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ORIGINAL ARTICLE

Evaluation of Dose Distribution in Field Junction Area and Risk Organs for Supine and Prone Treatment Techniques in Craniospinal Irradiation

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OBJECTIVE

The aim of this study is to investigate dose distributions in junction regions and organs at risk in asymmetric collimation techniques and divergence matching techniques used in craniospinal treatments.

METHODS

In the anthropomorphic phantom, the junction area and organ at risk doses were determined for eight different craniospinal irradiation (CSI) techniques with the help of thermoluminescent dosimeter (TLD) and treatment planning system (TPS). These techniques differ in terms of the parameters of the table being angled/un-angled, using block/multi-leaf collimator, and being in supine/prone position.

RESULTS

There was no statistically significant difference between TPS and TLD doses of all techniques. The lowest doses of cribriform plate are 1.82 Gy in PM, and 1.84 Gy in PAM. The lowest dose in lenses is 0.19 Gy in PB. The lowest dose of thyroid is 1.27 Gy in PB and highest dose of PAM is 1.35 Gy. Average small intestine dose of 1.92 Gy in non-table angle decreases to 1.08 Gy with table angle. The highest kidney doses are 0.14 Gy in SM. Ovaries take an average dose of 0.09 Gy in non-table angled and average of 0.13 Gy in table-angled techniques.

CONCLUSION

It has been determined that CSI technique in supine without table angle and protected with special blocks, is superior to other techniques due to its better dose homogeneity in treatment volume, providing immobilization in daily use and ease of application.

Keywords: Awareness; educational level; electronic survey; knowledge; oral cancer; public health.

Introduction

In tumors located in the cerebellum; tumor cells are spillage into the craniospinal fluid in up to 40% of cases and metastases develop along the nervous axis. Therefore, the clinical target volume is determined as the area extending from the whole brain, meninges, and below the spinal cord to the coccyx. The cranium is irradiated from two mutually parallel lateral areas perpendicular; to the sagittal plane and the spinal cord consists of treatment areas where it is irradiated in the coronal plane from the posterior area.[1-3] Due to its irregular shape, this radiotherapy technique is defined as craniospinal irradiation (CSI), which is a

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very complex treatment technique.[4,5] The CSI technique involves at least one or two junction areas that are not homogeneous for the dose. The difference in thickness between the brain and the spine junction is important in terms of avoiding the risk of dose escalation and reduction, depending on the overlap of areas and gap.[6-8] Narayana et al. demonstrated the need to pay attention to appropriate technical characteristics and increased thyroid, lower jaw, pharynx, and larynx dosage.[7-10]

Several methods have been improved to provide the bonding between the brain and the spinal field, such as adjacent area use, gap use, wedge filter entry, beam straightening, and junction movement.[1,7-10] Many centers use table angles while completing merging areas, although it increases the complexity of the treatment. If the length of the spinal field is too long and the geometry on the junction area is different from the upper cervical spinal cord, an increased source skin distance or a second posterior field is required. Efforts to protect lenses to prevent cataract formation can cause treatment failure in this area.[9]

One of the most commonly used techniques for CSI is Asymmetric Collimation Techniques (ACT) and the other is Divergence Matching Techniques (DMT). The aim of the ACT, in which half of the beam is closed asymmetrically with the help of collimators in mutually parallel cranial areas and the upper spinal area, and the other half is used, is to reduce the hot spots that may occur at the field junctions by reducing the geometric half shadow.[1,11,12]

In DMT; an appropriate angle is given in the right and left cranium areas. In the spinal area, the table is rotated 90° and the gantry angle is given so as to eliminate the beam divergence. Thus, the beam edges are made parallel to prevent the formation of hot spots.[12]

In most radiotherapy department, CSI is performed in the prone position, with the opposite fields enclosing the entire brain and the upper cervical spine covering the caudal extent of the singular sac. Since children who are to be treated with CSI are required to undergo anesthesia, they are treated with supine technique.[9]

In this study, using ACT and DMT, which are widely used because of the simplest, most reliable and useful techniques among CSI, the application of these techniques in the prone and supine position was dosimetrically investigated and block or Multi-Leaf Collimator (MLC). The difference to be made by the protections using MLC was measured. In addition, it was investigated whether the table angle would be beneficial in reducing the hot spots caused by the overlap of the areas due to the divergence of the rays in the neck joint area.

The aim of this study is to show the effect of the table angle on critical organ doses in the junction areas of CSI, to determine the most appropriate technique for clinical practice by increasing patient comfort and to prevent set-up errors.

Materials and Methods

All measurements were carried out on “Alderson Rando Phantom 475,” which was made of material equivalent to human tissue. Alderson Rando Phantom was prepared with vacuum beds in the supine and prone position, 195 cross-sectional images were taken with Computed Tomography (CT) from the top of the head to the cervical vertebra line 3 mm and from here to the sacral 4th vertebra line in 5 mm sections. (Fig. 1).The contours of the regions to be measured using the CT sections of the Rando phantom transferred to the treatment planning system (TPS) were determined. The CT sections of the places to be measured are transferred on to paper and placed on the relevant phantom sections to determine where the Thermoluminescent Dosimeter (TLD) rods with dimensions of 1×1×6 mm^3 (Harshaw TLD-100) are to be placed. To reduce the error in the treatment setup, care is taken to ensure that each point has the same TLD at each measurement.

