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Dosimetric study of field junction in adjacent beams using asymmetric collimators and MLC

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Abstract Adjacent treatment fields are commonly employed in external beam radiation therapy, such as the mantle and inverted-Y fields for the treatment of Hodgkin's disease. In some cases, the adjacent fields are orthogonal, such as the craniospinal fields used in the treatment of medulloblastoma. Another example is the irradiation of head and neck tumors when the lateral neck fields are placed adjacent to the anterior supraclavicular field. In each of these situations, there is a possibility of introducing very large dosage errors across the junction. Consequently, this region is at risk for tumor recurrence if it is underdosed or severe complications if it is overdosed. Four millimeter overlap and gap resulted in an unacceptable dose in homogeneity in the junction. As a result of this study, the magnitudes of hot and cold spots might be clinically acceptable for 3 mm gap between photon fields.

Key words field junctions; linear accelerator; dosimetric study

A number of techniques have been devised to achieve dose uniformity in the field junction region. Here fields are angled away from a common line of abutment to avoid overlap of the fields due to their geometric divergence. The separation or gap between the fields is calculated on the basis of geometric divergence [1] or isodose curve matching [2–3]. In this method, the beam is split along the plane containing the central axis by using a half-beam block or a beam-splitter, thus removing the geometric divergence of the beams at the split line.

In clinical practice, the fields are usually abutted at the surface if the tumor is superficial at the junction point. Care is however taken that the hot spot created due to the overlap of the beams at depth is clinically acceptable, considering the magnitude of the over-dosage and the volume of the hot spot. In addition, the dosage received by a sensitive structure such as the spinal cord must not exceed its tolerance dose [4–6].

For the treatment of deep-seated lesions such as in the thorax, abdomen, and pelvis, the fields can be separated on the surface. It is assumed in this case that the cold spots created by the field separation are located superficially where there is no tumor [7].

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Methods

Method of field separation

As stated earlier, the field separation can be accomplished geometrically or dosimetrically.

Dosimetric instrumentation

Linear accelerator – Elekta model – high energy (dual energies) 6 and 15 MV photon beam and multi electron energies (6, 8, 10, and 15 MeV). The treatment planning system used in this work of Eclipse Planning system. Absolute dosimetry system is recommended by international atomic agency for high accuracy in calibration for photon and electron beams in radiotherapy. Absolute dosimetry system included electrometer model PTW – unidose and ionization chamber 0.6 cm farmer type – for relative doseimetry radiographic films. Farmer dosimeter model [2570/1B (#1164)], radiographic film model Kodak types of X-ray film for verification model X-Omate types V and PTW company for automatiev water phantom model S3.

Methods to solve photon-photon junctioning issues

Align the divergent edges of the beam

If it is possible to align the divergent edges of the beams, there will be hot or cold spots generated as the penumbra of each beam will 'cancel out' the other. The

negative aspect of this option is that the beams will have an oblique incidence on the target surface (usually a minor effect) and at the other side of the field the beam will travel more deeply into the patient at depth (due to increased divergence).

Use a half beam block

By moving one of the independent jaws to midline, a half beam block can be created. This forms a non-divergent field edge centrally. This method is best used when the reason for junctioning is due to contour irregularity or different target volumes (e.g. breast tangents and supraclavicular fossa field). The half beam block functions in a similar method to the aligning of divergent beams, but is easier to set up (less movements of the couch/gantry) and means that the beam is not oblique on the skin surface [8–10].

Geometric

If the geometric boundary of the field is defined by the 50% decrement line (line joining the points at depth where the dose is 50% of the central axis value at the same depth), the dose at the point of junction between the beams will add up to be 100%. The dose distribution laterally across the junction is more or less uniform, depending on the inter-field scatter contribution and the penumbra characteristics of the beam. If the two fields are incident from one side only and made to junction at a given depth the dose above the junction will be lower and below the junction higher than the junction dose. In the case of four fields when two fields are incident from one side and two from the parallel opposed direction, the fields are usually made to junction at the midline depth (e.g., mantle and inverted Y fields).

The separation of fields can be determined by optimizing the placement of fields on the contour so that the composite isodose distribution is uniform at the desired depth and the hot and cold spots are acceptable. The accuracy of this procedure depends on the accuracy of the individual field isodose curves especially in the penumbra region [11–12].

In the current study, Elekta linear accelerator to determine the absorbed dose you should start with mechanical check should be initially followed, to ensure the suitability of the machine to perform the dosimetric measurements. The laser lines compromise the cross wires in the light field area should be checked. The isocentre point for gantry, collimator and couch rotation should be checked to ensure. Then adjust the solid phantom at 100 cm source skin distance, and locating the 0.6 ionization chamber at the depth of maximum dose for each energy (1.5 cm for 6 MV), with zero degree gantry angle, zero degree collimator angle and zero degree couch angle according to international atomic agency protocol (Technical report series 398). Measuring pressure and temperature to calculate the factor for pressure and temperature, p which estimate the effect of pressure and temperature on measurement.

