Painful locking screws with tibial nailing, an underestimated complication

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Abstract

Background Tibial fractures represent approximately 3–4% of reported fractures. Locked, intramedullary nails are commonly used to restore length and alignment and provide rotational stability. Few studies have assessed the complication rate of locking screws.

Materials and methods We conducted a retrospective observational study of all patients who underwent tibial nailing at our institution between the 01/01/15 and 30/06/17. All patients were followed up for at least 1 year post-operatively. For inclusion, patients had to be over 16 years of age and had undergone tibial nail fixation following a traumatic fracture. Post-operative radiographs were used to assess the configuration and features of locking screws.

Results One hundred and twenty-six individuals underwent tibial nailing over the 30-month period, with 95 followed up at least 1 year. Twenty-seven per cent of individuals reported pain attributed to locking screws at follow-up. Upon radiographic assessment, no significant difference was seen between symptomatic and asymptomatic cohorts in terms of proud screw heads proximally (7% vs 5%, $p > 0.99$) or distally (14% vs 17%, $p > 0.99$), long screw tips proximally (52% vs 48%, $p = 0.81$) or distally (51% vs 50%, $p > 0.99$), or tibiofibular joint penetration proximally (31% vs 23%, $p = 0.60$). However, there was a higher incidence of distal tibiofibular joint penetration in symptomatic versus asymptomatic individuals (4% vs 25%, $p = 0.025$).

Conclusion Twenty-seven per cent of patients with a tibial nail report painful locking screws. Patients with symptomatic distal locking screws had a higher incidence of radiographic distal tibiofibular joint penetration.

Keywords Tibial fractures · Surgery · Fracture fixation · Intramedullary · Complications · Intramedullary nailing

Introduction

Tibial shaft fractures are common, with an estimated incidence of 21.5/100,000/year in men and 12.3/100,000/year in women [1, 2]. The peak incidence in males is between 10 and 20 years of age, whilst in women, it is between 30 and 40 years of age, with commonly reported mechanisms of injury including sports, walking, indoor activities and road traffic accidents [1].

Long bone nailing is a technique used since the early twentieth century by Hey Groves on gunshot fractures before being developed in the 1940s by Gerard Kuntscher to produce 'marrow nailing' [3]. Initial 'marrow nailing' relied on the elastic fit of the nail within the medullary canal for stability. The 1970s saw the addition of locking screws that hugely improved the construct's ability to control length, alignment and rotation [4, 5]. Tibial nails can be inserted with or without prior reaming of the medullary canal [6]. More recent developments in intramedullary tibial nailing (IMN) include the introduction of obliquely orientated locking screws to help prevent malalignment [7] and the suprapatellar approach for nail insertion to avoid disruption of the patellar retinaculum [8]. Contemporary patients undergoing tibial nailing have demonstrated long-term functional outcomes comparable to the normal population [9].

Studies of post-operative complications of tibial nailing have concentrated on anterior knee pain with an incidence reported from 10 to 86%. Yet few studies have investigated other causes of pain in IMN. A small number of studies have identified penetration of tibiofibular joints by locking

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screws and proposed this as an iatrogenic cause of post-operative pain [10–12]. Two of these studies used computed tomography (CT) assessment of the proximal tibiofibular joint (PTFJ) in small numbers of patients reporting pain post-operatively, 2 and 30, respectively. Another study by Cain et al evaluated locking screw position using CT in 165 patients post-tibial IMN fixation in relation to both proximal and distal tibiofibular joints; however, the incidence of associated pain was not known in this cohort.

We present the findings of a retrospective observational study aimed to determine the reported incidence of post-operative pain associated with locking screws within our institution and assess for correlation with radiographic features of the screws.

Materials and methods

We conducted a retrospective observational study investigating all patients who underwent IMN fixation for a tibial shaft fracture at our institution between the 1 January 2015 and the 30 June 2017. For inclusion, patients had to be over 16 years of age and had undergone tibial IMN fixation following a traumatic fracture. Patients were excluded if there was no available follow-up documentation. Patients were initially identified through TheatreMan software by searching for listed surgeries containing keywords 'tibia' and 'nail' within the specified time period. Patient demographics and information regarding whether the fracture was open or closed was obtained using Electronic Patient Records (EPR). All patients were followed up for at least 1 year post-operatively.