For this purpose, TLD slots in prepared containers (density 0.99 g/cm^3) are painted in green and red colors and separated from each other (Fig. 2a, b).

To precisely determine the location of the TLD rods to be placed in the dose measurement points determined in the junction areas and critical organs, 0.5 mm diameter and 6 mm long lead wires were placed in the TLD slots in the prepared plugs and the CT of the Rando Phantom was taken again under the same conditions as the first installation. Dose measurement points are contoured in CT sections that transferred to the TPS (Fig. 3a, b).

While determining the treatment areas, to prevent set-up errors during irradiation, the origin was determined by placing markers in three points for each position, one on the front or back, and one on each side for the set-up of the supine and prone position at the level of the cervical 2nd vertebra. There are four treatment fields; two opposite cranial fields, the upper spinal, and the lower spinal fields, which are the standard treatment fields of the CSI technique.

Fig. 1. Rando Phantom supine and prone position with vacuum bed.

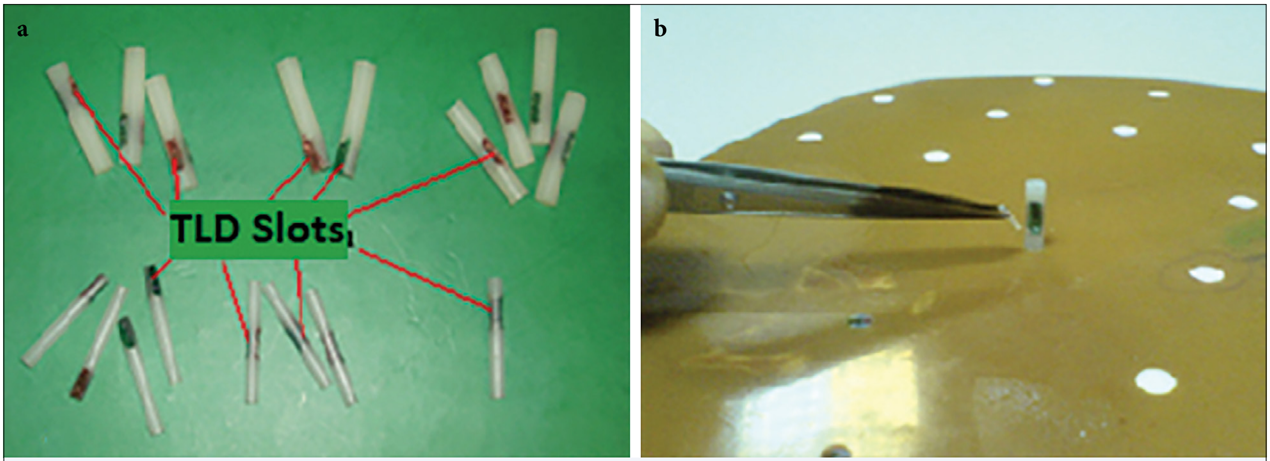

Fig. 2. TLD slots. (a) TLD slots, (b) Inserting TLDs in TLD slots.
TLD: Thermoluminescent dosimeter.

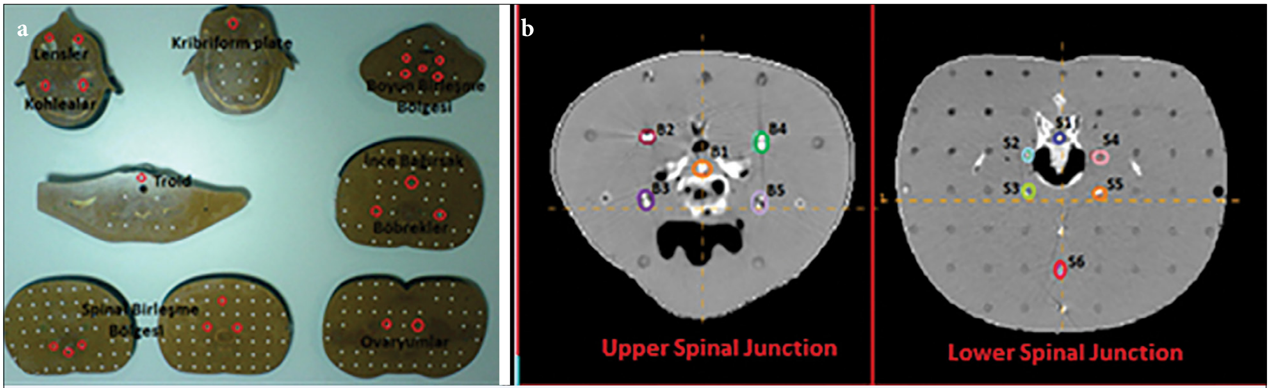

Fig. 3. (a) Rando Phantom dose measurement points. (b) Contoured dose measurement points in the junction area.

