Anatomical study of the placement of proximal oblique locking screws in intramedullary tibial nailing

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Intramedullary tibial nailing was performed in ten paired cadavers and the insertion of a medial-to-lateral proximal oblique locking screw was simulated in each specimen. Anatomical dissection was undertaken to determine the relationship of the common peroneal nerve to the cross-screw.

The common peroneal nerve was contacted directly in four tibiae and the cross-screw was a mean of 2.6 mm (1.0 to 10.7) away from the nerve in the remaining 16. Iatrogenic injury to the common peroneal nerve by medial-to-lateral proximal oblique locking screws is therefore a significant risk during tibial nailing.

The success of intramedullary nailing and the development of newer designs of nail have prompted its use in the treatment of complex fractures. In tibial nailing, coronal or sagittal proximal locking has been supplemented by the use of oblique locking screws. Cadaver dissection and clinical reports have confirmed previous concerns regarding potential neurovascular injury from proximal tibial hardware and coronal or sagittal proximal locking screws, but none has reported the use of oblique proximal locking screws. Following intramedullary nailing of 20 cadaver tibiae, dissection was undertaken to determine the relationship of the common peroneal nerve to the oblique proximal locking screws of a proprietary tibial nail.

Materials and Methods

We used ten skeletonally-mature cadavers (seven female, three male), four of which had been embalmed using a technique which preserved tissue flexibility, and six in a traditional manner with phenol and formalin. None had evidence of previous knee surgery or obvious deformity of the lower limbs. The technique of insertion of the intramedullary nails was the same in each cadaver. An anterior transverse incision was made just below the patella and its ligament was reflected inferiorly. In the traditionally-embalmed limbs the anterior cruciate ligament often had to be sacrificed. The exposed entry point of the nail was at the junction of the tibial plateau and the anterior slope of the tibia, in line with the medial one-third of the tibial tuberosity and thereby avoiding damage to intra-articular structures. The tibia was breached with an appropriate awl and an unreamed solid titanium nail (9 mm × 320 mm, 9° proximal bend; Synthes (Canada) Ltd, Ontario, Canada) was inserted using the regular jig. Rotational alignment was controlled with reference to the tibial crest and coronal and sagittal alignment could also be observed from this neutral reference point. A distal cortical window was cut to assess intramedullary alignment. In each case, the nail was inserted so that the proximal bevelled anterior surface was just beneath the anterior tibial cortex.

Each limb was dissected in an identical manner. A lateral approach was used and the common peroneal nerve was identified posterior to the lateral femoral condyle and traced distally around the fibular neck to its divisions and respective intramuscular entry points.

Using the oblique (45°) jig slot and appropriate calibrated drill and guides, the drill was passed from medial to lateral, noting when the lateral tibial or fibular cortex was breached. The shortest distance between the tip of the drill and the common peroneal nerve was recorded in millimetres. The incision was deepened to allow 90° of knee flexion, dividing structures as necessary. In the traditionally-embalmed limbs the anterior cruciate ligament often had to be sacrificed. The exposed entry point of the nail was at the junction of the tibial plateau and the anterior slope of the tibia, in line with the medial one-third of the tibial tuberosity and thereby avoiding damage to intra-articular structures. The tibia was breached with an appropriate awl and an unreamed solid titanium nail (9 mm × 320 mm, 9° proximal bend; Synthes (Canada) Ltd, Ontario, Canada) was inserted using the regular jig. Rotational alignment was controlled with reference to the tibial crest and coronal and sagittal alignment could also be observed from this neutral reference point. A distal cortical window was cut to assess intramedullary alignment. In each case, the nail was inserted so that the proximal bevelled anterior surface was just beneath the anterior tibial cortex.

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All the angular measurements were determined by inserting a Steinmann pin into the tibial crest parallel to the jig on initial insertion of the nail. Any subsequent rotation was measured as the angle between the pin and the jig. To facilitate this, digital images were taken of every limb and each angle measured using Adobe Photoshop software (Adobe Inc., San Jose, California).

