

JUNCTION PLANE DOSIMETRY IN DIFFERENT TECHNIQUES OF COBALT-60 HEAD AND NECK IRRADIATION

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ABSTRACT

Study of dose at the junction between lateral and anterior field in irradiation technique of head and neck cancer with a Cobalt-60 teletherapy machine was performed in anthropomorphic rando phantom with TLD-100 chips as dosimeters. Doses were compared in three different techniques ; straight field (Technique 1), couch turntable in lateral field (Technique 2) and couch turntable in lateral field with a half beam block device in anterior field (Technique 3). When normalize dose at any point of the junction as a percentage of the dose at the center of lateral field, the mean doses in Technique 1, Technique 2 and Technique 3 are $112.56 \pm 13.51\%$, $103.69 \pm 12.29\%$ and $97.20 \pm 12.25\%$ respectively. Measurements were done three times in each technique to assess for the setup reproducibility. It was found that only the reproducibility in Technique 1 and 2 was acceptable. This report is an attempt to investigate the dosimetry at the junction plane in different techniques of head and neck irradiation and suggest an appropriate technique which provides a reproducibly uniform dose distribution across the junction of head and neck irradiation with the Cobalt-60 teletherapy machine.

INTRODUCTION

The irradiation technique of head and neck cancer commonly performed with the lateral and anterior field to treat the primary tumor and the draining lymphatics. Because of an overlapping of the beam divergence of these adjacent fields makes the dose at the junction to be non-uniform. Many studies have been reported to solve this problem. These included the use of couch and collimator rotation in lateral field,¹ the gantry rotation in anterior field (with the couch rotated 90°).² More recently, the introduction of asymmetric collimators in linear accelerator machine has allowed a treatment to be performed in the monoisocentric technique.^{3,4} The advantage in this technique is a couch movement not being required. Therefore it is theoretically more

accurate and setup reproducibility can be acquired. In our institution, the main treatment unit for head and neck irradiation is Cobalt-60 teletherapy machine due to its appropriate energy, less cost and easy maintenance. But there is a disadvantage from a large penumbra that makes the problem of the matching field overdosage being more severe. Moreover, with a symmetric collimating system, the monoisocentric technique cannot be performed by this unit. In this work, we proposed to investigate for the junction plane dosimetry in different techniques of head and neck irradiation and determine a suitable technique that may provide both a good dose uniformity at the junction and setup reproducibility to be considered as our routine treatment technique.

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MATERIALS AND METHODS

Firstly, the lateral and anterior treatment fields were defined on a rando phantom by the Shimadzu conventional simulator with 80 cm. source–skin–distance. From simulation, junction was shown at the level of a thyroid notch. Measurements of dose at the junction were performed with the TLD-100 chips (LiF:MgTi, 3.2x3.2x0.9 mm, Harshaw Chemical, Germany). Because its appropriate thickness represented a good dose resolution at the junction. A 2 mm. thick of perspex sheet was trimmed to match with the neck contour of the rando phantom and thirty-seven holes were drilled in a regular pattern of six rows with a spacing of 1.5 cm. This 2 mm. perspex sheet was covered by the phantom and allowed the TLDs to be fitted and removed during the measurements.

Then the phantom was treated in Cobalt-60 treatment room with three different techniques. Each time a position of the phantom was carefully reproduced from the simulation. The details of each setting-up technique are described in the following.

TECHNIQUE 1-STRAIGHT FIELD

In this technique, phantom was firstly treated with the two lateral opposing fields. Dose delivered to the reference point (at a half of separation at a level of field center) in each field was 100 cGy. Anterior field was given a dose of 200 cGy at depth 4 cm. All fields were treated with 80 cm SSD. Positions of the collimator and couch were confirmed to be at 0 angle in every measurement. Measuring of dose in this technique will illustrate the dose at the junction when an overlapping of beam divergence between the two fields existed.

