

Research Article

*International Journal of Orthopaedics Research***Non-Surgical and Surgical Treatment of Chronic Pain in Older Adults with Unilateral or Index-Knee Osteoarthritis: A Systematic Review****João Pedro Brandão Wantuil***, **Fillippo Leite Prazeres**, **Giovani Jose Coury Costa** and **Lucas Tavares Domingos**

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Submitted: 2026, Aug 10; **Accepted:** 2026, Sep 14; **Published:** 2026, Sep 25

Citation: Wantuil, J. P. B., Prazeres, F. L., Costa, G. J. C., Domingos, L. T. (2026). Non-Surgical and Surgical Treatment of Chronic Pain in Older Adults with Unilateral or Index-Knee Osteoarthritis: A Systematic Review. *Int J Ortho Res*, 9(3), 01-14.

Abstract

Background: Treatment of chronic knee osteoarthritis pain in older adults spans education, exercise, medication, injections, osteotomy and arthroplasty. Trials studying unilateral disease or bilateral disease assessed through an index knee are under-represented and rarely synthesized across the full treatment pathway.

Methods: PubMed, the MEDLINE-indexed subset of PubMed, Google Scholar and SciELO were searched for free-text original studies published from January 2015 to July 2026. Systematic reviews, meta-analyses, protocols and irrelevant reports were excluded. A PICO framework guided eligibility. Non-surgical pain outcomes were pooled when clinically comparable; surgical evidence was synthesized narratively because interventions, comparators and outcomes were heterogeneous.

Results: Twenty-seven studies were included: 19 non-surgical and eight surgical. Three non-surgical comparisons were meta-analysed in the primary synthesis ($n=202$), yielding Hedges' g -0.56 (95% CI -1.18 to 0.06 ; $I^2=0\%$). A contextual sensitivity analysis adding open-label placebo ($n=262$) gave g -0.56 (95% CI -0.96 to -0.15). Randomized surgical evidence showed that total knee arthroplasty improved pain and function relative to non-surgical care but increased serious adverse events, whereas partial and total knee replacement had similar 5-year clinically important outcomes in isolated medial compartment disease.

Conclusions: Exercise, education and self-management remain the core first-line treatment, but the review now explicitly integrates the surgical pathway. Total knee arthroplasty is effective for appropriately selected advanced disease, unicompartmental arthroplasty is suitable for isolated unicompartmental osteoarthritis, and high tibial osteotomy may be reasonable in carefully selected varus medial-compartment disease. Figure layout and evidence presentation were revised to improve readability and the PICO framework is now explicit.

Keywords: Knee Osteoarthritis, Chronic Pain, Older Adults, Unilateral, Total Knee Arthroplasty, Unicompartmental Arthroplasty, High Tibial Osteotomy, Systematic Review

1. Introduction

Knee osteoarthritis (KOA) is a highly prevalent degenerative joint disorder and a major cause of chronic pain, functional limitation, and disability, particularly among older adults. Its pathophysiology is multifactorial and involves progressive articular cartilage degeneration, subchondral bone remodeling, synovial inflammation,

muscle weakness, altered joint biomechanics, impaired gait, sleep disturbance, and peripheral and central pain sensitization. The clinical presentation of KOA is heterogeneous, and the severity of pain and functional impairment does not necessarily correspond to the extent of structural abnormalities observed on imaging. Consequently, current international recommendations support an

individualized and multimodal therapeutic approach that integrates patient education, therapeutic exercise, physical activity, and weight management as fundamental components of care, with pharmacological and procedural interventions selected according to symptom severity, functional impairment, comorbidities, and response to previous treatments [1-3].

Clinical management becomes particularly complex in older adults because KOA frequently coexists with multimorbidity, frailty, sarcopenia, impaired balance, fear of falling, and polypharmacy. These factors may influence treatment tolerance, adherence, rehabilitation potential, and the risk of adverse events, requiring careful consideration of the balance between clinical benefit and treatment related harm. In addition, disease laterality and anatomical distribution may substantially affect therapeutic decision making. Unilateral and bilateral involvement can produce distinct compensatory movement patterns and alterations in joint loading, whereas unicompartmental or multicompartmental disease may influence the indication for biomechanical interventions, rehabilitation strategies, joint preserving procedures, or arthroplasty. Thus, interpretation of treatment outcomes should consider not only symptom severity but also patient characteristics, joint involvement, disease distribution, and the functional consequences of KOA [1-3].

A broad spectrum of conservative and surgical interventions is currently available for KOA, ranging from exercise-based rehabilitation, weight management, analgesic therapies, intra articular procedures, and biomechanical strategies to joint preserving surgery and arthroplasty. However, these therapeutic approaches are often evaluated independently, resulting in fragmented evidence and limiting direct interpretation of their relative effectiveness and safety across different clinical profiles. Furthermore, heterogeneity in study populations, intervention protocols, outcome measures, follow up periods, and definitions of treatment response complicates the translation of available evidence into individualized clinical decision making. A comprehensive synthesis integrating both conservative and surgical strategies is therefore necessary to clarify their respective roles within the therapeutic continuum of KOA. The objective of this systematic review was to compare the available evidence regarding the effectiveness and safety of conservative and surgical interventions for knee osteoarthritis, focusing on clinically relevant outcomes including pain, physical function, mobility, health related quality of life, and treatment related adverse events.

2. Material and Methods

2.1. Protocol and Reporting

The review was designed and reported according to PRISMA 2020. Because the request evolved across iterative manuscript drafts, the current version is best considered an updated single-reviewer review and meta-analysis that requires independent verification before journal submission [4-7].

2.2. Research Question and PICO

The research question was formulated as follows: *In older adults*

with unilateral or index-knee osteoarthritis, which non-surgical and surgical interventions are effective in reducing chronic pain and improving clinically relevant outcomes?

