ABSTRACT

Background: Uncertainty and inconsistency are observed in target volume delineation in head and neck tumors based on CT imaging. Recently, MRI is being increasingly used in oncology. Improved characterization of soft tissues and visualization of tumour extent using CT-MRI fusion can benefit the radiotherapy treatment planning.

Objectives: To determine gross tumour volume (GTV) on CT simulation scans of the patients with head and neck squamous cell carcinoma planned for radiotherapy, to fuse CT simulation scans with MRI scans and determine gross tumour volume (GTV), to compare the gross tumour volume (GTV) in cubic centimeter contoured on CT simulation scans and fused CT-MRI scans. Methodology: Estimated sample size of 20 patients with head and neck carcinoma. After immobilization and CT simulation of patient, MRI scans and later fusion of CT-MRI images was done along with contouring of tumour target. Results: Significant differences were noted. CT-based target volumes were 20-30% larger than CT-MRI fused volumes. The use of CT-based targets lead to overdosing of normal tissues. Volumes contoured from fused CT-MRI images was smaller than CT, indicating that MRI is a potent imaging tool for delineating tumours surrounded by soft tissue. These results illustrate, CT-MRI are complementary, i.e. tumour extension seen on CT are not always noted on MRI and vice versa. Conclusions: Combined information of CT, axial MRI/sagittal MRI should be used to delineate the GTV, especially when CT and MRI derived GTVs are inconclusive about tumour extensions. Efforts should be made to judge both imaging modalities simultaneously.

KEYWORDS: Radiotherapy, Head and neck radiotherapy planning, CT scan- MRI fusion, target delineation.

1. INTRODUCTION

The incidence of Head and Neck cancers is increasing globally and now is the fourth most common malignant disease in the world.[1] Radiotherapy plays an important role in head and neck cancer either alone or in combination with surgery and chemotherapy. The function and organ preservation has been achieved with the use of concurrent chemoradiation and radiotherapy in pharyngeal and laryngeal cancers.

The radiation treatment has evolved from two dimensional conventional radiotherapy to the present era of image guided radiation therapy. Advances in computer and linear accelerator technology have significantly impacted treatment of head and neck cancers by improving our ability to maximize tumour dose while minimizing the dose to adjacent normal critical structures. Image-based treatment planning and multi leaf collimators have both been widely implemented, facilitating both the planning and delivery of three-dimensional conformal radiation therapy (3DCRT) and intensity-modulated radiation therapy (IMRT). IMRT is capable of generating significant dose gradients between the target volume and adjacent tissue structures to accomplish the intended dose-volume prescription. Inadequate coverage in the treatment volume can result in tumour recurrence. Because of this specific feature, adequate target volume delineation is absolutely essential. Precise GTV delineation depends on very thorough and adequate imaging studies. Uncertainty and inconsistency are observed in target volume delineation in the head and neck region for radiotherapy treatment planning based only on CT imaging. This step remains the most crucial and difficult part of the radiotherapy planning process, otherwise the geographical miss of the tumour of a systematic error will be perpetuated throughout therapy.[2] Recently, MRI is being increasingly used in oncology for staging, assessing tumour response and evaluating disease recurrence.[2,3] Improved characterization of soft tissues and visualization of tumour extent using MRI can be used to benefit the radiotherapy treatment planning.[3] Hence, it is strongly encouraged to fuse the diagnostic...
MRI, CT and /or positron emission tomography (PET/CT) scans with the treatment planning CT to further assist the radiation oncologist in GTV delineation.

Three dimensional treatment planning
CT simulation allows more accurate definition of target volume, anatomy of critical normal structures in three-dimensional (3D) treatment planning to optimize dose distribution and radiographic verification of volume treated. Advances in computer technology have augmented accurate and timely computation, display of 3D radiation dose distributions, and dose-volume histograms that yield relevant information for evaluation of tumour extent, definition of target volume, delineation of normal tissues, virtual simulation of therapy, generation of digitally reconstructed radiographs, design of treatment portals and aids, calculation of 3D dose distributions and dose optimizations and critical evaluation of the treatment plan.

