SYSTEMATIC REVIEW

Impact of the Opening-Wedge and Closing-Wedge High Tibial Osteotomy on Clinical Outcomes of Total Knee Arthroplasty: A Systematic Review of Comparative Clinical Studies

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Abstract

Objectives: Eventually, both closing-wedge high tibial osteotomy (CW-HTO) and opening-wedge high tibial osteotomy (OW-HTO) may fail, necessitating conversion to total knee arthroplasty (TKA), one of the most successful procedures in orthopedic surgery. This systematic review aimed to answer the following question: What are the clinical and surgical outcomes of TKA after CW-HTO and OW-HTO?

Methods: The main electronic databases were searched up to November 2025. Only studies that included comparative arms for both closing-wedge high tibial osteotomy (CW-HTO) and opening-wedge high tibial osteotomy (OW-HTO) were considered for further assessment. The primary outcomes included knee joint function scores, such as the International Knee Society (IKS) score and the Knee Society Score (KSS). A meta-analysis was not feasible because of heterogeneity in the reported data and follow-up periods. The Joanna Briggs Institute (JBI) critical appraisal tool was used to assess the methodological quality of each included study.

Results: Of the 6,756 records identified and screened, three comparative clinical studies, including a total of 541 TKA cases, were included in this systematic review. Two studies reported no significant difference in KSS or range of motion after TKA between patients who had previously undergone CW-HTO and those who had undergone OW-HTO. However, one study reported improvements in walking ability in both groups after 80–90 months of follow-up. The most frequently reported complications were skin necrosis, joint stiffness, infection, peroneal nerve injury, and posterior tibial nerve injury.

Conclusion: The limited available evidence precludes definitive conclusions. Current data suggest potential benefits after TKA following either CW-HTO or OW-HTO, including earlier relief of joint loading, shorter recovery time, and improved clinical outcomes, with no significant differences between the two HTO techniques.

Level of evidence: V

Keywords: Closing wedge high tibial osteotomy, Knee osteoarthritis, Opening wedge high tibial osteotomy, Systematic review, Total knee arthroplasty

Introduction

Osteoarthritis (OA) is the most prevalent musculoskeletal disorder globall,[1] affecting about 7.6% of the population in 2020, equivalent to 595 million individuals. The prevalence is projected to increase by 60%–100% by 2050 due to factors such as aging populations, rising obesity rates, and lifestyle changes.[1,2] OA is a degenerative joint disease that causes significant pain and discomfort for patients, primarily affecting their daily functioning.[3] Total knee arthroplasty (TKA) and high tibial osteotomy (HTO) have been introduced as common treatments for knee joint OA.[4]

HTO is frequently performed in younger patients with high activity demands,[6] often presenting with varus alignment or damage to the medial compartment cartilage, in combination with ligamentous deficiencies or meniscus tears.[5] The main aim of high tibial osteotomy (HTO) is to correct the mechanical axis of the lower limb and reduce load stress on the pathological medial compartment. HTO

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has been shown to produce satisfactory short-term clinical results, with many patients regaining acceptable functional outcomes.[6] High tibial osteotomy (HTO) includes osteotomies of the proximal tibia using either opening wedge (OW-HTO) or closing wedge (CW-HTO) approaches.[7] Closing-wedge high tibial osteotomy (CW-HTO) involves removing a triangular wedge of bone from the lateral side of the proximal tibia and bringing the cut surfaces together to correct varus deformity, which slightly shortens the tibia and is usually performed through a lateral approach. In contrast, opening-wedge high tibial osteotomy (OW-HTO) is performed on the medial side, where the bone is cut and opened like a hinge, and the gap is filled using bone graft or a spacer, slightly lengthening the tibia and typically using a medial approach.[8-10]

Although high tibial osteotomy (HTO) can effectively delay the need for joint replacement by correcting malalignment, long-term follow-ups indicate that a significant proportion of patients eventually require conversion to total knee arthroplasty (TKA). For instance, a meta-analysis reported a survival rate of 84.4% at 9 to 12 years of follow-up, but it also noted that many of these patients will likely require total knee arthroplasty (TKA) in the future.[11] Primeau et al.[12] reported a 21% conversion rate from opening-wedge high tibial osteotomy (OW-HTO) to total knee arthroplasty (TKA) at a 10-year follow-up. Moreover, in a retrospective study, Keenan et al.[13] reported a 36% conversion rate from opening-wedge high tibial osteotomy (OW-HTO) to total knee arthroplasty (TKA) at a mean follow-up of 6.3 years.

