Meniscal root tears: a silent epidemic

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THE CLINICAL PROBLEM

Half of adults will experience knee pain at some point during their lives, resulting in approximately 4 million primary care office visits in the USA annually.[1] The majority of these visits for knee pain evaluation are due to osteoarthritis (OA).[2] As of 2015, it was estimated that 14 million people in the USA have symptomatic knee OA,[3] and this number is expected to increase to up to 28 million over the next decade.[4] One of the most common factors that can initiate the cascade of knee OA is meniscus tears.[5]

Meniscus root tears are a specific type of meniscal injury that have gained attention over the past 5 years and have been reported to account for 10%–21% of all meniscal tears, affecting nearly 100 000 patients annually.[6–8] Untreated meniscal root tears have been reported to result in altered joint biomechanics and accelerated articular cartilage degeneration. In this regard, the 'recently' recognised pathology of meniscal root tears has been reported to precipitously worsen articular cartilage degeneration (figure 1), cause painful bone oedema and lead to progressive OA (figure 2) if left untreated.[9–13] Furthermore, it is important to recognise the association of meniscal injuries leading to subchondral insufficiency and potentially spontaneous osteonecrosis of the knee (SONK). Previously, SONK was a pathology often diagnosed as an 'idiopathic' osteonecrosis of the knee prior to the recognition that this pathology was caused by a meniscal tear.[9 13–15] However, the pathogenesis of SONK continues to be debated in the literature with many aetiologies, including certain meniscal tears and meniscectomy, reported to be the primary cause of insufficiency fracture development. It was recently reported that the term SONK is a misrepresentation of the aetiology and pathogenesis of the condition, and should be replaced with 'subchondral insufficiency fractures of the knee' (SIFK).[16]

Early detection of degenerative root tears in patients over 50 years old is crucial, because knee joint loading can be restored to a near native state if this lesion is properly diagnosed and timely treated,[17] and the progression of OA can be significantly slowed.[18 19] It is also important to actively look for acute root tears in patients with multiligament knee injuries and ACL tears because of the increased risk of root tears in these patient populations. Thus, the purpose of this clinical practice work, given the drastic and costly downstream effects of untreated meniscal root tears progressing to OA for both patients and society, is to note that significant attention should be directed towards this 'silent epidemic,' and therefore it is important that all physicians recognise this pathology.

STRATEGIES AND EVIDENCE

Pathophysiology

Meniscal root tears are defined either as an avulsion of the insertion of the meniscus attachment or complete radial tears that are located within 1 cm of the meniscus insertion.[10 20] Meniscal root tears have been previously classified into five types[21]: (1) partial root tear, (2) complete radial root tear, (3) complete root tear with a bucket handle meniscus tear, (4) oblique tear into the root attachment and (5) root avulsion fracture (figure 3). Due to the recent recognition of the effects of this pathology, there has been a recent emphasis to characterise the effects of meniscal root tears including an early diagnosis of this pathology, biomechanical consequences of root tears, optimal techniques for root repairs and overall long-term outcomes.

Biomechanical studies have demonstrated that meniscal root injuries interrupt the continuity of the circumferential fibres, and hence lead to failure of the normal meniscal function to convert axial loads into transverse hoop stresses.[10 17 22–24] A root tear effectively results in a disruption of its attachment and can lead to meniscal extrusion, which results in increased intra-articular pressure on the medial and lateral knee compartments during joint loading

