the verification process, and the value of shift set up irradiation on X; Y and Z axis. There is no difference statistically between two software s. Mosaiq software is more complicated in image processing. IViewGT software has an advantage in its better simplicity but shows the same quality.

1. Background
Nasopharyngeal carcinoma is a malignancy that has unique epidemiological characteristics, with incidents that vary according to race and geographic differences. In Indonesia, nasopharyngeal cancer is the number 4 cancer after cervical cancer, breast and skin [1]. Several methods are known to treat this cancer such as radiotherapy, surgery, and chemotherapy. Surgery is often constrained by the location and size of the tumor, so it can only take some of the tumor mass or it cannot be done at all. Radiotherapy has a very important role in the treatment of nasopharyngeal cancer [2]. Radiotherapy is used in about half of all malignancies. Radiotherapy uses ionizing radiation that is directed to the tumor and causes damage to the tumor cells but radiation can also cause damage to normal tissue, so it should be directed as accurately as possible to tumor tissue [3].

Verification of radiation set up (geometric) is the process to ensure that the position and volume of the irradiated tumor are the same as planned. The purpose of radiation set-up verification is to ensure that the radiation set-up accuracy of the radiation provided is still within the limits allowed in the
irradiation plan. Verification is done by comparing the image or data information of the treatment planning with radiation therapy provided with the Electronic Portal Imaging Device (EPID) modality device or using the Cone Beam-based CT [1].

Use of Electronic Portal Imaging Device (EPID) is installed on the Linac Elekta modalities using IViewGT software and Mosaiq software. In performing radiation set up verification, orthogonal image portal retrieval process that is set at position Gantry 00 and Gantry 2700 then radiographic image matching between Digital Reconstruction Radiograph (DRR) and image portal is conducted. The matching result is a recommendation of shifting the axis of the examination table towards the lateral, vertical, and longitudinal direction [1].

According to Permenpan Number 29 Year 2013 on Functional Position of Radiographer and Credit Score and Permenkes Number 52 Year 2015 on Technical Guidelines of Functional Position Radiographer and Credit Score, it is explained that a radiotherapist has the task to verify the set-up of irradiation with the device photo portal electronic (EPID) in preparation for external radiotherapy service measures [4] [5].

The previous study has been done in the head and neck area [6] and also in nasopharynx [7]. This research conducted to describe the details of the verification process and the differences between two softwares. Based on the regulations, and accordance with Standard Operational Procedure (SOP) in Radiotherapy Unit Radiology Installation of Dr. Sardjito Hospital Yogyakarta, radiotherapists perform the process of radiation set up verification. The implementation of radiation set up verification on conformal radiotherapy of nasopharyngeal cancer was performed before irradiation at a fraction of irradiation to one, two, three, and four as the subsequent mean and then tenth and twentieth fractions with each shift tolerance of 2 to 3 mm [8]. Those areas needing further research and development are identified by category and recommendations are given, which should also be of interest to equipment manufacturers [9].

2. Research Methods

This study was quantitative analytical study, with aim to determine the difference in the verification of the irradiation set up between the EPID Mosaiq software and IViewGT in conformal radiotherapy of nasopharyngeal cancer. The subjects of this study were images of nasopharyngeal cancer portal in conformal radiotherapy stored in the EPID database. The population in this study were all radiation set up verification on conformal radiotherapy of 60 patients from July 2017 to October 2017. According to [9], the samples used in this study were 52 samples. The result of radiation set up verification is then processed by tabulation. Wilcoxon test was used for determining the difference of radiation set up verification with Mosaiq and IViewGT EPID software s on conformal radiotherapy nasopharyngeal cancer.

3. Results and Discussion

3.1. Verification Process Set Up Irradiation Software

a. Verification Process Set Up Irradiation with Mosaiq Software
The process of verifying the set up of irradiation using Mosaiq software is displayed in Figure 1. Verification process is by matching radiographic images between DRR and image portal with image fusion method and or checkerboard pattern. The correction is obtained by comparing the DRR image generated from TPS planning compared to the image portal. To facilitate field reference radiation detection and anatomical suitability can be done by adjusting the image illumination and filter variation. From the AP and Lateral images automatically, the shift values from the isocenter point are in centimeters on the X-axis (Right-Left), Y-axis (Superior-Inferior) and Z-axis (Anterior-Posterior).