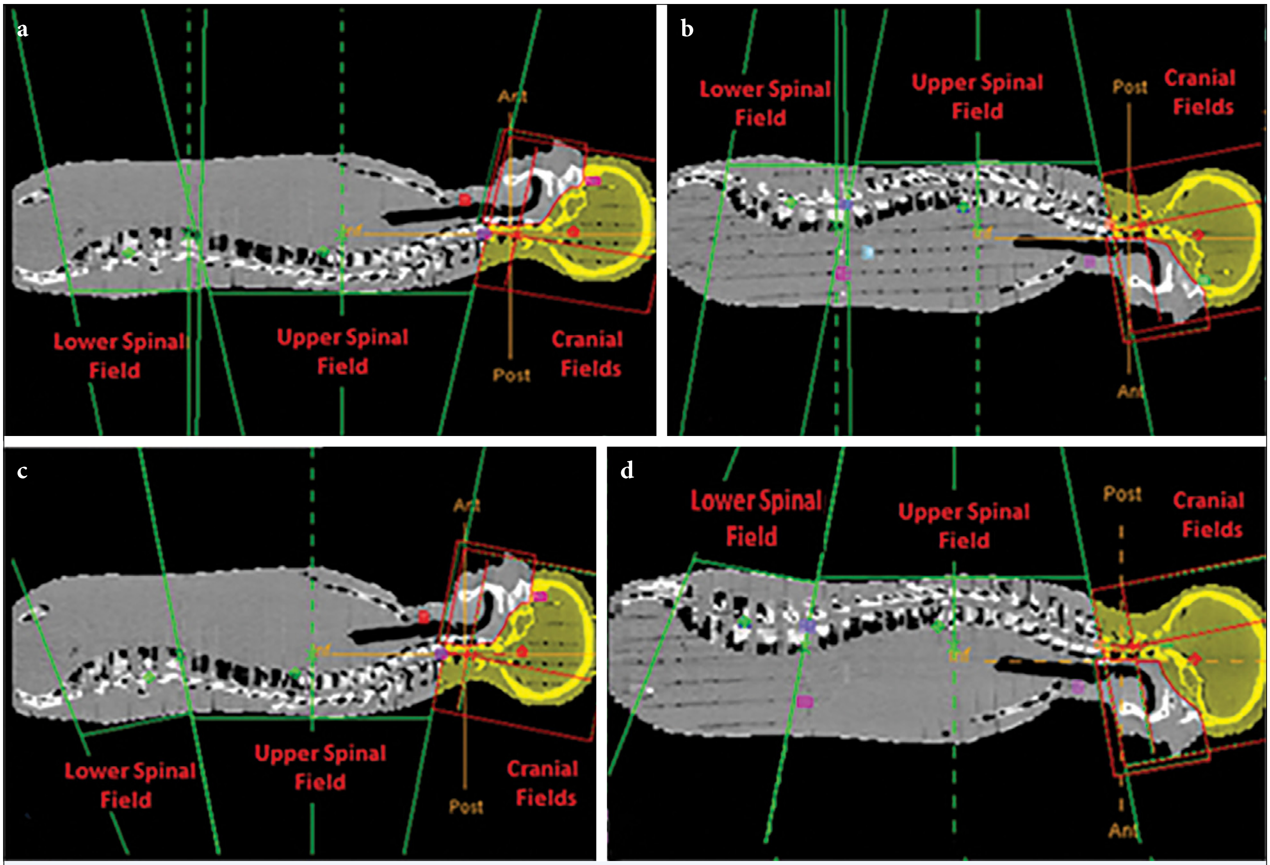

Fig. 4. (a) SB (b) PB (c) SAB (d) PAB (a and b Sagittal view of non-angled table with blocked plans; c and d angled tabled with blocked plans).
SB: Supine, non-angled table and blocked, PB: Prone, non-angled table and blocked, SAB: Supine, angled table and blocked, PAB: Prone, angled table and blocked.

In this study, treatment plans were made for all techniques with 6 MV photon energy suitable for CSI depth using Elekta linear accelerator.

With using TPS the treatment fields for different parameters, including supine (SB: Supine, non-angled table and blocked, SAB: Supine, angled table and blocked, SM: Supine, non-angled table and with MLC, and SAM: Supine, angled table and with MLC) and prone (PB: Prone, non-angled table and blocked, PAB: Prone, angled table and blocked, PM: Prone, non-angled table and with MLC, and PAM: Prone, angled table and with MLC) positions were determined using ACT and DMT together (Fig. 4a-d).

Using ACT, the isocenters are placed at the same depth and the axis passing through the isocenter circles is centered on the spinal plane to ensure that the dose distribution is homogeneous (Fig. 4a, b). Treatment doses in TPS were distributed homogenously between 95% and 106%.

