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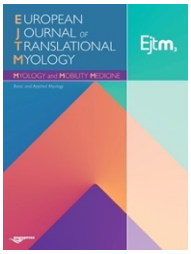

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Clinical efficacy of ramp lesion treatment: a systematic review and meta analysis study

Parsa Torkaman, Omid Elahifar, Mohsen Fathi, Hossein Hamdollahzadeh, Mohammadreza Sarshar, Kamal Arjmand, Ali Torkaman

Bone and Joint Reconstruction Research Center, Department of Orthopedics, School of Medicine, Iran University of Medical Sciences, Tehran, Iran

Abstract

Ramp lesions, tears involving the peripheral attachment of the posterior horn of the medial meniscus, significantly impact knee stability and function, particularly in association with anterior cruciate ligament injuries. However, evidence regarding optimal treatment strategies remains inconclusive. This systematic review and meta-analysis aimed to evaluate and compare the clinical efficacy of various treatment modalities for ramp lesions. A comprehensive systematic search was conducted across major electronic databases, including PubMed, Scopus, and Web of Science, up to June 2025. Studies were included based on predefined eligibility criteria. Data extraction was performed and meta-analytic synthesis was conducted using random-effects models. A total of 17 studies met inclusion criteria. The pooled mean difference demonstrated significant improvements in both IKDC (MD=28.5 points; 95% CI: 27.9–29.2) and Lysholm scores (MD=28.5 points; 95% CI: 27.9–29.2). Subgroup analyses revealed notable effectiveness for AIR compared to CM and PM, with statistically significant subgroup differences ($p<0.05$). The overall treatment success rate was 87% (95% CI: 83–92%). Across techniques, patient-reported outcomes improved markedly (IKDC fixed-effect pooled Mean Difference [MD] 28.8 points, 95% CI 28.2–29.4; random-effects overall effect significant; $I^2=98\%$). In anterior vs posterior all-inside subgroups, IKDC showed no robust between-approach difference on the random-effects test ($\chi^2=0.51$, $p=.48$), with a small fixed-effect difference ($\chi^2=4.34$, $p=.04$). Lysholm scores also improved substantially (fixed-effect pooled MD 28.0 points, 95% CI 27.3–28.7), and the between-approach difference was significant, favoring the posterior subgroup on the fixed-effect model. The pooled clinical success proportion was 90% without a significant difference between approaches ($p=.10$). The findings indicate that

surgical interventions, particularly All-inside repair has effectively improved knee function and patient-reported outcomes following ramp lesions compared to conservative management and partial meniscectomy. However, no significant difference was detected between anterior and posterior all-inside repair techniques.

Keywords: ramp lesion, all-inside repair, conservative management.

Introduction

Ramp lesions represent injuries to the peripheral attachment of the posterior horn of the medial meniscus, an anatomical region critical for knee stability and joint biomechanics. Traditionally, these lesions have received limited attention in clinical practice, primarily due to their subtle presentation and challenging visualization during routine arthroscopic procedures.[1,2] However, with advancements in arthroscopic techniques and imaging modalities, ramp lesions are now increasingly recognized as clinically significant entities, particularly in the context of Anterior Cruciate Ligament (ACL) injuries. Ramp lesions frequently coexist with ACL ruptures and have been identified as a major contributing factor to persistent knee instability, suboptimal clinical outcomes, and subsequent complications if left untreated.[3,4]

The prevalence of ramp lesions in the literature ranges widely, with estimates varying from approximately 9% to nearly 40% among patients undergoing ACL reconstruction. This broad prevalence underscores the importance of consistent evaluation and diagnosis in clinical practice. Early identification of ramp lesions is critical because failure to detect and adequately address these injuries can lead to chronic knee instability, recurrent pain, and an increased risk of progressive joint degeneration and osteoarthritis.[5,6] Therefore, integrating careful evaluation for ramp lesions into the standard diagnostic protocol during ACL reconstruction has emerged as a recommended best practice, aiming to optimize patient outcomes and long-term joint health.[7-9]

