The Knee 58 (2026) 104258

Contents lists available at ScienceDirect

The Knee

journal homepage: www.elsevier.com/locate/thekne

Review

Impact of meniscal root tears on knee osteoarthritis development: A systematic review of the literature

Gianluca Canton [a], Andrea Marchetti [a,*], Belinda Trobec [a], Michelangelo Scordo [a], Alessandra Mazzon [a], Chiara Ratti [a], Manuela Deodato [b], Alex Buoite Stella [b], Luigi Murena [a]

[a] Orthopaedics and Traumatology Unit, Cattinara Hospital – ASUGI, Department of Medical, Surgical and Health Sciences, Trieste University, Trieste, Italy
[b] Department of Medical, Surgical and Health Sciences, University of Trieste, Trieste, Italy

ARTICLE INFO

Article history:
Received 12 April 2025
Revised 24 August 2025
Accepted 13 October 2025

Keywords:
Meniscal root tears
Knee
Osteoarthritis
Cartilage degeneration

ABSTRACT

Background: Meniscal root tears (MRTs) are a significant cause of knee pain and dysfunction. An MRT can alter the biomechanics of the knee joint, leading to cartilage damage and osteoarthritis. This systematic review aims to evaluate the impact of MRTs on the progression of knee osteoarthritis in patients undergoing non-operative treatment.

Methods: A systematic review was performed based on the PRISMA guidelines in PubMed, Scopus, and ScienceDirect databases ("meniscal root injuries" OR "meniscal root tears") AND ("osteoarthritis" OR "joint degeneration").

Results: Eight studies, including 1160 patients with MRTs, met the inclusion criteria. MRTs were associated with more severe cartilage damage on the medial femoral condyle (Noyes score, 4.95; $P < 0.001$) and on the medial tibial plateau (Noyes score, 3.9; $P < 0.005$) compared with other meniscus tear patterns. Eighty per cent of medial meniscus posterior root tears had an ICRS grade ≥2 chondral lesions at the medial femoral condyle, and those chondral lesions had a more progressive and faster nature compared with medial meniscus posterior horn tears. MRTs and meniscal extrusion were predominant factors associated with accelerated osteoarthritis progression (odds ratio 4.64; 95 % confidence interval, 1.61–13.34; $P = 0.004$).

Conclusions: MRTs have a crucial role both in the initiation and the progression of knee osteoarthritis, leading to severe cartilage damage and dramatic consequences on quality of life. Early diagnosis and appropriate management could preserve knee function and delay osteoarthritic changes.

Contents

1. Introduction 2
2. Materials & methods 2
   2.1. Information sources and search strategy 2
   2.2. Eligibility criteria 3
   2.3. Data items 3
   2.4. Selection and data collection process 3

* Corresponding author at: SC (UOC) Clinica Ortopedica e Traumatologica, Ospedale di Cattinara, Strada di Fiume 447, 34149 Trieste TS, Italy.
E-mail addresses: andrealbe94@gmail.com, andrea.marchetti@sanita.asugi.fvg.it (A. Marchetti).

https://doi.org/10.1016/j.knee.2025.10.012
0968-0160/

2.5. Synthesis methods . . . 4
2.6. Study risk of bias assessment, reporting bias assessment, and certainty assessment . . . 4
3. Results. . . 4
3.1. Study selection . . . 4
3.2. Study characteristics . . . 4
3.3. Results of individual studies. . . 4
3.3.1. Cartilage lesions . . . 4
3.3.2. Osteoarthritis progression . . . 6
4. Discussion. . . 6
5. Conclusion . . . 8
Funding sources . . . 8
CRediT authorship contribution statement . . . 8
Declaration of competing interest . . . 8
References . . . 8

