Imaging for salivary gland sparing radiotherapy

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Abstract

One of the major side effects of radiotherapy in the head-and-neck area is a reduced saliva production due to the high radiation-sensitivity of the salivary glands. The reduced salivary flow induces difficulties in swallowing, eating, speaking, and often induces dental caries. This thesis addresses the aspects of the radiotherapy treatment of HN cancer patients and the radiation-induced complications of the largest salivary glands, the parotid and submandibular glands. The topics follow the same path as a patient during treatment: from imaging, through radiotherapy planning and the daily treatment, to unfortunately in some cases, radiation-induced xerostomia.

Magnetic resonance imaging (MRI) strategies to visualize both the tumour and the salivary glands were explored. The feasibility of perfusion MRI to assess the blood perfusion characteristics of the head-and-neck tumours was investigated. Compared to healthy tissue, the blood perfusion within the tumour was significantly increased. Perfusion MRI was shown to be a promising tool in tumour characterisation and to guide the radiotherapy treatment.
As for the salivary glands, MR sialography was used to obtain high-resolution images, which show the outline of the gland as a medium-intense signal with high-intense ducts inside. The MRI images were superior to CT in defining the outline of the submandibular gland, resulting in a significant increase in defined volume and by that a more accurate sparing of the gland.

Improvements in the radiotherapy treatment were obtained by adapting the dose distribution to reduce the dose to the salivary glands. An advanced intensity-modulated radiotherapy (IMRT) technique was used, resulting in a decrease in mean dose to the submandibular gland of 12 Gy. This amount of reduction will reduce the chance of complication of 85% to 50%.
Another improvement in the treatment was accomplished by optimizing the immobilization of the patients during treatment. Patients are treated in daily fractions and differences in patient positioning results in uncertainties in tumour position within the patient. To reduce this uncertainty, patients were immobilized with a special head support and a thermoplastic mask. Improvements in this head support reduced the movement during treatment, resulting in better treatment accuracies.

Finally, the chance of developing a complication given a certain dose distribution to the parotid gland was investigated to further improve clinical decision making. To accomplish accurate modelling on a large dataset, a combined dataset of the University Medical Center Utrecht and the University of Michigan Hospital was used. The mean dose was found to be the best prediction dose parameter and a mean dose of 40 Gy to the parotid gland resulted in a 50% chance of a complication.

The improvements in the radiotherapy treatment of head-and-neck cancer patients described in this thesis will make an important difference in preventing radiation-induced xerostomia and improve the quality of life of these patients. This will reduce the occurrence of submandibular gland complications from the 80% we see nowadays to 50% or less.