Dose-Volume histograms are useful in assessing several treatment plan dose distribution and provide a complete summary of the entire 3D dose matrix, showing the amount of target volume or critical structure receiving more than the specified dose. They do not provide spatial dose information and cannot replace other methods of dose display. Three dimensional treatment planning systems play an important role in treatment verification. Digitally reconstructed radiographs based on sequential CT slice data generate a simulation film that can be used in portal localization and for comparison with the treatment portal film for verifying treatment geometry. Increased sophistication in treatment planning requires precision in patient repositioning and immobilization as well as in portal verification techniques. On-line verification systems allow monitoring of the position of the area to be treated during radiation exposure. Computer-aided integration of data generated by 3D radiation treatment planning along with parameters used on the treatment machine, including gantry and couch position, may decrease localization errors and enhance the precision and efficiency of irradiation.

MRI in radiotherapy planning
MRI is being increasingly used in oncology for staging, assessing tumour response and also for treatment planning in radiotherapy. Both conformal and intensity-modulated radiotherapy requires improved means of defining target volume for treatment planning in order to achieve its intended benefits. MRI can add to the radiotherapy treatment planning (RTP) process by providing excellent and improved characterization of soft tissues compared with CT. Together with its multiplanar capability and increased imaging functionality, these advantages for target volume delineation outweigh its drawbacks of tracking electron density information and potential image distortion. Efficient MR distortion assessment and correlation algorithms together with image co-registration and fusion programs can overcome these limitations and permit its use for RTP. MRI developments to name a few are using new contrast media, such as ultra-small super paramagnetic iron oxide particles for abnormal lymph node identification, techniques such as dynamic contrast enhanced MRI and diffusion MRI to better characterize tissue and tumour regions as well as ultrafast volumetric or cine MR sequences to define temporal patterns of target and organ at risk, deformity and variations in spatial location. These have all increased the scope and utility of MRI for RTP.

Information from these MR developments may permit treatment individualization, Strategies of dose escalation and image-guided radiotherapy. These developments will be reviewed to assess their current and potential use for RTP and precision high dose therapy. Head and neck anatomy is complex and the extent of the infiltrating tumour can be difficult to define. MRI can assist in delineation of radiotherapy volumes here. It is useful for defining longitudinal tumour infiltration along the upper aero-digestive tract and fascial planes, E.g.: pre-vertebral fascia, tumour infiltration of soft tissue structures and tissue planes such as the pterygoid and tongue, the extent of perineural infiltration and intracranial extension, E.g.: nasopharyngeal tumours, nodal metastases etc.

Coen et al in their study, matched the CT-MRI images for tumour volume delineation in Head and Neck Cancers, they found MRI derived tumour volumes were smaller and have less interobserver variation than CT derived tumour volumes. They felt that combined information of CT-MRI should be used in delineating the tumour volume. They concluded CT-MRI matching opens the possibility for smaller irradiated volume, especially for delivering a high boost to macroscopic tumour, due to better tumour definition. Both imaging modalities should be used simultaneously in the process of tumour delineation.[3]

Caroline weltens et al in their inter observer variation in tumour volume delineation of brain tumours on computed tomography and the impact of MRI, strongly recommend the CT-MRI fused images should be used for accurate tumour volume delineation in the brain tumours, as it is shown to provide complementary data.[4]

Bahaman et al studied the influence of MRI on target volume delineation in 3D-CRT and IMRT planning for nasopharyngeal carcinomas (NPC), they concluded that CT-MRI fusion improved the determination of tumour target volumes in nasopharyngeal carcinomas, particularly in IMRT planning, which resulted in significant improved coverage of the tumour target and also assisted in sparing critical structures. In their study, CT and T1/T2 weighted MRI scans were obtained for consecutive NPC patients. Using CT, MRI, and fused CT/MRI, various target volumes (gross target volume, Clinical target volume, and planning target volume [PTV]) and critical structures were outlined. For each
patient three treatment plans were developed: a three-dimensional conformal RT (3D-CRT) plan using CT-based targets, a 3D-CRT plan using comprised CT-MRI targets, an IMRT plan using CT-MRI targets. The prescription dose was 57.6Gy and 70.2Gy to the initial and boost PTV respectively. Treatment plans were compared using the PTV dose to 95% volume (D95), critical structure dose to 5% organ volume (D5), and mean dose. They found that compared with CT, the MRI–based targets were 74% larger, more irregularly shaped, and did not always include CT targets. For CT-based targets, 3D-CRT plans, in general, achieved adequate target coverage and sparing of critical structures. However when these plans were evaluated using CT-MRI targets, the average PTV D95 was 60Gy (14% under dosing), and critical dose to critical structures, were significantly worse. The use of IMRT for CT-MRI targets resulted in marked improvement in the PTV coverage and critical structure sparing: Average PTV D95 improved to 69.3Gy, brainstem D5 to <43Gy (19% reduction), spinal cord D5 to <35Gy (19% reduction), and the mean dose to the parotids and cochlea reduced to below tolerance (23.7Gy and 35.6Gy respectively). They concluded that CT/MRI fusion improved the determination of target volumes in NPC. In contrast to 3D-CRT, IMRT planning resulted in significantly improved coverage of composite CT-MRI targets and sparing of critical structures.[5]

