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Research Article

Correlation between Open Wedge High Tibial Osteotomy and Progression of Patellofemoral Osteoarthritis (A Systematic Review)

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Abstract

Background: Medial open wedge high tibial osteotomy (MOWHTO) is an effective surgical procedure for the treatment of medial compartment osteoarthritis of the knee as well as for the correction of lower extremity misalignment. The main purpose of an OWHTO is to realign the mechanical axis of the leg to offload the medial compartment. With favorable clinical outcomes such as delaying end-stage arthritis, providing pain reduction, and improvement of joint function, MOWHTO has become increasingly popular. However numerous advantages of MOWHTO have been addressed, and it has been reported that MOWHTO would adversely affect the patella-femoral joint. Several studies state that MOWHTO leads to patella Baja and alteration in patellar tracking, as an opening wedge at the transverse osteotomy moves the tibial tuberosity distal to the joint subsequently causing increased patella-femoral contact pressure. The purpose of this systemic review is to evaluate the evidence of the correlation between open wedge high tibial osteotomy and progression of patello-femoral osteoarthritis and whether PF OA progression influences the clinical outcome.

Aim of the Work: The purpose of this systemic review is to evaluate the evidence of the correlation between open wedge high tibial osteotomy and progression of patello-femoral osteoarthritis and whether PF OA progression influences the clinical outcome.

Materials and Methods: This is a systematic review study and meta-analysis on human subjects studied in different works of literature collected from different medical websites up to December 2022 to evaluate the evidence of Correlation between open wedge high tibial osteotomy and progression of patello-femoral osteoarthritis and whether PF OA progression influences the clinical outcome. The study was performed in the Orthopedic Surgery Department, Belhoul European Hospital, Dubai-UAE, during the period from February 2021 to 1st December 2022. The search was conducted by using the databases: JBJS (Journal of bone and joint Surgery), Medline PubMed library, developed by the National Center for Biotechnology Information (NCBI) of the US National Library of Medicine (NLM) (www.ncbi.nlm.nih.gov/PubMed), and in the library of the Cochrane Database (http://www.cochrane.org) as well as Google Scholar search that published before the year 2022. The following keywords: "knee osteoarthritis" [Abstract or Title], "high tibial osteotomy" [Abstract or Title], "open wedge osteotomy" [Abstract or Title], "patellofemoral osteoarthritis" [Abstract or Title].

Results and Conclusion: The results of this study suggest that during MOWHTO, increase in posterior tibial slope after operation; the former is more likely to cause postoperative patella infra than the latter, but its safety is higher than the latter. Clinically, for patients with serious patellofemoral osteoarthritis, MOWHTO can prevent the complication of the patella and be preferred. OWHTO does not affect the results of postoperative complications.

Keywords: Correlation; OWHTO; Patellofemoral Osteoarthritis

Introduction

Medial open wedge high tibial osteotomy (MOWHTO) is an effective surgical procedure for the treatment of medial compartment osteoarthritis of the knee as well as for the correction of lower extremity misalignment [1-3]. The main purpose of an OWHTO is to realign the mechanical axis of the leg to offload the medial compartment [1].

With favorable clinical outcomes such as delaying end-stage arthritis, providing pain reduction, and improvement of joint function, MOWHTO has become increasingly popular [2,3].

However numerous advantages of MOWHTO have been addressed, and it has been reported that MOWHTO would adversely affect the patella-femoral joint. Several studies state that MOWHTO leads to patella Baja and alteration in patellar tracking, as an open-

ing wedge at the transverse osteotomy moves the tibial tuberosity distal to the joint subsequently causing increased patella-femoral contact pressure [4,5].

Varus-valgus alignment was also reported to affect the progression of patello-femoral osteoarthritis in a compartment-specific manner [6].

There is still a debate regarding whether Pattello-Femoral osteoarthritis (PF OA) significantly progresses after conventional OWHTO, some studies reported that OWHTO progress PF OA, whereas other studies found that there is no difference in PF OA between OWHTO and closed wedge high tibial osteotomy (HTO), so it remained unclear whether PF OA progression is associated with poor clinical outcomes after OWHTO, some studies no significant relationship between PF OA progression and poor outcome, other study showed severely affected joint with poor outcomes [7,8].

However, it is difficult to conclude that MOWHTO contributes to the deterioration of the articular cartilage of the patello-femoral joint [6].