All tibial nail fixations were performed under consultant supervision in a level I trauma centre complying with BOAST guidelines [13]. Operations were performed without a tourniquet in a laminar flow theatre. Patients received a general anaesthetic with prophylactic Augmentin at induction. A suprapatellar or infra-patellar approach was used, and a Stryker (Newbury, UK) tibial nail was used for all operations.

Data were extracted by two of the authors (PB and SM) reviewing complications recorded from letters completed following fracture clinic follow-up. These clinic letters had been scanned and uploaded onto Electronic Patient Records. Time to onset of pain was recorded as the date of the first clinic letter in which it was documented. Subsequently, the radiographic union score in tibial fractures (RUST) [14] was calculated for the radiograph performed in closest proximity to the first letter attributing pain to locking screws.

Initial post-op radiographs (anteroposterior, AP, and lateral views) were used to establish configuration of locking screws and assess screws for head prominence, long screw tips and whether tibiofibular joints appeared penetrated proximally or distally Fig. 1a–c. Screw heads were recorded as prominent if there were > 2 threads between the head of the screw and bone. Screw tips were recorded as long if there were > 2 threads between the tip of the screw and bone.

Demographics and complications were collected by two researchers independent of the operating surgeons into a Microsoft Excel (Reading, UK) spreadsheet and subsequently anonymized prior to analysis. Radiographic assessment was performed for all individuals by one researcher (PB), before 20 records were analysed again by the first researcher and independently by a second researcher (TA) to assess for intra- and inter-observer variability. Reliability was assessed by calculating the kappa coefficient for radiographic features recorded.

Statistical analysis was performed using GraphPad Prism (Prism version 7.0c for Mac, GraphPad Software, La Jolla California USA, www.graphpad.com). Fisher's exact test was used to compare prevalence of radiographic features between symptomatic and asymptomatic cohorts, with $p < 0.05$ considered to be significant. Statistical analysis performed by PB and checked by SM.
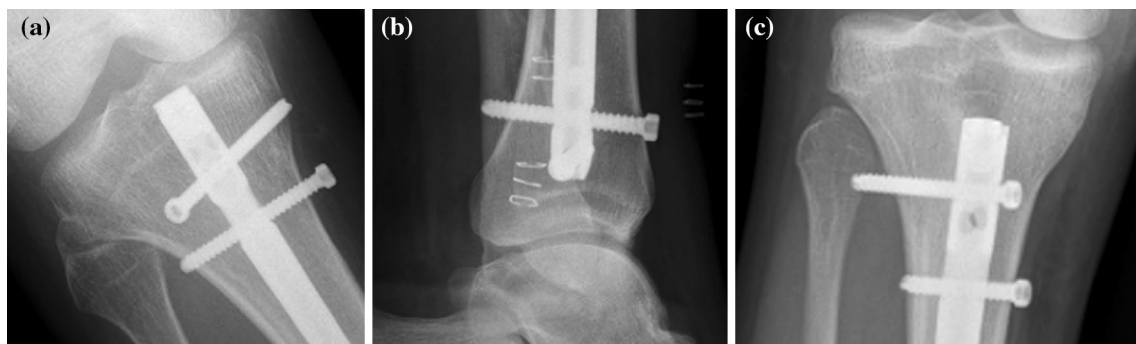
Fig. 1 **a** Proud screw head proximally. **b** Long AP screw tip distally. **c** AP view demonstrating PTFJ penetration