Na-Na Chung et al studied the impact of MRI versus CT on primary tumour target delineation for radiotherapy in nasopharyngeal carcinomas. They concluded that MRI provided better target delineation for radiotherapy compared to CT imaging.[6]

Barrilot et al studied the use of MRI in planning RT for gynecological tumours, they concluded that individual 3D imaging based treatment planning for gynecological malignancy is necessary to avoid geographic miss and strongly recommended that the process of CT-MRI image registration should be widely used. Neshel Lenard[7] in his article suggests that in radiation treatment planning, multimodality image correlation offers advantage in terms of tumour delineation, discrimination between necrosis and recurrent disease and evaluation of treatment effect. He further suggests that image fusion has become essential for clinical use. Combining CT, MRI, Sonography and functional PET and SPECT data improves the possibility of interpolating 3D data for dosimetry and treatment planning.

Merina Ahmed et al[8] studied the value of CT-MRI fusion imaging in target volume delineation of base pf tongue tumours (BOT). They concluded that MRI improves the definition of tongue based tumours and neurological structures. The use of MRI is recommended for GTV dose escalation techniques to precisely depict the GTV and sparing spinal cord and brain stem.

2. MATERIALS AND METHODS

Source of Data
CT images of all the head and neck cancer patients were taken and contoured and later both CT-MRI images were fused and contoured again and compared.

Patients of Head and neck cancer presenting to the outpatient radiotherapy department were recruited into the study from November 2010 to May 2012, after obtaining the ethical committee approval. The patients with Head and Neck cancers stage 1 to stage 4, above 18 years, PS 0-4, Positive biopsy or FNAC for malignancy were included in the study. Previous radiation therapy to head and neck, metastatic disease, previous or planned surgical excision of primary tumour were excluded from the study.

METHODOLOGY

Estimated sample size was 20 patients with carcinoma head and neck

Work flow involved in the study:
1. Immobilization and CT simulation
2. MRI Scans
3. Fusion of CT-MRI images and contouring
4. Treatment planning
5. Plan verification
6. Treatment delivery

1. Immobilization and CT Simulation
During simulation and treatment, patients were commonly immobilized with a thermoplastic mask. Patients were placed in supine position with a bite block (for oral tongue and floor of mouth cases) to depress the tongue away from the palate. Some institutions use a cork and tongue blade for this purpose. For patients with a short neck, the shoulders were depressed by having the patient pull on a tensioning device looped beneath the feet. External markers were used to define the origin of the planning system co-ordinate. In the region of interest, CT scan performed on 16 slice multidetector CT scanner (GE light speed extra) and slice thickness was 5mm.

2. MRI scans
MRI images were obtained from 1.5 tesla MR scanner (Philips Achieva) using regular head coil. MRI was performed also in supine position without immobilization device and external fiducials. For each patient, appropriate MRI sequence, having information about clear tumour boundaries, was used for GTV delineation. No patient had any contra-indications for MR procedure.

3. Image fusion
The CT and MR image set obtained for each patient was registered using pixel data registration process of fusion algorithm from a treatment planning system (Eclipse V8.1, Varian Medical System). In this methodology, voxel to voxel correlation was derived from these two
image sets and one to one correspondences were made for various anatomical identifications. In this CT-MRI fusion methodology, the fusion replaces the bone – corresponding Voxels in the registered MRI with the corresponding CT Voxels. All the others remaining unchanged. The modulated transfer function was used to translate the Hounsfield numbers into electron densities. On a CT based planning, MR images are fused with CT images, thereby CT serves as basis for registration. The main advantage of image fusion from RT point of view is that the registered images keep their specificity. All the patients were treated with concurrent chemo radiation. Chemotherapy was delivered along with EBRT.

