PEDIATRIC CRANIOSPINAL IRRADIATION WITH GENERALANESTHESIA AT HUE CENTRAL HOSPITAL

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ABSTRACT

Purpose: *To give advantages and disadvantages in pediatric Craniospinal Irradiation (CSI) planning with general anesthesia, to evaluate some criteria about doses covering at Planning Target Volume (PTV), Organs At Risk (OARs) and junction areas.*

Materials and Methods: *There were 10 pediatric patients with an average age of 4 years (minimum 2 years, maximum 7 years) underwent CSI technique with general anesthesia from August 2017 to August 2018. We applied 3D-CRT (3D conformal radiation therapy) technique for CSI (plan 1) and Volumetric Modulated Arc Therapy technique (VMAT) to boost primary tumor. All processes of taking CT simulation and daily radiotherapy delivery in pediatric patients were done under general anesthetic.Radiotherapy was given on Linac of Elekta AXESSE, Image Guided Radiotherapy performed by cone beam CT/XVI device, radiotherapy plans were made by XiO 5.10 and Monaco 5.11.*

Results and Discussion: *Prescribed dose 54Gy (30 fractions). The medium coverage dose at PTV1 was 90%, PTV2 95% the medium high dose (hotspot) at the junction areas was 115%. Critical organs such as lungs, liver, kidneys, optic nerves, brainstem ... received the acceptance limited dose.*

Conclusion: *Pediatric Craniospinal Irradiation is completely done with general anesthesia. The advantages of CSI are high accuracy and efficacy. Furthermore, the rotation treatment couch in 270 degrees for planning and treatment would limit high dose and missing dose at the junction areas. The disadvantages are taking a long time in planning and treatment delivery, requiring many official persons involved.*

Key words: *Craniospinal Irradiation (CSI), Volumetric Modulated Arc Therapy (VMAT), general anesthesia, pediatric.*

I. INTRODUCTION

Craniospinal irradiation is a common indication in pediatric cancer. Primary tumor location is mostly at posterior fossa of brain, and has tendency to early invade to whole central nervous system. In most cases, cancer cells have invaded widely in brain and spinal at present. Multidisciplinary management is important, surgery is to remove most of tumor volume, combination of chemotherapy and radiotherapy is to manage remnant tumor volume and metastasis sites where surgery is unable to reach, or prophylactic irradiation to spinal, improve quality of life.

Craniospinal irradiation is a complicated technique, because treating volume includes of whole brain and spinal butfield size limitation of LINAC can not cover whole volume when using one isocenter, thus it is necessary to use 2 or 3 isocenters for matching brain and spinal fields. Field matching has to assure dose homogeneity on

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whole PTV1. Affects from equipment or setting up errors are likely to make overlap, causing hotspots or make gap between fields, leading to coldspots, then recurrent risk is increased.

Nowaday, in Vietnam, Craniospinal Irradiation has been applied broadly in radiation unit. However, it's application in pediatrics is pourer because it requires much resource and time for planning and treatment.

Oncology center of Hue Central Hospital has deployed CSI by 3D-CRT for PTV1 and VMAT for PTV2 on AXESSE – ELEKTA LINAC since 2015, and from July 2017, CSI has been performed routinely for pediatrics under aenesthesia.

II. PATIENTS, MATERIALS AND METHOD

2.1. Patients

Ten high risk medulloblastoma pediatrics indicated with CSI.

2.2. Materials

- AXESSE LINAC.
- Specific simulation CT scan.
- Planning software XiO 5.10 and Monaco 5.11.
- Image guide instruments in radiotherapy, XVI

-Patient immobilizing equipments: Bodyfit vaccum bag and three-point Thermomask

2.3. Method

Patients' position were supine, looking upward face under aenesthesia, immobilized by Bodyfit and three-point thermomask, images have been recorded from top of skull to end of sacrum, 5mm slice thickness

We used 2 plans:

+ Plan 1: CSI with 3D-CRT technique planned by XiO 5.10 software.

+ Plan 2: Boost irradiation at tumor with VMAT planned by Monaco 5.11 software.

Photon beams 6MV, 10MV and SAD distance were used.

Three isocenters were used.

