Acta Orthop. Belg., 2011, **77**, 414-418

CASE REPORT

Vascular injury involving proximal medial-to-lateral oblique locking screw insertion in tibial intramedullary nailing

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Orthopaedic surgeons have reported increased neurologic complications with the employment of next-generation tibial nail fixation with variable proximal and distal locking options. However, vascular injury due to oblique screw placement has not been documented. We describe a case in which a medial-to-lateral oblique locking screw led to significant vascular injury. The judicious use of these screws and their relative contribution to fracture stability should be carefully considered for individual cases. Additionally, drill penetration through the far tibial cortex may not be obvious and utilizing oscillation or reverse drilling techniques may be of benefit. Lastly, the forward thrust of the popliteal artery with the use of a positioning bump in the popliteal fossa may place the vascular structure at increased risk of injury. Employing means to avoid these injuries and minimize risks in pertinent patients is of utmost importance.

Keywords : tibial nail ; vascular injury ; proximal oblique screw.

INTRODUCTION

Owing to the high incidence of fixation failure, infection, and wound problems associated with plating, the indications for tibial nailing continue to expand (*1*). Likewise, newer nail designs that provide additional sagittal and oblique proximal and distal locking options have been developed with the intention of offering increased mechanical stability for complex fracture stabilization (*2,6*). However, the placement of these sagittal and oblique locking screws can be unsafe due to the close anatomic proximity of neurovascular structures. Although associated neurologic injuries have been described, there is only one case report in the literature documenting a serious vascular complication with proximal sagittal screw insertion (*10*). Vascular compromise due to oblique screw placement has never been noted. We present a novel case of vascular injury arising from proximal oblique medial-to-lateral screw placement during tibial nail insertion. Understanding the risks associated with oblique screw placement may provide insight to the prevention of potentially limb-threatening neurovascular complications.

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No benefits or funds were received in support of this study

Fig. 1a & b. — AP R ankle & Lateral R ankle, post - reduction and splinting. These radiographs display a fracture of the middle to distal third of the tibial diaphysis with 15° of angulation and 75% displacement in the coronal plane after an attempted closed reduction.

CASE REPORT

A 49 year-old female presented with right lower extremity pain and deformity after a fall. She displayed palpable dorsalis pedal and posterior tibial pulses and a normal distal motor and sensory examination. Radiographs demonstrated a displaced spiral fracture of the distal third of the tibia. The fracture proved to be unstable following reduction (Fig. 1a & b), and it was recommended that she proceed with stabilization of her injury with an intramedullary nail.

The patient was taken to the operating room for fixation. Due to the distal nature of the fracture, a next-generation tibial nail with distal locking options was selected. A triangular bump was placed beneath the thigh maintaining 110° of knee flexion, and a reamed Synthes® tibial nail (Expert Tibial Nail System, West Chester, PA) was inserted through a standard patellar tendon splitting approach. Using the proximal alignment guide, two oblique screws were drilled, measured, and inserted. During the drilling of the medial-to-lateral oblique screw, there was no change in pitch or sensation indicating penetration of the far cortex, and the drill bit passed beyond the tibia into the soft tissues of the posterior-lateral knee. The drill bit was removed, and a screw was measured and inserted. It did not demonstrate good purchase on the far cortex and was subsequently removed. A proximal and two distal medial-to-lateral static locking screws were placed, and the remainder of the surgery was completed without noted complication (Fig. 2a & b).

During application of sterile dressings and a post-mold splint, the patient's toes were noted to be pale and cool. The splint was removed, and neither the dorsalis pedal nor the posterior tibial pulses were present on doppler examination. Palpable femoral and dopplerable popliteal pulses were appreciated, but no distal flow was noted. The lower extremity compartments were also noticeably swollen and tender. Intracompartment measurements using a Stryker® (Kalamazoo, MI) pressure monitor yielded 65, 65, 65, and 45 mmHg for the anterior, lateral, superficial posterior, and deep posterior compartments, respectively (with a diastolic pressure of 85 mmHg). Vascular surgery was immediately consulted, and consent was obtained for a four-compartment lower extremity fasciotomy, angiography with a possible vascular repair or bypass.

A two-incision fasciotomy was performed with wide release of all four compartments. No pulses were appreciated on doppler examination after the decompression. Angiography was then performed which demonstrated occlusion in the retrogeniculate distribution of the popliteal artery (Fig. 3a). The vascular surgery team then undertook an exploration of the popliteal fossa. Significant haematoma was noted, and although the tibial nerve was intact, the popliteal artery was completely transected. The proximal and distal ends of the vessel were identified and repaired primarily. A post-repair angiogram was performed with restoration of distal flow in the anterior tibial, dorsalis pedal, and posterior tibial arteries (Fig. 3b).