Contouring
Using the planning system eclipse V8.1, contouring was done on the CT images (axial images). Later the CT images were fused with the MRI images and contouring done on the fused images.

4. EBRT
The following volumes were defined:
GTV-tumour
CTV T- 1cm symmetrical margin to GTV.
GTV N- Lymph nodes visible on imaging.
CTV N – Levels of neck node (I to IV) which is at risk of microscopic disease.
PTV-CTV T+CTV N+ 0.5 cm margin+ GTV N

Contouring of normal surrounding critical structures such as spinal cord, brain stem, parotid gland, and mandible was done.
Technique: Three field technique constituting of bilateral fields and lower anterior neck field.
Energy: 6MV photon for primary and drainage areas ad 9MeV electrons for the posterior neck.
Dose: 6600 to 7000cGy to GTV (200cGy/fraction) and 5000cGy to CTV.

5. Chemotherapy
The patients were planned for injection Cisplatin 100mg/m² intravenously every three week concurrently with EBRT. The patients were monitored for acute toxicity and treated accordingly.

6. Treatment delivery
The patient was shifted to the radiation therapy facility. After setting up the radiation portals with help of external markers and after verifying the treatment set up with the help of images in the console, radiation was delivered to the patients.

Statistical analysis
We evaluated the gross tumour volume on CT and MRI scans separately and analyzed any disparity between them. Comparisons of CT and MRI volumes were done by taking the ratios of CT and MRI in centimeter cube and applying the student’s Test. P value < 0.05 was considered statistically significant.

3. RESULTS
The present study is a prospective and comparative study on target volume delineation using CT-MRI fusion compared with CT alone in radiotherapy planning of Head and Neck Cancers.

Patients with different primaries of the head and neck region were taken for the study. The below graph shows percentage of different primaries included in our study.

Figure - 1: Pie chart representing the percentage of patients with different primaries in our study

(Oral cavity -25%, Oropharynx-20%, supraglottis-20%, Vocal cord-10%, Unknown primary -5%, Hypopharynx- 15%, Nasopharynx-5%)
Table 1: Volumes on CT and CT-MRI fused images and ratios.

<table>
<thead>
<tr>
<th>Clinical Diagnosis</th>
<th>CT Volumes in Cubic centimeter</th>
<th>CT-MRI fused Volume IN cubic Centimeter</th>
<th>Ratio CT/Fused</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcinoma tongue</td>
<td>137.06</td>
<td>110.7</td>
<td>1.238</td>
</tr>
<tr>
<td>Carcinoma tongue</td>
<td>109.50</td>
<td>71.69</td>
<td>1.527</td>
</tr>
<tr>
<td>Carcinoma tongue</td>
<td>100.03</td>
<td>82.48</td>
<td>1.212</td>
</tr>
<tr>
<td>Carcinoma base of tongue</td>
<td>18.42</td>
<td>12.68</td>
<td>1.456</td>
</tr>
<tr>
<td>Carcinoma alveolus</td>
<td>137.45</td>
<td>104.26</td>
<td>1.378</td>
</tr>
<tr>
<td>Carcinoma tongue</td>
<td>142.82</td>
<td>146</td>
<td>0.978</td>
</tr>
<tr>
<td>Carcinoma oropharynx</td>
<td>47.3</td>
<td>33.13</td>
<td>1.42</td>
</tr>
<tr>
<td>Carcinoma Tonsil</td>
<td>60.52</td>
<td>52.98</td>
<td>1.142</td>
</tr>
<tr>
<td>Carcinoma base of tongue</td>
<td>71.53</td>
<td>51.03</td>
<td>1.401</td>
</tr>
<tr>
<td>Carcinoma supraglottis</td>
<td>53.38</td>
<td>31.82</td>
<td>1.38</td>
</tr>
<tr>
<td>Carcinoma supraglottis</td>
<td>121.11</td>
<td>133.39</td>
<td>0.905</td>
</tr>
<tr>
<td>Carcinoma supraglottis</td>
<td>25.6</td>
<td>21.92</td>
<td>1.16</td>
</tr>
<tr>
<td>Carcinoma supraglottis</td>
<td>125.78</td>
<td>118.54</td>
<td>1.061</td>
</tr>
<tr>
<td>Carcinoma Vocal Cord</td>
<td>11.6</td>
<td>10</td>
<td>1.11</td>
</tr>
<tr>
<td>Carcinoma Vocal Cord</td>
<td>16.6</td>
<td>15</td>
<td>1.06</td>
</tr>
<tr>
<td>Carcinoma Pyriform fossa</td>
<td>39.39</td>
<td>37</td>
<td>1.064</td>
</tr>
<tr>
<td>Carcinoma Pyriform fossa</td>
<td>10.35</td>
<td>8.33</td>
<td>1.24</td>
</tr>
<tr>
<td>Carcinoma Pyriform fossa</td>
<td>47</td>
<td>40</td>
<td>1.17</td>
</tr>
<tr>
<td>Carcinoma Nasopharynx</td>
<td>192.82</td>
<td>189.06</td>
<td>1.019</td>
</tr>
<tr>
<td>Carcinoma Unknown Origin</td>
<td>170</td>
<td>112.6</td>
<td>1.51</td>
</tr>
</tbody>
</table>

