



Radiation exposure of the hands and thyroid gland during percutaneous wiring of wrist and hand procedures

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The aim of this study was to investigate the radiation exposure of the hands and thyroid glands of orthopaedic surgeon and assistant during procedures involving percutaneous wiring of the hand and wrist. The radiation dose to the hand and thyroid glands was prospectively studied from a total of 30 percutaneous hand and wrist procedures. Four thermoluminescent dosimeters were used to measure the radiation exposure. Cases were divided depending on fracture location (i.e. wrist, metacarpal, phalangeal) and surgical experience (i.e. Senior House Officer, Registrar, Consultant).

Mean radiation exposure in the hand for the surgeon was 0.80 mSv and 0.87 mSv for the assistant. There was a significant difference in the unshielded thyroid group compared to the shielded thyroid group ($p < 0.05$). The duration and number of exposure decreases with increasing experience. We also found a trend whereas we operate from proximal to distal (wrist to phalangeal), the total direct hand exposure increases.

Radiation exposure in the hands and thyroid glands during percutaneous wiring of hand and wrist procedures were within the recommended limit. However, for the junior orthopaedic trainee, the risk of over radiating oneself is higher as the duration and number of exposure increases. We recommended the use of thyroid shield and adherence to the ALARA principle in any fluoroscopic assisted procedures. Routine monitoring of radiation exposure is essential in preventing radiation related disease.

Keywords : radiation exposure ; wiring procedures ; hand ; wrist.

INTRODUCTION

The mobile fluoroscope or image intensifier is an invaluable tool in orthopaedic trauma surgery. Its use has increased with the development of minimal access surgical techniques (12).

The literature suggests that radiation exposure to the hands and thyroid glands of orthopaedic surgeons and their assistants fall within recommended yearly exposure doses in procedures such as intramedullary nailing and fracture manipulation (5, 10). Percutaneous wiring of wrist and hand procedures predispose the operating surgeons and the

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operative assistants to increased radiation exposure, due to proximity and direct hand exposure in the operative field. To our knowledge, there is no current published evidence reporting radiation exposure doses in hands and thyroid glands during these procedures. The aim of this study is to assess the radiation exposure doses in hands and thyroid glands of operative surgeons and the operative assistants during percutaneous wiring of wrist and hand procedures.

MATERIALS AND METHODS

Radiation dose to the hands and thyroid glands were prospectively studied. Four thermoluminescent dosimeters (TLD) were used to record the radiation exposure. Patients undergoing wrist and hand procedures were involved. There were 30 cases in total, which were evenly distributed into distal radius fracture (wrist) group, metacarpal fracture (metacarpal) group and the phalangeal fracture (phalangeal) group. Cases were further subdivided based on surgical experiences into SHO (senior house officer) group, registrar group and consultant group. Data was collected in a standardised format. Demographic data, operative notes and radiation data were examined.

The thyroid TLDs were worn over the thyroid shield in half of the cases and half of the cases under the shield. The hand TLDs were worn on the dorsal aspect of the dominant hand of both surgeons and the operative assistant.

The TLDs were sent for measurement after each 5 cases performed. The reading was performed by the Radiation Protection Institute of Ireland which also supplied the TLDs.

The mean radiation exposure dose for the each TLD was calculated and the results are presented in the tables and graphs.

RESULTS

The wrist group consists of 7 distal radius and ulnar styloid fractures and 3 with distal radius fractures only. The metacarpal group consists of five fractures of the 1st metacarpal base (Bennet's) ; two fractures of the 5th metacarpal base and 3 mid diaphyseal 5th metacarpal fractures. The phalangeal group consists of 5 proximal phalanx fractures, 3 middle phalanx and 2 distal phalanx fractures.

Table I. — Mean dose (mSv = milliSievert)) per procedure for hands and thyroid glands for surgeon and assistant

Operator	Mean Dose / case (mSv)	
Surgeon Hand	0.80	
Assistant Hand	0.87	
Surgeon Thyroid	0.21 Shielded	0.67 Unshielded
Assistant Thyroid	0.22 Shielded	0.69 Unshielded

The results from the TLDs showed a mean dose of 0.80 mSv (+/- 0.07 mSv) to the surgeon's hand and a mean of 0.87 mSv (+/- 0.05 mSv) to the operative assistant's hand. The thyroid gland TLDs showed a mean dose of 0.67 mSv (+/- 0.01 mSv) in the surgeon unshielded group and 0.69 mSv (+/- 0.01 mSv) in the assistant unshielded group, versus a mean dose of 0.21 mSv (+/- 0.01 mSv) in the surgeon shielded group and 0.22 mSv (+/- 0.01 mSv) in the assistant shielded group (table I). There is a significant difference in the mean dose in the thyroid gland TLDs comparing the shielded to the unshielded group (p value < 0.05).