TKA is an effective surgical intervention for end-stage knee osteoarthritis, aimed at decreasing pain, correcting deformity, and restoring daily joint function.[14] As TKA is the definitive surgical treatment for knee OA,[15] it is essential to evaluate the outcomes of this treatment (i.e., TKA) following OW-HTO and CW-HTO. Moreover, the technical differences between closing-wedge (CW-HTO) and opening-wedge (OW-HTO) high tibial osteotomy procedures can lead to variations in TKA outcomes, potentially influencing surgical decision-making, preoperative planning, and the prediction of clinical results.[16]

This study was designed to systematically review the literature regarding the postoperative outcomes of TKA following closing versus opening-wedge high tibial osteotomy. Our aim is to investigate whether outcomes after TKA surgery are affected by previous open or closed high tibial osteotomy.

Materials and Methods

In this study, we systematically reviewed the literature on the clinical outcomes of TKA following OW-HTO and CW-HTO, respectively. We adhered to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) 2020 guidelines and checklist for reporting systematic reviews.[17] Additionally, this systematic review was registered in the International Prospective Register of Systematic Reviews (PROSPERO) (CRD42023494161, https://www.crd.york.ac.uk/PROSPERO/view/CRD42023494161).

Search Strategy

A comprehensive search was conducted independently by two authors (MKH and MS) in online databases including PubMed, Embase, Scopus, the Cochrane Library, and Web of Science up to November 2025, with no time restrictions. An additional search was conducted in Google Scholar (pages one to ten) and ProQuest to review all records and gray literature. The evaluation of randomized clinical trials (RCTs) was performed by searching clinicaltrials.gov to ensure comprehensive inclusion of all relevant information. Additionally, ongoing studies registered in PROSPERO were reviewed to avoid any overlap.

The search strategy was developed using controlled vocabulary terms (MeSH terms) and free-text terms, and it was approved by MHE and AM. A combination of keywords and phrases was employed to cover the entire relevant scope of the study. The refined search strategy was as follows: ("high tibial osteotomy" OR "open wedge high tibial osteotomy" OR "closing wedge high tibial osteotomy") AND ("Total Knee Arthroplast" OR "TKA" OR "total knee replacement"). For each database, the search strategy was adjusted to ensure optimal performance. The final search strategy can be found in [Supplementary 1 file].

Screening, Inclusion/Exclusion Criteria

The PICOD strategy was used to facilitate the selection of articles for this systematic review. The review aimed to assess adult patients (P) diagnosed with osteoarthritis (OA) who had undergone non-invasive therapies and rehabilitation interventions as the initial phase of treatment. Accordingly, the studies included two separate groups of patients, with each group receiving either OW-HTO or CW-HTO interventions (I). Regarding outcome ascertainment (O), we focused on studies that compared the post-operative outcomes of TKA in patients with a prior surgical history of OW-HTO and CW-HTO. These outcomes included Knee Society Score (KSS), International Knee Society (IKS), Hip-Knee-Ankle (HKA) angle, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), 12-item Short Form Survey (SF-12) evaluating the impact of the intervention on individuals' everyday life, knee alignment, patellar height, stability, stair climbing, and walking distance. Based on the characteristics of the intervention and the conditions in which the studies took place, comparative clinical studies with OW-HTO and CW-HTO interventional groups were deemed acceptable in terms of design and were therefore included in this systematic review (D).