Accurate detection of ramp lesions poses diagnostic challenges, primarily because conventional imaging techniques such as standard MRI have variable sensitivity and specificity in identifying these subtle injuries. While MRI serves as a useful initial screening tool, definitive diagnosis often requires direct arthroscopic inspection. Arthroscopy allows surgeons to visualize the meniscus directly, assess lesion severity, and simultaneously perform therapeutic interventions. Hence, arthroscopic evaluation remains the gold standard for ramp lesion diagnosis and treatment planning, further emphasizing the need for increased awareness and training among orthopedic surgeons.[10-12] Multiple therapeutic approaches have been proposed for ramp lesion management, each reflecting distinct clinical philosophies and methodologies. Surgical techniques such as All-Inside Repair (AIR) have gained prominence due to their effectiveness in restoring meniscal integrity and knee stability. AIR can be performed via posterior or anterior portal based on surgeons' expertise and opinion. Conservative Management (CM), involving physical therapy, activity modification, and non-surgical interventions, remains a viable option for selected patients, particularly those presenting with stable lesions or low functional demands. Conversely, Partial Meniscectomy (PM) has become less favored over time due to the associated risk of accelerated joint degeneration stemming from the loss of meniscal tissue.[13-15]

Despite growing clinical experience with these treatment modalities, considerable uncertainty persists regarding their relative efficacy and long-term outcomes. Thus, this systematic review and meta-analysis aim to evaluate the clinical efficacy of different ramp lesion treatment modalities.

Methods and Materials

This systematic review and meta-analysis adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Systematic search

A comprehensive and systematic search was conducted in major electronic databases, including PubMed, Scopus, and Web of Science, covering all available records up to June 2025. The search strategy involved relevant Medical Subject Headings (MeSH) terms and tailored keywords

specific to ramp lesions and their associated treatments. The specific terms utilized included combinations of: (“ramp lesion” OR “medial meniscus ramp lesion”) AND (“treatment” OR “repair” OR “surgical repair” OR “all-inside repair” OR “partial meniscectomy” OR “conservative management”) AND (“outcome” OR “clinical outcome” OR “success rate”).

Inclusion and eligibility criteria

The central questions of our study were: Are surgical techniques that are used for treating RAMP lesion better than non-surgical techniques? If yes, which of the surgical treatments has better efficacy? Eligibility criteria were developed following the PICO (Population, Intervention, Comparison, and Outcome) framework. Population (P): Patients diagnosed with ramp lesions of the medial meniscus, irrespective of age, gender, or concomitant knee injuries. Intervention (I): Treatment methods including All-inside Repair (AIR), Partial Meniscectomy (PM), and Conservative Management (CM). Comparison (C): Comparative analyses between different surgical or conservative treatment methods for ramp lesions. Outcome (O): Primary outcomes involved clinical assessments such as the International Knee Documentation Committee (IKDC) score, Lysholm score, and overall treatment success rates. Studies were excluded if they involved animal models, biomechanical analyses, case reports, narrative reviews, editorials, conference abstracts without available full-text articles, cadaveric studies, or studies lacking clear postoperative outcome data. Non-clinical investigations and studies without clearly defined treatment methods for ramp lesions were also excluded.

For the purpose of this review, treatment success was defined as a favorable postoperative clinical outcome following ramp lesion management, as i) improvement from baseline or achievement of an acceptable postoperative level on validated knee-specific patient-reported outcome measures (e.g., IKDC, Lysholm, Tegner, KOOS), and/or ii) absence of clinically relevant symptoms or instability attributable to the ramp lesion (e.g., no persistent posteromedial pain, negative/normalized clinical stability tests), and/or iii) no requirement for reoperation or revision for ramp-lesion–related failure during the reported follow-up. Because the included studies did not apply a single standardized definition, treatment success criteria were not uniform across studies; therefore, we extracted outcomes as reported by each study and synthesized them using the closest comparable endpoints available.

Data extraction and outcome measures

Two independent authors conducted data extraction utilizing a pre-defined, standardized extraction form, with any discrepancies resolved by consensus or consultation with a third reviewer. Extracted information included the first author's name, publication year, country, study design (randomized controlled trials, retrospective cohort studies, case-control studies), total sample size, demographic details of participants (age, gender distribution), specific treatment modalities applied (All-inside Repair, Partial Meniscectomy, or Conservative Management), follow-up duration, and key outcomes such as preoperative and postoperative IKDC and Lysholm scores, as well as treatment success rates. Additionally, relevant statistical measures including means, standard deviations, and 95% Confidence Intervals (CIs) were recorded whenever available to enable quantitative analysis.

