MR PERFORMANCE OF AN MR-LINAC PROTOTYPE

Panu Vesanen[1], Jukka Tanttu[1], Juha Oila[1], Tiina Näsi[1], Annemaria Halkola[1], Tero Virta[1], Falk Uhlemann[2], Johan Overweg[2], and Jarmo Ruohonen[1]

[1]*MR Therapy, Philips Healthcare, Vantaa, Finland,* [2]*Philips Innovative Technologies, Hamburg, Germany*

Purpose

In treatment of cancer by conventional radiotherapy, motion of the target and nearby organs limits the accuracy of the treatment delivery. A combined MRI and linear accelerator system[1–3] (MR-Linac, MRL) aims to reduce the inaccuracies due to both intra- and inter-fraction motion by providing image guidance with excellent soft-tissue contrast. In this abstract, results about MR performance of an industry-built MRL prototype based on volunteer imaging are presented.

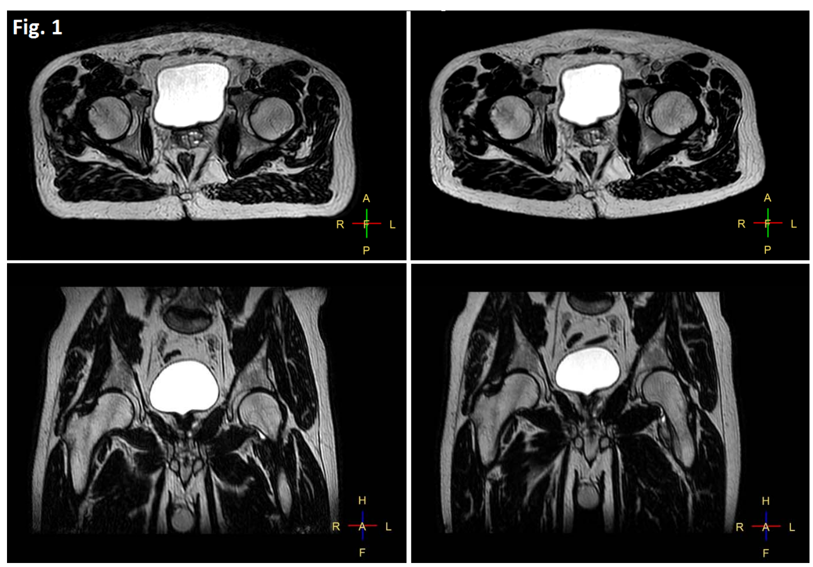
Methods

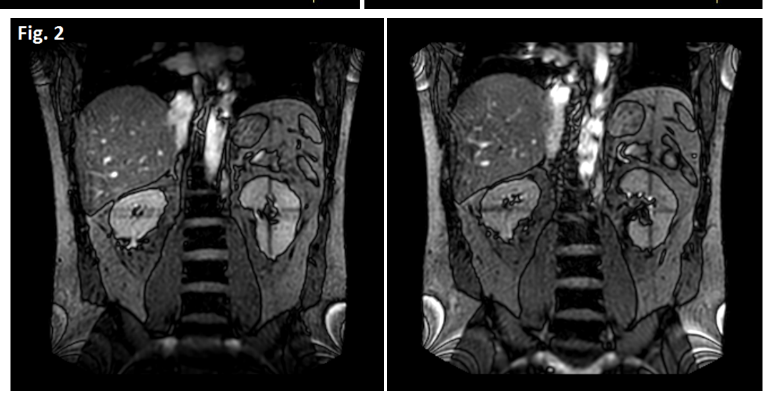
The MR subsystem for the MRL device is based on the design of a diagnostic 1.5T scanner (Philips Ingenia, Best, The Netherlands). To address the interference between the MR and Linac, modifications have been made to the cryostat, gradient coil, integrated body coil, and the surface coils. To create a window with uniform and minimized attenuation for the photon beam, the central parts of the cryostat, gradient, and integrated RF body coil are designed to be free of coil windings and/or lumped components. The diameter of the patient bore is 70 cm. In addition, two MRL-dedicated phased-array RF coils have been designed. The central parts of the anterior and posterior coils (8 channels total) are free of lumped components and made out of radiation transparent materials. The accelerator hardware (Elekta, Crawley, UK) is located on a circular gantry around the cryostat. In this study, the accelerator was not used for delivering radiation and the gantry was static during MR imaging.

To investigate the imaging performance of the integrated MRL prototype, 20 healthy volunteers were imaged with the MRL scanner and with a commercially available diagnostic 1.5T scanner (Philips Ingenia). Pelvis, abdomen, and head & neck anatomies were studied. We chose two imaging sequences that are envisioned to be needed in the clinical use of MRL. For position verification before delivering the treatment and for assessing the need for adaptations in the treatment plan, we employed a T_2-weighted 3D TSE sequence with T_R/T_E = 1600/257 ms, echo train length of 108, and SENSE factor of 3.4. The resolution was 1.5×1.5×2.0 mm^3 , FOV RL×AP×FH = 460×320×300 mm^3, and imaging time 2 min 3 s. For motion monitoring during the treatment delivery, we used a 2D balanced SSFP sequence with T_R/T_E = 3.4/1.7 ms, SENSE factor of 3, and a flip angle of 40°. The resolution was 3×3 mm^2, FOV 460×400 mm^2, slice thickness 5 mm, and imaging time 0.198 s. The dynamic series consisted of axial, coronal, and sagittal slices acquired sequentially. The volunteers were re-scanned directly afterwards with an Ingenia scanner using the same sequences. With the MRL prototype, data were acquired using the dedicated MRL anterior and posterior coils. With Ingenia, its standard diagnostic anterior and posterior coils were used.

Results

Fig. 1 shows axial and reformatted coronal images of the pelvis of a male volunteer (179 cm, 83 kg) acquired with the MRL prototype (left) and Ingenia (right) using the T_2-weighted 3D sequence. By visual inspection, no significant difference in the image quality or extent of the usable FOV can be seen. Mean SNR calculated from the hip joints and averaged over 9 volunteers is 193±30 for MRL and 210±21 for Ingenia. The minor difference in the SNR can be explained by the differences in the MRL and diagnostic receiver coil geometries. Fig. 2 shows a snapshot of the dynamic series of the abdomen with the MRL prototype (left) and Ingenia (right). No significant differences in the image quality are visible.





Conclusion

A prototype of an industry-built MR-Linac device has been assembled. The quality of images obtained with the prototype was compared to that obtained with a commercially available 1.5T scanner. No significant differences were found in the image quality or SNR.

References

1. Raaymakers et al., Integrating a 1.5 T MRI scanner with a 6 MV accelerator: proof of concept. Phys. Med. Biol. 2009;54:N229–N237.
2. Fallone et al., First MR images obtained during mega-voltage photon irradiation from a prototype integrated linac-MR system. Med. Phys. 2009;36:2084–2088.
3. Dempsey et al., A Device for Realtime 3D Image-Guided IMRT. Int. J. Rad. Onc. 2005;63:S202.