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TECHNICAL NOTE

An intraoral cone system for a Neptun 10PC linear accelerator

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Abstract. Intraoral irradiation, the treatment choice for well defined oral-cavity tumors, is done using intraoral cone (IOC) systems. In this study, an IOC system was developed for a Neptun 10PC linac. Beam parameters necessary to plan an intraoral electron treatment were evaluated for two applicators, a flat and a beveled end. Measurements were performed using a Scanditronix (p-Si) diode field detector in a Scanditronix (RFAplus) 3-D (three-dimensional) water phantom. Percent depth dose distributions, beam profiles, and leakage dose distributions for the developed cone system are presented.

Key words: intraoral cone • oral cavity • electron boost

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Introduction

Treatment of early carcinoma of oral cavity using external beam radiation therapy alone usually encompasses a significant amount of normal healthy tissue [1, 2, 5, 7]. For well defined tumors, in order to deliver a local boost to the tumor, an IOC electron beam technique is considered superior to brachytherapy, or kilo voltage techniques [5, 6]. In this study the objectives were designing, constructing and dosimetry of an electron cone system for a Neptun 10PC linear accelerator.

Methods and materials

An IOC system was attached to the treatment head of a Neptun 10PC linac using one of machine's wedge holders [4]. The electron mode activation mechanism was not modified, i.e. electron mode microswitches, detached from the standard electron applicators, were used. Cone system includes an aluminum plate from which the applicators are designed to hang down (Fig. 1). Two acrylic

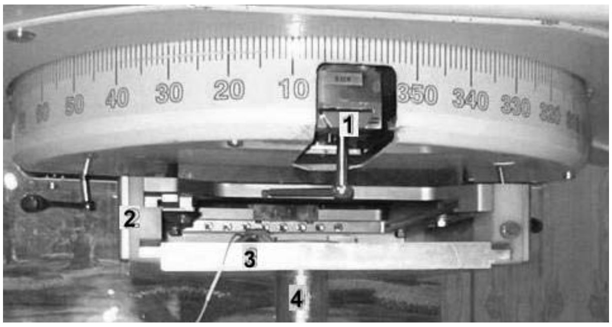

Fig. 1. Intraoral electron cone system attachment to treatment head. 1 – one of four electron mode microswitches removed from the standard electron applicators; 2 – wedge holder; 3 – aluminum plate; 4 – applicator system.

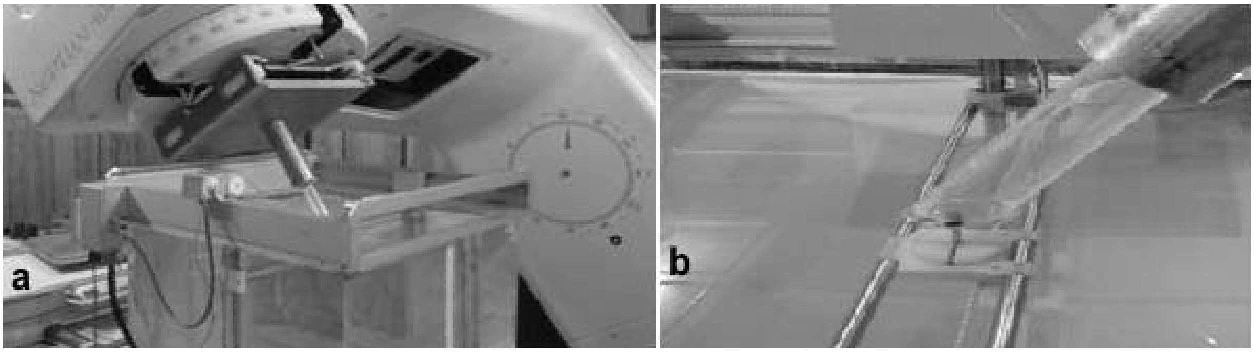

Fig. 2. Measurement setup for the beveled end cone, (a) the gantry was rotated until the end of the cone was flush with the water surface, (b) cone end position with respect to detector.

tubes, a flat end and a 45-degree beveled end, with an inner diameter of 3 cm, were used. Measurements were performed for a 10 MeV electron beam, using a Scanditronix (p-Si) diode field detector in a Scanditronix (RFAplus) 3-D water at 100 cm skin source distance (SSD). For beveled end cone, gantry was rotated until the end of the cone was flush with water surface (Fig. 2) and the percent depth dose (PDD) curves were measured at the center of the field and perpendicularly to water surface. Cone ratios were obtained at d_{max} and relative to the output of a standard 10 × 10 cm^2 field. To study leakage, applicators were inserted into water up to 10 cm of their length and measurements were performed perpendicularly to the applicator, and also along the applicator's length, 20 mm away from the applicator wall and the results were normalized to the central axis D_{max}.