TECHNIQUE 2- COUCH TURNTABLE IN LATERAL FIELD

The couch turntable was introduced when phantom was treated in lateral field to eliminate the lower border of beam that diverged into the superior border of an anterior field. The couch was turned in the direction of the beam to create a transverse match with the anterior field. The angle of couch turntable depends on the length of treatment field and SSD. It can be calculated from the following equation.⁵

$$\text{Tan } \theta = \frac{\text{field length}}{\text{distance}} \dots\dots\dots(1)$$

In this experiment, the angle of couch turntable is 4°.

TECHNIQUE 3-COUCH TURNTABLE IN LATERAL FIELD WITH A HALF BEAM BLOCK IN ANTERIOR FIELD

A half beam block device provides a mean to reduce a penumbra on one side of the beam by shielding half of the beam at a field central axis. Therefore, when it was introduced to the anterior field, it will match with the lower border of lateral field that the couch turntable is being used. With this device, the field length of the anterior field has to be double and block the upper half of the field.

RESULTS

The results of junction plane dosimetry in three different techniques of head and neck irradiation were presented in Fig. 3 - Fig. 5. Dose at each point was normalized as a percentage of dose at the reference point. Mean dose at the junction, dose variation (determined from a standard deviation of the mean dose) and also a setting-up reproducibility (assessed from a mean of the standard deviation from 3 measurements) are summarized in Table 1.