When different small fields were irradiated to measure absorbed dose for each field. Results carried out by TPS were compared with practical data of 0.6 ionization chamber. And relative measurements by film and relative dosimetry PTW. Estimating the standard film to be the reference dose gradient by irradiating different films to gradual from 20 to 100 monitor units. Where the irradiated film placed in the perspex sheets placed at surface, process the film and draw an isodose curve through which we can determine the absorbed dose for each irradiated film optical density value can be determined. When irradiated different fields and determined the absorbed dose for each field and compared the results with the TPS data.

Results and discussion

Methods with varying degrees of complexity were employed for field matching. Techniques combined half beam blocking and machine rotations to achieve geometric alignment. Asymmetric beam matching allowed use of a single iso-centre technique. Where field matching was not undertaken a gap between tangential and nodal fields was employed. Results demonstrated differences between techniques and variations for gaps and overlaps. Geometric alignment techniques produced more homogenous dose distributions in the match region than gap techniques or those techniques not correcting for field divergence.

One photon beam (each of them 6 MV, and 20 cm × 20 cm field size) have been adjoined with different separations (0, 0.1, 0.3, and 0.5 cm, gaps; Fig. 1–5).

One could argue that the 0.3 cm width would be a suitable selection for abutment region width because it possesses a shape that appears to “transition” between the smaller and larger abutment region widths. Conversely, the 0.5 cm (Fig. 5) width could also be a suitable selection because all widths greater than 1.0 cm display similar, if not the same, results. We selected the 0.5 cm abutment region width to display subsequent results of the various matching techniques throughout the remainder of this work. We did so primarily for one reason. While all flat phantom measurements were conducted with an MLC that has 0.5 cm leaf widths, our clinical breast measurements were conducted with the 1.0 cm leaves, due to the larger length of the fields. The 0.1 cm abutment region width is considered too narrow to evaluate a match produced by fields with wider leaf widths and with angled collimator settings [13].

Given the relative placement on the dose axis of the graphs, it was apparent that regardless of matching tech-

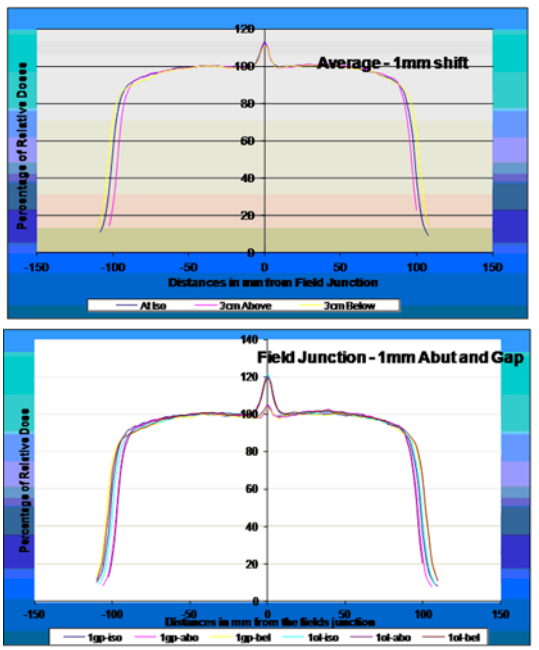

Fig. 1 Fields junction for energy 6 MV using film XV and XTL were used

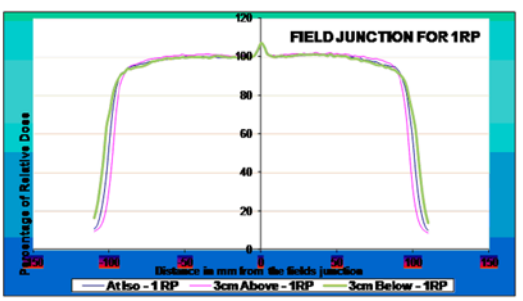

Fig. 2 Study on fields junction energy: 6 MV; XV and XTL films were used

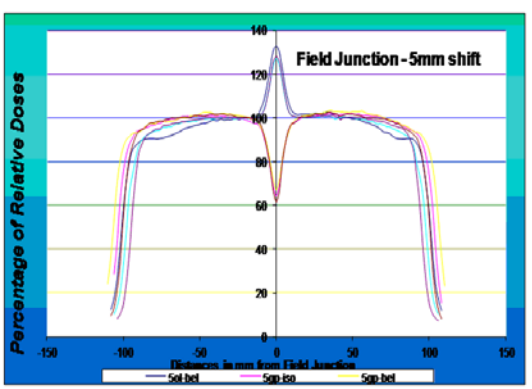

Fig. 5 For 5 cm depth overlap between two adjacence fields was well displayed. For that should be taken into considered the depth and gap between to avoid overlapping between treatment adjacence fields- (for example depth 5 cm is equivalent to depth of spinal cord in cranial spinal irradiation)

