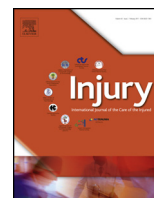




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## High incidence of screw penetration in the proximal and distal tibiofibular joints after intramedullary nailing of tibial fractures—A prospective cohort and mapping study

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### ABSTRACT

**Background:** Intramedullary-nails (IMN) are the treatment of choice for most tibial shaft fractures due to their minimally-invasive nature and non-demanding surgical technique. However, a potential iatrogenic pitfall is intra-articular interlocking screw positioning within the proximal (PTFJ) and distal (DTFJ) tibiofibular joints that may go unrecognized.

**Objective:** To evaluate the incidence of intra-articular screw penetration of the PTFJ and DTFJs after interlocking of IMN for tibial fractures.

**Intervention:** Reamed IMN using modern techniques, including proximal interlocking via standard aiming jig and distal interlocking either freehand or using SureShot<sup>®</sup>.

**Methods:** Prospective series of 165 consecutive patients with a tibial shaft fracture managed with an IMN. Diagnosis and incidence of penetration of the PTFJ and DTFJ was assessed on protocolled low-dose postoperative CT-scans (standardized clinical practice for assessing rotational alignment). The degree of penetration of the TFJ's was graded as: Grade 1—slight breach of the tibial cortex; Grade 2—clear penetration of the tibial cortex with intra-articular screw tip; and Grade 3—penetration of both tibial- and fibular cortices with screw tip in fibula.

**Results:** Of the 165 tibial shaft fractures, using the AO/OTA classification, 69% were simple, 16% wedge and 15% complex fractures. Following IMN 42% of patients had intra-articular screw penetration of their PTFJ whilst 39% had penetration of their DTFJ. 66% of patients had penetration of either one- or both of their TFJs. The grading of PTFJ violation was distributed as follows: Grade 1 in 24 patients; Grade 2 in 26 patients and Grade 3 in 19 patients. DTFJ violation was graded as: Grade 1 in 21 patients; 40 patients had Grade 2 violation; and four patients had a Grade 3 penetration.

**Conclusions:** This diagnostic imaging study reports a high rate of intra-articular screw penetration of the PTFJ and DTFJ after interlocking of IMN for tibia shaft fractures. A prospective cohort study is underway to evaluate its clinical significance.

Changes to enable alteration in forced angle of interlocking screw trajectory and avoidance of the anteromedial to posterolateral locking screw may reduce the incidence of TJJ violation.

**Level of evidence:** Level II – Diagnostic Imaging Study

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### Introduction

Tibial fractures are relatively common, and diaphyseal tibial fractures account for approximately 3–4% of all reported long bone fractures [1–3]. They are usually associated with low velocity

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torsional injuries in the older population, and high energy blunt trauma in the younger population [4]. The majority of these fractures are managed with intramedullary nails (IMN) using modern surgical techniques. This is secondary to advantages such as a simple and reproducible technique, enhanced fracture haematoma and soft tissue preservation, and low/predictable rates of infection, non-union and mal-union [5–8]. Not only are IMN's the treatment of choice for the above reasons they have also been shown to have long-term functional outcomes comparable to the population norm [6]. However, IMN has been associated with a number of complications including rotational malalignment, anterior knee pain, reduced knee and ankle range of motion and propagation of the fracture [9–16].

In 2010, Laidlaw and colleagues [17] raised awareness of a less frequently quoted complication: proximal tibiofibular joint (PTFJ) pain which they attributed to PTFJ screw locking screw penetration. In this study they identified two patients with lateral sided knee pain and accompanying computed tomography (CT) identifying screw penetration of the PTFJ. Subsequently, Labronic and colleagues [15] analysed a cohort of patients reporting lateral sided knee pain following placement of an IMN for a diaphyseal tibial fracture. They identified that in 70% of those patients with lateral sided knee pain, CT scans revealed PTFJ penetration by locking screws. Based on their clinical observation in two patients, Laidlaw [17] undertook a cadaveric study identifying a “danger zone” or an angle of screw trajectory that would most likely violate the PTFJ if screw length selection was incorrect.