1. Introduction

Osteoarthritis represents the most common form of arthritis with an important socioeconomic burden. Indeed, osteoarthritis is associated with important consequences on the quality of life of the sufferers due to severe pain and loss of mobility [1,2]. The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2021 showed that 595 million people had osteoarthritis in 2020, and it ranked 10th in terms of years lived with disability in adults over 70 years old. Among all joints, the knee was the most affected joint in osteoarthritis and compared with 2020, cases of osteoarthritis in the knee are projected to increase by 74.9 % [1,2]. The major risk factors are age, body mass index (BMI) and knee injuries [1–4]. Recently, among knee injuries, meniscal lesions have been associated with the start and progression of osteoarthritis [5]. Indeed, menisci play a significant role in supporting a healthy knee environment. Their function includes shock absorption, friction reduction, load distribution, increasing congruity of the knee joint, stability, joint lubrication, and proprioception [6]. Biomechanically, the menisci support 50 % of the compressive load of the knee in extension and 85 % at 90° of flexion, thus reducing the mechanical stress on the cartilage surface and the subchondral bone [6]. Meniscal root tears (MRTs) are defined as either avulsion of the insertion of the meniscus attachment or complete radial tears within 10 mm of the meniscus insertion [7]. Patients with a root lesion commonly have posterior knee pain and joint line tenderness, especially with squatting, but they could also recall a popping sound during light activities such as ascending stairs or kneeling. Magnetic resonance imaging (MRI) is the gold standard method for diagnosing a root tear. Signs of root tear on MRI include medial meniscal extrusion (>3 mm) in the coronal plane, high signal indicating a disruption of the posterior meniscal root in the axial view, the ghost sign (defined as 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 [8]. Over the past 5 years, MRTs have emerged as a distinct and clinically significant type of meniscal injury, accounting for about 20 % of all meniscal tears. Among these tears, degenerative tears of the medial meniscus posterior root are the most common. Interestingly, roughly 80 % of these medial meniscus root tears occur in individuals who are obese and lead a sedentary lifestyle or are over 50 years old [9]. Meniscal root lesions have gained increasing attention due to their potential implications in the development of osteoarthritis [5]. The biomechanical consequences of a root tear are relevant as it results in a complete loss of the biomechanical properties of the meniscal tissue. Therefore, authors report them to be comparable to a complete meniscectomy [9,10].

Despite extensive research recognizing knee injury as a major risk factor for the development of knee osteoarthritis, the definition of knee injury continues to be heterogeneous across studies; moreover, no previous study has investigated the relationship between a specific meniscal lesion, such as MRTs treated conservatively and the development of osteoarthritis. Therefore, the main aim of this systematic review was to explore the existing literature on the effect of non-surgically treated meniscal root lesions on the development of osteoarthritis, shedding light on the mechanisms and contributing factors involved.

2. Materials & methods

This study was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [11]. This study is registered in the PROSPERO Registry CRD42024564379.

2.1. Information sources and search strategy

A systematic review of the literature was performed on 16th January 2025, using PubMed, Scopus, and ScienceDirect based on the following keywords: (‘‘meniscal root injuries” OR ‘‘meniscal root tears”) AND (‘‘osteoarthritis” OR ‘‘joint degeneration”).

2.2. Eligibility criteria

The inclusion criteria were as follows: studies providing clinical or radiological outcomes of non-operative treatment of meniscus root lesions, retrospective or prospective studies including randomized controlled trials, nonrandomized trials, cohort studies, case–control studies, and case series, and papers in English without any restriction on publication date. Exclusion criteria were as follows: non-English language papers and studies that did not provide clear clinical results, case reports, literature reviews, letters to the editor, biomechanical reports, ex vivo or cadaveric studies, editorial commentaries.

2.3. Data items

Articles were equally and randomly assigned to six authors (M.S., A.M., C.R., M.D., A.B.S., L.M.) who screened abstracts and full texts of eligible papers. The selection procedures were double-checked by two other authors (A.M. and B.T.). Any disagreement between raters was resolved through discussion with a third author (G.C.).

2.4. Selection and data collection process

The included studies were equally and randomly assigned to six authors (M.S., A.M., C.R., M.D., A.B.S., L.M.) who extracted data through an electronic spreadsheet of Microsoft Excel. The process was double-checked by two other researchers (A.M. and B.T.); any disagreements were resolved between them or discussed with the first author (G.C.). Of 399 findings, duplicates and non-English papers were eliminated, and articles were screened based on title and abstract, leading to 38 matching articles (Figure 1). Most of the eliminated articles were focused on clinical outcomes and osteoarthritis progression following MRT surgical treatment. Of the 38 matching articles, reports and studies based on animals, cadavers, and laboratory studies were excluded, but also reviews and *meta*-analyses were excluded.