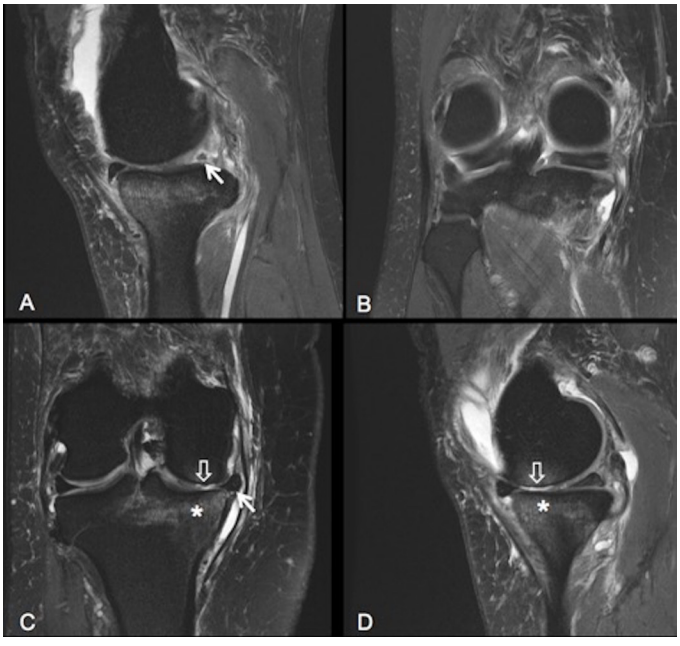

Figure 1 Sagittal (A) and coronal (B) fast spin echo (FSE) T2-weighted fat suppression images show the oblique tear of the posterior horn of the medial meniscus extending into the root attachment (white arrow). Coronal (C) and sagittal (D) FSE T2-weighted fat suppression images show the peripheral meniscal extrusion at the medial joint line (arrow), grade IV chondromalacia (block arrow) and subchondral marrow oedema (asterisk).

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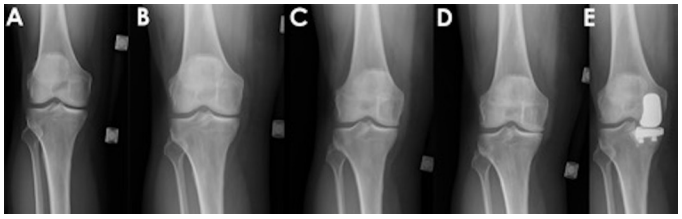

Figure 2 (A–E) Right knee plain radiographs' sequence demonstrating the natural history of a medial compartment with an unrepaired posterior medial meniscal root tear over a period of 12 months with progressive medial compartment joint space narrowing and ultimately a conversion to a medial compartment hemiarthroplasty.

(figure 4),[17 25] which ultimately can lead to arthritis. Increased joint contact pressure over time is detrimental to both the articular cartilage and underlying supporting bone and can lead to rapid degenerative changes, which are comparable with the arthritic changes seen following a total meniscectomy.[10] The deleterious effects of a meniscectomy have long been known since Fairbank reported in 1948 increased degenerative changes in knees that had undergone meniscectomy.[26]

Medial meniscus root repair

To restore the function of the meniscus after medial meniscus root tears, a transosseous meniscal root repair technique is most commonly used and involves the passing of two simple sutures through the meniscal root tear edge and tunnels in the proximal tibia (figure 5).[14 27 28] After passing the repair sutures through the two tibial tunnels, the sutures are then tied over a bone bridge or a surgical button[14 29 30] (figure 5). The two-tunnel repair technique allows for a higher ultimate load to failure, a broader anatomical footprint and the release of biological factors to enhance healing of the meniscal root repair.[17 31–37] The advantage of this technique is the ability to reduce and fix the meniscal root to the broad anatomical footprint to maximise its healing potential.[17] In addition, the transtibial tunnels may contribute to the release of biological factors that can enhance the healing of the meniscal root repair.[33–37]

Clinical evidence

The important findings in the biomechanical studies of the effects of meniscal root tears on joint contact loads[10 17 21 23–25] have been supported by clinical studies. Chung *et al*[38] reported that medial meniscal root repairs slowed the progression of intra-articular arthritic changes compared with patients who underwent a partial meniscectomy.[38] Along with the overall difference in arthritic changes, 35% of the patients who had undergone a meniscectomy to treat a meniscal root tear underwent conversion to total knee arthroplasty (TKA) by 5-year follow-up, whereas none of the patients who had undergone a meniscal root repair underwent conversion to TKA.[38] To further support the importance of recognising and repairing meniscal root tears, Krych *et al*[39] reported poor clinical outcomes, worsening of OA and a 31% conversion to arthroplasty in 52 patients treated conservatively for posterior root tears at a mean follow-up of 5 years.

In a study of 197 consecutive TKAs, 92.8% of patients under 60 years had a meniscal root tear as a primary identified factor leading to the development of OA.[40] The potential for early progression to knee OA, resulting in TKA, after a meniscal root tear treated non-operatively or with meniscectomy, has large implications given the US$57 900 overall cost of a TKA. Moreover, studies have indicated that indirect costs associated with TKA can grow to as much as US$68 000 per patient, increasing the economic burden on the patient and the overall healthcare infrastructure. In this regard, Krych *et al* reported that the 16 patients (31%) with untreated meniscal root tears that underwent conversion to TKA by 5-year follow-up resulted in a US$1.1 million direct cost to society.[39] Although TKA is a cost-effective treatment when compared with non-operative management for end-stage OA, treating medial meniscal root tears conservatively or with meniscectomy will likely accelerate the rise in the projected volume of TKA cases, putting further strain on the US healthcare system due to the increased costs. This is particularly important because OA caused by meniscal root tears can be prevented by early diagnosis and treatment.

