**Evaluation of Treatment Volume Determination for Irradiation of chordoma: an Original Article**

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**ABSTRACT**

Objective: Chordomas are relatively rare tumors arising from the remnants of the notochord. These locally aggressive tumors may cause destruction of bone and extension into adjacent soft issues. Radiation therapy (RT) may be used as a treatment modality for management of chordomas. Chordomas are considered as radio resistant tumors, and high doses may be required to achieve durable local control rates with irradiation. In this context, treatment volume definition is a critical component of safe and effective radio therapeutic management.

Materials and Methods: Meticulous assessment has been performed on an individual basis for consideration of lesion size, location, symptomatology, patient preferences, and predicted outcomes of management. Treatment volume determination by use of multimodality imaging within corporation of MRI or by computed tomography (CT)-simulation images only was comparatively assessed for patients irradiated for chordoma in our study.

Results: Optimal target coverage and sparing of normal tissues was prioritized in radiation treatment planning. In our study, ground truth target volume has been found to be identical with treatment volume determination based on CT-MR fusion based imaging.

Conclusion: Toxicity profile of radiation delivery is an important aspect of radio therapeutic management given the typically critical location of chordomas in intricate association with vital neurovascular structures. Precision and accuracy in treatment volume definition is a critical component of irradiation for chordoma. Incorporation of MRI in treatment volume determination procedure can be considered for improving the optimization of target volume definition for precise radiation delivery despite the need for further supporting evidence.

Keywords: chordoma, radiation therapy (RT), magnetic resonance imaging (MRI), irradiation

**INTRODUCTION**

Chordomas are relatively rare tumors arising from the remnants of primitive embryonal cells also referred to as the notochord [1-3]. Most frequent locations for chordoma include the skull base and sacrum. A slow growth pattern with an indolent disease course is common, however, these locally aggressive tumors may cause destruction of bone and extension into adjacent soft tissues [4,5]. Affected patients may suffer from several symptoms depending on lesion location. Surgery is a main therapeutic modality for management of chordomas, however, complete surgical resection may not be feasible for tumors in the vicinity of critical neurovascular structures, and local recurrences may represent a considerable concern [5-7]. In this context, radiation therapy (RT) may be used as a treatment modality to address residual disease or recurrences, and also as the primary mode of management in selected patients [7-10]. Irradiation by use of conventionally fractionated RT (CFRT) or radio surgery as Stereotactic Radio surgery (SRS), Fractionated Stereotactic Radiation Therapy (FSRT), and Stereotactic Body Radiation Therapy (SBRT) or Stereotactic Ablative Body Radiotherapy (SABR) may serve as a viable therapeutic option with promising results for management of various central nervous system (CNS) disorders and for many other benign and malignant tumors throughout the human body [11-32]. As for chordomas, the role of irradiation has been addressed in several studies [7-10]. Chordomas are considered as radio resistant tumors, and high doses may be
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required to achieve durable local control rates with irradiation [33]. Toxicity profile of radiation delivery is an important aspect of radio therapeutic management given the typically critical location of chordomas in intricate association with vital neurovascular structures. In this context, treatment volume definition is a critical component of safe and effective radio therapeutic management. In this study, we evaluated incorporation of multimodality imaging for treatment volume determination for irradiation of chordomas.

MATERIALS AND METHODS

Treatment volume determination by use of multimodality imaging with incorporation of MRI or by computed tomography (CT)-simulation images only was comparatively assessed for patients irradiated for chordoma in our study. Ground truth target volume used as reference for actual treatment and comparison purposes has been determined by board-certified radiation oncologists after thorough evaluation, colleague peer review, collaboration, and ultimate consensus. Meticulous assessment has been performed on an individual basis for consideration of lesion size, location, symptomatology, patient preferences, and predicted outcomes of management. CT-simulator (GE Lightspeed RT, GE Healthcare, Chalfont St. Giles, UK) has been utilized for radiation treatment simulation for RT planning at our department. Planning CT images have been acquired and then transferred to the contouring workstation (Sim MD, GE, UK) for delineation of treatment volumes and surrounding critical organs. Either CT-simulation images only or fused CT and MR images have been used for treatment volume determination for irradiation. Treatment volume definition with CT only and by incorporation of CT-MR fusion has been assessed comparatively. Definition of the ground truth target volume has been performed by board-certified radiation oncologists after thorough evaluation, collaboration, colleague peer review and ultimate consensus to be utilized for actual treatment as well as for comparative analysis. Synergy (Eleka, UK) linear accelerator (LINAC) has been used for treatment delivery with routine utilization of Image Guided Radiation Therapy (IGRT) techniques.