Results and discussion

Relative to the standard electron applicator (5 × 5 cm^2 field size), PDD curves for oral cones tend to be closer to the surface and beveled end applicator has the shallowest PDD (Fig. 3). Surface dose is higher for oral cones and increases with X-ray jaw settings and obliquity of beam incidence. Effect of X-ray jaw setting and gap on depth dose distributions was not significant (Fig. 4). Cone uniformity indexes (the ratio of the area where the dose exceeds 90% of its value at the central axis to the geometric beam cross-sectional area at the phantom surface) [3] were calculated using d_{max} beam profiles (shown in Fig. 5) and the results are presented Table 1. Effect of X-ray jaw settings on radiation leakage outside the flat applicator is shown in Fig. 6. Since leakage was greater for smaller jaw settings, 20 × 20 cm^2 was selected as the optimum setting. Leakage was limited to the depth of 3 cm, while the applicator was inserted 10 cm deep in water. At larger depths, the leakage dose was only due to X-rays, about 1% of D_{max}. For beveled applicator, the radiation leakage distributions are

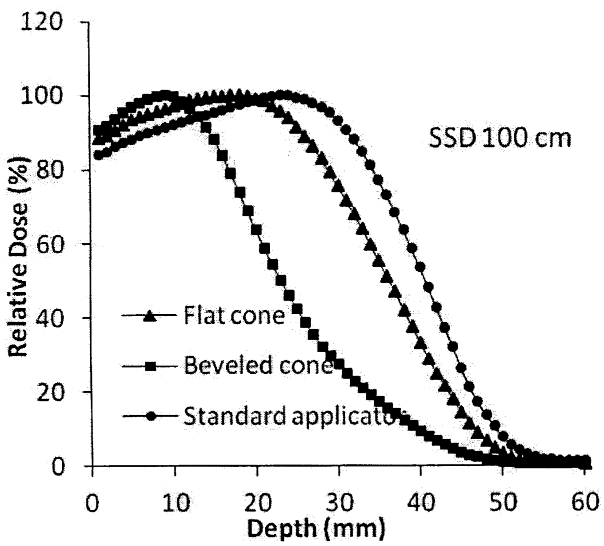

Fig. 3. PDD curves for flat and beveled cones and standard applicator (5 × 5 cm^2 field size) in X-ray jaw setting of 15 × 15 cm^2 and at SSD = 100 cm.

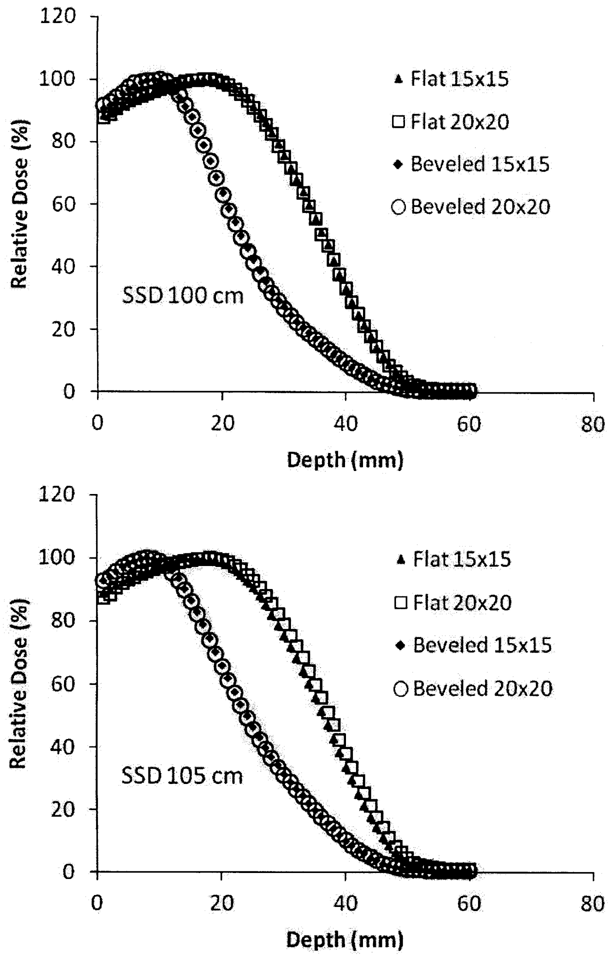

Fig. 4. PDD curves for flat and beveled cones, 15 × 15 and 20 × 20 cm^2 X-ray jaw settings at SSD = 100 and 105 cm.

Table 1. Uniformity indexes for oral cones with X-ray jaw setting of 20 × 20 cm² at SSD = 100 and 105 cm

X-ray jaw setting (cm²)	SSD =100 cm		SSD = 105 cm	
	Flat	Bevel	Flat	Bevel
15 × 15	0.68	0.62	0.64	0.64
20 × 20	0.68	0.60	0.64	0.62

