World Congress on Medical Physics
& Biomedical Engineering
June 3–8, 2018, Prague, Czech Republic, www.iupesm2018.org

IUPESM
PRAGUE 2018

Abstract ID 535
Optically stimulated luminescence dosimeters as an alternative to radiographic film for performing “head-wrap” linac leakage measurements

Tanya Kairn[1,2], Holly Stephens[3,4], Scott Crowe[1,2], Samuel Peet[1,2]
1. Royal Brisbane and Women's Hospital, Brisbane, Australia
2. Queensland University of Technology, Brisbane, Australia
3. Genesis Cancer Care Queensland, Genesis Care, Brisbane, Australia
4. University of Adelaide, Adelaide, Australia
t.kairn@gmail.com

Aims & objectives

The head-wrap measurement:

- An important part of the process of accepting and commissioning each new (or modified) medical linear accelerator (linac)
- Involves running the most penetrating photon beam with radio-sensitive (usually silver halide radiographic) film covering the radiation emitting parts of a the linac, in order to produce film darkening in regions of elevated radiation leakage [1, 2]
- Produces qualitative results that allow ionisation chamber measurements to be localised in regions of maximum leakage, to verify the linac's compliance with international limits [1] and ensure that minimal out-of-field dose is delivered to radiotherapy patients

Aims & objectives

Use of electronic patient imaging techniques have led to radiographic film declining in use, decreasing in availability and increasing in cost [3, 4].

A simple, reusable, non-chemical solution for performing linac head wrap measurements is needed.

Can we reliably use discrete dose points measured using optically stimulated luminescence dosimeters (OSLDs) to detect regions of increased leakage radiation, as a substitute for radiographic film?

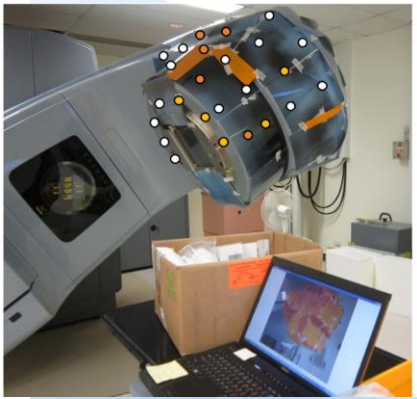
Materials and methods

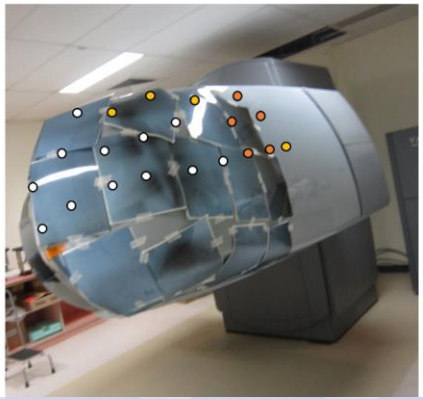
60 OSLDs (Landauer nanoDot) were positioned at regular intervals over the linac head by a member of the research team who was unfamiliar with the usual patterns of linac leakage as well as the specific leakage pattern of the linac under investigation.

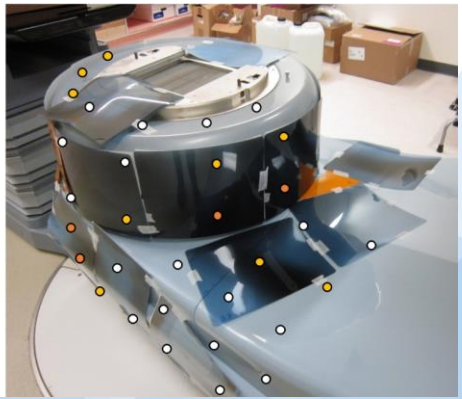
OSLDs were irradiated using 20,000 MU from the Varian iX linac, with all jaws and collimators closed (the same collimator arrangement and number of MU that would be used for a radiographic film head wrap).

Results & discussion

The OSLD measurements were able to detect linac head leakage and quantify high and low doses (from 0.6 to 44.7 cGy per 10,000 MU) with sufficient geometric precision to guide the use of an ionization chamber to measure doses in the patient plane and around the waveguide.







