Comparison of Long-term Radiographic Outcomes and Rate and Time for Conversion to Total Knee Arthroplasty Between Repair and Meniscectomy for Medial Meniscus Posterior Root Tears

CME

A Systematic Review and Meta-analysis

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Background: Previous meta-analyses have demonstrated superior outcomes in patients undergoing arthroscopic repair of medial meniscus posterior root tears (MMPRTs) compared with meniscectomy. However, these analyses have considered only short- or midterm outcomes and low-quality evidence.

Purpose: To compare the mid- to long-term rates of radiographic osteoarthritis (OA) between repair and meniscectomy for MMPRT.

Study Design: Systematic review and meta-analysis; Level of evidence, 4.

Methods: PubMed, EMBASE, Ovid/MEDLINE, and Cochrane Central Register of Controlled Trials databases were queried for articles evaluating repair and meniscectomy for MMPRT. Articles were eligible if they had a minimum mean 4-year follow-up for radiographic OA or conversion to total knee arthroplasty (TKA) and were at least level 3 evidence. Radiographic OA was assessed using Kellgren-Lawrence (KL) progression. Rates of conversion to TKA and International Knee Documentation Committee (IKDC) scores were also extracted. DerSimonian-Laird binary random-effects models were created to evaluate differences in radiographic OA and TKA conversion rates, with odds ratios (ORs) representing pooled estimates. Continuous random-effects models with standardized mean differences (SMDs) were used to compare postoperative IKDC scores.

Results: Repair and meniscectomy cohorts were followed for a mean of 64.8 months and 62.5 months, respectively, for KL progression; and 82.8 months and 73.8 months, respectively, for TKA rates and IKDC scores. Overall, 59 of 144 (41%) patients undergoing surgical intervention for MMPRT demonstrated OA progression; 18 of 82 (22%) who underwent repair for MMPRT exhibited OA progression compared with 41 of 62 (66%) who underwent meniscectomy (OR, 0.17; 95% CI, 0.03-0.83; $P = .029$). Overall, 30 of 143 (21%) patients converted to TKA; 9.8% (8/82) of patients who underwent repair converted to TKA (range, 47-131 months), while 36% (22/61) who underwent meniscectomy converted to TKA (range, 17.8-101 months) (OR, 0.15; 95% CI, 0.05-0.44; $P < .001$). No significant differences between postoperative IKDC scores were observed (SMD, 0.51; 95% CI, -0.02 to 1.05; $P = .06$).

Conclusion: Medial meniscus posterior root repair results in significantly lower rates of radiographic OA progression and conversion to TKA at >60-month follow-up. On the basis of these findings, we recommend consideration of repair of MMPRTs when degenerative changes are not severe, as it can yield improved outcomes.

Keywords: medial meniscus; root tear; arthroscopy; osteoarthritis

Medial meniscus posterior root tears (MMPRTs) have been increasingly recognized as a cause of knee pain. Meniscal extrusion secondary to MMPRT impairs the transmission of circumferential hoop stresses, profoundly altering meniscal biomechanics and kinematics.[1,6,25,28] These altered kinematics are thought to result in accelerated degeneration of articular cartilage and increased risk of

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osteoarthritis (OA).[14,21] Nonoperative management and meniscectomy for MMPRT have been reported to yield high rates of conversion to total knee arthroplasty (TKA).[9,24] As a result, recent interest has turned toward repair methods for meniscus preservation, as biomechanical evidence has suggested posterior root repair restores normal joint contact pressure and kinematics.[27,28,35] Subsequent clinical research has supported these findings, showing that repair leads to improved clinical outcomes and slows the progression of OA; however, such data have been limited to short-term follow-up.[9,13]

While previous meta-analyses have confirmed that clinical and functional improvements are experienced by patients undergoing arthroscopic repair for MMPRT when compared with meniscectomy, these analyses have considered only short- to midterm outcomes given the available data.[7,14,17,32] Furthermore, these reviews have evaluated studies with low levels of evidence, which may introduce heterogeneity and reporting bias.[22] While these studies are useful for generating hypotheses to guide more rigorous study designs, they do not represent a high level of evidence.[3,16,22,38] Given these limitations and the publication of longer-term data, evaluation of the functional and radiographic outcomes of MMPRT treatment approaches should be revisited with a study design that is less susceptible to these limitations.

