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Initial experience with the Siemens MAGNETOM Free.Max for GYN brachytherapy: How low can we go?

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ABSTRACT

Purpose: To share our initial clinical experience using the Siemens MAGNETOM Free.Max low field strength (0.55T) scanner for gynecological brachytherapy, including establishing sequences, assessing geometric distortion for a titanium tandem and ring (T&R) applicator, and providing images from our first clinical case.

Methods: Following GEC-ESTRO[1] and AAPM TG-303[2] guidelines for imaging sequences, T2 images were acquired of a female volunteer. The optimized T2 protocols were then used to image a titanium T&R applicator encased in gelatin. The phantom was also imaged using a CT scanner to quantify geometric distortion. Following this validation work, our first patient case was performed.

Results: For volunteer scans, scan times were approximately 5 minutes per sequence, and the images were found to be clinically acceptable by our physician. For the T&R applicator in a gelatin phantom, artifacts were observed at the tip of the tandem and at fixation points in the applicator. However, use of the applicator solid model in the treatment planning system can mitigate the geometric error caused by this distortion. For patient T2 images, there was little contrast between the tandem and hypo-intense cervical tissue, making digitization using MRI alone challenging.

Conclusions: T2 images can be acquired with a low field strength MRI scanner to aid in gynecological brachytherapy treatment planning.

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INTRODUCTION

MRI imaging provides superior soft tissue contrast for GYN brachytherapy, and the ability to acquire MRI images within a radiation oncology department allows for a more streamlined and efficient workflow. Though some data has been published about low field strength MRI for GYN brachytherapy,[3] little data has been published with the Siemens MAGNETOM Free.Max scanner (0.55T). Henry Ford Health has the first installation of this MRI simulator in a radiation oncology department. This abstract shares our initial experience with the Free.Max scanner for GYN brachytherapy, including 1) establishing ***sequences for clinical use***, 2) assessing ***geometric distortion*** for a titanium tandem and ring applicator, and 3) providing ***images from our first clinical case***.

IMAGING SEQUENCES

Using GEC-ESTRO[1] and AAPM TG-303[2] as guidelines, we acquired and optimized T2 sequences for brachytherapy planning by scanning a female volunteer (Table 1). Figure 1 shows the GEC-ESTRO required 2D para-axial and para-sagittal acquisitions as well as a 3D acquisition. 3D acquisition allow nearly isotropic images that can be oriented in any way, potentially replacing both the para-sagittal and para-coronal 2D acquisitions.[2] However, 3D images also have slightly different contrast than the more familiar 2D T2 images, lower in-plane resolution, and are more sensitive to motion due to longer scan times. TG-303 recommends the acquisition of a 3D T2 sequence in addition to the mandatory 2D T2 sequences set forth by GEC ESTRO. A T2 BLADE axial acquisition was also tested, which was less sensitive to patient motion artifacts and had comparable image quality as the T2 FSE axial image.

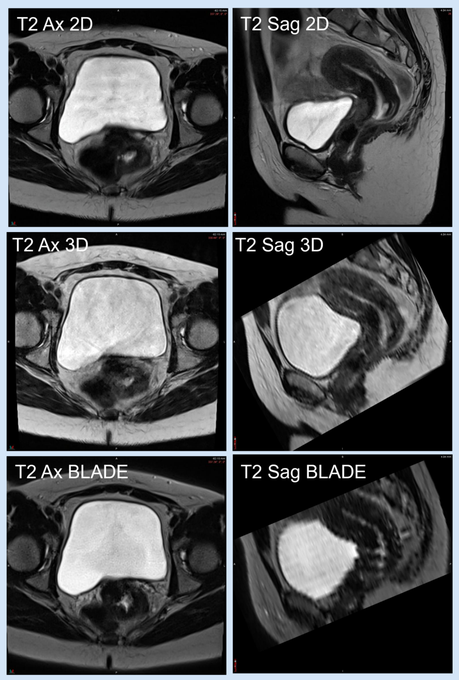

Figure 1. Female pelvis volunteer scans for 2D acquisitions, 3D acquisition, and Axial BLADE, corresponding to sequences in Table 1.

Table 1. Siemens MAGNETOM Free.Max T2 sequences.