Results

One hundred and twenty-six patients over the age of 16 years underwent tibial nailing over the 30-month period. Twenty-eight of these did not complete a full year of follow-up at our trauma centre and instead would have been transferred back to the care of their local hospital. Patient demographics are summarized in Table 1. Of the 95 individuals included in the study, 78% were male, and mean age was 42 (range 16–90) years. Closed fractures accounted for 53% of presentations. Of the fractures presenting open, 42% required a plastic surgical procedure for soft tissue management. Initial tibial nail fixation occurred at a mean of 1.7 (range 0–14) days following injury.
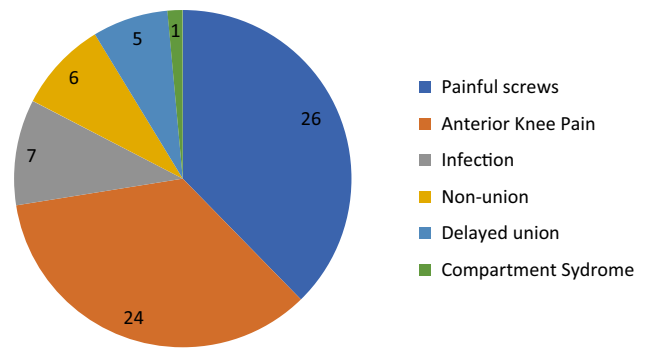
Twenty-seven per cent of patients reported post-operative pain associated with locking screws. Fifteen per cent reported only symptomatic proximal locking screws, 5% reported only symptomatic distal locking screws, and 7% reported both symptomatic proximal and distal locking screws. Other complications recorded were anterior knee pain (24%), post-operative infection (7%), non-union (6%), delayed union (5%) and compartment syndrome (1%) (Fig. 2).

Proximal locking screws were configured as oblique only (45%), oblique and lateral (42%) or lateral only (12%). Distal locking screws were configured lateral only (67%), lateral and anteroposterior (32%) or anteroposterior only (1%) (Table 2). There was no significant difference observed in the breakdown of proximal screw configuration between asymptomatic and symptomatic patients: oblique only (two screws) (43% vs 48%, $p = 0.81$), oblique and lateral (two screws) (35% vs 24%, $p = 0.43$), oblique and lateral (three screws) (8% vs 14%, $p = 0.41$) or lateral only (two screws) (11% vs 14%, $p = 0.70$). No significant difference was observed in the breakdown of distal screw configuration between asymptomatic and symptomatic patients: lateral only (two screws) (67% vs 67%, $p > 0.99$), lateral and anteroposterior (two screws) (7% vs 8%, $p > 0.99$) or lateral and anteroposterior (three screws) (24% vs 25%, $p > 0.99$).

Radiographic assessment of proximal locking screws did not demonstrate any significant difference between symptomatic and asymptomatic patients with regard to

Fig. 2 Breakdown of complications recorded

proud screw heads (7% vs 5%, $p > 0.99$), long screw tips (52% vs 48%, $p = 0.81$) or screws penetrating the tibiofibular joint (31% vs 23%, $p = 0.60$). Distally, there was no significant difference observed between asymptomatic and symptomatic patients with regard to proud screw heads (14% vs 17%, $p > 0.99$) or long screw tips (51% vs 50%, $p > 0.99$). However, there was a significantly higher observed rate of screws penetrating the distal tibiofibular joint in those reporting pain as opposed to those who were asymptomatic (4% vs 25%, $p = 0.025$) (Table 3). Kappa coefficient for inter-observer reliability was 0.445 (moderate), and for intra-observer reliability, it was 0.74 (good).

Time to onset of pain attributed to locking screws was variable between patients affected (Table 4). RUST scores of radiographs at time of pain onset were as follows (mean, range): 0–3 months (10, 9–11), 3–6 months (10.5, 8–12), 6–9 months (11.6, 11–12), 9–12 months (11, 10–12), > 12 months (11.875, 11–12).

Table 1 Patient demographics

Mean age, years (range)	42 (16–90)
Male	78%
Female	22%
Open fracture	47%
Closed fracture	53%
Mean days to surgery (range)	1.7 (0–14)

Table 2 Summary of whole cohort screw configuration and radiographic features

	Proximal	Distal
Screw configuration		
AP only	–	1%
Oblique only	45%	–
Lateral only	13%	67%
AP and lateral	–	32%
Oblique and lateral	42%	–
Screw features		
Screw head proud (AP)	–	3%
Screw head proud (Lateral)	6%	12%
Screw tip long (AP)	–	10%
Screw tip long (oblique)	24%	–
Screw tip long (lateral)	32%	39%
Penetrating tibiofibular joint	25%	5%

