Total Skin Electron Therapy Treatment Planning Based on the Cylinder Dose Simulation and Computer Animation Techniques

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Introduction

Total skin electron therapy (TSET) is widely used to treat cutaneous T-cell lymphoma[1]. In TSET, different techniques of patient positions, including Stanford and rotational, are used to achieve the goal the uniform skin dose coverage during the treatment[2]. There is no existing research that has compared the performance of these techniques. In this study, a TSET treatment planning system, based on the Monte Carlo dose simulation on cylindrical phantom, was built to model the dose distribution over the patient skin in TSET and compare which of the Stanford and rotational techniques had more uniform dose coverage over the patient's body surfaces.

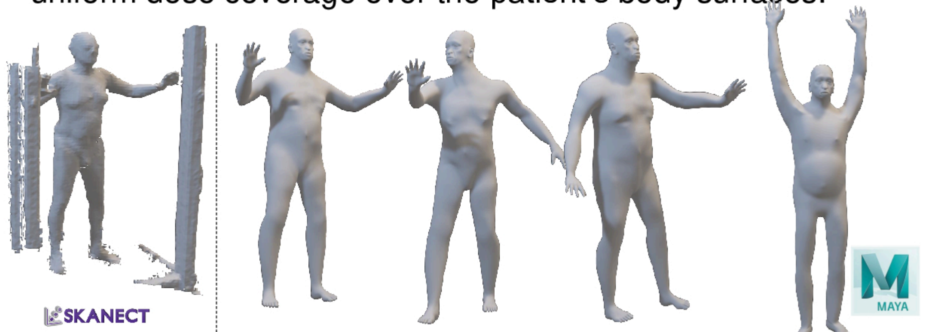


Figure 1 (a): Raw 3D contour of the patient in AP position extracted from the structured light sensor (b): The contour of PA-AP positions edited from the marquee mesh (c) and (d): LAO-RPO and RAO-LPO positions created from animation, (e): The patient's position in rotary technique, created from animation.

Methods

In Stanford technique, the patient is treated by a broad electron beam in 6 body positions, while in the rotational technique, the patient keeps one position with the rotation of the rotary table underneath during the treatment. The 3D body meshes of position in Stanford technique were extracted from the 3D body sensor (Occipital, San Francisco, CA) before the TSET treatment. A set of marquee mesh is edited in animation software (Maya) to fit one position's contour of Stanford technique. The contours of other positions in Stanford and rotational techniques are created through animation. Monte Carlo simulation (GAMOS) was run to simulate the dose distribution on the cylindrical water phantoms in the electron beam. The radii of the phantom ranges from 5cm to 20cm, with length of 30cm, to simulate different body parts in human body. The circular dose distribution in the central region of the phantom, derived from the exponential summation of the surface depth dose, was converted to the relationship between the relative dose and the cosine value of the incidental angle of the beam.

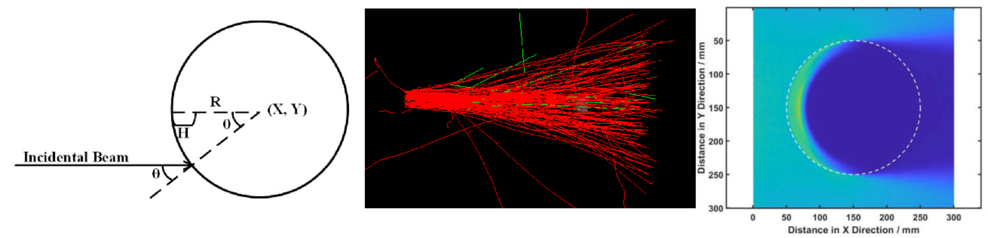


Figure 2 (a): the incidental electron beam hitting the surface of the phantom in top view (b): The trajectories of the electron particles in GAMOS simulation. (c): The planar dose profile in the central region of one phantom.

Based on the derived relationship in simulation, the treatment planning system extracted the normal vector in the point on the 3D contour of the patient position, compared with the incidental beam angle, and then calculated the relative dose value on that point. The dose distribution for each positions was interpolated from the point dose values and the cumulative dose distribution was summed through computer animation techniques used in TSET Cherenkov study[3].

