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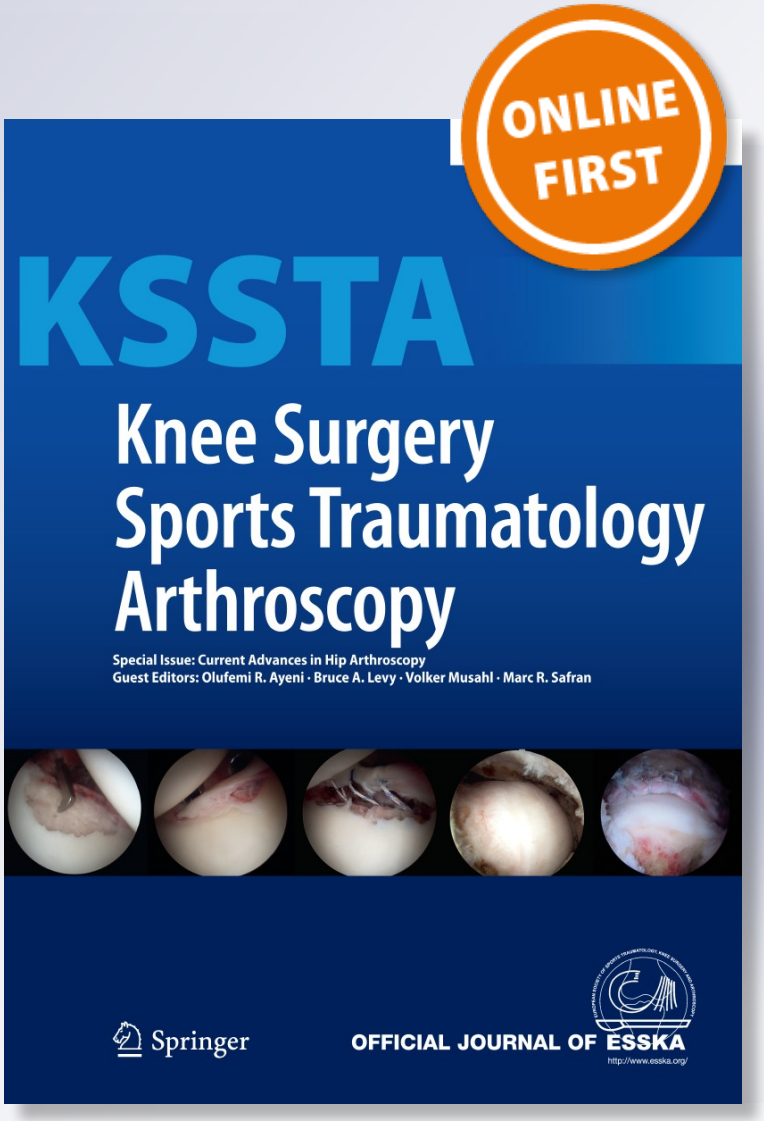

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Anterior meniscus root avulsion following intramedullary nailing for a tibial shaft fracture

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Abstract This paper presents the first reported case of iatrogenic injury to the anterior medial meniscal root attachment following intramedullary nailing for a tibial shaft fracture. The patient experienced a closed right tibia–fibula fracture 7 years prior to presentation, which was treated with a reamed intramedullary nail. The nail was removed 3 years after the index surgery due to chronic anterior knee pain, which persisted following hardware removal. At presentation, the patient was diagnosed with an anterior horn medial meniscal root tear likely secondary to insertion of the intramedullary nail through the anatomic footprint of the anterior medial root. After undergoing a medial meniscus anterior horn root repair, the patient was asymptomatic and resumed normal activities.
Level of evidence Case report, Level IV.

Keywords Intramedullary tibial nailing · Meniscus root avulsion · Tibial shaft fracture · Medial meniscus · Anterior meniscus root

Introduction

Tibial shaft fractures are the most common long bone fracture [7]. The treatment of choice for these injuries is reamed intramedullary nailing, which leads to a higher rate of union, decreased risk of malalignment, and decreased time to weight bearing when compared with closed treatment [3, 7, 10, 14, 18]. However, intramedullary nailing is not without complications, including knee pain, arthritis, malunion, non-union, and malrotation [3, 6, 7, 14, 22]. The most common complication, anterior knee pain, has been reported in between 56 and 73 % of patients following reamed tibial IMN [6, 14].

The aetiology for anterior knee pain is complex and likely multifactorial. Previous studies have suggested that incisional pain, prominence of the nail above the plateau, residual fracture malalignment, and intra-articular cartilage damage may each contribute to knee pain following nail insertion [6, 7, 14]. Yet another potential aetiology of anterior knee pain is iatrogenic injury to the anterior horn of the medial meniscus because the anterior medial meniscal root footprint lies in close vicinity to the recommended starting point for tibial nail insertion [9, 12, 23]. This injury may lead to profound negative sequelae in the knee over time, including anterior pain, rapid cartilage degeneration, and early arthritis [11, 20].