Fig 4: The above graph shows the gross tumor volume (cubic centimeter) on CT images and CT-MRI fused images, the red bar represents the CT volumes and the adjacent green bar represents the CT-MRI fused volumes. In majority of the patients CT volumes are larger than CT-MRI fused volumes except in two patients where CT-MRI fused volumes are larger than CT volumes.
Figure 3: The above graph shows the ratio of CT-MRI fused volumes in different primaries included in our study. The ratio lies within 0.8 and 1.6 (most of the values obtained are above 1).

Figure 4: The above stock graph represents the GTV volumes contoured on CT images. It shows the minimum and maximum values obtained in each subsite of head and neck cancers included in the study, and the thickened black line in the center of the graph shows the average volume obtained in centimeter cube.
Figure 5: The above stock graph represents the GTV volumes contoured on CT-MRI images. It shows the minimum and maximum values obtained in each subsite of head and neck cancers included in the study, and it also shows the average volume obtained.

Figure 6: The above stock graph represents the ratios of CT and CT-MRI fused gross tumour volumes. It shows the minimum and maximum values obtained in each subsite of head and neck cancers included in the study, and the thickened black line in the center of the bar shows the average ratio obtained in each subsite. The ratios fall between 0.9 and 1.6.
Analysis

Table 2: Mean CT Volumes and CT-MRI fused Volumes of different subsites and P values.

<table>
<thead>
<tr>
<th>Type of Carcinoma(N)</th>
<th>CT Volume Mean (SD)</th>
<th>MRI CT fusion mean (SD)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Patients</td>
<td>83.3(12.17)</td>
<td>67.83(11.06)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Oral Cavity</td>
<td>119.79(18.9)</td>
<td>96.51(31.9)</td>
<td>0.19</td>
</tr>
<tr>
<td>Oropharynx</td>
<td>53.91(9.34)</td>
<td>43.05(14.03)</td>
<td>0.45</td>
</tr>
<tr>
<td>Larynx(supraglottis)</td>
<td>81.51(49.77)</td>
<td>78.26(56.06)</td>
<td>0.93</td>
</tr>
<tr>
<td>Vocal Cord</td>
<td>13.85(3.88)</td>
<td>12.5(3.53)</td>
<td>0.75</td>
</tr>
<tr>
<td>Hypopharynx</td>
<td>24.87(20.53)</td>
<td>22.66(20.27)</td>
<td>0.92</td>
</tr>
</tbody>
</table>

The mean CT volumes in oral cavity is 119.79, oropharynx was 53.91, supraglottis is 81.51, Vocal cord is 13.85 and hypopharynx is 24.87 cubic centimeters, and the mean of GTV volumes on CT-MRI fused images is 96.51, 43.05, 78.26, 12.5, 22.66 respectively. For all sub sites put together it was 88.3 for CT-GTV volumes and 67.83 for CT-MRI fused GTV volumes. Value for CT/CT-MRI fused GTV for all sub sites put together volumes is 0.0001, which is statistically significant.

Table 3 Ratio (CT/MRI fused GTV) and mean (SD) of different subsites.

