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Repair of a complete radial tear in the midbody of the medial meniscus using a novel crisscross suture transtibial tunnel surgical technique: a case report

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Abstract Complete radial meniscus tears have been reported to result in deleterious effects in the knee joint if left unrepaired. An emphasis on meniscal preservation is important in order to restore native meniscal function. In this case report, a complete radial tear of the medial meniscus midbody was repaired using a novel crisscross suture transtibial technique. This technique secured the anterior and posterior meniscal horns, which were released from their extruded and scarred position along the capsule, using crisscrossing sutures passed through two transtibial tunnels and secured over a bone bridge on the anterolateral tibia. In addition, the repair was supplemented with the injection of platelet-rich plasma and bone marrow aspirate concentrate to promote the healing of the meniscal tissue. Complete healing on second-look arthroscopy is presented, including in the previously unreported white–white meniscal zone.

Level of evidence Case Report, Level IV.

Keywords Medial meniscus · Meniscus midbody · Meniscus repair · Platelet-rich plasma · Bone marrow aspirate concentrate

Introduction

Radial meniscus tears are oriented perpendicular to the meniscal axis and may result in cartilage degeneration if left unrepaired [3, 18, 23, 27]. Therefore, numerous meniscus repair techniques have been developed for partial and complete radial meniscus tears, including the all-inside single or double horizontal suture and the double-crossed horizontal suture techniques [19]. While outcomes after repair of radial meniscal tears are generally favourable [21, 25], less than satisfactory healing has been reported following repair of complete radial tears in the meniscal midbody [7].

The transtibial pull-out repair technique has been well described and biomechanically validated for repair of meniscus root tears [1, 14, 17, 24]; however, to date, this technique has not been described or evaluated for repair of radial tears in the meniscus midbody. The purpose of this report was to present a novel crisscross suture transtibial tunnel surgical technique for repair of a complete radial tear in the midbody of the medial meniscus and to report on healing following second-look arthroscopy at 6-month follow-up and clinical outcomes at 12-month follow-up. We hypothesized that it would be possible to (1) use a transtibial pull-out suture approach to reduce and secure the torn margins of a radial tear in the meniscus midbody and (2) enhance healing through biological augmentation with the combined effect of platelet-rich plasma (PRP), bone marrow aspirate concentrate (BMAC), and transtibial tunnel drilling.

Case report

A 29-year-old male was referred to clinic with complaints of right knee pain exacerbated by running. He was injured 3 months prior to presentation after a mountain biking accident. On examination, the patient was tender to palpation along the medial joint line. He had posterior knee pain with squatting and negative Apley and McMurray

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tests. Plain radiographs were obtained, and an outside magnetic resonance imaging (MRI) series was reviewed.

The history, physical examination, and imaging findings were consistent with a complete radial tear in the midbody of the medial meniscus (Fig. 1) with normal articular cartilage of his right knee. Treatment options including partial meniscectomy, meniscus repair, meniscus allograft transplantation, and conservative management were discussed with the patient. After considering all options, the patient elected to undergo a right knee arthroscopy and meniscus repair with PRP and BMAC augmentation to promote enhanced meniscal healing.

Surgical technique

The patient was induced under general anaesthesia. In the prone position, a bone marrow aspirate was harvested from his left iliac crest. The patient was returned to the supine position. Medial and lateral arthroscopic portals were made adjacent to the patellar tendon. On arthroscopic examination, a complete radial tear was visualized in the midbody of the medial meniscus (Fig. 2a). The anterior horn had subluxed anteriorly and was scarred into the medial gutter. An accessory medial arthroscopic portal was made, and an arthroscopic scissor biter was used to free the retracted