White = < 5 cGy/10,000 MU

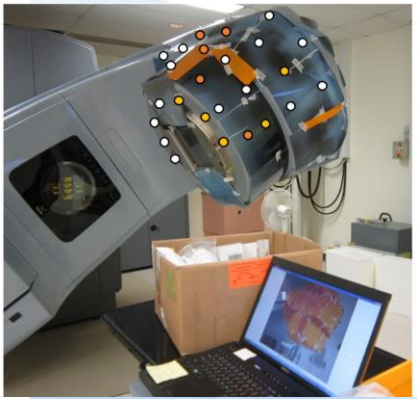
Yellow = 5 to 10 cGy/10,000 MU

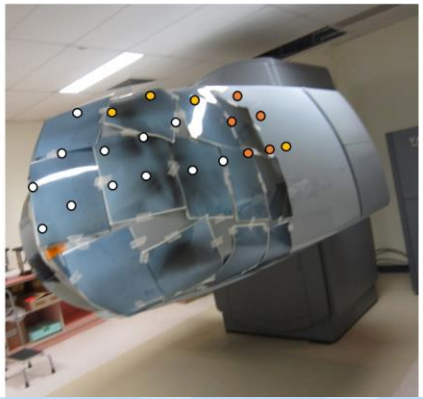
Orange = > 10 cGy/10,000 MU.

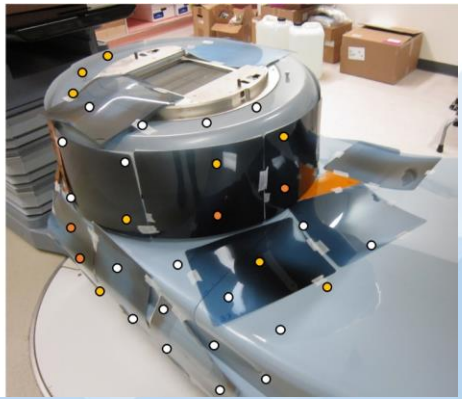
Results & discussion

Highest leakage doses were found in regions:

- Around the sides of the secondary collimators
- Lateral to the bending magnet, target, primary collimator and flattening filter, and
- At the edges of the shielding above the accelerating waveguide.







White = < 5 cGy/10,000 MU

Yellow = 5 to 10 cGy/10,000 MU

Orange = > 10 cGy/10,000 MU.

Results & discussion

It may be desirable to replace the use of radiographic film with newer types of self-developing radiographic film, which have a growing role in radiotherapy departments [3]. However, while radiochromic film is sensitive enough to detect and measure low doses of radiation after appropriate scanning and analysis [5], up to five times as many MU need to be delivered to produce a response visible to the human eye, when using radiochromic film rather than radiographic film [6]. Additionally, the relatively small size and large expense of currently available radiochromic film sheets mean they are better suited to performing spot checks in regions of concern, than to measuring dose around the whole linac head.

Results & discussion

Film measurements (rather than discrete point dose measurements such as those used in this work) are recommended for head wraps [1], to eliminate the possibility of missing or misplaced internal shielding or gross errors in electron beam steering [2], because discrete measurements at selected points will not necessarily detect a small area of high leakage" [2]. The results reported in this work suggest that OSLD point dose measurements are able to detect even the small regions of elevated leakage that exist around a well-shielded and appropriately-steered linac. However, the risk of failing to detect a small but intense source of leakage radiation during a head wrap conducted using OSLDs alone should be minimised, by using the largest possible number of OSLDs, positioned as closely together as is practical, or by repeating the test using several different sets of measurement points.

Conclusion

Reusable point dosimeters such as OSLDs are a promising solution to the problem of diminishing availability (and increasing expense) of film stock for linac head-wrap tests

Some reservations:

- Need to carefully calibrate and correct for response to scattered out-of-field radiation
- Need to minimise the risk of failing to detect small regions of high leakage by using as many measurement points as possible
- Need to remember that the use of radiographic film for this purpose is still widely recommended (including by the IEC) and the use of a discrete dosimeter must be justified

References

1. International Electrotechnical Commission.: Medical electrical equipment - Part 2-1: Particular requirements for the basic safety and essential performance of electron accelerators in the range 1 MeV to 50 MeV. 3rd edition. International standard, IEC 60601-2-1 (2009)
2. Cramb, J.: Radiation Protection in External Beam Radiotherapy. In: Trapp, J., Kron, T. (eds.) *An Introduction to Radiation Protection in Medicine*. pp. 171-203. Taylor & Francis, New York (2008)
3. Das, I.J.: Introduction. In: Das, I.J. (ed.) *Radiochromic Film: Role and Applications in Radiation Dosimetry*. pp. 22-25. CRC Press, New York (2017)
4. Kairn, T.: Intensity-modulated radiotherapy and volumetric-modulated arc therapy. In: Das, I.J. (ed.) *Radiochromic Film: Role and Applications in Radiation Dosimetry*. pp. 194-227. CRC Press, New York (2017)
5. Aland, T., Moylan, R., Kairn, T., Trapp, J.: Effect of verification imaging on in vivo dosimetry results using Gafchromic EBT3 film. Phys. Medica. 32(11), 1461-1465 (2016).
6. Butson, M.J., Peter, K.N., Cheung, T. and Metcalfe, P.: High sensitivity radiochromic film dose comparisons. Phys. Med. Biol. 47(22), N291-N195 (2002).

Conflict of interest

The authors declare that they have no conflict of interest.