The evaluation of radiation-induced changes in water content of the parotid gland using MRI

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Introduction: A reduced salivary flow (xerostomia) is the most common side effect after radiotherapy (RT) in patients with head-and-neck cancer. Xerostomia induces difficulty in swallowing, eating and speaking and early onset of dental caries. The underlying effects causing radiation-induced xerostomia are still not fully understood. The water content of the parotid gland is most likely changing due to radiation damage. Various non-invasive MR methods to study water content are available, from which MR sialography and a multi-point Dixon technique were applied in this study. With the Dixon technique, it is also possible to investigate the fat content. Fat is, after water, the second main component of the parotid gland [1].
The goal of this study was to investigate whether MRI could be used to determine radiation-induced changes in the water content and the ductal system of the parotid gland after RT.

Methods: Five healthy subjects were scanned to determine the natural variation in water content in healthy parotid glands. In order to find this variation, the average signal in the parotid gland was normalized to the signal of a reference material. Three patients were included, they all received a different mean dose to the parotid glands in the RT treatment. The difference in mean dose resulted in a difference in remaining functionality of the glands (see table 1). Due to this difference in mean dose and flow, the effect of radiation-induced damage to the parotid gland can be studied within one subject.
The images were acquired on a 3.0 T MR scanner (Achieva, Philips Medical Systems, Best, NL), using lateral located circular surface coils (FLEX M) as the receive coils. Spatial inhomogeneities in coil sensitivity were corrected using CLEAR. The persons were scanned in an immobilization mask to prevent movement artifacts. All images had a sagittal orientation, an in-plane resolution of 0.4 mm and a slice thickness of 4 mm. The sialography images were acquired using a MS TSE sequence (TR/TE/FA = 6000/190/90). The multi-point Dixon technique was a 2D gradient-echo sequence (TR/TE/FA = 65/9.9/90) using 4 echoes (ΔTE =0.5) [3].

	D_{left} (Gy)	D_{right} (Gy)	$Flow_{left}$ (%)	$Flow_{right}$ (%)
Patient 1	18	53	117	21
Patient 2	25	51	95	25
Patient 3	29	16	28	66

Table 1 *Patient characteristics. D is the mean dose to the parotid glands. The flow was measured using Lashley cups [2] and was expressed as a pre-RT flow rate.*

Results & Discussion: The sialography images of the healthy subjects showed the salivary ductal system consisting of the Stenson's duct and several branches within the parotid gland. The contour of the gland was clearly visible as an area of increased signal intensity (figure 1 A). This correlated nicely with delineations made on an anatomical T1-weighted image. The sialography images of the patients were very similar to the images of the healthy subjects. There was no clear difference between the functioning and damaged glands in the patients (figure 1 A & D). All sialography signal intensities of the irradiated glands were in the range of the natural variation between the healthy subjects (table 2). The standard deviation of the sialography is large due to the high signal intensity of the ducts compared to the parotid gland area.
The Dixon water and fat images of the healthy subjects showed a homogeneous water and fat content among the parotid gland. The images of the patients were again very similar to the images of the healthy subjects. There was no difference between the Dixon water images of the functioning and damaged glands (figure 1 B & E), the signal intensities of the irradiated glands were also within the range of the natural variation (table 2). However, there was a difference in the Dixon fat images between the functioning and the damaged gland in patients (figure 1 C & F). The fat signal intensity of patient 1 and patient 2 was respectively 36 % and 58 % higher than the natural variation in signal intensity of the Dixon fat images (table 2).

	Mean	SD
Sialography	0.67	0.33
Dixon water	0.13	0.03
Dixon fat	0.29	0.08

Table 2 *Signal intensity in the parotid glands of five healthy subjects, expressed by the mean normalized signal intensities and the standard deviation (SD).*

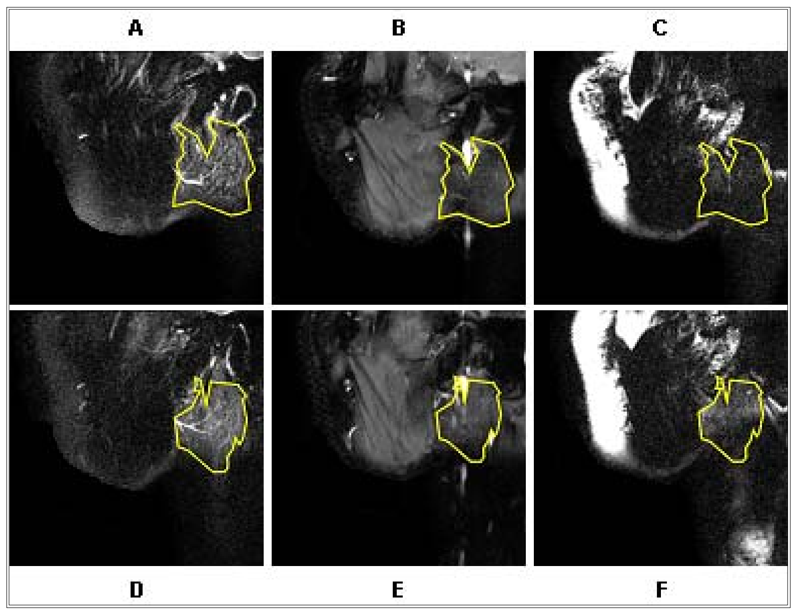

Figure 1 *The sialography (A&D) and Dixon water (B&E) and fat (C&F) images of patient 2 in the same slice. The top images are from the functioning gland, which received a low dose. The bottom images are from the damaged gland, which received a high dose.*

In order to determine the effect of radiation damage on the ductal system and the water and fat content of the parotid gland, more patients will be scanned before and at several time points after RT.

Conclusions: With MR sialography and the multi-point Dixon method, it was possible to visualize the water content of the parotid gland. The ductal system was nicely visualized with MR sialography. In this small pilot study however, we observed no damage to the large ductal system of the parotid gland or a change in water content of the parotid gland as a radiation-induced effect. It appeared that there was a difference in the fat content after a high RT dose, while the water content did not change. This could account for a difference in tissue composition.

References:
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