- **Population (P):** The target population comprised older adults with chronic symptomatic knee osteoarthritis, generally with a mean age or minimum age of 60 years or older. Studies were eligible if they included participants with unilateral disease, predominantly unilateral disease, or analyses specifically focused on the index or target knee.
- **Intervention (I):** Eligible interventions included both non-surgical and surgical treatment strategies. Non-surgical interventions comprised patient education, self-management programs, therapeutic exercise, hydrotherapy, mind-body exercise, adjunctive therapies, and intra-articular injections. Surgical interventions included total knee arthroplasty (TKA), unicompartmental knee arthroplasty (UKA), and high tibial osteotomy (HTO).
- **Comparator (C):** Comparators included no treatment, usual care, minimal educational interventions, active non-surgical comparators, surgical versus non-surgical management, and head-to-head comparisons between different surgical procedures.
- **Outcomes (O):** The primary outcome was chronic pain. Secondary outcomes included physical function, health-related quality of life, adverse events, serious adverse events, revision surgery or conversion to arthroplasty, patient satisfaction, and postoperative or post-intervention recovery profile.

Eligible studies were original interventional or comparative investigations with free full-text availability published between January 2015 and July 2026. Systematic reviews, meta-analyses, study protocols, narrative reviews, conference abstracts, and non-interventional studies were excluded.

2.3. Information Sources and Search Strategy

PubMed, MEDLINE, ScienceDirect, Google Scholar, and SciELO were searched through 30 May 2026. The search was restricted to original studies published between January 2015 and July 2026 for which the full text was freely available. Systematic reviews and meta-analyses were excluded from the final eligibility assessment; however, their reference lists were examined to identify additional potentially relevant primary studies. After full-text assessment, 27 primary studies met the eligibility criteria and were included in the qualitative synthesis.

2.4. Eligibility, Study Selection and Data Extraction

Eligible reports were original human intervention studies published in English, Portuguese or Spanish, with older-adult samples and a knee osteoarthritis pain outcome. The review considered both non-surgical and surgical treatment pathways. One reviewer screened titles, abstracts and full texts and extracted data on design, sample, laterality, intervention, comparator, pain outcome, follow-up and key findings. The retained corpus consisted of 50 full-text reports assessed for eligibility, of which 27 primary studies were included.

2.5. Risk of Bias, PICO Alignment and Synthesis Methods

Randomized comparative studies were assessed using adapted RoB 2 judgements across randomization, deviations from intended interventions, missing outcome data, outcome measurement and selective reporting. Certainty was judged using GRADE. Non-surgical pain outcomes were pooled only when interventions and comparators were sufficiently similar for a defensible synthesis. Hedges' g was used, together with restricted maximum likelihood and modified Hartung-Knapp confidence intervals. Surgical studies were not pooled because procedures, comparators, outcome scales and follow-up intervals were too heterogeneous [6,7].

3. Results

3.1. Study Selection

As shown in Figure 1, 50 full-text reports were assessed for eligibility. Of these, 23 reports were excluded, resulting in the inclusion of 27 primary studies in the review, comprising 19 studies investigating non-surgical interventions and eight studies evaluating surgical treatments. Complete records of the initial database exports generated during the identification stage were not retained in the earlier review workflow; therefore, the corresponding identification data could not be retrospectively reconstructed and are reported as a methodological limitation rather than estimated or imputed.

