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CASE REPORT

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Marginal fractures of the medial tibial plateau: possible association with medial meniscal root tear

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Abstract We report two cases of marginal fractures of the medial tibial plateau associated with medial meniscal root tears. Both patients sustained knee dislocations, with complete tears of the posterior horn medial meniscal root. One sustained a "reverse Segond fracture"; the other sustained an "anteromedial impingement fracture" of the tibial plateau. The meniscal root tears were arthroscopically confirmed and repaired. In the first patient, the integrity of the meniscal root repair was confirmed at a 6-month follow-up arthroscopy for lysis of adhesions. In the second patient, follow-up MRI at 10 months demonstrated a healed meniscal root. The association of medial meniscal root tear with marginal fractures of the medial tibial plateau has not been previously reported.

Keywords Magnetic resonance imaging · Knee dislocation · Reverse Segond fracture · Tibial plateau · Medial meniscal root

Introduction

Marginal fractures of the medial tibial plateau have been amply reported in the literature as markers for significant internal derangement of the knee. These previous reports, however, did not describe concomitant injury to the root of the medial meniscus [1–4]. Posterior horn medial meniscal root tears permit pathologic extrusion of the medial meniscus at the medial joint line, and contribute to the development of accelerated medial femorotibial compartment degenerative arthritis [5–8]. In an effort to prevent medial compartment degenerative arthritis in two young individuals, arthroscopic repair of the posterior horn medial meniscal root avulsion was performed, in both cases utilizing a posteromedial portal and modified traditional knee arthroscopic techniques. Our purpose is to describe two cases of traumatic avulsion of the posterior horn medial meniscal root associated with marginal fractures of the medial tibial plateau and multiligament tears.

Case report

Case 1

An 18-year-old female pedestrian struck by an automobile sustained injury to her right knee. By history, she sustained transient femorotibial dislocation. Examination under anesthesia demonstrated incompetence of the medial collateral ligament, anterior and posterior cruciate ligaments. Radiographs of the knee revealed a triangular avulsion fracture fragment arising from the medial margin of the tibial plateau (Fig. 1a). Magnetic resonance imaging (MRI) confirmed clinically suspected femoral avulsions of the anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL), and an avulsion fracture of the medial corner of the tibial plateau by the capsular fibers of the medial collateral ligament (MCL) (Fig. 1b). In addition, MRI revealed avulsion of the posterior horn medial meniscal root (MMR) (Fig. 1c,d), as well as evidence of transient patellar

Fig. 1 Eighteen-year-old woman pedestrian struck with reverse Segond fracture. AP radiograph (**a**) and coronal fast spin echo inversion recovery (FSEIR) image (**b**) demonstrate a triangular avulsion fracture fragment adjacent to medial margin of tibial plateau (*block arrow*). The MR image (**b**) demonstrates that the avulsion fragment maintains its attachment to the deep capsular fibers of the medial collateral ligament; bone bruises at the apposed surfaces of the lateral femoral condyle and tibial plateau reflect sequelae of valgus impaction. Consecutive more posteriorly located coronal FSEIR images (**c**, **d**) demonstrate avulsion of the posterior horn medial meniscal root (*curved arrow*) with bone marrow edema at the posteromedial tibial plateau

dislocation. The ligamentous injuries and posterior horn MMR avulsion were confirmed arthroscopically.

The patient underwent primary arthroscopic repair of the PCL and MMR avulsions, with open reduction and internal fixation of the medial tibial plateau fracture. Due to the severity of the knee injury in this low-functional-demand patient, ACL reconstruction was deferred, to be carried out at a later date if symptomatic laxity persisted. A posteromedial arthroscopic portal was utilized (Fig. 2a–c) to place a bioabsorbable corkscrew suture anchor into the posterior intercondylar eminence, just anterior to the tibial insertion of the PCL, the anatomic location of the posterior horn MMR anchor. A Viper (Arthrex, Inc., Naples, FL, USA) suture passer, commonly employed in rotator-cuff tendon repair, was then utilized to pass the sutures through the free edge of the avulsed MMR. Knot tying tensioned the MMR down to its former insertion site. Six-month second-look arthroscopy confirmed the integrity of the posterior horn MMR repair. Eighteen-month clinical follow-up revealed nearly full range of motion with ligamentous stability,