The duration of exposure and total screening decreases with increasing experiences : in the SHO group, the mean duration of exposure and the total screening are 50% more than in the consultant group (figs 1, 2). Thus, the total dose of exposure was higher when junior surgeons were operating.

When we compare the data of each group, a trend emerges, where as we move from proximal to distal (wrist to phalanx), the total direct exposure increases (fig 3). Therefore, the phalangeal group had the most total direct exposure compared to the wrist group.

DISCUSSION

Percutaneous wrist and hand wiring procedures increased radiation exposure to orthopaedic surgeons and the operative assistants. This is due to the proximity and their position in the radiation field. Barry *et al* (3) suggest that hand exposure increases due to proximity to the operative field. Arnstein *et al* (1) performed a cadaveric study which showed that radiation exposure is 100 times

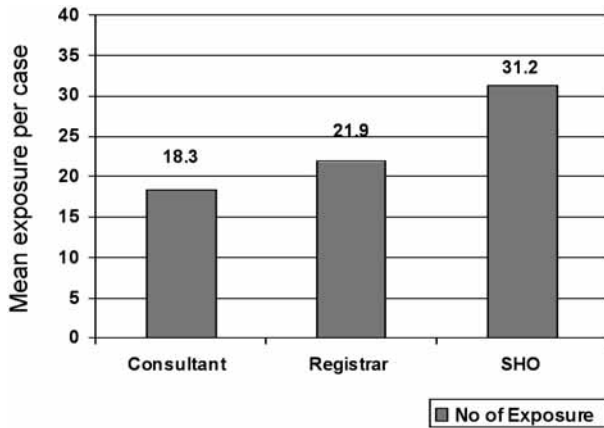


Fig. 1. — Mean exposure taken during procedure per case subdivided based on surgical experience.

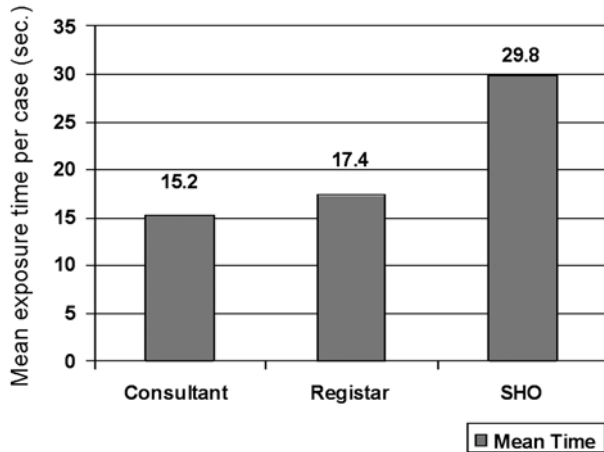


Fig. 2. — Mean duration of exposure during procedure per case subdivided based on their surgical experience.

greater at 15 cm from the radiation source compared to 30 cm. In other fluoroscopy assisted procedures, the operators can position themselves at a distance from the radiation source during screening but in these cases, the surgeons and the operative assistants have to maintain the fracture reduction and position during operating. Furthermore, maintaining reduction and position prior to wiring increases the risk of direct hand exposure in the radiation field.

From our result, the mean exposure dose to the hand is 0.80 mSv in the surgeons and 0.87 mSv in the assistant group. The difference is not statisti-

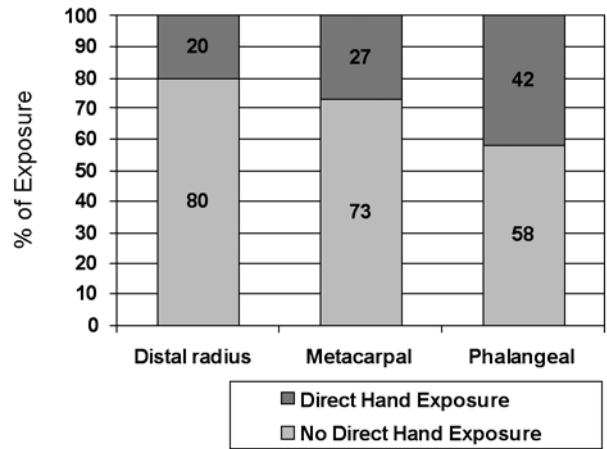


Fig. 3. — The percentage of direct hand exposure within each type of procedure from proximal to distal (wrist to phalangeal).

cally significant but the explanation for the higher mean dose in the assistant group is due to the assistant's role in maintaining the position and reduction during these procedures.