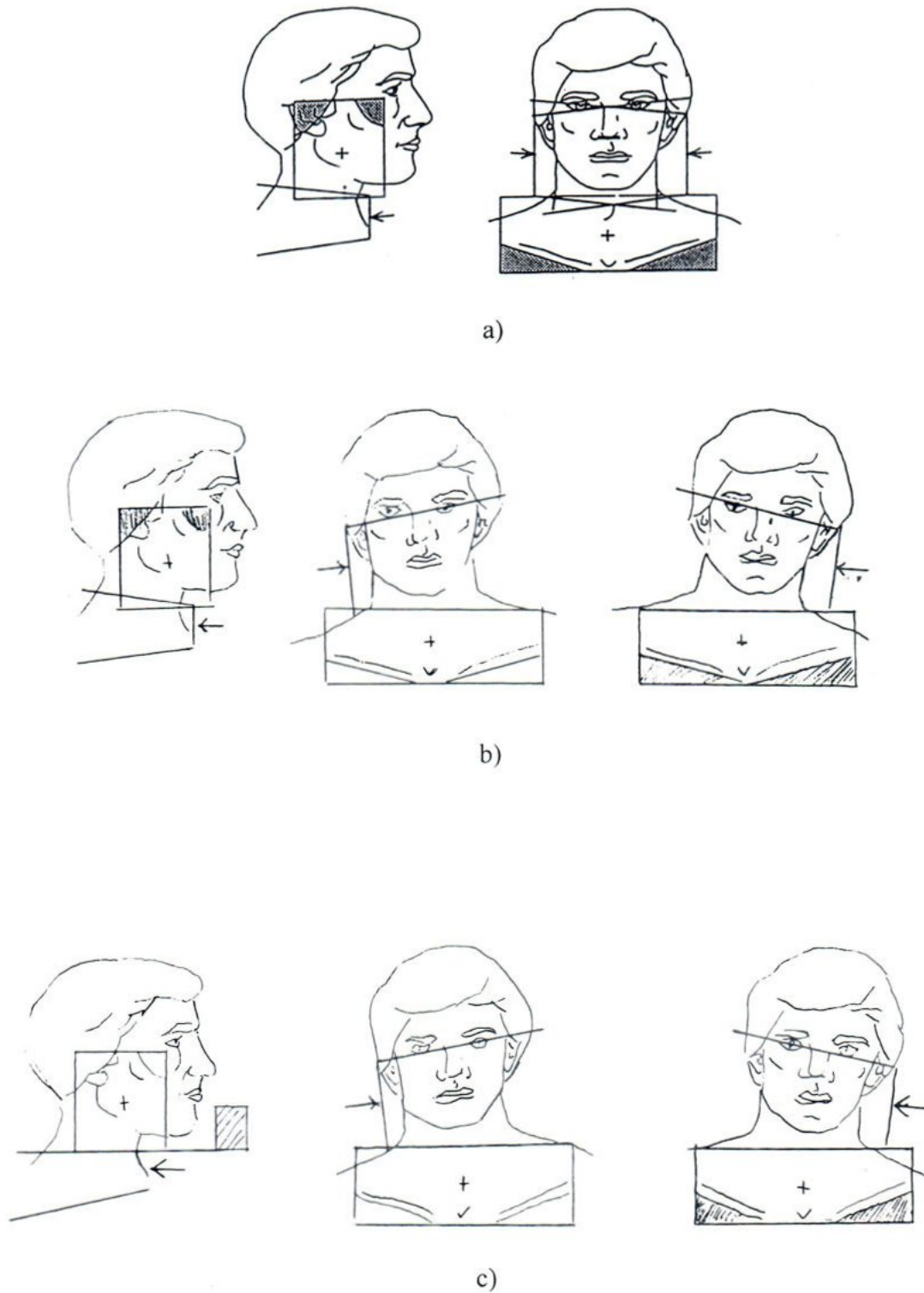


Fig. 1. The diagram illustrate a) Technique 1-straight field, b) Technique 2-couch turntable in lateral field c) Technique 3 –couch turntable in lateral with a half beam block in anterior field

