

Review of Meniscal Root Tears: Diagnosis, Classification and Treatment

Miten Rajendra Sheth¹, Sachin Ramchandra Tapasvi², Shantanu Sudhakar Patil²

Abstract:

Meniscal root tears include direct avulsions off the tibial plateau or radial tears adjacent to the root itself. These injuries eventually behave as meniscectomized knee and predispose to accelerated degeneration. The present review accounts for the current development in diagnosis and management of these injuries and also gives details of authors preferred method of treatment of these injuries.

Keywords: Meniscal root tear, classification, management

Introduction

The menisci are integral to overall function of the knee and play a key role in shock absorption, joint stabilization, and possibly proprioception [1,2]. More importantly, each individual meniscus dissipates around 70-90% of the axial load transmitted through its respective compartment, and hence protects the articular cartilage [3]. In addition to menisco-capsular attachments, there are four meniscal roots that firmly anchor the medial and lateral menisci to the anterior and posterior tibial inter-condylar region [4]. For the menisci to function properly, the bio-mechanical integrity of both anterior and posterior roots on the tibial plateau must be maintained [5,6].

Occurring on either the medial or lateral meniscus, root tears by definition include direct avulsions off the tibial plateau or radial tears adjacent to the root itself [7]. These tears left untreated result in loss of hoop tension and altered tibio-femoral contact forces. These injuries eventually will behave similar to a meniscectomized knee and predispose to accelerated degeneration [3,4,6]. Improved ability to detect them, and an increased understanding of their bio-mechanical consequences, has prompted a lot of research in the field of root tears and their management. This review summarizes the literature regarding assessment of meniscal root tears, their classification and treatment.

Diagnosis

Meniscal root tears can occur in both acute and chronic settings. Acute tears of the posterior root of the lateral meniscus have been associated with contact anterior cruciate ligament (ACL) injuries, where as those of the

posterior root of the medial meniscus are either seen in younger patients with multi-ligament injuries or in older patients with subtle trauma due to hyper-flexion or squatting [8,9,10]. More frequently, posterior root tears are chronic injuries associated with meniscal extrusion, observed in older patients, as an expression of osteoarthritis [2,9,11].

Of the possible four sites for a root tear, a posterior root tear of the medial meniscus is most common. This may be because of the fact that it is the least mobile of all meniscus roots [2,12]. In general, posterior horns of the menisci bear more load than anterior horns, especially at 90° of flexion, and are more likely to be injured [13]. Posterior root tears of the medial meniscus have a reported higher prevalence in Asian countries, where a floor-based lifestyle is habitual, especially in the older population (over 50 years of age) [14,15]. Individuals with a higher body weight index, lower activity level, varus mal-alignment and females are at an increased risk [16].

Anterior root tears are very infrequent, and may occur as a consequence of tibial tunnel drilling during ACL reconstruction, or intra-medullary nailing for a tibial shaft fracture [17,18].

Diagnosis of a meniscal root injury is difficult and challenging because the clinical presentation is unlike that of a meniscal body tear. Mechanical symptoms classic of a meniscal injury may not be present [19]. Further, posterior root tears of the medial meniscus may be diagnosed in patients with knee pain without any recollected traumatic event [20]. A popping sensation in the knee at onset followed by severe pain may indicate an acute posterior root tear. Symptoms resolve eventually and patients are able to walk, but residual posterior knee pain may persist [16,21,22]. In our practice an interesting finding noted by some patients is sudden onset of pain on getting up from a chair or while trying to climb stairs. These patients also report inability to sit cross-legged on the floor, after the onset of pain. The natural history of untreated root tears follows a protracted course with premature and extensive degeneration the rule rather than the exception [6, 7,23].

¹The Knee Clinic, First floor, Panchsheel Building, Paanch Rasta, Mulund West, Mumbai, India.