RESULTS

Radiation treatment planning has been performed by use of the available treatment planning systems at our tertiary cancer center. Optimal target coverage and sparing of normal tissues was prioritized in radiation treatment planning. Synergy (Eleka, UK) LINAC has been utilized for RT administration. Irradiation treatment volume definition by CT-only imaging and by CT-MR fusion based imaging has been comparatively evaluated. In our study, ground truth target volume defined by board-certified radiation oncologists after thorough assessment, collaboration, colleague peer review, and ultimate consensus has been found to be identical with treatment volume determination based on CT-MR fusion based imaging.

DISCUSSION

Chordomas are relatively rare but locally aggressive tumors with predilection for local recurrence. RT with conventional fractionation or radio surgery has been utilized for improving local control rates and for definitive management in selected cases. Recent years have witnessed considerable achievements in the discipline of radiation oncology with introduction of adaptive RT approaches and state of the art treatment delivery techniques including incorporation of automatic segmentation techniques, molecular imaging methods, Adaptive Radiation Therapy (ART), Image Guided Radiation Therapy (IGRT), Intensity Modulated Radiation Therapy (IMRT), Breathing Adapted Radiation Therapy (BART), and stereotactic irradiation with SRS, FSRT, and SABR [34-44]. Sophisticated technologies including radio surgery may facilitate focused irradiation with robust immobilization and offer improvements in precision and accuracy of radiation treatments, nevertheless, treatment volume determination becomes more important given the high doses of radiation in a single or a few fractions. Accuracy in treatment volume determination is an integral part of successful chordoma irradiation. Defining larger than actual treatment volumes may significantly increase exposure of adjacent normal tissues which may result in excessive radiation induced toxicity. On the other hand, inadequate encompassing of the target volume may lead to treatment failure. At this point, there is an obvious need for improved target volume determination and localization. IGRT techniques may offer improved target localization, and combined use of registered CT and MR images may assist in optimization of treatment volume definition for precise RT delivery. Multimodality imaging for irradiation treatment volume determination has been assessed in
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several studies [45-63]. Our study may add to the literature with regard to addressing of multimodality imaging for treatment volume determination for chordoma irradiation.

In conclusion, precision and accuracy in treatment volume definition is a critical component of irradiation for chordoma. Incorporation of MRI in treatment volume determination procedure can be considered for improving the optimization of target volume definition for precise radiation delivery despite the need for further supporting evidence.

REFERENCES

[1] Sun X, Hornicek F, Schwab JH (2015) Chordoma: an update on the pathophysiology and molecular mechanisms, Curr Rev Musculoskelet Med 2015 8(4):344-352.

[2] Chauvel A, Taillat F, Gille O, Rivel J, Vital JM, et al. (2005) Giant vertebral notochordal rest: a new entity distinct from chordoma. Histopathology 47(6): 646-649.

[3] McMaster ML, Goldstein AM, Bromley CM (2001) Chordoma: incidence and survival patterns in the United States. Cancer Causes Control 12: 1-11.

[4] Chugh R, Tawbi H, Lucas DR, Biermann JS, Schuetze SM, et al. (2007) Chordoma: the nonsarcoma primary bone tumor. Oncologist 12(11):1344-1350.

[5] Samii A, Gerganov VM, Herold C, Hayashi N, Naka T, et al. (2007) Chordomas of the skullbase: surgical management and outcome. J Neurosurg 107:319–324.

