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Reappraisal of Target Definition for Sacrococcygeal Chordoma: Comparative Assessment with Computed Tomography (CT) and Magnetic Resonance Imaging (MRI)

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ABSTRACT

Objective: Chordomas account for a relatively small proportion of intracranial and primary bone tumors. However, they may cause local bone destruction with a typically aggressive disease course. Chordomas arise from embryonic remnants of the primitive notochord. Common localizations for chordoma include the spheno occipital region, sacrococcygeal region, and vertebral bodies. While distant metastasis is typically rare, chordomas may cause mass effect on the brainstem, cranial nerves and the spinal cord. Also, palpable mass may be a presentation for sacrococcygeal chordomas. While surgery remains to play a major role for successful management of sacrococcygeal chordomas, irradiation may serve as a complementary or alternative therapeutic strategy in certain circumstances. In the current study, we aimed at assessing target definition for sacrococcygeal chordomas with comparative evaluation of Computed Tomography (CT) and Magnetic Resonance Imaging (MRI).

Materials and Methods: Primary objective of the current study was focused on target definition for sacrococcygeal chordomas with comparative evaluation of CT and MRI. All included patients were referred for RT at Department of Radiation Oncology at Gulhane Medical Faculty, University of Health Sciences for sacrococcygeal chordoma. We have performed a comparative analysis of target definition by CT simulation images for radiation treatment planning and with MRI.

Results: As the main result of this study, we have found that CT and MRI defined target definition resulted in differences.

Conclusion: In this study, we have found that CT and MRI defined target definition resulted in differences. Thus, fusion of CT and MRI has been utilized for ground truth target volume determination. Our results may have implications for implementation of multimodality imaging for target definition of sacrococcygeal chordomas despite the need for further supporting evidence.

Keywords: Sacrococcygeal Chordoma; Radiation Therapy (RT); Target Definition; Computed Tomography (CT); Magnetic Resonance Imaging (MRI)

Abbreviations: CT: Computed Tomography; MRI: Magnetic Resonance Imaging; EBRT: External Beam Radiation Therapy; IMRT: Intensity Modulated Radiation Therapy; ART: Adaptive Radiation Therapy; AAPM: American Association of Physicists in Medicine; ICRU: International Commission on Radiation Units and Measurements; IGRT: Image Guided Radiotherapy

Introduction

Chordomas account for a relatively small proportion of intracranial and primary bone tumors. However, they may cause local bone destruction with a typically aggressive disease course. Chordomas arise from embryonic remnants of the primitive notochord. Common localizations for chordoma include the sphenooccipital region, sacrococcygeal region, and vertebral bodies. While distant metastasis is typically rare, chordomas may cause mass effect on the brainstem, cranial nerves, and the spinal cord. Also, palpable mass may be a presentation for sacrococcygeal chordomas. Microscopically, physaliphorous cells can be observed [1,2]. Sacrococcygeal chordomas may extend to the sacrum and may manifest as painful swelling within the sacrococcygeal region. Typical findings on Computed Tomography (CT) include an expansile lesion accompanied by peripheral calcification. Magnetic Resonance Imaging (MRI) may serve as an excellent imaging tool for assessment of osseous extent and soft tissue involvement. Both surgery and irradiation may be utilized for management of chordomas [3-11]. Irradiation may be used as an adjuvant or alternative therapeutic approach. External Beam Radiation Therapy (EBRT), particule therapy, and Stereotactic RT techniques may be utilized for effective management. While using higher doses for irradiation may contribute to improved local control outcomes, toxicity profile of radiation delivery should also be taken into account to maintain patient's quality of life.

Several advances have taken place in technology in the millennium era. Molecular imaging methods, Image Guided RT (IGRT), automatic segmentation techniques, Intensity Modulated RT (IMRT), stereotactic RT, and Adaptive RT (ART) have been introduced for optimal radiotherapeutic management of patients [12-49]. Admittedly, improved treatment outcomes may solely be achieved through close collaboration among related disciplines for cancer management. Tumor boards may significantly contribute to bringing together surgical oncologists, radiation oncologists, medical oncologists, imaging and other relevant specialists to discuss about patient, tumor, and treatment characteristics. While surgery remains to play a major role for successful management of sacrococcygeal chordomas, irradiation may serve as a complementary or alternative therapeutic strategy in certain circumstances. In the current study, we aimed at assessing target definition for sacrococcygeal chordomas with comparative evaluation of CT and MRI.

Materials and Methods

At our Department of Radiation Oncology at Gulhane Medical Faculty, University of Health Sciences, we have long been treating a high patient population from several places from Turkey and abroad. Within this context, several benign and malignant tumors have been irradiated at our tertiary cancer center for decades. The primary objective of the current study was focused on target definition for sacrococcygeal chordomas with comparative evaluation of CT and MRI. All included patients were referred for RT at Department of Radiation Oncology at Gulhane Medical Faculty, University of Health Sciences for sacrococcygeal chordoma. We have performed a comparative analysis of target definition by CT simulation images for radiation treatment planning and with MRI. CT simulations of the patients were performed at CT-simulator (GE Lightspeed RT, GE Healthcare, Chalfont St. Giles, UK) available at our institution. Also, MRI of patients have been acquired and used for comparative assessment. A Linear Accelerator (LINAC) with the capability of contemporary IGRT techniques has been utilized for irradiation. After rigid patient immobilization, planning CT images have been acquired at CT simulator for radiation treatment planning. Thereafter, acquired RT planning images have been transferred to the contouring workstation via the network. Treatment volumes and critical organs have been defined on these images and structure sets have been generated. Also, target definition has also been performed on MRI for comparison. All patients have been treated by using state of the art RT techniques at the Department of Radiation Oncology at Gulhane Medical Faculty, University of Health Sciences.