Therefore, the purpose of the current study was to compare the mid- to long-term rates of radiographic OA between repair and meniscectomy for MMPRT. It was hypothesized that, at minimum 4 years postoperatively, patients undergoing repair would experience (1) superior functional outcome scores, (2) lower rates of progression to OA, and (3) lower TKA conversion rates compared with patients undergoing meniscectomy.

METHODS

Search Strategy

The study identification and selection process were conducted in accordance with the 2009 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.[33] The following databases were searched for original articles published before July 2020: PubMed, EMBASE, Ovid/MEDLINE, and Cochrane Central Register of Controlled Trials. The following search terms were used: "medial meniscal" OR "medial meniscus" AND "avulsion" OR "root tear" OR "radial tear." All articles were evaluated with no additional restrictions. This review was registered with PROSPERO before commencement of the current study (ID: CRD42020197015).

Data Collection

Two independent investigators (L.M.K. and K.N.K.) reviewed all abstracts of identified articles for agreement with the following inclusion criteria: (1) articles presenting original data; (2) articles available in English; (3) articles reporting on repair or meniscectomy interventions for the treatment of MMPRT (defined as within 9 mm of the bony root attachment)[26,29]; (4) a minimum 4-year radiographic follow-up or known conversion to TKA associated with a specific intervention; and (5) level of evidence of 1 to 3, as described by Sackett et al.[37] Of these studies, those that directly compared radiographic outcomes of repair and meniscectomy were included in the meta-analysis, as this was the primary study outcome. The following exclusion criteria were applied during article selection: (1) basic science or biomechanics articles, (2) technical notes, (3) editorial articles, (4) review articles, and (5) articles reporting on multiligament intervention. Full-length texts were obtained when abstracts were insufficient for screening purposes. The references of all included articles were reviewed to ensure all relevant studies were included.

Two independent reviewers (L.M.K. and K.J.) extracted the following items from each included study, as available: surgical intervention, level of evidence, number of participants (total, men, and women), mean follow-up, mean participant age, mean participant body mass index (BMI), clinical outcomes, radiographic outcomes, and conversion to TKA or alternative reporting of failed primary intervention. Reviewers also assessed the quality of each study using the modified Coleman Methodology Score (mCMS).[10] Not all included articles reported all of the statistical parameters required for meta-analysis; the corresponding author in the study of Bernard et al[2] was contacted for standard deviation data not originally reported in the manuscript. Any discordance between reviewers was settled by a third, independent reviewer (K.N.K.).

Quantitative Synthesis of Outcomes

The pooled event rate with 95% CI of each population of patients treated with either repair or meniscectomy was

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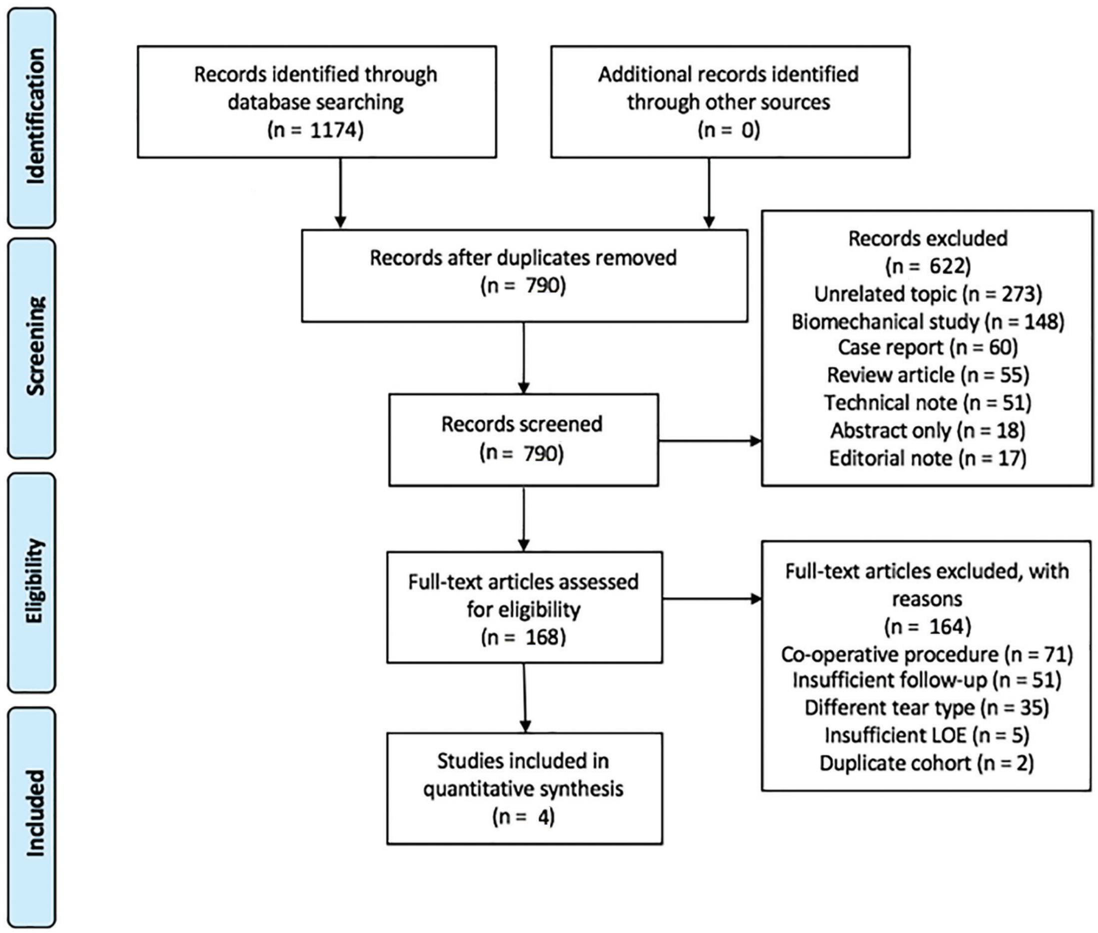