Studies involving animals, cadavers, literature reviews, case reports, conference proceedings, books, and clinical studies lacking both intervention groups were excluded from consideration. Patients with a history of prior surgical interventions or concurrent rehabilitation and orthobiologic interventions on the knee were also excluded. Duplicate records and documents published in languages other than English were removed from the systematic review.

Two reviewers (MKH and FN) independently assessed the records for relevancy based on the title and abstract. The full text of the papers was then reviewed against the inclusion criteria. In case of any disagreements, the final decision was made by a third researcher, NJ. The flow diagram of the review process is shown in [Figure 1].

Data extraction

The clinical outcomes of interest were grouped into two categories: (I) post-operative scores, including KSS, HKA angle, WOMAC, SF-12, limb alignment, knee stability, no-aid walking, walking distance, and walking up stairs after TKA; and (II) post-operative complications, including skin necrosis, peroneal nerve injury, joint stiffness, and surgical site infection. Data were extracted and assessed by two authors (MKH and MS) under supervision in the following order: (1) Author; (2) Country; (3) Publication date (year); (4) Sample size; (5) Gender; (6) Age at the time of high tibial surgery (years); (7) Age at the time of total knee arthroplasty; (8) Body mass index (BMI) at the time of TKA; (9) Follow-up time (months); (10) No-aid walking distance (meters); (11) Walking distance (meters); (12) Pain Score (0-10 points); (13) KSS (0-10 points); (14) HKA angle; (15) WOMAC (0-50 points); (16) SF-12 (0-10 points); and (17) Any post-operative complications.

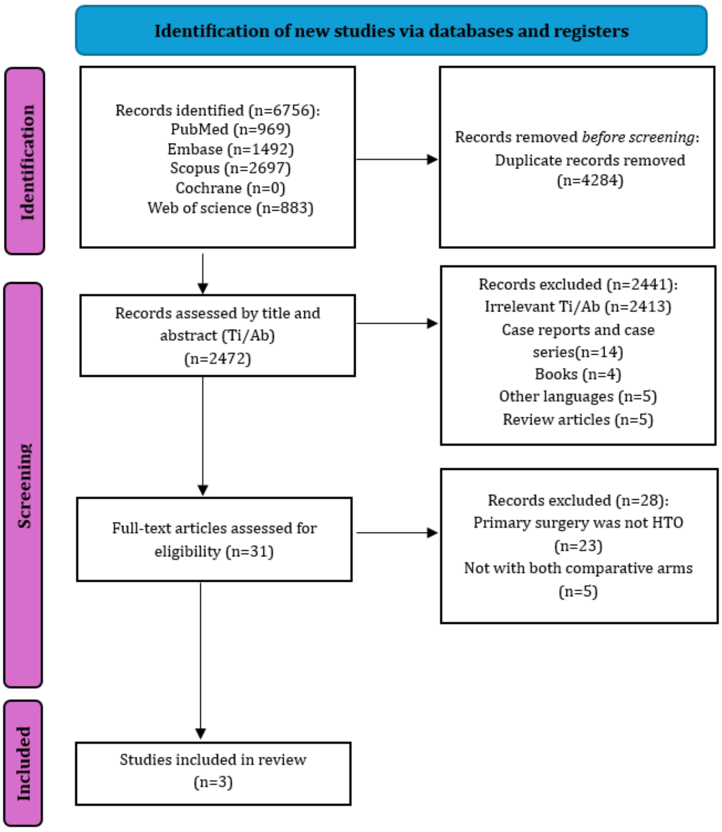

Figure 1. PRISMA flow diagram of the systematic review study selection

Quality Assessment

Two reviewers (MS and FN) assessed the risk of bias in the studies, while the verification of the process and results was performed by two additional reviewers (NJ and MD). The quality assessment of the reviewed studies was carried out using the Joanna Briggs Institute (JBI) critical appraisal tool for case series studies.[18] This checklist consists of 10 questions, focusing on several methodological areas, including the sampling of eligible patients, measurement and reporting of outcomes, appropriate follow-up procedures, and the adequacy of statistical methods. Each item on the checklist was rated as Yes, No, Unclear, or Not Applicable, according to the JBI guidelines. Items were rated as "Yes" if the item was fully addressed, "No" if it was not presented, "Unclear" in cases of ambiguity, or "Not Applicable" if it did not apply. The answer "Yes" was assigned 1 point, while other answers received 0 points, resulting in a maximum possible score of 10 points.

