In 2010, the United States Food and Drug Administration announced its white paper ‘Initiative to reduce unnecessary radiation exposure from medical imaging’. This showed that fluoroscopy used in an operating theatre environment could lead to a radiation exposure equivalent to between 250 and 3500 chest radiographs, depending on the procedure in question. Orthopaedic procedures rely heavily on intra-operative fluoroscopy and as such have attracted particular attention.

The management of femoral fractures by intramedullary nailing has been shown to be more effective than traction and cast bracing and is a widely practised treatment for fractures of the femoral shaft in adults. Intramedullary tibial nailing, with or without reaming, remains popular when treating closed fractures of the tibia or open fractures up to grade IIIA.

During intramedullary nailing for these fractures, the insertion of distal locking screws can at times be technically challenging. Perhaps the most common technique of distal locking relies on two-dimensional radiographs to guide what is essentially a three-dimensional procedure. The design of intramedullary nails has changed since their first introduction, but distal locking remains a difficult part of the procedure, leading to a prolonged operation time and increased exposure to radiation. Many radiographs may be required as surgeons attempt to locate the distal hole of the intramedullary nail. The long-term effects of radiation and their relationship to different types of cancers still remain uncertain. Consequently, there is a need to develop a surgical technique that can limit the use of radiation and anaesthetic during a distal locking procedure.

Several techniques have been described, which fall into five categories: computer-assisted, nail-mounted guides, image-intensifier-mounted techniques, hand-held guides and free-hand techniques. Self-locking nails have also been described, although these are perhaps best used in areas where fluoroscopy is not available. This is because they do not have the same resistance to torsional forces as conventional locked screws and in the case of Fixion IM Nail® (Disc-O-Tech Medical Technologies Ltd, Herzliya, Israel) devices may have to be removed post-mortem because of issues during cremation.

**Nail-mounted guides**

A common question is why distal locking screws cannot be inserted with a jig similar to that used for proximal screws. The difficulty is created by the rotational and bending deformities that the nail experiences during insertion. These frequently render the jig inaccurate for both the tibia and the femur. In addition to the deformation of the nail, the lengthy distance between the mounting of the proximal jig and the distal locking screws leads to minor manufacturing errors becoming magnified. Further problems include deformation of the jig by its own weight or when the surgeon applies force to it.

Despite these troubles, various distal locking jigs have been produced for use with tibial nails, manufactured by several companies such as Stryker (Stryker Corporation, Kalamazoo, Michigan), Synthes (Synthes GmbH, Zuchwil, Switzerland) and Orthofix (Verona, Italy). All jigs have had good results in studies when compared with free-hand distal locking. However, in practice improved results with these jigs appear less reproducible, as evidenced by many surgeons still favouring free-hand techniques.

**Computer-assisted**

A recent development in the placement of distal locking screws relies on the use of computer models combined with imaging. This technology has been widely used by neurosurgeons for many years and various prototypes have been developed for distal locking. Initial results for these in the laboratory were good, although there has until very recently been no commercially available system.

This however changed with unveiling of Smith and Nephew’s Trigen Sureshot system (Smith & Nephew, Memphis, Tennessee). Unveiled in 2009, it uses an electromagnetic field to align the drill guide with the centre of the screw hole – identified by a probe inserted into the cannulated nail. Limitations include its inability to be used within 200 mm of a pacemaker and interference from nearby metal, such as that used for positioning patients during the procedure. Again, laboratory results have been excellent, but this system’s ease of use and success has not been compared with free-hand distal locking in vivo. Additionally, in times of economic austerity, the system must be purchased and the probes are one-use only.

**Free-hand technique**

In routine practice it appears that a free-hand technique is the most commonly used. This relies on using an image intensifier to obtain perfect circles. This involves placing the nail halfway between source and camera and adjusting the position until the circles are in the centre of the screen. The intensifier is then adjusted in coronal and transverse planes until perfect circles are achieved. A bone awl is then moved under guidance of serial images until the tip is seen to lie in the centre of the circle; the awl is then used to open the lateral cortex. A drill is next placed into this hole and an attempt made to visually line up with intensifier so that the three points: the centre of the drill hole; the drill tip and the drill butt are all in line. Kelley et al described that the successful drilling of distal locking screws relied on the alignment of these points.
This method has been modified over the years with the introduction of K-wires and cannulated drill bits\textsuperscript{21} or Steinmann pins to replace the awl.\textsuperscript{22} Another common variation is the use of a radiolucent drill or drill guides that allow the holes to remain visible when the drill is in position.\textsuperscript{23}

**Hand-held guides**

There have been several hand-held guides described but none appears widely used. Such guides included a large diameter drill guide with a long handle to line up with the image intensifier and keep the surgeon’s hands out of exposure.\textsuperscript{24} Other methods involved lining up washers or rings with the intensifier to ensure that the initial Steinmann pin or drill bit was directly perpendicular to the nail.\textsuperscript{25} However, any hand-held guides can be awkward to position. Once a position has been achieved it may be difficult to maintain, so often requires an assistant.\textsuperscript{26}

**Image intensifier mounted guides**

Guides have been developed which can attach onto the intensifier to allow aiming of the hole through the guide.\textsuperscript{27} These require significant skill on the part of the radiographer, can be displaced and are hindered by the difficulty in making small
movements with a bulky intensifier. Importantly, no evidence exists that these guides result in increased success, decreased operating time, or decreased radiation exposure.

Goodall and Goulet described a laser guidance system mounted on the intensifier, which identifies the location of the skin incision and drill entry point. Meanwhile Goulet et al. used two lasers fitted to the intensifier in order to generate a crosshair marking the centre of the beam. Both these methods, however, described modification to the intensifier with additional equipment.

Our personal technique is a novel and simple method based on the laser guidance system proposed by Goodall and Goulet et al.

**Method**

Our technique requires transparent surgical drapes for both the screen and image intensifier. Using a free-hand technique, the image intensifier is aligned with the distal screw holes, so that the round hole appears as a perfect circle on the image; this indicates coaxial alignment of the screw holes (Fig. 1). The image intensifier is then locked in its rotational axis.

The scalpels are then lined up on the skin (Fig. 2), so that it overlies the centre of the hole, and a stab incision is made.

The image intensifier is then moved along its longitudinal axis, with the rotational arm locked so that the laser-aiming device of the image intensifier is focussed on the skin incision. The image intensifier is locked in this position.

The drill tip is then placed on the bone and, using the image intensifier, aligned with the superior aspect of the hole (Fig. 3).

The drill butt is then lined up so that the laser cross hair illuminates the posterior aspect of the drill; this confirms that the three points described by Kelley et al. are in line (Fig. 4). A hole is then drilled, while maintaining the cross hair at the centre of the posterior aspect of the drill at all times.

**Discussion**

It was recognised by Kelley et al. that successful placement of the distal locking screws relies on accurately defining three landmarks in space; the centre of the drill hole, the entry point on the skin, and the butt end of the drill. If all three of these are aligned, the centre of the screw hole will be consistently found during drilling. Kelley et al. suggested placing a plastic cone on the image intensifier to coincide with the centre of the beam. Our method uses the laser from the image intensifier to ensure that all three of these landmarks are lined up, without the use of additional equipment or unnecessary radiation exposure. It is a simple modification of techniques that have already been described, with only the need to ensure that a transparent sterile cover/screen is used for the image intensifier in order to allow penetration by the laser.

**References**