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart of included and excluded articles. LOE, level of evidence.

compared for progression in Kellgren-Lawrence (KL) score of 2 or more grades and for conversion to TKA.[9,18] For each population of patients treated with either repair or meniscectomy, the standardized treatment effect was calculated using standardized mean difference (SMD), with a 95% CI for the postoperative International Knee Documentation Committee (IKDC) score as a measure of patient-reported functional outcome.[11] SMDs and pooled event rates were analyzed using random-effects modeling to generate forest plots and account for anticipation of heterogeneous populations included in the analysis.[12] Heterogeneity was evaluated using I^2 statistics.[15] A $P \leq .05$ was considered statistically significant. All analyses of SMD and event rate computations with a 95% CI were performed using OpenMeta [Analyst] software (Version 10.12, Brown U).[39]

RESULTS

Study Selection

The initial query populated 1174 articles. After removal of 384 duplicate articles, the search identified 4 studies that met the inclusion and exclusion criteria (Figure 1).[2,8,9,20] Chung et al[8] and Chung et al[9] reported on overlapping cohorts; in cases of overlap, the longest-term outcome was included in quantitative analysis, while the short-term outcome was excluded (Table 1).

Patient and Study Characteristics

In the meta-analysis of OA progression, a total of 144 patients were included, with 82 patients undergoing repair and 62 undergoing meniscectomy (Table 3).[2,9,20] All 4 studies investigating outcomes associated with repair used a transtibial pull-out technique with simple stitch configuration.[2,9,20,40] The mean age was 52 years for repair and 54 years for meniscectomy; 82.9% of the repair group were women compared with 79.3% of the meniscectomy group; and the mean follow-up was 64.8 months for repair and 62.5 months for meniscectomy (Table 1).

In the meta-analyses of conversion to TKA and postoperative IKDC score, 158 patients were included, with 82 undergoing repair and 76 undergoing meniscectomy (Table 1).[2,8,20] All 3 studies used the transtibial pull-out technique

TABLE 1
General Study Characteristics[a]

Study	Study Design	LOE	No. of Patients (No. per group)[b]	Patients, M, F	Surgical Intervention	Mean Follow-up, mo	Mean Age, y	BMI	mCMS	Technique
Repair										
Bernard et al[2] (2020)	Comparative cohort	3B	45 (**15**/15/15)	5, 10	Repair	74	46.1	32	76	Transtibial pull-out with simple stitch
Chung et al[8] (2020)	Comparative cohort	3B	55 (**37**/18)	5, 32	Repair	125.9 ± 21.2	56.8 ± 7.1	26.2 ± 2.4	64	Transtibial pull-out with simple stitch
Chung et al[9] (2015)	Comparative cohort	3B	57 (**37**/20)	4, 33	Repair	72 (IQR; 60-110)	55.5 ± 7.1	26.1 ± 2.4	76	Transtibial pull-out with simple stitch
Kim et al[20] (2011)	Comparative cohort	3B	58 (**30**/28)	5, 25	Repair	48.5	55.2 ± 8.7	26.81 ± 2.57	71	Transtibial pull-out with simple stitch
Meniscectomy										
Bernard et al[2] (2020)	Comparative cohort	3B	45 (15/**15**/15)	5, 10	Meniscectomy	74	48.8	33.9	76	
Chung et al[8] (2020)	Comparative cohort	3B	55 (37/**18**)	3, 15	Meniscectomy	101.4 ± 45.9	60.7 ± 7.9	27.9 ± 3.9	64	
Chung et al[9] (2015)	Comparative cohort	3B	57 (37/**20**)	4, 16	Meniscectomy	67.5 (IQR; 60-96)	55 ± 14	27.4 ± 3.3	76	
Kim et al[20] (2011)	Comparative Cohort	3B	58 (30/**28**)	4, 24	Meniscectomy	46 ± 12.2	57.4 ± 6.8	27.39 ± 4.85	71	