Results

Study Selection

A total of 6,756 potentially relevant records were identified through the search strategy, which was reduced to 2,472 after the removal of duplicates. Of these, 2,413 records were excluded due to irrelevance found in the title and abstract, as well as 28 records that were books, case reports, case series, review studies, or non-English manuscripts. This process resulted in 31 studies with relevant objectives being selected for full-text assessment.

After a thorough review, studies with irrelevant intervention groups and inappropriate primary surgeries prior to TKA were excluded. Three full-text articles were retrieved for further evaluation, and all met the eligibility criteria.[19-21] All three studies were comparative clinical studies published between January 4, 2013, and July 11, 2017, including a total of 460 patients. More details of the included studies are shown in [Table 1].

Although the eligibility criteria were favorable, the primary outcome variables lacked sufficiently homogeneous data for analysis. Additionally, the variability in follow-up times and sample sizes prevented a thorough statistical analysis.

Table 1. Baseline Characteristics of the included studies

Study (Author, Country, Year)	No. of participants	Intervention group, n (%)		Follow-up time	Outcome parameters	Time interval to TKA
		OW-HTO	***CW-HTO***			
Bastos R. (Brazil, 2013)	118 TKA procedures in 141 participants	24 (17.0)	117 (82.9)	24 months after TKA	**(1)** Pre-post-op IKS scores; **(2)** Pre-post- HKA angle; **(3)** Any medial or lateral releases; **(4)** The thickness of the tibial cut (laterally for medial compartment arthrosis and medially for lateral compartment arthrosis); **(5)** Valgus degrees while cutting the femur; **(6)** Any complications during TKA; **(7)** Any post-op complications; **(8)** Tourniquet time	12.2 ± 6.3 years (range, 1.5-34.4)
Preston S. (USA, 2014)	376 TKA procedures	77 (20.4)	188 (79.5)	CW-HTO group, mean: 88 months OW-HTO group, mean: 59 months	**(1)** WOMAC score; **(2)** Knee Society Score (KSS); **(3)** SF-12 score; **(4)** five-year survivorship of patients having undergone TKA	NR
Ehlinger M. (France, 2017)	135 TKA procedures	58 (42.9)	77 (57.0)	CW-HTO group, mean (range): 84.9 months (2-136) OW-HTO group, mean (range): 88.9 months (2-136)	**(1)** Unassisted walking; **(2)** Walking upstairs; **(3)** Walking more than 1000 m; **(4)** Mean flexion (degrees); **(5)** Mean extension (degrees); **(6)** Frontal stability; **(7)** Sagittal stability; **(8)** Lateral or medial ligament release; **(9)** Radiologic varus (<180°); **(10)** Early post-op complications (<3 months); **(11)** Late complications; **(12)** 10-year survival rate after TKA	CW-HTO group, mean (range): 155 months (12-393) OW-HTO group, mean (range): 104 months (8-332)

Quality Assessment

Based on the methodological quality assessment of the three included comparative clinical studies using the JBI critical appraisal checklist for case report studies, the studies demonstrated acceptable results, with identified strengths and some limitations [Table 2]. All three studies clearly defined inclusion criteria and employed valid methods for condition identification. Furthermore, each study adequately reported demographic and clinical information of participants, as well as follow-up outcomes. However, consistent limitations were observed in the consecutive inclusion of participants, which was not confirmed in any of the studies. The clarity of reporting on the demographic details of the presenting sites or clinics was also lacking in two of the three studies. The consistent use of appropriate statistical analysis across all studies is a strength, suggesting that despite some limitations in study design or reporting, the findings were analytically sound.