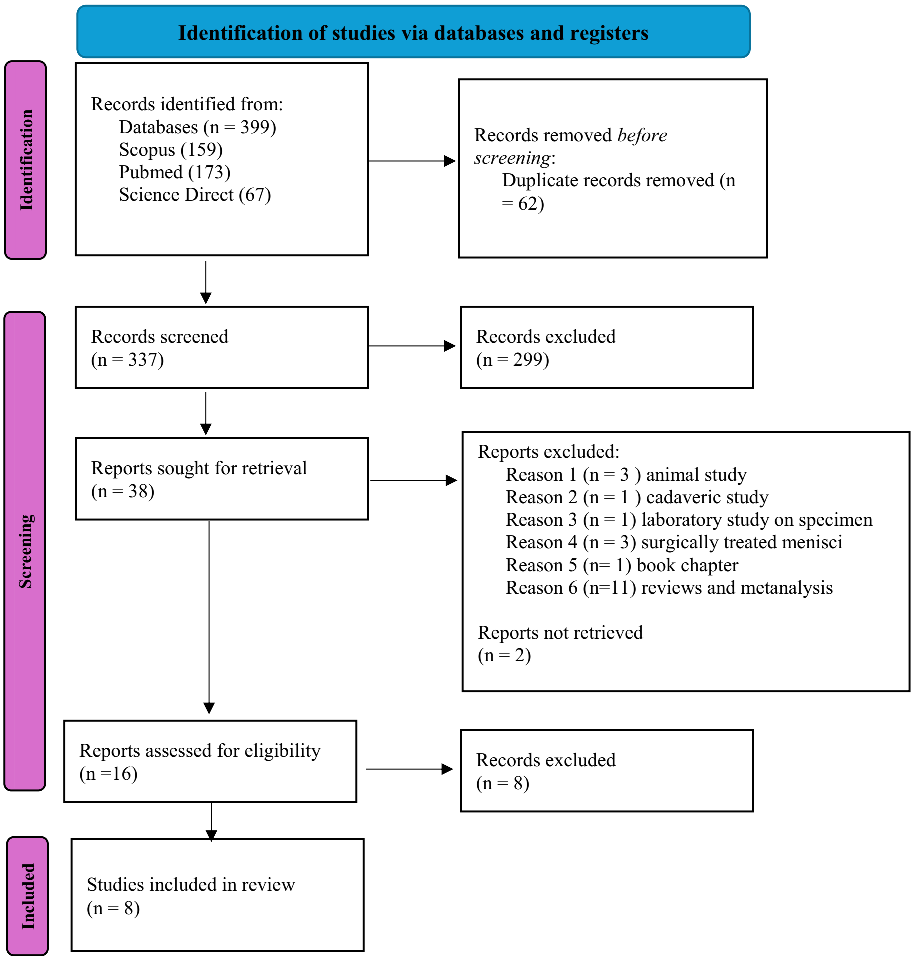

Figure 1. Prisma 2020 flow diagram of the literature screening performed in this study.

2.5. Synthesis methods

The eight final articles were included in the present review on osteoarthritis progression after non-operative treatment of MRTs. The references for all included studies were assessed and screened to ensure integrity and thoroughness. The two investigators extracted relevant data independently. The following data were extracted from each included study: demographics, study design, followmup times, treatment groups, evaluation scores adopted, and overall radiographic findings. The Oxford Levels of Evidence set by the Oxford Centre for Evidence-Based Medicine were used to categorize evidence levels [12].

2.6. Study risk of bias assessment, reporting bias assessment, and certainty assessment

The quality of the selected studies was evaluated using the Methodological Index for Nonrandomized Studies (MINORS) score [13]. The checklist consists of 12 items, of which the last four are specific for comparative studies. Each item was scored from 0 to 2 points. The ideal scores were 16 points for non-comparative studies and 24 for comparative studies.

3. Results

3.1. Study selection

A total of eight studies [14–21] published from 2012 to 2019 that reported non-operative treatment outcomes of MRT lesions were finally included in the review. The PRISMA 2009 diagram illustrates the studies that were identified, included, and excluded, as well as the reason for the exclusion (Figure 1). The studies analyzed had an average MINORS score of 12.9 (Table 1), suggesting moderate to low methodological quality of the available literature.

3.2. Study characteristics

Eight studies involving 1160 patients with posterior meniscus root lesions (PMRLs) were included in the review (Table 2). The mean total follow up was 25.46 months (standard deviation (SD) ± 21.06; ranging from 5.7 to 60 months). Patients were reported in all studies, with an overall mean of 57.48 (range 48–62.8) years. The mean BMI of the patients was 29.17 (SD ± 2.72; range 26.02–33.4).

3.3. Results of individual studies

3.3.1. Cartilage lesions

Five studies reported cartilage lesions associated with MRT: two prospective [14,16], one retrospective [19], and two comparative studies [15,21] involving 909 patients.

Henry et al. identified different articular cartilage lesions depending on meniscus tear morphology, particularly affecting the medial femoral condyle (MFC), medial tibial plateau (MTP), and lateral tibial plateau (LTP), while no significant findings were reported for the lateral femoral condyle (LFC). Most tear morphologies showed cartilage lesions, except for vertical tears. Root tears were specifically associated with more severe cartilage damage on MFC (Noyes score, 4.95; $P < 0.001$) and MTP (Noyes score, 3.9; $P < 0.005$). Evaluating the relationship between medial meniscus tear morphology and chondral degeneration in the knee, root tears were associated with significantly more severe cartilage degeneration compared with the other tears (Noyes score, 55.71; $P < 0.001$) [14].

Guermazi et al. highlighted that the distribution of WORMS (Whole-Organ Magnetic Resonance Imaging Score) cartilage grades showed greater cartilage loss (WORMS 3–6) in the group of patients with medial meniscus root tears compared to the no-tear group. They also observed a higher relative risk of incident or progressive tibiofemoral cartilage damage in patients with MMRT (2.03 (95 % CI: 1.18, 3.48)) compared with those with other types of meniscal tears (1.84 (95 % CI: 1.32, 2.58)) [16].