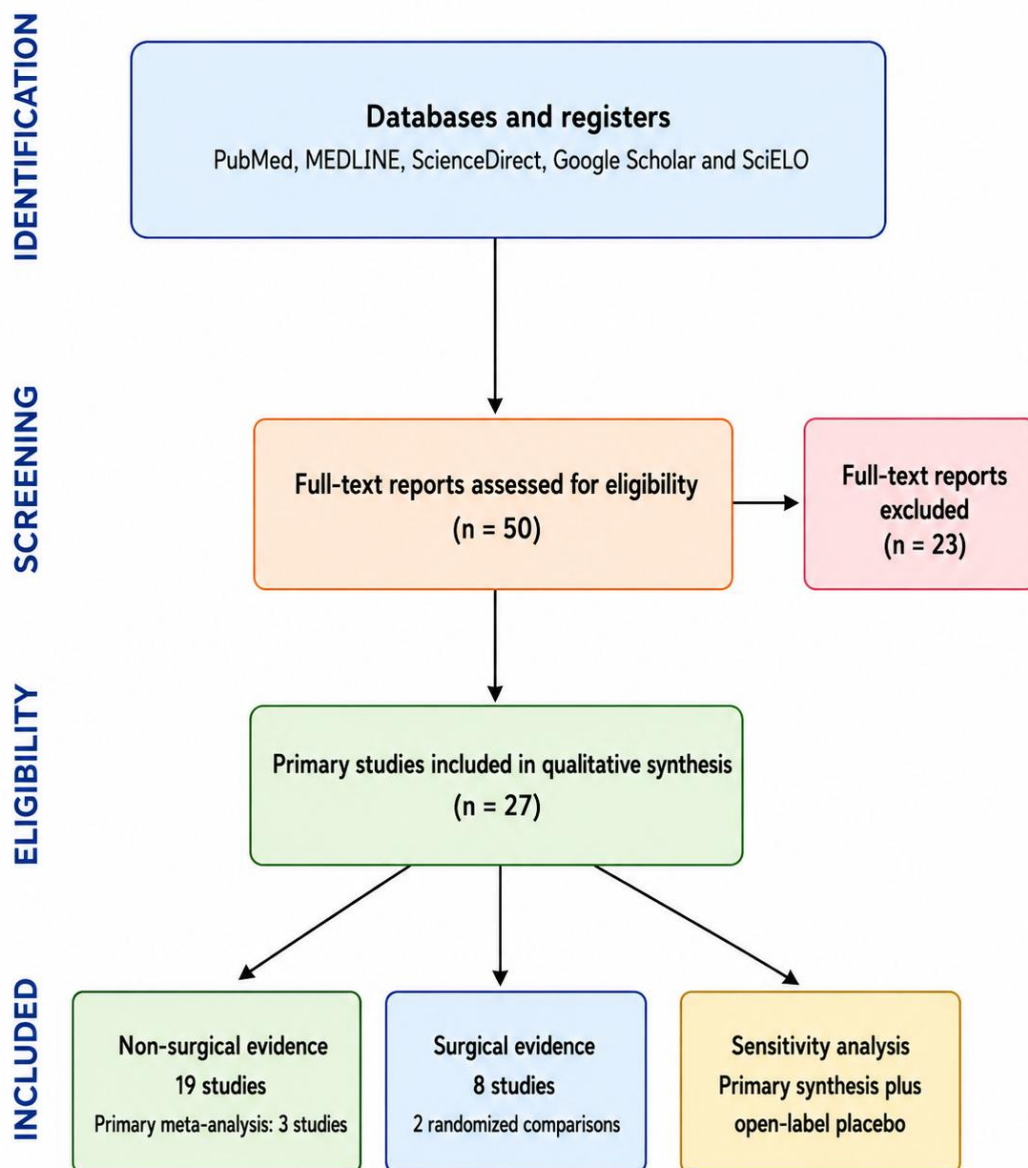


Figure 1: Diagram of the Study Selection Process

3.2. Study Characteristics

Table 1 provides a detailed overview of the methodological characteristics and principal pain-related findings of the 27 primary studies included in the review. For each study, it summarizes the design and sample characteristics, the definition of laterality or the target knee, the intervention or surgical procedure evaluated, the comparator, and the main findings related to pain. The non-surgical

evidence consisted predominantly of randomized and quasi-experimental studies evaluating exercise, educational, behavioural, rehabilitative, adjunctive, and injectable interventions, whereas the surgical evidence included randomized comparisons and prospective or retrospective cohort studies assessing total knee arthroplasty, unicompartmental knee arthroplasty, and high tibial osteotomy.

PANEL A. NON-SURGICAL INTERVENTIONS (N = 19)					
Study	Design, setting, and sample	Knee definition	Intervention	Comparator	Principal pain-related finding
Oliveira Neta et al., 2016 [8]	Quasi-experimental study; Brazil; n = 13; mean age, 62 years	Not clearly reported	Resistance training	No parallel control group	Pain and physical function improved after the intervention; interpretation is limited by the uncontrolled design.
Cheung et al., 2017 [9]	Pilot RCT; United States; yoga, n = 32; exercise, n = 31; education, n = 23; mean age, 71.6 years	Index or symptomatic knee	Yoga or aerobic and strengthening exercise	Education control	Yoga reduced pain compared with education, while both active interventions produced clinical improvements.
Dias et al., 2017 [10]	RCT; Brazil; n = 65 analyzed; women aged ≥ 65 years	Index or affected knee	Hydrotherapy	Control group	Hydrotherapy resulted in lower WOMAC pain scores and improved physical function.
Ganji et al., 2018 [11]	RCT; Iran; n = 82 older adults	Not clearly reported	Self-management education	Routine care	The intervention reduced pain intensity at the 8-week follow-up.
Harper et al., 2019 [12]	Pilot RCT; United States; n = 35; age ≥ 60 years	Index or symptomatic knee	Low-load resistance exercise with blood-flow restriction	Moderate-load resistance exercise	The intervention was feasible, but no clear superiority in pain reduction was demonstrated.
Chen et al., 2019 [13]	Quasi-experimental study; China; n = 171; age ≥ 60 years	Not clearly reported	Home-based exercise combined with education	Education alone	The combined intervention improved pain and physical function.
Langworthy et al., 2019 [14]	Post hoc subgroup analysis of an RCT; United States; n = 170; age ≥ 40 years	Strictly unilateral disease	Extended-release triamcinolone acetonide	Saline placebo or crystalline triamcinolone	Pain benefits were observed at selected time points; however, the evidence was indirectly applicable to older adults.

Ye et al., 2020 [15]	RCT; China; n = 56; age >60 years	Not clearly reported	Baduanjin exercise	No additional exercise	Physical function improved, although pain outcomes were incompletely reported.
Wang et al., 2020 [16]	Cluster RCT; China; older adults; 48-week follow-up	Index knee	Adherence-focused home exercise program	Standard exercise guidance	The intervention improved exercise adherence and knee-related symptoms.
Pinheiro et al., 2020 [17]	Three-arm RCT; Brazil; n = 45 older women	Index knee	Kinesio taping	No-tension taping or control	No clinically meaningful short-term improvement in pain was observed.
Xiao and Li, 2021 [18]	Controlled trial; China; n = 266; mean age, approximately 70 years	Not clearly reported	Wuqinxi exercise	Control group	Favorable effects were reported, although concerns remained regarding outcome scales and reporting quality.
Wang et al., 2021 [19]	Three-arm controlled study; China; n = 128; age >60 years	Not clearly reported	Quadriceps training, Baduanjin, or a combined program	Active intervention groups	The combined program produced greater and more sustained improvements than either intervention alone.
Olliges et al., 2022 [20]	RCT; Germany; n = 60; mean age, 66.9 years	Predominantly unilateral disease	Open-label placebo	No treatment	A moderate reduction in pain was observed, although the effect appeared sensitive to contextual factors.
Lin et al., 2022 [21]	Pilot RCT; Taiwan; n = 38 older adults	Not clearly reported	Computer-assisted rowing exercise	Conventional exercise	Both exercise groups demonstrated improvements, without clear evidence of superiority.
Wang et al., 2022 [22]	RCT; China; n = 27 older adults	Not clearly reported	Herbal hot compress combined with exercise	Exercise alone	An additional clinical benefit was reported, although the sample size was small.
Qiu et al., 2023 [23]	RCT; China; n = 42; all participants aged >60 years	Not clearly reported	Hip-focused exercise combined with rehabilitation	Rehabilitation alone	No statistically significant between-group difference in pain was identified.