Throughout her hospitalization, the patient returned to the operating room for split-thickness skin grafting of her fasciotomy wounds. At six weeks post-procedure, she was weaned to weight-

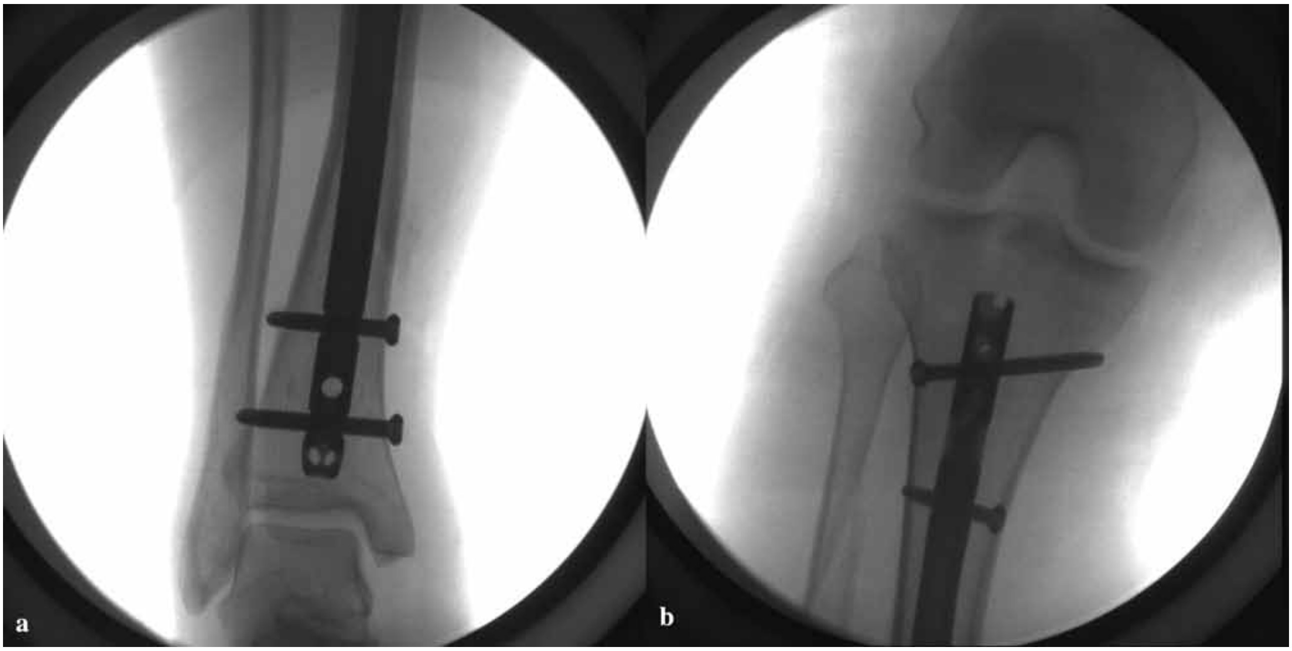

Fig. 2a & b. — AP fluoroscopy of proximal and distal tibia, intraoperative. These fluoroscopic images display the insertion of a reamed intramedullary tibial nail with proximal and distal locking screws.

bearing as tolerated, and following a recent clinical evaluation, she continues to display a well-perfused extremity without evidence of impending vascular compromise.

DISCUSSION

In recent years, new tibial nails have been developed to address the concerns with intramedullary fixation in proximal and distal shaft fractures and malalignment (*2*). Due to a high rate of fracture fixation failure, wound complications, and infections associated with traditional plate fixation, indications for newer-generation intramedullary nail fixation and use of these oblique locking options continue to expand (*6*). However, with an increased selection and expanded scope of utilization, the use of new intramedullary nails and their locking options have led to a number of unintended outcomes (*4,5,9*).

Although rare, cases of vascular compromise with sagittal locking screws have been documented. Williamson and Kershaw described a case in which insertion of an anterior-posterior superiorly directed proximal screw led to a traumatic laceration of the popliteal artery necessitating an interposed reverse saphenous vein bypass graft (*10*). Urban and Tornetta also illustrated a case in which placement of long distal locking screws caused a vascular occlusion that resolved following removal of the bolts (*4*). Bono *et al* performed a cadaveric study exploring the relationship of anterior-posterior distal locking screws and the proximity of relevant neurovascular structures. They concluded that with standard techniques, these vital structures were in danger of injury (*1*).

Prevention of neurovascular complications involving oblique locking screw placement in tibial fracture fixation involves many considerations. First, the necessity of proximal oblique locking screws should be determined during preoperative planning, and factors such as fracture pattern and stability should be carefully considered. The addition of these screws significantly improves stability of proximal tibial fractures compared to the use of transverse locking screws alone (*2,6*). However, in fractures of the tibial diaphysis, this additional degree of stability may not be necessary. Direct

Fig. 3a & b. — Intraoperative angiography, oblique R knee, pre & post repair. Intraoperative angiographic evaluation of the right lower extremity perfusion revealed a defect in the distribution of the retrogeniculate popliteal artery with compromised distal circulation. A post-repair angiogram displayed reconstitution of caudal flow.

medial-to-lateral screws are recognized as a safer construct and have less likelihood of neurovascular injury as compared to oblique or sagittal screw configurations (*10*).

