Systematic evaluation of Stereotatic Radiosurgery effects in metastasis and acoustic neurinomas using MRI

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INTRODUCTION: Stereotactic radiosurgery (SRS) is a specific form of radiation therapy used to treat tumors and other abnormalities in the brain. This technique uses a few highly focused X-rays beams usually delivered in a single high-dose. To maximize the radiation dose in the tumor, and to minimize the damage in collateral healthy areas, the treatment uses a frame-like device that keeps the head still in a stereotactic system, and a three-dimensional Treatment Planning System (TPS) that gives the location and strength for each X-ray beam, using as input a tomographic image of the brain. Normally, treatments computed by the TPS are validated using physical models, phantoms, radiation detectors or radiosensitive gels [1]; which are used to verify prescribed doses and not the actual biological effects suffered by patients that undergo a SRS. We hypothesize that with MRI it could be possible build a map of the actual biological damage caused by the SRS treatment, so that to provide feedback *in vivo* to the TPS. With such a map, SRS treatments could be computed or modified taking into account the effective tissue damage in previous treatments, instead of only estimated dose distributions. In a previous work [2] we showed that T2w MR images could provide information about changes associated to radiated tissue, and those changes could be correlated with the induced tissue damage. In the present work we perform a systematic MRI follow up study to verify biological damage in three patients before and after a SRS, which now includes proton density (PD), T2w, T2w-Flair and ADC images.

METHODS: Three patients treated with brain SRS were included in this study. Written informed consent was obtained from every patient prior to the SRS. Two patients (1 male 42 y.o., 1 female 28 y.o.) had both a benign acoustic neurinoma and the third patient (male 44 y.o.) had a solitary brain metastasis. The SRS treatment was planned using a FastPlan® TPS (version 5.5 2007, Varian), considering a single dose delivered with 6MV arc beams from a Varian 21EX linear accelerator with cone collimators. The marginal dose was of 12.5 Gy for benign tumors. The patient with brain metastasis was treated with a whole brain radiation (dose of 30.0 Gy) and after 22 weeks with a SR (marginal dose of 18.0 Gy). The patients were scanned 1 day before the SRS and for 3 months after the SRS (scans at days 1, 2, 3, 6, 7, 30, 60 and 90 post SRS) with identical entire-brain MRI protocols. All pre-SRS MR images were obtained with a 1,5T Philips Achieva MR scanner, and the remaining ones with a 1,5T Philips Intera MR scanner. The protocol consisted of the following images: PD and T2w acquired using a single dual turbo spin echo (TR/TE1/TE2: 9434/10/110 ms; flip angle 90; turbo factor 14; res. 1.7x1.7x1.7 mm), T2w-FLAIR (TR/TI/TE: 14679/3000/150 ms; flip angle 90; turbo factor 46; res. 1.7x1.7x1.7 mm), multi b DWI (EPI single shot; TR/TE: 12273/100 ms; b factor: 0, 200, 400, 1000; res. 2.58x2.58x2.58 mm). The images were registered using SPM (http://www.fil.ion.ucl.ac.uk/spm/) and ADC maps were computed using a home-made software written in Matlab (The Mathworks, Natick, 2008).

RESULTS: T2w, T2w-FLAIR and ADC images showed significant changes attributable to the SRS, whereas visual changes in PD images were limited. The time response to radiation shown by MR images was different between benign and malignant lesions. Benign neurinomas started showing a few changes after two months. In contrast, metastasis showed significant image changes one month after the SRS. The faster response observed for the metastasis might be due to the previous whole brain radiation, differences in radiation sensitivities between tissues or the higher dose involved in the SRS. Some radio-necrotic focuses were observed in perilesional areas of the metastasis, indicating that small differences might exist between the TPS planning and the actual damage, although a more rigorous quatitative analysis must be done to demonstrate this hypothesis. Importantly, those differences cannot be explained by tumor growth, as it has been reported that tumoral volume is constant or even tends to decrease in metastases after SRS [3,4].

CONCLUSION: We demonstrated that MRI, in particular T2w, T2w-Flair and ADC sequences, is capable of detecting metabolic changes associated with damage caused by the SRS. Even though there was correlation between planned doses and observed image changes, small differences were found, which could be explained by an increased radioactive sensitivity in peritumoral areas or by dose underestimations obtained from the TPS. Despite of the small number of presented experiments, the obtained results help to validate our hypothesis that MRI could be used to create an *in vivo* tool to evaluate radiation damage, providing a new form of feedback to TPS.

REFERENCES: [1] Crescenti et al. Med Phys. 34, 4:1286-97 (2007). [2] Andia et al. Proceedings ISMRM. 3849 (2008). [3] Kanga et al. Eur J of Rad (2008) in press. [4] Peterson et al. Radiology 211: 807-814 (1999).

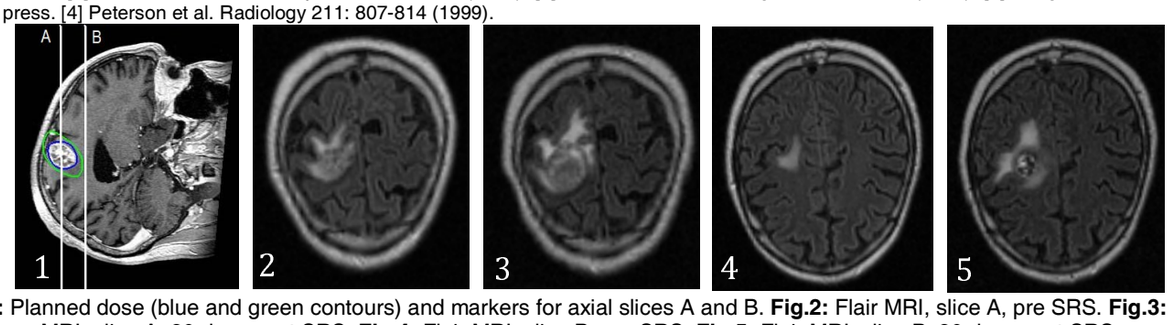

Fig.1: Planned dose (blue and green contours) and markers for axial slices A and B. **Fig.2:** Flair MRI, slice A, pre SRS. **Fig.3:** Flair MRI, slice A, 30 days post SRS. **Fig.4:** Flair MRI, slice B, pre SRS. **Fig.5:** Flair MRI, slice B, 30 days post SRS.

No Reveiewer Comments Exist..