When planning the treatment, first the upper spine field was adjusted in the supine position 180° and in the prone position with a 0° gantry angle allow the beam enter to the body from the back. The upper limit is the cervical 2-3, vertebral level was set to pass under the jaw to protect the oral cavity and the largest treatment field was opened. The upper spinal field isocenters is 20 cm below the cranial field. The lateral borders were expanded to leave the vertebrae in 1 cm. Cranial fields; the cervical field opening asymmetrically to the 2-3. Vertebra level and the lower border rotated to overlap with the upper limit of the collimator upper spinal field, with the gantry angles of 90 and 270, with the area boundaries at the front, back and upper, 2 cm in the skull. For this study; the collimator angle was calculated to be 11° according to the field dimensions.

To ensure the homogeneous dose distribution an appropriate normalization point was determined in

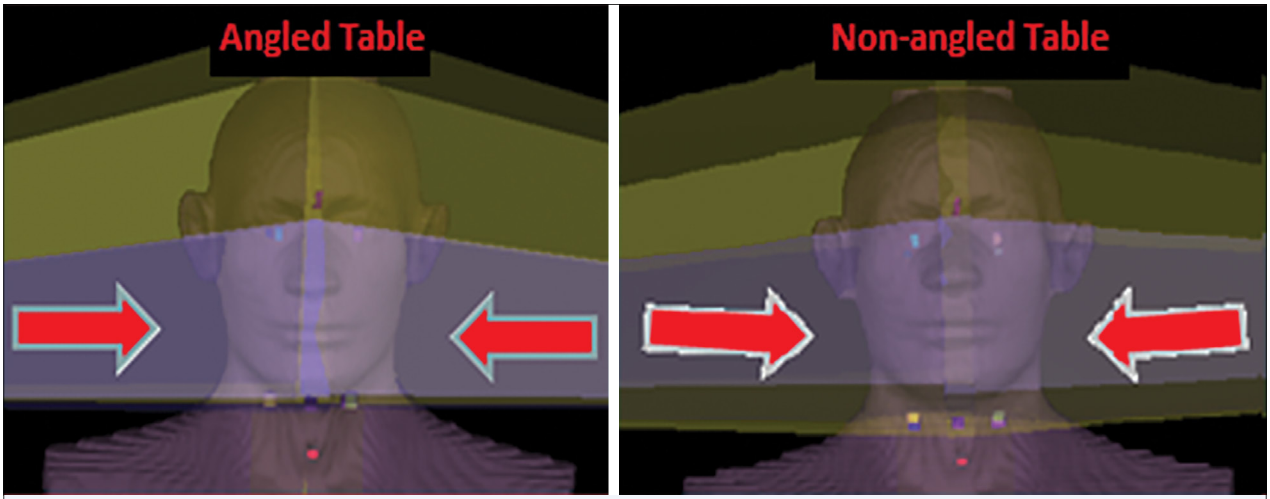

Fig. 5. Cranial field's angled table and non-angled table spinal area has a table angle of 270° and a gantry angle of 11° (Fig. 6).

the center of the two opposite fields, not too close to the blocks, and a dose of 180 cGy/fraction was given.

The upper part of the lower spinal field was opened so that the jaws would open asymmetrically to intersect the upper spinal field at the level of the vertebrae and the lower border to enclose the sacral 2. vertebra where the subarachnoid space, the last seen of the cerebrospinal fluid, ended. While the lower spinal field, intervertebral and sacral foramens remain within the treatment field, blocks are drawn as if the other healthy tissues were in the lower spinal area protection. The dose is normalized to the appropriate depth on the central axis to cover the whole spine.

In the supine and prone position, DMT was also used in addition to the standard fields prepared with ACT in table angled and blocked/MLC plans (Fig. 4c, d).

In the supine position, the angle which should be given to the table in cranial fields and the angle given to gantry in the lower spinal field are calculated to eliminate divergence in the neck and spinal junction region.

The right cranial field was gantry 270° while the table angle was -3°, and gantry 90° while +2° was given to table for eliminate the divergence (Fig. 5).

In the lower spinal area, the table is rotated 270° and adjusted to the divergence of the lower limit of the upper spinal field by giving a 169° gantry angle. In the supine position, the divergence was eliminated by giving a table angle of +2° when the right cranial field was 90° and a table angle of -3° when the left cranial field was 270°. The lower spinal area has a table angle of 2700 and a gantry angle of 110 (Fig. 6).

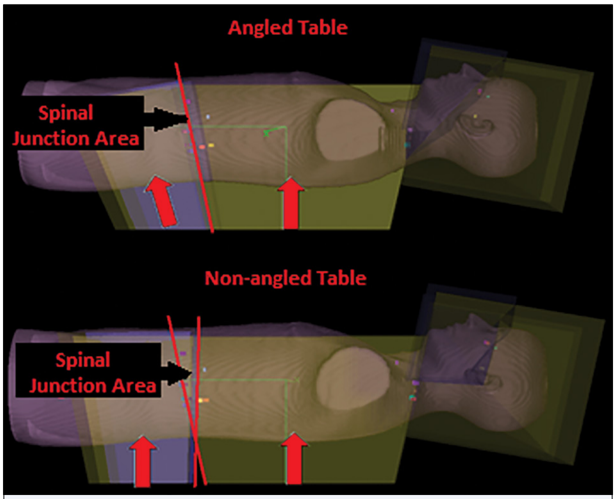

Fig. 6. Upper and lower spinal fields junction area.

