New Multileaf Collimator with a Leaf Width of 5 mm Improves Plan Quality Compared to 10 mm in Step-and-Shoot IMRT of HNC Using Integrated Boost Procedure

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**Purpose:** To investigate whether a new multileaf collimator with a leaf width of 5 mm (MLC-5) over the entire field size of 40 × 40 cm² improves plan quality compared to a leaf width of 10 mm (MLC-10) in intensity-modulated radiotherapy (IMRT) with integrated boost for head and neck cancer.

**Patients and Methods:** A plan comparison was performed for ten patients with head and neck cancer. For each patient, seven plans were calculated: one plan with MLC-10 and nine beams, four plans with MLC-5 and nine beams (with different intensity levels and two-dimensional median filter sizes [2D-MFS]), and one seven-beam plan with MLC-5 and MLC-10, respectively. Iso-center, beam angles and planning constraints were not changed. Mean values of common plan parameters over all ten patients were estimated, and plan groups of MLC-5 and MLC-10 with nine and seven beams were compared.

**Results:** The use of MLC-5 led to a significantly higher conformity index and an improvement of the 90% coverage of PTV1 (planning target volume) and PTV2 compared with MLC-10. This was noted in the nine- and seven-beam plans. Within the nine-beam group with MLC-5, a reduction of the segment number by up to 25% at reduced intensity levels and for increased 2D-MFS did not markedly worsen plan quality. Interestingly, a seven-beam IMRT with MLC-5 was inferior to a nine-beam IMRT with MLC-5, but superior to a nine-beam IMRT with MLC-10.

**Conclusion:** The use of an MLC-5 has significant advantages over an MLC-10 with respect to target coverage and protection of normal tissues in step-and-shoot IMRT of head and neck cancer.

**Key Words:** IMRT · Multileaf collimator · 5 mm leaf width · Conformity index (CI) · Head and neck cancer (HNC)

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Ein neuer Multileafkollimator mit einer Lamellenbreite von 5 mm verbessert die Planqualität im Vergleich zu einer Lamellenbreite von 10 mm bei der „step-and-shoot“-IMRT mit integriertem Boostverfahren bei Kopf-Hals-Tumoren

**Ziel:** Gegenstand dieser Untersuchung war, ob bei der intensitätsmodulierten Radiotherapie (IMRT) von Kopf-Hals-Tumoren mit integriertem Boost ein neuer kommerzieller Multileafkollimator mit einer Lamellenblende von 5 mm (MLC-5) über eine Feldgröße von 40 × 40 cm² zu einer Verbesserung der Planqualität im Vergleich zu einer Lamellenblende von 10 mm (MLC-10) führt.


**Ergebnisse:** Der Einsatz eines MLC-5 führt im Vergleich zu einem MLC-10 zu einer signifikanten Verbesserung des Konformitätsindex und zu einer Erhöhung von V90 des PTV1 (Planungszielvolumen) und PTV2 (Tabellen 1–4, Abbildung 3). Dies konnte für Neun- und Sieben-Felder-Pläne gezeigt werden. Innerhalb der Neun-Felder-Plangruppen mit MLC-5 führte eine Verringerung der...

**Schlussfolgerung:** Die Verwendung eines MLC-5 weist gegenüber einem MLC-10 signifikante Vorteile bezüglich der Zielvolumenabdeckung und der Normalgewebschonung bei der „step-and-shoot“-IMRT von Kopf-Hals-Tumoren mit integrierter Boostapplikation auf.

**Schlüsselwörter:** IMRT · Multileafkollimator · 5-mm-Leafbreite · Konformitätsindex · Kopf-Hals-Tumoren

### Introduction

Intensity-modulated radiotherapy (IMRT) gains increasing acceptance in radiation therapy of head and neck cancer (HNC) due to the homogeneous target volume coverage and protection of organs at risk (OARs) like spinal cord, brain stem or parotid glands [2, 8, 13, 19]. A frequently utilized technique is the step-and-shoot IMRT using a multileaf collimator (MLC) [6]. Another advantage of IMRT is the possibility to integrate a boost, which saves time and leads to a slightly higher, biologically more effective single dose in the boost volume [14]. The quality of dose distribution for step-and-shoot IMRT can be improved both by a higher number of radiation fields and lower leaf width. However, phantom studies have demonstrated that more than eleven fields cannot further improve plan quality; the same applies to a leaf width < 3 mm [1, 9–11].

