Dose build up characteristics with eXaSkin bolus during 6MV radiotherapy: MO*Skin* dosimetry results

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T Al-sudani[1], P Metcalfe[1,2], D Cutjar[1], K Utitsarn[1], A Ceylan[2], J Davis[1] and A Rosenfeld[1]
[1]Centre for Medical Radiation Physics, University of Wollongong, Wollongong, NSW 2522, Australia.
[2]Illawarra Cancer Care Centre, Wollongong, Australia

E-mail: tahas274@uowmail.edu.au

Abstract: Skin dose evaluation is important to ensure adequate dose to the superficial target volume and to avoid severe skin toxicity. The purpose of this study is to investigate the build-up dose characteristics of eXaSkin bolus for 6MV photon beams and evaluate this material for use in skin tumor treatment. Using a 6MV Varian LINAC with field size of 10x10cm^2, the surface and build up dose characteristics of eXaSkin (thickness=3, 5, 8, 10, 15 and 26 mm) was investigated in comparison with solid water (thickness=2, 5, 15, 20 and 26 mm). Dose measurements were performed using a MO*Skin* dosimeter and advanced Markus chamber. Additionally, the percentage surface dose measurements for various oblique incident beams with 3mm thick of both bolus was investigated. Measurements were performed using MO*Skin* dosimeter and compared with advanced Markus chamber. D_{max} of eXaSkin for 6MV was approximately 0.9 cm that is consistent with the higher density of this material (ρSW=1.04 g/cm^3 ρeXa=1.7±0.03 g/cm^3). This bolus also exhibits higher dose in the build-up region between 2-10 mm depths and higher dose at oblique incident beams than solid water. Preliminary results suggest that eXaSkin is a promising candidate for use in the treatment of superficial tumors without producing excessive skin reaction.

1. Introduction

Medical linear accelerators are currently used to treat cancer with high energy X-rays (Megavoltage) [1-4]. Primary tumours are located close to many critical structures and delivering sufficient radiation dose to the primary and lymph nodes requires special attention to protect these structures [5]. As skin is critical organ, many research were investigated the immobilization devices and bolus material on skin dose [6]. Lee [7] found that the skin dose was increased about 18% caused by the bolus effect of a thermoplastic mask material during IMRT treatment of the head and neck cancer patients. Accurate assessment of surface and skin doses with eXaSkin bolus (a new material) can provide valuable information for clinical consideration to avoid near surface recurrence and severe skin toxicity.

2. Materials and Methods

2.1 Build-up region dose measurements

The eXaSkin bolus (AnatGe, Spain) is a new material (figure 1), which is composed of two components. A combined components of eXaSkin produced a new material, this material is hardening in a two minutes. For build-up measurements, the eXaSkin cuts off into 10x8 cm^2 dimensions with different

thicknesses. The density of eXaSkin was calculated. The build-up region of eXaSkin at depths (0, 3, 5, 8, 10, 15 and 26 mm) was compared with build-up of solid water (Gammex, model 457, USA) (figure 2) at depths (0, 2, 5, 15, 20 and 26 mm) by using advanced Markus chamber and MO*Skin* dosimeters. PDDs were performed with 6MV Varian Clinac iX (Varian Medical Systems, Palo Alto, CA) at Illawarra Cancer Care Centre for irradiated field size of 5x5 cm^2 and 10x10 cm^2 at 100 cm SSD with 10 cm solid water as backscatter. Rawlinson [9] over-response correction formula for advanced Markus ionization chamber as follows:

$$P(d, E) = P'(d, E, G) - \xi(d, E, G) \quad (1)$$

$$\xi(d, E, G) = \xi(0, E, G) \times e^{-4.0d/dmax} \quad (2)$$

$$\xi(0, E, G) = c(E) \times (s/w) \times \rho^{0.8} \quad (3)$$

Where *P* is the true PDD, *P'* is the measured PDD, ξ is an over-response correction factor, E is the beam energy, d is depth in the phantom, ρ is mass density of chamber wall, s/w is the ratio of electrode separation (s) to the diameter of the sidewall (w), For E=6MV photon beam energy, d_{max}=15 mm and c (E) = 0.27.

