ABSTRACT
The surgical technique of ante-grade femoral nailing utilizing intraoperative ultrasound to assist with the accurate three-dimensional localisation of the proximal entry point is demonstrated. Adjunctive intraoperative ultrasound in the management of femoral fractures is easy to conduct, reduces operative time and assists with accurate percutaneous internal fixation in complex fracture patterns. Intraoperative ultrasound is particularly useful in the management of obese patients and in fractures of the proximal femur where significant deformity is present.

KEYWORDS
Ultrasound, femoral fracture, nailing, technique.

INTRODUCTION
Internal fixation of proximal femoral fractures by antegrade intramedullary devices typically requires passage of the fixation device through the piriformis fossa or trochanteric apex. Failure to select an accurate proximal femoral entry point risks malreduction of the fracture or subsequent suboptimal positioning of the proximal cross locking screw(s) within the femoral head. For fractures of the femoral shaft where the proximal femur has minimal deformity due to injury, accurate localisation of the proximal femoral nail entry point can be easily obtained by a combination of intraoperative fluoroscopy and direct palpation (Fig 1).

There are circumstances however where selection of the nail entry point using these methods becomes more difficult, due either to patient obesity or the presence of more complex fracture patterns. In particular, this applies to proximal femoral shaft and subtrochanteric femoral fractures, where flexion and rotation of the proximal fragment makes three dimensional localisation of the femoral entry point using fluoroscopy and
palpation alone less accurate (Fig 2). In these fracture patterns, while fluoroscopic images assist with cranio-caudad and medial-lateral positioning of the nail entry point, orientation in the anterior-posterior plane is less certain, with a tendency to enter the femur more anterior than predicted. Alternatives to improve localisation of the entry point in three dimensions include the use of lateral and rotated fluoroscopy images (time consuming and often with suboptimal clarity) or to conduct more extensive surgical dissection.

At our institution, we have found intra-operative ultrasound useful in a variety of surgical procedures about the hip and pelvic region. We have previously described the use of intraoperative ultrasound for the conduct of hip arthroscopy in the central, peripheral and extra-articular compartments including proximal iliotibial band release [1-3]. We have since applied these techniques to the management of patients with femoral fractures undertaking percutaneous internal fixation by antegrade intramedullary nail.

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We have found the use of intraoperative ultrasound a useful adjunct to the use of fluoroscopy, enabling the accurate localisation of the proximal femoral nail entry point in three dimensions, particularly in obese patients or those with significant deformity or displacement of the proximal femur. For the management of skeletal trauma, intra-operative ultrasound has previously been described for the removal of metalwork (K wires, cross locking screws) and to assist in the reduction of femoral shaft fractures [4-7].

This technique is easy to conduct, reduces operative time and assists with the accurate percutaneous nailing of complex femoral fractures.

SURGICAL TECHNIQUE

At our institution we prefer to conduct antegrade intramedullary femoral nailing procedures with the patient in a supine position upon a traction table, although the techniques of ultrasound we describe are equally valid and easy to conduct with the patient in lateral decubitus traction position.

The patient is placed supine with a padded perineal post and attention is made to the adequacy of binding and pressure area care to the foot. The patient is typically administered a general anaesthetic and intravenous antibiotic prophylaxis. The contralateral leg is placed into abduction and flexion to enable access for the fluoroscopy image intensifier between the legs. Traction to the operative leg is applied and, where possible, closed reduction is obtained utilizing fluoroscopic guidance in two planes. The ultrasound machine is placed on the operative side of the patient, ensuring accessibility and ease of vision for the operating surgeon. All other equipment is placed according to surgeon’s preference for femoral intramedullary nailing procedures.

At our institution we use a LOGIQe ultrasound (General Electric Healthcare, Sydney Australia) with a 4C-RS 2.0-5.5 megahertz transducer for intraoperative imaging about the hip and pelvic region. The ultrasound transducer is prepared by placing non-sterile gel on the transducer, which is then covered with a sterile plastic transducer bag (Elastic Fluoro Cover 91x76cm, Bard Lifemed, North Ryde, NSW, Australia). The sterile transducer bag is then placed and secured in the fluid collection pouch of a vertical isolation drape. A small quantity of sterile urinary catheterisation lubricant or sterile water is applied to the ultrasound probe site to improve conductivity of the ultrasound signal.

We recommend the combined use of intraoperative fluoroscopy and ultrasound to assist with accurate localisation of the nail entry site and placement of the proximal skin incision (Fig 3). Fluoroscopy in the anterior-posterior plane is used to provide two-dimensional images to assist with the cranio-caudad and medial-lateral positioning of the nail entry point. Ultrasound imaging is used to assist with the anterior-posterior location of the proximal femoral entry point and to orientate the surgeon with respect to flexion and rotation of the proximal femoral fragment. For intramedullary nailing procedures the ultrasound probe is initially oriented transverse to localize the greater trochanteric tip and assess orientation of the proximal femur should deformity be present (Fig 4). This is particularly useful in substantially obese patients. The transducer is subsequently oriented in a longitudinal direction to the proximal femoral fragment at the level of the greater trochanter tip, accounting for any flexion or rotatory deformity of the proximal fragment that may be present (Fig 5, Video 1). For percutaneous procedures, the location of the skin incision is judged taking into account the location of the greater

Figures 3 and 4. Fig 3 (left): Combined use of intraoperative ultrasound and fluoroscopic imaging to obtain accurate three-dimensional orientation of the proximal femoral fragment and trochanteric entry point. Fig 4 (right): Initial transverse ultrasound imaging of proximal femur.

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trochanter relative to the thickness of the overlying adipose layer (Fig 6). Standard fascia and muscle splitting techniques for proximal femoral intramedullary nailing are conducted. Both ultrasound and fluoroscopy are able to guide the initial placement of instrumentation such as an awl or guide-wire used for the initial development of the femoral entry point. As ultrasound does not have conductivity to allow diagnostic imaging within bone, only the bone surface can be appreciated by intraoperative ultrasound and therefore after initial development of the proximal entry point, the remainder of the procedure is conducted with fluoroscopic imaging using standard techniques (Fig 7).

CONCLUSION

Intraoperative ultrasound is a simple and useful adjunct to fluoroscopy in the accurate three-dimensional localisation of the proximal entry point in antegrade femoral nailing procedures. The technique is particularly useful in the management of obese patients and in fractures of the proximal femur where significant deformity is present.

REFERENCES