Pediatric Total Skin Commissioning on Siemens Artiste Linear Accelerator

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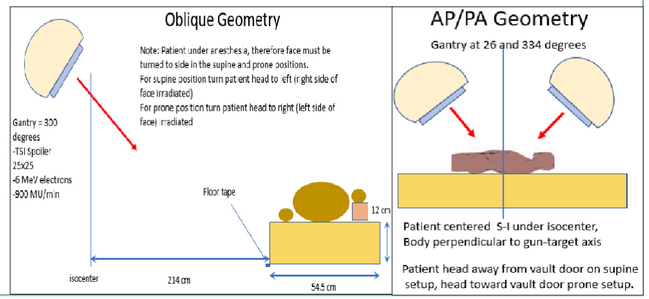
Introduction

Our clinic routinely treats adult total skin electron irradiation (TSI) patients. Patients must stand, posing, for long periods of time during irradiation. Children requiring sedation cannot stand for long periods of time. The purpose of this study was to commission a recumbent TSI procedure on a Siemens Artiste accelerator accommodating the necessary sedation for treating a 3.5-year-old T-cell lymphoma patient with skin involvement. Our approach was informed by Duefel and Antolak who previously developed a recumbent TSI technique with a Varian Truebeam at the Mayo Clinic.

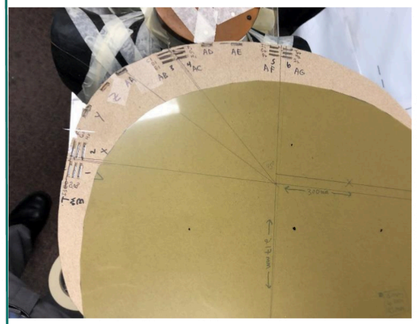
Methods

Treatment consists of 6 equally-weighted and spaced, low-energy, electron irradiations about the patient axis. We modified a 25x25 electron cone by removing the scrapers and bolting a 6mm thick acrylic sheet across the opening in order to disperse and lower the treatment beam energy. Gantry angles were chosen to maximize flatness. Flatness and symmetry measurements were performed with EBT3 GafChromic film, and TLD-100 rods across a Styrofoam plane in both treatment configurations (AP/PA, obliques), as well as measured about an Alderson-RANDO anthropomorphic phantom. The geometry of the AP/PA and oblique beams are different and the PDD curves needed to be found by superimposing dose measurements at different depths in both geometries to determine the over-all effective treatment PDD. Absolute dose calibrations were performed by cross-calibrating a parallel plate ion chamber with our standard monthly farmer chamber. Absolute dose was confirmed over the Alderson-RANDO phantom using calibrated OSLD detectors.



Results

Planar flatness was within 11% across all treatment dimensions for all beams. Dose uniformity across the Alderson-RANDO phantom was within +/- 15% (n=35) (excluding Apex of head). We found a broad bremsstrahlung component (1.6% on axis, 5 cm deep). The effective spoiled electron energy was found to be ~5 MeV, which is slightly higher than our standard total skin irradiation setup.

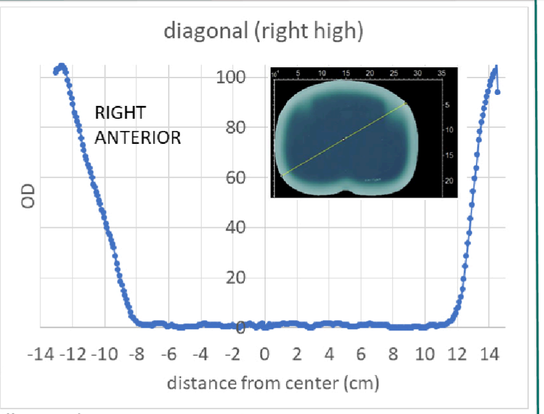


Right: OSLD detectors were placed on Rando phantom in commissioning as well as on patient during treatment to monitor surface doses

Left: GafChromic film as well as TLD-100 rods were placed within Rando phantom slices to measure spoiled electron beam penetration