[6] Lanzino G, Dumont AS, Lopes MB, Laws ER (2001) Skull base chordomas: overview of disease, management options, and outcome. NeurosurgFocus10:E12.

[7] Walcott BP, Nahed BV, Mohyeldin A, Coumans JV, Kahle KT, et al. (2012) Chordoma: current concepts, management, and future directions. LancetOncol 13: 69-76.

[8] Pennicooke B, Lafer I, Sahgal A, Varga PP, Gokaslan ZL, et al. (2016) Safety and Local Control of Radiation Therapy for Chordoma of the Spine and Sacrum: A Systematic Review. Spine (PhilaPa 1976)41 Suppl 20(Suppl 20):S186-S192.

[9] Casali PG, Stacchiotti S, Sangalli C, Olmi P, Gronchi A (2007) Chordoma. Curr Opin Onco 119:367-370.

[10] Catton C, O’Sullivan B, Bell R, Laperriere N, Cummings B, et al. (1996) Chordoma: long-term follow-up after radical photon irra diation. RadiotherOncol41:67-72.

[11] Sager O, Beyzadeoglu M, Dincoglan F, Demiral S, Gamsiz H, et al. (2020) Multimodality management of cavernous sinus meningiomas with less extensive surgery followed by subsequent irradiation: Implications for an improved toxicity profile. J Surg Oncol 6: 056-061.

[12] Beyzadeoglu M, Sager O, Dincoglan F, Demiral S, Uysal B, et al. (2020) Single Fraction Stereotactic Radiosurgery (SRS) versus Fractionated Stereotactic Radiotherapy (FSRT) for Vestibular Schwannoma (VS). J Surg Oncol6: 062-066.

[13] Dincoglan F, Beyzadeoglu M, Sager O, Demiral S, Uysal B, et al. (2020) A Concise Review of Irradiation for Temporal Bone Chemodectomas (TBC). Arch OtolarngolRhinol 6: 016-020.

[14] Dincoglan F, Sager O, Uysal B, Demiral S, Gamsiz H, et al. (2019) Evaluation of hypofractionated stereotactic radiotherapy (HFSRT) to the resection cavity after surgical resection of brain metastases: A singlecenter experience. Indian J Cancer 56: 202-206.

[15] Dincoglan F, Sager O, Demiral S, Gamsiz H, Uysal B, et al. (2019) Fractionated stereotactic radiosurgery for locally recurrent brain metastases after failed stereotactic radiosurgery. Indian J Cancer 56: 151-156.

[16] Dincoglan F, Sager O, Demiral S, Uysal B, Gamsiz H, et al. (2017) Radio surgery for recurrent glioblastoma: A review article. Neurol Disord Therap 1: 1-5.

[17] Demiral S, Dincoglan F, Sager O, Gamsiz H, Uysal B, et al. (2016) Hypofractionated stereotactic radiotherapy (HFSRT) for WHO grade I anterior clinoid meningiomas (ACM). Jpn J Radiol 34: 730-737.

[18] Gamsiz H, Beyzadeoglu M, Sager O, Demiral S, Dincoglan F, et al. (2015) Evaluation of stereotactic body radiation therapy in the management of adrenal metastases from non-small celllungcancer. Tumori 101: 98-103.

[19] Sager O, Dincoglan F, Beyzadeoglu M (2015) Stereotactic radiosurgery of glomus jugulare tumors: Current concepts, recent advances and future perspectives. CNS Oncol 4: 105-114.

[20] Dincoglan F, Beyzadeoglu M, Sager O, Demiral S, Gamsiz H, et al. (2015) Management of patients with recurrent glioblastoma using hypofractionated stereotactic radiotherapy.Tumori101:179-184.