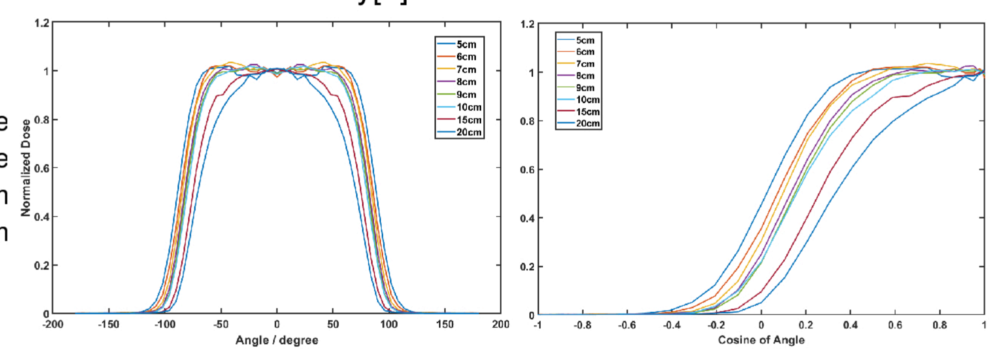
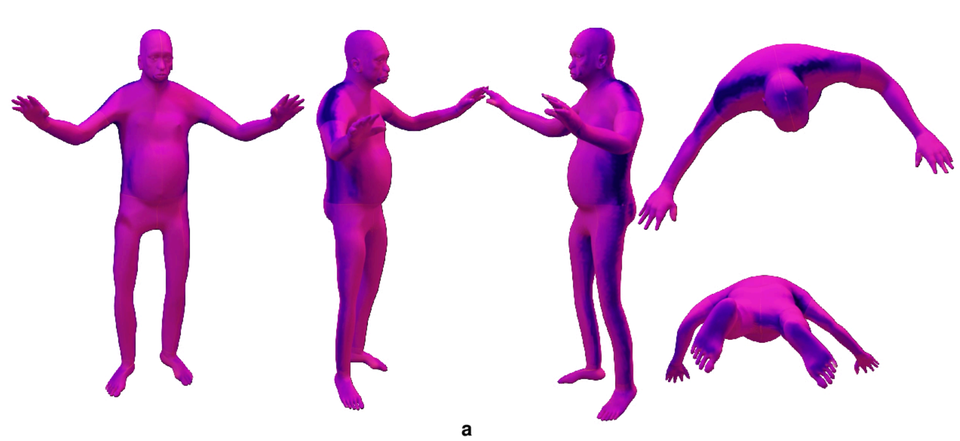


Figure 3: The plot of the normalized exponentially weighted accumulative dose distribution vs incidental beam angle (a) to the surface and the cosine value of the angle (b) for cylindrical water phantoms with different radii.

Results



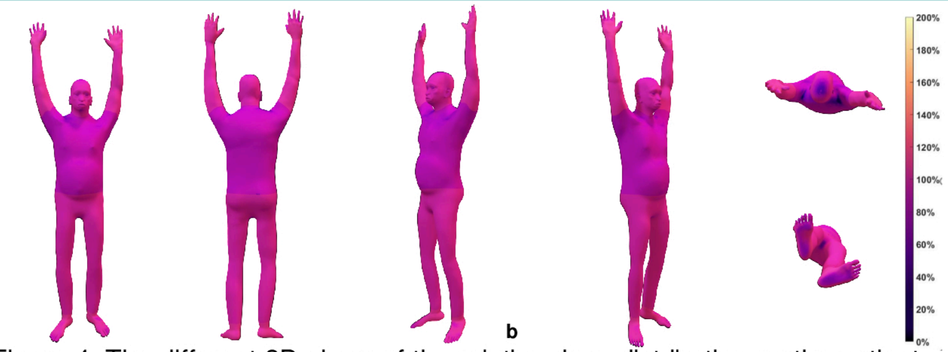


Figure 4: The different 3D views of the relative dose distribution on the patient body in Stanford (a) and rotary (b) techniques

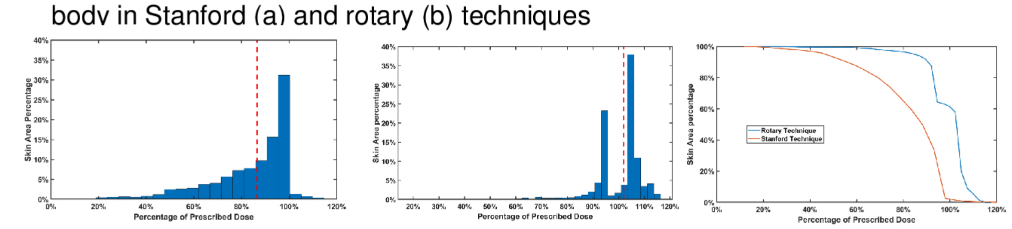


Figure 5. Histogram of the surface area dose distribution in Stanford (a) and rotational (b) techniques, with the red dashed line represents the mean surface dose. (c): The comparison of the DAH (dose area histogram) curves between Stanford and rotational techniques.

The 3D dose distribution showed more dose anomaly in Stanford techniques, especially in the edges of different positions, while the dose distribution in rotary technique was more uniform in most body regions. For both techniques, under-doses regions were observed in the regions of feet and perineum. These regions requires supplemental boost fields in clinical scenarios[4].

Conclusion

The treatment planning system introduced in this study is a good tool to analyze the dose distribution in TSET treatment. Through the comparison, the rotational technique had more uniform dose distribution in most skin regions than the Stanford technique.

Acknowledgements

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References

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