Park et al. evaluated the distribution of chondral lesions within the MFC and compared the effects of medial meniscus posterior root tears (MMPRT) and medial meniscus posterior horn tears (MMPHT). MMPRTs were associated with more severe chondral lesions in the far medial compartment of the MFC, whereas MMPHT predominantly affected the central–central region. They reported that 80.6 % (25 of 31) of patients with MMPRT had MFC chondral lesions graded ≥ 2 according to ICRS. Moreover, chondral damage in MMPRT cases had a more progressive and rapid course compared to MMPHT [15].

Krych et al. also evaluated the changes in the medial compartment of the knee in patients with a diagnosis of MMPRT treated conservatively. Patients were stratified into two groups based on MRI follow up intervals: Group 1 (20 knees; subacute) had MRIs within 12 months, and Group 2 (21 knees; chronic) had MRIs after more than 12 months. Meniscal extrusion increased significantly in both subacute ($P = 0.03$) and chronic groups ($P < 0.01$). Using modified Outerbridge cartilage scores, medial femur cartilage scores worsened in subacute ($P = 0.03$) and chronic groups ($P < 0.001$). Medial tibial cartilage scores worsened in subacute ($P < 0.01$) and chronic groups ($P < 0.001$) [19].

Table 1
MINORS score.

	1. A stated aim of the study	2. Inclusion of consecutive patients	3. Prospective collection of data	4. Endpoint appropriate to the study aim	5. Unbiased evaluation of endpoints	6. Follow up period appropriate to the major endpoint	7. Loss to follow up not exceeding 5 %	8. A control group having the gold standard intervention	9. Contemporary groups	10. Baseline equivalence of groups	11. Prospective calculation of the sample size	12 Statistical analyses adapted to the study design.	Total
Henry et al. (2012) [14]	2	1	0	2	2	1	1	0	0	0	0	1	10
Guermazi et al. (2013) [16]	2	1	1	2	2	2	1	0	0	0	0	2	13
Neogi et al. (2013) [18]	2	1	1	2	2	2	1	0	0	0	0	2	13
Krych et al. (2017) [20]	2	2	1	2	2	2	1	0	0	0	0	2	14
Krych et al. (2018) [19]	2	2	1	2	2	2	1	0	0	0	0	2	14
Park et al. (2019) [15]	2	1	1	2	2	2	1	0	0	0	0	2	13
Foreman et al. (2019) [17]	2	1	1	2	2	2	1	0	0	0	0	2	13
Kim et al. (2019) [21]	2	1	1	2	2	2	1	0	0	0	0	2	13

Kim et al. found that in patients with MMPRT, the tear gap was significantly associated with meniscal extrusion ($P = 0.001$), with a larger tear gap correlating with a greater meniscal extrusion ($P = 0.001$). Higher rates of cartilage wear were observed in cases of extrusion compared with those without ($P = 0.001$). Additionally, the severity of arthritis (Kellgren–Lawrence (K-L) grades III and IV) was significantly associated with increasing relative percentage of extrusion ($P = 0.001$). As the size of the meniscal root lesion increases, so does the extent of extrusion, thereby increasing the likelihood of osteoarthritis development [21].

3.3.2. Osteoarthritis progression

Three studies, one prospective [18] and two retrospectives [17,20], highlighted osteoarthritis progression linked to MRLs involving 251 patients.

Foreman et al. analyzed MRIs of knees without radiographic osteoarthritis (K-L 0–1) that progressed to advanced-stage osteoarthritis (K-L 3–4) over 4 years. They found meniscal extrusion (odds ratio (OR) 6.30 (95 % confidence interval (CI) 2.57–15.49; $P < 0.001$)) and root lesions (OR 4.64 (95 % CI 1.61–13.34; $P = 0.004$)) to be predominant factors significantly associated with accelerated osteoarthritis progression. Those types of lesions were present in 9 % of knees at the first evaluation, increasing to 45 % at the 2-year follow up, and reaching 94 % at the 4-year follow up [17].

Suhas et al. conducted a study investigating the natural progression of untreated meniscal root lesions. Radiographic scores using the K-L scale worsened significantly ($P = 0.0021$) at the last follow up, increasing by 2 grades of the K-L scale at the final follow up. Two patients in the study group underwent total knee arthroplasty (TKA) [18].

Krych et al, in another study, highlighted that 31 % of patients underwent TKA at a mean of 30 ± 32 months after diagnosis of MMRT. Patients with higher K-L scale grades were associated with increased rates of TKA conversion ($P = 0.01$). Mean K-L scale grades and arthritis rates progressed over time on radiographs, respectively increasing from 1.5 ± 0.7 to 2.4 ± 1.0 ($P < 0.001$) and 78 % from 51 % ($P = 0.01$). Overall, 87 % of patients failed non-operative treatment [20].