Radiation therapy process (included of 5 basic steps)

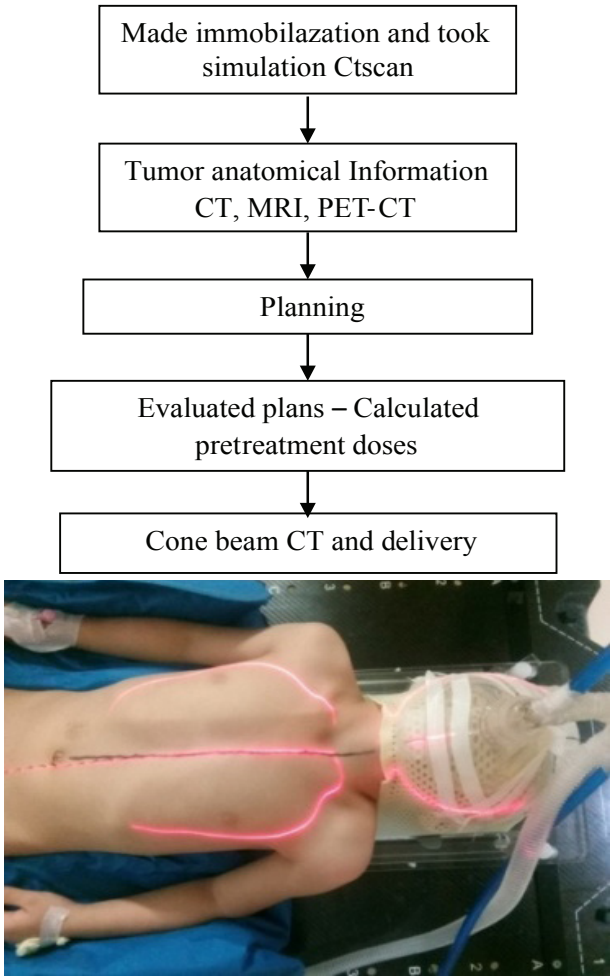

Figure 1. Patient immobilizationtaking simulation Ctscans

2.3.1. Immobilization and taking simulation CT scan

In radiotherapy, patient's immobilization is very important, especially on pediatrics due to their incorporation to radiotherapy staffs. Therefore, we had to combine to anesthesia to immobilize patient position throughout immobilization, taking Ctscan and delivery.

Most pediatrics' organs and systems has been developed after treatment, if there were errors at doses on normal structures, they can be affected. We used Bodyfit immobilization and three-point thermomask to minimize these errors.

Because of combining to anesthesia, patients could not be setted at bended neck during simulation and treatment, an it would affect airway under aenesthesia.

After finishing immobilization, patients had been taken simulation Ctscans, from top of skull to end of sacrum with 5 mm slice thickness. All images had been tranfered to planning software.

2.3.2. Anatomy information

Radio-oncologists defined anatomy information of tumor and adjacent normal tissues based on simulation images, and might combined to MRI, PET-CT by using fusion function of Monaco 5.1 software.

2.3.3. Planning

Medical physicist chose values: energy levels, gantry angles, setting-up collimator, couch angles and rotation arches of gantry.

Made 2 plans with 3D-CRT (plan 1) and VMAT (plan 2)

We had to assure the optimal dose at tumor volume, and minimize dose to adjacent normal tissues in plans. Based on defined clinical target volume (CTV), planning target volume (PTV) and organs at risk, we analyzed and compared on three axial, coronal and sagital planes and on Dose Volume Histogram (DVH), especially at junctons' overlaps and gaps. If all matched RTOG criteria, then plans were approved.

2.3.4. Plan evaluation

For every completed plan, practitioners and physicists evaluated plans based on dose distributions on PTV1, by calculating volumes (cm^3) PTV1 received doses of 90%, 95%, 100%, 110%, 115% of prescription dose. PTV2 received doses of 95%, 100%, 110% of prescription dose.