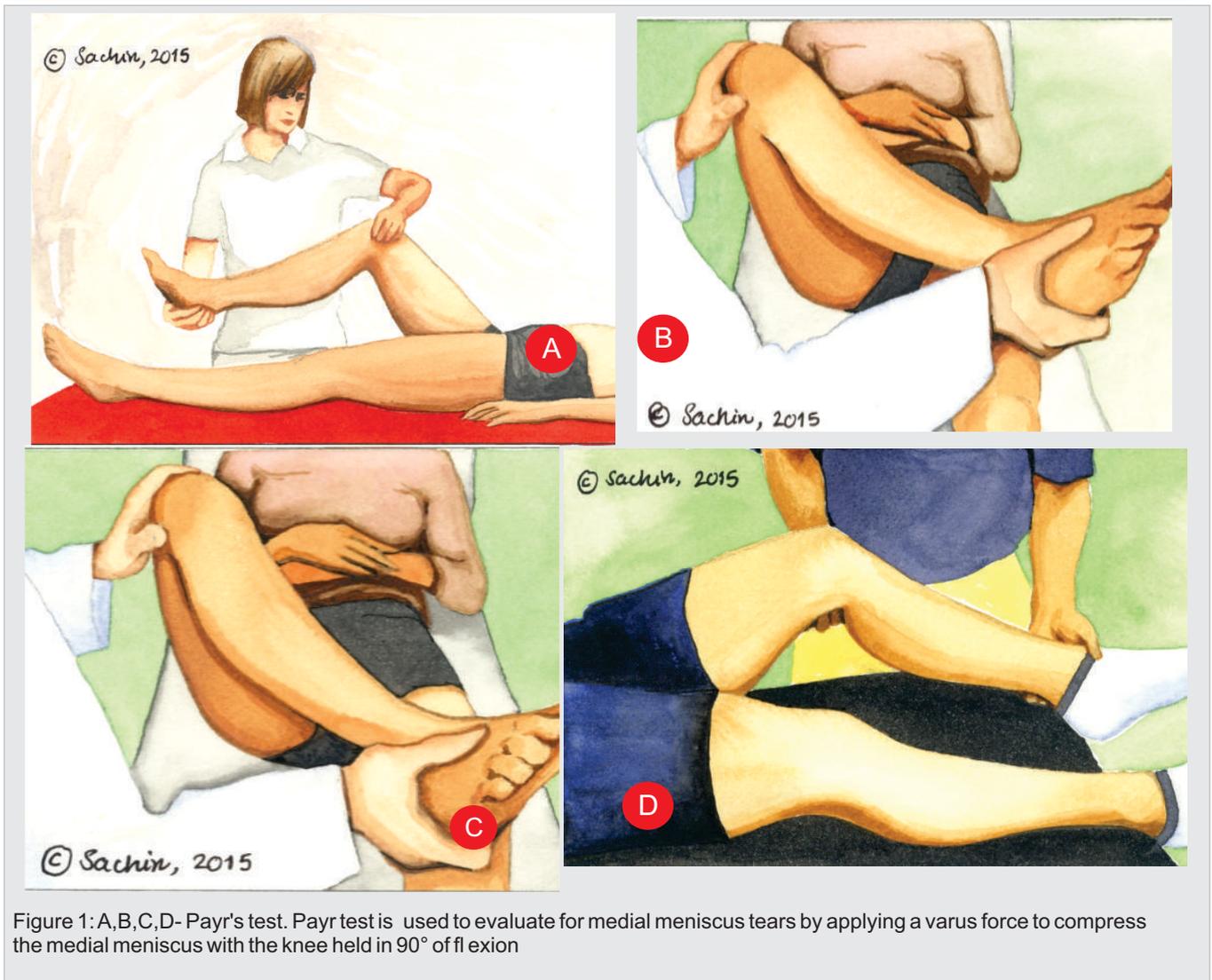
²The Orthopaedic Speciality Clinic, Paranjpe Road, Pune India.

Address for correspondence:

Dr Sachin R Tapasvi

The Orthopaedic Speciality Clinic, 16 Status Chambers, 1221/A Wrangler Paranjpe Road, Pune 411004