Abafita et al., 2025 [24]	Assessor-blinded RCT; Australia; n = 117; mean age, 62.5 years	Index knee	Yoga	Strengthening exercise	Both interventions improved pain, and yoga was non-inferior to strengthening exercise.
Brumini et al., 2025 [25]	Three-arm RCT; Brazil; n = 45 completers; age ≥ 60 years	Index knee	Corticosteroid injection before resistance exercise	Saline injection or placebo	Corticosteroid injection did not provide additional pain-related benefit.
Plavoukou et al., 2025 [26]	Pilot RCT; Greece; n = 42; mean age, 68.4 years	Index or target knee	Sensor-augmented telerehabilitation	In-person physiotherapy	Favorable functional outcomes were observed, although the comparator was an active treatment.
PANEL B. SURGICAL INTERVENTIONS (N = 8)					
Study	Design, setting, and sample	Knee definition	Procedure	Comparator	Principal pain-related finding
Skou et al., 2015 [27]	RCT; Denmark; n = 100; moderate-to-severe osteoarthritis eligible for unilateral TKA	Strictly unilateral surgical indication	TKA followed by a 12-week non-surgical program	Non-surgical program alone	TKA produced greater improvements in pain and function but was associated with more serious adverse events.
Beard et al., 2019, TOPKAT [28]	Multicenter RCT; United Kingdom; n = 528; medial-compartment osteoarthritis	Target knee requiring unilateral replacement	Partial knee replacement	Total knee replacement	Both procedures produced similar clinically important outcomes; the small advantage favoring partial replacement was below the MCID.
King et al., 2021 [29]	Prospective cohort; Canada; n = 1,051; mean age, 67 years	Index operated knee	Primary TKA	Single-arm cohort	Substantial improvements in pain and physical function were observed after surgery.
Oliveira et al., 2023 [30]	Prospective cohort; Brazil; n = 190; 153 participants aged ≥ 65 years	Operated knee	Primary TKA	Single-arm cohort	Pain, physical function, and health-related quality of life improved after TKA.
Cheng et al., 2020 [31]	Retrospective cohort; China; n = 195 patients and 209 knees; 65 patients aged >80 years	Unicompartmental target knee	Oxford unicompartmental knee arthroplasty	Comparison between age groups	Pain and function improved across age groups, with similar complication rates.

King et al., 2021 [29]	Prospective cohort; Canada; n = 1,051; mean age, 67 years	Index operated knee	Primary TKA	Single-arm cohort	Substantial improvements in pain and physical function were observed after surgery.
Oliveira et al., 2023 [30]	Prospective cohort; Brazil; n = 190; 153 participants aged ≥65 years	Operated knee	Primary TKA	Single-arm cohort	Pain, physical function, and health-related quality of life improved after TKA.
Cheng et al., 2020 [31]	Retrospective cohort; China; n = 195 patients and 209 knees; 65 patients aged >80 years	Unicompartmental target knee	Oxford unicompartmental knee arthroplasty	Comparison between age groups	Pain and function improved across age groups, with similar complication rates.
Tille et al., 2021 [32]	Prospective matched cohort; Germany; 116 UKA procedures with matched TKA controls	Unicompartmental target knee	Unicompartmental knee arthroplasty	Matched total knee arthroplasty	UKA was associated with faster short-term functional recovery.
Li et al., 2023 [33]	Retrospective cohort; China; n = 76; 34 geriatric patients	Medial-compartment osteoarthritis with varus alignment	Medial opening-wedge high tibial osteotomy	Single-arm cohort	Pain and function improved, although bone union was slower in older patients.
Akar et al., 2025 [34]	Retrospective cohort; Turkey; n = 123; age ≥65 years	Varus or medial-compartment target knee	Medial opening-wedge high tibial osteotomy	Single-arm cohort	

Legend: MCID:minimal clinically important difference; RCT: randomized controlled trial; TKA: total knee arthroplasty; UKA: unicompartmental knee arthroplasty; WOMAC:Western Ontario and McMaster Universities Osteoarthritis Index.

Table 1: Characteristics and Main Findings of the Included Studies

3.3. Non-surgical evidence

As illustrated in Figure. 2A, active non-surgical interventions generally improved pain and physical function. The available evidence encompassed resistance training, hydrotherapy, home-based exercise, yoga, Baduanjin, Wuqinxi, rowing-based exercise, telerehabilitation, and self-management education. Self-management education reduced pain compared with routine care, whereas the short-term effect observed with open-label placebo was likely influenced by contextual mechanisms and was therefore evaluated separately from active rehabilitation interventions [8-13,15,16,18-26].

The primary meta-analysis presented in Figure. 2A pooled three clinically comparable interventions—yoga, hydrotherapy, and self-management education—comprising 202 participants. The pooled estimate favoured the interventions, although the confidence interval crossed the null (Hedges' $g = -0.56$, 95% CI -1.18 to

0.06 ; $I^2 = 0\%$). Inclusion of the open-label placebo study in the sensitivity analysis produced an almost identical point estimate but a narrower confidence interval that excluded the null (Hedges' $g = -0.56$, 95% CI -0.96 to -0.15). This stability in the point estimate suggests that the overall effect magnitude was not materially altered, although the placebo finding should remain conceptually distinct from the effects of active rehabilitation [9-11,20].

3.4. Surgical evidence

Figure. 2B summarises the randomised surgical evidence using the original outcome scales. Among patients eligible for unilateral total knee arthroplasty, total knee arthroplasty combined with non-surgical care produced greater improvements in pain and function than non-surgical care alone (KOOS4 adjusted mean difference, 15.8 ; 95% CI 10.0 to 21.5), but serious adverse events were more frequent (24 versus 6; $P = 0.005$). In patients with isolated medial-compartment osteoarthritis, the TOPKAT trial showed that partial

and total knee replacement achieved similar clinically important outcomes at five years; the small advantage in Oxford Knee Score associated with partial replacement remained below the minimal clinically important difference [27-28]. Because the surgical studies evaluated distinct procedures, comparators, and outcome metrics, their estimates were not statistically pooled.