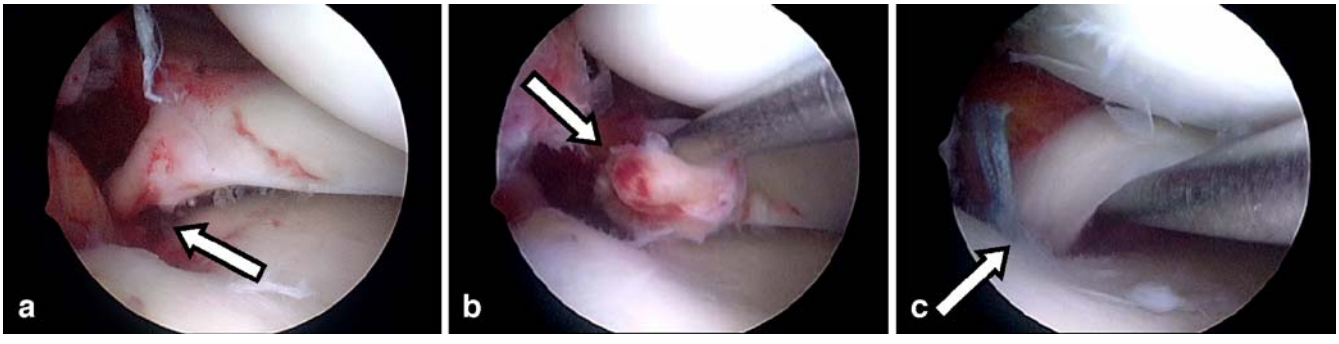

Fig. 2 Eighteen-year-old woman (same patient as Fig. 1) underwent arthroscopic repair of the posterior horn MMR avulsion utilizing a posteromedial portal. Arthroscopic image (**a**) demonstrates the MMR avulsion in situ. Image (**b**) demonstrates a probe elevating the avulsed MMR. Final image (**c**) demonstrates sutures in the MMR following re-implantation of the root anchor into the posterior medial intercondylar eminence. A *block arrow* indicates the meniscal root in each image