2.3.5. Cone beam CT and delivery

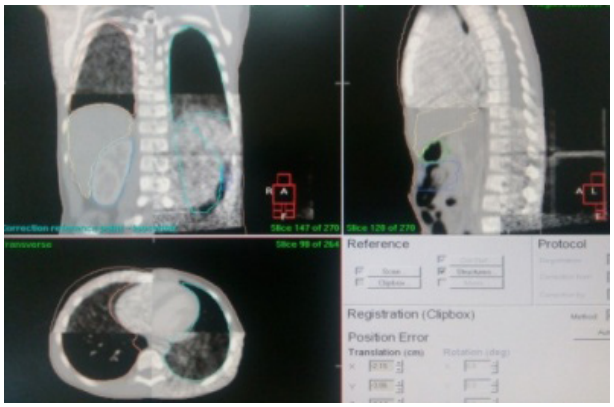

Figure 2. Conebeam CT

Patients had been put under aenesthetic and setted up at same position of simulation on treatment couch, Conebeam CT was performed, radio-oncologists checked matching between simulation and XVI Conebeam images, then Medical physicists move isocenters after corrected then delivery. After finishing delivery, patients had been moved to resurection unit for following up by aenethestic doctor.

III. RESULTS AND DISCUSSION

3.1. Results

+ Plan1: CSI 36Gy/ 20Fx, 3D- CRT technique.

+ Plan2: Boost irradiation at tumor 18Gy/ 10Fx, VMAT technique.

For plan1, after 7 fractions, we moved isocenters 5mm in one direction. The aim of this movement is to minimize overdose or underdose at field junction during daily setting up patient position.

3.1.1. Plan 1: Craniospinal Irradiation

For isocenter 1, we used 6 MV energy level with 2 opposite gantry angles: 90^0 and 270^0 to irradiate whole brain and upper part of cervical. Treatment couch were 0^0, collimators were rotated to make correspondance between the two cranial fields (isocenter 1) and upper cervical field (gantry 180^0). Then lower edge of two cranial fields would be paralell to upper edge of cervical field (isocenter 2).

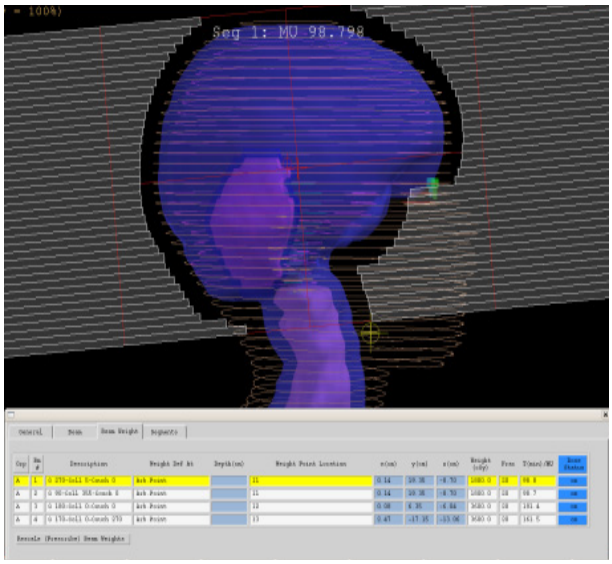

Figure 3. Field size socenter 1

For isocenter 2, we used 10 MV energy level with gantry 180^0, couch 0^0, collimator 0^0 for upper spinal irradiation. We moved isocenter so that upper edge of field was paralell and matched lower edge of isocenter 1's field. Then limitted overdose and underdose at field junctions.

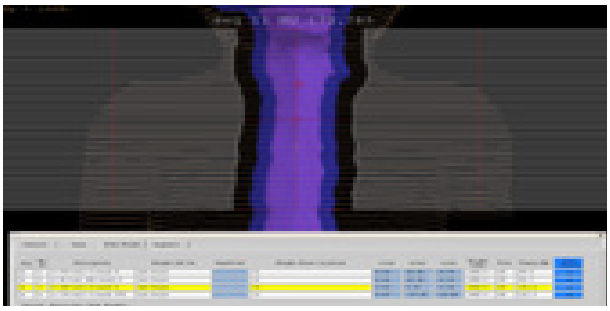

Figure 4. Field size socenter 2

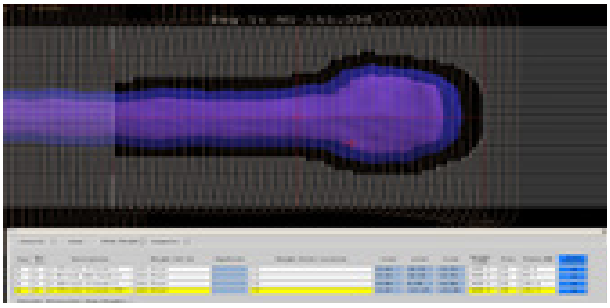

Figure 5. Field size socenter 3

For isocenter 3, we used 10 MV energy level with gantry 170^0, couch $270^{0,}$ collimator 90^0 for lower spinal irradiation. Gantry had been rotated to make upper edge of isocenter 3's field paralell and matched lower edge of isocenter 2's field, and the similiarity was made for isocenter 2.

