TECHNICAL NOTE

Variations in skin dose using 6MV or 18MV x-ray beams

P. K. N.Yu[1], T. Cheung[1], M. J. Butson[1,2]

[1]*City University of Hong Kong, Dept. of Physics and Materials Science, Kowloon Tong, Hong Kong*
[2]*Illawarra Cancer Care Centre, Dept. of Medical Physics, Crown St, Wollongong, N.S.W*

Abstract

This research aimed to quantitatively evaluate the differences in percentage dose of maximum for 6MV and 18MV x-ray beams within the first 1cm of interactions. Thus provide quantitative information regarding the basal, dermal and subcutaneous dose differences achievable with these two types of high-energy x-ray beams. Percentage dose of maximum build up curves are measured for most clinical field sizes using 6MV and 18MV x-ray beams. Calculations are performed to produce quantitative results highlighting the percentage dose of maximum differences delivered to various depths within the skin and subcutaneous tissue region by these two beams. Results have shown that basal cell layer doses are not significantly different for 6MV and 18MV x-ray beams. At depths beyond the surface and basal cell layer there is a measurable and significant difference in delivered dose. This variation increases to 20% of maximum and 22% of maximum at 1mm and 1cm depths respectively. The percentage variations are larger for smaller field sizes where the photon in phantom component of the delivered dose is the most significant contributor to dose. By producing graphs or tables of % dose differences in the build up region we can provide quantitative information to the oncologist for consideration (if skin and subcutaneous tissue doses are of importance) during the beam energy selection process for treatment.

Key words build up, photon beams , skin dose

Introduction

When cancer patients are treated with radiation therapy, various skin reactions have been noticed. Early stage effects include Erythema and in some cases desquamation[1]. Occasionally late effects such as Telangiectasia may occur. Fibrosis can occur if the subcutaneous tissue dose is too high. Low skin dose is normally not the treatment aim, however when doses to these regions are greater than tolerance level for individual patients, the amount of skin dose should be taken into account within the treatment criteria. Both 6MV and 18MV x-ray beams are used extensively in radiotherapy with the higher energy beams being more penetrating. Dose in the build up region from both beams is contributed to by photon in-phantom scatter and by electron contamination, or electrons produced outside of the phantom/patient in question[2-5]. This note examines the differences in percentage dose delivered within the first 1cm of tissue, ie. the skin and subcutaneous tissue, from these two types of beams. Specifically, results are quoted at 3 depths of interest. These being:- 0.07mm, which represents the lower depth of the basal cell layer[6], 1mm which represents the lower depth of the dermal layer and 1cm depth which represent a position within the subcutaneous tissue.

Corresponding author: M. Butson, Department of Medical Physics, P.O Box 1798, Wollongong 2500, N.S.W Australia Fax: 61 2 42265397, Email: butsonm@iahs.nsw.gov.au
Received: 13 August 2002; Accepted: 28 May 2003

Materials and methods

Measurements were performed with a Varian 2100C medical linear accelerator at 6MV and 18MV peak x-ray energies. Photon beam measurements were made using an Attix Model 449 parallel plate ionization chamber[7] in a solid water[8] stack phantom. The Attix chamber is specifically designed for surface and build up dose measurements and results have shown that less than 1% error in measured ionization is recorded with this chamber[7]. The chamber was connected via a triaxial cable to a Keithley model 2540 electrometer with 300V bias voltage applied. Percentage dose build up curves were measured on the central axis for various beam configurations from the surface to depths of 40mm. Measurements were performed with radiotherapy field sizes of 5cm x 5cm up to 40cm x 40cm and a 100cm SSD. It is acknowledged that surface