### Table 1. Verification Results Set Up Irradiation in the form of suggestion shift toward X, Y and Z axis

| Offset (Beam) |       |
|--------------|-------|
| Inferior     | 0.1 cm|
| Left         | 0.0 cm|
| Anterior     | 0.0 cm|

The result of radiation set up verification using Mosaiq software in Figure 2 resulted in a value of shifting centration toward the patient’s Y / inferior axis as far as 0.1 cm, and there was no shift of centration on the X-axis (Right-Left) and on the Z-axis (Anterior-Posterior).

b. Verification Process Set Up Irradiation with IViewGT Software

![Figure 2. The process of verifying the set up of irradiation using IViewGT software](image)
After the DRR and Portal image are displayed on the computer screen, it is continued with creating lines on the DRR as field marks to be irradiated and anatomical references. Then match the radiographic image between the DRR and the image portal by the radiation field suitability method and anatomical suitability.

The correction is obtained by comparing the DRR image generated from TPS planning compared to the image portal image. To facilitate radiation and anatomical, field detection can use the illumination setting of the image. From the image of AP obtained the value of shift toward X-axis and Y-axis, whereas from Lateral image obtained the value of shift toward the Y-axis and Z-axis. The value of shift from AP and Lateral image is combined by using the formula of IViewGT software so that it results in value of shift towards X-axis, Y-axis, and Z-axis.

| Table 2. Results Verification Set Up Radiation AP and Lateral |
| ----------------------------------------------------------- |
| IViewGT AP Offset | Horisontal 0,1 mm | Vertical 0,1 mm |
| IViewGT Lateral Offset | Horisontal 0,3 mm | Vertical 0,1 mm |

The result of radiation set up verification using IViewGT software in Table 2, AP projection resulted in a shift value of the centration toward the X-axis as far as 0.1 cm and toward the Y-axis as far as 0.1 cm. The Lateral projection of Table 2, produces a value of shifting of the centration toward the Z-axis as far as 0.0 cm (no shift) and toward the Y-axis as far as 0.1 cm. The displacement value of the AP and Lateral projection is entered into the formula table of the IViewGT software to obtain a shift value toward the left X / lateral axis of the patient as far as 0.1 cm, toward the patient's Y / inferior axis as far as 0.1 cm and on the Z-axis (anterior-posterior) no shifting.

3.2. Verification Result Set Up Irradiation

The result of radiation set up verification on between Mosaiq software with IVViewGT is shown in table 3.

| Table 3. Comparison of radiation set up |
|----------------------------------------|
| Software (axis) | Samples | Mean | Minimum Value | Maximum Value |
| Mosaiq (X-Axis) | 52 | 0,02 | -0,30 | 1,60 |
| IViewGT (X-Axis) | 52 | 0,00 | -1,70 | 0,50 |
| Mosaiq (Y-Axis) | 52 | -0,02 | -0,40 | 0,40 |
| IViewGT (Y-Axis) | 52 | 0,03 | -0,30 | 0,30 |
| Mosaiq (Z-Axis) | 52 | 0,07 | -0,40 | 0,70 |
| IVViewGT (Z-Axis) | 52 | 0,02 | -0,50 | 0,60 |

In table 3, the result of verification of set up irradiation on X-axis, Y-axis, and Z-axis between Mosaiq software with IVViewGT with 52 samples. In the Mosaiq software, the mean value is 0.02 cm on the other side, in the IVViewGT software, the mean value on the X-axis is 0.00 cm, smaller than the Mosaiq software. On the Y-axis Mosaiq software, the mean value is -0.02 cm and, in the IVViewGT software, the mean value on the Y-axis is 0.03 cm, higher than the Mosaiq software. On the Z-axis Mosaiq software, the mean value is 0.07 cm, and in the IVViewGT software, the mean value on the Z-axis is 0.02 cm, smaller than the Mosaiq software.
3.3. Statistical Analysis Comparison Verify Set Up Irradiation