However, although the etiopathogenesis of lateral sided knee pain is clinically suspected to be secondary to PTFJ screw penetration, to the best of our knowledge the overall incidence of PTFJ locking screw penetration in patients undergoing IMN for tibial shaft fractures remains unknown. Conversely when looking at the distal tibiofibular joint (DTFJ) we were unable to find any case series or studies addressing the issues of DTFJ interlocking screw penetration following IMN of tibial fractures. For this reason, we aimed to evaluate the incidence and degree of intra-articular screw penetration of the – PTFJ and DTFJ after interlocking of IMNs for diaphyseal tibial fractures using modern techniques. Hence, we undertook a large prospective cohort study of 165 patients, who underwent a bilateral low-dose CT for the assessment of rotational malalignment as per institutional protocol. Our hypothesis was that intra-articular PTFJ and DTFJ locking screw penetration is uncommon when evaluated prospectively in patients –not selected for any particular clinical symptoms– in a large prospective cohort study.

## Materials & methods

Our Institutional Review Board (IRB) waived requirement for approval of this imaging study, in accordance to the Declaration of Helsinki.

### Study subjects

Between January 2009 and September 2016, 165 consecutive patients at our level one trauma hospital underwent protocolled low-dose bilateral CT-scan with tibial shaft fractures treated with a locked IMN for assessment for rotational malalignment of the tibia. For patients to be included in the study they were required to be over the age of 12 years, and to have suffered a unilateral tibial fracture amenable to treatment with an IMN. Patients that fulfilled the above criteria, though did not have a CT scan encapsulating the PTFJ and DTFJ adequately were excluded from the study.

One hundred and eighteen (71%) males and 47 (29%) females aged between fourteen and 90 years of age (mean = 42 years) were identified as eligible for inclusion in this diagnostic imaging study. Patients were classified according to the AO/OTA classification system [18] into groups: 113 (69%) were simple fractures, 27 (16%)

were wedge type, and 25 (15%) complex. Ninety-nine patients (60%) had mid-shaft (middle third) fractures, 47 (29%) distal third, six (3%) proximal third and thirteen (8%) were segmental. There were 44 (26%) compound injuries. In 131 subjects the tibial shaft ( $\pm$ fibular) fracture was an isolated injury (80%), whilst in the remaining 20% they had been involved in a multi-trauma. Nine patients were identified as having compartment syndrome pre-operatively and subsequently underwent fasciotomies either prior to or at the same time as definitive management of the tibial shaft fracture. One hundred and thirty-two patients (80%) had an associated fibular fracture (24 distal, 30 proximal, 65 shaft, 13 segmental), whilst 27 patients (16%) had a posterior malleolar fracture. Depicted in Table 1.

### Surgical technique

All IMN procedures were undertaken at a single institution, and were conducted by a mix of consultants (9), and supervised trainees (51) representing daily practice in our Level I Trauma Centre. All 165 included patients were treated with a standard IMN system (TRIGEN META-Nail Smith & Nephew, USA [19]), and reamed as per the treating surgeon's routine. Distal screw interlocking was performed either by freehand using the perfect circles technique with intraoperative image intensifier or using the TRIGEN SURESHOT<sup>®</sup> Distal Targeting System (TRIGEN META Nail, Smith & Nephew, USA [19]). Single leg preparation with positioning bolster and intraoperative plain fluoroscopy was used in all cases.

The average nail-length was 340 mm (range, 260–400 mm) and width averaging 10 mm (range, 8.5–13 mm). All patients had at least one interlocking screw placed both proximally and distally, with a total of 310 proximal interlocking screws and 356 distal interlocking screws being placed with aid of the standard IMN jig proximally and either plain image intensifier or TRIGEN SURESHOT distally (TRIGEN META-Nail Smith & Nephew, USA [19]).

### Computed tomography CT scanning protocol

As part of the standard institutional postoperative protocol, all patients underwent a protocolled bilateral low-dose CT scan, for

**Table 1**  
Patient and Fracture Characteristics.

Patient Characteristics	Breakdown
Male: Female	117:48
Age	14–90 (Mean 42 yrs)
Multi-trauma	33 (20%)
Left: Right	80:85
Fracture Characteristics	Breakdown (%)
<i>Fracture Location</i>	
Proximal	6 (3)
Shaft	99 (60)
Distal	47 (29)
Segmental	13 (8)
<i>Fracture Classification</i>	
Simple	113 (69)
Wedge	27 (16)
Complex	25 (15)
<i>Associated Injuries</i>	
Compound injury	44 (27)
Compartment Syndrome	9 (5)
Posterior Malleolar Fracture	27 (16)
<i>Fibular fracture</i>	
Proximal	132 (80)
Shaft	30 (23)
Distal	65 (49)
Segmental	24 (18)
	13 (10)

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