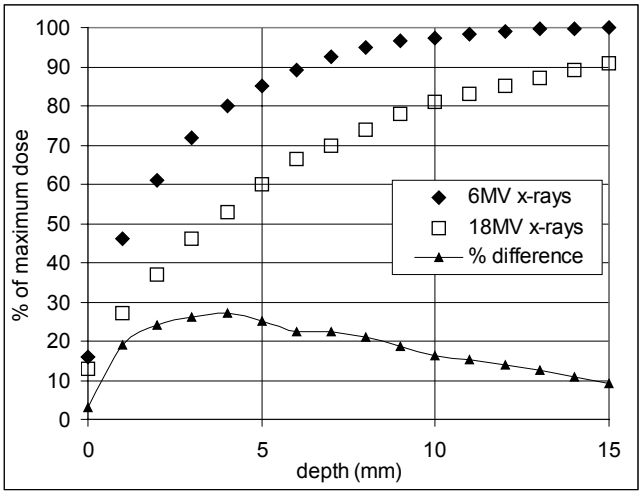
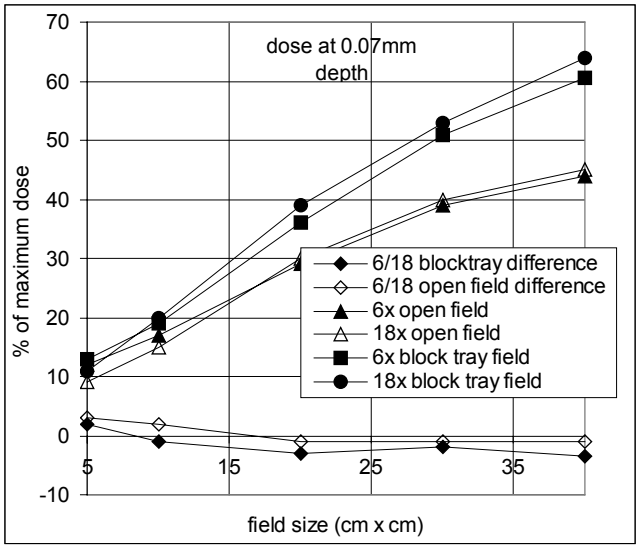


Figure 1. *Percentage build up doses and percentage dose differences between a 10cm x 10cm x-ray field at 6MV and 18MV energy.*

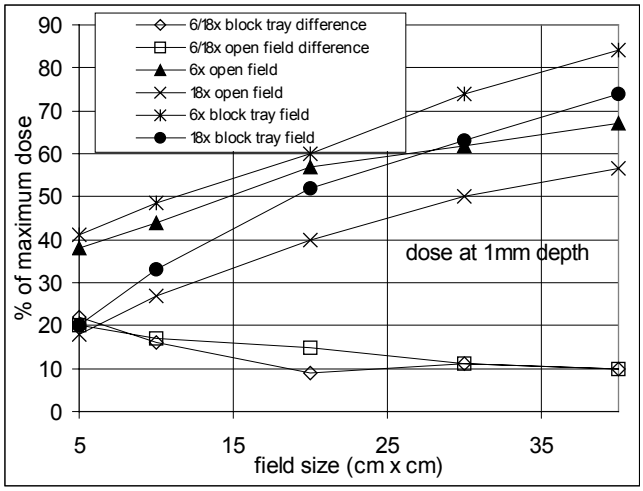
and build up doses will vary with SSD for both energies but to highlight differences between the two energies a specific standard SSD was chosen for analysis. The effects of a 6mm thick Perspex block tray were investigated at both energies. This type of tray is clinically used at our centre for non-MLC machine treatments.

Results and discussion

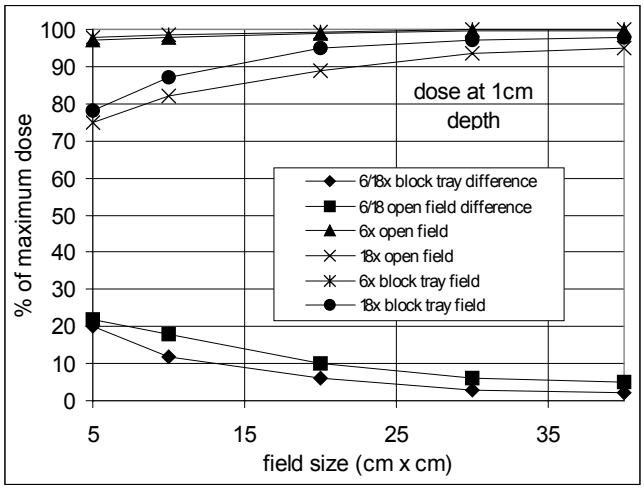
Figure 1 shows the measured build up dose curves for a 10cm x 10cm field at 6MV and 18MV energies. The position of maximum dose for a 6MV x-ray beam was measured at 15mm in this beam configuration and at 33mm for the 18MV beam. Also shown on the curve is the percentage dose difference between the two beams within the first 15mm of media traversed. The surface dose for the two beams is 16% and 13% for 6MV and 18MV respectively. Larger variations in dose between the two curves are seen beyond the surface. The largest variations are seen between the depths of 2mm and 5mm. Contributions to absorbed dose in the build up region come from two sources. 1. photon in-phantom scatter and 2. electron contamination. From previous studies at 6MV energy, it has been shown that electron contamination is the predominant dose depositor at the surface and beyond this region, phantom scatter takes over[9]. To expand the differences seen in dose between 6MV x-ray and 18MV x-ray beams figures 2a,b and c have been created. Results show the percentage dose of maximum produced by the 6MV and 18MV x-ray beams as a function of field size at the chosen depths of 0.07mm, 1mm and 1cm. Both open and block tray fields are shown. The block trays are used to place lead blocks on for the shielding of critical structures when a non-MLC machine is used. Also shown on the figures is the percentage of maximum dose difference between the two beams for all field sizes. Figure 2a



