The effect of surgical experience on the amount of radiation exposure from fluoroscopy during dynamic hip screw fixation

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ABSTRACT

INTRODUCTION Dynamic hip screw (DHS) fixation for proximal femur fractures is one of the most common procedures in trauma that requires the use of fluoroscopy. Emphasis is often placed on producing the 'perfect picture', which may lead to excessive use of fluoroscopy, without added patient benefit. This study, the largest of its kind, aimed to determine the effect of surgical experience on the amount of radiation exposure from fluoroscopy during DHS fixation.

METHODS All hospital admissions for extracapsular proximal femur fractures to our institution between 2007 and 2012 were analysed. Patient demographics, fracture configuration, grade of surgeon and the total radiation dose after fixation were recorded. Analysis of variance was performed to assess differences in radiation levels between different grades of surgeon.

RESULTS A total of 1,203 patients with a mean age of 81.3 years (range: 21–105 years) were included in the study. The majority of the fractures were three-part (33.3%), followed by two-part (32.2%), four-part (25.7%) and basicervical (8.9%). Registrars (ST3–ST8) used a significantly higher radiation dose than consultants for all fracture types ($p=0.009$). When analysed separately by trainee group, the most junior registrars (ST3–ST4) and the most senior registrars (ST7–ST8) were found to use significantly higher radiation levels than consultants ($p=0.037$ and $p<0.001$ respectively).

CONCLUSIONS The level of surgical experience does influence the amount of radiation exposure from fluoroscopy during DHS fixation. Surgical trainees should not ignore the potential harmful effects of radiation and should be equipped with the knowledge of how to keep the radiation exposure as low as possible.

KEYWORDS

Radiation – Fluoroscopy – Hip fracture – Dynamic hip screw – Surgical training – Education

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The use of intraoperative fluoroscopy for fracture fixation is a requirement in trauma and orthopaedic surgery. The orthopaedic surgeon and other theatre personnel are therefore at an increased risk to radiation exposure during fluoroscopy guided procedures that could lead to harmful side effects over time. It has been suggested that all radiation has a potential to cause harm, with a cumulative relationship existing between absorbed radiation and its side effects.¹ The other contrasting theory is that radiation has little or no hazardous effect below a threshold dose.^{2,3} Nevertheless, repeated use of low doses of radiation is still concerning as there is evidence to suggest that exposure to radiation over time is associated with an increased risk of adverse effects such as malignancies, ocular injuries and thyroid disorders.^{4–9}

It is the responsibility of the operating surgeon to minimise radiation exposure to patients by adopting the ALARA (as low as reasonably achievable) principle.⁵ Although this

same principle should be practised when it comes to our own protection, there seems to be a lack of awareness among surgical trainees.¹⁰ There have been only a few studies, involving low patient numbers, that have specifically investigated the effect of surgical experience on radiation exposure to the operating surgeon during proximal femur fracture fixation.^{11,12}

Dynamic hip screw (DHS) fixation for proximal femur fractures is one of the most common procedures in trauma that requires the use of intraoperative fluoroscopy. It is also one of the first few procedures that trainees are left to perform unsupervised. Emphasis is often placed on producing the 'perfect picture', which can lead to excessive use of fluoroscopy without any actual clinical benefit. The primary aim of this study was to determine the effect of surgical experience on the amount of radiation exposure from fluoroscopy during DHS fixation.

Methods

The study was approved by the local research and audit department. All hospital admissions for extracapsular proximal femur fractures to a major trauma centre between 2007 and 2012 were included. Patient demographics, fracture configuration, grade of operating surgeon and total radiation dose after DHS fixation were recorded. Owing to the change in training structure and terminology over the study period, surgeon grades were categorised as:

- > *Group 1:* Senior house officer (SHO)/clinical fellow, equivalent to foundation year 2, and core surgical trainee years 1–2
- > *Group 2:* Specialist registrar (SpR) years 1–2, equivalent to specialty trainee (ST) years 3–4
- > *Group 3:* SpR years 3–4, equivalent to ST years 5–6
- > *Group 4:* SpR years 5–6/trauma fellow, equivalent to ST years 7–8
- > *Group 5:* Consultant

All screening was performed using a mobile C-arm fluoroscopy unit (BV Libra; Philips, Eindhoven, Netherlands). The total filtration of the x-ray tube was 6.35mm, the focus-to-detector distance was 99.5cm and the diameter of the routinely used input field of view was 17cm. The dose of the patient was monitored and recorded in accordance with the *Ionising Radiation (Medical Exposure) Regulations 2000* by means of a dose area product meter that was permanently built into the x-ray tube housing.