Notably, the study by Ehlinger (2017)[20] and Preston (2014)[21] met 8 of the 10 JBI criteria with affirmative responses. Furthermore, Bastos (2013)[19] fulfilled 7 criteria, with some uncertainty due to two items rated as unclear. While Preston's study had clearer reporting, it missed two criteria entirely. Using the method proposed by Barker et al., the authors concluded that all three studies were adequately designed and the overall risk of bias was low.[22]

Table 2. Quality Assessment Using JBI tool for clinical case series

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total
Bastos R. (2013)	Y	U	Y	N	Y	Y	Y	Y	N	Y	7
Preston S. (2014)	Y	Y	Y	N	Y	Y	Y	Y	N	Y	8
Ehlinger M. (2017)	Y	U	Y	N	Y	Y	Y	Y	Y	Y	8

Table 2. Continued

Y, Yes; N, No; U, Unclear; N/A, Not applicable

Q1. Were there clear criteria for inclusion in the case series?

Q2. Was the condition measured in a standard, reliable way for all participants included in the case series?

Q3. Were valid methods used for the identification of the condition for all participants included in the case series?

Q4. Did the case series have consecutive inclusion of participants?

Q5. Did the case series have complete inclusion of participants?

Q6. Was there clear reporting of the demographics of the participants in the study?

Q7. Was there clear reporting of clinical information of the participants?

Q8. Were the outcomes or follow-up results of cases clearly reported?

Q9. Was there clear reporting of the presenting site(s)/clinic(s) demographic information?

Q10. Was statistical analysis appropriate?

Study Characteristics

A total of three studies were included in this systematic review, comprising comparative clinical studies with both OW and CW intervention groups for comparison. The studies were conducted in France and the USA and were published between January 4, 2013, and July 11, 2017 [Table 1]. These three clinical studies included 541 cases of TKA (382 CW and 159 OW). The studies focused on assessing the clinical and radiological indices related to knee joint function as their primary clinical outcome. The clinical outcomes were measured with follow-up periods ranging from 2 to 136 months, as outlined in [Tables 3 and 4].

Table 3. Clinical scores outcomes of studies

Study (Author, Country, Year)	IKS Before-Op		IKS After-Op		KSS Before-Op		KSS After-Op		WOMAC Before-Op		WOMAC After-Op		SF-12 Before-Op		SF-12 After-Op	
	OW	*CW*	*OW*	*CW*	*OW*	*CW*	*OW*	*CW*	*OW*	*CW*	*OW*	*CW*	*OW*	*CW*	*OW*	*CW*
Bastos R. (Brazil, 2013)	56.3 ± 13.6	53.6 ± 16.8	84.8 ± 13.8	87.5 ± 14.1	-	-	-	-	-	-	-	-	-	-	-	-
Preston S. (USA, 2014)	-	-	-	-	90.02	89.20	160.54	154.05	43.58	42.57	67.42	66.85	30.27	30.50	36.25	34.26
Ehlinger M. (France, 2017)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 4. Knee functional outcomes

Study (Author, Country, Year)	Knee flexion Before-Op		Knee flexion After-Op		Knee extension Before Op		Knee extension After-Op	
	OW	*CW*	*OW*	*CW*	*OW*	*CW*	*OW*	*CW*
R. Bastos (Brazil, 2013)	119.8±14	112.7±16.5	111.7±21.2	114.8±13.0	2.1±4.8	3.1±5.3	0.5±3.0	0.3±3.6
S. Preston (USA, 2014)	-	-	-	-	-	-	-	-
M. Ehlinger (France, 2017)	110 (75-140)	108 (70-140)	111 (80-130)	110 (65-140)	-4 (0-(-20))	-6 (0-(-30))	0 ((-10)-0)	-1 ((-20)-0)

Demographic and Clinical Characteristics of patients

Most of the participants were male (60.4%, n=292), and 39.6% were female (n=191). The studies included adult participants with a total mean age of 60.24 ± 6.16 years, comprising both genders. The mean follow-up time was 67.55 months, with a range of 62.7 to 72.4 months. The mean time from HTO to TKA was 140 ± 86.6 months, as reported in two studies. [19,20] At the time of TKA, the mean age of patients in the opening-wedge group was 62.49 years, compared to 62.76 years in the closing-wedge group.