Table 3 Comparison radiographic features between asymptomatic and painful cohort (TFJ—tibiofibular joint)

	Asymptomatic proximal (%)	Painful proximal (%)	p Value	Asymptomatic distal (%)	Painful distal (%)	p Value
Head proud	7	5	> 0.99	14	17	> 0.99
Tip long	52	48	0.81	51	50	> 0.99
Penetrating TFJ	31	23	0.60	4	25	0.025

Table 4 Breakdown of time to recorded onset of pain and RUST score (RUST—radiographic union score for tibial fractures)

Time from surgery (months)	0–3	3–6	6–9	9–12	>12
Number of patients	3	4	5	7	7
Average RUST score	10	10.5	11.6	11	12

Discussion

In our study, we have demonstrated a significant burden of post-operative pain attributed to symptomatic locking screws, with 27% of patients reporting them as painful in follow-up. To our knowledge, this is the largest study to date that assesses radiographic features of locking screws in patients having undergone tibial nailing to compare with symptomatic prevalence.

Within our cohort, 15% of individuals reported symptomatic proximal locking screws only, 5% reported symptomatic distal locking screws only and 7% reported both symptomatic proximal and distal locking screws. However, assessment of post-operative radiographs did not demonstrate an association between most radiographic features assessed (proud screw head, long screw tip, penetrating proximal tibiofibular joint) and clinical incidence of symptomatic screws. In addition, RUST evaluation of radiographs around time of pain onset failed to demonstrate a significant contribution of delayed or non-union to presentation of painful locking screws.

Laidlaw et al. initially demonstrated disruption of the proximal tibiofibular joint (PTFJ) caused by locking screw penetration with CT imaging of two patients presenting with lateral/posterolateral knee pain after tibial nailing. They furthered their study through imaging and cadaveric investigation to identify a 'danger zone'. The 'danger zone' was found to be between 44.7° and 72.1° on the right and between 40.6° and 73.0° on the left, and four different tibial nail prostheses were demonstrated to project proximal locking screws in its direction.

Labronici et al. subsequently illustrated penetration of the PTFJ on a slightly larger scale. They performed imaging on a cohort of 30 patients reporting knee pain post-operatively and found that 68.9% had penetration of the PTFJ by a locking screw [11]. Penetration of the distal tibiofibular joint was not assessed in this study. Not all patients with penetration of the PTFJ experience pain in this study, as the results of our study echo.

The only study that has assessed both tibiofibular joints is by Cain et al. who imaged all tibial nails post-operatively as part of their institutional protocol and examined both the PTFJ and distal tibiofibular joint (DTFJ) for locking screw penetration. They found that 42% had PTFJ disruption and 39% had DTFJ disruption, combined to demonstrate that 66% of patients had disruption of at least one tibiofibular joint [12]. However, this study does not include patient symptoms and as such is unable to comment on correlation of pain with joint penetration.

Our results, in addition to the current literature, suggest that tibiofibular joint penetration by locking screws is a cause of post-operative pain distally. To reduce the incidence of intra-articular locking screws, intra-operative imaging must be effectively utilized, and this could include anteroposterior and lateral assessment at distal locking screw insertion and oblique imaging at proximal locking screw insertion. The oblique proximal radiograph could be taken perpendicular to the angle of the 'danger zone' previously identified.

Limitations of this study are that it is a retrospective analysis of data from only one level I major trauma centre with a high volume of lower limb trauma. No standardized pain tool was used in follow-up, and thus, we cannot comment on the degree of pain experienced by patients in relation to symptomatic screws. Future prospective work should look to clarify that patient's symptoms resolve upon removal of the attributed troublesome locking screws.

Conclusion

Painful locking screws are an under-reported complication with 27% of patients with a tibial nail complaining of pain from locking screws. Patients experiencing distal pain associated with locking were significantly more likely to demonstrate radiographic joint penetration. Surgeons should consider carefully the screw length and configuration when inserting a tibial nail.

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest to disclose.

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