

Assessment of the efficacy of Proguard RR-2 radio-protective gloves during forearm manipulation

P.R. Calder^{a,*}, T.D. Tennent^b, P.W. Allen^c

^a Royal London Hospital, Whitechapel, London, UK

^b Royal National Hospital, Stanmore, Middlesex, UK

^c Princess Alexandra Hospital, Harlow, Essex, UK

Accepted 6 December 2001

Abstract

The hazards of ionising radiation are well known and precautions, such as lead aprons and thyroid shields are routinely used. Orthopaedic surgeon's hands are at particular risk from direct and scatter radiation, when manipulating forearm fractures, due to the proximity of the image intensifier. The use of lead gloves has been recommended in the literature but are seldom employed. Proguard RR-2 gloves provide similar tactile sensitivity to double gloves and are claimed by the manufacturer to provide up to 55% protection in vitro at a direct beam energy level of 60 kV. This claim was tested in a clinical setting. **The gloves were worn during forearm manipulations and the radiation dose measured using thermoluminescent dosimeters (TLDs). The results demonstrated a radiation attenuation of 60–64%.**

These gloves appear to achieve a good compromise between protection and sensitivity and should be included in routine protection against ionising radiation during MUA.

© 2003 Elsevier Science Ltd. All rights reserved.

1. Introduction

The image intensifier is an essential tool in the trauma orthopaedic surgeon's trade. The danger from radiation exposure is well appreciated and measures have been employed to reduce excessive radiation doses to the surgeon's body.

It is common practice to wear lead aprons during fluoroscopy and many surgeons use thyroid shields and lead protective glasses routinely. During the manipulation of forearm fractures the surgeon's hands are at risk from ionising radiation both directly from the primary beam and indirectly via scatter radiation deflected from the patient. Lead gloves are not, however, routinely used by orthopaedic surgeons. The Proguard RR-2 radiation reducing gloves (Cook (UK) Ltd., Monroe House, Letchworth, Hertfordshire) have been developed to allow dexterity, comfort and tactile sensitivity.

The aim of this study was to evaluate both radiation exposure to the surgeon's hands, during forearm manipulation and radiation attenuation provided by the Proguard RR-2 gloves in a clinical setting.

2. Materials and methods

The Proguard RR-2 gloves are manufactured using a combination of lead, bismuth, tungsten and tin. They are 0.012–0.2 mm thick and come in a range of sizes (6.0–9.0 in half sizes). The gloves are packed sterile, may be reused and retail at £30.00 per pair. Following in vitro studies, Cook (UK) Ltd. claim 55% radiation reduction from a direct beam energy value of 60 kV.

During two 6-week periods the same surgeon (PC) manipulated consecutive forearm fractures wearing the Proguard RR-2 gloves. The surgeon was right handed. The first period was at the Princess Alexandra Hospital (PAH), Harlow, Essex and the second at Whipps Cross Hospital (WCH), London. In both hospitals, the image intensifiers used varied between a Siemens Siremobile and a Phillips BV25. The kV and mA were recorded following each procedure.

Thermoluminescent dosimeter (TLD) sensors were attached to the distal phalanges of both index fingers of the surgeon. One set of sensors were attached under the gloves on the skin and a second set were attached superficial to the glove, slightly offset so not to impede the X-ray beam (Fig. 1). When not in use the TLDs were stored in an envelope with a fifth TLD attached in order to measure background radiation.

* Corresponding author. Present address: 92 Sketty Road, Enfield EN1 3SF, UK.

E-mail address: peterandsam@calderp.freeseve.co.uk (P.R. Calder).

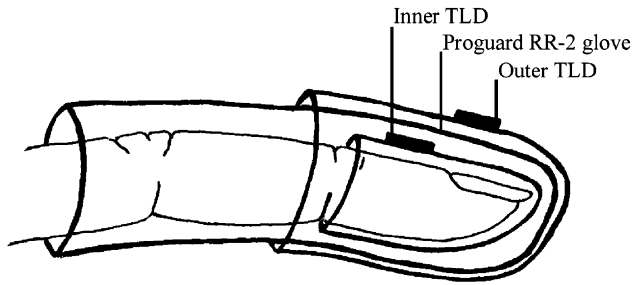


Fig. 1. Arrangement of the TLD and Proguard RR-2 gloves during testing.

Fracture reduction was confirmed using the image intensifier. During fluoroscopy the forearm was held in position shown in Fig. 2. The image was coned down whenever possible to reduce the risk of the surgeon's hands entering the primary beam. The cumulative radiation dose both to the surgeon's hands and attenuation provided by the gloves was calculated following each 6-week period.

The number of forearm manipulations performed per surgeon per year at both PAH and WCH were obtained from the theatre logbooks.

Statistical analysis was performed using the Student's *t*-test.

3. Results

Twenty forearm fractures were manipulated over the two study periods. Eight cases were performed at PAH and 12 cases at WCH. The surgeon reported no subjective difficulty, during the procedures, whilst wearing the gloves.

In study period 1 (PAH), the mean kV was 58 (50–80) and mA 0.8875 (0.3–5.0). In study period 2 (WCH), the mean kV was 52 (45–70) and mA 0.625 (0.3–2.7). There was no statistical difference between the two groups.