Mobility and Flexibility Outcomes

Ehlinger et al. assessed outcomes related to knee function based on walking ability. At a mean follow-up of 88.9 months (range: 4 to 134 months) for OW-HTO and 84.9 months (range: 2 to 136 months) for CW-HTO, Ehlinger et al. reported improvements in walking abilities. The study revealed that 55.7% of patients were able to walk without assistance, while only 19.1% could walk a distance of more than 1,000 meters. These improvements included increased ability to walk unassisted, walking distances exceeding 1,000 meters, and enhanced frontal knee joint stability.

Moreover, the median knee flexion angle was reported as 110° (range: 70° to 140°). In contrast, Bastos et al. showed that patients undergoing CW-HTO and OW-HTO had a mean flexion of 112.7° ± 16.5°. However, those undergoing OW-HTO achieved a mean flexion of 119.8° ± 14.0°. Furthermore, the HKA angle was reported as 179.7° ± 6.3° and 178.5° ± 6.1° in patients with CW-HTO and OW-HTO, respectively. Regarding limb alignment, two studies found no differences between the groups and reported no significant radiological differences post-TKA.

Knee Function Outcomes

Regarding the preoperative knee function indices, Preston et al. reported mean KSS scores of 90.02 and 89.20 in patients with CW-HTO and OW-HTO, respectively, with no significant difference between the two groups. Similarly, Bastos et al. observed IKS knee scores of 53.6±16.8 for CW-HTO and 56.3 ± 13.6 for OW-HTO, and IKS function scores of 60.5±1.6 for CW-HTO and 59.4 ± 15.1 for OW-HTO. The mean WOMAC scores reported by Preston et al. were 42.5 for CW-HTO and 43.5 for OW-HTO, with no significant difference between the two groups. Moreover, there was no significant difference between the two groups in the mental and physical components of the SF-12 scores, with P-values of 0.87 and 0.86, respectively. Two studies indicated no significant difference regarding KSS and range of motion after TKA between CW-HTO and OW-HTO. The studies also revealed that the 5-year survivorship rates for TKA were equivalent for both CW-HTO and OW-HTO, with no significant difference between the two.

Post-operative complications

Among the included studies, one reported post-operative complications, and one reported intra-operative data following TKA after CW-HTO and OW-HTO. Ehlinger et al., with a mean post-operative interval of 86.7 months, confirmed that early post-operative complications (12.3%) were higher in patients who had OW-HTO compared to CW-HTO (8.3%); however, the difference was not statistically significant. On the other hand, they showed that the most frequent complications, including skin necrosis, followed by joint stiffness, infection, peroneal nerve injury, and posterior tibial nerve injury, were more common in the CW-HTO group (12%) compared to the OW-HTO group (6%), with a P-value<0.05.

Bastos et al. reported intra-operative complications in four cases (2.8%), with no significant difference between OW and CW groups. The complications included medial epicondyle fracture in the OW group and tibial fractures and one lateral collateral ligament laceration in the CW group.

Discussion

Knee OA was reported as the most common joint disorder in the United States in 2010,[23] with different surgical options, including HTO and TKA, often affecting a large number of patients' lifestyles. Eventually, patients may require TKA due to HTO failure, highlighting its role as an interim treatment optionv. For varus gonarthrosis, common surgical options include lateral CW-HTO, OW-HTO, dome osteotomy, or a combination of these techniques.[24,25] Accordingly, this systematic review aimed to evaluate the outcomes of TKA surgery following OW-HTO and CW-HTO.

