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Short communication

The comparison of Co-60 and 4 MV photons matching dosimetry during half-beam technique

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Abstract

In this phantom study, we tried to compare matching dosimetry differences between half-blocking of Co-60 and asymmetric collimation of the 4 MV photons during craniospinal irradiation. The dose distributions are compared and discussed. Firstly, some gaps with different sizes are left between cranial and spinal field borders. Secondly, the fields are overlapped in the same sizes. We irradiate the films located in water-equivalent solid phantoms with Co-60 and 4 MV photon beams. This study indicates that the field placement errors in $\pm$ 1 mm are acceptable for both Co-60 and 4 MV photon energies during craniospinal irradiation with half-beam block technique. Within these limits the dose variations are specified in $\pm$ 5%. However, the setup errors that are more than 1 mm are unacceptable for both asymmetric collimation of 4 MV photon and half-blocking of Co-60.

Keywords: Caniospinal irradiation; Half-beam block technique; Matching dosimetry

1. Introduction

Tumors with a high probability of cerebrospinal space involment may entail craniospinal irradiation (Benk et al., 1995). Due to the non-co-planar application of this treatment dosimetric problems may occur during irradiation. Matching of the superior and inferior fields is crucial and different techniques have been proposed to overcome the problem produced by field junctioning (Dyk et al., 1977; Glasgow and Marks, 1983; Griffin et al., 1976). Half-beam Block technique is one of the widely credited techniques in which the collimator is opened twice the treatment field while centre of the superior field (cranial field) is matched with border of inferior field (spinal field) and inferior port shielded (Fig. 1). During irradiation necessary protections are applied with individual blocks. Since the central beam is at the field border, no gapping or overlapping is required. However different energies may exhibit variations in dose distribution. As could be expected the edges of Co-60 half beam cannot be sharp as the edge of a 4 or 6 MV linear accelerator half-beam. In this study we tried to investigate the dosimetric differences at the matching area of the cranial and spinal fields of Co-60 half-beam application or 4 MV linear accelerator asymmetric collimation.

2. Materials and methods

Dose uniformity of the matching area was examined with a solid water phantom. After placing Kodak X-Omat V films at 2 cm depth of the phantom, the system was irradiated

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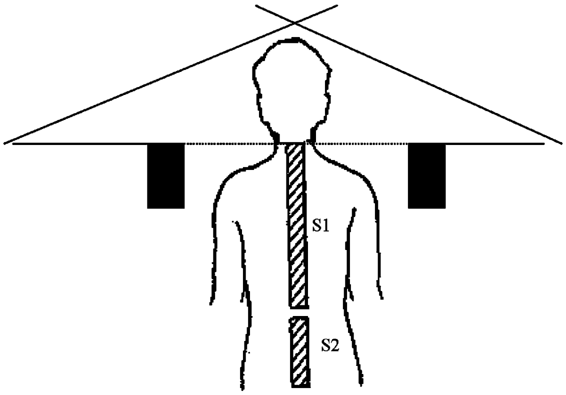

Fig. 1. A typical half-beam treatment fields for cranial–spinal irradiation.

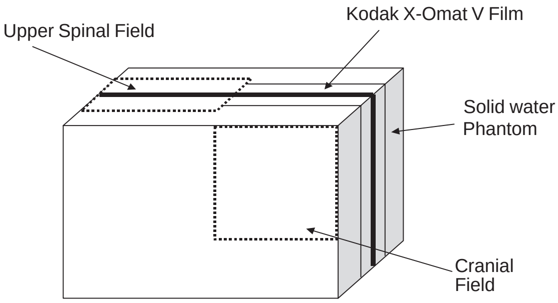

Fig. 2. Three fields arrangement for experimental set-up.

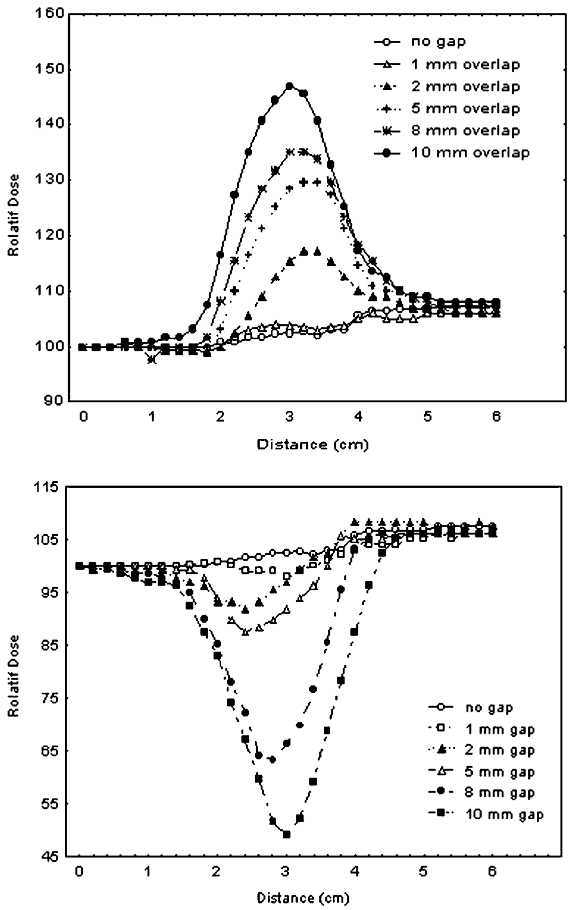

Fig. 3. Results of film dosimetry at junction region using half-beam irradiation by Co-60 beams in the three fields technique.