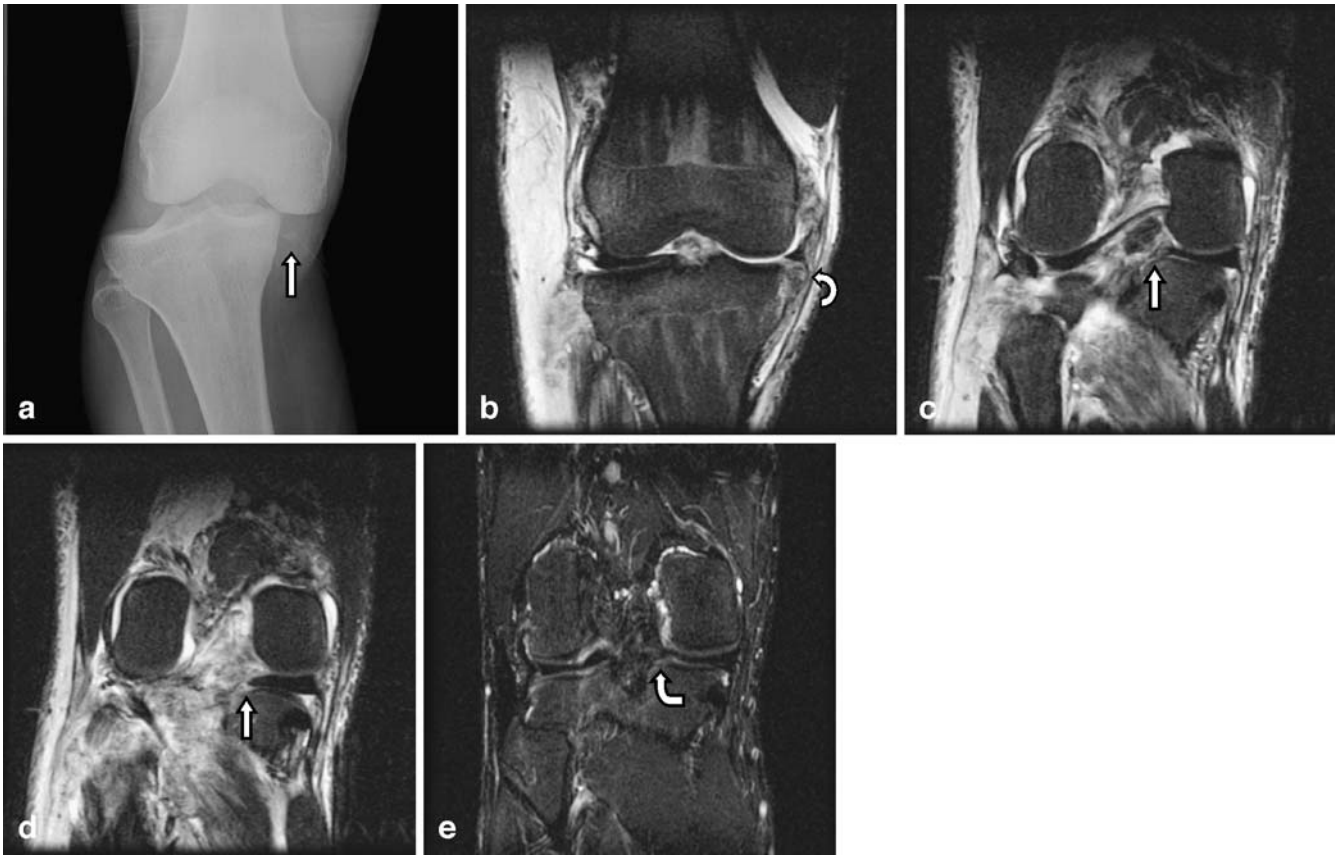

Fig. 3 Twenty one-year-old man—status post soccer slide tackle—sustained a posterolateral knee dislocation with "anteromedial impingement" fracture. AP radiograph (**a**) demonstrates persistent posterolateral dislocation of the proximal tibia with respect to the distal femur, resulting in abutment of the medial tibial margin by the medial femoral condyle; the small impaction fracture fragment (*block arrow*) is medial to the proximal tibia. Coronal FSEIR image (**b**), following reduction of dislocation, demonstrates fracture fragment adjacent to medial margin of tibial plateau (*curved arrow*). More posteriorly located consecutive coronal FSEIR images (**c**, **d**) demonstrate avulsion of the posterior horn medial meniscal root (*block arrow*); note high-grade partial injury to the popliteus myotendinous junction. Coronal FSEIR image (**e**) 10 months post-operative demonstrates uniform dark signal at the anchor site (*curved arrow*) of the posterior horn medial meniscal root, suggesting healed avulsion

except for asymptomatic mild anterior laxity. She has remained fully functional, performing activities of daily living without pain.

