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Image intensifier position for hand and wrist fractures

G. Van Staden, K. Farrant, R. Richards, T. Bunker

Princess Elizabeth Orthopaedic Centre and Royal Devon & Exeter Hospital, Exeter, UK

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1. Introduction

The Ionising Radiations Regulations (1995) [1] dictate that when radiographers use C-arm image intensification the radiation source should be placed below the patient and the collimator above the patient. Such a position works well for common procedures such as pinning hip fractures and performing intramedullary fixation of long bones. However, when reducing and pinning small fractures, such as those of the hand, wrist and foot, better definition is required by the surgeon, and this means getting the collimator as close to the fracture as possible. If the radiation source is below the fracture, and the collimator above, then as the collimator is approximated to the wrist fracture, the surgeon's view of what he is doing is impeded. Moreover with the collimator lowered down on to the fracture the source is closer to the floor and therefore the cone of radiation comes closer to the surgeon, who is unable to stand away from the source because he is maintaining the reduction. Psychologically it is daunting for the surgeon to be looking at the radiation source, whether he is close to, but outside the cone of radiation, or whether he is within it. For these reasons it has been common practise for surgeons to invert the C-arm for such procedures. This allows the collimator to be placed immediately adjacent to the fractured part (albeit with a radiolucent hand table between the two to prevent damage to the collimator), gaining better definition of the fracture. Most importantly it allows the surgeon to see what he is doing, both physically and on the image intensifier at the same time. Finally it allows the surgeon to be well outside the cone of radiation, both physically and psychologically. However, radiographers now refuse to grant the request of surgeons to invert the C-arm for hand and wrist fractures, quoting the 1995 regulations, and stating that it is the radiation scatter back from the operating room floor which endangers the surgeon, and not the direct beam. This can make the job of the surgeon well nigh impossible. We therefore decided to examine the relative radiation to the surgeon while using the C-arm in the regulation manner and in the inverted position.

2. Method

A typical operating room scenario was created in a Nuclear Medicine measurement laboratory portraying a forearm manipulation. A phantom arm, made of perspex blocks and a stainless steel rod was used to simulate the forearm, based on kilovoltage (kV) data collection from actual theatre measurements used for similar procedures, found to lie between 50–55 kV. The phantom forearm was placed on a radiolucent support table 70 cm from the floor. The floor surface was identical to that found in the operating suite, and would therefore have the same reflective qualities. A “phantom surgeon” was now placed 40 cm distant to the phantom forearm, and a 180 cm^3 ionisation chamber dosimeter was used to measure the amount of radiation exposure at various body sites of the phantom surgeon. A dosimeter was placed at 10 cm from the floor to represent the ankle and foot; at 80 cm behind a 0.25 mm lead apron to represent the groin; at 152 cm to represent the thyroid and at 170 cm to represent the eyes; finally dosimeters were placed at either end of the phantom forearm (outside the cone of primary radiation) to represent the hands of the operating surgeon. A Picker Orbiter C-arm Image Intensifier was used for screening at 52 kV with the source below the phantom forearm (as required by the 1985 Ionising

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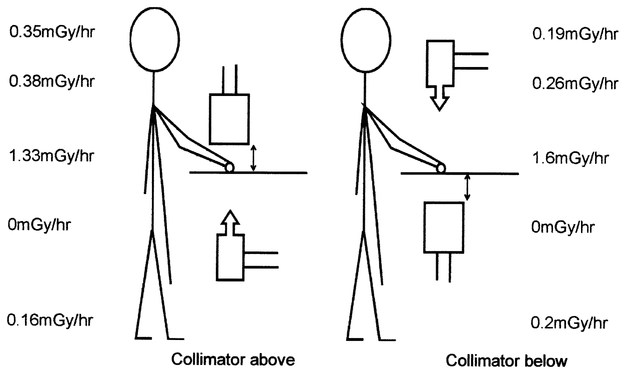

Fig. 1. Illustrating the positions used to simulate theatre forearm procedure and the resultant radiation dosages measured.

Radiation Regulations), and then with the C-arm inverted (the surgeon preferred method.)

Screening times of a number of seconds were needed to allow a dose to be read by the dosimeter, which was measured in milliGrays per hour (mGy/h.)

As a control, similar screenings were performed on an anatomical body phantom simulating screening of a hip fracture, using 81 kV from an average of clinically collected dosage of kV data.

3. Results

Radiation dosages for the phantom forearm using the intensifier with the source below the patient and inverted are shown in Fig. 1. With the radiation source below the patient (regulation) higher doses were obtained for the eyes and thyroid than with the source above the phantom (surgeon preferred), but the dosage to the hands was less. Both methods showed equal dosage to the foot and ankle, and no radiation was measured at the leaded groin.

Measurements on the hip phantom showed that the regulation method of source below the patient was safer to the surgeon.

4. Discussion

The image intensifier is an indispensable tool in the area of fracture reduction and fracture fixation. As fracture care becomes more and more complex, and both patients and their legal advocates expect ever improving standards, screening times in orthopaedic and trauma operating theatres are set to continue to rise. It therefore behoves every member of the operating theatre team to be increasingly aware of radiation protection measures. Whilst the inverse square law, and lead gowns, can protect radiographers, nurses, and anaesthetists, the surgeon is often unable to stand back from the radiation source during the screening, for he is either having to manually hold a fracture reduction, or hold an internal fixation device (drill or screw). Ionising Radiation Regulations have therefore been enforced in order to protect the patient and the most vulnerable member of the operating team, the surgeon.

In the area of reduction and fixation of hand and wrist fractures, and to a certain degree foot fractures, the regulations come into conflict with the surgeons ability to see what he is doing. As far as we could determine this conflict of interests has not previously been researched. We therefore decided to investigate whether obeying the regulations was in the best interests of radiation protection to the surgeon during such manoeuvres, or not. The results in fact show that the regulation method not only prevents the surgeon from seeing what he is doing, but also causes increased radiation to the surgeon's eyes and thyroid. Conversely, by inverting the image intensifier such that the collimator is below the forearm and the source above, not only allows the surgeon to see what he is doing but also gives less radiation to his eyes and thyroid.

We would therefore conclude that the Ionising Radiation Regulations should be amended to allow surgeons operating on the periphery of the limbs to invert the image intensifier so that the source is above the patient and the collimator below, should they deem it necessary for reduction or fixation of hand, wrist or foot fractures.

References

[1] Royal Devon & Exeter Healthcare Trust Rules for Use of Ionising Radiation, Version 1.1, September 1995, Appendix 3, Section 9iii.