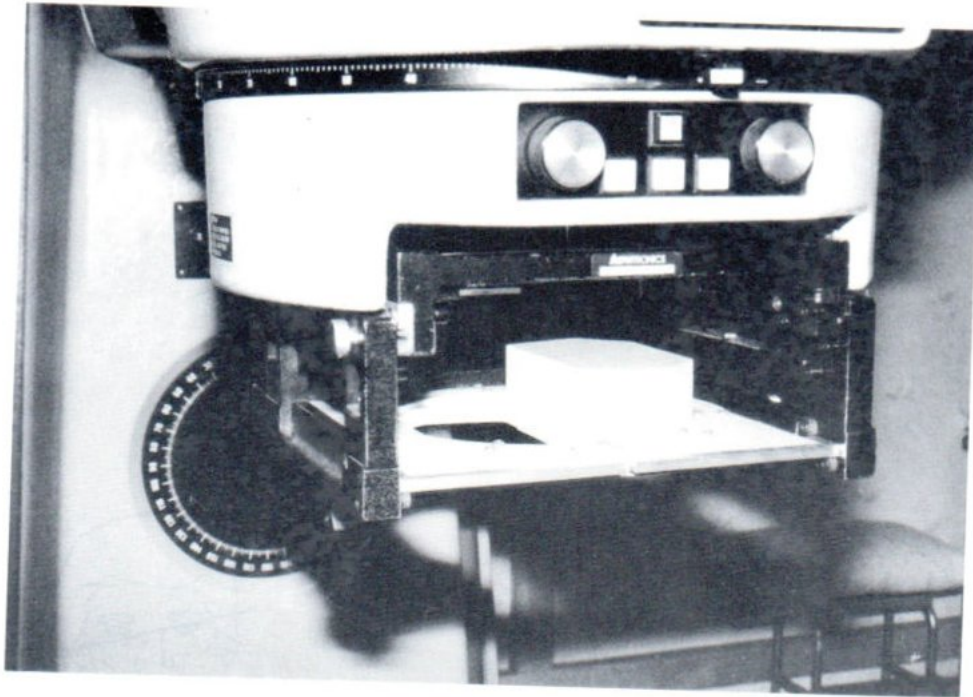


Fig. 2. A half beam block device

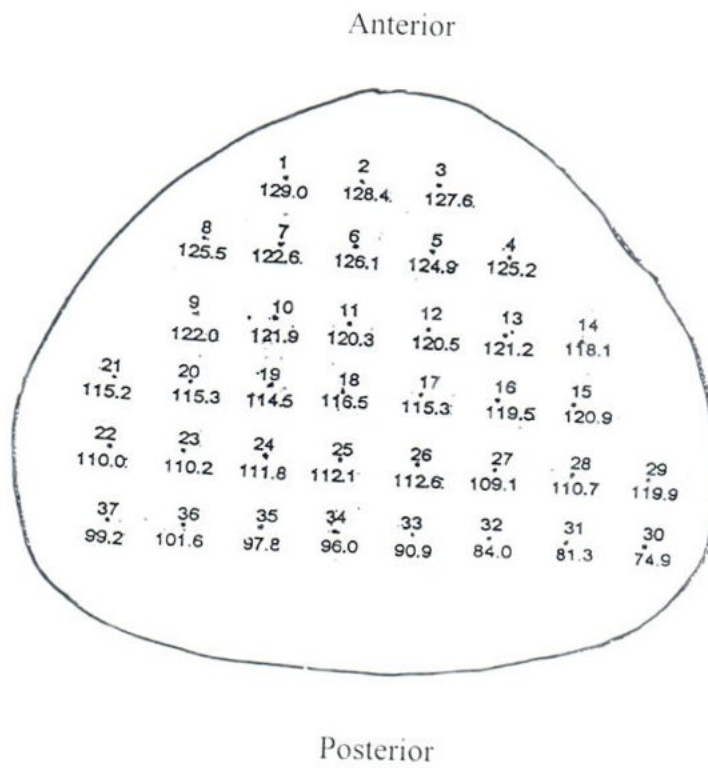


Fig 3. Dose distribution at a junction plane in the technique of straight field.

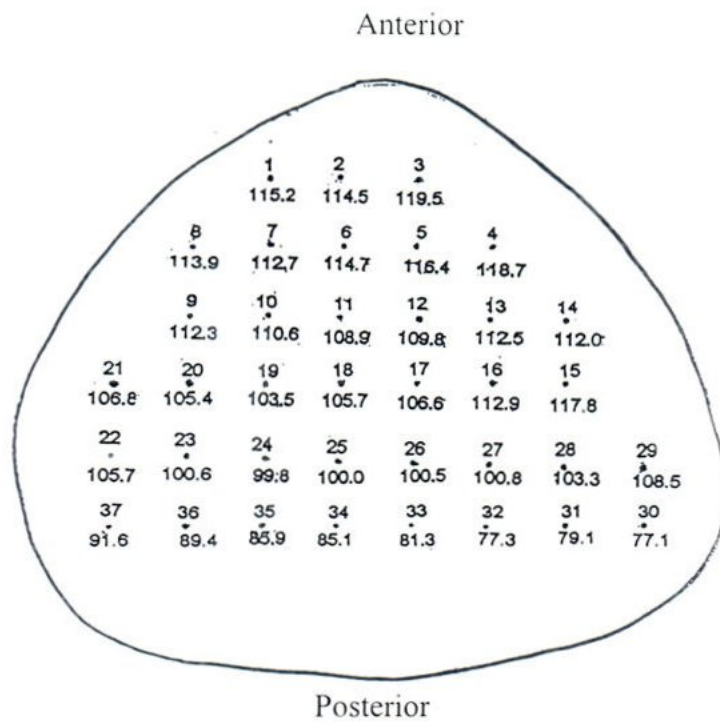


Fig 4. Dose distribution at a junction plane in the technique of couch turntable in lateral field.