[21] Demiral S, Beyzadeoglu M, Sager O, Dincoglan F, Gamsiz H, et al. (2014) Evaluation of Linear Accelerator (Linac)-Based Stereotactic Radiosurgery (Srs) for the Treatment of Cranioopharyngiomas. UHOD-Uluslararasi Hematoloji Onkoloji Dergisi 24(2): 123-129.
Evaluation of Treatment Volume Determination for Irradiation of chordoma: an Original Article

[22] Gamsiz H, Beyazedoğlu M, Sager O, Dincoglan F, Demiral S, et al. (2014) Management of pulmonary oligometastases by stereotactic body radiotherapy. Tumori 100: 179-183.

[23] Demiral S, Beyazedoğlu M, Sager O, Dincoglan F, Gamsiz H, et al. (2014) Evaluation of linear accelerator (linac)-based stereotactic radio surgery (srs) for the treatment of craniofacial tumors. UHOD -Uluslararası Hematoloji-Onkoloji Dergisi 24: 123-129.

[24] Dincoglan F, Sager O, Gamsiz H, Uysal B, Demiral S, et al. (2014) Management of patients with ≥ 4 brain metastases using stereotactic radiosurgery boost after whole brain irradiation. Tumori 100: 302-306.

[25] Sager O, Beyazedoğlu M, Dincoglan F, Uysal B, Gamsiz H, et al. (2014) Evaluation of linear accelerator-based stereotactic radiosurgery in the management of glomus jugulare tumors. Tumori 100: 184-188.

[26] Sager O, Beyazedoğlu M, Dincoglan F, Uysal B, Gamsiz H, et al. (2014) Evaluation of linear accelerator (LINAC)-based stereotactic radiosurgery (SRS) for cerebral cavernous malformations: A 15-year single-center experience. Ann Saudi Med 34: 54-58.

[27] Sager O, Beyazedoğlu M, Dincoglan F, Demiral S, Uysal B, et al. (2013) Management of vestibular schwannomas with linear accelerator-based stereotactic radiosurgery: a single center experience. Tumori 99: 617-622.

[28] Dincoglan F, Beyazedoğlu M, Sager O, Uysal B, Demiral S, et al. (2013) Evaluation of linear accelerator-based stereotactic radio surgery in the management of meningiomas: A single center experience. J BUON 18: 717-722.

[29] Demiral S, Beyazedoğlu M, Uysal B, Oysul K, Kahya YE, et al. (2013) Evaluation of stereotactic body radiotherapy (SBRT) boost in the management of endometrial cancer. Neoplasma 60: 322-327.

[30] Dincoglan F, Sager O, Gamsiz H, Uysal B, Demiral S, et al. (2012) Stereotactic radiosurgery for intracranial tumors: A single center experience. Gulhane Med J 54: 190-198.

[31] Dincoglan F, Beyazedoğlu M, Sager O, Oysul K, Sirin S et al. (2012) Image-guided positioning in intracranial non-invasive stereotactic radiosurgery for the treatment of brain metastasis. Tumori 98: 630-635.

[32] Sirin S, Oysul K, Surenkoc S, Sager O, Dincoglan F, et al. (2011) Linear accelerator-based stereotactic radiosurgery in recurrent glioblastoma: A single center experience. Vojnosanit Pregl 68: 961-966.

[33] Stacchiotti S, Sommer J; Chordoma Global Consensus Group (2015) Building a global consensus approach to chordoma: a position paper from the medical and patient community. Lancet Oncol 16:e71-83.

[34] Sager O, Dincoglan F, Demiral S, Uysal B, Gamsiz H, et al. (2020) Adaptive radiation therapy of breast cancer by repeated imaging during irradiation. World J Radiol 12: 68-75.

[35] Sager O, Dincoglan F, Demiral S, Uysal B, Gamsiz H, et al. (2019) Utility of Molecular Imaging with 2-Deoxy-2-[Fluorine-18] Fluoro-Dglucose Positron Emission Tomography (18F-FDG PET) for Small Cell Lung Cancer (SCLC): A Radiation Oncology Perspective.Curr Radiopharm 12: 4-10.