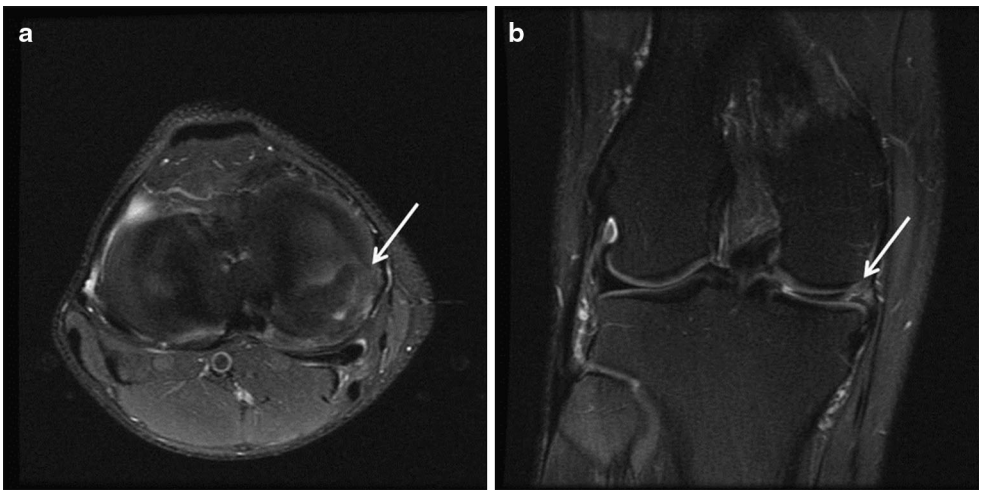

Fig. 1 Preoperative MRI was consistent with a radial medial meniscus tear on **a** axial and **b** coronal fat suppression views (*right knee*)

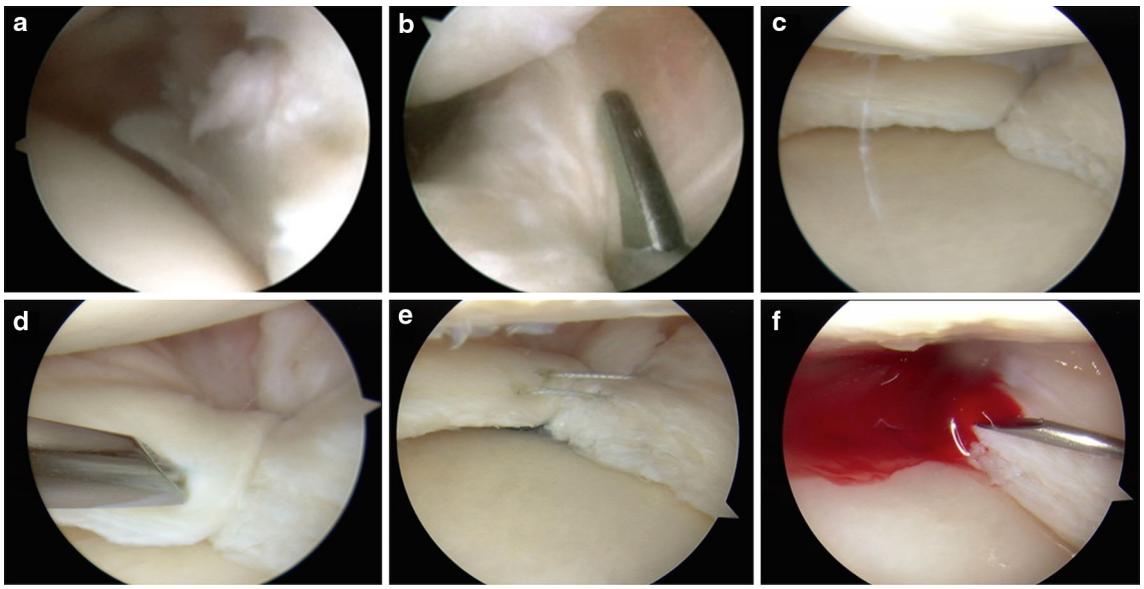

Fig. 2 Arthroscopic images showing the progression of the surgical repair (*right knee*). **a** A complete radial tear in the midbody of the medial meniscus; **b** freeing the meniscus from its scarred in position along the joint capsule; **c** securing the anterior and posterior horns; **d** reapproximating the torn margins; **e** two horizontal mattress sutures in the radial tear; **f** PRP and BMAC adjuvant

anterior horn from the capsule in the medial gutter (Fig. 2b). Once this was done, the main volume of the medial meniscus anterior horn was reduced back on top of the margin of the medial tibial plateau. In a likewise fashion, the posterior horn was released from its extruded and scarred position in the medial gutter. This allowed the posterior horn to be pulled anteriorly into place along the medial tibial plateau margin about a centimetre away from the capsule.