Statistical analysis and data synthesis

Statistical analyses were performed using random-effects models due to anticipated clinical and methodological heterogeneity among the included studies. Effect sizes for continuous variables, specifically improvements in IKDC and Lysholm scores, were calculated as pooled mean differences with corresponding 95% confidence intervals. Treatment success rates were expressed as proportions with 95% confidence intervals calculated using inverse-variance methods. Heterogeneity among studies was assessed using the I^2 statistic, where values above 50% indicated substantial heterogeneity, and significance was determined at $p<0.05$. Subgroup analyses were conducted based on different treatment modalities to evaluate potential differences in outcomes and identify sources of heterogeneity. Funnel plots were visually inspected to assess publication bias, and further statistical tests, such as Egger’s test, were applied when deemed appropriate. All statistical analyses, including the generation of forest and funnel plots, were performed using R statistical software (version 4.2.2; R Foundation for Statistical Computing, Vienna, Austria) and RStudio (version 2023.03.0; RStudio, Inc., Boston, MA, USA). The meta package in R was specifically used for conducting meta-analytic procedures and visualizations.

Results

Our initial search yielded 1942 articles from PubMed, Scopus, and Web of Science, from which we eliminated 860 duplicates. After reviewing the titles and abstracts of the remaining 1,938 records, we retrieved 88 full-text articles for further evaluation. Ultimately, 17 studies[16-32] met our eligibility criteria and were included in the systematic review and meta-analysis (Figure 1). Detailed characteristics of the included studies are summarized in Supplementary materials, Table 1.

Characteristics of included studies

A total of 17 studies were included in this systematic review and meta-analysis, comprising various treatment methods for ramp lesions: All-inside Repair, Conservative Management, and Partial Meniscectomy. Study designs included randomized controlled trials (RCTs), retrospective cohort studies (RCS), and case-control studies (CCS). Sample sizes ranged from 12 to 248 patients. Key patient-reported outcomes included the International Knee Documentation Committee (IKDC) score, Lysholm score, and treatment success rates.

IKDC score improvement

The pooled analysis of IKDC scores demonstrated significant overall improvement post-intervention. The random-effects model indicated a mean difference (MD) of 28.5 points (95% CI: 27.9–29.2, $p<0.01$), with substantial heterogeneity ($I^2=98\%$, $p<0.01$). Subgroup analysis by intervention revealed the highest improvement in IKDC scores with AIR (MD = 28.0; 95% CI: 27.3–28.7), followed by inside-out repair (MD = 32.5; 95% CI: 30.6–34.4), PM (MD = 29.9; 95% CI: 21.1–38.7), and CM (MD = 23.7; 95% CI: 14.2–33.2). Notably, significant subgroup differences were observed ($p=0.04$). Subgroup analysis by surgical approach did not show a difference on the random-effects test ($\chi^2=0.51$, $p=.48$), while a small difference appeared under the fixed-effect model ($\chi^2=4.34$, $p=.04$); both the posterior and anterior all-inside subgroups independently demonstrated significant pre- to post-operative gains.

Lysholm score improvement

Analysis of the Lysholm scores showed a significant pooled mean difference of 28.5 points (95% CI: 27.9–29.2, $p<0.01$). Substantial heterogeneity was present ($I^2=98\%$, $p<0.01$). Subgroup analyses indicated notable improvements across treatments, with the highest observed in the AIR group (MD = 28.0; 95% CI: 27.3–28.7), inside-out repair group (MD = 32.0; 95% CI: 29.7–34.2), and CM group (MD = 30.8; 95% CI: 21.8–39.7). Differences among subgroups were statistically significant ($p<0.01$). In contrast to IKDC, the test for subgroup differences favored a between-approach effect on both fixed ($\chi^2=180.71$, $p<0.01$) and random-effects models ($\chi^2=4.45$, $p=0.03$), with larger pooled improvement in the posterior subgroup on the fixed-effect model, while both approaches remained individually significant despite high within-subgroup heterogeneity.