perpendicularly with differing doses of 25, 50, 75, 100, 150 and 200 cGy both with Co-60 and 4 MV linear accelerator with a field size of 10×10 cm. Films were developed with an automatic film processor. Macbeth TD931 Optic densitometer located at the field centre recorded the optic density of the irradiated film. Optic density results and given doses were transferred to *Y*-axis and *X*-axis of a coordinate system respectively and calibration curve was drawn. Results were linear at the doses between 75 and 110 cGy, so 75 cGy was chosen for film dosimetry.

For the cranial field; collimator was opened as $18 \times 36\,cm^2$ with a focus surface distance (FSD) of 90 cm. Centre of the field was settled at the field border and by applying half-block asymmetric field was reduced to $18 \times 18\,cm^2$. For the spinal field collimator was opened as $6 \times 36\,cm^2$ with FSD of 90 cm. Similarly centre of the field was settled at the field border and half-blockings was applied. Followingly solid water phantom was irradiated with 75 cGy at 4.5 cm. depth (Fig. 2). Irradiation was performed with gaps and overlaps of 0, 1, 2, 5, 8 and 10 mm. All the measurements were repeated with Co-60 under the same conditions but with 80 cm. FSD (Fig. 3).

2.1. Verification of dose uniformity at the junction of two parallel asymmetric fields

The film was placed at a depth of 1 cm for maximum dose in the solid water phantom. Initially, the field was determined by closing its half with asymmetric collimators ($X1 = 10$, $X2 = 0$, $Y = 10$). Then, the field was collimated ($X1 = 0$, $X2 = 10$, $Y = 10$). The measurements were performed with 4 MV photons. Scanning the film placed at the centre of the film showed +8% dose variation at the matching area (Fig. 4) which points that digital display tolerance was less than +1 mm. for 4 MV linear accelerator (ORION).

2.2. Matching dosimetry for asymmetric field using 4 MV photons

A film was placed between two 8 cm thick solid water slabs. Arranged longitudinally to the gantry. The lateral fields (cranial fields) were defined by closing half of the inferior with the asymmetric collimators ($X1 = 18$,

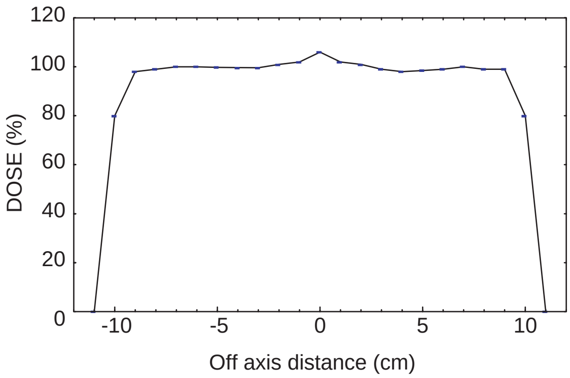

Fig. 4. Results of film dosimetry at the junction of two parallel asymmetric field (4 MV).

$X2 = 0$, $Y = 18$). The posterior field (spinal field) was set-up by rotating the gantry back to the vertical position and defined by the asymmetric collimators ($X1{=}0$, $X2{=}18$, $Y{=}6$). These measurements were performed using 4 MV photons with gaps and overlaps of 0, 1, 2, 5, 8, 10 mm at the junction level. The films were scanned at the depth of the reference point for posterior field in superior inferior direction. The results of the measurements are shown in Fig. 5.

The films obtained from both techniques were developed in the same bath condition and analysed with Macbeth TD931 Optic densitometer for the junction level at 4.5 cm depth and every 2 mm. The optic densities were converted to absorbed dose using the calibration curve.

In both techniques every doses are normalized to the cranial dose, which is 100%. The relative doses are shown on the Y-axis and the length of the junction are shown the X-axis. The dose profiles are drawn and compared with each other (Figs. 3 and 5).

3. Results

The film exposed to evaluate the dose uniformity at the matching field with half-beam field using Co-60 were scanned at 4.5 cm depth, the horizontal axis represents the relative distance from the junction of the cranial and spinal fields. When no gap (0 mm gap) was used, dose inhomogeneity was +2%. When 1, 2, 5, 8 and 10 mm gaps were used, dose inhomogeneities were 4%, 8%, 12%, 36% and 50%, respectively. When overlaps of the same sizes are used dose inhomogeneities were 5%, 17%, 29%, 35% and 47%, respectively (Fig. 3). Same procedure was repeated using 4 MV asymmetric collimators. With 0 mm gap, dose inhomogeneity was + 2% with 1, 2, 5, 8 and 10 mm gaps dose inhomogeneities were 4%, 8%, 38%, 49%, and 53% and with 1, 2, 5, 8 and 10 mm overlaps dose inhomogeneities were 5%, 19%, 61%, 76% and 88%, respectively (Fig. 5).