[a]Follow-up and age values are presented as mean ± SD unless otherwise indicated. BMI, body mass index; F, female; LOE, level of evidence; M, male; mCMS, modified Coleman Methodology Score.
[b]No. of patients per respective subgroup (repair, meniscectomy, conservative treatment) are boldfaced.

with simple stitch configuration. The mean age was 53 years for repair and 56 years for meniscectomy; 81.7% of the repair group were women compared with 80.3% of the meniscectomy group; and the mean follow-up was 82.8 months for repair and 73.8 months for meniscectomy (Table 1).

Inclusion and exclusion criteria, and differential conditions for assigning patients to receive either repair or meniscectomy for MMPRT are described in Table 2. Notably, Bernard et al[2] also listed a BMI >30 as a relative contraindication; however, they state that each study participant was considered on a case-by-case basis. Despite this, the mean BMI in this study was in the obese range (Table 1). Chung et al,[8] Chung et al,[9] and Kim et al[20] noted patients selected for meniscectomy were those with meniscus root ends less amenable to repair, implying potentially more extensive trauma or degeneration. However, all 4 studies mitigated the influence the severity of pathology may have had by demonstrating no preoperative differences in osteoarthrosis between the repair and meniscectomy cohorts.

KL Progression

Overall, 59 of 144 (41%) patients who underwent surgical intervention for MMPRT demonstrated OA progression as represented by KL grade (Table 3). Pooled event rates of KL progression of radiographic OA were significantly lower (P = .029) for the MMPRT repair cohort (18/82; 22%) compared with those who underwent meniscectomy (41/62; 66%) (odds ratio [OR], 0.17; 95% CI, 0.03-0.83) (Figure 2). This represented a 83.5% reduced odds of progressing to radiographically apparent OA with MMPRT repair compared with meniscectomy. While nonoperative management was not included in our meta-analysis because of the paucity of studies, it is notable that Bernard et al[2] reported 3 of 11 patients (27.3%) who underwent no surgical intervention demonstrated KL progression during a 74-month follow-up period. Heterogeneity was considered significant (I^2 = 75.11%; P = .02).

Conversion to TKA

Overall, 30 of 143 (21%) patients who underwent surgical intervention for MMPRT ultimately underwent TKA (Table 3). Pooled event rates of treatment conversion to TKA after primary surgical intervention were significantly lower ($P < .001$) for MMPRT repair (8 of 82; 9.8%) than for meniscectomy (22 of 61; 36%) (OR, 0.15; 95% CI, 0.05-0.44) (Figure 3).

All repair patients who underwent conversion to TKA were reported on by Chung et al,[8] with conversion occurring during a range of 47 to 131 months. There was substantial variability between studies in reported time to conversion to TKA in the meniscectomy cohort. Kim et al[20] reported a mean of 17.8 months to conversion, while Bernard et al[2] reported a mean of 66.2 months to conversion. Chung et al[8] reported a range of 30 to 101 months. Of note, Bernard et al reported that 4 of their 15 study participants (26.7%) who underwent no surgical intervention converted to TKA at a mean of 75.2 months. Heterogeneity was considered insignificant (I^2 = 0%; P = .37).