Treatment success rates

Treatment success was evaluated in 14 studies, involving 937 cases overall. The pooled success rate was high, with a random-effects model showing an overall success proportion of 87% (95% CI: 83–92%). However, significant heterogeneity was noted ($I^2=85\%$, $p<0.01$). Individual studies success rates varied, with Screpis et al. (2025) and Thaunat et al. (2016) reporting notably high success rates of 99% and 95%, respectively. Subgroup analyses did not detect a clear difference between posterior and anterior approaches (fixed-effect $\chi^2=0.75$, $p=.39$; random-effects $\chi^2=2.70$, $p=.10$). Notably, heterogeneity was negligible within the posterior subgroup ($I^2=0\%$) but remained high within the anterior subgroup ($I^2=87\%$).

Summary of findings

Across studies, outcomes improved markedly but with substantial heterogeneity. IKDC showed a pooled postoperative improvement of MD ≈ 28.5 points (random-effects; I^2 up to 98%), with subgroup estimates of AIR ≈ 28.0, inside-out ≈ 32.5, partial meniscectomy ≈ 29.9, and conservative ≈ 23.7 (subgroup difference $p\approx0.04$). Lysholm improved similarly (MD ≈ 28.5; random-effects), with higher gains in inside-out (~32.0) than AIR (~28.0) and conservative

(~30.8) (subgroup difference $p<0.01$). The pooled treatment success rate was ~87% (95% CI ~83–92%; I^2 ~85%). In the posterior vs anterior all-inside comparison, differences were not significant for IKDC ($p\approx0.48$) or success ($p\approx0.10$), while Lysholm favored one approach with a significant subgroup effect ($p\approx0.03$).

Discussion

This systematic review and meta-analysis aimed to compare the clinical efficacy of available treatments for medial meniscus ramp lesions and to determine whether all-inside repair provides superior outcomes. Across 17 included studies, surgical management outperformed conservative care, with all-inside repair showing greater improvements in IKDC and Lysholm scores than partial meniscectomy or conservative management and achieving high overall success rates (≈87–90%). These effects were consistent in subgroup analyses favoring all-inside repair over other modalities, while no robust difference was detected between anterior and posterior all-inside approaches. Taken together, our findings support prioritizing all-inside repair when surgery is indicated for ramp lesions.

When we contrasted anterior versus posterior all-inside approaches, both strategies produced large, clinically meaningful gains in patient-reported function, but the pattern of between-approach differences varied by outcome. For IKDC improvement, our subgroup test was non-significant on the random-effects model ($\chi^2=0.51$, $p=.48$) and only marginal on the fixed-effect model ($\chi^2=4.34$, $p=.04$), indicating no robust superiority of one approach over the other; nevertheless, each subgroup independently showed significant pre- to post-operative gains despite considerable heterogeneity (overall $\tau^2=169.413$; $I^2=98\%$). By contrast, Lysholm improvement favored a between-approach effect on both fixed ($\chi^2=180.71$, $p<.01$) and random-effects models ($\chi^2=4.45$, $p=.03$), with the posterior subgroup pooling to the larger fixed-effect improvement while heterogeneity remained high—particularly within anterior repairs ($\tau^2=141.395$; $I^2=98\%$). Mechanistically, the posterior route may facilitate more anatomic suture placement and direct visualization of the meniscocapsular junction, whereas anterior repairs may be selected for different tear morphologies or performed across a steeper learning curve, which could inflate variance; regardless, both approaches delivered substantial symptomatic and

functional recovery. These findings integrate with our main results and figures and should be interpreted alongside the consistently large pooled mean differences observed across studies.

Importantly, the high overall "success" proportion (~0.90) did not differ by approach on either fixed-effect (χ^2=0.75, p=.39) or random-effects testing (χ^2=2.70, p=.10), suggesting that—despite the Lysholm separation—the choice of anterior versus posterior all-inside access does not materially change the probability of achieving a satisfactory clinical endpoint. Notably, between-study variability in success was negligible for posterior repairs (I^2=0%) yet substantial for anterior repairs (I^2=87%), a pattern consistent with the Lysholm heterogeneity and plausibly attributable to case selection, technical nuance (e.g., portal strategy, device choice), and postoperative rehabilitation differences. Practically, these data support either approach as a reasonable option when tailored to tear morphology and surgeon expertise, while underscoring the need for standardized indications, operative technique, and outcome definitions in future comparative trials to clarify whether the small between-approach differences in continuous scores translate into durable, patient-important benefits.