Email: stapasvi@gmail.com



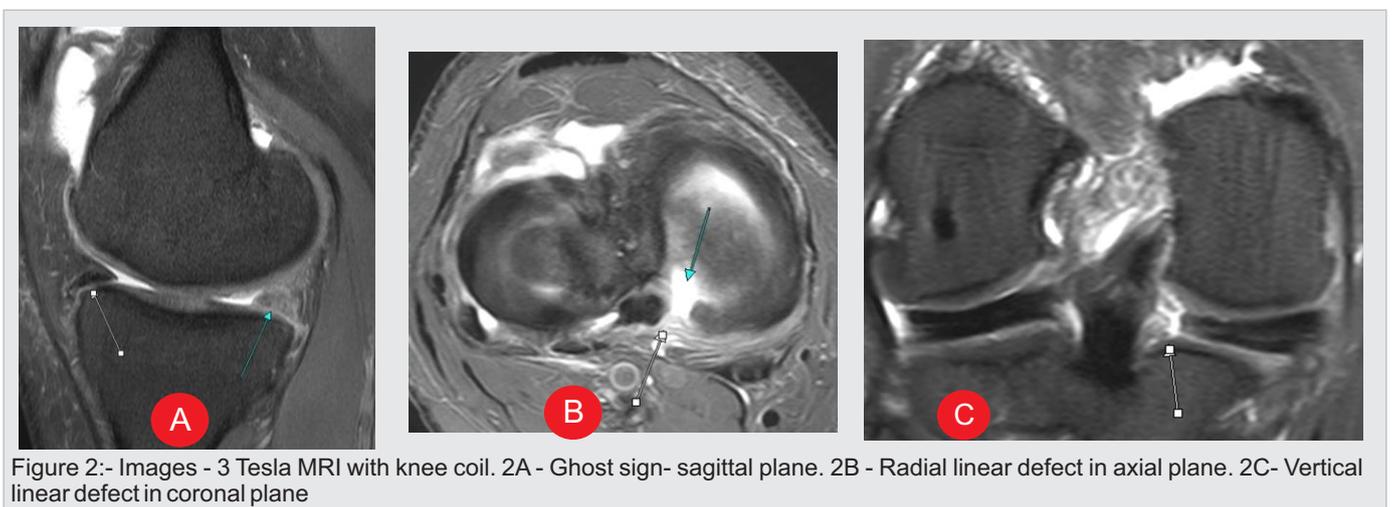
2. Physical examination

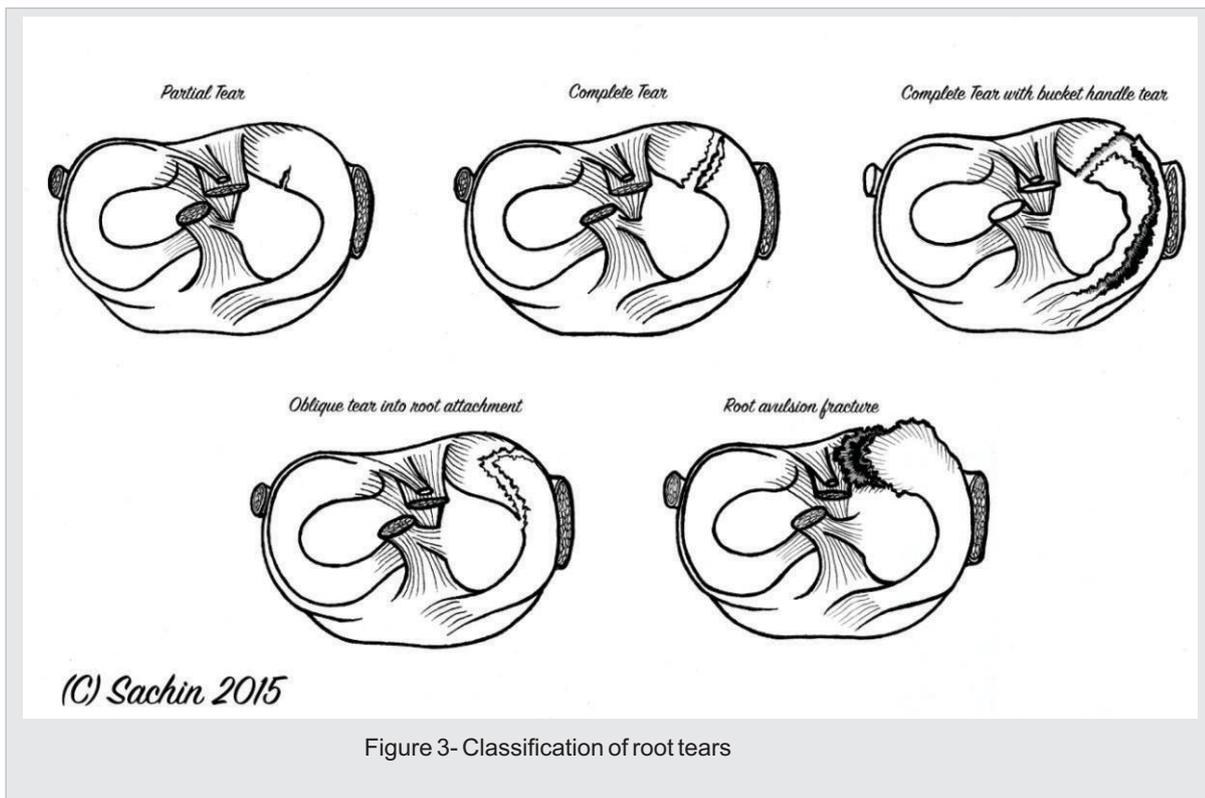
The most common signs are posterior knee pain with deep flexion and joint line tenderness [21]. In our practice Payr's test (Fig 1) has proved to be a useful adjunct to medial joint line tenderness and McMurray test to diagnose acute posterior tears of the medial meniscus in patients with early to moderate arthritis. Additionally, the extruded meniscus may be palpated over the anteromedial joint line,

when the knee is given a varus stress in full extension [24].