Statistical analysis

The distribution of radiation levels was assessed using the Shapiro–Wilk test. Where recording of radiation levels was

not normally distributed between groups of surgeon grades, natural log transformation was applied. The relationship between radiation levels and grade of surgeon was examined using analysis of variance techniques. A two-tailed p -value of $p < 0.05$ was considered statistically significant. All analysis was performed using SPSS® version 21 (IBM, New York, US).

Results

Over the 5-year study period, 1,203 patients with a mean age of 81.3 years (range: 21–105 years) were admitted with an extracapsular proximal femur fracture. The majority of these fractures were three-part (33.3%), followed by two-part (32.2%), four-part (25.7%) and basicervical (8.9%) (Table 1).

The proportions of operations carried out by each group of surgeons are shown in Table 2. The mean natural log patient exposure to radiation varied between the groups of surgeon grades ($p = 0.084$) and was lowest for consultants (Table 2). There was a significantly increased level of radiation exposure to patients when assessments were made by trainees compared with consultants ($p = 0.009$). When analysed separately by trainee group, the most junior SpRs (group 2) and the most senior SpRs (group 4) were found to expose patients to radiation at significantly higher levels than consultants ($p = 0.037$ and $p < 0.001$ respectively).

The mean radiation exposure for the SHO/clinical fellow group was lower than for any of the SpR groups. This is likely to be due to the higher proportion of procedures performed on simple two-part and basicervical fractures (49% vs 39%). Furthermore, at our institution, all cases operated on by a SHO or clinical fellow would be under the direct supervision of either a consultant or senior SpR.

Table 1 Distribution of the study population by fracture type and grade of surgeon

	2007	2008	2009	2010	2011	2012	Total
Number of patients	50	227	270	257	245	154	1,203
Mean age in years	80.1 (SD: 9.6)	82.1 (SD: 11.0)	81.4 (SD: 12.1)	80.11 (SD: 13.5)	81.6 (SD: 10.4)	81.9 (SD: 10.2)	81.3 (range: 21–105)
<i>Fracture type</i>							
Basicervical	3	16	24	19	26	19	107
2-part	24	72	70	95	78	48	387
3-part	12	80	97	76	85	50	400
4-part	11	59	79	67	56	37	309
<i>Grade of surgeon</i>							
SHO/clinical fellow	9	45	73	44	59	28	258
SpR1–2	8	16	52	52	58	46	232
SpR3–4	15	53	13	49	32	17	179
SpR5–6/trauma fellow	12	93	106	74	64	44	393
Consultant	6	20	26	38	32	19	141

SD = standard deviation; SHO = senior house officer; SpR = specialist registrar

Table 2 Mean radiation dose per operation by grade of surgeon

Grade of surgeon	Patients operated on	Mean radiation dose
SHO/clinical fellow	258 (21.4%)	225cGycm ²
SpR1–2	232 (19.3%)	252cGycm ²
SpR3–4	179 (14.9%)	248cGycm ²
SpR5–6/trauma fellow	393 (32.7%)	262cGycm ²
Consultant	141 (11.7%)	217cGycm ²
Total	1,203 (100%)	245cGycm²

SHO = senior house officer; SpR = specialist registrar

Figure 1 For the lateral view, the C-arm should be positioned so that the femoral shaft, neck and head are in a straight line (bold lines).

Discussion

The results of our study indicate that surgical experience does affect the amount of radiation exposure from fluoroscopy during DHS fixation. The two key steps in DHS fixation are the reduction of the fracture, and obtaining a good position of the guidewire on both anteroposterior (AP) and lateral views. This is to ensure that the lag screw placement in the femoral head has a tip–apex distance of <25mm to reduce the risk of cut-out and subsequent failure of fixation.¹⁵ It is these two steps that often lead to the excessive use of fluoroscopy.

Reducing use of fluoroscopy

In our experience, reducing the fracture with more traction and internal rotation results initially in lower use of

fluoroscopy than starting by applying gentle increments. Once satisfactory reduction is obtained, both the translation of the start point on the lateral view and the angulation of the wire are important. The entry point on the AP image can be determined roughly by folding one corner of a piece of paper on to its opposite edge. This creates an angle of approximately 135° and can therefore be used as a guide for the level of the entry point of the guidewire in the lateral cortex of the femur, using the lesser trochanter as a landmark.¹⁴

When obtaining the lateral view, the C-arm should be positioned so that the femoral shaft, neck and head are in a straight line (Fig 1). This makes positioning the guidewire on the lateral view easier once a satisfactory entry point on the AP view is achieved, and often requires between 5° and 25° of rotation of the C-arm back towards the AP view from a flat position laterally.

If the translation of the lateral view needs to be corrected, it is key that the base of the angle guide is ‘walked’ anteriorly or posteriorly on the femoral shaft. This is achieved by ensuring that either the proximal two spikes or distal two spikes of the angle guide base are always in contact with the femur. This would allow a more controlled shift in the anterior and posterior direction but maintaining the entry point on the AP view at all times. The surgeon would then just have to drop or raise his or her hand to angle the guidewire in the same line as the intensifier and x-ray tube. We recommend the use of the above tips as, in our experience, they enable more efficient use of fluoroscopy.

