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EASTERN TIME [GMT-4]

Long field VMAT for total spine irradiation

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INTRODUCTION

At our centre when radiotherapy to the entire spinal column is indicated, extended Source Surface Distance (SSD) Parallel Opposed Pair (POP) field geometry has been used. The extended SSD POP geometry has a field length limitation and is not appropriate for tall patients.

AIM

To develop a VMAT planning, patient specific delivery Quality Assurance (QA) and delivery technique that is adequate to treat long targets such as the entire spinal column.

METHOD

PLANNING

- A VMAT plan was generated with 2 intersecting arcs associated with 2 separate isocentres separated longitudinally

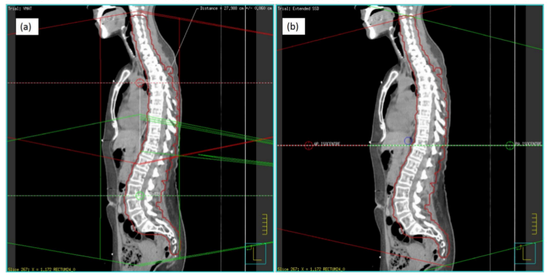

Figure 1: Field geometry for total spine irradiation (a) 2 arc VMAT with 2 isocentres and (b) extended SSD POP

- Over the axial range of arc intersection, optimization regions of interest were used to control the dose in the overlap region to a clinically acceptable level
- VMAT dose distributions were compared with extended SSD distributions in terms of coverage, conformity and organ at risk doses

PATIENT SPECIFIC DELIVERY QUALITY ASSURANCE

- ArcCheck was used to validate the dose over the axial range of the arc intersection
- To avoid irradiating the ArcCheck electronics, the inferior border of each control point of the inferior field was reduced in the treatment planning system. Fields were exported to the record and verify system for delivery QA. Figure 2 shows this required field modification.
- The dosimetric impact of small setup variations in the longitudinal direction was simulated by deliberately introducing setup errors of ±2 mm for the superior Isocentre.

METHOD (CONT'D)

- Composite dose distributions were measured and compared with planned distributions

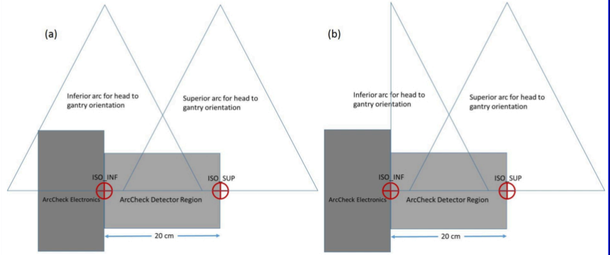

Figure 2: QA geometry (a) Planned field geometry (b) Modified field geometry to avoid irradiation of ArcCheck electronics

RESULTS

PLANNING

- The sagittal and coronal dose distributions for the VMAT and extended SSD POP planning techniques are illustrated in Figures 3 and 4, respectively. The VMAT planning technique spares the anterior anatomy well as compared with the extended SSD POP technique.

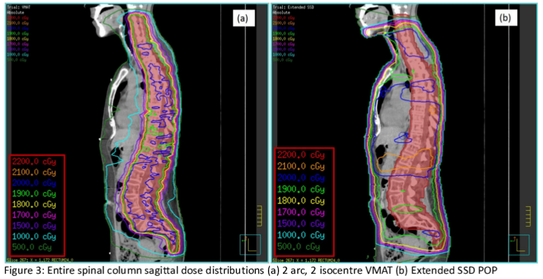

Figure 3: Entire spinal column sagittal dose distributions (a) 2 arc, 2 isocentre VMAT (b) Extended SSD POP

- Selected dose metrics are summarized in Table 1.

Table 1: Total spine irradiation dose metrics and conformity for VMAT and extended SSD technique

Dose Metric	VMAT	Extended SSD POP
Mean dose to Right Kidney (cGy)	358	1063
Mean dose to Left Kidney (cGy)	401	405
Mean dose Right Lung (cGy)	545	767
Mean dose Left Lung (cGy)	552	972
Maximum point dose (cGy)	2134	2224
Mean dose to tissue outside PTV (cGy)	473	664
RTOG Conformity Index[1]	1.03	3.3
Conformation Number[2]	0.87	0.29

RESULTS (CONT'D)