3. Radiographic Evaluation

Plain radiographs must ideally include anteroposterior, true lateral, patellar skyline and Rosenberg views of the knee as well as a standing, coronal, weight-bearing scanogram of both lower limbs [7]. These radiographs are



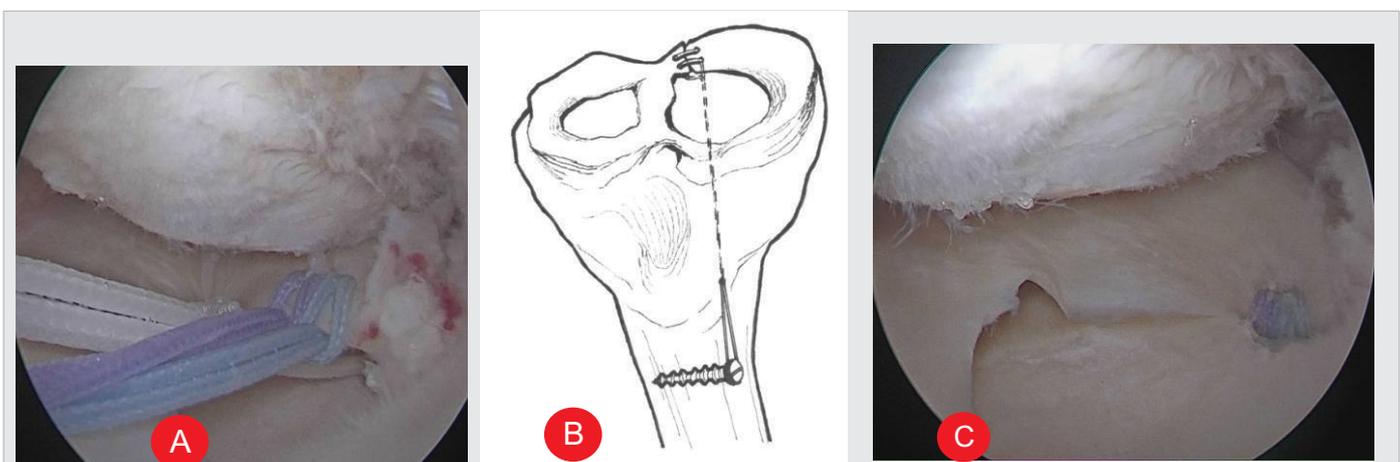


used to judge overall limb alignment and joint space narrowing. Traumatic root tears, mostly identified in younger patients, have unremarkable radiographs except in cases with bony root avulsions [25]. Degenerative root tears, common in older patients, are more often than not accompanied by varus alignment and arthritic changes on radiographs [11, 1]. The presence of arthritis and the degree of arthritis has an influence on the treatment offered to patients with a degenerative root tear.

4. Magnetic Resonance Imaging (MRI) Evaluation

If a root tear is suspected on the basis of clinical findings, an MRI must be obtained. MRI scan is the gold standard in diagnosing these lesions [2]. A high index of suspicion is necessary to pick up these tears on MRI scans. Recent

studies have proposed that MRI could have a 100% detection rate if images in all three planes are reviewed along with clinical symptoms. 'Ghost sign'-absence of an identifiable meniscus on sagittal plane; radial linear defect at the root insertion on axial plane; and a vertical linear defect at the root insertion on coronal plane, are the best indicators of a root tear [26,27] (Fig. 2). Absolute meniscal extrusion >3mm or a relative extrusion >10% are significantly associated with articular cartilage degeneration and highly correlate with the presence of a root tear [28,29]. Sub-chondral bone marrow edema usually precedes a root tear and subsides when the tear occurs but insufficiency fractures may be seen as well [8,30]. Recently, fat-suppressed volume isotropic turbo spin echo acquisition (FS 3D VISTA) with reader defined



axial reconstruction has been described as a powerful diagnostic tool for visualization of root tears [31].

Classification

With the hope of ensuring uniform and improved reporting, meniscal root tear patterns have been categorized by several authors on the basis of MRI as well as arthroscopy.

MRI:

Posterior medial meniscus root lesions can be classified as: degeneration and tear, the latter being categorized into partial or complete with delineation of the point of failure as entheses, mid-substance, or meniscal junction [32].

Arthroscopy:

LaPrade et al, on the basis of tear morphology, classified all root tears as: partial stable root tears (type 1), complete radial tears within 9 mm from the bony root attachment (type 2), bucket-handle tears with root detachment (type 3), complex oblique or longitudinal tears extending into the root attachment (type 4), and avulsion fractures of the root attachment (type 5). Radial root tears are subclassified into types 2A, 2B and 2C (0 to <3 mm, 3 to <6 mm, and 6-9 mm respectively). In addition, complete posterior lateral meniscal root tears with intact menisco-femoral ligament(s) can be considered a variant tear pattern [33].

Degenerative medial meniscus root tears can be classified as: non-displaced and widely displaced, the latter group being associated with greater meniscal extrusion, and more severe chondral wear and arthritis [34]. Posterior lateral meniscus root tears can be classified as: avulsion of the root (type 1), radial tear of the posterior horn close to the root with an intact menisco-femoral ligament (type 2), and complete detachment of the posterior horn (type 3) [35].

Treatment.

