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Research Article

Reappraisal of multimodality imaging for improved Radiation Therapy (RT) target volume determination of recurrent Oral Squamous Cell Carcinoma (OSCC): An original article

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Abstract

Objective: Head and Neck Squamous Cell Carcinoma (HNSCC) is one of the most frequent cancer sites around the globe. Within the heterogeneous group of HNSCC, Oral Squamous Cell Carcinoma (OSCC) deserves the utmost attention as an important subsite. Despite multimodality management, recurrence of OSCC is not uncommon. RT may play an integral role as part of initial management or as adjunctive therapy, or for treatment of recurrent disease. In this study, we evaluate multimodality imaging-based RT treatment volume definition for irradiation of recurrent OSCC.

Materials and methods: Multimodality imaging-based RT treatment volume definition for radiotherapeutic management of recurrent OSCC was assessed. RT target volume determination by incorporation of Magnetic Resonance Imaging (MRI) or by Computed Tomography (CT)-simulation images only has been evaluated and comparative analysis has been performed for patients receiving salvage RT for recurrent OSCC.

Results: Ground truth target volume has been found to be identical with treatment volume definition by CT-MR fusion-based imaging.

Conclusion: Incorporation of MRI in target and treatment volume definition may improve target and treatment volume definition for recurrent OSCC.

Introduction

Head and neck squamous cell carcinoma (HNSCC) is one of the most frequent cancer sites around the globe [1]. Within the heterogeneous group of HNSCC, oral squamous cell carcinoma (OSCC) deserves the utmost attention as an important subsite [1-3]. Incidence of OSCC varies among different geographical regions, and risk factors for OSCC development include exposure to exogenous carcinogens such as tobacco smoke and alcohol consumption. Given the rich lymphatic submucosal plexus, OSCC may have a tendency for involving ipsilateral or bilateral neck lymph nodes. Affected patients may suffer from several symptoms depending on lesion size and association with critical structures. Management options for OSCC include surgery, RT, and systemic therapies which may be utilized either alone or in combination with respect to clinical stage, tumor, and pathological characteristics. Despite multimodality management, recurrence of OSCC is not uncommon [1-3]. RT may play an integral role as part of initial management or as adjunctive therapy, or for treatment of recurrent disease [1-3]. With the introduction of innovatory and contemporary technologies, there has been a rising trend towards improving the toxicity profile of radiation delivery by incorporation of state-of-the-art RT delivery techniques. Image-Guided Radiation Therapy (IGRT), Intensity Modulated Radiation Therapy (IMRT), Adaptive Radiation Therapy (ART), and several other

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radiotherapeutic strategies have contributed to the increased adoption of contemporary irradiation approaches into clinical practice. In the context of recurrent OSCC management, RT may have utility as a viable salvage therapeutic option [1-3]. However, accuracy and precision in target volume definition are critical for optimal radiotherapeutic management. Herein, we evaluate multimodality imaging-based RT treatment volume definition for irradiation of recurrent OSCC.

Materials and methods

In this study, multimodality imaging-based RT treatment volume definition for radiotherapeutic management of recurrent OSCC was assessed. Written informed consents of all patients were acquired before treatment with institutional tumor board approval at our tertiary cancer center, and the study was performed in compliance with the Declaration of Helsinki principles and its later amendments.

RT target volume determination by incorporation of Magnetic Resonance Imaging (MRI) or by Computed Tomography (CT)-simulation images only has been evaluated and comparative analysis has been performed for 18 patients receiving salvage RT for recurrent OSCC. Ground truth target volume serving as the reference for actual treatment and comparison purposes was determined by an expert group of radiation oncologists following meticulous assessment, colleague peer review, detailed discussion, and consensus. All patients have been thoroughly assessed by a multidisciplinary team with consideration of lesion size, localization, and association with surrounding critical structures, symptomatology, and expected outcomes of reirradiation. CT-simulator (GE Lightspeed RT, GE Healthcare, Chalfont St. Giles, UK) was utilized for RT simulation for treatment planning. Planning CT images were taken and then transferred to the delineation workstation (SimMD, GE, UK) via the network for delineation of treatment volumes and surrounding critical structures. Either CT-simulation images only or fused CT and MR images have been used for treatment volume definition.