Results

This original research article has been designated for reappraisal of target definition for sacrococcygeal chordomas with comparative evaluation of CT and MRI. Irradiation procedures have been carried out at our Radiation Oncology Department of Gulhane Medical Faculty at University of Health Sciences, Ankara. Prior to treatment, all included patients have been individually evaluated by a multidisciplinary team of experts from surgical oncology and radiation oncology. We considered the reports by American Association of Physicists in Medicine (AAPM) and International Commission on Radiation Units and Measurements (ICRU) for accurate radiation treatment planning. Radiation physicists have generated radiation treatment plans by taking into account the relevant normal tissue dose limitations through meticulous consideration of contemporary guidelines and clinical experience. Tissue heterogeneity, electron density, CT number and HU values in CT images have also been considered by radiation physicists for precise radiation treatment planning. Main endpoint of radiation treatment planning has been to achieve optimal target coverage without violation of normal tissue dose constraints. Image Guided Radiotherapy (IGRT) techniques including kilovoltage cone beam CT and electronic digital portal imaging have been used, and radiation treatment was performed by Synergy (Elekta, UK) LINAC. As the main result of this study, we have found that CT and MRI defined target definition resulted in differences. Thus, fusion of CT and MRI has been utilized for ground truth target volume determination.

Discussion

Chordomas comprise a relatively smaller proportion of intracranial and primary bone tumors. Nevertheless, they may cause local bone destruction with a typically aggressive disease course. Chordomas originate from embryonic remnants of the primitive notochord. Common localizations for chordoma include the sphenooccipital re-

gion, sacrococcygeal region, and vertebral bodies. While distant metastasis is typically rare, chordomas may cause mass effects on the brainstem, cranial nerves, and the spinal cord. Also, palpable mass may be a presentation for sacrococcygeal chordomas. Microscopically, physaliphorous cells can be observed [1,2]. Sacrococcygeal chordomas may extend to the sacrum and may manifest as painful swelling within the sacrococcygeal region. Typical findings on Computed Tomography (CT) include an expansile lesion accompanied by peripheral calcification. Magnetic Resonance Imaging (MRI) may serve as an excellent imaging tool for assessment of osseous extent and soft tissue involvement. Both surgery and irradiation may be utilized for management of chordomas [3-11]. Irradiation may be used as an adjuvant or alternative therapeutic approach. External Beam Radiation Therapy (EBRT), particule therapy, and stereotactic RT techniques may be utilized for effective management. While using higher doses for irradiation may contribute to improved local control outcomes, toxicity profile of radiation delivery should also be taken into account to maintain patient's quality of life. Several advances have taken place in technology in the millennium era.

Molecular imaging methods, Image Guided RT (IGRT), automatic segmentation techniques, Intensity Modulated RT (IMRT), stereotactic RT, and Adaptive RT (ART) have been introduced for optimal radiotherapeutic management of patients [12-49]. Admittedly, improved treatment outcomes may solely be achieved through close collaboration among related disciplines for cancer management. Tumor boards may significantly contribute to bringing together surgical oncologists, radiation oncologists, medical oncologists, imaging and other relevant specialists to discuss about patient, tumor, and treatment characteristics. While surgery remains to play a major role for successful management of sacrococcygeal chordomas, irradiation may serve as a complementary or alternative therapeutic strategy in certain circumstances. In the current study, we aimed at assessing target definition for sacrococcygeal chordomas with comparative evaluation of CT and MRI. At our Department of Radiation Oncology at Gulhane Medical Faculty, University of Health Sciences, we have long been treating a high patient population from several places from Turkey and abroad. Within this context, several benign and malignant tumors have been irradiated at our tertiary cancer center for decades. The primary objective of the current study was focused on target definition for sacrococcygeal chordomas with comparative evaluation of CT and MRI. All included patients were referred for RT at Department of Radiation Oncology at Gulhane Medical Faculty, University of Health Sciences for sacrococcygeal chordoma.

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We considered the reports by American Association of Physicists in Medicine (AAPM) and International Commission on Radiation Units and Measurements (ICRU) for accurate radiation treatment planning. Radiation physicists have generated radiation treatment plans by taking into account the relevant normal tissue dose limitations through meticulous consideration of contemporary guidelines and clinical experience. Tissue heterogeneity, electron density, CT number and HU values in CT images have also been considered by radiation physicists for precise radiation treatment planning. Main endpoint of radiation treatment planning has been to achieve optimal target coverage without violation of normal tissue dose constraints. Image Guided Radiotherapy (IGRT) techniques including kilovoltage cone beam CT and electronic digital portal imaging have been used, and radiation treatment was performed by Synergy (Elekta, UK) LINAC. As the main result of this study, we have found that CT and MRI defined target definition resulted in differences. Thus, fusion of CT and MRI has been utilized for ground truth target volume determination. In the context of radiation oncology, optimal target definition and critical organ sparing may be considered among the critical components of optimal radiotherapeutic management. While definition of larger treatment volumes could lead to excessive radiation induced toxicity, definition of smaller treatment volumes may result in treatment failures. Adaptive RT strategies and multimodality imaging-based target definition have been suggested for achieving improved outcomes [50-102]. In this study, we have found that CT and MRI defined target definition resulted in differences. Thus, fusion of CT and MRI has been utilized for ground truth target volume determination.

Our results may have implications for implementation of multimodality imaging for target definition of sacrococcygeal chordomas despite the need for further supporting evidence.

Conflicts of Interest

There are no conflicts of interest and no acknowledgements.

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