The aim of this process is to limit overlaps or gaps at fields' junctions, then limit overdose or underdose at junctions, give homogeneity on PTV for prescription dose cover.

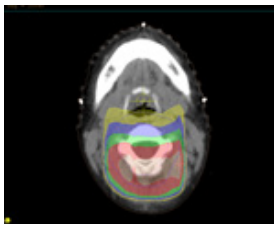

Figure 6. Isodose curve shown on CT image at junction socenter 1&2

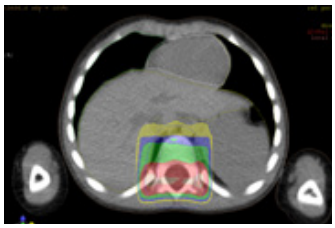

Figure 7. Isodose curve shown on CT image at junction socenter 2&3

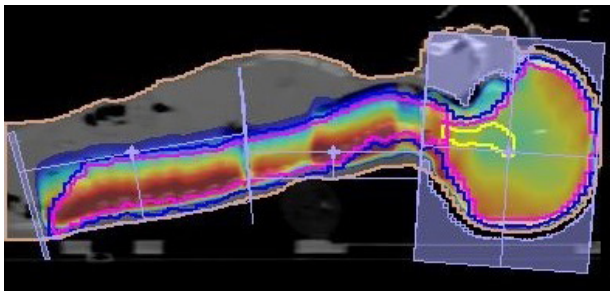

Figure 8: Isodose curve show on CT image ofPTV1

3.1.2. Plan 2: Boost irradiation at primary tumor 18Gy/ 10Fx, VMAT technique.

- Applied arc radiation therapy, Volume modulated arc radiotherapy VMAT.

- We used photon 6MV energy level, gantry rotated in 2 arcs, each arc was 140^0(40^0-180^0, 180^0-320^0), collimator 15^0

- After chosing values for doses, beam angles, then specific dose distribution of relating beams would be performed by software. The algorithms were made by convolution principle. Because movement of gantry and MLCs is continuously, we could make beams with any size.

- Coverage to PTV2 achieved at least 95% of prescription dose, hotspot 110%. Organs at risk were in allowed range.

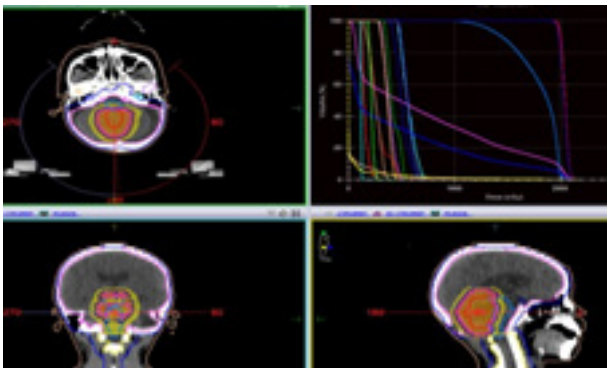

Figure 9. Isodose curve shown on CT images of PTV2

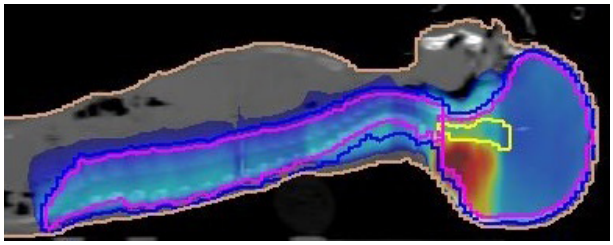

Figure10: Isodosecurve show on CT image of both plans

3.1.3. Summation of plan 1 and plan 2

- We analyzed isodoses on axial, coronal, sagittal planes and DVH then found it optimal: 90% of prescription dose covered whole PTV1, 95% of prescription dose covered whole PTV2. Doses of organs at risk achieved were not desirable but still in allowed range.

