3D MR sialography as a tool to visualize and investigate radiation-induced changes to the salivary glands and ducts in patients

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Introduction: Salivary dysfunction is a prevalent side effect suffered by patients receiving head and neck radiotherapy (RT) and has serious consequences in their quality of life. The standard methods of measuring salivary gland function impairment are Tc-99m scintigraphy and salivary flow measurements using Lashley's cups. Neither of them can give spatial information on the radiation-induced damage to the salivary glands and ducts. Obtaining this information could lead to optimisation of the radiation dose delivery to the salivary glands, using intensity modulation radiation therapy (IMRT) treatment planning, and eventually prevention of this side effect. We investigated the potential of using 3D MR sialography for these purposes. MR sialography is an imaging technique that has the unique property of using saliva itself as contrast medium and thus visualizing the salivary duct system as a function of the containing saliva. We developed and evaluated a 3D MR Sialography protocol on healthy volunteers and conducted a pilot study with patients, to investigate whether it was possible to depict differences between the salivary duct systems pre- and post-RT.

Materials & Methods: Eleven healthy volunteers were scanned for the development of a 3D MR sialography protocol that includes the major salivary glands and ducts (submandibular and parotid) in one scan volume. The scan was performed with a 3D turbo spin echo (TSE) with proset water selective excitation pulse with the following imaging parameters: TSE factor 88, slice thickness 1.5 mm, number of slices between 47 and 55 depending on the anatomy, acquisition matrix 256x256 (half scan), reconstruction matrix 512x512, field of view (FOV) 200x200 mm^2, resulting in a total scan duration time between 8 to 9 min depending on the number of slices. A 2 element circular surface coil was used. A subjective duct visibility scoring system was developed, that ranged from 0 to 4 for the parotid ducts and 0 to 2 for the submandibular ducts. The score was maximum when the whole trajectory of the salivary ducts was visible. The reproducibility of the measurement in long-term time-intervals (6 months) was tested on 6 volunteers. That was important in order to reliably conclude that the differences in patients from pre- and post-treatment sialographic images resulted from radiotherapy. Then, 9 patients with T1-4N0-2M0 naso- or oropharyngeal cancer were scanned with that protocol pre-RT, 6 weeks, 6 months and 1-year post-RT, in the immobilization mask as at the RT treatment position. Image registration between the CT and the MR sialography was performed and thus with the dose distribution. Salivary flow measurements using Lashley's cups were carried out at the same time intervals as well.

Results: Our protocol provides good quality 3D sialographic images of the submandibular and parotid duct systems including up to the second order small duct brunches (fig.1) and is reproducible (fig.2). In healthy volunteers, as well as in patients before RT, the duct visibility score was the maximum. Moreover, in case of the healthy volunteers the score was reproducible in long-term time intervals while in patients it was only reproducible for those glands (total 5 parotid glands and 2 submandibular glands) receiving dose <20 Gy. Those were also the only glands from which saliva was collected post-RT. The score reduced to 1 or 2 for the parotid ducts and to 1 for the submandibular glands receiving dose > 20Gy at 6 weeks post -RT. Recovery in the duct visibility was observed 6 months and 1 year post post-RT compared to that 6 week post-RT for those glands receiving dose between 25-45 Gy but there was no improvement for those glands receiving a dose > 45 Gy (fig. 3). The recovery in duct visibility was followed by a recovery in the salivary flow.