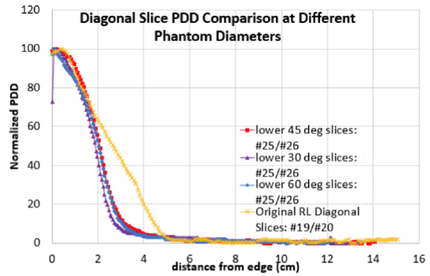
Location	OSL	Dose (cGy)	Location	OSL	Dose (cGy)	
lower spine	69L	209	Apex of head	79C	74	
posterior chest	71U	215	Anterior neck	19G	240	
posterior head	94K	204	Anterior neck right 45	21V	217	
mid back	114	202	right shoulder/chest	586	202	
left ilium	85S	211	left shoulder/chest	84M	195	
right ilium	08C	208	Midway umbilicus-pubis	16t	228	
left armpit	21V	211	" front right 45	04H	227	
right armpit	76H	205	" back right 45	08C	234	
left lovehandle	16t	206	lateral lower thigh	482	177	
rt lovehandle	54B	208	rt lovehandle	839	209	
left jaw	60I	212	Anterior lower thigh	62S	197	
right jaw	13L	214	Center mid-back	71U	194	
center chest	53C	225	center chest	02i	223	
pubis	839	226	**Umbilicus Belt**			*Angle*
umbilicus	31m	230	Umbilicus (Anterior)	74K	224	0
forehead	39C	210	Umbilicus belt	60I	216	15
			Umbilicus belt	00B	223	30
			Umbilicus belt	53C	220	45
			Umbilicus belt	86H	235	60
			Umbilicus belt	30Y	209	75
			Umbilicus belt (lateral)	41R	180	90
Average over all OSLs:	208.8889					

Right: GafChromic film profiles were measured along four slices within the Rando phantom and the film profiles were confirmed via TLD rod measurements positioned using thin cardboard inserts between the slices. Regions of dose over-lap were discovered in the largest diameter RANDO cross-sections, particularly in the anterior left and right corners (60° and 300° positions).
The Rando phantom was shifted along the S-I axis and the tests repeated to confirm it was indeed a phantom diameter issue and not a positional scatter issue.



Below: The equivalent depth of penetration (energy) for this technique is slightly higher than our standing TSI (modified Stanford technique). However, if the patient diameter exceeds a set threshold the field overlaps greatly change the equivalent treatment beam energy.

Dose fall off comparison: bigger rando vs smaller rando region



Treatment Procedure

Day #1 -3 supine positions
AP position consists of two beams,
Plus LAO and RAO
4 treatment beams: 919 x 2 + 3967 x2
Total MU: 9772 MU

Day #2 -3 prone positions
PA position consists of two beams,
Plus LPO and RPO
4 treatment beams: 919 x 2 + 3967 x2
Total MU: 9772 MU

Grand total MU: 19544
(21.7 minutes beam-on)

Conclusions

Patient treatment was highly successful, with no further evidence of skin disease.

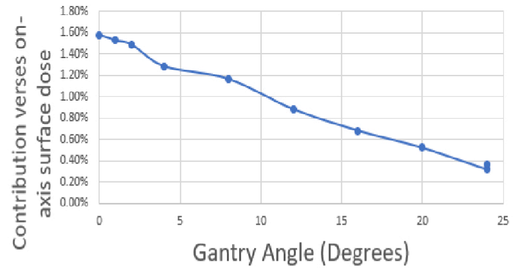
The patient's fractional skin dose was very sensitive to daily positioning changes and needed to be monitored via OSLD *in-vivo* measurements and patient position re-adjusted each fraction

Patients with height < 100 cm and chest (largest) diameter < (15 cm AP, 23 cm LR) may be treated with this procedure.

Total Beam on time for this procedure is ~22 minutes which is shorter than our standard adult TSI procedure. However, the patient positioning time is greater and more complicated in the recumbent TSI procedure.

Patient required additional electron boosts to the perineum, scalp, and axillary areas, which is standard in our traditional TSI treatments.

Bremsstralung Contribution



Above: Bremsstrahlung contribution measured at 5 cm depth in solid water verses on-axis surface dose. This and all ion chamber measurements were made with shielded triaxial cables to avoid stem-effect contribution. In Oblique geometries patient was positioned 5 degrees off of the central axis to reduce bremsstrahlung contribution.

References

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Total skin electron therapy in the lying-on-the-floor position using a customized flattening filter to accommodate frail patients

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