Significant Benefit of Optimized 3D SPACE Sequences in Radiation Therapy Treatment

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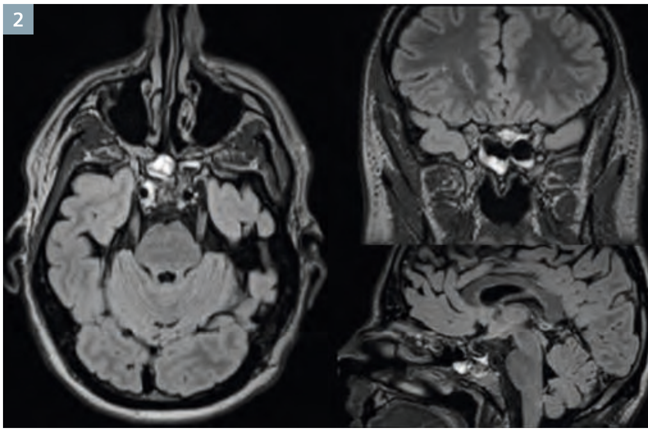
MR images used in radiation therapy have other requirements than conventional diagnostic MR images. In radiation therapy, the exact extent and position of lesions in relation to critical structures have to be determined in order to ensure an effective and safe treatment of the patient. This requires high in-plane spatial resolution, thin slices without slice gaps, and a minimal geometric distortion. In addition, due to image registration and patient fixation, a sub-optimal patient set-up is often required, including flexible coil solutions and a flat table top.

MR imaging struggles with system-related and patient-induced geometric distortions. For radiation therapy, the imaging protocols must be optimized to give minimal geometric distortions in the imaging volume. In general, the geometric integrity is best preserved by using spin-echo based sequences with high acquisition bandwidth. In the current workflow, MR images used for therapy planning have to be registered to a CT dataset. The imaging protocol must thus also be optimized to give sufficient image contrast and adequate spatial resolution to ensure an accurate image registration, with a trade-off between registration accuracy and image quality. Acquiring thin slices (<2-3 mm) without slice gaps using standard 2D multi-slice acquisitions results in either low signal-to-noise ratio or unreasonably long acquisition times, the latter not only inconvenient for the patient but also an increased risk of introduction of motion artefacts in the images.

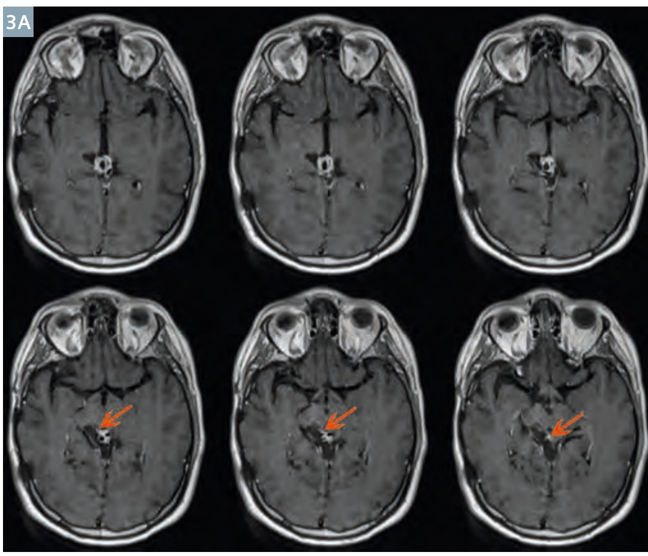
Although still not optimal for all applications, we found several examinations to benefit from the use of optimized fast isotropic 3D acquisitions. Utilization of the SPACE sequence for therapy planning has increased the possibilities we have to delineate small tumors intended for treatment with high-dose radiotherapy. The sequence has shown to be very helpful in defining small benign as well as malignant brain tumors. At our clinic, these tumors are treated with stereotactic radiotherapy that involves a very narrow margin between the gross tumor volume and the planning target volume intended for treatment, which makes an exact tumor volume definition essential for successful treatment.

