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Does it really spin? Intra-medullary nailing of segmental tibial fractures—A cadaveric study

Mateen H. Arastu [a], Brendan Sheehan [b], Elizabeth Oddone Paolucci [c,d], Richard E. Buckley [b,*]

[a] University Hospital Coventry and Warwickshire, Coventry, UK
[b] Division of Orthopaedic Trauma Surgery, Foothills Medical Centre, Calgary, Alberta, Canada
[c] Department of Surgery, Faculty of Medicine, University of Calgary, Alberta, Canada
[d] Department of Community Health Sciences, Faculty of Medicine, University of Calgary, Alberta, Canada

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ABSTRACT

This study aims to quantify the effect of intra-medullary reaming on rotational displacement of both long diaphyseal segmental tibial fractures (Melis Type III) and short (Melis Type IV) in a cadaveric model with differing degrees of soft tissue stripping.

Eighteen fresh-frozen cadaveric specimens (9 matched pairs), median age at death was 85 years (68–92) were used to perform a standardized reaming procedure for an intra-medullary tibial nail and the rotational displacement of the segmental fracture fragment (long and short diaphyseal fractures) was recorded. Rotational displacement was recorded using a goniometer and K-wires positioned in the proximal, segmental and distal fracture fragments.

Type III fractures rotate more than Type IV fractures ($p < 0.0001$). In Type III fractures reaming to fit with 0%, 50% and 100% soft tissue stripping resulted in rotational displacement of 11.7 SD 12), 13 (SD 16.5) and 307.3 (SD 118.1) degrees respectively. In Type IV fractures reaming to fit with 0%, 50% and 100% soft tissue stripping resulted in rotational displacement of 8.5 (SD 5.5), 12.7 (SD 9.9) and 135.3 (SD 147.1) degrees respectively. The use of a pointed reduction clamp or unicortical plate eliminated rotational displacement.

Reaming is a major risk factor for rotational displacement of segmental tibial fractures irrespective of the degree of soft tissue stripping. Long diaphyseal segmental fractures rotate more than shorter segmental fractures. We recommend always clamping the fracture during reaming to avoid rotational displacement.

Introduction

Segmental tibial fractures are rare and are often the result of high-energy trauma with significant soft tissue stripping at the site of injury. A classification of segmental tibial fractures was proposed by Melis et al. which included types I–IV (Fig. 1) [1]. Minimally invasive osteosynthesis techniques are paramount in order to preserve the soft tissue envelope around a fracture in order to maintain blood supply to promote fracture union and avoid complications [2]. Treatment of these difficult fractures remains controversial and includes non-operative management, open reduction and internal fixation, external fixation and intra-medullary nailing [1,3–10]. The associated complications with this injury pattern are non-union, delayed union, malunion, osteonecrosis and infection [1,11,12].

Techniques have been described in order to maintain the reduction of the fracture prior to intra-medullary reaming which include the use of a pointed reduction clamp to hold the segmental component of the fracture, temporary unicortical plating or using a Farabeuf clamp [1,11,13,14]. Rotational displacement is undesirable as it potentially will strip the remaining soft tissue vascular attachments to the fracture fragment and result in delayed healing, infection, malunion or non-union.

However, there is no scientific evidence in the literature that undesirable rotational displacement of segmental tibial fractures when treated with intra-medullary nailing is a direct consequence of reaming the fracture. This study aims to quantify the effect of intra-medullary reaming on rotational displacement of both long

* Corresponding author at: Division of Orthopaedic Trauma Surgery, Foothills Medical Centre, 0490 Ground Floor, McCaig Tower, 3134 Hospital Drive NW, Calgary, Alberta, Canada T2N 5A1. Tel.: +1 403 944 8371; fax: +1 403 270 8004.
E-mail address: buckclin@ucalgary.ca (R.E. Buckley).