[36] Sager O, Dincoglan F, Demiral S, Uysal B, Gamsiz H, et al. (2019) Breathing adapted radiation therapy for leukemia relapse in the breast: A case report. World J Clin Oncol 10: 369-374.

[37] Sager O, Dincoglan F, Uysal B, Demiral S, Gamsiz H, et al. (2018) Evaluation of adaptive radiotherapy (ART) by use of replanning the tumor bed boost with repeated computed tomography (CT) simulation after whole breast irradiation (WBI) for breast cancer patients having clinically evident seroma. Jpn J Radiol 36: 401-406.

[38] Sager O, Dincoglan F, Uysal B, Demiral S, Gamsiz H, et al. (2017) Splenic Irradiation: A Concise Review of the Literature. J App Hem BiTran 1: 101.

[39] Sager O, Beyazedoğlu M, Dincoglan F, Demiral S, Uysal B, et al. (2015) Adaptive splenic radiotherapy for symptomatic splenomegaly management in myeloproliferative disorders. Tumori 101: 84-90.

[40] Özsavaş EE, Telatar Z, Dirican B, Sağır O, Beyazedoğlu M (2014) Automatic segmentation of anatomical structures from CT scans of thorax for RTP. Comput Math Methods Med 2014: 472890.

[41] Dincoglan F, Beyazedoğlu M, Sager O, Oysul K, Kahya YE, et al. (2013) Dosimetric evaluation of critical organs at risk in mastectomized left-sided breast cancer radiotherapy using breath-hold technique. Tumori 99: 76-82.

[42] Sager O, Beyazedoğlu M, Dincoglan F, Oysul K, Kahya YE, et al. (2012) Evaluation of active breathing control-moderate deep inspiration breath-hold in definitive non-small cell lung cancer radiotherapy. Neoplasma 59: 333-340.
Evaluation of Treatment Volume Determination for Irradiation of chordoma: an Original Article

[43] Sağer Ö, Dinçoğlan F, Gamsiz H, Demiral S, Uysal B, et al. (2012) Evaluation of the impact of integrated [18f]-fluoro-2-deoxy-D-glucose positron emission tomography/computed tomography imaging on staging and radiotherapy treatment volume definition of nonsmall cell lung cancer. Gulhane Med J 54: 220-227.

[44] Sager O, Beyzadeoglu M, Dinçoğlan F, Oysul K, Kahya YE, et al. (2012) The Role of Active Breathing Control-Moderate Deep Inspiration Breath-Hold (ABC-mDIBH) Usage in non-Mastectomized Left-sided Breast Cancer Radiotherapy: A Dosimetric Evaluation. UHOD - Uluslararası Hematoloji-Onkoloji Dergisi 22: 147-155.

[45] Sager O, Dinçoğlan F, Demiral S, Beyzadeoglu M (2020) Evaluation of Target Volume Determination for Irradiation of Pilocytic Astrocytomas: An Original Article. ARC Journal of Cancer Science 6: 1-5.

[46] Demiral S, Beyzadeoglu M, Dinçoğlan F, Sager O (2020) Evaluation of Radiosurgery Target Volume Definition for Tectal Gliomas with Incorporation of Magnetic Resonance Imaging (MRI): An Original Article. Biomedical Journal of Scientific& Technical Research (BJSTR) 27: 20543-20547.

[47] Beyzadeoglu M, Dinçoğlan F, Demiral S, Sager O (2020) Target Volume Determination for Precise Radiation Therapy (RT) of Central Neurocytoma: An Original Article. International Journal of Research Studies in Medical and Health Sciences 5: 29-34.

[48] Sager O, Dinçoğlan F, Demiral S, Beyzadeoglu M (2020) Radiosurgery Treatment Volume Determination for Brain Lymphomas with and without Incorporation of Multimodality Imaging. Journal of Medical Pharmaceutical and Allied Sciences 9: 2398-2404.

[49] Demiral S, Beyzadeoglu M, Dinçoğlan F, Sager O (2020) Assessment of Target Volume Definition for Radio surgery of Atypical Meningiomas with Multimodality Imaging. Journal of Hematology and Oncology Research 3: 14-21.