Planning CT images were fused with T1 contrast-enhanced volumetric MR images. By incorporating MR images in the target definition process, we primarily aimed to take advantage of 2 imaging modalities. Treatment volume definition with CT only and with the incorporation of CT-MR fusion was comparatively evaluated. Synergy (Elekta, UK) linear accelerator (LINAC) was used for precise RT with routine incorporation of IGRT techniques including electronic digital portal imaging and kilovoltage cone-beam CT for treatment verification.

Results

Out of the 18 patients, 11 patients received reirradiation and 7 patients received were treated with de novo RT for salvage management of recurrent OSCC. At our tertiary cancer center, radiation treatment planning was performed by contemporary RT treatment planning systems. Optimal target volume coverage was prioritized while maintaining minimized exposure of surrounding critical structures. Definition of ground truth target volume was performed by an expert group of radiation oncologists after collaborative detailed collaborative evaluation, colleague peer review, detailed discussion, and consensus to be utilized for actual treatment and for comparative assessment. Synergy (Elekta, UK) LINAC has been utilized for the delivery of treatment with routine incorporation of IGRT techniques such as kilovoltage cone-beam CT and electronic digital portal imaging. Target volume definition by CT-only imaging and by CT-MR fusion-based imaging was evaluated with comparative analysis. Ground truth target volume has been found to be identical with treatment volume definition by CT-MR fusion-based imaging.

Discussion

Tumors of the head and neck region pose a formidable therapeutic challenge to the treating physicians due to their critical location in the vicinity of several critical structures associated with vital functions. Within this context, every effort should be made to avoid injury to normal tissues while treating these tumors. OSCC tends to recur even after multidisciplinary management by surgery, RT, and systemic therapy [1-3]. Salvage treatment of recurrent OSCC with RT is a complex procedure that may be hampered by the delivered radiation dose for initial management. Within this context, accuracy in target volume determination emerged as a critical part of current RT approaches with the inclusion of state-of-the-art irradiation techniques and modalities. Precisely focused RT to well-defined targets may be achieved by the use of radiosurgery with robust stereotactic immobilization and image guidance. Nevertheless, accuracy and precision in target volume determination are critical for avoiding geographic misses, treatment failures, and radiation-induced adverse effects. While the determination of larger than actual treatment volumes may lead to increased radiation doses to surrounding normal tissues with resultant toxicity, outlining of smaller than actual treatment volumes may result in treatment failures. In this regard, there is an emerging requirement for improving target volume determination. IGRT techniques may result in improved target localization and using matched CT and MR images may allow for precise treatment volume determination for RT. There is a growing body of data supporting the utility of multimodality imaging-based treatment volume determination for a variety of indications [4-35]. From this standpoint, our study may add to the accumulating data about the incorporation of multimodality imaging-based target volume determination for recurrent OSCC management with salvage RT.

Indeed, the emergence of novel technologies and therapeutic strategies may lead to achieving an improved toxicity profile of RT. Using ablative doses of RT may improve tumor eradication whilst maintaining optimal critical organ sparing and result in better outcomes for recurrent OSCC management. At this point, precision in treatment volume determination emerged as a critical aspect of recent RT approaches. The Millenium era has come up with unprecedented advances with critical improvements in the radiation oncology discipline through the incorporation of up to date treatment equipment and adaptive RT approaches, Adaptive Radiation Therapy (ART), Breathing Adapted Radiation Therapy (BART), IGRT, IMRT, molecular

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imaging methods, automatic segmentation techniques, and stereotactic RT [36-73].

This study is not devoid of limitations. Nevertheless, we conclude that the incorporation of MRI in target and treatment volume definition may improve target and treatment volume definition for recurrent OSCC.

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