Comparing our results with previous studies underscores the robustness and consistency of our findings. The pooled mean improvement in IKDC scores observed in our analysis was approximately 28.5 points, aligning closely with other systematic reviews and clinical studies examining knee repair procedures. For instance, previous systematic reviews have reported similar improvements ranging from 25 to 30 points in IKDC scores following meniscal repair techniques, suggesting that our findings fall within expected clinical improvement ranges. This consistency emphasizes the reliability and clinical relevance of our results.[33,34]

In our subgroup analysis, AIR showed meaningful improvement in patient-reported outcomes (on the order of several tens of points on common knee scales). This aligns with prior comparative studies: AIR provides clinical results comparable to other repair techniques with shorter operative time and quicker recovery, while meniscal repair (vs partial meniscectomy) better preserves knee biomechanics and native anatomy. Although partial meniscectomy may show similar or slightly faster early symptom relief in selected tear patterns, it removes meniscal tissue and is associated with adverse contact mechanics and higher osteoarthritis risk over time.[35,36]

Lysholm scores in our analysis revealed a significant pooled mean improvement of approximately 28.5 points, consistent across various treatment strategies. Existing literature supports this finding, as numerous previous reports have highlighted marked improvements in Lysholm scores post-intervention. For example, clinical studies investigating meniscal repair outcomes have documented Lysholm score improvements ranging from 20 to 35 points. Such congruence between our meta-analysis and existing literature underscores the validity and generalizability of our findings, suggesting that all evaluated treatments effectively enhance knee function and patient satisfaction.[37,38] Regarding treatment success rates, our analysis demonstrated an overall success rate of approximately 87%, closely matching previous findings reported in literature, which generally document success rates between 80% and 95% for ramp lesion interventions. Notably, individual studies included in our review, such as Screpis *et al.* (2025) and Thaunat *et al.* (2016), exhibited particularly high success rates, corroborating the effectiveness of these treatment modalities.[17,29-32]

The clinical importance of ramp lesion treatment is increasingly recognized due to its significant impact on knee joint stability, function, and long-term patient outcomes. Ramp lesions, which involve injuries to the peripheral attachment of the posterior horn of the medial meniscus, have traditionally been underdiagnosed but are now identified as critical factors influencing anterior cruciate ligament reconstruction outcomes and overall knee health.[39,40] Proper management of ramp lesions is essential because untreated lesions may lead to persistent knee instability, ongoing pain, and accelerated degenerative changes, increasing the risk of osteoarthritis. The integrity of the medial meniscus is crucial for distributing load, stabilizing the knee joint, and facilitating smooth joint mechanics. When ramp lesions remain untreated or inadequately treated, patients may experience recurrent episodes of knee instability, leading to diminished quality of life and reduced physical activity levels.[41,42] Our findings support that identifying and addressing ramp lesions can be clinically meaningful, particularly in the setting of ACL injury where the posteromedial menisco-capsular complex functions as a secondary stabilizer. In practice, this reinforces a low threshold for systematic posteromedial inspection (including trans-notch visualization and, when needed, accessory posteromedial portals) during ACL reconstruction—especially in patients with high-grade pivot shift, posteromedial joint-line tenderness, or MRI features suggestive of a ramp lesion. Given the consistently favorable postoperative improvements and high pooled success rate, repair should be strongly considered when the lesion