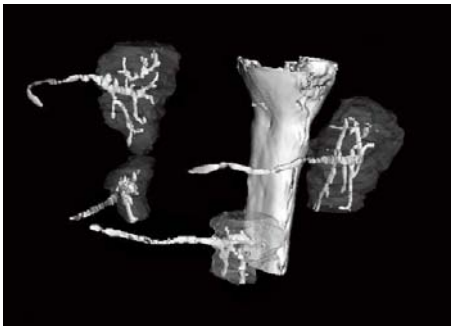

Fig. 1 Parotid ducts and submandibular ducts in 3D of a healthy volunteer as derived by thresholding the source data of the MR sialography

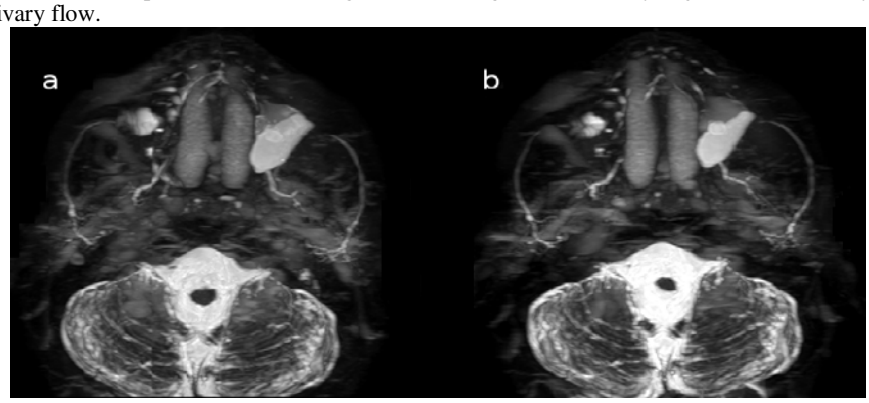

Fig. 2 Transverse maximum intensity projection (MIP) images of the MR sialogram of a healthy volunteer a) base line measurement b) 6 months later demonstrating the reproducibility of the MR sialography in time.

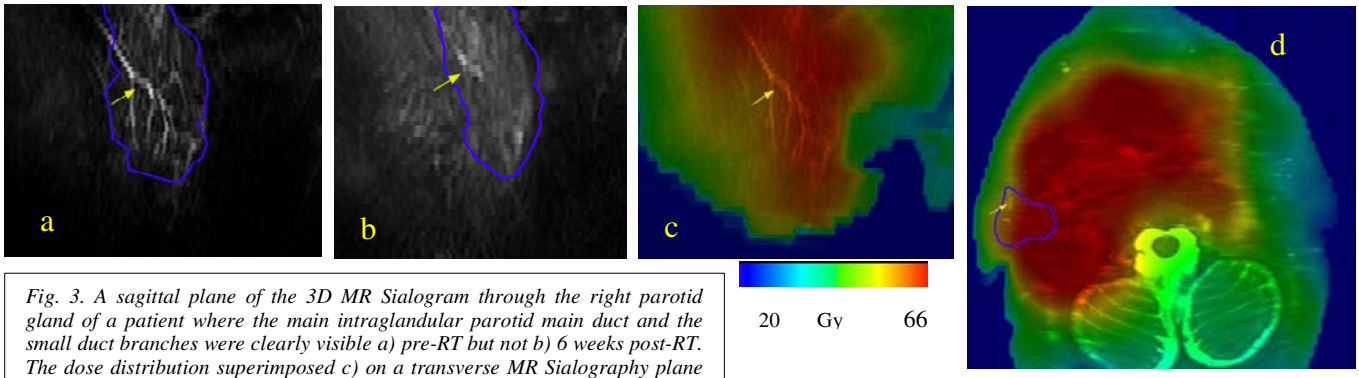

Fig. 3. A sagittal plane of the 3D MR Sialogram through the right parotid gland of a patient where the main intraglandular parotid main duct and the small duct branches were clearly visible a) pre-RT but not b) 6 weeks post-RT. The dose distribution superimposed c) on a transverse MR Sialography plane d) on the same sagittal. The yellow arrow indicates the same point of the intraglandular parotid duct. The blue contour is the right parotid gland.

Conclusions: 3D MR sialography is a novel approach in investigating salivary dysfunction and a useful tool to image and provide spatial information of the radiation-induced changes to the salivary system.