Cancer Therapy & Oncology
International Journal
ISSN: 2473-554X

Juniper Publishers
key to the Researchers

Research Article
Volume 21 Issue 3 - May 2022
DOI: 10.19080/CTOIJ.2022.21.556062

Cancer Ther Oncol Int J

Improved Target Volume Definition for Radiotherapeutic Management of Parotid Gland Cancers by use of Multimodality Imaging: An Original Article

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Submission: April 28, 2022; **Published:** May 10, 2022

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Abstract

Objective: Parotid gland cancers account for the majority of salivary gland malignancies. In terms of management, surgical resection is a principal treatment modality. Total parotidectomy is a widely accepted surgical procedure, however, there may be the risk for facial nerve palsy. Radiation therapy (RT) has a well-established role for management of parotid gland cancers. RT may serve as a treatment modality for definitive management in the setting of inoperability. Also, RT may have an integral role as part of multidisciplinary management or as salvage therapy for recurrent disease. Clinical target volume definition is a critical part of radiotherapeutic management, and should be performed vigilantly to achieve optimal treatment results. Herein, we evaluate target volume definition for radiotherapeutic management of parotid gland cancers by use of multimodality imaging.

Materials and methods: Either the CT-simulation images only or registered CT and MR images were utilized for target volume determination of patients with parotid gland cancers who were referred for RT at Department of Radiation Oncology, Gulhane Medical Faculty, University of Health Sciences. A comparative analysis has been performed to assess target definition by CT only and with incorporation of CT-MR registration based imaging.

Results: Patients referred to Department of Radiation Oncology, Gulhane Medical Faculty, University of Health Sciences for radiotherapeutic management of parotid gland cancers were assessed for target volume definition by CT-only imaging or CT-MR registration based imaging in this study. Ground truth target volume was found to be identical with CT-MR registration based imaging in this study for radiotherapeutic management of parotid gland cancers.

Conclusion: This study reveals improved treatment volume determination for parotid gland cancers by incorporating of MRI in the RT treatment planning procedure despite the need for further supporting evidence.

Keywords: Parotid gland cancer; Radiation therapy (RT); Magnetic resonance imaging (MRI)

Introduction

Salivary gland neoplasms are relatively rare tumors of the head and neck region, however, they include a great variety of histological types which renders them a formidable challenge for imaging specialists and clinicians. There is a wide range of differential diagnoses which may effect both prognosis and management strategies. Patients with salivary gland neoplasms may suffer from a variety of symptoms based on lesion size, localization, and association with critical structures. The head and neck region composes a relatively smaller part of the human body, nevertheless, it includes very important parts associated with critical functions. Within this context, optimal management of tumors located in this critical body region is mandatory to avoid functional impairments along with quality of life deterioration.

Imaging may have a major role for assessment of salivary gland neoplasms [1-5]. Differentiation between benign and malign tumors may be challenging, however, imaging characteristics may assist in resolving this critical issue. Preoperative localization of the lesions may be detected by imaging. Also, imaging may allow

for characterization of the tumors along with documentation of locoregional extension, perineural spread, and nodal involvement. Another utility of imaging is for differential diagnosis, detecting recurrent disease, assesseing treatment response, and predicting malign transformations.

Parotid gland cancers account for the majority of salivary gland malignancies. In terms of management, surgical resection is a principal treatment modality [6-10]. Total parotidectomy is a widely accepted surgical procedure, however, there may be the risk for facial nerve palsy. Radiation therapy (RT) has a well-established role for management of parotid gland cancers [11-18]. RT may serve as a treatment modality for definitive management in the setting of inoperability. Also, RT may have an integral role as part of multidisciplinary management or as salvage therapy for recurrent disease. Adjuvant RT in the postoperative setting may be utilized for T3 or T4 tumors, bone invasion, incomplete or close resection margins, and pathological lymph node positivity.

Clinical target volume definition is a critical part of radiotherapeutic management, and should be performed vigilantly to achieve optimal treatment results [19]. It is very important to improve target definition for radiotherapeutic management of parotid gland cancers in the era of sophisticated RT techniques including Intensity Modulated Radiation Therapy (IMRT), Image Guided Radiation Therapy (IGRT), Adaptive Radiation Therapy (ART). Robust immobilization techniques, multimodality imaging and image fusion methods have clearly contributed to achieving optimized radiotherapeutic results. While current RT practice mostly utilizes Computed Tomography (CT) imaging for treatment simulation, additional information from other imaging modalities may assist in improved delineation of target volumes and critical structures. Herein, we evaluate target volume definition for radiotherapeutic management of parotid gland cancers by use of multimodality imaging.

Materials and Methods

A comparative analysis has been performed in this study to investigate whether multimodality imaging may improve target volume definition along with interobserver and intraobserver variations for radiotherapeutic management of parotid gland cancers. For this purpose, we comparatively evaluated RT target volume determination by integrating Magnetic Resonance Imaging (MRI) or by CT-simulation images only. For actual treatment and comparison purposes, a ground truth target volume was defined for each patient on a collaborative basis by board certified radiation oncologists after detailed assessment, colleague peer review, and consensus. Referred patients had parotid gland cancers, and treatment with RT was decided after thorough multidisciplinary evaluation on an individual basis. Appropriate treatment strategies and protocols were considered by taking into account patient, tumor, and treatment characteristics. Lesion sizes, localizations and association with normal tissues, expected outcomes of management, patient symptomatology and preferences along with logistical issues were discussed before the decision making process.