IKDC Score

The mean IKDC score for the repair cohort was 74.1, while the mean IKDC score of the meniscectomy cohort was 64.2

TABLE 2
Patient Selection Comparison[a]

Study	KL Grade Inclusion	Outerbridge Classification Inclusion	Varus Alignment Exclusion	Concomitant Pathology Contraindications	Repair vs Meniscectomy Differential Criteria
Repair					
Bernard et al[2] (2020)	Grade ≤2	ND	Unaddressed >5°	Instability, subchondral collapse, >2 cm^2 grade 3+ defect	Root tear patients in 2010 and after with acute trauma or chronic degeneration with retained quality of meniscal tissue
Chung et al[8] (2020)	Grade ≤ 2	Grade ≤ 3	>5° resulting in HTO[b]	Multiligament injury	1. Meniscal ends suitable for repair 2. Willingness to modify lifestyle 3. Willingness to use crutches for 6 weeks
Chung et al[9] (2015)	Grade ≤ 2	Grade ≤ 3	>5° resulting in HTO[b]	Multiligament injury	1. Meniscal ends suitable for repair 2. Willingness to modify lifestyle 3. Willingness to use crutches for 6 weeks
Kim et al[20] (2011)	Grade ≤ 2; or grade 3 with HTO[c]	ND	ND	Multiligament injury	1. Meniscal ends suitable for repair 2. Willing to use crutches for 6 weeks
Meniscectomy					
Bernard et al[2] (2020)	Grade ≤ 2	ND	Unaddressed ≥5°	Instability, subchondral collapse, >2 cm^2 grade 3+ defect	Root tear patients before 2010 with acute trauma or chronic degeneration with retained quality of meniscal tissue
Chung et al[8] (2020)	Grade ≤ 2	Grade ≤ 3	>5° resulting in HTO[b]	Multiligament injury	1. Meniscal ends not suitable for repair 2. Not willing to use crutches for 6 weeks
Chung et al[9] (2015)	Grade ≤ 2	Grade ≤ 3	>5° resulting in HTO[b]	Multiligament injury	1. Meniscal ends not suitable for repair 2. Not willing to use crutches for 6 weeks
Kim et al[20] (2011)	Grade ≤ 2; or grade 3 with HTO[c]	ND	ND	Multiligament injury	1. Meniscal ends not suitable for repair 2. Not willing to use crutches for 6 weeks

[a]HTO, high tibial osteotomy; KL, Kellgren-Lawrence; ND, not described.
[b]Concomitant high tibial osteotomy due to varus malalignment >5° was excluded.
[c]KL grade 3 included if alignment was correctable by HTO.

TABLE 3
Functional, Radiographic, and TKA Rate Outcomes[a]

Study	Mean IKDC Score		KL Score			TKA
	Pre	Post	Pre	Post	Progression	Conversion Rate
Repair						
Bernard et al[2] (2020)	ND	72.3 ± 20	1.6 ± 0.86	1.7 ± 0.52	4 of 15	0 of 15
Chung et al[8] (2020)	41 ± 9.6	63.7 ± 20.6	1.1 ± 0.57	ND	ND	8 of 37
Chung et al[9] (2015)	40.1 ± 7.9	73.7 ± 11.1	1 ± 0.58	1.9 ± 0.67	5 of 37	0 of 37
Kim et al[20] (2011)	42.6 ± 6.3	77.2 ± 6.3	2.1 ± 0.76	ND	9 of 30	0 of 30
Meniscectomy						
Bernard et al[2] (2020)	ND	74 ± 20.7	1.2 ± 0.56	2.5 ± 0.76	4 of 14	9 of 15
Chung et al[8] (2020)	37.6 ± 7	44.4 ± 19	1.1 ± 0.80	ND	ND	10 of 18
Chung et al[9] (2015)	37.9 ± 6.8	49.3 ± 23.5	1 ± 0.79	3.2 ± 0.93	16 of 20	7 of 20
Kim et al[20] (2011)	42.3 ± 6.3	74.1 ± 4	2.1 ± 0.79	ND	21 of 28	3 of 28

[a]Values are presented as mean ± SD unless otherwise indicated. IKDC, International Knee Documentation Committee; KL, Kellgren-Lawrence; ND, not described; TKA, total knee arthroplasty.