(a)



(b)



(c)

Figure 2. *Percentage dose of maximum as a function of field size for 6MV and 18MV x-ray beams and percentage dose of maximum variations between the two beams at a) 0.07mm depth (Basal) b) 1mm depth (Dermal) c) 1cm depth (Subcutaneous).*

highlights the closeness of percentage dose delivered to the area of the basal cell layer near the surface. The largest variation between the two beam energies is 4% over all field sizes. This is of importances if a beam energy is selected to maximize or minimize dose to the basal cell layer. As both beams produce similar results, neither have an advantage in skin sparing for the basal cell layer area for entry dose delivery. However, if exit dose from a parallel-opposed beam is taken into account, the 18MV beam would produce a higher total basal layer dose due to the increased penetration of the beam delivering more dose to the exit side. Figure 2b shows results at 1mm depth which we have chosen as it represents a depth at the lower end of the dermal layer depth. At this depth, there are contributions to dose from electron contamination and photon scatter. There are large variations at this depth in deposited dose between 6MV and 18MV x-ray beams. For example, at 5cm x 5cm, there is more than 20% difference ranging down to 10% difference at 40cm x 40cm. The 6MV x-ray beam giving the higher dose. This is due to the higher contribution to dose from in-phantom scatter at the lower energy where the photon "build up" effect is larger for lower energies. At 1cm depth within the subcutaneous tissue, there is a large difference between delivered doses for smaller field sizes, eg 22% at 5cm x 5cm. The differences reduce for larger field sizes with a 40cm x 40cm field only producing approximately 2%-5% difference at 1cm depth in dose between the 6MV and 18MV beams.

When clinically assessing the use of an x-ray beam for treatment, the depth of the tumour and penetration of the beam required are taken into account. The data supplied above would also provide further information if the dose to the skin or subcutaneous tissue needed to be considered and may effect the choice of energy used. Most radiotherapy centers should have existing data for percentage build up dose produced by their linear accelerators at different beam energies. By creating tables or graphs from this data, quantitatively differences in skin and subcutaneous doses deliverable for each linear accelerator machine can be seen.

Conclusion

Both 6MV and 18MV x-ray beams produce similar dose deposition at the surface and at the basal cell layer depths for entry beams at all field sizes. As the depth increases, the 6MV beam does deliver higher doses with 10%-22% of maximum variations at 1mm depth and 2%-22% variation at 1cm depth. By measuring build up doses and producing either curves or tables highlighting the differences in dose delivered to these regions, we can easily supply more accurate quantitative information to the oncologist on the radiation doses delivered to the skin and subcutaneous tissue in radiotherapy by various beam types.

Acknowledgements

This work has been fully supported by a grant from the Research Grants Council of HKSAR, China (Project No. CityU 1051/02P).

References

1. Turesson, I., Thames, H. D., *Repair capacity and kinetics of human skin during fractionated radiotherapy: erythema, desquamation, and telangiectasia after 3 and 5 year's follow-up,* Radiother Oncol, 15: 169-88, 1989.
2. Hounsell, A. R., Wilkinson, J. M., *Electron contamination and build-up doses in conformal radiotherapy fields,* Phys Med Biol 44: 43-55, 1999.
3. Beauvais, H., Bridier, A., Dutreix, A., *Characteristics of contamination electrons in high energy photon beams*, Radiother Oncol 29: 308-16, 1993.
4. Nilsson, B. *Electron contamination from different materials in high energy photon beams*, Phys Med Biol 30: 139-51, 1985.
5. Hannallah, D., Zhu, T. C., Bjarngard, B. E., *Electron disequilibrium in high-energy x-ray beams*, Med Phys 23: 1867-71, 1996.
6. Williams, P., Warwick, R., Dyson, M., Bannister, L., *Gray's Anatomy 37th edition* Churchill Livingston London, 1989.
7. Rawlinson, J.A., Arlen, D., Newcombe, D., *Design of parallel plate ion chambers for build up measurements in megavoltage photon beams*, Med Phys 19: 641-8, 1992.
8. Constantinou, C., Attix, F. H., Paliwal, B. R., *A solid water phantom material for radiotherapy X-ray and gamma ray beam ray calculations* , Med. Phys. 9: 436-441, 1982.
9. Butson, M.J., Perez, M. D., Mathur, J. N., Metcalfe, P. E., *6MV x-ray dose in the build up region: empirical model and the incident angle effect*, Australas Phys Eng Sci Med 19: 74-82, 1996.