Results

In the study, dose values obtained with TPS and TLD at 21 different points with eight different CSI techniques examined were compared for different parameters and the compatibility of the data was evaluated (Table 1).

Considering the necessity of taking the treatment dose of the cribriform plate completely, the most appropriate dose measured by TLD; 1.82 Gy with 101.11% in the PM technique, and the PAM technique also yielded a gain of 102.22%-1.84 Gy.

When critical organs are taken into consideration, it has been determined that the most appropriate dose of the cribriform plate, which is one of the most frequently encountered areas of recurrences, is

Table 1 Average dose values obtained with TPS and TLD for all planning techniques

Region	Technique	SB	PB	SM	PM	SAB	PAB	SAM	PAM
Cribriform plate	TLD (Gy)	1.92	1.87	1.91	1.82	1.93	1.87	1.89	1.84
	TPS (Gy)	1.96	1.90	1.92	1.86	1.95	1.90	1.91	1.87
Right lens	TLD (Gy)	0.21	0.19	0.22	0.21	0.22	0.21	0.22	0.19
	TPS (Gy)	0.22	0.20	0.20	0.19	0.23	0.21	0.22	0.20
Left lens	TLD (Gy)	0.21	0.19	0.22	0.21	0.22	0.21	0.22	0.19
	TPS (Gy)	0.22	0.20	0.20	0.19	0.23	0.21	0.22	0.20
Right cochlea	TLD (Gy)	1.70	1.87	1.75	1.86	1.74	1.90	1.74	1.91
	TPS (Gy)	1.75	1.90	1.72	1.88	1.77	1.94	1.73	1.95
Left cochlea	TLD (Gy)	1.70	1.87	1.75	1.86	1.74	1.90	1.74	1.91
	TPS (Gy)	1.75	1.90	1.72	1.88	1.77	1.94	1.73	1.95
Neck junction B1	TLD (Gy)	1.71	1.74	1.71	1.73	1.70	1.73	1.74	1.76
	TPS (Gy)	1.76	1.78	1.77	1.80	1.76	1.77	1.83	1.84
Neck junction B2	TLD (Gy)	1.77	1.79	1.79	1.80	1.89	1.86	1.88	1.90
	TPS (Gy)	1.83	184	1.84	1.85	1.90	1.91	1.94	1.94
Neck junction B3	TLD (Gy)	1.39	1.53	1.41	1.52	1.49	1.53	1.51	1.53
	TPS (Gy)	1.44	1.58	1.46	1.57	1.52	1.55	1.55	1.58
Neck junction B4	TLD (Gy)	1.76	1.77	1.80	1.81	1.85	1.88	1.90	1.89
	TPS (Gy)	1.84	1.83	1.85	1.84	1.89	1.92	1.95	1.93
Neck junction B5	TLD (Gy)	1.41	1.49	1.43	1.53	1.48	1.50	1.50	1.54
	TPS (Gy)	1.45	1.55	1.47	1.56	1.51	1.54	1.54	1.58
Thyroid	TLD (Gy)	1.28	1.27	1.50	1.52	1.27	1.29	1.34	1.35
	TPS (Gy)	1.32	1.32	1.33	1.33	1.32	1.34	1.32	1.33
Small intestine	TLD (Gy)	1.97	1.87	1.98	1.86	1.13	1.04	1.15	1.01
	TPS (Gy)	1.94	1.89	1.93	1.90	1.09	1.08	1.09	1.07
Right kidney	TLD (Gy)	0.12	0.13	0.14	0.11	0.11	0.12	0.13	0.12
	TPS (Gy)	0.12	0.12	0.13	0.12	0.11	0.11	0.11	0.11
Left kidney	TLD (Gy)	0.12	0.13	0.14	0.11	0.11	0.12	0.13	0.12
	TPS (Gy)	0.12	0.12	0.13	0.12	0.11	0.11	0.11	0.11
Spinal junction S1	TLD (Gy)	1.87	1.78	1.89	1.79	1.88	1.81	1.89	1.80
	TPS (Gy)	1.85	1.83	1.85	1.83	1.86	1.83	1.86	1.83
Spinal junction S2	TLD (Gy)	1.95	1.88	1.93	1.91	1.70	1.63	1.69	1.65
	TPS (Gy)	1.91	1.95	1.90	1.94	1.64	1.67	1.66	1.68
Spinal junction S3	TLD (Gy)	2.16	2.02	2.14	1.99	1.51	1.40	1.55	1.36
	TPS (Gy)	2.11	2.07	2.10	2.06	1.50	1.44	1.50	1.44
Spinal junction S4	TLD (Gy)	1.96	1.90	1.92	1.89	1.69	1.65	1.68	1.62
	TPS (Gy)	1.92	1.96	1.91	1.93	1.64	1.68	1.65	1.68
Spinal junction S5	TLD (Gy)	2.15	2.03	2.16	2.00	1.53	1.42	1.53	1.36
	TPS (Gy)	2.11	2.07	2.10	2.06	1.50	1.44	1.50	1.44
Right ovary	TLD (Gy)	0.10	0.09	0.09	0.08	0.14	0.13	0.14	0.13
	TPS (Gy)	0.10	0.09	0.10	0.10	0.13	0.12	0.13	0.12
Left ovary	TLD (Gy)	0.10	0.09	0.09	0.08	0.14	0.13	0.14	0.13
	TPS (Gy)	0.10	0.09	0.10	0.10	0.13	0.12	0.13	0.12