The treatment options for meniscal root tears include conservative management, partial meniscectomy and repair. Factors confounding the decision-making process include: age of the patient, symptoms, cartilage status, presence or absence of meniscal extrusion, type, location and chronicity of the root lesion.

Conservative treatment:

Although non-operative management of root tears fails to restore native bio-mechanics and may induce arthritic changes over time, certain patients may best be treated non-surgically [36]. Symptomatic treatment with rest, cryotherapy, anti-inflammatory medications, activity modification, and/or unloader bracing may alleviate joint pain. Patients with multiple co-morbidities, advanced age,

and severe osteoarthritis must attempt a period of non-operative treatment before undergoing surgical intervention [1,3,7].

Partial Meniscectomy

Partial meniscectomy is the preferred treatment option in patients with chronic root tears and symptomatic grade III or IV chondral lesions (pre-existing arthritis) who fail non-operative treatment, and patients with partial root tears with a major portion of the footprint intact.

Advantages of partial meniscectomy over repair include reduced operative time, easier post-operative rehabilitation, and faster return to activities and sports. These gains and improved short-term subjective scores must be read cautiously, knowing that patients undergoing root repair have better improvement in scores and less progression of arthritic changes over time [1,15,16,38].

Repair

Since root tears bio-mechanically simulate a total meniscectomized state, there has been a recent trend towards repair and reattachment over meniscectomy [6,8]. Surgical repair is best reserved for patients with good cartilage status and relatively acute root tears. Indications for meniscal root repair include: (i) acute symptomatic root tears with minimal arthritis, (ii) chronic symptomatic root tears, having failed conservative treatment, without significant pre-existing arthritis or varus mal-alignment, (iii) lateral meniscus root tears concomitant with ACL injuries [1,5,7,9,10,20,39].

Several techniques and fixation methods have been described to repair either medial or lateral root tears. The surgical techniques fall into two broad categories: pull-out suture repairs and suture anchor repairs. Recent description of surgical landmarks has facilitated accurate identification of the roots and the key is anatomic repair irrespective of the technique used [40,41].

Pull-out suture repair:

The pull-out suture method involves drilling of one or two tibial tunnels, with an ACL guide, at the root insertion. Standard anteromedial and anterolateral portals are sufficient to complete the repair using a suture passing device or shuttle, and non-absorbable ultra-high molecular weight poly-ethylene (UHMWPE) sutures [1]. A posterior trans-septal portal and high posteromedial or posterolateral portals have been used to improve visualization and suturing of the roots [5,42,43]. Several single or double suture configurations have been described and can be used, though it seems that two stitches are better than one, and the modified Mason-Allen technique provides the best bio-mechanical strength [20,44]. The sutures can be retrieved through the

proximal tibial bone tunnels, made employing an ACL guide, and they can then be fixed using a bone bridge, button or screw and washer [5,20,25,44].

Suture anchor repair:

In the setting of multi-ligament or revision surgery, suture anchor repair seems to be the better option as it avoids the need for tibial bone tunnels. Most suture anchor techniques involve creation of an accessory posteromedial or posterolateral portal [45,46]. An arthroscopic knot is placed directly on the meniscal root with a knot pusher and more precise tensioning of the repair is theoretically possible.

Our preferred method

The senior author's current preferred technique for medial meniscus posterior root fixation involves a trans-osseous pull-out suture repair. Besides two standard portals, a 2-cm oblique incision is made over the anteromedial tibia for drilling trans tibial tunnels. Whilst performing the root repair with a concomitant ACL reconstruction, care should be taken to avoid coalition of tunnels. A commercial suture passing device is used to thread two UHMWPE sutures through the root. A bone tunnel is created with an ACL tibial guide, using a 4.5mm reamer over the guide pin. The two sutures are retrieved from these tunnels, the knee is cycled and then these sutures are tied over a fixation post; one with the knee in extension and other with the knee in 90° of flexion. This ensures uniform tension across the repair in this range, and allows range-of-motion exercises post-operatively.

Rehabilitation:

As of today, there is no real consensus regarding post-operative rehabilitation after root repair.

Isometric quadriceps strengthening exercises can be started immediately on the first post-operative day itself. Both immobilization for a variable period of time, and immediate passive motion have been suggested in the early post-operative period [1, 20]. Slow, progressive increase in range of motion, individualized to each patient, is advised over ensuing weeks. The general consensus is to restrict weight-bearing for first six weeks, followed by a progressive increase to full weight bearing by two months [1, 39]. Return to full activity and sports can be expected by four-six months post-operatively, depending on other concomitant injuries [1, 7].

Treatment Outcomes:

Several authors have reported outcomes comparing the three existing modalities of treatment.