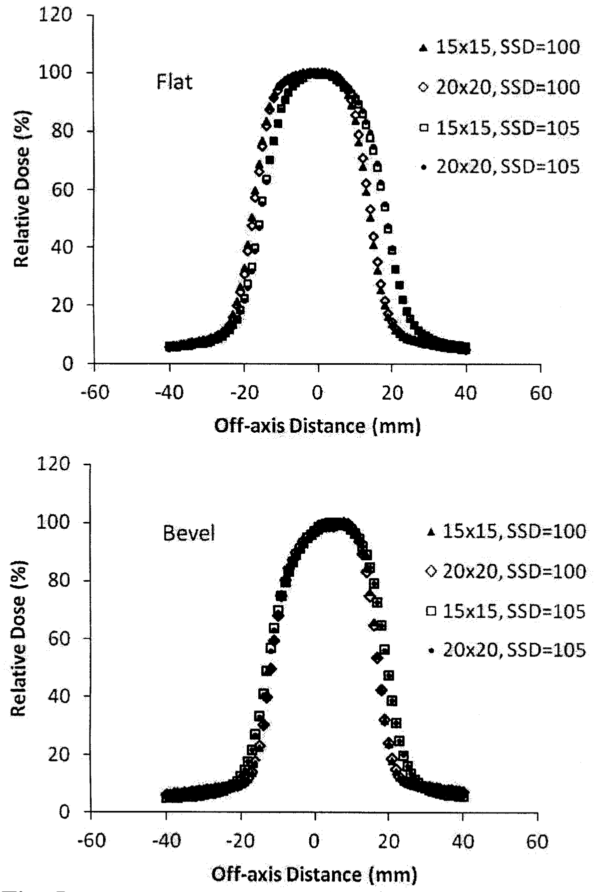

Fig. 5. Beam profiles measured at d_{max} at SSD = 100 and 105 cm for X-ray jaws of 15 × 15 and 20 × 20 cm² for flat and beveled cones.

shown lateraly at depths of 18, 28 and 37 mm starting at 20 mm away from the applicator wall in Fig. 6, and axialy in Fig. 7. For beveled applicator, the radiation leakage was due to both X-rays and electrons. The energy of the

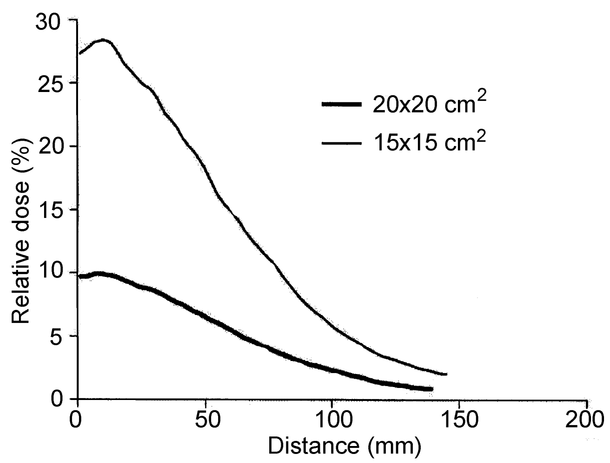

Fig. 6. Radiation leakage profile outside the flat applicator, measured at depth of d_{max} (18 mm) and normalized to dose at the central axis d_{max} as a function of distance from wall for 15 × 15 and 20 × 20 cm² X-ray jaw settings.

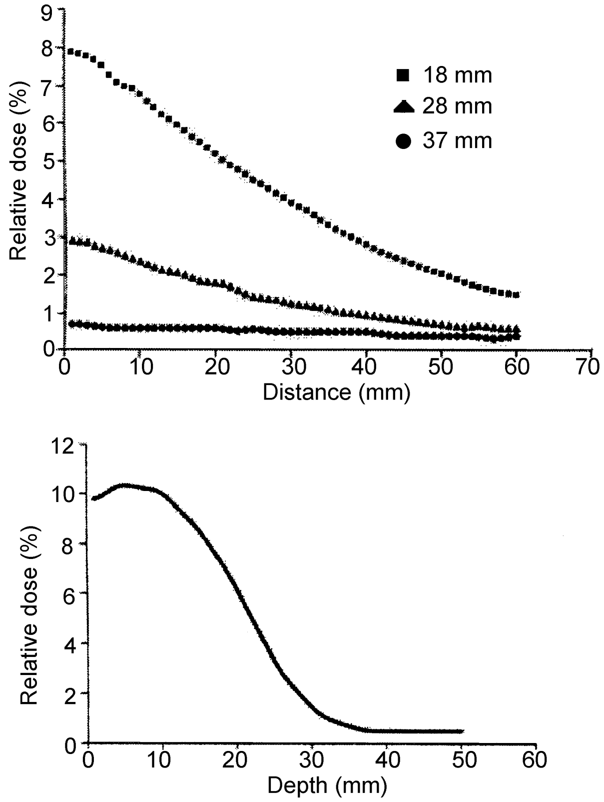

Fig. 7. Beveled applicator radiation leakage distributions for X-ray jaw setting of 20 × 20 cm², (above) perpendicular to tube at depths of 18, 28 and 37 mm, (below) along the length of tube 2 cm away from the wall.

electron beam outside of the wall is about 5 MeV and it contributes to about 10% of the D_{max}.

Conclusions

An intraoral cone system was developed for electron beam radiation treatment and boosting of the primary tumors in the oral cavity to a high-dose level. The largest jaw setting, 20 × 20 cm², was selected due to its lower leakage. At 100 cm SSD and for a 10 MeV electron beam, the flat cone is suitable for tumors with a 2.1 cm lateral extension compared to the beveled cone of the same size which is suitable for treating a planning target volume (PTV) of 1.8 cm diameter.

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