Due to the extremely unstable status of the medial meniscus, a novel transtibial pull-out suture technique using two 5-mm transtibial tunnels was employed to firmly secure the torn margins of the medial meniscus on the medial margin of the medial tibial plateau, while the repair healed (Fig. 2c). Standard cannula shuttle instruments were used to shuttle two sutures into the posterior aspect of the anterior horn and two additional sutures into the anterior aspect of the posterior horn for a total of four sutures (Fig. 3). The sutures were spaced to pass through both the outer and middle thirds of the medial meniscus. A curved cannula was used to pass a nitinol wire through the meniscus, while a grasper pulled the wire out the lateral portal. A suture was passed into the end of the nitinol wire, and the wire was pulled back out through the medial portal to shuttle the suture through the meniscus body tissue. Then, using a ring grasper, each suture was pulled out the medial arthroscopic portal.

A 3-cm incision was made over the anteromedial tibia, and a guide pin was drilled near the far edge of the medial tibial plateau along the native position of the torn posterior edge of the medial meniscus. A second pin was placed directly at the torn margin of the anterior horn of the medial meniscus. Guide pins were utilized to ensure the tunnels would not converge after they were reamed. Proper guide pin positioning was confirmed leaving an 8-mm bone bridge between the two pins. Next, the guide pins were over-reamed using a 5-mm reamer. Braided No. 2 non-absorbable passing sutures with premade loops (FiberLink, Arthrex, Naples, Florida) were passed through each tunnel and pulled out the medial portal. A cannula was used to ensure a soft tissue suture bridge had not formed and to pass the sutures from the anteromedial portal down the reamed transtibial tunnels. The passing sutures were then used to draw the meniscal repair sutures down their respective tunnels. The anteriorly placed sutures were passed through the posterior transtibial tunnel, and the posteriorly placed sutures were passed through the anterior transtibial tunnel. As tension was applied to the sutures, the crisscross orientation of the sutures allowed for reapposition of the torn margins of the medial meniscus and restoration of the continuous semilunar shape of an intact meniscus (Figs. 2d, 3). Once the meniscus was reduced into its final position, the sutures ends exiting the tibial tunnels were tied using a standard surgeon's knot over the anteromedial tibial cortex (Fig. 3) with the knee in 90° of flexion. The security of the meniscus midbody was confirmed by visualization and probing.

Next, a standard meniscus repair incision was made over the superficial medial collateral ligament. Four horizontal mattress sutures were then placed in the radial tear, and the margins of the tear were further secured (Fig. 2e) [7, 19]. Fluid was then evacuated from the joint, and the PRP and BMAC preparations were injected into and around the repair (Fig. 2f). The deep tissues were closed, and an immobilizer brace was used to keep the knee in full extension and to protect the repair.