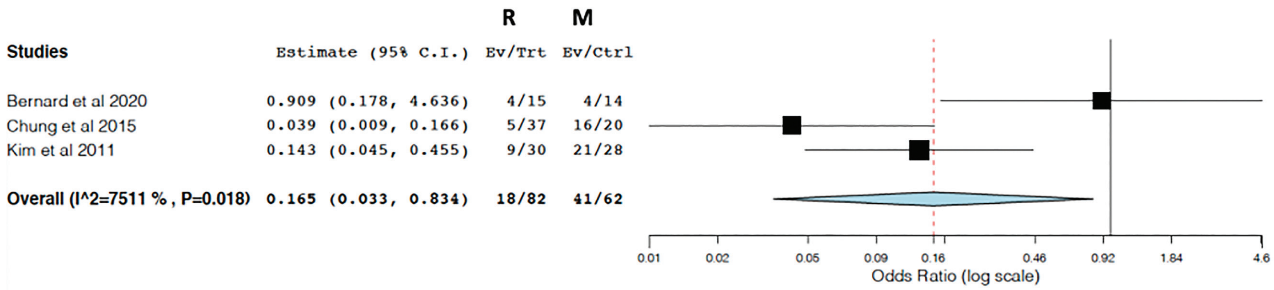

Figure 2. Forest plot of pooled event rates of osteoarthritis progression demonstrated by Kellgren-Lawrence grade. Ev/Ctrl, events within control group; Ev/Trt, events within treatment group; M, meniscectomy; R, repair.

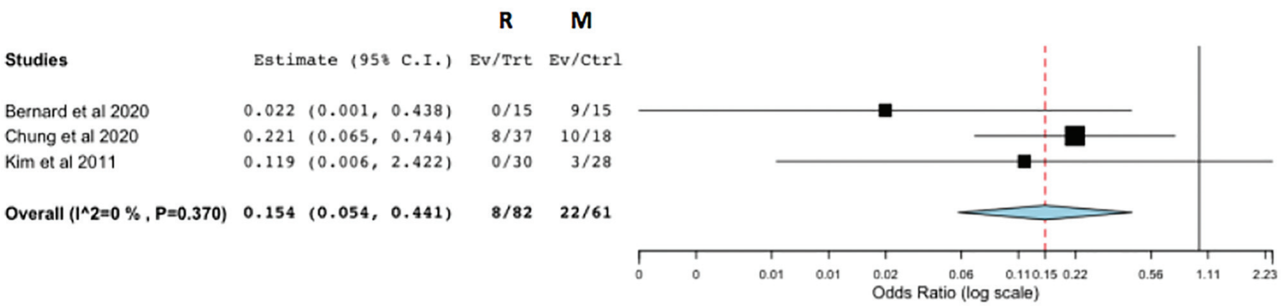

Figure 3. Forest plot of pooled event rates of conversion to total knee arthroplasty. Ev/Ctrl, events within control group; Ev/Trt, events within treatment group; M, meniscectomy; R, repair.

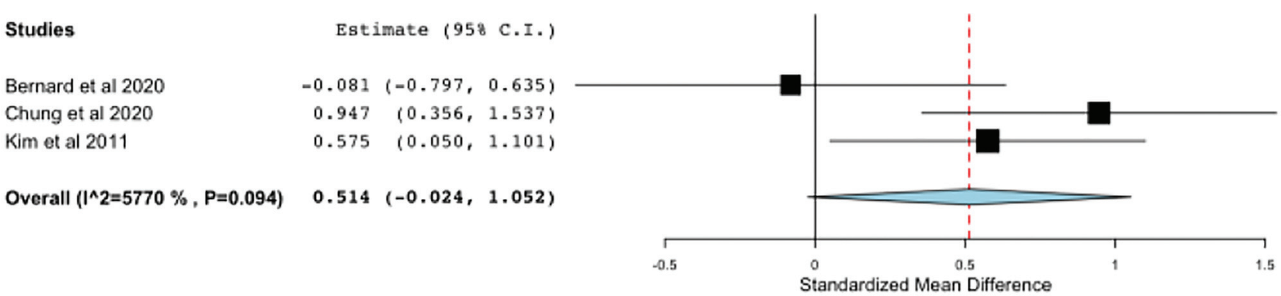

Figure 4. Forest plot of standardized mean differences of patient-reported functional outcomes demonstrated by the International Knee Documentation Committee postoperative score.

(Table 3). Continuous random-effects meta-analysis of the IKDC score (Figure 4) demonstrated no significant differences between patients who underwent repair versus meniscectomy (SMD, 0.51; 95% CI -0.02 to 1.05) Heterogeneity was moderate (I^2 = 57.7%; P = .09).

Quality Assessment

The mCMS has been used in previous meta-analyses of MMPRT surgical interventions.[32] Articles included in the meta-analysis of KL progression exhibited a mean mCMS of 74.3 and a mean score of 70.3 for articles included in the meta-analysis of conversion to TKA and postoperative IKDC score, indicating good quality of study design incorporated in these analyses.[10] This quality assessment is reiterated by the nature of the studies as all were level 3, demonstrating inherent limitations as study design deviates from level 1 randomized controlled trials.[37]

DISCUSSION

The main finding of the current study was that patients who underwent repair of MMPRTs experienced significantly lower rates of progression of radiographic OA compared with those who underwent meniscectomy. Patients who underwent MMPRT repair also experienced significantly lower rates of conversion to TKA than those who underwent meniscectomy, although clinical outcomes as evaluated through the IKDC score did not significantly differ.