The length of each tibia was measured from the medial joint line to the tip of the medial malleolus. The entry point of the nail was measured as the distance from the insertion of the patellar ligament, and the distance for lateral cortical (tibia or fibula) penetration was estimated using the calibrated drill and a 1 mm incremental ruler. All measurements in relation to the fibula were referenced from its proximal tip. There was no anatomical variation of the common peroneal nerve in any cadaver and all measurements were agreed between two expert observers (BGJ and RM).

Statistical analysis. All data were of normal distribution and were reported as the mean and SD. Comparisons between legs used paired statistical methods (paired t-test) with a significance level of p = 0.05. Analyses were performed using Minitab version 13 (Minitab Ltd., Coventry, United Kingdom).

Results
The key variables are shown in Table I. There was no statistically significant difference in any variable between the left and right legs. Figure 1 shows the superimposed positions of drilling medially to laterally in all the right tibiae, performed with the nail in neutral rotation. The size of the fibular head was variable and the course of the common peroneal nerve around the fibular neck was likewise variable in its distance from the proximal tip of the fibula. However, since the common peroneal nerve was noted to be adherent to the fibular neck in all limbs, it did not move appreciably irrespective of the method of preparation.

The common peroneal nerve was contacted directly in four tibiae and the cross-screw was a mean of 2.6 mm (1.0 to 10.7) away from the nerve in the remaining 16. The mean length of simulated cross-screw required before the lateral cortex of the fibula was penetrated and potential nerve damage occurred was 73.0 mm (SD 6.29). By contrast, the length of cross-screw required to penetrate the tibial cortex posteriorly to the fibula was 59.0 mm (SD 7.93), and to penetrate the tibial cortex anterior to the fibula 56.5 mm (SD 9.40) (Table II).

Direct contact occurred with the common peroneal nerve in four legs with the nail inserted in neutral align-
Discussion

Intramedullary tibial nailing risks iatrogenic injury to surrounding neurovascular and intra-articular structures. The course of the common peroneal nerve has been clearly defined in many classical anatomical texts. More recently, concerns about possible iatrogenic injury have produced further anatomical work demonstrating the various branches of the nerve, and safe zones for insertion of the implant have been defined.3-5

Our study has demonstrated the vulnerability of the common peroneal nerve in a commonly-performed procedure in which secondary insertion of the implant is predetermined by the implant and not the surgeon. Indeed, some designs of tibial nail allow only oblique proximal locking. We have shown that when drilling a 45° oblique locking screw hole from medial to lateral, the common peroneal nerve is vulnerable. The literature from some manufacturers does not advocate the use of radiological control for drilling this hole. However, we believe that these screws should be placed under image guidance and that attention should be paid to the length of the potential screw by the surgeon. Indeed, some designs of tibial nail allow only oblique proximal locking.

We suggest that designs of implants should take into consideration not just the bony anatomy but also the surrounding tissues in order to minimise potential iatrogenic injury.

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References


Table II. The mean length (mm) of simulated oblique cross-screw required for lateral fibular or tibial penetration of the cortex with confidence intervals (CI). Rotation implies placement of the screw immediately anterior or posterior to the fibula.

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<thead>
<tr>
<th></th>
<th>Mean (sd)</th>
<th>95% CI</th>
<th>99% CI</th>
</tr>
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<tbody>
<tr>
<td>Neutral alignment</td>
<td>73.0 (6.29)</td>
<td>67.74 to 78.26</td>
<td>65.22 to 80.78</td>
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<td>External rotation</td>
<td>59.0 (7.93)</td>
<td>50.68 to 67.32</td>
<td>45.94 to 72.06</td>
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<tr>
<td>Internal rotation</td>
<td>56.5 (9.40)</td>
<td>44.93 to 68.27</td>
<td>37.35 to 75.95</td>
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