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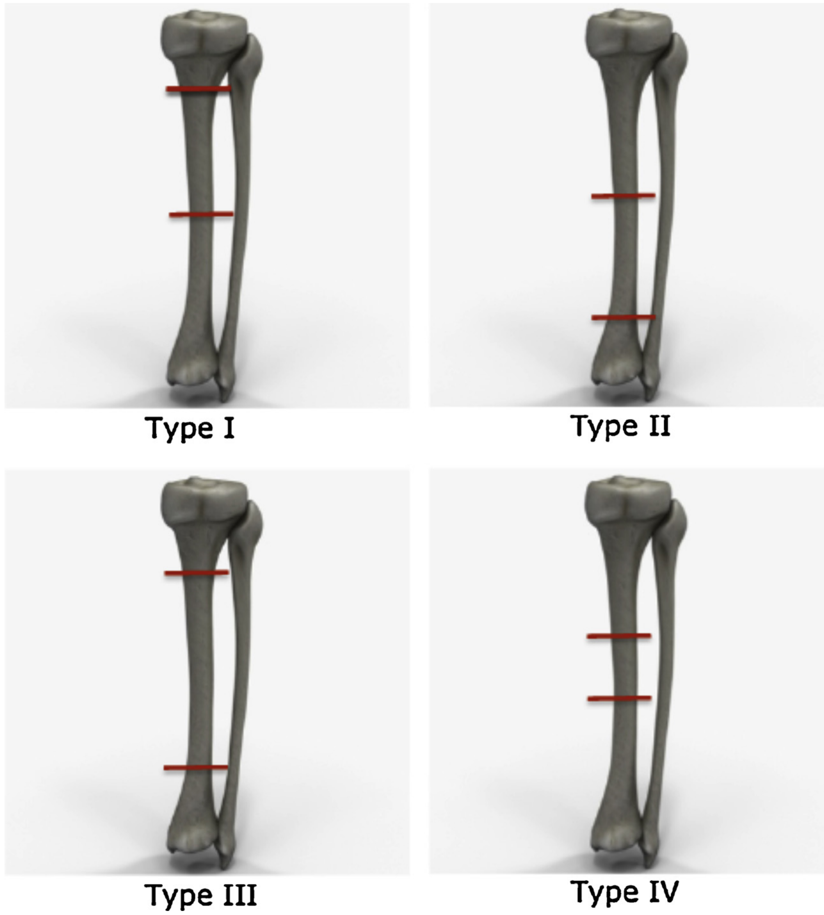

Fig. 1. Melis segmental tibia fracture classification. Type I – fractures in the proximal and middle third. Type II – fractures in the middle and distal third. Type III – fractures in the proximal and distal third creating a long central fracture fragment. Type IV – fractures in the middle third creating a short central fracture fragment.

diaphyseal segmental tibial fractures (Melis Type III) and short (Melis Type IV) in a cadaveric model with differing degrees of soft tissue stripping.

Materials and methods

Institutional Review Board approval was obtained to perform the study. Eighteen fresh-frozen lower limb cadaveric specimens (9 matched pairs) were obtained from Department of Anatomy, University of Calgary. One specimen was excluded secondary to pathologic bone and one specimen was used as a trial to optimize the methodology and time points for measuring rotational displacement. A total of 16 specimens were included in our final results. The median age of the cadaveric specimens was 85 years (68–92). There were 12 male specimens and 4 female specimens. The mean intra-medullary canal size for the specimens at ream to fit was 11.8 mm.

The cadaveric specimen was secured with a clamp around the femur and 1.6 mm unicortical K-wires were inserted into the tibial tuberosity, midportion of the segmental fracture fragment and mid malleolar point in a parallel fashion using a ruler (Fig. 2A and B). Small vertical stab incisions were used and an oscillating saw (1.5 cm blade) used to create a transverse segmental tibia fracture, either 2.5 cm (Melis Type IV fracture) or 12 cm (Melis Type III fracture) in length with the midportion of the tibia (isthmus) at the centre of the fracture fragment (measured equidistant from the tibial plafond and plateau). This process was repeated to create a same level segmental fibula fracture either 3.5 cm or 12 cm in length. With the fracture reduced, all three K-wires were parallel. A total of 8 Type III and 8 Type IV fractures were used.

Soft tissue stripping was performed sharply with a scalpel blade. In the specimens classified as 0% soft tissue stripping access to the segmental fracture to use the oscillating saw was made by 2 cm vertical incisions over the antero-medial border of the tibia; 50% soft tissue stripping all of the soft tissue attachments were removed from the antero-lateral border of the tibia and inter-osseous membrane was left intact. When 100% soft tissue stripping was performed, all of the antero-lateral and posterior tissues including the inter-osseous membrane were dissected from the segmental tibial fragment. Linear circumferential incisions were used to create tracts for the K-wires to rotate freely as during the methodology optimization K-wires were not fully rotating due to soft tissue impedance (Fig. 3). If a greater degree of rotational displacement occurred then the K-wire in the intermediate fragment was removed in order to visualize this and prevent impedance of rotation.

A medial parapatellar approach was used to perform a standardized intra-medullary reaming technique with new reamers (Expert Tibial Nail, Synthes, Mississauga, ON, Canada) starting with an 8.5 mm end-cutting reamer then increased sequentially in 0.5 mm increments until the canal had been over reamed by one reamer size. The size at which ream to fit was achieved was noted for each specimen when cortical chatter was first achieved. As the tibia was reamed by one investigator, a second maintained a manual reduction of the fracture fragment using axial load. The degree of axial load applied was judged by the investigator in order to maintain an adequate fracture reduction under direct visualization as may occur during freehand intra-medullary tibial nail. The fracture fragment was anatomically reduced under direct