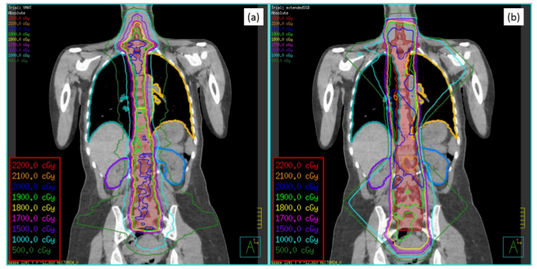

Figure 4: Entire spinal column coronal dose distributions (a) 2 arc, 2 isocentre VMAT (b) Extended SSD POP

PATIENT SPECIFIC DELIVERY QUALITY ASSURANCE

- Planned and composite measured dose distributions were compared using SNC Patient 6.7.4 (SunNuclear) over the axial range illustrated in Figure 5

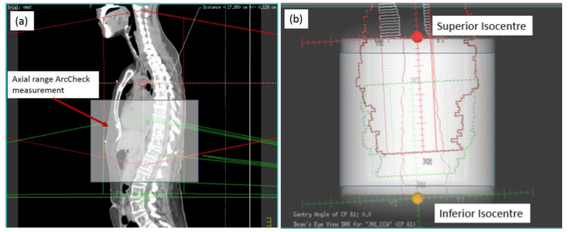

Figure 5: ArcCheck measurement geometry. (a) Axial range of ArcCheck overlaid on patient anatomy. Central 12 cm of detector region encompasses overlap region of both arcs (b) Region of overlapping arcs displayed on ArcCheck phantom. Hashed lines show maximum aperture of each arc

- Figure 6 shows the comparison of the composite planned and measured dose distributions

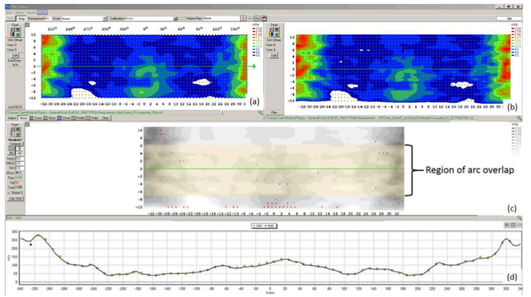

Figure 6: Comparison of ArcCheck measurement (a) with planned dose distribution (b). Panel (c) illustrates the dose difference map. The region of arc overlap is outlined is highlighted. Gamma analysis settings are 2% dose difference, 2 mm distance to agreement, 5 % dose threshold, Global normalization. (d) Measured and planned dose profile corresponding to horizontal green line in (c). Displayed results are not shifted

RESULTS (CONT'D)

PATIENT SPECIFIC DELIVERY QUALITY ASSURANCE (CONT'D)

- Results of ArcCheck composite measurements are summarized in Table 2

Table 2: Composite ArcCheck measurement results including measurements with deliberate ±2 mm shift to superior isocentre

Measured Composite Distribution	% Measurement points passing evaluation criteria
Isocentre shifts applied as planned	96.2%
Superior Isocentre shifted 2mm less than planned shift	91.2%
Superior Isocentre shifted 2mm more than planned shift	92.0%

- With the isocentre shifts applied according to the planned isocentre shifts, the pass rate meets our institution's criteria (pass rate > 95%)
- The dose difference map Figure 6(c) indicates that the majority of the measurement points that do not meet the evaluation criteria are outside the region of arc overlap at the edge of the detector region and may be due to difference in measurement scattering conditions rather that the overlap of 2 arcs.

CONCLUSIONS

- A technique for planning total spine irradiation using overlapping VMAT beams has been developed.
- The reduction of dose to adjacent organs at risk and dose distribution conformity as compared with the extended SSD POP technique is of clinical interest.
- A method to perform Patient Specific Delivery QA using existing equipment has been developed for commissioning of this technique. Use of this PSQA technique on a routine basis may not be practical considering the need to modify the planned fields.
- This technique has been further developed to include other palliative sites that previously required extended SSD to encompass target volumes.

REFERENCES

[1]Shaw E, Scott C, Souhami L, *et al.* Single dose radiosurgical treatment of recurrent previously irradiated primary brain tumors and brain metastases: Final report of RTOG protocol 90–05. *Int J Radiat Oncol Biol Phys* 2000;47:291–298.

[2]van't Riet A, Mak AC, Moerland MA, *et al.* A conformation number to quantify the degree of conformality in brachytherapy and external beam irradiation: Application to the prostate.*Int J Radiat Oncol Biol Phys* 1997;37:731–736.

CONTACT INFORMATION

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