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ORIGINAL STUDY

Risk of ionising radiation to trainee orthopaedic surgeons

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We undertook this study to determine the amount of scattered radiation received by the primary surgeon, assistant and patient during dynamic hip screw fixation for proximal femoral fractures. Data was collected from fifty patients. Five registrars were included as operating surgeon and four senior house officers as assistant surgeon. Radiation was monitored by thermo luminescent dosimeters placed on the surgeon and assistant .The approximate distance of surgeon and assistant from the operative site was measured. A dosimeter on the unaffected hip of patients measured the radiation to the patient. The results show that the surgeon's dominant hand receives the highest dose of radiation and radiation exposure is dependent on the experience of the operator. Our study concludes that exposure to radiation during this procedure is well below the toxic levels ; however greater awareness is needed for harmful effects of exposure to long term low dose radiation.

Keywords : ionising radiation ; trainees ; dynamic hip screw fixation.

INTRODUCTION

Ionising radiation is an integral part of our life. We are continuously exposed to gamma radiation such as cosmic radiation, radon in air and the radio isotopes in our food (*11*). The average background radiation in UK is 2.2 mSv, with regional averages ranging from 1.5 mSv to 7.5 mSv (*13*).

Fluoroscopy is an invaluable tool in orthopaedic surgery and its use has increased significantly over the last twenty-five years. It helps to reduce operative time, increases accuracy of surgery and reduces the size of the operative field[1] thus minimizing patient morbidity but the main disadvantage is radiation exposure. The key principle of the use of ionising radiation is to keep the dose to as low as reasonably achievable.

The purpose of our study was to determine the amount of scattered radiation received by the primary surgeon, first assistant and the patient during dynamic hip screw fixation for fractures of the proximal femur using fluoroscopy.

Most surgeons have less knowledge about radiation physics and its harmful effects. It is of paramount importance that the surgeons are not only aware of harmful effects of radiation but also having adequate knowledge to keep the radiation exposure as low as possible. In contrast to high-level exposure, the risks and long-term results of

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low-level exposure are relatively unknown and unclear. The main concerns are what exactly is considered low-level radiation and whether cumulative exposures produce any significant long-term changes (2) ; these questions remain unanswered to date.

Although the hands of the surgeon are very close to the primary beam, the amount of radiation received during a specific operative procedure is almost unknown and little information is available on the long-term effects of radiation on tissues of high sensitivity, such as the eyes or the thyroid gland.

MATERIALS AND METHODS

We carried out a prospective study of fifty patients who underwent dynamic hip screw fixation for fracture of the proximal femur. Five registrars were the operating surgeons and four SHOs were assistant surgeons for the procedure. The registrars were trainees from year one to three. Complicated cases requiring consultant involvement were excluded from this study. The amount of fluoroscopic screening time and total radiation exposure was noted. The same image intensifiers (3K Image Intensifier with image store memory facility, Siemens AG, Munich, Germany) were used in all the procedures. Radiographers operated the image intensifier, which is the standard practice in our institution. Standard fluoroscopic techniques were used in this study. The surgeon wore a lead apron with no thyroid shield or hand protection.

The measurements of hand, forehead and thyroid exposure were made using thin layer lithium fluoride thermo luminescent dosimeter chips (TLD 100H). These chips function on the basis of thermoluminescence and store the energy of the scattered X-rays as a charge in their crystalline structure. After heating the chips, the absorbed energy is set free as light. The amount of scattered rays can then be calculated from the quantity of emitted light.

The anatomical sites for dosimeter measurements in the operating surgeon and first assistant were the forehead, the thyroid gland, and the tip of the index finger of the dominant hand of the surgeon. The forehead was chosen to represent the lens of the eye, as this and the thyroid have a high sensitivity to radiation.

During the measurement, the chips were fixed with a paper adhesive on the forehead and over the thyroid and to the surgeon's fingertip under a glove. One dosimeter was placed on the opposite side of the patient's pelvis, 25 cms from the operative field. The surgeon was 45-60 cms away from the primary x-ray beam and the assistant was more than 60 cms.

RESULTS

The cumulative screening time was 40 minutes. The mean screening time was 48 seconds per case. The results are tabulated in Table I, II and III.

Table I shows the radiation dose received by the forehead, neck and hand of the primary and assistant surgeon. The hands of the primary surgeon and assistant surgeon receive the highest dose of radiation as these are quite close to the operative field, thus illustrate increase in radiation with decreased distance between the surgeon and the x-ray beam.

Table II shows the average screening time depending upon the seniority of the surgeon. The screening time was considerable less with more experienced surgeon.

Table III lists the radiation dose received by forehead, thyroid and hand of the operating surgeon.

DISCUSSION

Majority of the studies focusing on the radiation hazards to the surgeons have emphasized caution due to uncertainty of the long term effects of low-dose radiation (*6,14,15,16*).

In orthopaedics, the hands of the operating surgeon receive the highest radiation exposure (*14,15,16*). Fortunately, the hands are relatively insensitive to radiation with an annual extremity dose limit of 150 mSv for non-radiation workers (1990 Recommendation of ICRP) (*17*).