The data normality test of the Mosaiq and IViewGT software on the three axes is non-distributed data. The statistical analysis comparison of verification of set up of irradiation between Mosaiq software with IViewGT is by using Wilcoxon test with a 95% confidence level, with the result there was no difference in the verification of the irradiation set up between Mosaiq EPID software and IViewGT conformal radiotherapy of nasopharyngeal cancer on the X-axis, Y-axis and Z-axis (p-value > 0.05).

| Axis     | p-value | Information    |
|----------|---------|----------------|
| X-axis   | 0.361   | No difference  |
| Y-axis   | 0.102   | No difference  |
| Z-axis   | 0.199   | No difference  |

3.4. Description of Verification Process Set Up Radiation

Verify the set-up of irradiation using Mosaiq software is more complicated when compared to using IViewGT software. In the verification process, the radiotherapist must take some initial steps before the verification begins. The first step is to connect the portal image with the DRR manually by following under the position of AP or Lateral (through image information) then equate the magnification factor. The centration between the DRR with the portal image is adjusted and then select the image display in the process verification (dual view or quad view). The choice of image filters to support the verification process also varies as sharpen, reduce noise, Contrast Limited Adaptive Histogram Equalization (CLAHE), Adaptive Histogram Equalization (AHE), Display Equalization [10].

There is four-way verification method used in Mosaiq software: point, curve, grayscale, or with manual registration. Researchers only use manual registration method in practical use at the hospital.

The verification process of setting up irradiation using IViewGT software is simpler. DRR displays sent from TPS are marked for radiation field reference and anatomical location, and then verification process is done by matching the reference location to the existing portal image. If the position of the AP is verified then the DRR display and portal image will appear automatically in the AP position as well as in the Lateral position [11]. Also with the help of Display Equalization filters, it is enough to assist in the verification process. The Radiotherapist in this hospital prefers to use IViewGT software rather than the Mosaiq software because it is simpler.

3.5. Verification Results Set Up Patient Irradiation

As presented in table 5, the result of verification of set up irradiation on three axes.

| Software Type | X-Axis | Y-Axis | Z-Axis |
|---------------|--------|--------|--------|
| Mosaiq        | 0.02   | -0.02  | 0.07   |
| IViewGT       | 0.00   | -0.03  | 0.02   |

The manual books of software are said to be good if it can detect the slightest shift with the result of shifting away or not equal to zero. So in table 5 it appears that IViewGT software is more accurate on the Y-axis (inferior-superior) as far as -0.03 cm. The Mosaiq software is more accurate on the right-left axis 0.02 cm and the Z-axis (anterior-posterior) as far as 0.07 cm.
The negative value on the mean on the X-axis means the software is shifting the irradiation table to the left and if the positive value means to the right. On the Y-axis the negative value means the software table irradiated out of gantry and the positive value into gantry. The negative value on the mean on the Z-axis means the software table radiation towards the posterior/downward and positive values to anterior/towards the top [11][10]. So based on result, both softwares equally show the same shift direction either on the three axes.

3.6. Analysis Results Comparison of Verification Set Up Radiation between Two Softwares

Based on the result of the different test, the comparison of set up irradiation between Mosaiq software with IViewGT on X-axis has p-value 0.361, on Y-axis has p-value 0.102 and on Z-axis have p-value 0.199. The results of this study statistically showed no difference between two softwares. So it can be concluded that the verification of the set up of irradiation can use Mosaiq software as well as with IViewGT software.

IViewGT software on the X-axis has a minimum value of shift of -1.7 cm and a maximum of 0.5 cm while the software Mosaiq has a minimum value of shifts of -0.3 cm and a maximum of 1.6 cm. IViewGT software on the Y-axis has a minimum value of 0.3 cm shift and a maximum of 0.3 cm while Mosaiq software has a minimum value of shift of -0.4 cm and a maximum of 0.4 cm. IViewGT software on the Z-axis has a minimum shift value of -0.5 cm and a maximum of 0.6 cm while Mosaiq software has a minimum shift value of -0.4 cm and a maximum of 0.7 cm.

From the data then IViewGT Software and Mosaiq software equally have a shift value greater than 2 mm on the X axis, Y-axis and on the Z axis. If the value of the shift is greater than 2-3 mm it must be set up again in accordance with the shift that has been obtained from the software Mosaiq and IViewGT. The second set up is done because in the conformal radiotherapy technique of nasopharyngeal cancer many critical organs can limit the maximum dose to the tumor [8].