3.1.4. Coverage and homogeneity on PTVs

Plans' evaluation:

Coverage on PTV1 and PTV2 have been shown in table 1.

Prescription dose 90% covered 100% of PTV1; 95% covered 95% of PTV1; 100% covered of 87% PTV1 and 115% covered 0,01% of PTV1.

Prescription dose 95% covered 100% of PTV2; 100% covered 95% of PTV2 and 110% covered 0.01% of PTV2.

Table 1: Mean values of PTV received presciption dose (10 patients)

	PTV1 Volume %					**PTV2 Volume %**		
Presciption dose %	90%	95%	100%	110%	115%	95%	100%	110%
1	100	95	87	7	0.01	100	95	0.01
2	100	96	88	8	0.01	100	95.5	0.02
3	100	95.5	88	7	0.01	100	95.3	0.01
4	100	97	88.5	8	0.01	100	95.7	0.02
5	100	97.5	88.7	8.6	0.01	100	95.8	0.01
6	100	95.5	87.5	7	0.01	100	96	0.02
7	100	96.5	87.8	7.5	0.01	100	95	0.01
8	100	98	88	8	0.01	100	96.2	0.02
9	100	99	88.6	8.7	0.01	100	96.5	0.01
10	100	100	90	9.5	0.01	100	96.7	0.02
SD %	±0.02	±1.1	±2.19	±0.52	±0.01	±0.12	±0.9	±0.22

According to Guide of QUANTEC, Version 10.2010

Table 2: Mean dose of Organs at risk (10 patients).

OARs	**Serial organs**		**Parallel organs**	
	Tolerance	Plans' values	Tolerance	Plans' values
Heart			Mean dose< 26%	21.5%±1.4
Lung (both sides)			V20 ≤ 30%	29.7%±1.2
Liver			Mean dose< 28 Gy	Mean dose =13.9 Gy±1.1
R Kidney			Mean dose< 28 Gy	Mean dose =20.8 Gy±1.1
L Kidney			Mean dose< 28 Gy	Mean dose =8.6 Gy±1.1
Brainstem	Dmax<54Gy	Dmax= 52.6 Gy±1.1		
Brain	Dmax<60 Gy	Dmax=58.2 Gy±1.1		
R optic nerve	Dmax<55 Gy	Dmax=41Gy±1.1		
L optic nerve	Dmax<55 Gy	Dmax=40.7Gy±1.1		
R cochlea	Mean dose ≤ 45Gy	Mean dose = 41.4Gy±1.1		
L cochlea	Mean dose ≤ 45Gy	Mean dose = 41.3Gy±1.1		

On table 2, organs at risk received safe dose, lower than their limited D_{gh}.

Table 3: Mean values that organs at risk received at least 5%, 25%, 50%, 75% of prescription dose (10 patients).

OARs	V5 (%)	V 25 (%)	V50 (%)	V75 (%)
Heart	30.72 Gy	28.12 Gy	25.59	6.06
Lung (both sides)	32.58 Gy	7.56 Gy	2.04	1.37
Liver	28.15 Gy	15.70 Gy	1.78	1.28
R kidney	33.15 Gy	8.27	2.17	1.33
L kidney	35.12 Gy	7.70	2.02	1.27
Brainstem	46.26 Gy	42.52	40.87	39.50
R optic nerve	38.06 Gy	37.19	36.43	32.32
L optic nerve	38.48 Gy	37.79	36.94	34.20
R cochlea	40.96 Gy	40.61	40.35	39.80
L cochlea	53.41 Gy	100.00	100.00	100.00

3.2. Discussion

Coverage and homogeneity on PTV1 did not reach 95% of presciption dose because spinal position under anesthesia, distance from source to PTV1 in one field was much different and caused different coverage.