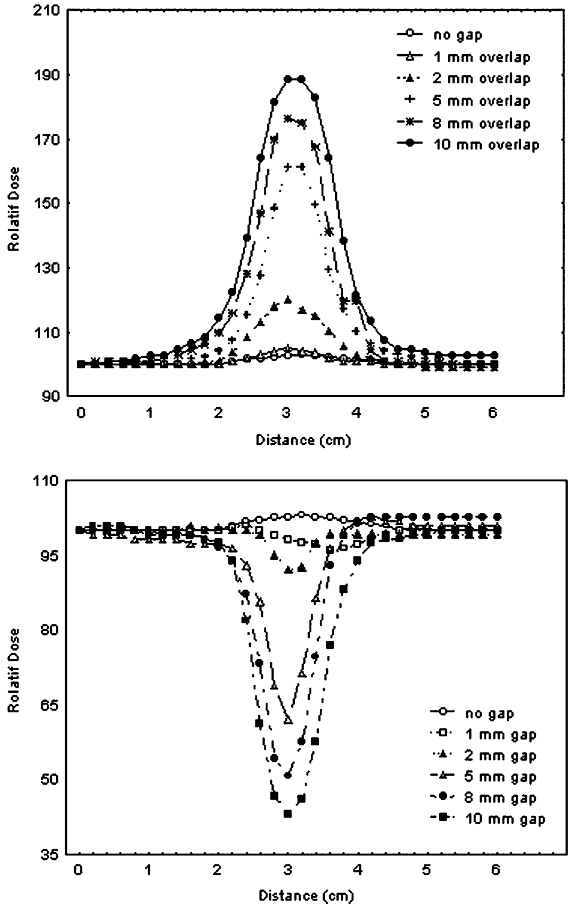

Fig. 5. Results of film dosimetry at junction region using half-beam irradiation by 4 MV asymmetric beams in the three fields technique.

4. Discussion

There are different techniques introduced to improve the dose homogeneity at the junction level during craniospinal irradiation. Each method has its own limitations (Gillin and Kline, 1980) reported if no correction is used for beam divergence in the three-field technique, matching level dose could reach to 140% of the prescribed dose at the reference depth. The half-beam technique, has some advantages and is more preferable for the craniospinal irradiation. In this technique, the penumbra at the field edge can effect the matching dose distributions. Both Co-60 machines with half-blocking and 4 MV photons with asymmetric collimators have been used during craniospinal irradiation with half-beam block technique. The penumbra depends partly upon the source size (i.e. 2 cm source diameter of Co-60). It is clear that the half-beam edge of the Co-60 beam is not as sharp as expected from a point source like the linear accelerator.

There are only a few studies about matching dosimetry. The specific comparison between Co-60 (with blocks) and

4 MV (with asymmetric collimation) has not previously been performed with this method. The results of the study are shown in Figs. 3 and 5.

In our study, we have found that ± 1 mm field placement errors were acceptable for each machine and dose variations were ± 5%. On the other hand ± 2, 5, 8, 10 mm field placement errors cannot be accepted in either Co-60 or 4 MV. However, when the field placement errors were more than ± 2 mm then the dose variations were less with Co-60. The extended penumbra of Co-60 machine can prevent the rapid fall of dose beside the field edge (Tinkler and Lucraft, 1995). As this falling is not linear, dose variations in gapping positions are less than in overlapping positions. Especially in clinics using fixed SSD techniques it must be taken into consideration that dose fall of field edge is not rapid with half-beam blocking with Co-60 machine. However, the weight of the half-block used in Co-60 machine for the half-beam technique makes the linear accelerator with asymmetric collimator more practical. Display tolerance for a given field size is ± 2 mm in the quality assurance program. In our study we determined the display tolerance was less than +1 mm for 4 MV photon.

Meanwhile, half-beam block technique is reported to have some limitations. Williamson reported that the field size of the upper spine field cannot exceed 20 cm (Williamson, 1979).

The moving junction technique used by some investigators has not been discussed here separately. With this technique, dose distribution at the junction plane could be expected as shown in Figs. 3 and 5. However, the same section of the body is not overdosed throughout the entire treatment. Over dose will be reduced by using two or three matching regions during the treatment.

In conclusion, the half-beam block technique should be practiced with serious attention with either Co-60 and 4 MV photon beam application in craniospinal irradiation, even 2 mm or more setup errors exceeds ICRU recommendations regarding inhomogeneity (beyond ± 5% inhomogeneity) with both Co-60 half-blocking or 4 MV photon asymmetric collimation. However, it should be noted that though beyond ICRU limitations the inhomogeneities are less with Co-60.

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