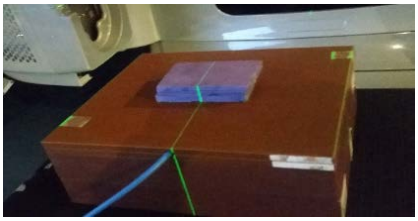


Figure 1. eXaSkin material

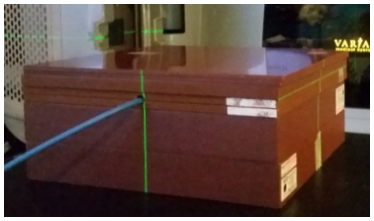


Figure 2. Solid water slabs phantom

2.2 oblique incident beam

The percentage surface doses (PSD) for different incident angles were measured using an advanced Markus chamber and MOSkin. The oblique incidence beam was investigated at 0º, 15º, 30º, 45º, 60º and 75º beam angles for 6 MV photon beams, 100 SSD and 10x10 cm^2 field size. Furthermore, the effect of different incident beam angles on the 3mm solid water and 3mm eXaSkin bolus was compared.

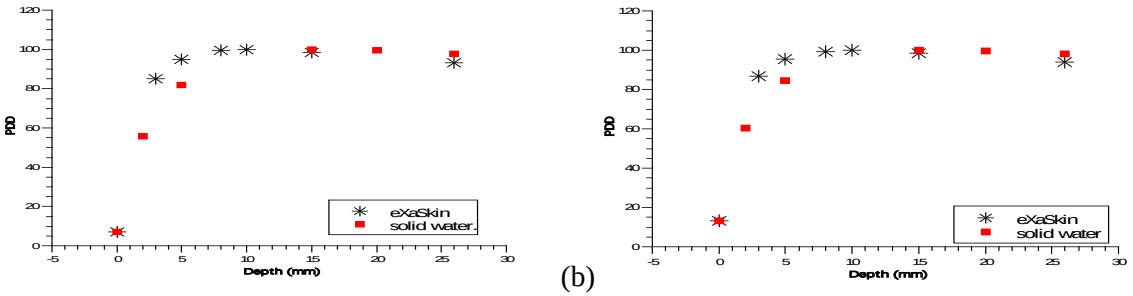
3. Results and Discussion

3.1 build-up region dose measurements

The density of eXaSkin material was calculated by measure its slabs dimensions and their weights. The density of eXaSkin is 1.7± 0.03 g/cm^3 compared with the solid water, which it is, equals to 1.04 g/cm^3. (Figure 3 and figure 4) show the PDD measurement by the advanced Markus chamber and MOSkin dosimeter with the eXaSkin and the solid water phantom as a bolus material for field size of 5x5 cm^2 and 10x10 cm^2. The PDD of eXaSkin for both field sizes are higher than PDD of solid water at (2-10 mm).

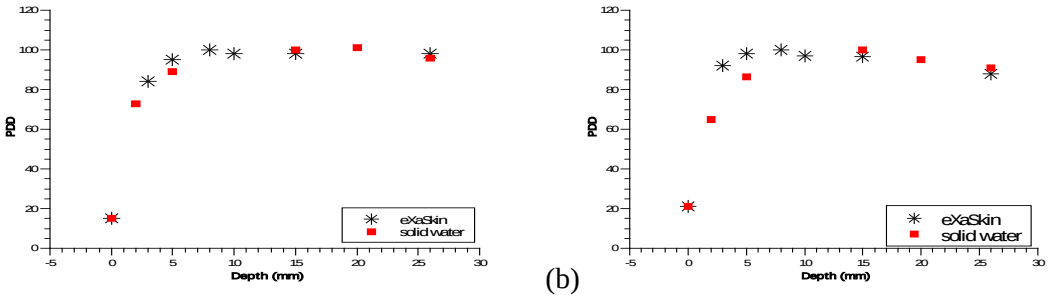
The d_{max} of solid water was at 15mm depth (density 1.04 g/cm^3) and when compared it with the eXaSkin density (1.7 g/cm^3), the d_{max} of eXaSkin was 9 mm.

The comparison of the PDD of eXaSkin between advanced Markus measurements and MO*Skin* measurements for both field sizes 5x5 and 10x10 cm^2 (Figure 5) shows that a large difference is at 0mm for both field sizes (7%) and that attribute to the water equivalent depth (WED of MO*Skin* is 0.07 mm while WED of advanced Markus 0 mm after applying over response correction factor).