Through a thorough examination of the three included articles, this study showed that, in general, TKA surgical outcomes were not significantly different between the OW-HTO and CW-HTO groups. Additionally, it appears that TKA was more frequently required in the CW-HTO group. Bastos et al. showed similar improvements in the IKS knee and function scores, patellar height index (Blackburn-Peele index), HKA angle, knee joint extension deficit, and knee joint flexion degrees following both types of HTO in 141 cases after two years of follow-up.[21] Preston et al. reported similar findings, confirming no significant difference between OW-HTO and CW-HTO when examining clinical and functional outcomes. This assessment was based on indices such as SF-12, WOMAC, and IKS scores over a five-year period for 265 cases.[23] In line with the aforementioned studies, Ehlinger et al. found that clinical indices and knee joint function tests, including experiencing occasional pain, unassisted walking, climbing stairs (feeling difficult or impossible), walking more than 1,000 meters, leaving the house alone, mean knee joint extension degrees, and knee joint frontal and sagittal stability, all significantly improved irrespective of the HTO type. However, they found that late complications of TKA (including the need for revision surgery due to loosening, infection, etc.) were higher in patients who had undergone CW-HTO compared to OW-HTO.[22]

Two studies provided intraoperative data.[19,21] Despite differences in the parameters examined, both studies generally reported comparable outcomes. Bastos et al. found that intraoperative variables, including tourniquet time, the need for additional exposure (e.g., tibial tubercle osteotomy and quadriceps snip), femoral valgus cut angle, frequency of lateral release, and lateral epicondyle osteotomy, did not differ between the groups. However, tibial resection thickness and the frequency of medial release were significantly higher in the OW-HTO group.[19]

In contrast, Ehlinger et al. observed that the frequencies of hardware removal, lateral ligament release, stemmed TKA, conventional TKA, and navigated TKA were not significantly different between the groups. However, they reported that one-stage hardware removal and reuse of the primary incision occurred more frequently in the OW-HTO group.[22]

Given the clinical relevance of the intervention and the uncertainty surrounding this clinical question, several systematic reviews have been conducted using different methodological approaches. In agreement with the previous systematic review by Han et al., our findings confirmed that the outcomes of TKA after failed high tibial osteotomy were comparable between patients with prior CW-HTO and those with prior OW-HTO.[18] Despite similar conclusions, only two of the ten studies included by Han et al. simultaneously investigated comparative CW-HTO and OW-HTO arms. Moreover, because of the heterogeneity of clinical findings, a meta-analysis was not conducted. Therefore, their conclusions may have been influenced by studies that focused only on CW-HTO or OW-HTO separately. Similar to the present study, the review by Han et al. was also limited by "somewhat arbitrary" surgical indications for high tibial osteotomy. In addition to these limitations, relatively little research has addressed this clinical question, highlighting the need for further large-scale randomized clinical trials. The limitations of previous evidence, together with newly published clinical research, provide a strong rationale for conducting an updated systematic review to address the identified gaps.[16] Another systematic review was conducted by Cheng et al. in 2019.[26] Although the objective of their study differed from ours, as it focused on changes following OW-HTO and CW-HTO, we referenced their findings to support the comparison of clinical outcomes between the two techniques. Their pooled data reinforced our observation that both osteotomy methods yield comparable functional results, thus providing a useful benchmark despite differences in methodological approaches.

In addition to clinical outcomes, this review revealed that the main complications following TKA included joint stiffness, skin necrosis, and infection. This finding was relatively consistent with that of Erak et al., who reported that the most frequently encountered surgical complications were joint stiffness and subcutaneous hematoma.[27] Similarly, Treuter et al. found two cases of arthrofibrosis following TKA in patients who had previously undergone CW-HTO.[28]

In this systematic review, we evaluated the methodological rigor of each included study. We analyzed key elements, including study design, potential sources of bias, and adherence to predefined inclusion criteria, to assign an appropriate weight to each study. These weights were then incorporated into our decision-making framework, allowing studies with higher methodological quality and broader scope to have a greater influence on the overall conclusions [Please see Supplementary File 1, weighting model].

