Technical note with video

Transtibial single-tunnel all-inside technique for repair of a complete radial meniscal tear

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A B S T R A C T

Introduction: Radial meniscus tears significantly compromise knee biomechanics due to loss of the circumferential fiber connections and have been shown to be biomechanically equivalent to a total meniscectomy. There is a paucity of data regarding the biomechanical performance of radial meniscal repairs and numerous technical challenges associated with surgical repair. Further, current repair methods have been shown to lead to high rates of incomplete, nonanatomical healing of the meniscus and can potentially cause progressive joint degeneration and osteoarthritis. This is particularly true for the avascular portions of the meniscus. As a result, such injuries have been historically treated with a partial meniscectomy. There has been a growing interest in transtibial repair mechanisms as a potential solution to this challenging pathology.

Objectives: The purpose of this technical note is to detail a method for repairing a complete radial tear of the medial meniscus using a single-tunnel transtibial technique.

Methods: After a thorough history and clinical examination, and imaging, the patient was diagnosed with a complex medial meniscal tear with a primary radial tear component. A single tunnel transtibial meniscal repair was indicated and performed.

Results: An anatomic repair was achieved with tension across the defect. The patient successfully returned to activities.

Conclusions: Single-tunnel transtibial repairs of radial tears in the meniscus may provide increased stability by anchoring the meniscal leaflets to the tibia as well as a potential biological benefit by releasing growth factors and progenitor cells from the bone marrow.

Introduction

Radial tears are meniscal injuries that extend perpendicular to the meniscal axis and transect functionally critical circumferential collagen fibers, leading to structural failure that is biomechanically equivalent to a total meniscectomy.\textsuperscript{1,2} This causes a pathologic decrease in the contact area, an increase in contact pressures, and an acceleration of degenerative changes.\textsuperscript{3} Recent literature suggests that meniscal repair leads to superior clinical outcomes compared to meniscectomy, underscoring the importance of the preservation of meniscal tissue in young and active patients.\textsuperscript{4}

A diverse set of surgical techniques are presented in the literature for repairing radial tears. Most notably, all-inside or inside-out repairs with various horizontal mattress configurations have been commonly described.\textsuperscript{5} While these constructs bring the torn leaflets together and allow for tension to be applied across the defect, they provide limited stability for large tears.\textsuperscript{6} Furthermore, though inside-out repairs are effective in treating tears within the vascular periphery of the meniscus, they produce unsatisfactory healing in the avascular white-white meniscal zone.\textsuperscript{1} Therefore, there is a growing need for an improved standard for repair techniques of complete radial tears in the meniscus.\textsuperscript{7}

Transtibial repair techniques are a promising and biomechanically advantageous solution to this challenging pathology,\textsuperscript{1,8} providing increased stability relative to isolated horizontal repair patterns by anchoring the meniscal leaflets to the tibial plateau.\textsuperscript{1,5} As
such, this technical note outlines our method for a single-tunnel transtibial augmentation of a horizontal suture configuration for a complete radial tear of the medial meniscus.

Surgical technique

The patient is a 38-year-old male that sustained a buckling knee injury. Following the injury, he reported swelling and instability. Physical exam revealed a palpable effusion and tenderness about the medial joint line, active range of motion from 0 to 125°, a positive medial McMurray’s sign, and medial joint pain with terminal flexion. Radiographs showed maintained intra-articular joint space without malalignment of the lower extremity. Magnetic resonance imaging demonstrated a complex radial tear at the posterior aspect of the medial meniscus with a horizontal tear at the posterior body. The patient was indicated for surgical intervention based on his clinical presentation, imaging findings, and functional goals.

After induction of anesthesia and sterile preparation/draping, diagnostic arthroscopy is performed, confirming the presence of a complex radial tear of the posterior horn of the medial meniscus and a horizontal tear of the posterior body of the medial meniscus (Fig. 1). If needed, pie-crusting of the deep medial collateral ligament is performed to open the medial joint space and prevent injury to the chondral surface. To improve biology and facilitate healing, an arthroscopic shaver and ring curette are used to debride and decorticke the bony attachment of the mensicotibial ligaments on the tibial surface. While viewing through the anterolateral portal, a tibial aiming guide (Smith and Nephew) is inserted through the anteromedial portal and positioned along the previously decorticated area of the tibial surface (Fig. 2). A 2.4 mm drill-tipped pin is used to create a transosseous tunnel ending in the repair site on the tibia. The tibial aiming guide is then disassembled and the pin is over-drilled with a 4.5 mm cannulated drill. The 2.4 mm drill pin is then removed to leave the cannulated drill sheath at the base of the repair bed on the tibial surface.

The arthroscope is switched to the anteromedial portal. To assist with subsequent suture passage, a Cannula (Smith and Nephew) is placed through the anterolateral portal. A suture passer (Smith and Nephew) is introduced through the cannula to place a vertically
Fig. 3. Repairing the radial tear with a horizontal mattress suture configuration.

Fig. 4. Nitrol wire suture passer is used to pull the free suture ends through the transtibial tunnel.

Fig. 5. All-inside repair of a concomitant vertical horizontal tear in the medial meniscus.

(inferior to superior) oriented suture (Smith and Nephew) through the posterior leaflet of the torn meniscus and retrieved through the lateral portal. The superior limb of this suture is then passed through the anterior aspect of the radial tear from superior to inferior again with the Firstpass Mini to form a horizontal mattress suture configuration across the radial tear (Fig. 3). At this stage, the 2 limbs of the suture on the inferior surface of the meniscus are retrieved. A 5 to 10 mm loop of nitinol wire is passed through the 4.5 mm cannulated drill sheath (Fig. 4). An arthroscopic ring grasper is introduced through the cannula in the anterolateral portal and used to shuttle the suture limbs through the transosseous tunnel in the tibia. The shuttled sutures are then tensioned with arthroscopic visualization of the meniscal reduction. Sutures are tied over an Endobutton Fixation Device (Smith and Nephew) along the anterior tibial cortex.