The leaf width of MLCs in current use is 10 mm (MLC-10) with a maximum total field size of 40 × 40 cm² at the isocenter. Newer commercial collimators integrate thinner leaves either by the introduction of an additional micro-MLC into the beam or by the insertion of thinner leaves into the central area of the MLC and preservation of the usual 10-mm leaves in the outer area (e.g., dynamic IMRT with Varian 120MLC® or HD-120MLC®). In these collimators, the maximum field size with a smaller leaf width of 5 mm (MLC-5) is up to 22 × 22 cm².

The irradiation of patients with HNC frequently requires the inclusion of the entire cervical lymphatic drainage, causing radiation fields with a length of up to 25 cm extending from the base of the skull to the clavicle.

The first MLC-5 with an entire field size of 40 × 40 cm² (160MLC®, Siemens) has become commercially available in 2008. With this collimator it is possible to deliver a step-and-shoot IMRT with 5 mm leaf width over the whole treatment volume.

The goal of this study was to compare MLC-5 with traditional MLC-10 in HNC cases. Under otherwise same conditions, the improvement of plan quality in step-and-shoot IMRT of HNC via integrated boost procedure was analyzed.

### Patients and Methods

#### Patients

A comparison of IMRT plans with MLC-5 over 40 × 40 cm² and MLC-10 was performed on ten patients with HNC undergoing IMRT in 2008.

All patients were male; the mean age was 55 years (range, 42–70 years). The histopathology was squamous cell carcinoma (SCC) in all cases. Locations of the tumors were the oropharynx (n = 5), the tongue (n = 2), the tongue root (n = 1), the hypopharynx (n = 1), and the larynx (n = 1).

### Therapy

IMRT was the primary treatment in six cases and given as adjuvant treatment after surgery in four other cases.

In all cases, the entire cervical lymph drainage and the primary tumor or the postoperative tumor bed were irradiated using an integrated boost procedure. In all cases, concurrent chemotherapy was applied [12, 18].

### Technique

The planning system Virtuous, an in-house development of the German Cancer Research Center, was used for treatment planning and comparison of the plans [4]. Plan optimization was performed by the inverse treatment-planning program KonRad® (Siemens).

Both, a linear accelerator with an MLC-10 (Primus®, Siemens; P) and MLC-5 over 40 × 40 cm² (Artiste®, Siemens; A) were implemented, validated, and in daily use.

A head mask and a whole-body vacuum cushion were used. Treatment-planning contrast-enhanced computed tomography (CT) or magnetic resonance imaging (slice thickness 3 mm) was performed in stereotactic setup. The boost volume (PTV1) contained the macroscopic primary tumor or the tumor bed and a clinically tumor-free margin of 0.5–1 cm. The volume of the cervical lymphatic drainage (PTV2) generally contained the levels I–V, except submental lymph nodes. The mean PTV1 was 226.7 cm³ (range, 79–643 cm³), and the mean PTV2 was 1,456.1 cm³ (range, 1,077–2,149 cm³) including an additional safety margin of 0.5 cm for positioning error. The geometric center of PTV1 was the isocenter of radiation treatment. The spinal cord, brain stem and contralateral parotid gland were defined as OARs. In seven cases, the dose prescription in the integrated boost concept was 70.2 Gy for PTV1 and 57.6 Gy for PTV2 with a single dose of 2.2 Gy and 1.8 Gy per day, respectively. For the remaining three cases, the following doses were applied: for PTV1 67.2 Gy, 66 Gy, and 66 Gy, respectively and for PTV2 57.6 Gy, 57.6 Gy, and 54 Gy, respectively. The single doses were 2.1 Gy, 2.06 Gy, 2 Gy, and 1.8 Gy, respectively.