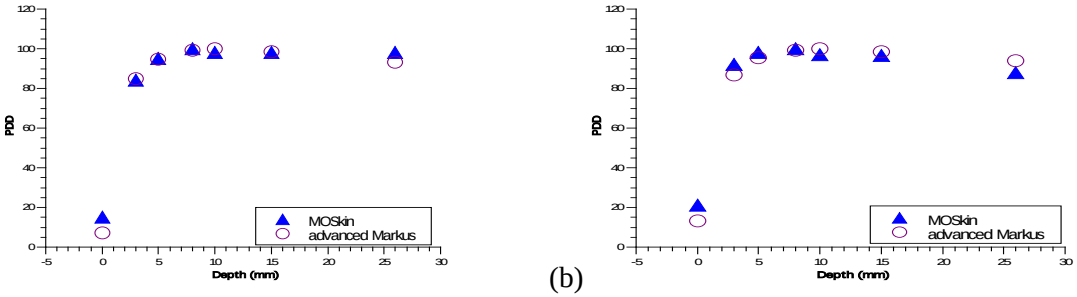
(a) (b)

Figure 3. Build up region for solid water vs eXaSkin by using advanced Markus chamber for a) 5x5 cm^2 and b) 10x10 cm^2.



(a) (b)

Figure 4. Build up region for solid water vs eXaSkin by using MO*Skin* dosimeter for a) 5x5 cm^2 and b) 10x10 cm^2.

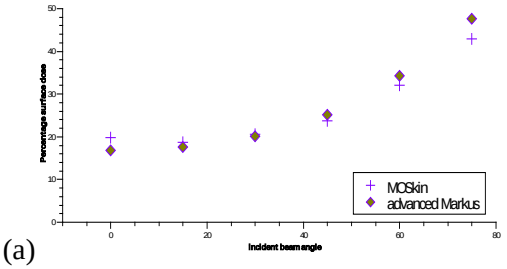


(a) (b)

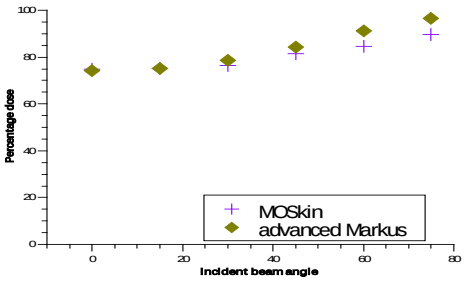
Figure 5. Comparing the PDD of eXaSkin in the build-up region between advanced Markus measurements and MOSkin dosimeter for a) 5x5 cm^2 and b) 10x10 cm^2.

3.2 oblique incident beam

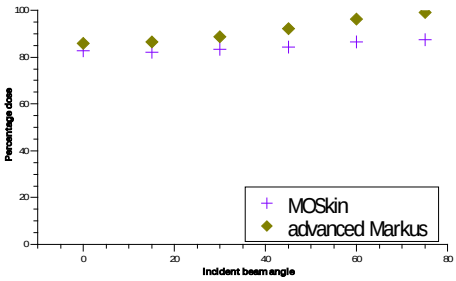
Figure 6a demonstrates the alteration of the percentage surface dose with oblique incident beam effect for 6MV, 100SSD and 10x10 cm^2 field size. Advanced Markus uncorrected measurements and MO*Skin* are used. Percentage dose increases when incident beam angle increases because the charge particle equilibrium CPE shifts near the surface and that agree with Jong [8] measurements. The measurements of percentage dose with 3mm of eXaSkin are the highest as in (figure 6c) when compared it with the percentage dose at 3 mm solid water (figure 6b) and at surface (figure 6a). The large difference in measurements between advanced Markus chamber and MO*Skin* with 3mm eXaSkin is -11% at 75º that attribute the eXaSkin bolus not covered the entire irradiated surface.



(a)



(b)



(c)

Figure 6. Percentage dose for the oblique incident beam by using advanced Markus chamber and MO*Skin* dosimeter a) at surface b) at 3mm solid water and c) at 3mm eXaSkin.

4. Conclusion

Skin dose assessment with eXaSkin bolus is essential to ensure deliver dose to the tumors near surface without producing excessive skin reaction. The new bolus exhibits high dose at depths 2-10 mm compared with solid water. It also exhibits high dose with different angle incident beams. This bolus is a viable option to treat the tumours near the surface.

5. Acknowledgments

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6. References

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