4. Discussion

Several studies have recognized the association between knee injuries and the development of osteoarthritis. The current systematic review highlights several critical aspects regarding the relationship between conservatively treated meniscal root lesions and the onset and progression of knee osteoarthritis. In particular, the study's results indicate that MRTs are strongly associated with accelerated cartilage degeneration and osteoarthritis progression. Moreover, non-operative treatments often lead to poor outcomes, as indicated by the high rates of osteoarthritis progression and TKA in patients managed conservatively.

Regarding the finding of cartilage degeneration, the severe cartilage damage associated with MRT can be attributed to the loss of meniscal function, including load distribution, shock absorption, and joint stability [6]. When meniscal circumferential fibers are disrupted, as in a root lesion, the transmission of circumferential hoop tension is impaired. This causes anterior and posterior displacement of the menisci, significantly altering knee kinematics and leading to dysfunctional meniscus, meniscal extrusion, and degenerative arthritis [9,22]. In vitro studies have demonstrated that untreated posterior meniscus root tears result in increased contact pressure, reduced contact surface area, and increased point-loading of the chondral surfaces with an unfavorable joint loading mechanics [23]. An MRT changes the knee's loading profile by decreasing the contact area for tibiofemoral axial loads and increasing mean and peak contact pressures by 25 % [24,25]. Functionally, an MRT is comparable with a total meniscectomy, underscoring its profound impact on joint biomechanics and long-term joint health [24]. However, surgical repair of a posterior root tear has been shown to restore tibiofemoral contact area and pressures to near-normal levels [26,27].

In addition to their chondroprotective role, the menisci serve as secondary stabilizers of the knee joint [7]. Factors such as fiber orientation, meniscal ligaments, and the contour of the superior surface enhance joint congruency, increase load tolerance, and ensure stability across various movements [28]. Medial MRTs also contribute to knee instability, though to a milder extent, and this effect is more pronounced in anterior cruciate ligament-deficient patients [29]. As already stated, medial MRTs are strongly associated with degenerative joint disease, but also with cartilage defects of the MFC [14,16] and meniscal extrusions (≥3 mm) [30]. Addressing meniscal extrusion promptly is crucial to mitigating further joint deterioration, as it can lead to osteophytosis, chondral lesions, additional meniscal tears, and osteoarthritis [31]. Additionally, Jeon et al. revealed a positive correlation between the time elapsed after injury and the severity of cartilage damage in MRT cases. Evidence suggests that the time from 2.5 to 6 months is crucial for performing meniscal root repair while extrusion remains <3 mm and cartilage damage has not progressed beyond grade 3. The same study, however, found that factors such as age, BMI, and mechanical alignment were not significantly correlated with these outcomes [32].

Concerning the progression of osteoarthritis, an MRT is linked not only to the initiation but also to the progression of osteoarthritis [18]. A medial meniscus root tear is strongly associated with the progression of cartilage wear. In one study, 39 % of MRTs showed progression of chondral disease after a mean of 3.5 months [21], and cartilage deterioration typically continues during the first year after the tear [19]. Overall, osteoarthritis progression occurs in 78 % of cases within 5 years of the diagnosis of MRT [20]. These studies underscore the necessity of anatomical reattachment, as nonanatomic repairs have been shown to yield biomechanical outcomes akin to the avulsed state, potentially resulting in inferior long-term prognosis [27,33].

Table 2
Overview of the studies included in the review.

First author (year) [ref. no.]	Type of study	No. of patients	Diagnosis	Purpose	Mean age	Mean BMI	Follow up	Outcome measures	Main results	Level of evidence
Henry et al. (2012) [14]	Prospective	103	MMT	Examine the association between MMT morphology and the pathogenesis of articular cartilage degeneration	48	28.8	MRI, ATS at 7 months	Fairbanks, Noyes score	Root lesions are more commonly associated with articular cartilage damage and chondral degeneration.	Level IV
Neogi et al. (2013) [18]	Prospective	37	MMPHT	Evaluate the effect of supervised exercise therapy on patients with MMPRT	55.8	–	X-rays, 35 months	K-L	Progression of the degenerative process from first to last follow up	Level IV
Guermazi et al. (2013) [16]	Prospective	596	PMRT	Assess the association between MMPRT and the development of tibiofemoral cartilage damage	62.8 ± 7.9	30.9 ± 5.2	X-ray weight bearing, MRI, 30 months	K-L	PMRT is associated with higher varus malalignment, effusion, and greater cartilage loss	Level II
Krych et al. (2017) [20]	Retrospective	52	MMPRT	Evaluate the mid-term clinical and radiographic outcomes of non-operative treatment for MMPRT and identify risk factors for worse outcomes	58 ± 10	33.4	MRI, 5 years	K-L	78 % of progression of osteoarthritis at 5 years	Level IV
Krych et al. (2018) [19]	Retrospective	41	MMPRT	Evaluate changes in the medial compartment of the knee over time following the diagnosis of a MMPRT	59.5 ± 8.8	–	MRI, 12 months	La Prade and Outerbridge	Meniscal extrusion and medial compartment cartilage degeneration in 1 year	Level IV
Park et al. (2019) [15]	Comparative	62	MMPRT/ MMPHT	Compare the progression rate of chondral lesions at the medial femoral condyle in patients with MMPRT vs. those with MMPHT	56.5	26.7	MRI, X-ray ATS, 5.7 months	ICRS (cartilage lesion 0–4, mapping system 9 zones)	39 % of MMPRT showed progression of chondral lesions after a mean of 3.5 months. Chondral lesions associated with MMPRT are far medial and progress faster than those lesions associated with MMPHT	Level III
Foreman et al. (2019) [17]	Retrospective cohort	162	Meniscal tears	Identified the joint factors associated with the development of accelerated osteoarthritis	61.1 ± 8.5	29.2 ± 4.4	X-ray, MRI, 4 years	K-L	Meniscal root tear and meniscal extrusion lead to higher rates of accelerated knee osteoarthritis (22 % at 2 years, 38 % at 4 years)	Level III
Kim et al. (2019) [21]	Comparative retrospective	107	MMPRT	Investigate factors associated with meniscal extrusion in degenerative medial meniscus posterior root tear	58.14 ± 9.64	26.02 ± 3	MRI, ATS, 6 months	K-L, Outerbridge	Chondral wear and arthritic changes are greater if meniscal extrusion is present	Level III