Both non-operative treatment and partial meniscectomy may provide short-term symptomatic relief but they do not halt progressive degeneration of the affected knee [2, 36]. These findings parallel bio-mechanical evidence

equating untreated root tears with knees having undergone total meniscectomy [3, 6,8]. An anatomic medial meniscal root repair heals well, restores hoop tension, and improves clinical and radiographic scores [1, 3,20,44]. There is no evidence to prove that root repairs retard the progression of arthritis, though it has been reported that repairs do better than partial meniscectomy in this regard [47]. Both methods of root repair (pull-out suture and suture anchor) result in improved functional scores [22,44,46] The optimal technique is yet to be determined, though it seems that that suture anchors provide superior biomechanical properties compared with pull-out sutures [48]. Complete healing of the repaired root and reduction of meniscal extrusion are less predictable [44] Posterior root tears of lateral meniscus have been treated conservatively and with root repair, with low level evidence justifying either line of management [5,36].

Complications:

Most intra-operative complications are related to surgical technique and include iatrogenic damage to ACL or cartilage of the ipsilateral compartment, and injury to posterior neuro-vascular structure [7] Potential complications unique to the pull-out suture technique include tunnel coalition during multi-ligament surgery, suture abrasion or stretching within tunnels, and displacement of the repaired root with knee movements post-operatively [1,49] Suture anchor repairs may fail due to inadequate knot tensioning during surgery or loosening of anchors post-surgery [21]. Meniscal root repair is a technically demanding surgery. Insufficient tension on the repair, inadequate tissue-bite or quality, and non-anatomic fixation may not restore joint biomechanics [21,50]. There is insufficient evidence to elucidate prevalence of re-tears and evidence regarding anterior root tears is yet lacking because of low incidence of these injuries.

Conclusion

Posterior root tears of either meniscus alter tibio-femoral mechanics and may lead to progressive degeneration of the knee. Clinical diagnosis is challenging and surgeons must be watchful to not miss these tears. Most root tears can be identified with improved MRI imaging and experienced reporting. Recent clinical studies suggest a clear benefit of repairing acute root tears especially in patients with minimal arthritic changes. An anatomic root repair, irrespective of the technique used, affords the best chance for healing, restoring original biomechanics and possibly retarding progression of arthritis. Further studies are needed to elucidate efficacy of different surgical techniques and long-term consequences of root repairs.