RT has been delivered by Synergy (Elekta, UK) linear accelerator (LINAC) available at our tertiary referral institution. CT-simulation was performed for all patients at CT-simulator (GE Lightspeed RT, GE Healthcare, Chalfont St. Giles, UK) in order to acquire high quality treatment planning images. After CT-simulation has been completed, acquired treatment planning images have been transferred to the contouring workstation (SimMD, GE, UK) by use of the network. Structure sets including treatment volumes and critical structures were defined. Either the CT-simulation images only or registered CT and MR images were utilized for target volume determination. A comparative analysis has been performed to assess target definition by CT only and with incorporation of CT-MR registration based imaging.

Results

Patients referred to Department of Radiation Oncology, Gulhane Medical Faculty, University of Health Sciences for radiotherapeutic management of parotid gland cancers were assessed for target volume definition by CT-only imaging or CT-MR registration based imaging in this study. Assessed tumor related parameters included the T staging, bony invasion, status of resection margins in the setting of surgery, and pathological lymph node positivity and other characteristics. Also, patient age, symptomatology, performance status, lesion location and association with critical structures were considered. We made use of reports by American Association of Physicists in Medicine (AAPM) and International Commission on Radiation Units and Measurements (ICRU) in RT treatment planning. In light of current guidelines and clinical experience, radiation physicists have generated plans with consideration of relevant critical organ dose constraints. Tissue heterogeneity. electron density, CT number and HU values in CT images were among the considered parameters by the radiation physicist in RT treatment planning. A pertinent aspect of treatment planning included achieving optimal treatment volume coverage without violation of critical organ dose constraints. The determination of ground truth target volume was done by board certified radiation oncologists following detailed assessment, colleague peer review, and consensus. Ground truth target volume was utilized for actual treatment and for comparison purposes. Treatment delivery was accomplished by incorporation of IGRT techniques such as kilovoltage cone beam CT and electronic digital portal imaging. Ground truth target volume was found to be identical with CT-MR registration based imaging in this study for radiotherapeutic management of parotid gland cancers.

How to cite this article: Selcuk D, Omer S, Ferrat D, Murat B. Improved Target Volume Definition for Radiotherapeutic Management of Parotid Gland Cancers by use of Multimodality Imaging: An Original Article. Canc Therapy & Oncol Int J. 2022; 21(3): 556062. DOI: 10.19080/CTOIJ.2022.21.556062

Discussion

Although salivary gland neoplasms account for a relatively smaller proportion of head and neck cancers, they include a variety of histological types. Imaging specialists and clinicians may have difficulties in diagnosis, and there may be a wide range of differential diagnoses. Patient symptomatology may vary with regard to lesion size, localization, and association with critical structures. The head and neck region is a relatively smaller portion of the human body, however, this critical region includes very important parts which are associated with critical body functions. Thus, it is imperative to consider adverse effects of therapies to get rid of functional impairments and quality of life deterioration.

Imaging techniques play an essential role in evaluation of salivary gland neoplasms [1-5]. It may be typically challenging to differentiate between benign and malign tumors, nevertheless, certain imaging characteristics may aid in differentiation. Preoperative tumor localization may be detected by imaging modalities. Imaging may also allow for tumoral characterization and documentation of critical characteristics including locoregional extension, perineural spread, and nodal involvement. Differential diagnosis, detection of recurrent disease, treatment response evaluation, and prediction of malign transformations may also be facilitated by use of imaging techniques.

Parotid gland cancers constitute the majority of salivary gland malignancies. Surgery is a main therapeutic modality [6-10]. A very common procedure for surgical resection is total parotidectomy, nevertheless, there may be the risk for facial nerve palsy. RT plays a significant role for management of parotid gland cancers [11-18]. RT may be used for definitive management in the setting of inoperability, and also may play a critical role as part of multidisciplinary management or as salvage therapy for recurrent disease. Indications for adjuvant RT in the postoperative setting may include T3 or T4 tumors, bone invasion, incomplete or close resection margins, and pathological lymph node positivity. Definition of the clinical target volume may be a complex procedure, and should be performed carefully for optimal radiotherapeutic management [19]. Multimodality imaging technologies and image fusion methods have improved target definition for several cancers. There is accumulating data supporting the utility of multimodality imaging for target definition of many tumors [20-52]. In the current RT practice, most commonly utilized imaging modality for treatment simulation purposes includes the CT. However, MRI may offer additional advantages over CT and may aid in improved target definition. In our study, ground truth target volume was found to be identical with CT-MR registration based imaging for radiotherapeutic management of parotid gland cancers. Our study may add to the growing body of evidence suggesting improved target volume determination by use of multimodality imaging.

There have been many advances in the context of radiation oncology recently with introduction of molecular imaging methods, automatic segmentation techniques, stereotactic RT, IMRT, IGRT, and ART [53-90]. In light of these advances, precision and accuracy in target volume definition has gained utmost importance. Within this context, our study may have clinical implications for routine incorporation of multimodality imaging in radiotherapeutic management of parotid gland cancers.

In conclusion, this study reveals improved treatment volume determination for parotid gland cancers by incorporating of MRI in the RT treatment planning procedure despite the need for further supporting evidence.

Conflict of Interest

There are no conflicts of interest and no acknowledgements.

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How to cite this article: Selcuk D, Omer S, Ferrat D, Murat B. Improved Target Volume Definition for Radiotherapeutic Management of Parotid Gland Cancers by use of Multimodality Imaging: An Original Article. Canc Therapy & Oncol Int J. 2022; 21(3): 556062. DOI: 10.19080/CTOIJ.2022.21.556062

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DOI: 10.19080/CTOIJ.2022.21.556062

How to cite this article: Selcuk D, Omer S, Ferrat D, Murat B. Improved Target Volume Definition for Radiotherapeutic Management of Parotid Gland Cancers by use of Multimodality Imaging: An Original Article. Canc Therapy & Oncol Int J. 2022; 21(3): 556062. DOI: 10.19080/CTOIJ.2022.21.556062