The observational surgical evidence was consistent with substantial improvements in pain and physical function after

total knee arthroplasty and with acceptable outcomes following unicompartmental knee arthroplasty in carefully selected older adults with isolated unicompartmental disease. High tibial osteotomy also provided symptomatic and functional benefits in selected patients with varus medial-compartment osteoarthritis. However, outcomes were less favourable in advanced radiographic disease, conversion to total knee arthroplasty was more frequent, and bone union was slower among geriatric patients [29-34].

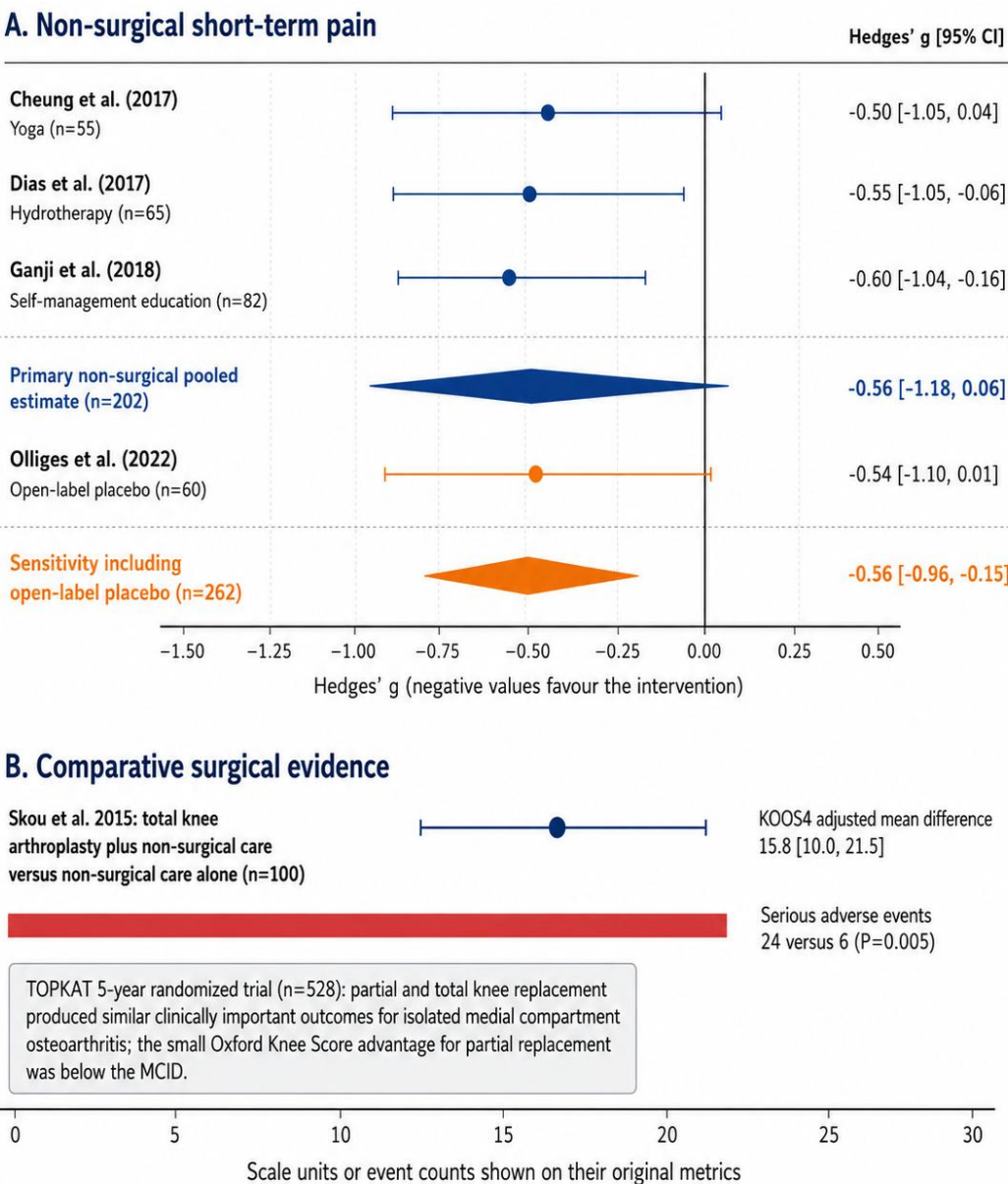
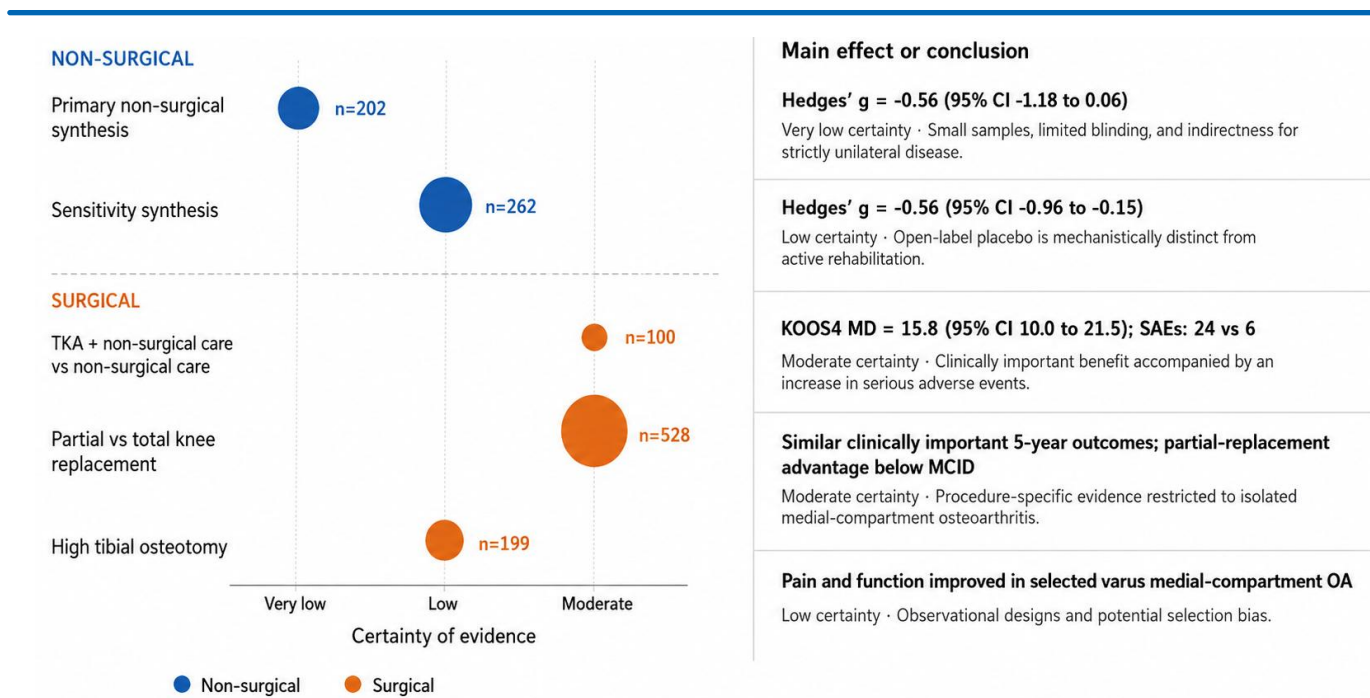