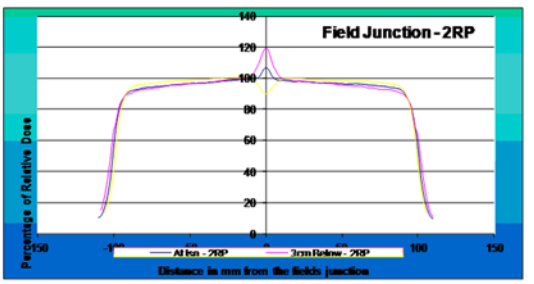

Fig. 3 Measurements profiles (of two adjacent photon beams (each of them was 6 MV, and 20 cm × 20 cm field size) have been adjoined with 0.2 cm separation)

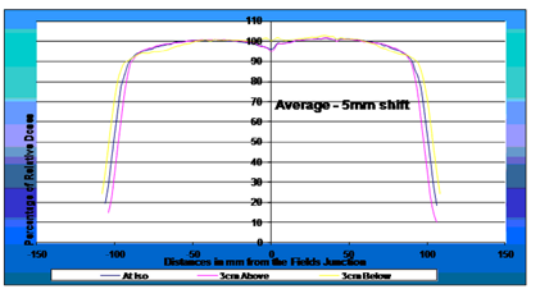

Fig. 4 Measurements profiles (of two adjacent photon beams (each of them was 6 MV, and 20 cm × 20 cm field size) have been adjoined with 5 mm separation). As shown in Fig. 4 due larger depth 3 cm in sufficient for display overlapping and over dose and under dose for gap in between two abut field

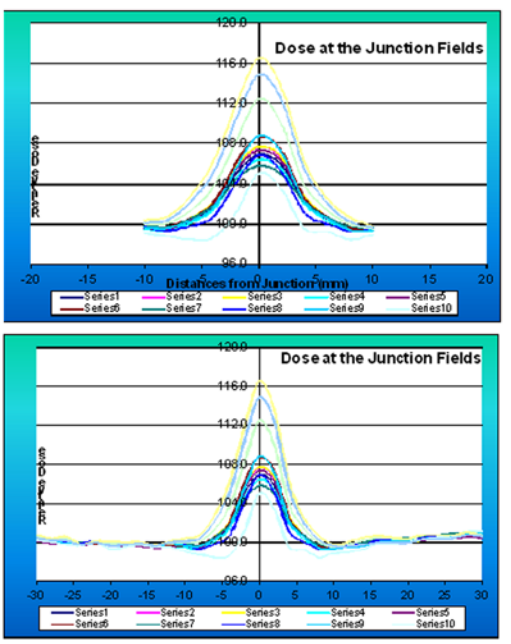

Fig. 6 Abutment region widths for the matching techniques. All graphs show a change in structure between the 0.1 cm and 0.5 cm abutment region widths. Regions wider than 0.3 cm appear to have a similar curve structure

nique or abutment region width, the dose within the abutment region appears to be greater than the treatment-field dose that was used for normalization. Fig. 5 also showed that as the abutment region width becomes smaller (0.3–0.50 cm), the average dose in the abutment region increases, suggesting a "hot" match. As the abutment region width becomes larger (0.5–1.0 cm), the average dose in the region decreases, becoming closer to 100% relative dose. This occurs as a result of a larger proportion of the abutment region encompassing the portion of the field outside of the penumbra and, therefore, in the flat uniform dose region that was used to normalize the film.

It can be shown from the previous figures that the larger the separation the deeper the start of appearance of the hot spots. This is expected owing to the divergent nature of the radiation beam. The larger the gap separation will mean that the two beams would start overlapping at deeper depth. In the previous figures measurements was used to calculate the resulting dose distribution. Geometric methods can be used to estimate the required gap separations (Fig. 6).

Conclusions

The purpose of this study is to evaluate the dosimetry across the junction between two field for 6 MV photon fields for divergent beam set-up beam (using asymmetric collimator jaws and MLc. In this study, film dosimetry technique was performed to measure dose profiles at depths of 1, 2, 3 and 5 cm in the junction of the matching photon fields. In order to investigate the changes in the dose distributions due to set-up uncertainties, dose profiles were measured at these depths using no gap, 2 and 4 mm overlaps and gaps between the photon fields. A 3 mm gap resulted in approximately very well gap in the photon field at 1, 3 and 5 cm depths, respectively, for divergent photon beams. Four millimeter overlap and gap resulted in an unacceptable dose inhomogeneity in the junction. As a result of this study, the magnitudes of hot and cold spots might be clinically acceptable for 2 mm gap between photon and electron fields [9–12].

Field matching techniques during the current study varied between centers. Film dosimetry used in conjunction using the phantom provided relative dose information for cranial spinal irradiation and Beast matching with supracl. Field [10]. The study highlighted difficulties in matching treatment fields to achieve homogenous dose distribution through the region of the match plane and the degree of inhomogeneity as a consequence of a gap between treatment fields [9–12, 14–15].

Matching field for photon beams treatment is very risk for patient if not consider. The depth of overlap and gap very [12, 15].

Conflicts of interest

The authors indicated no potential conflicts of interest.

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