is unstable, gapping, or clearly menisco-capsular/menisco-tibial detached on probing, as restoration of the menisco-capsular junction may help reduce residual rotational laxity during pivoting activities and potentially protect the ACL graft during rehabilitation and return to sport. At the same time, the marked heterogeneity across studies indicates that "one-size-fits-all" indications are not yet evidence-based, so patient selection should be individualized. Patients most likely to benefit from repair are those with i) ACL deficiency/ACL reconstruction, ii) unstable or larger ramp tears, iii) younger/high-demand athletes with frequent cutting and pivoting, and iv) persistent dynamic instability despite otherwise adequate ACL management. Conversely, in stable, small, well-vascularized lesions without gapping on probing, particularly in lower-demand patients, a more conservative strategy (e.g., abrasion/trephination or observation when appropriate) may be reasonable, though comparative data remain limited. Surgical technique selection can also be guided by context: all-inside approaches may offer efficiency and reduced soft-tissue dissection, whereas inside-out repair may be preferred when surgeons seek robust fixation for larger or complex tears—recognizing that direct technique-to-technique superiority cannot be definitively concluded from the current evidence base. Finally, these data can be incorporated into preoperative counseling and shared decision-making. Surgeons can explain that ramp lesion treatment is generally associated with meaningful improvements in validated knee scores and a high likelihood of clinical success, but that outcomes vary across studies due to differences in lesion definitions, techniques, and rehabilitation. Patients with high functional demands or clear instability-related symptoms can be counseled that repair may reduce the risk of persistent pivoting symptoms, while emphasizing that standardized definitions and higher-quality comparative trials are still needed to refine indications.

Ramp lesions involve disruption of the posteromedial menisco-capsular (and/or menisco-tibial) attachments of the medial meniscus, structures that contribute to meniscal "hoop" function and help restrain anterior tibial translation and excessive internal rotation—particularly in the ACL-deficient knee.[3,31,38] Loss of menisco-capsular integrity may allow increased posterior horn mobility and compromise the medial meniscus as a secondary stabilizer, which can manifest clinically as residual pivoting instability despite ACL reconstruction. From a biomechanical perspective, restoring the menisco-capsular junction through ramp lesion repair aims to re-establish the posterior horn's stabilizing role, improve load sharing across the medial

compartment, and reduce abnormal rotational laxity during cutting and pivoting maneuvers. Therefore, when a ramp lesion is identified at arthroscopy—especially in patients with high-grade pivot shift or persistent posteromedial symptoms—repair may have translational value by addressing a modifiable contributor to dynamic stability and potentially protecting the reconstructed ACL graft during early return-to-sport demands.[29,30,36]

Early and accurate diagnosis of ramp lesions enhances clinical outcomes significantly. Advanced diagnostic modalities, such as MRI and arthroscopic evaluation, have improved the detection rates, ensuring more patients receive timely and appropriate interventions. Clinicians now advocate routine assessment for ramp lesions during ACL reconstruction procedures, given their high prevalence in patients with ACL injuries. By systematically evaluating and addressing ramp lesions, surgeons can substantially improve knee stability and patient-reported outcomes, including pain relief and functional capacity.[43-45]

Each approach presents distinct advantages and clinical trade-offs. All-inside meniscal repair has grown in use because it is minimally invasive and achieves healing and functional outcomes comparable to other surgical methods, with shorter operative times and fewer nerve-related complications. In contrast, partial meniscectomy may offer faster symptom relief, but as it removes meniscal tissue, it does not restore native biomechanics; instead, it raises tibiofemoral contact stresses and is linked to greater degenerative risk. Conservative management is reasonable in carefully selected cases and has shown non-inferiority to arthroscopic partial meniscectomy at 5 years, yet for specific lesions, nonoperative care carries a high risk of progression and persistent instability.[27,35,43,46,47]

Treatment success rates observed across various studies further highlight the clinical importance of effectively addressing ramp lesions. Successful interventions improve not only immediate postoperative outcomes but also long-term knee function, delaying or preventing the onset of secondary degenerative changes. High treatment success rates, coupled with significant improvements in patient-reported outcome measures such as the IKDC and Lysholm scores, underscore the clinical relevance and effectiveness of ramp lesion treatments.[30,48] Despite its rigorous methodological approach, this study has several limitations. First, the substantial heterogeneity observed among the included studies, likely stemming from differences in patient populations, surgical techniques, rehabilitation protocols, and outcome assessment timings,

limits the generalizability of the results. Additionally, many included studies had small sample sizes, which may reduce the statistical power and potentially introduce selection bias. Furthermore, the majority of studies analyzed were retrospective or case series designs, inherently carrying risks of biases such as recall or selection bias, potentially affecting the reliability of pooled outcomes. Finally, the follow-up durations varied considerably across studies, raising concerns about accurately assessing long-term clinical efficacy and sustainability of treatment effects.[46,49,50]