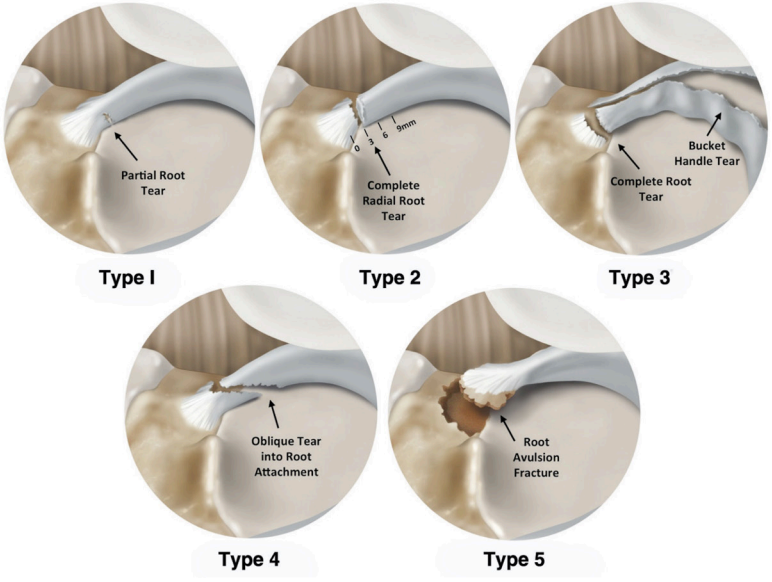

Figure 3 Illustrations of the meniscal root tear classification system in five different groups based on tear morphology. All meniscal tears are shown as medial meniscal posterior root tears for consistency in this illustration. The five tear patterns were classified based on morphology: partial stable root tear (type 1), complete radial tear within 9 mm from the bony root attachment (type 2), bucket-handle tear with complete root detachment (type 3), complex oblique or longitudinal tear with complete root detachment (type 4) and bony avulsion fracture of the root attachment (type 5). Reproduced with permission from LaPrade *et al*.[21]

KEY SURGICAL CONSIDERATIONS

It is important to repair the posterior medial meniscal root tear at its anatomical attachment site to restore normal joint loading profiles. Biomechanical studies have reported that a 3 mm non-anatomical displacement significantly alters meniscal function by failing to restore joint loading and contact areas.[41 42] This has been supported by clinical findings

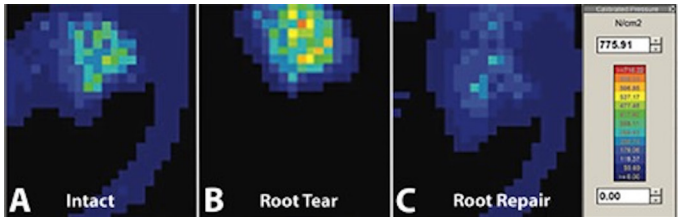

Figure 4 Representative Tekscan contact area and pressure maps of the medial and lateral compartments of a cadaveric specimen at 30° of flexion undergoing nine medial meniscus root tear and repair conditions. Root tears are noted to induce high pressures (indicated by the yellow and red colours), while root repairs significantly restore joint contact loads (blue and purple). Reproduced with permission from Padalecki *et al*.[17]

that meniscal extrusion >3 mm was associated with degenerative changes in the joint.[12] Other potential problems have been reported with the current repair techniques. These include the overall repair construct strength and a risk of meniscal repair displacement with early weight bearing.[32 43]

AREAS OF UNCERTAINTY

Repairs of posterior medial meniscal root tears have been reported to improve clinical outcomes and slow the progression of OA.[18 28 38 44] However, these studies have also demonstrated that the progression to OA is not completely diminished, which may reflect poor patient selection for repair in some circumstances. Patients with obesity (body mass index (BMI) >30), uncorrected malalignment or advanced cartilage changes at the time of presentation may not benefit from root repair.[45] In addition, non-anatomical repair of the meniscal root does not properly restore contact forces in the joint.[42] Furthermore, poor healing and cyclic displacement during loading can lead to the suture repair loosening and can cause meniscal extrusion, and can lead to an ineffective transmission of the hoop stress function of the meniscus and in turn negate the beneficial effects of a root repair.