[50] Beyzadeoglu M, Dinçoğlan F, Sager O, Demiral S (2020) Determination of Radio surgery Treatment Volume for Intracranial Germ Cell Tumors (GCTs). Asian Journal of Pharmacy, Nursing and Medical Sciences 8: 18-23.

[51] Sager O, Demiral S, Dinçoğlan F, Beyzadeoglu M (2020) Target Volume Definition for Stereotactic Radio surgery (SRS) Of Cerebral Cavernous Malformations (CCMs). Canc Therapy & Oncol Int J 15: 555917.

[52] Dinçoğlan F, Demiral S, Sager O, Beyzadeoglu M (2020) Utility of Multimodality Imaging Based Target Volume Definition for Radio surgery of Trigeminal Neuralgia: An Original Article. Biomed J Sci&Tech Res 26: 19728-19732.

[53] Dinçoğlan F, Beyzadeoglu M, Demiral S, Sager O (2020) Assessment of Treatment Volume Definition for Irradiation of Spinal Ependymomas: an Original Article. ARC Journal of Cancer Science 6: 1-6.

[54] Dinçoğlan F, Sager O, Demiral S, Beyzadeoglu M (2019) Incorporation of Multimodality Imaging in Radio surgery Planning for Cranioopharyngiomas: An Original Article. SAJ Cancer Sci 6: 103.

[55] Sager O, Dinçoğlan F, Demiral S, Gamsiz H, Uysal B, et al. (2019) Utility of Magnetic Resonance Imaging (Imaging) in Target Volume Definition for Radiosurgery of Acoustic Neuromas. Int J CancerClin Res 6: 119.

[56] Sager O, Dinçoğlan F, Demiral S, Beyzadeoglu M (2019) Evaluation of Radiosurgery Target Volume Determination for Meningiomas Based on Computed Tomography (CT) And Magnetic Resonance Imaging (MRI). Cancer SciRes Open Access 5: 1-4.

[57] Dinçoğlan F, Sager O, Demiral S, Beyzadeoglu M (2019) Multimodality Imaging for Radio surgical Management of Arteriovenous Malformations. Asian Journal of Pharmacy, Nursing and Medical Sciences 7: 7-12.

[58] Beyzadeoglu M, Sager O, Dinçoğlan F, Demiral S (2019) Evaluation of Target Definition for Stereotactic Reirradiation of Recurrent Glioblastoma. Arch Can Res 7: 3.

[59] Sager O, Dinçoğlan F, Demiral S, Gamsiz H, Uysal B, et al. (2019) Evaluation of the Impact of Magnetic Resonance Imaging (MRI) on Gross Tumor Volume (GTV) Definition for Radiation Treatment Planning (RTP) of Inoperable High Grade Gliomas (HGGs). Concepts in Magnetic Resonance Part A 2019, Article ID 4282754.

[60] Demiral S, Sager O, Dinçoğlan F, Beyzadeoglu M (2019) Assessment of target definition based on Multimodality imaging for radiosurgical Management of glomus jugulare tumors (GJTs). Canc Therapy & Oncol Int J 15: 555909.

[61] Demiral S, Sager O, Dinçoğlan F, Beyzadeoglu M (2019) Assessment ofComputed Tomography (CT) And Magnetic Resonance Imaging (MRI) Based Radiosurgery Treatment Planning for Pituitary Adenomas. CancTherapy & Oncol Int J 13: 555857.
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[62] Demiral S, Sager O, Dincoglan F, Uysal B, Gamsiz H, et al. (2018) Evaluation of Target Volume Determination for Single Session Stereotactic Radio surgery (SRS) of Brain Metastases. Canc Therapy & OncolInt J 12: 555848.

[63] Demiral S, Dincoglan F, Sager O, Uysal B, Gamsiz H, et al. (2018) Contemporary Management of Meningiomas with Radio surgery. Int J Radiol Imaging Technol 80: 187-190.

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