Table I. — Mean dose per body area per case
(Dose of radiation in mSv)

		Forehead	Neck	Hand
Surgeon	Range	0.02-0.04	0.02-0.06	0.10-0.14
	Mean	0.03	0.04	0.12
Assistant	Range	0.02-0.05	0.02-0.04	0.10-0.16
	Mean	0.03	0.03	0.13

Table II. — Average screening time depending upon the seniority of the surgeon

Registrar	Seniority in years	Number of cases	Average screening duration / case
1	1	8	62 sec
2	2	10	59 Sec
3	2	6	55 Sec
4	2	14	42 Sec
5	3	12	33 Sec

Table III. — Doses to each body part sustained by each registrar as operating surgeon

Registrar	Cumulative Finger Dose in mSv	Cumulative Forehead Dose in mSv	Cumulative Thyroid Dose in mSv
1	0. 50	0.11	0. 10
2	0. 44	0.10	0. 09
3	0.27	0.05	0.05
4	0.53	0.10	0.10
5	0.30	0.04	0.04
Mean	0.40	0.08	0.07
Median	0.44	0.10	0.09

Sanders *et al* observed that the mean radiation dose of the surgeon's finger was 0.28 mSv in 21 IM nailing procedures with an average fluoroscopy time of 3.6 minutes (*14*). In another study it was ascertained that the average radiation dose to the surgeons hand was 0.07 mSv per case for each of the four IM nailing ; the average duration of fluoroscopy being 2.9 minutes for the procedure (*5*).

In our study, the mean radiation exposure to the operating surgeon's dominant hand was 0.12 mSv. The range of exposure to radiation was very wide and was dependent upon the experience of the surgeon as shown previously by Goldstone *et al* who investigated radiation exposure with a TLD dosimeter on the middle phalanx of the operating surgeon's dominant hand (*5*).

The major reason for differences in radiation dose of trainee orthopaedic surgeons is due to surgical experience ; however collimation of the beam and the distance of the surgeon from the primary beam may play a part. Close cooperation and team work with the radiographer may allow closer beam collimation and shorter fluoroscopy times, hence reducing radiation dose to surgeon and patient.

Dosimetry studies showed that positioning the fluoroscopic beam vertically to the fracture site of the supine patient and x-ray source posterior to the patient provided lowest levels of scatter radiation to the surgeon in the normal working position (*10*).

Lead thyroid protection was not used in our study. The mean neck dose of radiation was 0.08 mSv for the operating surgeon in all 50 cases. As the hand of the surgeon is close to the operating field, much higher radiation to the hand than the forehead or thyroid is not surprising. The radiation delivered decreases as the distance from the source increases. The operating surgeon and the first assistant have almost the same radiation exposure in our study. It is most likely due to the fact that both are quite close to the operative field.

Riley in his study also showed that with appropriate usage the radiation exposure from fluoroscopy is relatively low and the surgeons hand receives the most exposure per case. The study demonstrated that maintenance and calibration of fluoroscopic machines are also important factors in reducing exposure risks (*12*).

Recommended dose limits are legal entities, which must not be exceeded and should not be even approached ; however the safe radiation dose is unknown. The cumulative lifetime dose at which radiation-induced cataract will appear is 2-4 Sv. It seems that it would be impossible to exceed this dose to the lens of the eye, even in a very busy operative environment ; nevertheless, the radiation exposure during professional activities has to be added to the individual day to day radiation exposure.

There is evidence that carcinogenic potential exists from low dose, low energy electromagnetic radiation especially, the formation of malignant nodules in the thyroid glands (*7,9*). It was shown that as little as 65 mSv of external radiation to the thyroid bed leads to a statistically increased incidence of thyroid cancer, many years later. However

Sanders *et al* have concluded that in a sample of 65 orthopaedic surgical procedures, there was no radiation exposure to the neck region of the first surgeon after using lead thyroid protection (*14*). The surgeon, assistant and the radiographer should follow the ALARA principle (*6*) (As Low As Reasonably Possible) of the International Commission on Radiological Protection (ICRP-1977) and position themselves so as to best limit the exposure. Proximity to primary beam is unavoidable, but scattered radiation can be reduced by positioning the source as far as possible from the surgeon in the antero- posterior position, and by directing the source away from the surgeon for the lateral position (*3*).

Giannoudis *et al* showed that the radiation dose and screening time were proportional to the complexity of fracture. The surgeon and radiographer seniority had a significant effect on screening time and radiation (*4*). A fluoroscopy-credentialing programme has shown to reduce the amount of radiation received by orthopaedic surgeons up to 10% before and after training (*8*).

The limitations of our study were that the duration of exposure also depended on the level of training of the radiographer, which could not be ensured in all the cases. The statistical power to detect an adverse health effect from low doses in an occupational setting requires a longer follow-up, which was beyond the scope of this study. The strengths were that it was performed at a single institution and the cases were of similar pattern. It helps to bring to light the relevance of radiation protection in situations where workers are exposed to protracted low dose radiation.

CONCLUSION

Our study shows that risk of exposure to ionizing radiation is higher for the operating surgeon. The dominant hand received the highest radiation. The radiation dose received is directly proportional to fluoroscopy time and inversely proportional to the experience of the surgeon. The dose received by the operating and the assistant surgeons does not exceed the national safety limits of non-classified workers.

The radiation dose during orthopaedic procedures can be kept to a minimum by awareness and a team approach between the radiographer, surgeon and theatre personnel. The experience of the surgeon and the radiographer are of importance in reducing the surgical operating time as well as the exposure to radiation. Close cooperation with the radiographer can help to minimize the dose by close collimation and reduction of fluoroscopy time. Thyroid lead shielding helps with procedural dose reduction to the surgeon and assistant. We also believe that a regular training focusing on awareness of radiation hazards and techniques of radiation protection is of paramount importance to keep radiation and scatter to a minimum.

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