In a recent systematic review of the outcomes of posterior medial meniscal root repairs, MRI examination demonstrated that medial meniscus extrusion was reduced in only 56% of the patients. In addition, second-look arthroscopy demonstrated that the healing status was complete in 62%, partial in 34% and failed in 3%.[18] In addition, in a recent study, clinical outcomes were correlated with reduction of meniscus extrusion.[19] Thus, improved root repair techniques with reduction of meniscal extrusion should be pursued to improve patient outcomes.

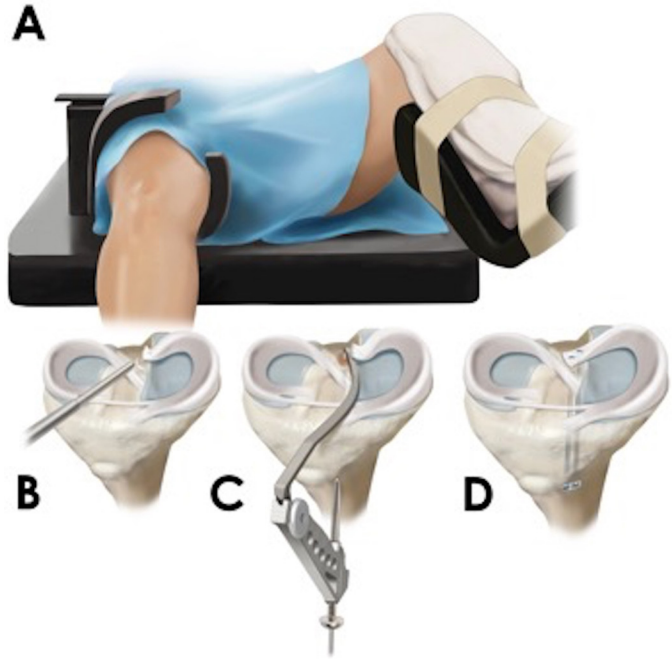

Figure 5 Technique of a transtibial meniscal root repair. The patient is placed in the supine position on the operating table (A). Standard anterolateral and anteromedial portals are created and the root tear is assessed with a probe for its severity and tear pattern. An accessory posteromedial portal is created to access the meniscal root and an arthroscopic grasper is used to mobilise the root and to determine the ideal location for repair (B). For a posterior medial root tear, an initial incision for the transtibial tunnels is made just medial to the tibial tubercle. Two transtibial tunnels are created at the location of the root with the use of a cannulated aiming device to position a drill pin with a cannulated sleeve (C). A suture-passing device is passed through the far posterior portion of the detached meniscal root, approximately 5 mm medial to its lateral edge, passing from the tibial to the femoral side. Before passing the second suture through the meniscus, the first suture is shuttled down through the more posteriorly placed tibial tunnel to avoid intra-articular suture tangling. The same steps are repeated with the second suture positioned through the mid-portion of the meniscal root, anterior to the first suture placed into the meniscus. The second suture is then pulled down through the anterior positioned tibial cannula. The sutures are tied over a cortical fixation device on the anteromedial tibia with the knee flexed to 90° (D).

GUIDELINES

A history of sudden posterior knee pain, especially after deep knee flexion or squatting, should alert the clinician to the possibility of a meniscus root tear (figure 6). Most patients with meniscal root injuries recall a precise time point when their knee pain began, and it often occurs with a minor traumatic event such as squatting.[14] The most common presenting symptoms in meniscal root tears are posterior knee pain and joint line tenderness, especially with deep squatting.[46] Another common symptom is a popping sound that is heard while participating in light activities, like ascending stairs or squatting.[47] Seil *et al*[48] described a test that has proven useful in diagnosing a medial meniscal root tear. It involves applying a varus stress to the knee while it is relaxed and in full extension and palpating the anteromedial joint line.[48] When there is a medial meniscal root avulsion, meniscal extrusion may be palpated at the medial joint line and the extrusion disappears when the knee is moved back to its normal anatomical position.[48] In addition, when performing a physical exam, it is important to identify if the patient has varus alignment or a high BMI because these have also been