Study limitations

Our study analysed the relationship between surgical experience and the effect it had on radiation exposure. There are, of course, other variables that may have had an effect on the amount of radiation exposure, such as the patient’s body mass index and seniority of the radiographer. As these are beyond our control in day-to-day clinical practice, it was felt that this was beyond the scope of our study. In addition, at our institution, all SHOs and inexperienced SpRs perform procedures under the supervision of a consultant. This could be a confounding factor in our data interpretation as the first surgeon was logged in our data analysis, independent of the presence or absence of a consultant. Nevertheless, given our large study population, these potential confounding factors should not significantly alter our current findings.

Comparison with the literature

The findings of our study are consistent with two smaller studies that have explored the influences on intraoperative radiation exposure.^{11,12} Botchu and Ravikumar analysed 60 patients with undisplaced intertrochanteric fractures and 60 with isolated lateral malleolar fractures without comminution who underwent fluoroscopically assisted fixation by the same approach and technique.¹¹ The authors broadly divided the hip and ankle groups depending on the operative experience of the operating surgeon (<3 years, 3–10 years and >10 years). They concluded that the experience of the operating surgeon is one of the most important factors

affecting screening time and radiation dose during femoral neck fracture fixation.

When Giannoudis *et al* examined the relationship between surgical experience and the radiation dose administered during fixation of extracapsular neck of femur fractures, they found that radiation levels were significantly higher for SHOs than for registrars.¹² The association between radiation dose and fracture configuration was also investigated. Four-part fractures required a higher radiation dose and screening time than two-part fractures. The two and three-part fractures performed by registrars were further analysed according to the experience of the radiographer. A significant inverse correlation was demonstrated between the experience of the radiographer and the dose of radiation administered. However, the findings of this study could have been skewed as there were only 10 cases performed by SHOs and 10 by consultants whereas there were 43 performed by registrars. To our knowledge, our study is the largest to date that has examined the effect of surgical experience on intraoperative radiation exposure.

The risk and prevalence of cancer in orthopaedic surgeons exposed to occupational radiation remains unclear.¹⁵ Mastrangelo *et al* found a significantly increased risk of tumours in orthopaedic surgeons who were exposed to occupational radiation.¹⁶ The authors reported a cancer incidence of 29% in the exposed orthopaedic group over a 24-year period. This was eight times higher than for the unexposed worker group, which was matched for age and sex. In another retrospective study, Chou *et al* demonstrated a prevalence of breast cancer in female orthopaedic surgeons that was 2.9 times higher than that in the general American female population.¹⁷

Zadeh and Briggs conducted a postal questionnaire study comparing a group of orthopaedic surgeons with obstetricians and gynaecologists.¹⁸ They found no clear association between occupational radiation exposure and increased risk of congenital abnormalities or childhood malignancies in orthopaedic surgeons' offspring. Given the inconclusive evidence currently available in the literature, the concern surrounding long-term exposure to low level radiation should not be ignored.

Radiation guidance

The International Commission on Radiological Protection (ICRP) is a recognised regulatory body that publishes recommendations on acceptable limits for annual radiation exposure.¹⁹ The maximum recommended occupational dose limit is 20mSv averaged over five years with no more than 50mSv in any one year. The ICRP also advocates three fundamental principles: justification, optimisation of protection and dose limitation. These principles should be given sufficient emphasis during surgical training to ensure that trainees are fully aware of the radiation risk and are economical with intraoperative fluoroscopy usage.

There are several factors that should be given consideration when using fluoroscopy in theatre. Scattered radiation from the patient is the main source of radiation for the

operating surgeon and theatre personnel during fluoroscopy. As the scatter dose rate is lower when standing further away from the patient, it is good practice to stand at a safe distance from the image intensifier and x-ray tube.

The scatter can also be reduced by placing the patient close to the image intensifier and far from the x-ray tube. The ICRP recommended configuration when using fluoroscopy is to have the intensifier above and the x-ray tube below the patient.¹⁹ The operating personnel should always stand on the intensifier side as this reduces the amount of radiation received by a tenth. The use of additional protective devices such as thyroid collars and goggles should be considered, especially when operating on larger patients as patient size increases the skin dose and scattered radiation.

Conclusions

This is the largest study to date on the effects of surgical experience on radiation exposure. While the findings of our study are intuitive, it has an important message that should not be ignored. Surgical trainees must be fully aware the potential harmful effects of radiation. Furthermore, they should be equipped with the knowledge of how to protect themselves adequately and keep the radiation exposure as low as possible.

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