If proximal oblique screws are determined to be beneficial, several technical points should be carefully considered. Neurovascular injury with medial-to-lateral oblique locking bolts may occur during drilling or screw insertion (*1*). During drilling, there may be no audible change in pitch or tactile change in sensation indicating violation of the far tibial cortex. This lack of physical confirmation of cortical perforation may lead to the advance of the drill into the posterior-lateral soft tissues of the knee and resultant injury (*5*). Intraoperative fluoroscopy has been proposed, but the literature does not support its use at this time (*9*). This limitation may be due to difficulty in obtaining adequate radiographic views of the posterior proximal tibia intraoperatively. One proposition to increase safety of screw placement is to set the drill on oscillate or reverse when penetrating the far tibial cortex. This measure would decrease the likelihood of inadvertent advance of the drill into the soft tissues of the posterior knee. Estimating the predicted range of the appropriate screw length may also avoid overzealous drill advance. Lastly, the surgical technique guide for our instrumentation advocates the termination of drilling prior to penetration of the far cortex to prevent neurovascular injury (*8*). Incorporation of this precaution provides an increased level of protection to the lateral and posteriorly based anatomic structures.

An important consideration to prevent popliteal injury with oblique medial-to-lateral screw placement is understanding the anatomy of the popliteal artery (PA) and its relationship to knee motion. The classic description of the PA describes bifurcation of the vessel at the inferior border of the popliteus muscle. However, variations in branching patterns have been noted in approximately 10% of patients (*3*). The PA is located 3 mm lateral to the lateral-most aspect of the posterior cruciate ligament and 2 cm distal to the tibial joint surface (*11*). External rotation of the tibial guide and nail may place the artery in jeopardy of injury from an

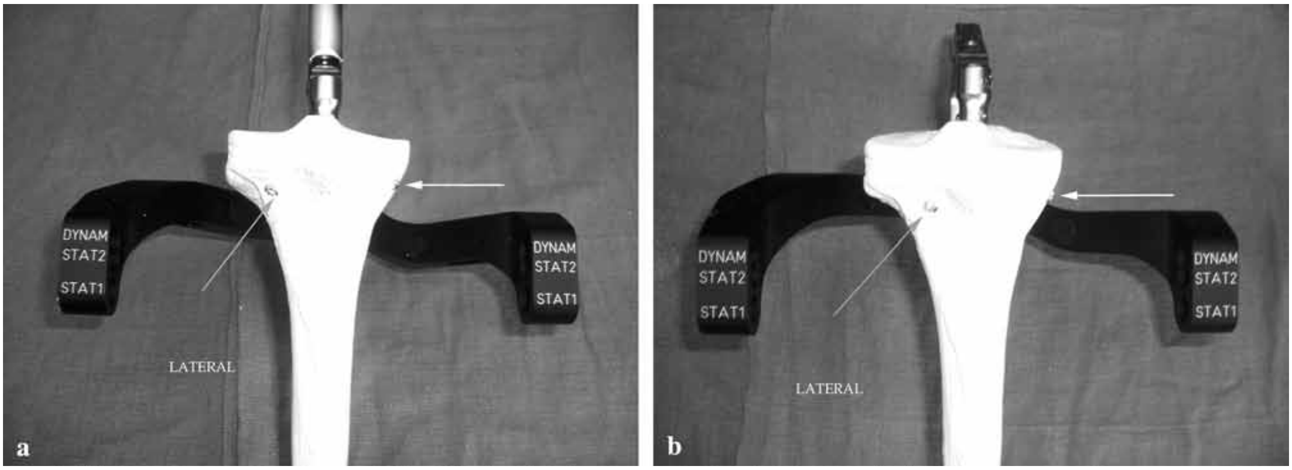

Fig. 4a & b. — Sawbone models, neutral & 15° degrees of external rotation. With the alignment guide placed in neutral alignment, the oblique screw tips are viewed from a posterior orientation. The medial-to-lateral screw and the lateral-to-medial screws are designated by grey and white arrows, respectively. With 15° degrees of external rotation on the alignment guide, the medial-to-lateral screw tip (grey arrow) migrates closer to the posterior tibial plateau and the adjacent popliteal artery, vein, and tibial nerve.

oblique medial-to-lateral locking screw (Fig. 4a & b). With obese, muscular, oedematous, or swollen legs in which the anterior tibial crest is not easily appreciated, misdirection of the guide may lead to vascular injury.

Also, the PA is located a few millimeters posterior to the knee capsule with only a small amount of intervening fat and soft tissue (*10*). With 90° of knee flexion, the neurovascular bundle migrates away from the posterior joint capsule and may drift posteriorly as much at 6-10 mm (*7,11*). Hyperflexion of the knee or a bump positioned in the popliteal fossa places an anteriorly directed force on the soft tissues adjacent to the PA thus potentially negating this protective benefit. Placing a bump in the popliteal fossa or utilizing a radiolucent triangle during oblique screw placement would thrust the PA closer to the posterior joint capsule and may place the vessel in danger of injury.

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