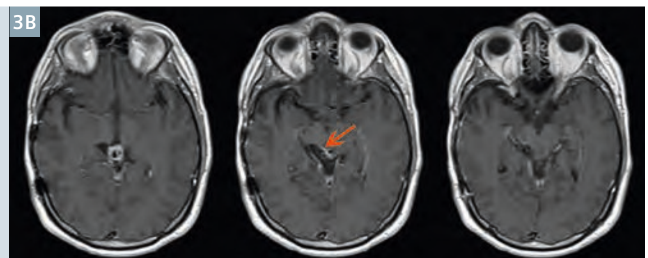
Further, we are in the initial stages of incorporating MRI in the workflow for brachytherapy for head-and-neck cancer patients. At our clinic, patients with cancer in the tongue and the base of tongue without nodal spread receive external radiotherapy combined with chemotherapy to the primary tumor site and to non-engaged lymph node sites. Some of the patients also receive an additional brachytherapy boost to the primary tumor site. The volume intended to receive the boost has been decided by the head-and-neck radio oncologist after a digital examination prior to brachy loop implantation. We have seen a great benefit of using a T1 3D SPACE MRI after the brachy loop implantation to reconstruct the loops and to verify that the tumor remnant is within reach of the radiotherapy. The possibility to reconstruct images in any arbitrary plane combined with the excellent image quality will increase the possibilities for us to offer patients a more exact treatment, sparing the salivary glands and mandibular bone. In conclusion, we are so far very satisfied with the SPACE sequence for several applications in radiation therapy and we see a great advantage of investing further optimization work to introduce the sequence in the treatment of other anatomical areas.

1 The gross tumor volume of a vestibular schwannoma on the T2-weighted SPACE **(1A)**, and T1-weighted contrast enhanced SPACE **(1B)**. The high (1 mm) and isotropic resolution of the SPACE sequence is highly beneficial for therapy planning of vestibular schwannoma as many schwanomma are as small as a few millimeters. The excellent image contrast on the T2-weighted SPACE may eliminate the need for contrast enhanced acquisitions.



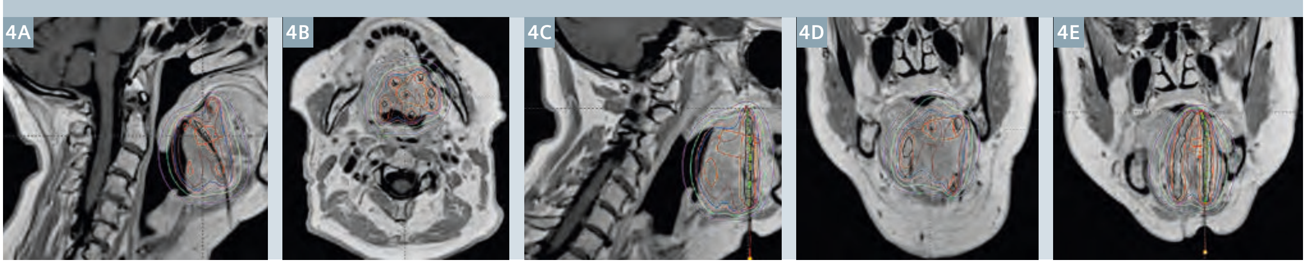
2 A patient diagnosed with a chordoma. Initial surgery was due to technical difficulties not completely radical and the patient will receive adjuvant radiotherapy to the remaining chordoma. Due to the close vicinity to the optical nerves it is extremely important to be able to define the exact volume of the tumor in order to minimize negative treatment effects of the radiotherapy. A T2-weighted SPACE dark fluid.

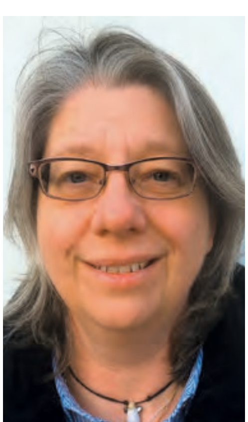




3 A patient who was diagnosed with a germinoma of the corpus pineale five years ago. He was initially treated with radio-chemotherapy and now shows a local recurrence. T1-weighted contrast-enhanced SPACE **(3A)** and standard T1-weighted contrast enhanced 2D TSE with a slice thickness of 3 mm **(3B)**. The standard 2D TSE was not sufficient to determine the extent of the recurrent tumor.

4 Dose distribution for a brachytherapy patient on a T1-weighted SPACE **(4A-C)**, and with an applicator reconstructed **(4D-E)**.





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