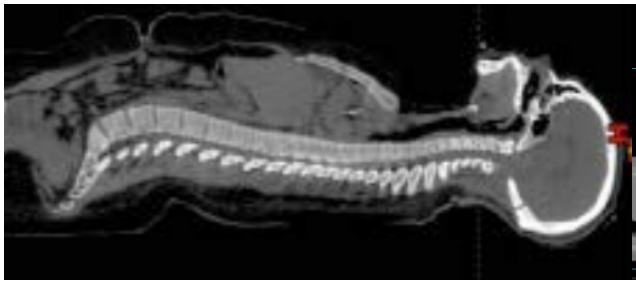

Figure 11:Patient position without anesthesia

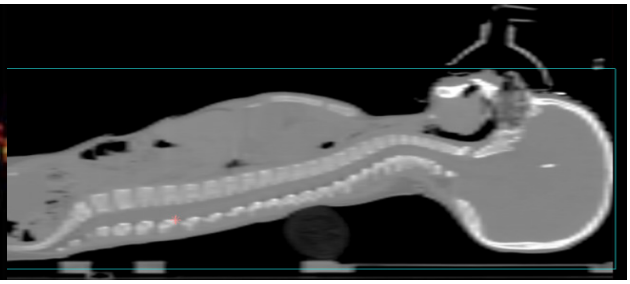

Figure 12: Patient position with anesthesia.

Field junction areas:

Plan1: after 7 fractions, we moved isocenters 5mm in one direction. The aim of this movement is to minimize overdose or underdose at field junction during daily setting up patient position

There were 2 junctions, so hotspot elevated to 115%. For limitting hotspots, we used field in field technique. Beside, we made plans without gap of junctions to assure PTV1 received higher than 90% of prescription dose. However, when compared to lower spinal irradiation without couch rotation 270^0, hotspot at junctions elevated to 135% and coldspot was 80% of prescription dose.

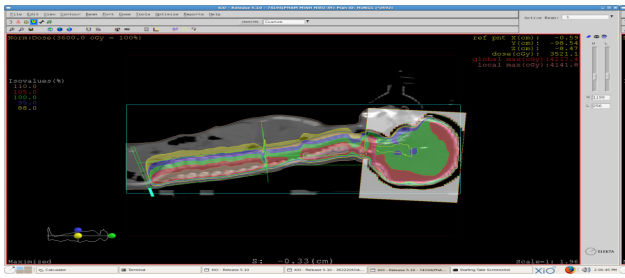

Figure13: Field junction site when couch rotated 270^0

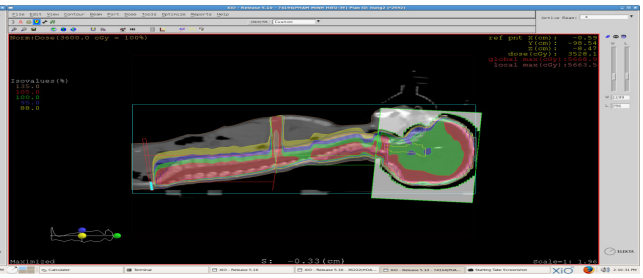

Figure14: Field junction site when couch did not rotate 270^0

270^0 couch rotation plan of isocenter 3 took more time for technicians to move instruments of aenathesia and rotate couch.

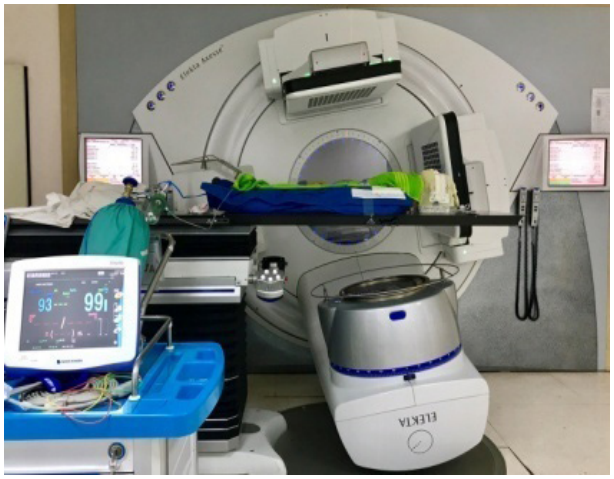

Figure15:Position of gantry and patient when delivering isocenter 3

IV. CONCLUSIONS

After analyzed this technique process, we found some following advantages and disadvantages:

Advantages:

- Thanks to aenathesia combination, pediatrics can tolerate craniaospinal irradiation safely with high precision and good treatment outcome.

- Applying 270^0 couch rotation for lower spinal irradiation in clinical practice could limit hotspot and reduce coldspot at field junctions.

Disadvantages:

- Take more time and staffs for planning and treatment delivery.

- Require additional aenesthetic instruments in daily radiation delivery.

- Expensive treatment cost.

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