ATS, arthroscopy; BMI, body mass index; K-L, Kellgren–Lawrence; MMPHT, medial meniscus posterior horn horizontal tear; MMPRT, medial meniscus posterior root tear; MMT, medial meniscus tear; MRI, magnetic resonance imaging; MRT, meniscus root tear; OA, osteoarthritis; PMRT, posterior meniscus root tear.

Higher K-L grades were associated with increased rates of TKA conversion [19]. Non-operative treatment, including physical therapy, showed short-term symptomatic improvement but failed to prevent osteoarthritis progression, particularly in patients with a higher BMI [18]. Furthermore, arthroscopic meniscectomy shows no advantage over conservative treatment of degenerative MRT [34]. Moreover, previous research shows that meniscal repair should be considered the first option in acute traumatic root tears in patients with almost normal or normal cartilage and chronic symptomatic root tears in young or middle-aged patients without pre-existing osteoarthritis. A secondary surgical indication is a lateral meniscus root lesion associated with an anterior cruciate ligament tear [35]. Meniscal repair has better clinical outcomes and less severe degenerative changes in a long-term follow up compared with arthroscopic partial meniscectomy. Also, a centralization procedure has been developed to allow a reduction in meniscus extrusion rates and a better meniscus hoop function. Surgery may be considered in patients with acute symptoms, but despite its good outcomes and while being the key to the prevention of osteoarthritis, there is no guarantee that it will not lead to degenerative joint disease, even if associated with centralization and high tibial osteotomy [15].

There were several limitations to this study. First, the methodological quality of the studies included was moderate to low, with a mean MINORS score of 12.87 out of 24. Most studies were non-randomized and retrospective in design, with level III and IV evidence, and only one was a level II prospective cohort study. Second, there was a substantial heterogeneity among the included studies in terms of study design and treatment modalities, which represents a potential source of confounding. Third, the measured outcome and follow up periods were not consistent between studies, nor were statistical data consistently reported by all studies, making direct comparison difficult and precluding us from using all studies in the *meta*-analysis of outcomes.

5. Conclusion

In summary, MRTs play a crucial role in both the initiation and progression of knee osteoarthritis. The severity of cartilage damage associated with these lesions highlights the need for a timely diagnosis and appropriate management to reduce osteoarthritis development. While conservative treatment often results in poor outcomes, surgical repair may better preserve knee function and delay the need for arthroplasty. Ongoing research and advancements in surgical techniques will further refine our understanding and treatment of meniscal root lesions, providing physicians with better options to treat these pathologies.

Funding sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sector.