The current study demonstrated that MMPRT repair delayed radiographic progression to OA compared with meniscectomy. Specifically, the current study found a 83.5% reduction in the odds of progressing to radiographic OA with repair compared with meniscectomy. These findings are in accordance with those by Krych et al[23] who also showed that KL progression was significantly more frequent in patients who underwent meniscectomy, with 91.7% of patients showing significant progression within a mean follow-up of 37 months. Chung et al[7] reported that both patients undergoing MMPRT repair and meniscectomy demonstrated significant joint space narrowing and KL progression; however, only 10.6% of patients who underwent repair showed progression and none progressed to KL grade 4. Together, this evidence indicates MMPRT repair may delay the mid- to long-term progression of radiographic OA as compared with meniscectomy. However, it is critical that repair be performed by an experienced surgeon, as previous investigations have demonstrated that nonanatomic root repair fails to restore joint contact forces, reinforcing the fact that propensity for OA progression results from suboptimal surgical intervention.[25]

The high rate of failure after partial meniscectomy or nonoperative management of MMPRT has driven investigators to examine the efficacy of MMPRT repair as an alternative treatment option.[9,24] Importantly, in this study, 9.8% of repairs progressed to TKA, while 36% of patients who underwent partial meniscectomy had conversion to TKA within >6-year follow-up period. A retrospective comparative study by Krych et al[23] demonstrated that meniscectomy provided no significant benefit for patients with symptomatic MMPRT compared with nonoperative management. Of the 26 patients in the meniscectomy cohort, 54% converted to TKA within the mean 5.5-year follow-up period. Chung et al[9] reported that the conversion to TKA in patients undergoing meniscectomy was as high as 35% within a 5-year follow-up period. Although subjective clinical scores seemed to improve in both the repair and the meniscectomy groups, long-term outcomes were found to be superior in the repair group with none of the study participants converting to TKA. In their subsequent study reporting on 10-year outcomes for the same cohort, Chung et al[8] reported conversion to TKA in 56% of patients undergoing meniscectomy, but only 22% of patients with repair. The available evidence suggests that repair of MMPRT results in significantly lower rates of conversion to TKA compared with treatment with meniscectomy at approximately 6 years postoperatively. Notably, both Chung et al[8] and Bernard et al[2] considered conversion to TKA to be demonstrative of treatment failure. The results of the current study suggest that MMPRT repair may significantly delay conversion to TKA relative to meniscectomy, which might be a positive outcome in this scenario. The goal of root tear repair or meniscectomy is arguably to avoid or delay osteoarthritic symptoms that ensue in the absence of surgical intervention. However, the individual goals of a patient may best inform whether conversion to TKA is in and of itself a treatment failure, or whether a delay in conversion to TKA relative to the nonoperative MMPRT knee is, in fact, a treatment success.

While our findings showed significant differences between repair and meniscectomy regarding osteoarthritic progression and rates of conversion to TKA, there was no significant difference when comparing the postoperative IKDC score between cohorts. A 2016 meta-analysis on short-term outcomes by Chung et al[7] reported a significant improvement in preoperative to postoperative Lysholm scores in a pooled repair cohort with a mean follow-up of 30.3 months. Although their analysis reported favorable outcomes for MMPRT repair, the included articles had relatively low levels of evidence and limited follow-up for a condition in which time is intrinsically related to degree of degeneration. The current investigation provides an analysis with studies of relatively good quality as well as mid- to long-term follow-up for radiographic OA progression of MMPRT and conversion to TKA. Further, the current meta-analysis is the largest pooled analysis for conversion to TKA after MMPRT repair at >5 years' follow-up. Additionally, Bin et al[4] suggested that meniscectomy is an effective form of treatment, defined by improvements in subjective clinical outcomes, according to the Lysholm score for patients with MMPRT, but the mean follow-up was relatively short at 28.3 months. These reports suggest that both repair and meniscectomy result in significantly improved patient-reported outcomes at short-term follow-up. Our data suggest that there is no significant difference between the 2 surgical treatments in terms of postoperative functional outcomes at mid- to long-term follow-up. This may be due to the difference in follow-up timing or differences in outcome scores utilized. Although the Lysholm score is often used to assess subjective clinical outcome pre- and postoperatively in patients with meniscal lesions, some studies suggest that it has inappropriate ceiling effects in some domains, including limp, instability, locking, and support.[5,36] Another explanation may be that higher rates of conversion to TKA or radiographic OA progression does not necessarily equate to dissatisfaction, poorer quality of life, and restriction of activities of daily living. Notably, comparison of postoperative IKDC scores approached significance, and there was significant heterogeneity in our meta-analysis of this outcome, which may indicate limited external validity of results to the general population. Future studies are warranted to reconcile these differences and explore the relationships between preoperative expectations and adverse events in MMPRT populations.