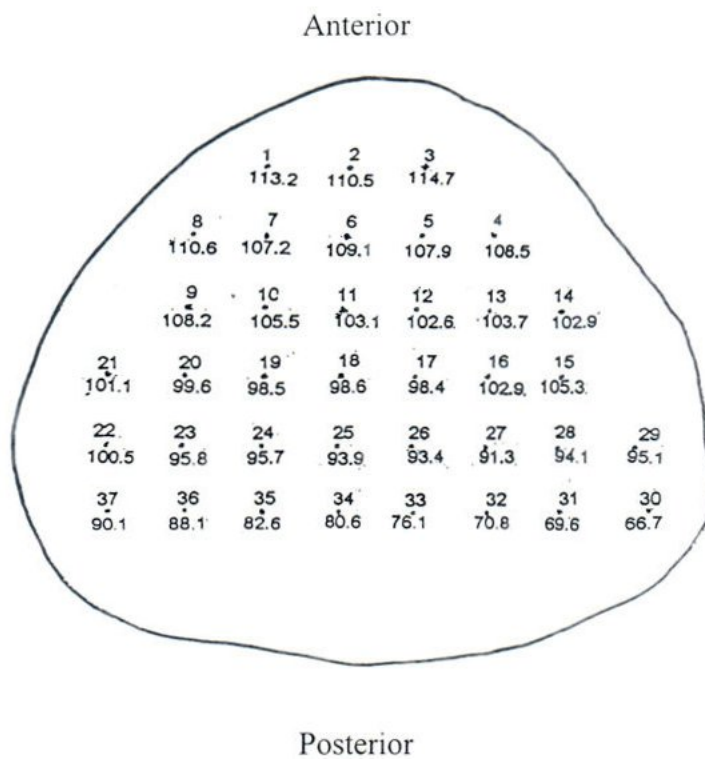


Fig 5. Dose distribution at a junction plane in the technique of couch turntable in lateral field with a half beam block in anterior field.

Table 1. Summary of junction plane dosimetry in three techniques.

Techniques	Mean Dose	Dose variation	Reproducibility
Straight field	112.56	13.51	2.09±1.03
Couch turntable	103.69	12.29	3.11±1.15
Couch turntable+HBB	97.20	12.25	7.72±4.55

HBB = half beam block

DISCUSSION AND CONCLUSION

Numerous methods have been introduced for solving a problem of non-uniformity of the dose at a field junction.^{1,2,6,-8} Recently, the technique of monoisocentric utilizing asymmetric collimation showed a potential advantage of more accurate and reproducibly dosimetry.^{3,4,9} It also reduced a number of setup factors that are subjected to error by an operator. But it is a technique available with the linear accelerator unit only. In the institute that Cobalt-60 teletherapy machine still be the main treatment unit for head and neck cancer, dosimetry at the junction was required to assess for a magnitude of a field matching problem. Efforts to study a dose distribution at the junction of various techniques available with the Cobalt-60 machine was proposed. In this study we used a technique of couch turntable to solve for the divergence of lateral beam. Actually a half beam block device has a limitation in a field dimension. From simulation, the length of lateral field was 14.5 cm. That means, if a half beam block is applied, the field length required to set is at 29 cm. Since the maximum field size available for this device was 20x20 cm and when was half blocked a field was reduced to 10x20 or 20x10 cm, therefore it is not enough for the lateral field length. We found that applying a couch turntable in lateral field can minimize both area and level of high dose. Measurements in Technique 1 clearly demonstrated a level of high dose (up to 110-130%) at the junction in a large portion of anterior neck. With a couch turntable,

this high dose region was decreased and presented a maximum dose not greater than 120%. Also, a mean dose in technique 1 and 2 was shown to improve from 112.56% to 103.69%. Among these techniques, the best uniformity of dose distribution was seen in technique 3. A mean dose at the junction in this technique (97.20%) was very close to a prescribed tumor dose. Moreover, the overdose was seen in a small area of neck and not greater than 115%. This high dose is still exist in the anterior neck due to the contour irregularity that we can not improve by using a compensator.

More interesting findings are dose variation and setup reproducibility. No difference in dose variation was seen in three techniques. It is unlikely in the setup reproducibility that only Technique 1 and 2 that provided an acceptable value. Reproducibility was worse in Technique 3. This may arise from a half beam block device. It required a correct position when fitted with a collimator to accurately provide the half blocked beam. Thus, it is easily subject to error by both an operator and the mechanic of the machine. In this technique, we tried to confirm the data by carefully repeating the measurements 5 times and the results were shown in Table 1.

In summary, the study of junction plane dosimetry in head and neck irradiation technique performed with Cobalt-60 suggested the technique of couch turntable in the lateral field to be

appropriate. It presented both the acceptable good dose uniformity and setup reproducibility. Even though, the application of a half beam block in the anterior field had the best dose uniformity at the junction but its reproducibility was not satisfied. However, not only the junction plane but also a whole treatment volume including critical organ such as lens, thyroid and brain that dosimetry should be carefully verified prior to the application in the routine clinical uses.

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