References

1. Bhatia S, LaPrade CM, Ellman MB, LaPrade RF. Meniscal root tears: significance, diagnosis, and treatment. *Am J Sport Med* 2014 42:3016-30.
2. Ozkoc G, Circi E, Gonc U, Irgit K, Pourbagher A, Tandogan RN. Radial tears in the root of the posterior horn of the medial meniscus. *Knee Surg Sports Traumatol Arthrosc* 2008 16:849-54.
3. Kim JG, Lee YS, Bae TS, et al. Tibiofemoral contact mechanics following posterior root of medial meniscus tear, repair, meniscectomy, and allograft transplantation. *Knee Surg Sports Traumatol Arthrosc* 2013 21(9): 2121-2125.
4. Brody JM, Lin HM, Hulstyn MJ, Tung GA. Lateral meniscus root tear and meniscus extrusion with anterior cruciate ligament tear. *Radiology* 2006; 239:805-810.
5. Ahn JH, Lee YS, Yoo JC, Chang MJ, Park SJ, Pae YR. Results of arthroscopic all-inside repair for lateral meniscus root tear in patients undergoing concomitant anterior cruciate ligament reconstruction. *Arthroscopy*. 2010; 26(1): 67-75.
6. Allaire R, Muriuki M, Gilbertson L, Harner CD. Biomechanical consequences of a tear of the posterior root of the medial meniscus: similar to total meniscectomy. *J Bone Joint Surg Am*. 2008; 90(9): 1922-1931.
7. Vyas D, Harner CD. Meniscus root repair. *Sports Med Arthrosc Rev*.2012; 20(2): 86-94.
8. Pagnani MJ, Cooper DE, Warren RF. Extrusion of the medial meniscus. *Arthroscopy*. 1991; 7(3): 297-300.
9. Koenig JH, Ranawat AS, Umans HR, Difelice GS. Meniscal root tears: diagnosis and treatment. *Arthroscopy*. 2009;25(9):1025-1032.
10. Feucht MJ, Salzmann GM, Bode G, Pestka JM, Kühle J, Südkamp NP, Niemeyer P. Posterior root tears of the lateral meniscus. *Knee Surg Sports Traumatol Arthrosc*. 2015 Jan;23(1):19-25.
11. Lee DH, Lee BS, Kim JM, et al. Predictors of degenerative medial meniscus extrusion: radial component and knee osteoarthritis. *Knee Surg Sports Traumatol Arthrosc* 2011;19:222-9.
12. Thompson WO, Thaete FL, Fu FH, Dye SF. Tibial meniscal dynamics using three-dimensional reconstruction of magnetic resonance images. *Am J Sports Med*. 1991;19(3):210-215; discussion 215-216.
13. Fox AJ, Bedi A, Rodeo SA. The basic science of human knee menisci: structure, composition, and function. *Sports Health*.2012;4(4):340-351.
14. Bin SI, Kim JM, Shin SJ. Radial tears of the posterior horn of the medial meniscus. *Arthroscopy*. 2004;20:373-8.
15. Habata T, Uematsu K, Hattori K, Takakura Y, Fujisawa Y. Clinical features of the posterior horn tear in the medial meniscus. *Arch Orthop Trauma Surg*. 2004;124:642-5.
16. Hwang BY, Kim SJ, Lee SW, Lee HE, Lee CK, Hunter DJ, Jung KA. Risk factors for medial meniscus posterior root tear. *Am J Sports Med*. 2012;40:1606-10.
17. LaPrade CM, Smith SD, Rasmussen MT, et al. Consequences of tibial tunnel reaming on the meniscal roots during cruciate ligament reconstruction in a cadaveric model, part 1: the anterior cruciate ligament. *Am J Sport Med* 2015;43:200-6
18. Ellman MB, James EW, Laprade CM, Laprade RF. Anterior meniscus root avulsion following intramedullary nailing for a tibial shaft fracture. *Knee Surg Sports Traumatol Arthrosc* 2015;23:1188-91.
19. Lee JH, Lim YJ, Kim KB, Kim KH, Song JH. Arthroscopic pull out suture repair of posterior root tear of the medial meniscus: radiographic and clinical results with a 2-year follow-up. *Arthroscopy*.2009;25(9):951-958.
20. Kim JH, Chung JH, Lee DH, Lee YS, Kim JR, Ryun KJ. Arthroscopic suture anchor repair versus pullout suture repair in posterior root tear of the medial meniscus: a prospective comparison study. *Arthroscopy*. 2011;27(12):1644-1653.
21. Nha KW, Jo JH, Lee DB. Clinical results of the radial tear of posterior root of medial meniscus. *J Korean Arthrosc Soc*. 2007;11:128-33.
22. Bae JH, Paik NH, Park GW, Yoon JR, Chae DJ, Kwon JH, Kim JI, Nha KW. Predictive value of painful popping for a posterior root tear of the medial meniscus in middle-aged to older Asian patients. *Arthroscopy*. 2013;29:545-9.
23. Harner CD, Mauro CS, Lesniak BP, Romanowski JR. Biomechanical consequences of a tear of the posterior root of the medial meniscus: surgical technique. *J Bone Joint Surg Am*. 2009; 91 Suppl 2:257-70.
24. Seil R, Duck K, Pape D. A clinical sign to detect root avulsions of the posterior horn of the medial meniscus. *Knee Surg Sports Traumatol Arthrosc*. 2011;19(12):2072-2075.
25. Raustol OA, Poelstra KA, Chhabra A, et al. The meniscal ossicle revisited: etiology and an arthroscopic technique for treatment. *Arthroscopy*. 2006;22:e681-e683.
26. Choi SH, Bae S, Ji SK, Chang MJ. The MRI findings of meniscal root tear of the medial meniscus: emphasis on coronal, sagittal and axial images. *Knee Surg Sports Traumatol Arthrosc*. 2012;20:2098-103.
27. Lee YG, Shim JC, Choi YS, Kim JG, Lee GJ, Kim HK. Magnetic resonance imaging findings of surgically proven medial meniscus root tear: tear configuration and associated knee abnormalities. *J Comput Assist Tomogr*. 2008;32:452-7.