Table 1

Doses and percentage attenuation for Proguard RR-2 gloves during MUA

	Right hand	Left hand
Outside glove	0.464 mSv	0.181 mSv
Inside glove	0.184 mSv	0.066 mSv
Attenuation of glove	60%	64%

In the corresponding 12-month period, 11 surgeons performed 95 forearm manipulations at PAH (mean 8.6 cases per surgeon per year) and 13 surgeons performed 154 forearm manipulations at WCH (mean 11.8 cases per surgeon per year).

The cumulative radiation dose for both study periods and attenuation provided by the radio-protective gloves is shown in Table 1.

4. Discussion

The effect of radiation to the hands of orthopaedic surgeons has been dramatically shown in the literature [1,2]. The total radiation dose required to cause malignant change is, however, unknown. The aim should, therefore, be to ensure minimum exposure to ionisation radiation. Hynes et al. [3] proposed recommendations to reduce ionising radiation with reference to whole body radiation. These include assessment of staff doses, the use of up-to-date X-ray equipment, which undergoes regular quality assurance and maintenance and staff training in order to protect the patient from unnecessary radiation and also to minimise the dose to staff.

When using an image intensifier a surgeon's hands can be exposed both directly from the primary X-ray beam and secondly from scattered radiation reflected from the patient. The scattered radiation dose is determined by the distance from the source [4] and increases as the area irradiated increases. Arnstein et al. [1] showed the dose to the surgeon's



Fig. 2. Position of the surgeon's hands in relation to the image intensifier during forearm manipulation.

hands in the primary beam was 100 times that measured at 15 cm from the source. They, therefore, recommended coning down of the image, removal of the antiscatter grid, avoidance of the primary beam and the use of a remote-positioning device. Barry [5] expected the surgeon's hands to have the highest exposure due to the close proximity of the operative field. Miller et al. [6] indicated that the head, neck and hands were at greatest risk to radiation and reported surgical gloves that should block 15–25% of radiation dosage. Noordeen et al. [7] recommended the control of the image intensifier by the operating surgeon using a foot pedal, this significantly reduced radiation doses. They also advised the usage of lead gloves but did not study their benefits.

Despite the literature radio-protective gloves are still seldom used in routine manipulation procedures. Lead gauntlets are cumbersome, offer poor tactile feedback, are a single size and felt by most surgeons to be uncomfortable. These problems have been addressed in the form of the Proguard RR-2 gloves. The gloves are packed sterile which also allows use in various operative scenarios.

This study demonstrates minimal radiation exposure to the surgeon's hands during forearm manipulation. This is based on the surgeon performing an average number of procedures per annum and is consistent with previous studies [8]. The Ionising Radiation Regulations [9] apply a dose limit of 500 mSv for the hands, forearms, feet and ankles in one calendar year. This is evidently an order of magnitude higher than that measured in this study. We accept that there was a small sample size and that procedures that involve higher doses of radiation, such as intramedullary nailing [10,11], were excluded from the study. The results, however, do show a radiation attenuation of 60–64% to scatter radiation and limitation of radiation exposure remains the priority.

In conclusion, irrespective of the small radiation doses involved in forearm manipulations every effort should be made to ensure a minimum radiation dose to the surgeon. We recommend the avoidance of the surgeons hands entering

the beam directly, coning down to minimise the amount of radiation dose, allowing maximum distance of the surgeons hands from the source and the use of radio-protective gloves. The use of Proguard RR-2 gloves has been shown to reduce the surgeon's hands to scatter radiation exposure.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References

- [1] Arnstein PM, Richards AM, Putney R. The risk from radiation exposure during operative X-ray screening in hand surgery. *J Hand Surg* 1994;19B:393–6.
- [2] Epelde F, Vives P. *Minerva*. *BMJ* 2000;321:250.
- [3] Hynes DE, Conere T, Mee MB, Cashman WF. Ionising radiation and the orthopaedic surgeon. *Br J Bone Joint Surg* 1992;74B:332–4.
- [4] Alonso JA, Shaw DL, Maxwell A, McGill GP, Hart GC. Scattered radiation during fixation of hip fractures. Is distance alone enough protection? *Br J Bone Joint Surg* 2001;83B:815–8.
- [5] Barry TP. Radiation exposure to an orthopaedic surgeon. *Clin Orthop* 1983;182:160–4.
- [6] Miller ME, Davis ML, MacClean CR, Davis JG, Smith BL, Humphries JR. Radiation exposure and associated risks to operating-room personnel during use of fluoroscopic guidance for selected orthopaedic surgical procedures. *J Bone Joint Surg A* 1983;65A:1–4.
- [7] Noordeen MHH, Shergill N, Twyman RS, Cobb JP, Briggs T. Hazard of ionising radiation to trauma surgeons: reducing the risk. *Injury* 1993;24:562–4.
- [8] Goldstone KE, Wright IH, Cohen B. Radiation exposure to the hands of orthopaedic surgeons during procedures under fluoroscopic X-ray control. *Br J Radiol* 1993;66:899–901.
- [9] Ionising Radiations Regulations 1999, SI 1999/3232. Stationery Office, 2000.
- [10] Sanders R, Koval KJ, Dipasquale T, Schmelling G, Stenzler S, Ross E. Exposure of the orthopaedic surgeon to radiation. *Am J Bone Joint Surg* 1993;75A:326–30.
- [11] Muller LP, Suffner J, Wenda K, Mohr W, Rommens PM. Radiation exposure to the hands and the thyroid of the surgeon during intramedullary nailing. *Injury* 1998;29:461–8.