To address the concomitant horizontal tear, an all-inside Fastfix 360 meniscal repair device (Smith and Nephew) is inserted through the anterolateral portal and used to create a horizontal mattress suture configuration (Fig. 5). The first suture is placed centrally in the anterior leaflet of the torn meniscus 5 mm from the edge of the radial tear. The second suture is placed equidistant in the central portion
of the posterior leaflet of the torn meniscus. Sutures are tensioned using the device-specific knot-pusher and reduction of the meniscus is directly visualized. Sutures are then cut flush with the meniscal surface. A second set of sutures is arthroscopically placed using an all-inside Fastfix 360 meniscal repair device now inferior to the first horizontal mattress suture at a distant equidistant from the tear, tied inside the joint. Sutures are tensioned and cut once again under direct visualization. Subsequently, a third horizontal mattress suture is placed at the meniscocapsular junction, superior and lateral to the previously placed sutures, at a distance equidistant to the radial tear. This last set of sutures are tensioned and subsequently cut. The final construct is evaluated with a probe to confirm appropriate reduction and torn meniscus with appropriate tension (Fig. 6).

Discussion

This technical note describes a single-tunnel transtibial augmentation of a horizontal mattress repair for a radial tear of the posterior horn of the medial meniscus. With this anatomical repair technique, each leaflet of the radial tear is repaired and secured to the tibia using transosseous sutures as though they are a single meniscal root. The meniscal leaflets are anchored to the tibial plateau allowing for increased stability of the anatomic repair. By taking advantage of the improved stability provided by transosseous fixation, the avascular meniscal zones could have improved healing.

Although the single-tunnel transtibial technique described here is technically challenging, biomechanical evaluations have provided consistently favorable outcomes. For example, a 2016 cadaveric study by Bhatia et al. described the improved biomechanical outcomes of transtibial repair with a crisscross suture pattern compared to inside-out horizontal suture repair for medial meniscal radial tears, finding significantly higher load to failure and lower gap sizes after 1000 flexion-extension cycles at 5 to 20 N. However, while there is limited initial data on single tunnel repairs, a 2015 cadaveric randomized trial by LaPrade et al. compared single-tunnel and 2-tunnel transtibial root repairs and found no significant difference in the biomechanical properties between the techniques.

It is postulated that horizontal repairs fail for these large radial tears because they are unable to tighten the meniscus back to its native shape leading to extrusion and continued violation of the meniscal circumferential collagen fibers. As such, the described transtibial repair technique serves as a potential solution based on efficacy in meniscal root repairs. By treating each leaflet of the meniscus similar to a detached root and anchoring them to the tibial plateau, the transtibial technique allows for increased stability and functional repair of the meniscus without violation of the circumferential fibers. In effect, the transtibial technique allows for optimal dissipation and conversion of axial loads into physiologic hoop stresses.

Clinical investigations have shown promising preliminary outcomes following meniscal repair utilizing this technique. In 2019, a study by Cinque and colleagues compared the outcomes of patients treated with horizontal repairs for longitudinal meniscal tears to patients treated with a transtibial repair for radial meniscal tears. The authors noted no difference in clinical outcomes at 3.5 years. Beyond biomechanical strength, transtibial tunnel drilling is hypothesized to provide a biological benefit to augment healing, with improved meniscal repair outcomes relative to isolated meniscal repairs in the context of a concomitant ACL reconstruction. The biologically augmented healing is believed to occur due to the increased release of progenitor cells and growth factors from underlying tibial bone marrow released during tibial tunnel drilling, similar to improved healing rates for meniscal repair with concomitant ACL reconstruction or marrow venting compared to repair without any marrow elements. Nonetheless, given the existing literature and outcome of this case, future investigations are necessary to evaluate the efficacy of this technique for complex radial tears of the meniscus.

Although there is increased stability obtained from anchoring the meniscal leaflets to the tibial plateau, one of the potential disadvantages of meniscal repair using transosseous tunnels is that it may lead to reduced mobility of the meniscus. However, unlike the lateral meniscus which is relatively mobile, the medial meniscus has attachments with the joint capsule and the deep medial collateral ligament, making the tissue inherently less mobile. Thus, careful attention to appropriate tunnel placement and avoiding over-tensioning the repair can potentially mitigating related concerns with excessive immobilization of the meniscus associated with this technique (Table 1).
Table 1
Advantages and disadvantages.

| Advantages                                                                 |                                                                 |
|---------------------------------------------------------------------------|------------------------------------------------------------------|
| • Increased stability of the repaired construct maximizing healing in avascular central zones of the meniscus |                                                                 |
| • Anatomic repair                                                        |                                                                 |
| • Biological benefit from growth factors and progenitor cells released during tibial tunnel drilling |                                                                  |
| • Tension is still applied across the torn meniscal leaflets              |                                                                 |
| Disadvantages                                                            |                                                                 |
| • Longer operative time                                                  |                                                                 |
| • Technically challenging relative to all-inside or outside-out repairs  |                                                                 |
| • Safety concerns                                                        |                                                                 |
| • Suture failure/attenuation within the tunnel\textsuperscript{16}        |                                                                 |
| • Challenges with concomitant anterior cruciate ligament reconstruction   |                                                                 |

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jcjp.2022.100075.

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