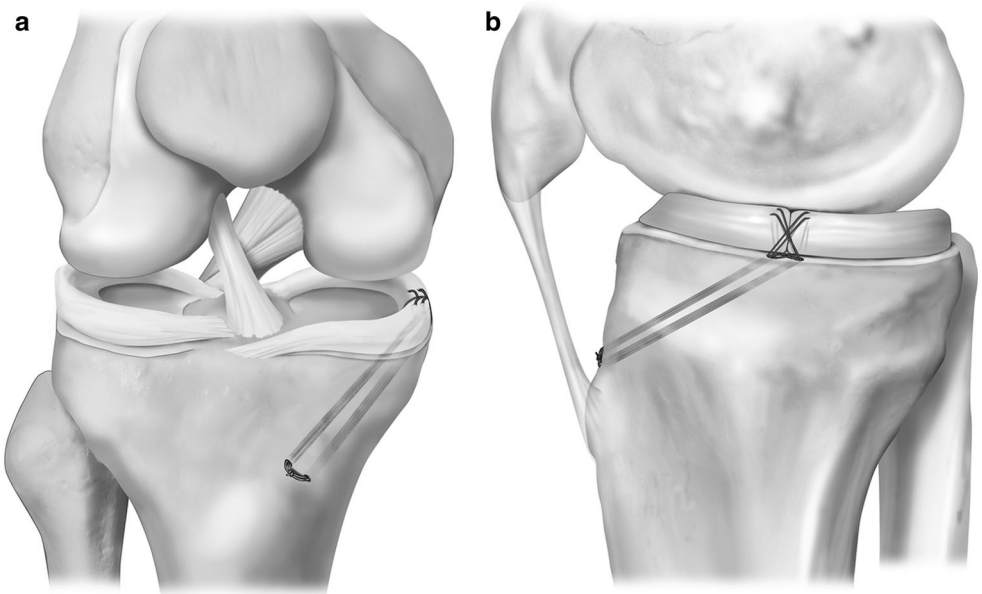

Fig. 3 **a** Anterior and **b** medial view illustrating the crisscross suture transtibial tunnel surgical root repair technique (*right knee*). Two sutures are passed through the anterior and posterior margins of the radial tear, respectively. The four sutures are pulled through a transtibial tunnel and secured over a bone bridge on the anteromedial tibial cortex

Post-operative protocols

The patient was non-weightbearing on his right lower extremity for 6 weeks. Passive range of motion was restricted from 0° to 90° of knee flexion for the first 4 weeks and increased as tolerated thereafter. After 6 weeks, partial protected weightbearing and cycling on a stationary bike were initiated. A medial unloader brace was used to protect the repair once weightbearing was started. Deep squatting, leg lifting, and sitting cross-legged were prohibited for 4 months post-operatively to maximize healing potential. After 4 months, the patient was allowed to resume unlimited low-impact activities.

Second-look arthroscopy

An MRI was ordered at 6 months post-operatively to determine the extent of healing. Results from the MRI were inconclusive. For this reason, even though the patient was asymptomatic, the patient underwent a second-look arthroscopy 6 months after surgery. The second-look arthroscopy revealed that the medial meniscus midbody had healed completely across the red–red, red–white, and white–white zones of the meniscus (Fig. 4). The superior and inferior surfaces of the meniscus were probed and found to be very stable. The meniscus was positioned at its native anatomical position on the margin of the tibial plateau. The tunnel apertures had healed completely and were indiscernible. The articular cartilage of the medial compartment was normal.

Clinical follow-up

At his one-year clinical follow-up, the patient reported no swelling or mechanical symptoms. He had a full range of knee motion, had no effusion or medial joint line pain, and could perform a full squat with no posterior or medial knee pain. The patient was able to resume his normal pre-injury activity levels, including climbing at the gym and biking upwards of 2 h. Rosenberg, anteroposterior, and lateral radiographs were obtained and revealed no medial or lateral compartment joint space narrowing. The patient was advised to continue strengthening by cross-training on low-impact activities as he advanced into higher impact activities.

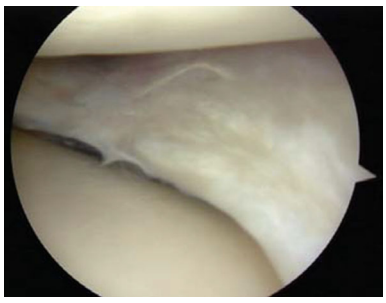

Fig. 4 Second-look arthroscopy revealed excellent healing at 6 months after repair. A horizontal mattress suture is still visible in the centre of the meniscus midbody

Discussion

This case report describes a novel crisscross suture transtibial tunnel repair technique that was used to treat a complete radial tear of the medial meniscus midbody. Our hypothesis was affirmed on second-look arthroscopy at 6 months, which demonstrated complete healing through the red–red, red–white, and white–white meniscal zones. In addition, we hypothesized that the biological augmentation provided by the injection of PRP and BMAC and the transtibial tunnel drilling may also increase the healing response. Although the effects of this biological augmentation cannot be definitely assessed from this case, it is possible that the influx of mesenchymal stem cells and growth factors helped to enhance healing, including in the previously unreported white–white zone of the meniscus.

Radial tears of the medial meniscus midbody reportedly account for 12 % of all meniscal radial tears [18]. Currently, there are no repair techniques that are designed for the midbody of the medial meniscus. Choi et al. [7] described an all-inside repair technique specifically designed for tears of the lateral meniscus midbody. At a mean follow-up of 3 years, they found that 57 % of repairs had only partially healed and 7 % had not healed. However, it is difficult to extrapolate whether these findings are applicable to the medial meniscus because of considerable anatomical [15], mobility [28], and biomechanical differences [17, 24] that have been reported between the medial and lateral menisci.