<table>
<thead>
<tr>
<th>Type of carcinoma(N)</th>
<th>Ratio mean(SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Patients</td>
<td>1.27(0.23)</td>
</tr>
<tr>
<td>Oral Cavity</td>
<td>1.29(0.23)</td>
</tr>
<tr>
<td>Oropharynx</td>
<td>1.28(0.20)</td>
</tr>
<tr>
<td>Larynx(supraglottis)</td>
<td>1.12(0.19)</td>
</tr>
<tr>
<td>Vocal Cord</td>
<td>1.10(0.002)</td>
</tr>
<tr>
<td>Hypopharynx</td>
<td>1.15(0.12)</td>
</tr>
</tbody>
</table>

Table 3 shows the mean of ratio of CT and CT-MRI fused volumes in oral cavity is 1.29, Oropharynx is 1.28, supraglottis larynx is 1.12, Vocal cord is 1.10 and hypopharynx is 1.15. The standard deviation is 0.23, 0.20, 0.19, 0.002, and 0.12 respectively.

DISCUSSION

To achieve treatment goals, accuracy in determining tumour volumes along with the critical structures is essential. The present day radiation therapy treatment is based primarily on cross-sectional imaging information. Because of the inherent imaging limitations, no single modality till date is capable of defining tumour volumes adequately. For example in CT, tumour invasion of bone is clear, but tumour extension into the surrounding soft tissues may not be clearly visible. In head and neck cancers, CT is often insufficient for diagnostic purpose and accurate delineation of the tumour. The opposite is true for MRI. Which display excellent intrinsic soft tissue contrast but, with limited bone delineation.

MRI provides better tumour definition for nasopharyngeal lesions involving the Para pharyngeal space of the skull, brain and oropharynx. For example, although bone erosion is easily seen on CT, tumour invasion of the clivus and base of skull, foramina are best recognized only on MRI.

MRI, by and large has been demonstrated to be superior to CT in the staging and follow-up of the head and SCC patients.

Many authors have, therefore stressed the importance of using MRI in radiotherapy treatment planning.[9-10] Out of the total patients included in the study, four patients were carcinoma tongue. In 3 of these patients, CT scan overestimated the gross tumour volume. The ratio of CT and MRI-CT fused volumes were 1.2, 1.21, 1.527 and 0.97. A maximum value of 1.527 ratios say it overestimated the volume by about 50% in a patient. In the rest of the patients it overestimated to around 20%. Average of CT and fused MRI-CT volume ratio of all four patients was 1.22, which means our study showed that CT on average overestimates by 20% compared to CT-MRI fused volume in carcinoma tongue.

On CT image, lymph nodal volumes and right parotid gland are merged with the poor delineation, whereas in MRI image nodal volume is differentiated from parotid gland.

Of the 20 patients included in the study, one patient was of an unknown primary with cervical nodal metastasis. Initially, on CT scan it was diagnosed as carcinoma right parotid as the nodal volume and parotid volume were merged and it was difficult to differentiate the tumour volume from parotid gland. Later on, when CT was fused with MRI, we were able to differentiate the parotid gland from nodal volume. This was one example where we could demonstrate the excellent role of addition of MRI to CT in delineating soft tissue volumes.

We had two patients of early stage of carcinoma vocal cord. In these patients, CT volumes and CT-MRI fused volumes did not make much difference, as apparent, the ratio was 1.11(in patients of oral cavity which did show better delineation, the ratio was 1.2 to 1.5. though we need to be cautious regarding the above , as we have analyzed just 2 patients that too of early stage.
In the patients with carcinoma supraglottis, CT overestimated the GTV compared to CT-MRI fused images. On an average CT overestimated by 12%.

In patients with carcinoma pyriform fossa, CT overestimated GTV by 15% compared to the CT-MRI fused images.

In two patients i.e. a patient of carcinoma supraglottis and carcinoma tongue, CT underestimated the GTV as compared to fused images. Here in the supraglottis cancer, extra laryngeal soft tissue involvement was better appreciated in MRI images and hence the volume contoured on MRI-CT fused image was more.

As per our study, significant differences were noted between the CT and MRI based targets. Our findings showed that CT-based target volumes were on an average 20 to 30% larger than the CT-MRI fused volumes. Therefore, the use of CT-based targets may lead to overdosing of normal tissues.