Case 2

A 21-year-old male athlete dislocated his right knee when another player stepped on the medial aspect of his knee during a soccer slide tackle. Examination performed under anesthesia demonstrated incompetence of the ACL, PCL, and lateral collateral ligament (LCL) complex. Radiographs of the knee demonstrated posterolateral dislocation of the tibia relative to the femur, with a small fracture fragment medial to the tibial plateau (Fig. 3a). Post-reduction MRI confirmed the presence of a minimally displaced fracture arising from the anteromedial tibial plateau margin (Fig. 3b), along with a proximal PCL tear, tibial avulsion of the ACL, and fibular avulsions of the fibular collateral ligament and biceps femoris tendon. In addition, MRI revealed avulsion of the posterior horn MMR (Fig. 3c,d). All intra-articular MRI findings were arthroscopically confirmed. The patient underwent arthroscopic ACL and PCL allograft reconstructions, open LCL and posterior lateral complex repair, as well as an arthroscopic MMR repair. MMR repair was accomplished utilizing the same technique as described in the first case. Follow-up MRI, 9 months post-operative, confirmed integrity of the re-implanted posterior horn MMR (Fig. 3e). At 1 year post-operative, the patient was pain-free and stable on examination, with full range of motion. He could run more than one mile, and resumed playing competitive soccer.

Discussion

Cortical avulsion of the rim of the medial tibial plateau by the deep capsular ligament, as seen in the first case, has been referred to as a "reverse" or "medial" Segond fracture. The mechanism of injury is thought to be valgus stress and probable external rotation to the flexed knee. Four such cases were previously reported [1, 2], with a consistent triad of injury involving tears of the PCL, MCL, and medial meniscus. The types of meniscal injury, when described, were "peripheral" medial meniscal tears and meniscocapsular separation. The ACL was injured in two of four previously reported cases. Our case shares the bicruciate and MCL injuries, but appears to differ in the nature of the meniscal injury, in that the posterior horn MMR was avulsed. MMR avulsion has been reported [7], although its incidence has not. In a series reviewing MMR tear and its role in medial meniscal extrusion [5], Lerer et al. found a 9.3% incidence of complete MMR tear; however, none were traumatic avulsions.

Cohen et al. were first to describe a fracture at the anterior medial tibial plateau margin, similar to that seen in Case 2, associated with disruption of the posterior lateral complex and PCL; this was referred to as an impingement fracture of the anteromedial tibial plateau [3]. They postulated that this fracture results from combined varus force and posterior translation of the tibia with the knee in hyperextension. This results in impingement of the anterior medial margin of the tibial plateau by the medial femoral condyle. This appears to be the mechanism of injury in Case 2. More recently, Archbold et al. reported a similar fracture dislocation with PCL, posterior lateral complex injury, and concomitant ACL tear, as in the case we describe [4]. Neither Cohen et al. nor Archbold et al. reported meniscal injury in the context of the anteromedial impingement fracture.

Our cases suggest that the presence of a reverse Segond fracture or anteromedial impingement fracture should prompt careful scrutiny of MMR status, particularly since avulsions may be subtle (Fig. 1c). MMR root tears and radial tears are similar, to the extent that they both destroy the ability of the meniscus to withstand hoop stress and thereby predispose to medial meniscal extrusion [5, 6]. Medial meniscal extrusion lays bare the articular surfaces of the medial femoral condyle and tibial plateau, increasing articular contact pressure and contributing to early-onset medial femorotibial degenerative arthritis.

The large majority of meniscal tears are not amenable to repair, and partial meniscectomy may be performed in an attempt to alleviate pain and prevent tear propagation [9]. Partial meniscectomy, however, does not restore the normal biomechanical function of the meniscus. The meniscal root is a specific area of the medial meniscus that is amenable to repair, since it is well vascularized and anchored to bone [10]. From a practical perspective, arthroscopic exposure to the insertion site of the MMR is difficult to achieve in the ligamentously intact knee. The reverse Segond and anteromedial impingement fractures, along with their concomitant multiligamentous injuries, permit ample arthroscopic exposure to the avulsed MMR and its tibial donor site, easing access for surgical repair.

In conclusion, these cases have demonstrated an association of posterior horn MMR avulsion with either a reverse Segond or anteromedial impingement fracture of the knee. Capsular and ligamentous incompetence inherent to these injuries facilitates exposure of the posteromedial knee in arthroscopic repair of the meniscal root, which can be safely accomplished via a posteromedial portal and modified arthroscopic technique.

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