Scan	Slice thickness [mm]	Acquisition Matrix	TR [msec]	TE [msec]	FOV phase x freq	# averages	Scan time [min:sec]
2D Para-axial	3	256x256	6890	117	24cm x 24 cm	3	4:36
2D Para-sagittal	3	256x256	5640	114	24cm x 24 cm	4	5:04
2D Para-coronal	3	256x256	5640	114	24cm x 24cm	4	5:04
3D T2 FSE	2.5	256x218	1350	99	22cm x 22cm	2	6:59
2D Axial BLADE	4	256x256	4630	178	24cm x 24 cm	1	4:48

GEOMETRIC DISTORTION

Using these scan parameters, T2 images were acquired with our titanium tandem and ring (T&R) applicator in a gelatin phantom. Additionally, CT images were acquired to investigate geometric distortion. As visualized in Figure 2, some small distortion artifacts were noted at the tip of the tandem and several fixation points in the applicator. If the MRI images were used to manually digitize the tandem, the artifact at the tandem tip would lead to an approximately 2mm error. However, this error can be reduced by either fusing to a CT image or by using the vendor-provided applicator solid model (Figure 2d).

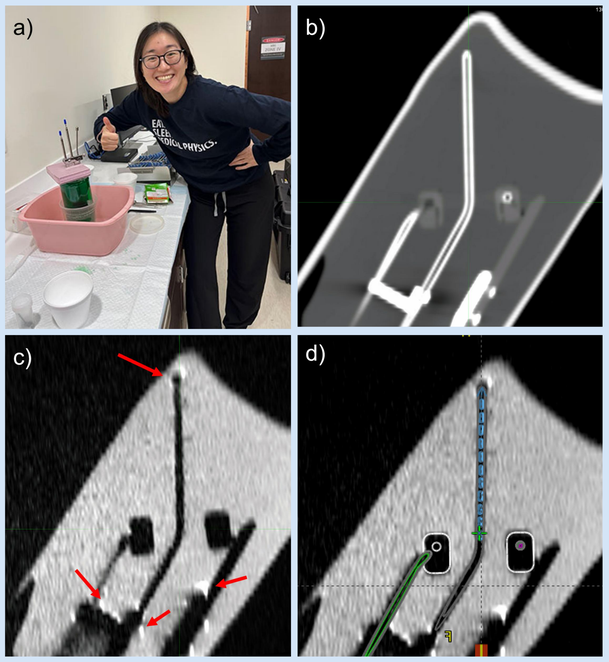

Figure 2. (a) Gelatin-based geometric phantom imaged using (b) CT and (c) Ax T2 MRI. (d) The Ax T2 images were then used for applicator reconstruction using a vendor-provided applicator solid model.

CLINICAL CASE

Axial T2 MRI and CT images are shown for our first clinical case (Figure 3). The CT images (acquired after MRI) were used for applicator reconstruction using a solid model, while the MRI images were used to aid in contouring the HR-CTV. If the MRI were used for treatment planning alone, the applicator would need to be clearly visible. Though the ring cap was easy to visualize on the MRI, the tandem was difficult to distinguish from hypointense cervical tissue.

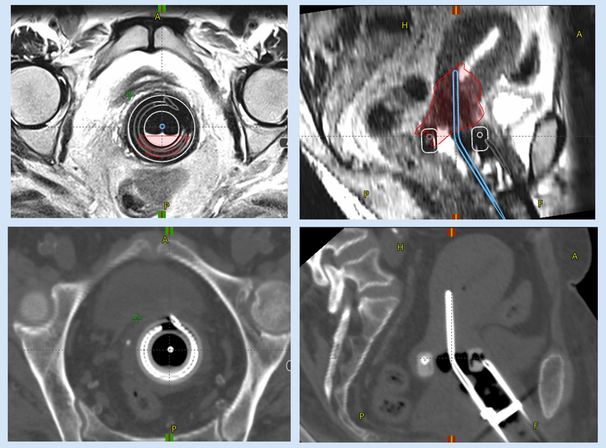

Figure 3. Ax T2 MRI and CT images of our first clinical patient. The applicator solid model is overlaid on the MRI images, illustrating the difficulty distinguishing the tandem and the cervical tissue.

CONCLUSIONS

Though lower in field strength than diagnostic MRI scanners, the Siemens MAGNETON Free.Max (0.55T) offers a feasible way to obtain MRI images for brachytherapy treatment planning within a radiation oncology department. The quality of the T2 images acquired was sufficient for treatment planning, allowing the physician to contour the HR-CTV using MRI, while applicator digitization could occur on CT images. The scan acquisition time was approximately 5 minute per sequence, and the acquisition of 3D T2 images allows the potential to acquire only one sequence for brachytherapy planning.

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