Figure 2: Treatment Effects Were Synthesized Separately for Non-Surgical and Surgical

3.5. Comparative Synthesis and Certainty

Figure 3 integrates the comparative effects, sample sizes, and certainty ratings across the principal non-surgical and surgical treatment pathways. The primary non-surgical synthesis included yoga, hydrotherapy, and self-management education compared with education, routine care, or control conditions (three studies;

n=202). The pooled estimate favored the interventions, although the confidence interval crossed the null (Hedges' g = -0.56, 95% CI -1.18 to 0.06), and certainty was rated very low because of small samples, limited blinding, and indirectness for strictly unilateral disease [9-11].



Legend: Bubble area represents the number of participants, whereas horizontal position represents the certainty rating. MD, mean difference; MCID, minimal clinically important difference; OA, osteoarthritis; SAEs, serious adverse events.

Figure 3: Comparative Synthesis and Certainty of Evidence Across Treatment Pathways

In the sensitivity synthesis, adding the open-label placebo study increased the evidence base to four studies and 262 participants but did not materially change the point estimate (Hedges' g = -0.56, 95% CI -0.96 to -0.15). Certainty was rated low because the contextual mechanisms of an open-label placebo differ from those of active rehabilitation [20]. In the randomized surgical evidence, total knee arthroplasty combined with non-surgical care produced a clinically important improvement over non-surgical care alone (KOOS4 adjusted mean difference 15.8, 95% CI 10.0 to 21.5), but serious adverse events were more frequent (24 versus 6), resulting in moderate certainty [27]. Partial and total knee replacement produced similar clinically important outcomes at five years, with a small partial-replacement advantage below the MCID; this procedure-specific evidence was also rated moderate [28]. High tibial osteotomy improved pain and function in selected patients with varus medial-compartment osteoarthritis, but

certainty remained low because the evidence was observational and susceptible to selection bias [33,34].

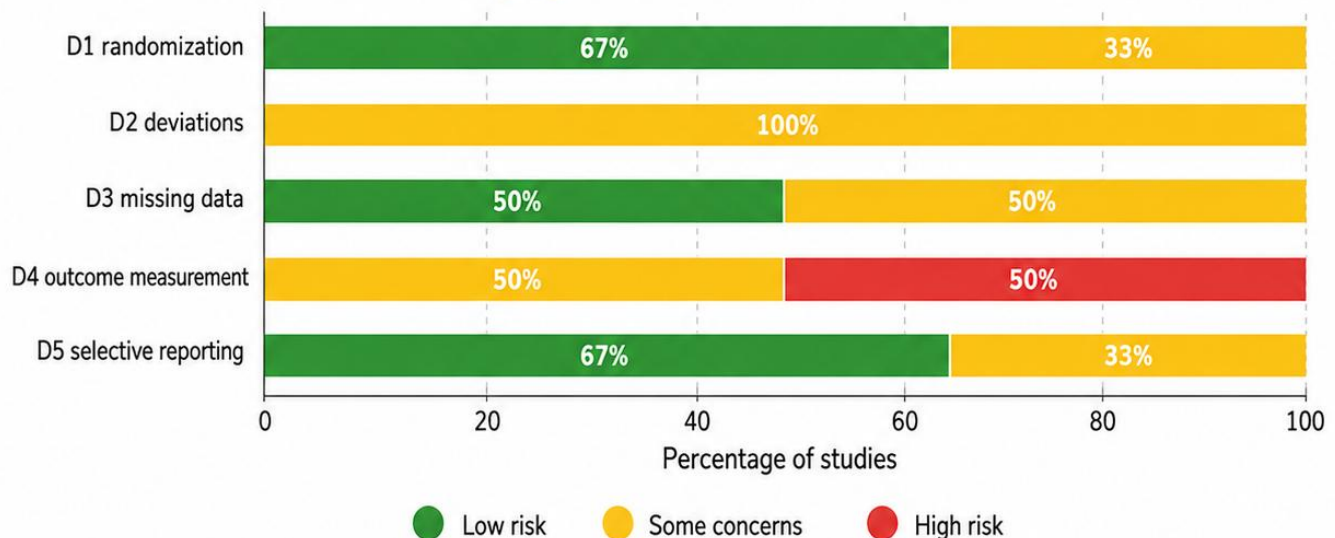
3.6. Risk of bias across randomized comparative evidence