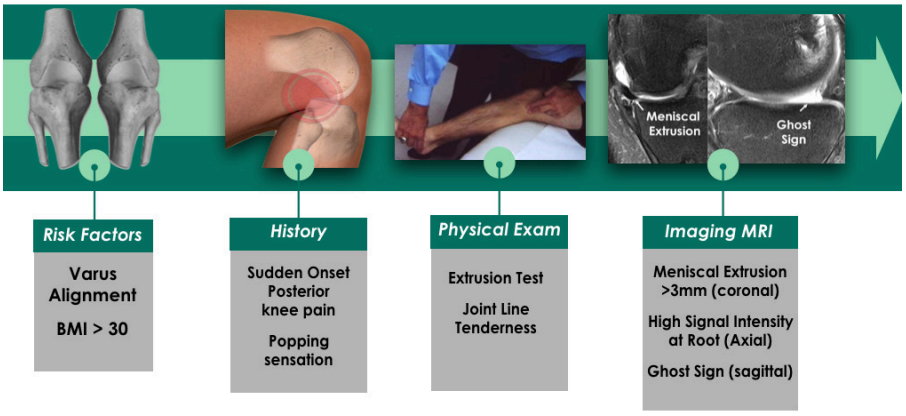

Figure 6 Flow chart describing the evaluation for a meniscal root tear. BMI, body mass index.

Figure 7 Flow chart demonstrating the different treatment options and patient selection criteria for a patient that is diagnosed with a meniscus root tear. Adapted with permission from Bhatia *et al*.[14] JSN, joint space narrowing.

reported to be significant risk factors for medial meniscal root tears[45]

Positive physical exam signs should raise suspicion for a meniscal root tear and the clinician should consider ordering an MRI or a referral to a specialist. However, full length alignment, Anteno-Posterior (AP) and knee flexion (Rosenberg) weight-bearing radiographs should always be ordered prior to ordering an MRI to assess the severity of the joint space narrowing and other degenerative signs. When the history and physical exam are suggestive of a meniscal root tear and there is sufficient medial compartment articular cartilage remaining, an MRI should be indicated. A physical exam consistent with a root tear should be combined with an MRI since many meniscal root tears are missed by physical examination alone.[49] MRI signs of medial meniscus root tears include (1) medial meniscal extrusion of ≥3 mm in a coronal section; (2) high signal indicating a disruption of the posterior meniscal root region in an axial view; and (3) a 'ghost sign', which is the absence of an identifiable meniscus in the sagittal plane, or increased signal replacing the normally dark meniscal tissue signal at the posterior root attachment (Figure 2). Because there is no specific physical examination specific for a meniscal root tear, when the history and physical exam are suggestive of a meniscal tear and there is sufficient medial compartment joint space remaining on weight-bearing radiographs, an MRI is indicated. Medial meniscal extrusions greater than 3 mm have been reported to be significantly associated with severe meniscal degeneration and meniscal root tears.[44] Meniscal extrusion and therefore a meniscal root tear can also be suspected with ultrasound examination. Meniscus extrusion, however, is not pathognomonic for a root tear, because other meniscus or articular cartilage pathologies can cause extrusion.[50]

TREATMENT RECOMMENDATIONS

The first key to successful treatment is to recognise the presence of a meniscus root tear. A clinician must maintain a high level of suspicion and obtain a knee MRI early in the clinical course when appropriate and before the rapid progression of arthritis initiates. Non-operative treatment is recommended for patients with significant comorbidities and those with advanced OA (Kellgren-Lawrence grade ≥3) on radiographs. For this subset of patients, symptomatic treatment with analgesics and a medial compartment unloader brace can help alleviate the symptomatology. For patients who progress to knee OA and fail non-operative treatment, a partial or TKA can be considered.

Active patients, regardless of age, should be referred early and considered for a meniscal root repair. Indications for a meniscal root repair include acute, traumatic root tears in patients with nearly normal or normal cartilage and chronic symptomatic root tears in young or middle-aged patients without significant pre-existing OA (figure 7). Meniscal root repair has been demonstrated to have high satisfaction rates and superior outcomes than arthroscopic meniscectomy for root tears.[6 10 11 44 51 52] Early referral of these patients for surgery had been demonstrated to significantly decrease the progression of knee OA and the requirement for TKA at mid-term follow-up.[14 38 39]

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