Distribution of scattered radiation in superficial X-ray therapy

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Introduction

It is known [1], that lead shields are used in superficial radiotherapy of the periorbital region to reduce the dose delivered to critical structures beneath the area requiring treatment, which are close to or over the eye [2, 3]. The protection efficiency of lead eye shields must be evaluated before their appliance in superficial X-ray therapy treatment.

One of the most recent evaluations of eye protection efficiency from direct X-rays for the case when the applicator is set in a certain distance from the irradiated area has been performed by M. J. Butson et al. [3].

However the superficial X-ray therapy is also performed when the applicator contacts with patient surface. In this case, the eye protection and the evaluation of protection efficiency raise some questions, because of the scattered photons, originating from the applicator and lead shielding.
**Purpose**

The purpose of this work was to investigate experimentally the angular distribution of scattered radiation of X-ray photons that were responsible for the doses registered on the head phantom surface without shielding and with a lead shielding during superficial X-ray therapy treatment, and to evaluate the efficiency of this shielding when the applicator contacts the phantom surface.
GULMAY D3225 X-ray therapy unit with a acrylic conical applicator (orbicular exposure field - Ø4 cm) was used for the irradiation of PMMA head phantom (Cardinal Health Model 76-414-4150, Ø16 cm, h =15.8 cm, ρ =1.190 g/cm³) without shielding and shielded with a pieces of lead (4.12 x 3.15 x 0.183) cm³.

A set of calibrated pencil dosimeters D-500 (dose range - 0.02÷5 Gy) were used for dose measurements. Dose values were estimated using analyser KID-6.
Methods

Central angle of 28.072 degrees was estimated for the irradiation field diameter, when the applicator had a contact with the phantom. In order to include the contribution of side scattered photons from the applicator to the phantom surface dose, dosimeters were placed around a phantom with an angular step of 15 degree. This arrangement enabled us to measure edge doses when the pieces of shielding lead were placed on the phantom’s surface just beneath the applicator.

Angular surface dose distributions (without and with a lead shielding) were measured changing the beam quality (80 kVp, 100 kVp, 120 kVp). Irradiation dose to the target, $DT = 4.0$ Gy at 0.5 cm depth was kept during all measurements. Irradiation parameters are provided in the Table 1.

<table>
<thead>
<tr>
<th>Tube voltage, kVp</th>
<th>$D_{0.5}$, Gy</th>
<th>$D_0$, Gy</th>
<th>Photon penetration depth, cm</th>
<th>HVL</th>
<th>Tube current, mA</th>
<th>FSD, cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>4.0</td>
<td>4.56</td>
<td></td>
<td>2.44 mm Al</td>
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<td></td>
</tr>
<tr>
<td>100</td>
<td>4.0</td>
<td>4.50</td>
<td>0.5</td>
<td>2.97 mm Al</td>
<td>20.0</td>
<td>20</td>
</tr>
<tr>
<td>120</td>
<td>4.0</td>
<td>4.45</td>
<td>0.5</td>
<td>5.33 mm Al</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results

Angular surface dose distributions

1 – GULMAY D3225 X-ray therapy unit; 2 – conical applicator; 3 – pencil dosimeter D-500; 4 – PMMA head phantom; 5 - lead eye shield
Results
Conclusions

Investigation has shown that the lead shielding placed on the phantom surface near by the applicator of X-ray irradiation unit “narrows” side scattering range of X-ray photons and reduces the doses in the shielded area depending on the beam quality and angular position. The most effective dose reduction of > 70% was obtained at the angle of 210°, which corresponds to the distance of 4 cm from the edge (applicator side) of Pb shielding plate. However due to the edge conditions (applicator - Pb plate) at 195° the dose reduction of < 20% was not satisfying. Dose reduction of ~50% at further from applicator edge of lead shielding is appropriate. Shielding effectiveness in these regions needs more detailed investigation.

References