Substantial between-study heterogeneity was observed (I^2 up to 98%), likely reflecting clinical and methodological variability across the included studies. Differences in ramp lesion characteristics and severity, patient demographics and concomitant injuries, surgical techniques (including approach, device choice, and suture configuration), rehabilitation and return-to-sport protocols, and follow-up duration may all have contributed to the wide dispersion of effect estimates. Methodological diversity (randomized trials and observational designs with variable risk of bias) and inconsistent outcome reporting may have further amplified heterogeneity.[10,11,15] Although random-effects models and subgroup analyses were applied, we could not perform robust sensitivity analyses or meta-regression due to incomplete reporting and an insufficient number of studies per covariate; therefore, pooled estimates should be interpreted cautiously.[51-53] Future research should prioritize standardized lesion definitions, operative techniques, rehabilitation protocols, and outcome measures to improve comparability and interpretability.

Another important limitation is the potential for publication bias and small-study effects, which may influence the magnitude and direction of the pooled estimates. Studies reporting favorable clinical outcomes after ramp lesion treatment are more likely to be published and indexed, whereas negative or null findings may remain unpublished, leading to an overestimation of treatment success and postoperative functional improvements in the meta-analysis. In addition, several included studies had relatively small sample sizes and observational designs, which can further amplify small-study effects and increase the likelihood of imprecise or inflated effect estimates. Although we visually assessed funnel plots when feasible, the limited number of studies available for some outcomes reduces the reliability of formal assessments of asymmetry. Consequently, our overall conclusions should be interpreted cautiously, and future prospective

studies and trial registration with transparent reporting of all outcomes are needed to mitigate publication bias and strengthen the evidence base.

Conclusions

This systematic review and meta-analysis suggests that, overall, ramp lesions tend to have better reported outcomes with surgical management than with conservative care. Among surgical strategies, AIR was associated with more favorable patient-reported outcomes and higher success rates than partial meniscectomy, supporting AIR as a preferred option when repairable tissue is present and surgical treatment is indicated. However, this guidance should be interpreted as conditional, because outcomes are likely influenced by study-to-study variability in tear chronicity and morphology, device type and suture configuration, concomitant procedures, rehabilitation protocols, and surgeon experience. In our pooled analyses, no clinically meaningful difference was identified between anterior and posterior AIR approaches, suggesting that approach selection can be individualized based on tear pattern, access/visualization, and surgeon expertise. Given the substantial heterogeneity and predominantly nonrandomized evidence, future studies should use standardized lesion definitions and indications, report operative and rehabilitation details consistently, and include longer follow-up to confirm durability and refine patient selection.

List of Abbreviations

Anterior Cruciate Ligament (ACL)

All-Inside Repair (AIR)

Conservative Management (CM)

Partial Meniscectomy (PM)

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)

Medical Subject Headings (MeSH)

Population, Intervention, Comparison, and Outcome (PICO)

Population (P)

Intervention (I)

Comparison (C)

Outcome (O)

International Knee Documentation Committee (IKDC)

Confidence Intervals (CIs)

Randomized controlled trials (RCTs)

Retrospective cohort studies (RCS)

Case-control studies (CCS)

Mean difference (MD)

Magnetic resonance imaging (MRI)

Corresponding Author

Ali Torkaman,

Email: alitorkaman1963@gmail.com

ORCID: 0009-0006-3350-8910

Parsa Torkaman: parsatorkaman@gmail.com, ORCID: 0000-0002-4475-0036

Omid Elahifar: elahifar.o@iums.ac.ir, ORCID: 0000-0003-215109445

Mohsen Fathi: mohsenfathi71@yahoo.com, ORCID: 0009-0001-8062-2701

Hossein Hamdollahzadeh: h.hamdollahzadeh@yahoo.com, ORCID: 0009-0007-7745-427X

Mohammadreza Sarshar: Mohammad.sarshar64@gmail.com, ORCID: 000-0002-5247-2574

Kamal Arjmand: arjmand.kamal@gmail.com, ORCID: 0009-0003-9388-924X

Contributions

All authors contributed equally to this article.

Conflict of interest

The authors declare no conflict of interest.