28. Choi CJ, Choi YJ, Lee JJ, Choi CH. Magnetic resonance imaging evidence of meniscal extrusion in medial meniscus posterior root tear. *Arthroscopy*. 2010;26(12):1602-1606.
29. Park H-J, Kim SS, Lee S-Y, et al. Medial meniscal root tears and meniscal extrusion transverse length ratios on MRI. *Brit J Radiol* 2012;85:e1032-7.
30. Umans H, Morrison W, DiFelice GS, et al. Posterior horn medial meniscal root tear: the prequel. *Skeletal Radiol* 2014;43:775-80.
31. Lim D, Lee YH, Kim S, et al. Fat-suppressed volume isotropic turbo spin echo acquisition (VISTA) MR imaging in evaluating radial and root tears of the meniscus: focusing on reader-defined axial reconstruction. *Eur J Radiol* 2013;82:2296-302.
32. Choi JY, Chang EY, Cunha GM, Tafur M, Statum S, Chung CB. Posterior medial meniscus root ligament lesions: MRI classification and associated findings. *AJR Am J Roentgenol*. 2014 Dec;203(6):1286-92.
33. LaPrade CM, James EW, Cram TR, Feagin JA, Engebretsen L, LaPrade RF. Meniscal root tears: a classification system based on tear morphology. *Am J Sports Med*.2015 Feb;43(2):363-9.
34. Bin SI, Jeong TW, Kim SJ, Lee DH. A new arthroscopic classification of degenerative medial meniscus root tear that correlates with meniscus extrusion on magnetic resonance imaging. *Knee*. 2015 Jul 31. pii: S0968-0160(15)00157-X. [Epub ahead of print]
35. Forkel P, Reuter S, Sprenger F, Achtnich A, Herbst E, Imhoff A, Petersen W. Differentiated patterns of lateral meniscus root tears in ACL injuries: application of a differentiated classification system. *Knee Surg Sports Traumatol Arthrosc*. 2015 Jan;23(1):112-8.
36. Shelbourne KD, Roberson TA, Gray T. Long-term evaluation of posterior lateral meniscus root tears left in situ at the time of anterior cruciate ligament reconstruction. *Am J Sports Med*. 2011;39(7):1439-1443.
37. Lim HC, Bae JH, Wang JH, Seok CW, Kim MK. Non-operative treatment of degenerative posterior root tear of the medial meniscus. *Knee Surg Sports Traumatol Arthrosc*. 2010; 18:535-9.
38. Han SB, Shetty GM, Lee DH, Chae DJ, Seo SS, Wang KH, Yoo SH, Nha KW. Unfavorable results of partial meniscectomy for complete posterior medial meniscus root tear with early osteoarthritis: a 5- to 8-year follow-up study. *Arthroscopy*. 2010;26:1326-32.
39. Papalia R, Vasta S, Franceschi F, D'Adamo S, Maffulli N, Denaro V. Meniscal root tears: from basic science to ultimate surgery. *Br Med Bull*. 2013;106:91-115.
40. LaPrade CM, Ellman MB, Rasmussen MT, et al. Anatomy of the anterior root attachments of the medial and lateral menisci: a quantitative analysis. *Am J Sport Med* 2014; 42:2386-92.
41. Johannsen AM, Civitarese DM, Padalecki JR, et al. Qualitative and quantitative anatomic analysis of the posterior root attachments of the medial and lateral menisci. *Am J Sport Med* 2012;40:2342-7.
42. Ahn JH, Wang JH, Yoo JC, et al. A pull out suture for transection of the posterior horn of the medial meniscus: using a posterior trans-septal portal. *Knee Surg Sports Traumatol Arthrosc* 2007;15:1510-3.
43. Rosslenbroich SB, Borgmann J, Herbolt M, Raschke MJ, Petersen W, Zantop T. Root tear of the meniscus: biomechanical evaluation of an arthroscopic refixation technique. *Arch Orthop Trauma Surg*.2013;133(1):111-115.
44. Feucht MJ, Kühle J, Bode G, Mehl J, Schmal H, Südkamp NP, Niemeyer P. Arthroscopic Transtibial Pullout Repair for Posterior Medial Meniscus Root Tears: A Systematic Review of Clinical, Radiographic, and Second-Look Arthroscopic Results. *Arthroscopy*. 2015 Sep;31(9):1808-16.
45. Engelsohn E, Umans H, Difelice GS. Marginal fractures of the medial tibial plateau: possible association with medial meniscal root tear. *Skeletal Radiol* 2007;
46. Jung YH, Choi NH, Oh JS, Victoroff BN. All-inside repair for a root tear of the medial meniscus using a suture anchor. *Am J Sports Med*. 2012;40(6):1406-1411
47. Chung KS, Ha JK, Yeom CH, Ra HJ, Jang HS, Choi SH, Kim JG. Comparison of Clinical and Radiologic Results Between Partial Meniscectomy and Refixation of Medial Meniscus Posterior Root Tears: A Minimum 5-Year Follow-up. *Arthroscopy*. 2015 Oct;31(10):1941-50.
48. Feucht MJ, Grande E, Brunhuber J, Rosenstiel N, Burgkart R, Imhoff AB, Braun S. Biomechanical comparison between suture anchor and transtibial pull-out repair for posterior medial meniscus root tears. *Am J Sports Med*. 2014 Jan;42(1):187-93
49. Cerminara AJ, LaPrade CM, Smith SD, Ellman MB, Wijdicks CA, LaPrade RF. Biomechanical evaluation of a transtibial pull-out meniscal root repair: challenging the bungee effect. *Am J Sports Med*. 2014 Dec;42(12):2988-95.
50. LaPrade CM, Foad A, Smith SD, Turnbull TL, Dornan GJ, Engebretsen L, Wijdicks CA, LaPrade RF. Biomechanical consequences of a non-anatomic posterior medial meniscal root repair. *Am J Sports Med*. 2015 Apr;43(4):912-20

Conflict of Interest: NIL
Source of Support: NIL

How to Cite this Article

Sheth MR, Tapasvi SR, Patil SS. Review of Meniscal Root Tears: Diagnosis, Classification and Treatment. *Journal of Trauma and Orthopaedics* Jan-March 2016;11(1):26-31-37.