

Intensity Modulated Radiation Therapy in the Head and Neck Region using Dynamic Multi-Leaf Collimation

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Abstract

One of the advantages with the IMRT technique with photon beams compared to conventional external radiation therapy is the possibility to conform the high-dose region to the target volume and reduce the dose to organs at risk (ORs). Furthermore treatment plans can be created that simultaneously deliver different prescribed dose levels to well-defined target volumes. The fact that different ORs in the head and neck region are often situated close to, or even overlap, the target volumes, IMRT treatments are considered to be particularly suitable. The subject of this work was to investigate conditions and requirements of the IMRT technique using dMLC (dynamic multi-leaf collimation) for head and neck treatments with the purpose of implementing the technique in the clinic.

A commercially available inverse treatment planning system (TPS) was investigated. The influence of different parameters on the dose distribution, and how to use the TPS in an optimum way were analysed. The TPS was found to be well suited for the creation of clinical IMRT treatment plans for head and neck tumours. The number of beams and the constraints and weight factors are critical parameters which have a great influence on the dose distribution.

The influence of set-up errors on dose distributions for both IMRT treatment plans and conventional treatment plans was studied, and evaluation of the ICRU method for taking set-up errors into account was performed. The sensitivity to set-up errors regarding the target volume was found to be dependent on the target dose coverage and the effect in the ORs dependent on the sharpness of the dose gradients outside the OR. In general, the ICRU method works satisfactorily for IMRT treatments as well as for conventional treatments. However, the method makes it difficult to include organs at risk with mainly parallel structure if they are situated adjacent to the target volume. Heterogeneities in the patients only have a small influence on the effect of set-up errors, which is presumed for the ICRU method.

The dose conditions for IMRT treatments with dMLC were investigated by experimental determination of the head scatter (photons scattered from the accelerator head) for small fixed MLC and dMLC fields. When the size of the MLC opening is much smaller than the jaw field size the influence of the MLC on head scatter reaching the patient is large and cannot be neglected. Head scatter in dMLC fields are not only dependent on the jaw field size, but also on the size of the MLC slit and the movement pattern of the leaves.

A new treatment strategy for treating tonsil cancer patients was developed using the advantages of the IMRT technique and introducing the concept of simultaneous integrated multi-target treatment (SIMT). The SIMT technique was shown, theoretically, to be able to replace the combined external beam radiation therapy and brachytherapy with a single session of external radiation therapy with reduced doses to the ORs.

Keywords: IMRT, dynamic MLC, head and neck, inverse treatment planning, optimisation, set-up errors, patient positioning, head scatter, SIMT, simultaneous dose delivery

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