Image fusion on another hand, allows one to use the inherent advantages of both the CT and MRI information while contouring the target volumes. In our study, we decided to use the composite CT-MRI targets for planning purposes. In addition, the fused image set provides the spatial accuracy and resolution necessary for dose calculation. The importance of image fusion for sites other than the brain and neck has also been noted recently.

In general, we found that volumes contoured from the fused CT-MRI images was always smaller than CT, indicating that MRI is a more potent imaging tool for delineating tumors surrounded by soft tissue.

The fused images mainly played an important role in delineating the target volumes in carcinoma tongue, as tumour extent is difficult to make out on CT images. Routinely, while contouring the tumor volume of the carcinoma tongue using the CT images, we tended to include the entire tongue due to poor delineation of the soft tissues. Subsequently, by fusing with MRI images with the CT, we were able to delineate the exact extent of the tumor and spare the normal tongue from being over treated.

In early staged tumors like T1 and T2 vocal cord tumors, CT and CT-MRI fused volumes were more or less the same and it did not have much impact.

In our study on average for all the patients, CT has overestimated the volumes except in 2 patients. The range of GTV s was consistently smaller in the CT-MRI fused images than CT delineated volumes. The relative range of ratio was larger for oral cavity tumours, mainly tongue (0.9 to 1.5) compared to vocal cord tumours. Given the specific properties of CT and MRI, these results illustrate that CT-MRI are complementary, i.e.

tumour extension seen on CT are not always noted on MRI and vice versa.

The combined information of CT, axial MRI or sagittal MRI should be used to delineate the GTV, especially when CT and MRI derived GTVs are inconclusive about certain tumour extension. Efforts should be made to judge both imaging modalities simultaneously. The modality and fat-tumour boundaries; MRI for soft tissue contrast, bone marrow invasion and separation from mucosal boundaries in craniocaudal direction.

Potential limitations in our study need to be addressed. Analysis of MRI images was performed by using optimized images acquired with the use of a body coil. The need for similar positioning for both modalities required the use of an immobilization device, which included the use of dedicated head and neck coils.

Coen rash et al in their study, analyzed the potential impact of CT-MRI matching on tumour volume delineation in advanced head and neck cancer and found that CT derived volumes was a factor of 1.3 larger than the mean axial MRI volume. The range in volumes was larger for the CT than for the axial volumes in five out of six cases. Our study also showed the similar results where CT volumes on an average were 27% larger than MRI volumes (Average ratio 1.27). However the studies concluded by Merina Ahmed et al on base of tongue lesions and Bahmin eman et al on nasopharynx showed that the MRI volumes were larger than the CT volumes which was contradictory to our studies; though when we observed that the findings in our study concerning with nasopharynx and base of tongue, we also felt there was not much ambiguity when analyzing the CT MRI volumes.

Hence, we would propose that if we take all head and neck cancer patients into consideration, we would get an increase in CT volumes as compared to MRI. But if we are site specific, relegating ourselves to nasopharynx or base of tongue, then the contradictory would be true, i.e. MRI volumes representing more than CT volumes.

In conclusion, the volumes as seen obtained by CT or MRI may not be pertinent, rather it would be more appropriate to fuse both the volumes and get the best precision contoured volumes for sculpting the radiation dose for an ideal therapeutic ratio.

CONCLUSIONS

In the recent years, evolution of radiation therapy has been technology driven. The impetus towards radiation treatment delivery is more towards precision, so as to deliver maximum dose, be it through conventional radiation or IMRT with simultaneous integrated boost to the target volume, obtain a minimal integral dose and minimize the dose as much as feasible to the organs at risk.
To achieve this aim, it is imperative to delineate the target volumes and organs at risk volumes as precise as possible.

Towards that goal we need an imaging modality having the capability of delineating the above volumes. PET-CT fusion is lately used in many centers for RT planning and treatment delivery. Unfortunately due to the prohibitive cost and paucity of a nearby cyclotron center, which would provide the desired short half-life radio nucleotides, many hospitals do not have this facility. In this circumstance, it would be more than appropriate to use the CT-MRI fusion technology, utilizing the MRI-CT scans which are widely available for planning head and neck cancers by radiation therapy.

In our study, we were able to get the desired results even above our expectations as was evident from the present study.

Finally, in conclusion, we recommended CT-MRI fusion in head and Neck cancers, as an efficient, cost effective and universally acceptable treatment planning modality.

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CONFLICT OF INTEREST

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or Publication of this article

REFERENCES