CRediT authorship contribution statement

Gianluca Canton: Writing – review & editing, Investigation, Data curation, Conceptualization. **Andrea Marchetti:** Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Belinda Trobec:** Writing – original draft, Investigation, Data curation, Conceptualization. **Michelangelo Scordo:** Writing – original draft, Investigation. **Alessandra Mazzon:** Writing – original draft, Investigation, Data curation. **Chiara Ratti:** Supervision, Investigation. **Manuela Deodato:** Writing – review & editing, Supervision, Investigation. **Alex Buoite Stella:** Supervision, Investigation, Data curation. **Luigi Murena:** Writing – review & editing, Supervision, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] GBD, 2021 Osteoarthritis Collaborators. Global, regional, and national burden of osteoarthritis, 1990-2020 and projections to 2050: a systematic analysis for the Global Burden of Disease Study 2021. Lancet Rheumatol 2023;5:e508–22. doi: https://doi.org/10.1016/S2665-9913(23)00163-7.
[2] Hunter DJ, Bierma-Zeinstra S. Osteoarthritis Lancet 2019;393:1745–59. doi: https://doi.org/10.1016/S0140-6736(19)30417-9.
[3] Muthuri SG, McWilliams DF, Doherty M, Zhang W. History of knee injuries and knee osteoarthritis: a meta-analysis of observational studies. Osteoarthritis Cartilage 2011;19:1286–93. doi: https://doi.org/10.1016/j.joca.2011.07.015.
[4] Poulsen E, Goncalves GH, Bricca A, Roos EM, Thorlund JB, Juhl CB. Knee osteoarthritis risk is increased 4-6 fold after knee injury – A systematic review and meta-analysis. Br J Sports Med 2019;53:1454–63. doi: https://doi.org/10.1136/bjsports-2018-100022.
[5] Ozeki N, Koga H, Sekiya I. Degenerative meniscus in knee osteoarthritis: from pathology to treatment. Life (Basel) 2022;12:603. doi: https://doi.org/10.3390/life12040603.
[6] Randazzo E, Duerr R, Baria MR. Meniscus root tears: a clinical review. Curr Sports Med Rep 2022;21:155–8. doi: https://doi.org/10.1249/JSR.0000000000000959.
[7] Pache S, Aman ZS, Kennedy M, Nakama GY, Moatshe G, Ziegler C. Meniscal root tears: current concepts review. Arch Bone Jt Surg 2018;6:250–9.
[8] Chahla J, LaPrade RF. Meniscal root tears. Arthroscopy 2019;35:1304–5. doi: https://doi.org/10.1016/j.arthro.2019.02.010.
[9] Bhatia S, LaPrade CM, Ellman MB, LaPrade RF. Meniscal root tears: significance, diagnosis, and treatment. Am J Sports Med 2014;42:3016–30. doi: https://doi.org/10.1177/0363546514524162.