Ethics approval and consent to participate

Not applicable

Availability of data and materials

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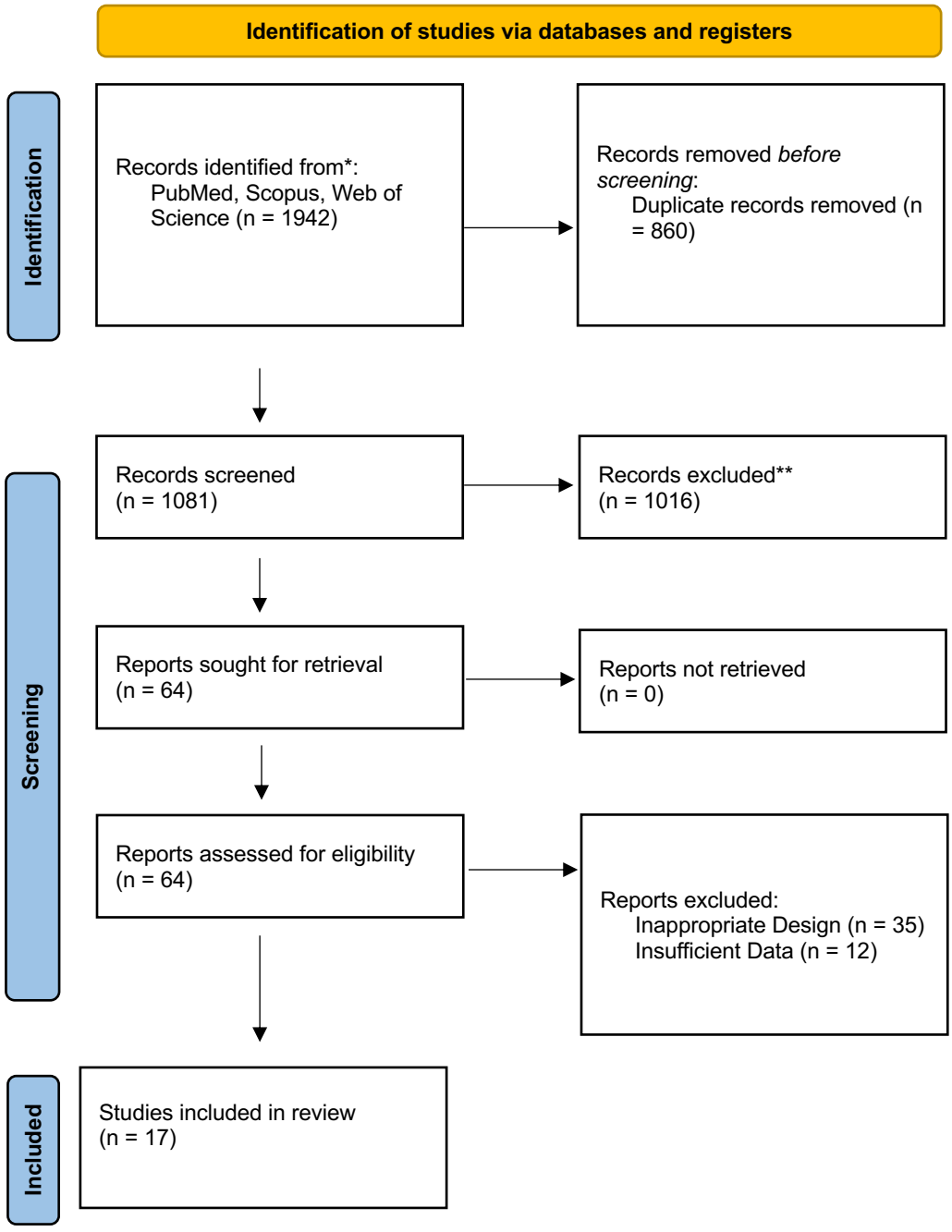
Figure 1. PRISMA flow diagram of the included studies



Online supplementary materials

Figure 1. The pooled Lysholm scores among different subgroups

Figure 2. The pooled IKDC scores among different subgroups

Figure 3. The funnel plots assesing publication

Figure 4. The pooled IKDC scores among different subgroups

Figure 5. The pooled IKDC scores among posterior versus anterior subgroups

Figure 6. The pooled Lysholm scores among posterior versus anterior subgroups

Figure 7. The pooled succus rate among posterior versus anterior subgroups

Table 1. Detailed characteristics of the included studies