Other studies have evaluated different techniques for meniscal radial tears [7, 19]. Matsubara et al. reported that double-crossed suture technique resulted in significantly better biomechanical outcomes than the double horizontal technique [19]; however, clinical outcomes have not been reported. In our study, the use of four sutures passing through two transtibial tunnels provided substantial stability to the repair construct, which we believe facilitated anatomical meniscal healing. In addition, anatomically accurate repairs are important because non-anatomical meniscus horn positioning has been reported to significantly alter meniscal function [26]. We postulate that increased stability provided through our novel transtibial tunnel pull-out suture technique promoted healing to a greater extent than techniques that rely on horizontal mattress or crossed sutures alone.

Complete healing to the inner edge of the meniscal width (white–white zone) was observed in this case. Complete radial tears span the white–white (minimally vascularized), red–white (partially vascularized), and red–red (extensively vascularized) zones of the meniscus. Tears reaching the outer third (red–red zone) of the meniscus often heal when repaired due to the extensive vascularization of this region [2, 5, 20]. On the other hand, there is substantially less vascularization in the red–white zone, or middle third, of the meniscus and therefore this region is less amenable to healing. However, healing has nevertheless been reported in this zone after repair, with Barber-Westin and Noyes reporting that 83 % of tears in the red–white zone were considered clinically healed after repair in a recent systematic review [4, 5, 11]. The complete healing response seen in our case is consistent with these reports of healing in the outer two-thirds of the meniscus after repair. We believe that the observation of healing in the inner-third of the meniscus has not been previously reported. However, this healing is consistent with others' hypothesis that PRP, which results in the release of growth factors into the knee joint, may facilitate healing of the white–white zone [30].

The role that biological agents (BMAC and PRP) played in this patient's healing response is indeterminable. However, it is theorized that BMAC contributes to a favourable healing environment by supplying undifferentiated mesenchymal stem cells that may be supplemented by the growth factors found in PRP. While currently under-investigated, early studies suggest that the two therapies are synergistic and together promote increased healing [6, 13, 16, 22]. Moreover, a recent study reported that injection of mesenchymal stem cells after partial meniscectomies resulted in a significant increase of meniscal volume in 24 % of patients [29]. In addition, the drilling of the transtibial tunnels has also been proposed as a source of increased bone marrow content at the repair site [9, 10, 12]. This theory is substantiated by a study reporting that ACL reconstruction tunnel drilling significantly increased the amount of platelet-derived growth factor in the knee joint when compared to partial meniscectomies [8]. Therefore, the combined effect of tunnel drilling and biological product injection may have contributed to the increased healing response observed in the white–white zone of the meniscus repair. Further studies are needed to investigate the effect of biological agents on meniscus healing.

This report has some limitations. Since this is a report of a single case, conclusions may not be generalizable regarding the efficacy of this novel repair technique without further biomechanical testing, clinical outcome studies, and comparative studies. In addition, we report on a second-look arthroscopy at only 6 months and clinical evaluation at 12 months; however, the complete healing that was initiated in the meniscus at 6 months indicates that the repair was successful in stimulating the healing response in all three zones of the meniscus. There are also concerns not only about the role of PRP and BMAC in the healing response, but also about the reproducibility of the composition of biological preparations. Additional concerns are possible unintended consequences after this repair technique, which fixated the meniscus to the tibial plateau with sutures through transtibial tunnels in a crisscross formation. While intended to provide additional stability, this formation may also potentially limit motion of the medial meniscus after healing. It is unknown whether this crisscross technique would place higher stress on the meniscus tissue. Finally, this surgical technique has been demonstrated for a radial tear in the midbody of the medial meniscus and will need to be evaluated independently for radial meniscal tears in other locations. Future studies are recommended to address these limitations.

Conclusions

A novel crisscross transtibial tunnel repair technique was used to repair a complete radial tear in the midbody of the medial meniscus. The anterior and posterior meniscal horns were reapposed and then secured by tensioning sutures in a crisscross orientation and tying the ends over a bone bridge on the anteromedial tibia. At second-look arthroscopy, complete healing of the meniscus was observed, including in the inner white–white avascular zone of the meniscus.

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