[10] Kennedy NI, Tagliero AJ, Krych AJ. Meniscal root tears. In: LaPrade RF, Chahla J, editors. Evidence-Based Management of Complex Knee Injuries. Philadelphia: Elsevier; 2022. p. 197–210. doi: https://doi.org/10.1016/B978-0-323-71310-8.00016-5.
[11] Moher D, Liberati A, Tetzlaff J, Altman DG. PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 2009;6:e1000097. doi: https://doi.org/10.1371/journal.pmed.1000097.
[12] Ball C, Sackett D, Phillips B, Haynes B, Straus S. Levels of evidence and grades of recommendations. EBM 2009. Available at: http://www.cebm.net/index.aspx?o=5653.
[13] Slim K, Nini E, Forestier D, Kwiatkowski F, Panis Y, Chipponi J. Methodological index for non-randomized studies (minors): development and validation of a new instrument. ANZ J Surg 2003;73:712–6. doi: https://doi.org/10.1046/j.1445-2197.2003.02748.x.
[14] Henry S, Mascarenhas R, Kowalchuk D, Forsythe B, Irrgang JJ, Harner CD. Medial meniscus tear morphology and chondral degeneration of the knee: is there a relationship? Arthroscopy 2012;28:1124–1134.e2. doi: https://doi.org/10.1016/j.arthro.2011.12.020.
[15] Park J-Y, Kim BH, Ro DH, Lee MC, Han H-S. Characteristic location and rapid progression of medial femoral condylar chondral lesions accompanying medial meniscus posterior root tear. Knee 2019;26:673–8. doi: https://doi.org/10.1016/j.knee.2019.03.003.
[16] Guermazi A, Hayashi D, Jarraya M, Roemer FW, Zhang Y, Niu J, et al. Medial posterior meniscal root tears are associated with development or worsening of medial tibiofemoral cartilage damage: the multicenter osteoarthritis study. Radiology 2013;268:814–21. doi: https://doi.org/10.1148/radiol.13122544.
[17] Foreman SC, Liu Y, Nevitt MC, Neumann J, Joseph GB, Lane NE, et al. Meniscal root tears and extrusion are significantly associated with the development of accelerated knee osteoarthritis: data from the Osteoarthritis Initiative. Cartilage 2021;13:239S–S248. doi: https://doi.org/10.1177/1947603520934525.
[18] Neogi DS, Kumar A, Rijal L, Yadav CS, Jaiman A, Nag HL. Role of nonoperative treatment in managing degenerative tears of the medial meniscus posterior root. J Orthop Traumatol 2013;14:193–9. doi: https://doi.org/10.1007/s10195-013-0234-2.
[19] Krych AJ, Johnson NR, Mohan R, Hevesi M, Stuart MJ, Littrell LA, et al. Arthritis progression on serial MRIs following diagnosis of medial meniscal posterior horn root tear. J Knee Surg 2018;31:698–704. doi: https://doi.org/10.1055/s-0037-1607038.
[20] Krych AJ, Reardon PJ, Johnson NR, Mohan R, Peter L, Levy BA, et al. Non-operative management of medial meniscus posterior horn root tears is associated with worsening arthritis and poor clinical outcome at 5-year follow-up. Knee Surg Sports Traumatol Arthrosc 2017;25:383–9. doi: https://doi.org/10.1007/s00167-016-4359-8.
[21] Kim J-Y, Bin S-I, Kim J-M, Lee B-S, Oh S-M, Park M-H. Tear gap and severity of osteoarthritis are associated with meniscal extrusion in degenerative medial meniscus posterior root tears. Orthop Traumatol Surg Res 2019;105:1395–9. doi: https://doi.org/10.1016/j.otsr.2019.09.015.
[22] Papalia R, Vasta S, Franceschi F, D'Adamio S, Maffulli N, Denaro V. Meniscal root tears: from basic science to ultimate surgery. Br Med Bull 2013;106:91–115. doi: https://doi.org/10.1093/bmb/ldt002.
[23] Yang Q, Zhu X-Y, Bao J-Y, Zhang J, Xue A-Q, Wang D-Y, et al. Medial meniscus posterior root tears and partial meniscectomy significantly increase stress in the knee joint during dynamic gait. Knee Surg Sports Traumatol Arthrosc 2023;31:2289–98. doi: https://doi.org/10.1007/s00167-022-07285-9.
[24] Banovetz MT, Roethke LC, Rodriguez AN, LaPrade RF. Meniscal root tears: a decade of research on their relevant anatomy, biomechanics, diagnosis, and treatment. Arch Bone Jt Surg 2022;10:366–80. doi: https://doi.org/10.22038/ABJS.2021.60054.2958.
[25] Espejo-Reina A, Prado-Novoa M, Espejo-Baena A, Peña-Trabalon A, Perez-Blanca A. Biomechanical consequences of anterior root detachment of the lateral meniscus and its reinsertion. Sci Rep 2022;12:6182. doi: https://doi.org/10.1038/s41598-022-10229-5.
[26] Johannsen AM, Civitarese DM, Padalecki JR, Goldsmith MT, Wijdicks CA, LaPrade RF. Qualitative and quantitative anatomic analysis of the posterior root attachments of the medial and lateral menisci. Am J Sports Med 2012;40:2342–7. doi: https://doi.org/10.1177/0363546512457642.
[27] LaPrade RF, DePhillipo NN, Larson CM. Editorial commentary: comparing medial and lateral meniscal root tears is like comparing apples and oranges. Arthroscopy 2020;36:1142–4. doi: https://doi.org/10.1016/j.arthro.2020.01.016.
[28] Fox AJS, Bedi A, Rodeo SA. The basic science of human knee menisci: structure, composition, and function. Sports Health 2012;4:340–51. doi: https://doi.org/10.1177/1941738111429419.
[29] Edwards C, Goldman BH, Turley J, Richey B, Deal MJ, Kalbac D. Outcomes after surgical repair of medial meniscal root tears: a review. J Knee Surg 2021;34:1599–602. doi: https://doi.org/10.1055/s-0040-1710565.
[30] Lee YG, Shim J-C, 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. doi: https://doi.org/10.1097/RCT.0b013e31812f4eb0.
[31] Wang Y, Wluka AE, Pelletier J-P, Martel-Pelletier J, Abram F, Ding C, et al. Meniscal extrusion predicts increases in subchondral bone marrow lesions and bone cysts and expansion of subchondral bone in osteoarthritic knees. Rheumatology (Oxford) 2010;49:997–1004. doi: https://doi.org/10.1093/rheumatology/keq034.
[32] Jeon S-W, Jung M, Choi CH, Kim S-G, Kim S-H. Factors related to meniscal extrusion and cartilage lesions in medial meniscus root tears. J Knee Surg 2021;34:178–86. doi: https://doi.org/10.1055/s-0039-1693708.
[33] LaPrade CM, Foad A, Smith SD, Turnbull TL, Dornan GJ, Engebretsen L, et al. Biomechanical consequences of a nonanatomic posterior medial meniscal root repair. Am J Sports Med 2015;43:912–20. doi: https://doi.org/10.1177/0363546514566191.
[34] Lee N-H, Seo H-Y, Sung M-J, Na B-R, Song E-K, Seon J-K. Does meniscectomy have any advantage over conservative treatment in middle-aged patients with degenerative medial meniscus posterior root tear? BMC Musculoskelet Disord 2021;22:742. doi: https://doi.org/10.1186/s12891-021-04632-8.
[35] Vyas D, Harner CD. Meniscus root repair. Sports Med Arthrosc Rev 2012;20:86–94. doi: https://doi.org/10.1097/JSA.0b013e31825186ca.