As shown in Figure 4, study-level RoB 2 assessments identified some concerns or high risk of bias across all randomized comparisons. Deviations from intended interventions were judged as presenting some concerns in every trial, while missing outcome data generated some concerns in half of the studies. Outcome measurement was the most problematic domain: half of the trials were judged at high risk and the remainder raised some concerns. Randomization and selective reporting were more frequently rated as low risk. These limitations support cautious interpretation of the pooled non-surgical estimates and contributed to downgrading the certainty of evidence.

A. Study-level RoB 2 judgments

	D1	D2	D3	D4	D5	Overall
Cheung 2017	?	?	?	—	?	—
Dias 2017	+	?	?	?	+	?
Ganji 2018	?	?	+	—	?	—
Olliges 2022	+	?	+	—	+	—
Skou 2015	+	?	+	?	+	?
TOPKAT 2019	+	?	?	?	+	?

B. Distribution of domain-level judgments



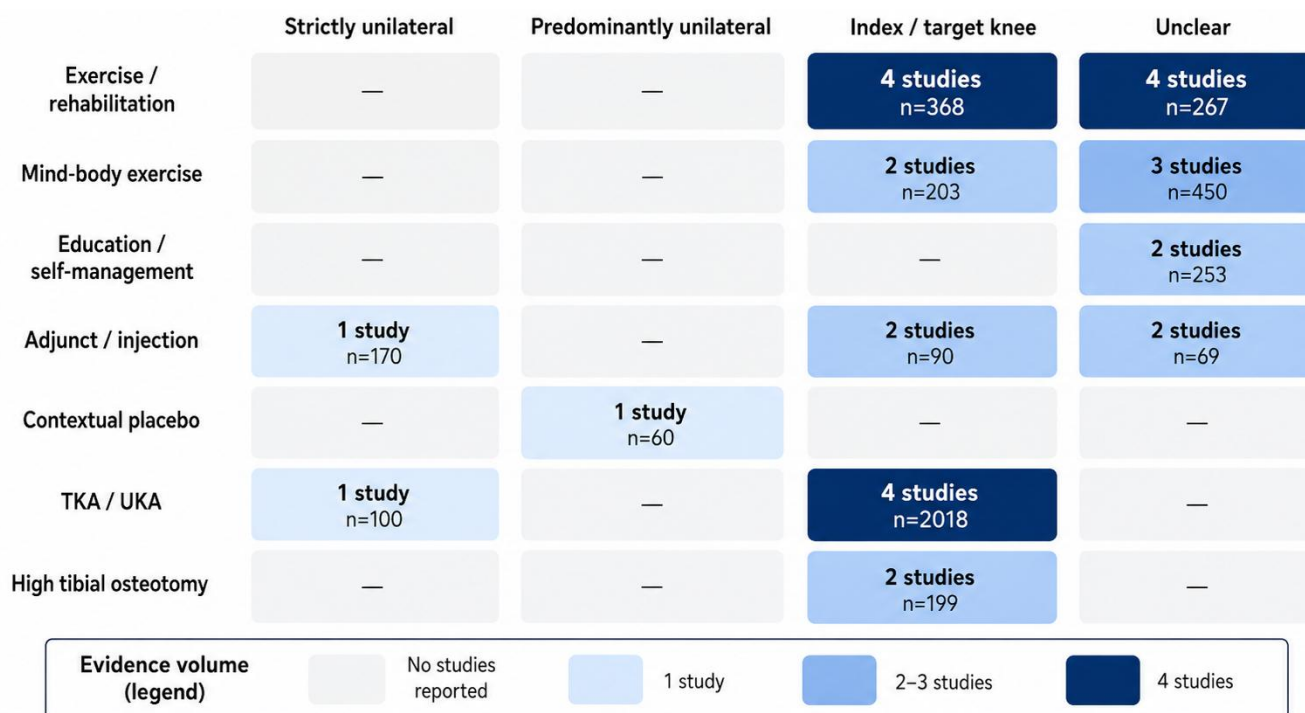
Legend: D1: randomization; D2: deviations from intended interventions; D3: missing outcome data; D4: outcome measurement; D5: selective reporting.

Figure 4: Risk of Bias Across Randomized Comparative Evidence

3.7. Evidence Gaps

Figure 5 demonstrates that explicit reporting of laterality remained uncommon. Evidence derived from strictly unilateral populations was sparse, whereas most studies either selected an index or target knee or did not report laterality clearly. The non-surgical evidence base was concentrated in exercise, rehabilitation, and mind-body interventions, particularly among index- or target-knee studies. Education and self-management, contextual placebo, and adjunct

or injectable approaches were represented by fewer studies. Within the surgical pathway, arthroplasty evidence was substantially more extensive than evidence for high tibial osteotomy. The principal research gaps therefore include the limited availability of strictly unilateral designs, inadequate reporting of laterality, and the comparatively small evidence base for osteotomy and non-exercise conservative treatments.



Legend: Cells Report the Number of Studies and Participants in Each Category; Darker Shading Indicates A Larger Evidence Volume and Does Not Represent Treatment Efficacy.