This review is limited by the available data from the included studies. Further randomized studies with larger sample sizes are needed to draw more accurate conclusions. Moreover, data collection in the included studies would have been more precise if performed consecutively and prospectively. Additionally, no clear medical indications or evidence-based preferences currently exist in the literature regarding the choice of surgical technique, leaving the surgical approach largely dependent on surgeons' experience. This has led to disproportionate study group sizes.

Patients who have previously undergone open-wedge or closing-wedge HTO may require TKA in the future.[29,30] TKA is currently the most effective treatment available and remains the preferred treatment option for late-stage osteoarthritis.[14,31] Although knee osteotomy remains a viable joint-preserving procedure, the use of TKA has continued to increase.[32-34] A meta-analysis could not be conducted because of heterogeneity among the included studies. Future studies using core and standardized indices of clinical and surgical outcomes may provide useful data for potential meta-analyses.

Conclusion

Despite the clinical relevance of OW-HTO and CW-HTO, variations in study design, outcome measures, and patient characteristics precluded data aggregation for quantitative synthesis. As a result, a narrative synthesis of findings from individual studies was provided to concisely present the available evidence comparing OW-HTO and CW-HTO in patients undergoing TKA. This review showed that clinical and radiological outcomes after TKA were not significantly different between patients with prior CW-HTO and those with prior OW-HTO. A meta-analysis could not be conducted because of heterogeneity in the reported data.

List of abbreviations

The abbreviations used in this manuscript are defined in [Table 5].

Table 5. List of abbreviations

Abbreviation	Meaning
TKA	total knee arthroplasty
HTO	high tibial osteotomy
OW	opening wedge
CW	closing wedge
IKS	international knee society
KSS	knee society score
SF-12	short form-12 survey of daily life activities
HKA	hip-knee-ankle
JBI	Joanna Briggs Institute
PROSPERO	international prospective register of systematic reviews
PRISMA	preferred reporting items for systematic reviews and meta-analyses
RCT	randomized clinical trial

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Supplementary file

Table S1. Weight of included studies

Study	Quality Assessment Score	Weight	Percent	Categorization
S. Preston (2014)	8	0.80	80%	High
R. Bastos (2013)	7	0.70	70%	Moderate
M. Ehlinger (2017)	8	0.90	80%	High

1.The complete search strategy

The final search strategy is presented below. This strategy was tailored to each database.

(“Osteotomy”[Mesh] OR “high tibial osteotomy” OR “open wedge high tibial osteotomy” OR “closing wedge high tibial osteotomy” OR “open-wedge high tibial osteotomy” OR “closing-wedge high tibial osteotomy” OR “high tibial osteotom*” OR “osteotom*” OR “wedge” OR “open” OR “close”) AND ("Arthroplasty"[Mesh] OR “Total Knee Arthroplast*” OR “knee arthroplast*” OR “TKA” OR “total knee replacement” OR “knee replacement”)

2.Weighting Model

Table S1. Continued

Given that the JBI tool for case series comprises ten criteria, the total score for each study was divided by 10 and multiplied by 100 to calculate the weight as a percentage. This percentage reflects the relative methodological rigor of each study and informs its contribution to the review's overall conclusions. Studies were then categorized as having high (above 75%), moderate (25–75%), or low (below 25%) methodological weight, ensuring that studies with stronger design and clearer reporting exert a proportionally greater influence in the synthesis of evidence. As presented in **Table** , the study by Ehlinger and Preston et al. demonstrated the highest methodological quality, achieving a score of 9 out of 10, corresponding to a 80% weight and categorized as high quality. Bastos et al. scored 7 respectively, resulting in weights of 70%. While Preston's study was also categorized as high quality, Bastos' study fell within the moderate range. This variation in methodological quality guided the relative influence of each study on the conclusions drawn from our systematic review, allowing for a more nuanced, quality-sensitive synthesis of the evidence.