The purpose of this report is to describe a case of iatrogenic injury to the anterior medial meniscal root attachment following intramedullary nailing for a tibial shaft fracture. To our knowledge, a meniscal root tear following intramedullary tibial nailing in a clinical setting has not been previously reported in the literature.

Investigation performed at the Steadman Philippon Research Institute, Vail, Colorado.

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Case report

A 38-year-old male presented to clinic with right anteromedial knee pain. The patient's past surgical history included a closed right tibia–fibula fracture 7 years prior to presentation that was treated with a reamed intramedullary nail and healed without complication. The nail was removed 3 years later secondary to chronic knee pain. At presentation, he reported persistent, chronic anteromedial knee pain unrelieved following nail removal that was worse with deep flexion and squatting activities. On physical examination, right knee range of motion was slightly limited compared to his contralateral knee in deep flexion due to anteromedial joint line pain. Palpation of the anteromedial joint line revealed tenderness and extrusion of the anterior horn of the medial meniscus.

Previous radiographs demonstrated an intramedullary tibial nail with an apparently appropriate starting point on the tibial plateau. His presenting radiographs revealed mild medial joint space narrowing and subchondral sclerosis. Magnetic resonance imaging (MRI) demonstrated detachment of the anterior horn of the medial meniscus with medial meniscal extrusion (Fig. 1). These images suggested that the nail placement detached the anterior root of the medial meniscus from its anatomic footprint.

During arthroscopic surgery, mild chondromalacia was noted along the anterior aspect of his medial compartment. The anterior horn of the medial meniscus was detached from its root attachment site on the anterior aspect of the tibial plateau, with the root adhered in a bed of scar tissue approximately 1 cm medial to the normal attachment site (Fig. 2a). The anterior horn was released from its extruded position and reduced to its normal anatomic position, and the tibial nail insertion site was verified to have overlapped with this normal anatomic attachment (Fig. 2b). Two simple non-absorbable sutures were placed through the root using a suture passer (Fig. 2c). Using a standard transosseous suture repair technique [11], a 5-mm bone tunnel was then reamed at the root attachment site to secure the meniscus to the proximal tibia, exiting the tibia anterolaterally to maintain in-line tension on the sutures. The sutures were then secured over a button on the anterolateral tibia with the knee flexed to 90°. Given the minimal bone stock remaining following his prior surgeries, a suture anchor was also placed in the tibial plateau just medial to the anatomic footprint for supplemental fixation. The anchor sutures were fed into the meniscal root, and probing of the final construct demonstrated a stable root repair.

Postoperatively, the patient was non-weight bearing for 6 weeks with knee motion initiating on postoperative day 1 from 0° to 90°. Full range of motion was allowed at 4 weeks following surgery, and weight bearing was advanced to full 6 weeks following surgery. By 2 months postoperatively, the patient had regained full knee motion and was asymptomatic. He noted that he could no longer palpate his anteriorly subluxed meniscus as he was able to do preoperatively. By 5 months, he had returned to high impact activities, including running, jumping, and full-time work.

Discussion

The most important finding of this case was the previously unreported complication of iatrogenic medial meniscal

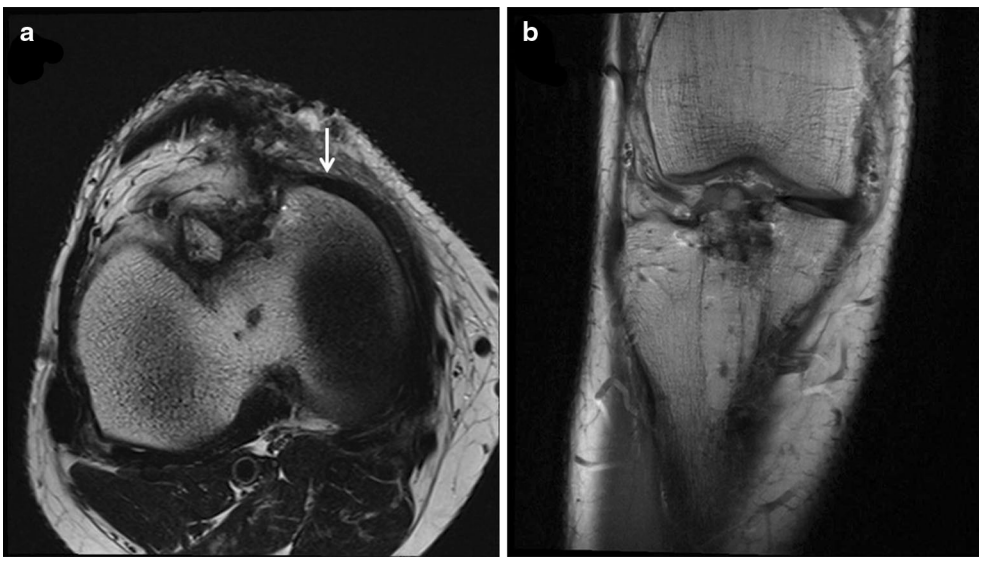

Fig. 1 Axial (**a**) and coronal (**b**) MR T2 fat suppression images demonstrating the insertion site of the tibial nail over the footprint of the anterior medial meniscal root, with an associated anterior medial meniscal root avulsion and anterior meniscal extrusion (*white arrow*)