Figure 5: Evidence Map by Treatment Pathway and Laterality Reporting

4. Discussion

This review synthesized evidence from 27 studies evaluating non-surgical and surgical treatments for chronic pain in older adults with unilateral or index-knee osteoarthritis. The non-surgical evidence indicated improvements in pain and physical function across several exercise, rehabilitation, and self-management strategies, but the quantitative estimate remained imprecise. The surgical evidence showed greater pain and functional improvement with total knee arthroplasty (TKA) plus non-surgical care than with non-surgical care alone, together with a higher frequency of serious adverse events. Partial and total knee replacement produced similar clinically important outcomes in isolated medial-compartment osteoarthritis, whereas the evidence for unicompartmental knee arthroplasty (UKA) and high tibial osteotomy (HTO) was mainly observational.

The non-surgical studies evaluated resistance training, hydrotherapy, home-based exercise, yoga, Baduanjin, Wuqinxi, rowing-based exercise, telerehabilitation, and self-management education [8-13,15-26]. Most studies reported improvement in pain, function, or both, although the magnitude of benefit varied and several comparisons did not demonstrate superiority over an active intervention. These findings support the use of structured exercise and education as components of non-surgical care, in agreement with current clinical guidelines [1-3]. However, differences in intervention content, sample size, follow-up duration, and outcome measurement prevent direct ranking of the

non-surgical modalities.

The quantitative synthesis of the clinically comparable non-surgical comparisons produced a Hedges' g of -0.56 (95% CI -1.18 to 0.06; I² = 0%) [9-11]. The direction of the estimate favored the interventions, but the confidence interval included the null value. Therefore, the pooled result does not provide a statistically conclusive estimate of benefit. The certainty of this evidence was rated very low because of small samples, limitations in blinding, and indirectness for strictly unilateral disease. The I² value should also be interpreted cautiously because the synthesis was based on a small number of studies.

When the open-label placebo trial was added in the sensitivity analysis, the point estimate remained -0.56 and the confidence interval narrowed to -0.96 to -0.15 [20]. This result indicates that inclusion of the contextual intervention did not materially change the estimated effect size. Nevertheless, open-label placebo differs from active rehabilitation in treatment content and mechanism. Its inclusion is therefore more appropriate as a sensitivity analysis than as part of the rehabilitation synthesis. The result suggests that contextual effects may influence short-term pain outcomes, but it should not be interpreted as evidence that placebo and active exercise are clinically equivalent.

The randomized comparison of TKA plus non-surgical care with non-surgical care alone showed an adjusted KOOS4 mean

difference of 15.8 points (95% CI 10.0 to 21.5) [27]. This finding indicates a clinically relevant improvement in pain and function among patients who met criteria for unilateral TKA. However, serious adverse events were more frequent in the surgical group (24 versus 6; $P = 0.005$). The result therefore demonstrates both a greater clinical benefit and a greater risk of harm. Interpretation of TKA outcomes in older adults should consider disease severity, comorbidity, frailty, and the capacity to complete postoperative rehabilitation.

In isolated medial-compartment osteoarthritis, the TOPKAT trial found similar clinically important outcomes after partial and total knee replacement at five years [28]. The small difference favoring partial replacement was below the minimal clinically important difference. Observational studies reported pain and functional improvement after UKA in older adults, including patients older than 80 years, and faster short-term functional recovery compared with TKA in selected populations [31,32]. These findings support UKA as a procedure for patients with disease limited to one compartment who meet the anatomical and functional criteria for partial replacement.

The evidence for HTO was based on retrospective cohorts of selected patients with varus medial-compartment osteoarthritis [33,34]. Both studies reported improvements in pain and function. However, slower bone union was observed in geriatric patients, and outcomes were less favorable in advanced radiographic disease. The certainty of this evidence remained low because the studies were non-randomized and susceptible to selection bias. The results therefore support HTO only for selected patients rather than for older adults with advanced or multicompartment osteoarthritis.

Laterality was not reported consistently. Strictly unilateral samples were uncommon, and many studies analyzed an index or target knee without clearly describing the status of the contralateral knee [8-34]. This limits the direct applicability of the findings to patients with confirmed unilateral disease. Contralateral symptoms and bilateral functional impairment may influence pain, gait, and measured treatment response. Future studies should define laterality, identify the analyzed knee, report contralateral symptoms and treatment, and present outcomes according to unilateral or bilateral involvement.

The risk-of-bias assessment identified some concerns or high risk in all randomized comparisons. Deviations from intended interventions were a frequent concern, and outcome measurement was the domain with the highest proportion of high-risk judgments. These limitations are relevant because pain is a subjective outcome and blinding is difficult in exercise and surgical studies. The RoB 2 and GRADE assessments therefore support cautious interpretation of the non-surgical pooled estimate and moderate certainty for the randomized surgical comparisons [6,7,27,28].

The findings support treatment selection according to clinical severity and anatomical pattern. Exercise, education, and self-

management remain appropriate non-surgical treatments because they were associated with improvements and have a lower risk of serious harm [1-3,8-26]. TKA produced greater improvement than non-surgical care in patients eligible for surgery, but with more serious adverse events [27]. Partial knee replacement and UKA may be considered for isolated unicompartmental disease, while HTO may be considered in selected varus medial-compartment osteoarthritis [28,31-34]. The available evidence does not support a single treatment sequence for all older adults; treatment choice should account for compartment involvement, symptom severity, radiographic findings, comorbidities, and expected recovery.

5. Conclusion

This review indicates that, in older adults with unilateral or index-knee osteoarthritis, structured exercise, education, and self-management are appropriate non-surgical options for reducing chronic pain and improving physical function, although the pooled estimate was imprecise and supported by very low-certainty evidence. In patients with advanced symptomatic disease who meet surgical criteria, total knee arthroplasty provides greater improvement in pain and function than non-surgical care alone, but it is associated with a higher frequency of serious adverse events. For isolated medial-compartment osteoarthritis, partial and total knee replacement produce similar clinically important outcomes, while unicompartmental knee arthroplasty and high tibial osteotomy may be considered in anatomically selected patients. Treatment decisions should therefore be based on disease severity, compartment involvement, laterality, comorbidities, frailty, expected recovery, and patient preferences.

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