Extrapolating from these results, we calculated an average radiation exposure in the hand for the surgeons and the operative assistants for a full working year. Using the data from our own fracture database, an average of 100 hand and wrist procedures performed in a year would give an average exposure of 80 mSv for the surgeons and 87 mSv for the operative assistant. Although these figures are below the recommended yearly dose of exposure in the hand (8), we should bear in mind that these readings are only for percutaneous wiring of wrist and hand procedures. Muller *et al* (10) have shown an average of 1.23 mSv per procedure for radiation exposure in the hands for unreamed intramedullary nailing. Goldstone *et al* (7) investigated radiation exposure to the hands in various orthopaedic procedures and found a maximum dose of 5.7 mSv for dynamic hip screw. So, in a full working year performing various fluoroscopy assisted orthopaedic procedures, orthopaedic surgeons and the operative assistants are at risk of over radiating themselves if precautions are not taken to reduce the radiation exposure.

The radiation exposure to the thyroid glands was shown to be significantly reduced in the shielded

group compared to the unshielded group. The mean radiation exposure dose in the shielded group was 0.21 mSv in the surgeon group and 0.22 mSv in the assistant group compared to 0.67 mSv and 0.69 mSv respectively in the unshielded group. Currently in the literature, there is conflicting evidence with regard to thyroid gland exposure during orthopaedic procedures. Sanders *et al* (11) found no radiation exposure in the neck region without thyroid shield for the first surgeon in over 65 orthopaedic surgical procedures, while another study performed on anthropomorphic phantom models showed radiation exposure dose of 5.1, 21, and 250 mSv in hip, spine and kyphoplasty procedures, respectively (13). Results from other studies are ranging from a mean exposure dose of 0.28 mSv to 0.07 mSv from intramedullary nailing procedures (7, 9, 11). There is no previous data on radiation exposure in thyroid glands from percutaneous hand and wrist procedures in the literature. Comparing our results to other studies looking at radiation exposure during intramedullary nailing, we found that our shielded results are within the average radiation exposure per procedures. We know that the intramedullary nailing procedure would have higher radiation exposure than percutaneous wiring cases, but our result of radiation exposure may be due to the proximity and positioning of the surgeons in relations to the C – arm.

Previous studies investigating the relationship between experience level and radiation exposure showed that less experienced surgeons received higher radiation dose (4, 7). The results are reflected as well in our study where the SHO group have an increase in duration and number of exposures taken during these procedures. The risk of increased exposure in junior orthopaedic surgeons is of concern as they may take more exposure and longer duration in performing procedures during their training. We felt that information regarding radiation exposure and its effect should be made compulsory as part of the formal training received by trainee orthopaedic surgeons. Awareness and early recognition of potential harmful effects of radiation exposure may prevent any future radiation exposure related disease.

Direct exposure increases the radiation exposure by 100 fold (1). In our study, we found a trend emerging as we operated more distally from wrist to phalangeal, the direct hand exposure increases. The explanation for the increase is due to the need to maintain reduction and position during the procedure. The use of lead gloves has been shown to reduce the radiation exposure in the hands during forearm fracture manipulation (5), but their use in the percutaneous wiring procedure still needs further evaluation as the gloves may not have the necessary tactile feedback.

The Ionising Radiation Regulation recommends a dose limit of 500 mSv for hand and 300 mSv for thyroid gland for a year duration (8). Even though the results are much lower, one must bear in mind that with multiple exposure from orthopaedic procedures with varying difficulty, one is at risk of over exposing oneself if precautions are not taken to reduce the radiation exposure. The ALARA (8) (as low as reasonably possible) principles should be followed where the radiation source should be as remote as possible from the surgeons. Protective shielding is a must in procedures involving fluoroscopy (6), and trainee surgeons should be aware and well informed with regard to radiation exposure and its effects. Further precautions such as the use of a mini C-arm have shown a significant reduction in radiation exposure (2).

In conclusion, we recommend a radiation protection course as a prerequisite for orthopaedic trainees and protective shielding including thyroid shielding in all fluoroscopy assisted procedures, with routine radiation exposure measurement to monitor exposure.

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