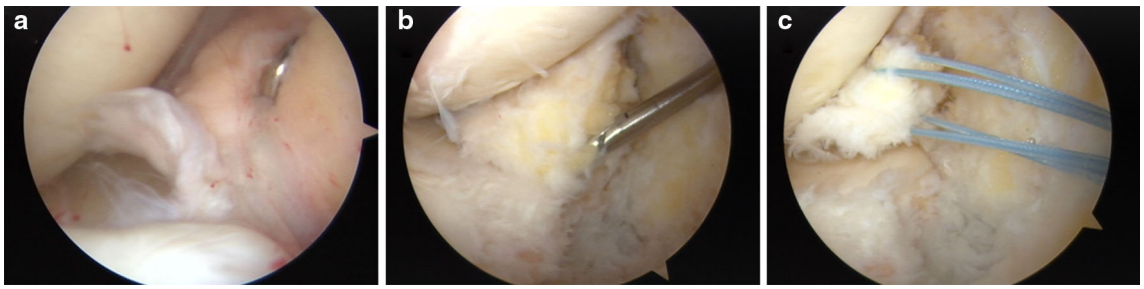

Fig. 2 Arthroscopic images demonstrating: **a** avulsion of the anterior root of medial meniscus; **b** tibial nail insertion site over anatomic footprint of root attachment site; and **c** sutures placed within anterior medial meniscal root in preparation for fixation through bone tunnel

anterior root avulsion after intramedullary nail treatment for a tibial shaft fracture. Given the high incidence of tibia fractures treated with an intramedullary nail [7], and the only recently discovered biomechanical and clinical importance of maintaining meniscal root integrity [1, 8, 11, 13, 19–21], this case elucidates the potential for iatrogenic meniscal root injury during tibial nail insertion to cause anterior knee pain and/or early joint degeneration.

Meniscal root tears result in a disruption of load distribution in the knee joint, meniscal extrusion, and an alteration in knee biomechanics and kinematics [5, 11, 13, 15, 16, 19, 20]. Alarmingly, a posterior horn medial meniscal root tear has been reported to result in a condition biomechanically similar to a total meniscectomy [1]. To date, the anatomy and function of the anterior meniscal root attachments remain largely unknown. Costa et al. [5] reported that anterior horn medial meniscal root tears result in >3 mm of meniscal extrusion, which has been associated with significant cartilage degeneration in radiographic studies [15]. Therefore, similar to posterior meniscal root avulsions, anterior root avulsions may result in the rapid development of degenerative joint disease as well.

The current recommendation for proper tibial nail insertion is to place the starting guidewire in-line with the medial aspect of the lateral tibial eminence on the AP radiograph and just proximal to the anterior articular margin on the lateral view [7, 17, 23]. This starting point has been reported to prevent iatrogenic damage to intra-articular structures [4, 17, 23]. In a cadaveric study, Tornetta et al. [23] described a safe zone for intramedullary nail placement that avoids damage to the menisci or articular cartilage of the knee, which corresponds radiographically to a point just medial to the lateral tibial eminence [17]. However, even with this starting point, intra-articular structural damage occurred in 20 % of their specimens, and an additional 30 % demonstrated the nail to be subjacent to one of the menisci [23]. The authors cautioned that the safe zone for nail placement is quite small and can be exceeded if a reamed nail is used.

Studies have described the anterior root as inserting in-line with the medial tibial eminence at an average of 7 mm anterior to the ACL tibial insertion [9] with a large cross-sectional attachment area reported to range from 61 to 139 mm^2 [9, 12]. In addition, three of the four variable insertion sites of the anterior medial meniscal root, which accounted for 97 % of knees in a study by Berlet and Fowler [2], were inserted on the anterior portions of the medial tibial plateau or intercondylar region of the tibial plateau. Therefore, given the recommended starting point for guidewire insertion, tibial nail insertion, and reaming may impart a high risk of directly avulsing some or all of the anterior medial meniscal root.

Conclusions

This case is the first to elucidate an iatrogenic anterior medial meniscal root avulsion after insertion of a tibial intramedullary nail for a diaphyseal tibia fracture. This injury resulted in long-term, chronic pain for the patient and was resolved with an anterior medial meniscus root repair. Further studies should investigate whether the area of the anterior root insertion and current recommended starting point for tibial intramedullary nails do indeed overlap, as suggested in this case and previous studies.

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