MMPRT increase tibiofemoral contact pressure and decrease the transmissibility of joint pressure, altering joint kinematics, and thereby leading to increased progression of secondary OA.[1,6,25,28,31,34] Because meniscectomy fails to restore hoop tension, the meniscus cannot effectively resist extrusion during loading, causing the partially meniscectomized knee to be biomechanically similar to a knee that underwent a complete meniscectomy.[1,6,25,28,31,34] Previous studies have shown no significant difference in peak contact pressure in knees with MMPRT and those with meniscectomy.[1] Over time, this increase in mechanical stress leads to the progression of OA and premature joint degeneration, which has driven researchers to determine the efficacy or

MMPRT repair.[1,6,25,28,31,34] This biomechanical evidence likely translates to the differences in OA progression observed in this study, although we cannot establish causation.

This meta-analysis largely reflects outcomes associated with repair and meniscectomy for MMPRT in individuals with a starting KL grade <3, with the exception of a small subset of patients from the Kim et al[20] cohort (n = 7) (Table 2). Radiographic evidence of advanced OA was considered a contraindication to operative intervention in all studies included in this analysis (Table 2).[2,8,9,20] However, there was less agreement with regard to patient selection for treatment arms. While Bernard et al[2] differentiated repair and meniscectomy patients by a fixed time point secondary to an institutional shift toward repair techniques, Chung et al[8,9] and Kim et al[20] selection criteria highlight the need for an improved understanding of operative outcomes when a patient is faced with a choice between repair and meniscectomy. The subjective nature of the patient's choice underscores the influence that a more complete understanding of long-term outcomes associated with each surgical option may have on a patient's decision. Patients unwilling or unable to undergo 6 weeks of crutch-dependent mobility secondary to MMPRT repair may choose differently with a full understanding of long-term outcomes associated with each surgical intervention, especially the likelihood of future TKA.

This study has some limitations. One limitation was the potential for publication bias, which is inherently a limitation of the included studies. Second, only 1 clinical outcome score was available for comparison. This analysis could not assess preoperative to postoperative changes in IKDC scores because of insufficient data reporting. Third, the current study investigated only 1 surgical repair technique (transtibial pull-out with simple stitch), although other technical approaches exist.[40] Further investigation is required to assess the long-term outcomes of this technique compared with alternative techniques. At this point, there are 2 commonly accepted techniques for MMPRT repair: transtibial pull-out and suture anchor.[19,30] The effects of different surgical techniques on long-term follow-up need to be further studied to understand these discrepancies, although these studies are not currently available. Fourth, we could not fully compare demographic data between studies because of underreporting of measures of variance. No significant difference was observed between Chung et al,[8] Chung et al,[9] and Kim et al[20] for BMI (repair: P = .46; meniscectomy: P = .91) or age (repair: P = .65; meniscectomy: P = .21). However, the Bernard et al[2] cohorts included seemingly younger participants with higher BMIs. While obesity is a well-documented risk factor for cartilage degeneration and meniscal tears, the outcomes reported by Bernard et al suggest that elevated BMI may not be as robustly predictive of meniscal degeneration in the setting of other modifiers.[41] It is possible that in the study of Bernard et al, participants' BMIs were not significantly high enough for the development of knee degeneration, and further investigation may be needed to determine whether obese patients truly benefit from meniscal repair. Last, while there were no significant differences between articles in the ratio of men to women enrolled (repair: P = .24; meniscectomy: P = .51), the pooled data consist of approximately 80% women, which may make the conclusions of this study less generalizable to men with MMPRT.

CONCLUSION

MMPRT repair results in significantly lower rates of radiographic OA progression and conversion to TKA at ≥60 months' follow-up compared with meniscectomy. On the basis of these findings, we recommend consideration of repair of MMPRTs when degenerative changes are not severe, as it can yield improved outcomes.

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