SB: Supine, non-angled table and blocked; PB: Prone, non-angled table and blocked; SM: Supine, non-angled table and with MLC; PM: Prone, non-angled table and with MLC; SAB: Supine, angled table and blocked; PAB: Prone, angled table and blocked; SAM: Supine, angled table and with MLC; PAM: Prone, angled table and with MLC; TLD: Thermoluminescent dosimeter; TPS: Treatment planning system; MLC: Multi-leaf collimator

obtained by PAM technique. Cribriform plate doses obtained with MLC protection showed an average reduction of 4% compared to those with specific block measures.

For all the techniques we applied, although the TLD doses we obtained in the lenses were very close to each other, the lowest dose was found to be 10.56% in the PB technique and 0.19 Gy/fraction. For the

Table 2 Statistical comparison of TPS and TLD data

TPS-TLD compatibility		p* Spearman test	r** Spearman test	r** Pearson test
No.	**Treatment technique**			
1.	SB	0.000	0.982	0.998
2.	PB	0.000	0.997	1.000
3.	SM	0.000	0.987	0.998
4.	PM	0.000	0.994	1.000
5.	SAB	0.000	0.975	0.998
6.	PAB	0.000	0.997	1.000
7.	SAM	0.000	0.971	0.998
8.	PAM	0.000	0.996	0.999

*There is no significant difference if $p<0.05$; **Good correlation if $r>0.50$, Weak correlation if $0.25<r<0.50$, there is no correlation if $r<0.25$ t and if $r<0$, inverse proportional correlation is accepted. SB: Supine, non-angled table and blocked; SAB: Supine, angled table and blocked; SM: Supine, non-angled table and with MLC; SAM: Supine, angled table and with MLC; PB: Prone, non-angled table and blocked; PAB: Prone, angled table and blocked; PM: Prone, non-angled table and with MLC; PAM: Prone, angled table and with MLC; TPS: Treatment planning system; TLD: Thermoluminescent dosimeter; MLC: Multi-leaf collimator

eight techniques we examined, the doses received by the lenses were extremely low and found to be within acceptable limits.

Cochleas within the entire volume treatment field need to be protected as much as possible from high doses. The lowest dose in this study was 94.44% at SB technique and 1.7 Gy/fraction; the highest dose was found to be 1.91 Gy/fraction with 106.11% in the PAM technique; and the values obtained with all techniques were within the limits.

The lowest doses for the thyroid were 70.66% in the PB and SAB techniques and 1.26 Gy/fraction of 25.6 Gy; the highest doses were seen in PAM from table-angled techniques with doses of 75% and 1.35 Gy/fraction.

For small bowel; the table is angled to the lower spinal field and the overlapping area resulting from the divergence in the junction region is removed, the non-angled table techniques dose was found an average of 106.66% with 1.92 Gy/fraction, dose to be reduced by an average of 60.14% and 1.08 Gy in planning techniques using a table angle.

The highest kidney dose was 7.78% with the SM technique and 0.14 Gy in the fraction was 2.8 Gy in total and was considered to be quite low and all techniques were feasible.

The table-angled techniques used to reduce excess doses in the SB receive an average of 0.09 Gy of 1.8 Gy/fraction, while the ovarian doses of the treatment area approaching the ovaries receive a total of 2.6 Gy of doses of 0.13 Gy/day.

The doses taken at the measuring point B1 on the spinal cord in the neck junction area are similar for all techniques examined. For all techniques, a 95% dose (1.71 Gy) of whole spine coverage was provided, and the maximum dose in the junction region was prevented from exceeding 107%.

In the spinal junction region, the measurement point S1 on the spinal cord is provided between 98% and 105% doses for the eight techniques. In addition, since the divergence has been removed from the junction area in the table angled techniques, it has been determined that the structures in the abdominal region prevent the excessive desire of the non-angled table techniques.

Planning and TLD measurement dose values of eight irradiated techniques were compared using the SPSS 13.0 statistical program.

