MR based radiation therapy treatment planning on an Avanto/TIM system

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Introduction:

3D CT data is the standard of care for treatment planning of external beam radiation therapy treatments [1] due to the spatial fidelity of the data, speed of acquisition, identification of the patient's external skin contour, visualization of bony anatomy, electron density information, and ability to image the patient in the treatment position. While MR provides excellent soft tissue contrast ideal for improved tumor and normal anatomy identification [2], these systems are poorly suited for imaging radiation therapy patients due to the physical dimensions of closed bore systems and the lack of large volumetric coverage of most RF surface coils.

The purpose of this work is to describe the use of a matrix coil system on a closed bore 1.5T MR scanner on a radiation therapy patient immobilized and then imaged in the treatment position with the goal of maintaining anatomical coverage, spatial resolution, and image quality sufficient for use in external beam treatment planning of the head and neck.

Materials and Methods: Figure 1(a) shows a Bear Claw (WFR/Aquaplast Corp., Wyckoff, NJ) head/neck/shoulder immobilization device on top of the table of an Avanto 1.5 T MR scanner (Siemens Medical Systems, Erlangen, Germany) while (b) shows the anterior coil elements of a 32 channel matrix coil system (TIM) on a volunteer, providing coverage from the top of the skull to the mid thorax (carina). Coils imbedded in the table as part of the posterior spine array are used to provide full volumetric RF coil coverage. Because patients must be imaged in the same position as during radiation therapy treatments, no additional padding is used. The radiation treatment isocenter is then land marked to the center of the imaging volume. After immobilization and movement into the MR scanner, patients are imaged with the protocol described in the table below.

Figure 1: (a) Bear Claw head/ neck/shoulder immobilization device placed on MR scan table.
(b) Volunteer immobilized in treatment position with matrix array covering imaging volume.

Imaging Protocol	Localizer	T1-weighted	T2-weighted
Series Number	1	2(pre Gd), 3(post Gd)	4,5 (fat suppression)
Imaging plane	3-plane	Axial	Axial
Pulse sequence	Gradient echo	Turbo Spin Echo	Turbo Spin Echo
TE/TR (msec)	5.9/35	7.7/820	106/3900
Field of View (cm)	40	28	28
Slice thick. (mm)	10	4	4
Slice sep. (mm)	5.0	1	1
Kx / Ky	256 / 166	256 / 192	256 / 192
Echo Train	-	3	19

Except for the localizer, all imaging series are prescribed as conventional axial planes and all series maintain the same prescription volume. Gadolinium contrast agent (Omniscan, GE Healthcare, Waukesha, WI) is delivered between the second and third series in the protocol. For each series, between 70 to 80 axial slices are prescribed. Prior to MR imaging, patients undergo a non contrast CT (GE Light speed RT, GE Healthcare, Waukesha, WI) scan in the department of Radiation Oncology as part of their routine treatment planning protocol. After spatially registering the MR and CT volumes, the target volumes can be defined on the MR data set and transferred to the CT data set, which is used by the radiation therapy treatment planning software to calculate dose.

Results: Total imaging time was approximately 30 minutes. Figure 2 shows registered reformatted sagittal images from both the CT and T2-weighted MR data set of a patient undergoing external beam irradiation treatment of the head and neck imaged with the MR parameters above. The target volume is indicated by the contour superimposed onto both the CT and MR data sets. These two data sets show the complementary information provided by these two modalities. Target volume definition (tumor plus treatment margin) are based on the MR data set while the CT data provided bony landmarks and external contour information. Figure 3 shows a treatment portal superimposed onto the CT data set with identified target volumes and critical structures (radiation sensitive normal structures).

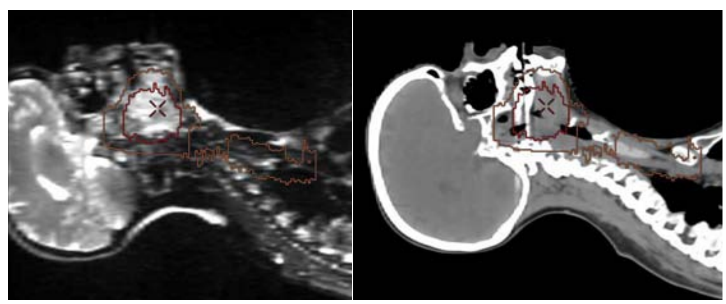

Figure 2: Reformatted, registered sagittal T2-weighted MR & CT images with MR identified tumor and nodal volume contours.

Discussion: Due to limited RF coil coverage and narrow bore diameters at high field strengths, the use of MR for radiation treatment planning has been limited to low field, open systems [3]. Advances in MR technology including bore diameters as large as 70 cm at field strengths of 1.5T as well as multi coil RF receiver technology have the potential to make these systems the new standard for MR imaging for radiation therapy treatment planning. The results of this study demonstrate initial technical feasibility of this concept and represent the first step towards the development of a high field MR-only treatment simulation system for radiation therapy treatment planning.

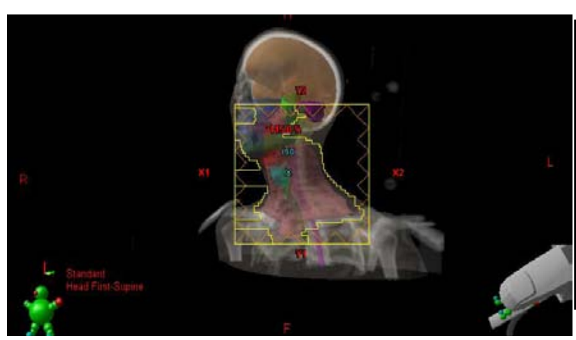

Figure 3: Beam's eye view with rendered structures superimposed on a digitally reconstructed radiograph

References

1. Barillot I, Reynaud-Bougnoux A. Cancer Imaging. 2006; 6:100-6
2. Khoo VS, Joon DL. Br J Radiol. 2006; 79 Spec No 1:S2-15
3. Chen Z, et al. Phys Med Biol. 2006; 51(6):1393-403.