Critical organs in the radiation of the nasopharyngeal region include the brainstem, spinal cord, optic chiasm, eye, eye lens, optic nerve, and parotid gland. The conformal radiotherapy technique aims to give lethal doses to the target volume but with the smallest dose on the organ at risk. Errors in set up irradiation when the results of verification exceed 2-3 mm but not set up again will result in critical organs in the nasopharyngeal region which is getting a dose greater than that allowed [3].

In the nasopharyngeal region, the results of radiation set-up verification have a tolerance level of 2-3 mm. If the result is more than 2-3 mm then there is correction of radiation point of radiation according to the recommended from each software with the help of the reference table position towards the X-axis (lateral/right-left), Y-axis (longitudinal/superior-inferior) and Z-axis (vertical/anterior-posterior) and re-verified until the result shows less than 2 mm [8].

The success of radiotherapy with conformal radiotherapy techniques also depends on the distribution of doses of Planning Tumor Volume (PTV) as well as the dose on the organ at risk (an organ at risk) near the target. Given the geometry of the accuracy of the set-up of radiation of the patient is crucial to the success of conformal techniques, it is necessary to evaluate the results of radiotherapy planning such as evaluation on DVH (Dose Volume Histogram) [8].

The previous research has been evaluating conformal radiotherapy technique planning for nasopharyngeal cancer cases. Data is exceeding the tolerance of 3 mm, retrieval of data on Treatment Planning System (TPS). A shift of 0 mm (according to plan), 3mm (tolerance limit), 5mm, 7mm and 10 mm were then compared to PTV (Planning Tumor Volume) and the risky
organ of the data. It is concluded that the magnitude of translation/shift is very influential on the value of PTV. It appears that the larger the displacement/translations, the more the average value of the radiation dose distribution in PTV decreases. If this is left unchecked and not corrected until the end of the irradiation, the possibility is irradiated irradiation targets entirely and there are lower dose and healthy tissue around the tumor getting radiation [7].

The critical organs in conformal radiotherapy of nasopharyngeal cancer are one of the spinal cord organs. The dose to be received by the spinal cord is greater if there is an irradiation of the irradiation set up close to the spinal cord organs. The dose limit for the spinal cord is Dmax <4500 cGy or 1 cc <5000 cGy, if exceeding the threshold limit may result in damage to the organ as may result in paralysis of the patient.

Verification of the accuracy of the position of the set-up of irradiation is essential, in order to fit the objectives of radiotherapy and to improve the effectiveness of conformal radiotherapy techniques. The purpose of verification of the set-up of irradiation is to ensure that the geometric accuracy of the radiation provided is still within limits allowed in the irradiation plan. Accurate, reproducible, reference and image quality planning procedures are essential for successful verification.

The existence of software to process the verification data set up irradiation also plays an important role. The better the portal image quality is generated, the more accurate the data processing as well as the irradiation set up will be. Based on this research, both softwares can produce verification result of set up irradiation with same result. Mosaiq software is more complex in image processing, but IViewGT software is simpler, but either shows no different quality.

4. Conclusion and Suggestion
The process of verification of radiation therapy set up by using Mosaiq software is verification process by matching radiographic image between Digital Reconstruction Radiograph (DRR) and image portal with image fusion method and or a checkerboard pattern, correction is obtained by comparing DRR image generated from TPS planning compared with image portal at AP and Lateral projections. The verification process of radiotherapy set up by using IViewGT software is the verification process by making a line on the DRR as a field mark to be an irradiated and anatomical reference and then match radiographic image between DRR and image portal with radiation field suitability method and anatomical conformity on AP and Lateral projections.

Verification using Mosaiq software got the average shift on the X-axis of 0 cm, on the Y-axis of the average value -0.02 cm, on the axis of Z the average value of 0.07 cm. Verification using IViewGT software obtained an average shift on the X-axis of 0.02 cm, on the Y-axis the average value of 0.03 cm, on the Z-axis the average value of 0.02 cm. The results showed no difference statistically between EPID software Mosaiq and IViewGT on the three axes (p-value > 0.05).

Mosaiq software is more complicated in image processing. IViewGT software has an advantage in its better simplicity but shows the same quality.

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