As a result of Spearman and Pearson correlation tests performed for planning and irradiation dose profiles of different CSI techniques, no statistically significant difference was found, and a strong correlation was found between TPS and TLD measurements (Table 2). Statistical analyzes were performed at $\alpha=0.05$ confidence interval.

Discussion

CSI is a radiotherapy technique that has to be careful the dosimetry needs to provide optimal tumor control, commonly used for the treatment of brain tumors at risk of spinal dispersion. The most common site of recurrence of the cranial subluxation is the cribriform plate. Therefore, care should be taken not to shade the cribriform plate while designing the blocks in the opposite cranial fields.[13,14] The organs at primary risk in CSI are lenses, cochleas, thyroid, small intestine, kidneys, and ovaries. The spinal cord may also be considered at primary risk due to the hot dose points at the junction regions. Tolerance doses of these organs (TD5/5 and TD50/5) should not be exceeded.[1]

The doses given to the cranium and spinal field vary in CSI used in the treatment of diseases such as medulloblastoma, ependymoma, germinoma, pinealoblastoma, and acute lymphoblastic leukemia, which are central nervous system tumors.[3,7]

CSI doses vary according to factors such as tumor type, age of the patient, and protocol of treatment applied. For medulloblastomas, we have a dose of 36 Gy to the spinal field with 1.8 Gy fractions and 54 Gy with an additional dose of 18 Gy in the cranial area and organ doses in the study were evaluated on this dose prescription.[2,3]

The data obtained with TLD and TPS were found to be compatible with each other in the techniques applied in our study. If we need to evaluate the techniques, we use to take the treatment dose of the cribriform plate in full, the most appropriate dose is; PM technique was obtained with 101.12% and 1.82 Gy, respectively, while the PAM technique was found to be 102.22% and 1.84 Gy. The highest obtained dose, 107.22% and 1.93 Gy, was found in the supine position, table angled, and block-protected technique. Cribriform plate doses obtained with MLC protection showed an average reduction of 4% compared to those with specific block measures. Hood et al.[14] report that the maximum error between TLD and TPS is over 60% of the predicted dose for 6 MV photon treatments on the cribriform plate. Although, the estimated dose throughout the brain is negligible. Small differences were found between MLC and block protection (5%). A reduction in the dose of the cribriform plate in the half-shadow region of the light was observed with MLC compared with blocking.

The minimum cataract formation doses for the lens were given as 5 Gy for T5/5 and 12 Gy for T50/5. Despite being very close for all the techniques, we are practicing, the lowest dose is 10.9 Gy/fraction, and 5.7 Gy total/fraction, in the case of the PB technique; the highest dose was obtained in SM and SAM technique 12.22% and 0.26 Gy/fraction in total 6.6 Gy. For eight techniques, the doses taken by the lenses are extremely low and within acceptable limits. Since there is no significant difference between lens doses obtained with MLC and special block protections, both are considered to be feasible. Ozkan et al.[1] are determined in the prone ACT 10.0%-3.6 Gy; 9.8-3.5 Gy in supine ACT; in prone DMT with 12.0%-4.3 Gy; and in supine DMT 10.0-3.6 Gy. In all four techniques, the doses received by the lenses are assumed to be low and within acceptable limits.

The entire volume of the cochlea within the treatment field should be protected from possible high doses. The tolerance doses of Meniere's syndrome for cochleas are 60 Gy for T5/5 and 70 Gy for T50/5. In this study, among the eight techniques examined, the lowest dose was obtained in the SB technique yielding 94.44% and 1.7 Gy/fraction, which is equivalent to a total dose of 51 Gy with additional treatment regimen and is compatible with the literature.[15] Higher doses have been achieved with the prone technique, which is due to the fact that it is difficult to position the spine parallel to the treatment table in the prone position. In PAM technique dose is the highest with 106.11% and 1.91 Gy/fraction totaling 57.3 Gy and within acceptable limits.

For thyroid hypothyroidism tolerance doses of the thyroid gland were 4.5 Gy for TD5/5 and 15 Gy for TD50/5.[1,10,15] In our study, the lowest doses were in the PB and PAB techniques with a total dose of 25.6 Gy/dose of 1.27 Gy/dose with 70.56%.[14] The highest doses were 75% with 1.35 Gy doses/fraction with PAM technique. Because it is tried to prevent the decrease of the dose at the edge of large fields. A homogeneous dose distribution was obtained, but doses were increased at the junctional regions. Accordingly, it was observed that the table angled planning technique did not reduce the thyroid dose. In the study of the effects of the low and high neck junctions made by Narayana et al.,[10] the mean thyroid doses obtained in the low neck junction region were found to be between 4.8 and 28.1 Gy in total and 25.6 and 27.2 Gy in high neck junctions. Although high neck junction seems to be more appropriate, it is not preferred because of the dose drop on the spinal cord in the junction area. Ozkan et al.[1] found that doses of thyroid in their studies were 74.6%-26.6 Gy in the prone ACT; 71%-25.6 Gy in the supine ACT; in the prone DMT was 22.8 Gy with 63.2%; and in supine DMT is 63-22.7 Gy. Since thyroid has more doses of ACT than DMT, there are more doses of thyroid in supine and prone positions in both techniques, and it is suggested that children should use appropriate electron beam in spinal area.

The table angled in the lower spinal area has been removed from the overlapping region resulting from divergence in the junction area, preventing the intestinal volume (about 160 cc) from being overdosed in this region. While the non-angled table had an average of 106.66%/fraction, 1.92 Gy in the fraction, and 38.4 Gy in total, the planning technique using the table angle took an average of 60.14% and 1.08 Gy in the fraction and 21.6 Gy in the fraction. Despite the advantages of the table angled technique, it must be considered that it is a difficult technique to apply and causes the prolongation of the treatment duration.

The minimum acute and chronic nephrosclerosis doses for kidneys were 20 Gy for T5/5 and 25 Gy for T50/5. For the eight techniques, we used in our study, the highest supine position from the kidney dose was considered to be 7.8% in the technique of table open and MLC preservation, 0.14 Gy in the fraction and 2.8 Gy in the fraction, and all techniques were feasible. Lee et al.[15] at work; electron, proton and photons, and the protons were best treated with a dose of 2%, then photons with a dose of 15% and electron with a final dose of 18%.

Girls were given sterilization dose for ovaries 2-3 Gy for TD5/5 and 6.35-12 Gy for TD50/5.[1,14] Blocks or MLC protections in supine and prone positions do not affect the ovarian doses, but the average dose of ovaries is 5% in non-angled table techniques whereas the dose applied with giving table angle to the lower spinal field is 7.5% in the applied techniques. In non-angled table techniques, a mean of 0.09 Gy/fraction is 1.8 Gy, whereas a table angled technique takes a total of 2.6 Gy with a daily average dose of 0.13 Gy. Non-angled table treatment techniques should be preferred to avoid sterilization problems with high doses that may be due to set-up errors due to close tolerance doses and difficulty of table angled techniques. Ozkan et al.[1] found that ovaries received doses of 10.0-3.6 Gy in the prone ACT, 9.8-3.5 Gy in supine ACT; and in prone DMT 10.0-3.6 Gy; and that 10.0%-3.6 Gy of dose can be taken in supine DMT. In both techniques, TD5/5 is at the limit of tolerance to the dose and the use of electron beams is recommended.

For the spinal cord, the tolerance of the 5 cm area is TD5/5 50 Gy and TD50/5 is 65-70 Gy. After radiotherapy 2nd and 4th months, the spinal cord temporary radiation demyelination (Lhermit Syndrome) may develop, in which case the sensation of sudden electrification that spreads from the hand to the arm and bicep when the patient moves to cause the spinal cord to stretch. This diagnosis heals spontaneously within 5 months. When the tolerance doses of your spine are exceeded, it is observed 6 months after the treatment of persistent radiation myelopathy.[1]

In the current study, the doses received at the measurement point B1 on the spinal cord in the neck junction area were similar for all the techniques examined. However, to prevent the dose, drop at the edge of the field, the table angled technique has been shown to increase the dose values at the junctional area, as the normalization point non-angled table technique was chosen more deeply than the skin according to the normalization point. For all techniques, a 95% dose (1.71 Gy) of whole spine coverage was provided and the maximum dose in the junction area was prevented from increasing above 107%. It is preferable to use a supine and non-angled table technique, which is easier to apply and the dose distribution is more homogeneous.

In this study, it was ensured that the doses of measurement point S1 on the spinal cord in spinal junction area were between 98% and 105% of doses in all techniques. However, it is seen that the supine technique is better able to be implemented with fewer setup errors because it is easier to make the spine parallels the treatment table according to the supine technique. However, since the prone technique can be controlled before treatment, it is a safer technique, despite the difficulty of application, compared to supine techniques. In addition, the table angled techniques in the area of abdominal constructions of the overdose, avoid overlapping.

Conclusion

The dose distributions obtained by the supine positioned planning have a more homogeneous dose distribution than the prone techniques. This is because it is more difficult to maintain the straightness of the spinal cord in prone position than supine techniques. When we compare table angled and non-angled techniques, it should be considered that despite the advantages of the table angled technique, it is a difficult technique to apply and causes the prolongation of the treatment duration. This research is designed on the human phantom and has no limitations in terms of application.

When we consider all the techniques we examined in the study in general, it can be said that it is a safer technique compared to the supine techniques, since the junctional areas can be controlled before the treatment in the techniques planned in the prone position. However, since it is easier to keep the spine parallel to the treatment table in supine techniques compared to prone techniques, it is seen that they can be applied better with less set-up error.

The CSI technique, which is also used in our clinic, is planned in the supine position without using a table angle, and by protecting with special blocks; it has been determined that it is superior to other techniques due to its better dose homogeneity in the whole treatment volume, the compliance of critical organ doses to the literature, providing immobilization in daily use and ease of application.

Note: This study was presented as a poster presentation at the 9th National Radiation Oncology Congress in 2010 and was included in the abstract book.

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