In particular, the possibility of the normal progression of pre-existing cartilage lesions could not be ruled out. Focal cartilage lesions of the joints are known to cause stress concentration in the rim of the defect, acting as a leading factor of arthritis [7].

In PTO, the tibial tubercle is attached to the distal tibia fragment by ascending osteotomy of the tibial tubercle; therefore, a gap opening atthe transverse osteotomy induces patella infra and a change in patella tracking. Which, in turn, leads to an increase in the contact pressure and consequent cartilage degeneration in the PF joint [7].

Aim of the Work

The purpose of this systemic review is to evaluate the evidence of the correlation between open wedge high tibial osteotomy and progression of patello-femoral osteoarthritis and whether PF OA progression influences the clinical outcome.

Materials and Methods

This is a systematic review study and meta-analysis on human subjects studied in different works of literature collected from different medical websites up to December 2022 to evaluate the evidence of Correlation between open wedge high tibial osteotomy and progression of patello-femoral osteoarthritis and whether PF OA progression influences the clinical outcome. The study was performed in the Orthopedic Surgery Department, Belhoul European Hospital, Dubai- UAE, during the period from February 2021 to 1st December 2022.

- **Type of the study:** The study represents works of literature using terms high tibial osteotomy, open wedge osteotomy, and knee osteoarthritis in the following electronic databases PubMed, Cochrane, and Google Scholar, regarding the outcome and possible complications. Types of participants: Patients with which high tibial osteotomy, open wedge osteotomy, and knee osteoarthritis.
- **Search strategy:** The search was conducted by using the databases: JBJS (Journal of bone and joint Surgery), Medline PubMed library, developed by the National Center for Biotechnology Information (NCBI) of the US National Library of Medicine (NLM) (www.ncbi.nlm.nih.gov/PubMed), and in the library of the Cochrane Database (http://www.cochrane.org) as well as Google Scholar search that published before the year 2022. The following keywords: "knee osteoarthritis" [Abstract or Title], "high tibial osteotomy" [Abstract or Title], "open wedge osteotomy" [Abstract or Title], "patellofemoral osteoarthritis" [Abstract or Title].
- **Inclusion criteria**: Studies were designed as interventional studies (RCTs or non-RCTs), studies on open wedge high tibial osteotomy and progression of patellofemoral osteoarthritis, studies on open wedge high tibial osteotomy, studies on patella-femoral osteoarthritis, and studies published in English.
- **Exclusion criteria:** Data that couldn't be reliably extracted, cadaver or Model Studies, patients with metastasis or myeloma or congenital deformity or systemic diseases affecting results.

Selection of domains of outcomes to be investigated.

- **Domains also included:** Risk of early complications (myocardial infarction, stroke, venous thromboembolism, or deep infection) or early mortality, reoperation or revision rate, and rate of recovery: rate of return to work, rate of return to sporting activities.

Methods of the review

- **Locating and selecting studies:** Abstracts of articles identified using the above search strategy were viewed, and articles that appear to fulfill the inclusion criteria were retrieved in full, when there is doubt, a second reviewer assessed the article, and a consensus was reached.
- **Quality assessment of the systematic review:** Methodological items for non-randomized studies (MINORS): The items are scored (0): not reported, (1): Reported but inadequate, and (2): Reported and adequate. The global ideal score is 16 for non-comparative studies and 24 for comparative studies.
- **Data extraction:** Data were independently extracted by use of standardized forms by two reviewers and cross-checked, Outcomes from included trials were combined using the systematic review manager software and manually screened for eligibility to be included.

The data recorded included general study characteristics such as the name of the lead investigator and year of publication, recruitment period, the median duration of follow-up, number of participants, and mean age and sex of the participants. Furthermore, the primary outcome measures and adverse event data or complications were extracted. Radiological outcomes of union, malunion, and nonunion were recorded after extraction from each article, then statistically analyzed for comparison between the two techniques.

Administrative design

- **Ethical considerations:** The study was conducted after approval of the protocol by the Local Research Committee and the Studies Committee as well as the Research Ethics Committee of our University.
- **Statistical considerations:** This study was conducted following the MOOSE (meta-analysis of observational studies in epidemiology) and PRISMA (preferred reporting items for systematic reviews and meta-analyses) flowcharts were produced based on the search results and the inclusion/exclusion criteria. We studied the risk of bias for each study using (The Cochrane collaboration tool for assessing the risk of bias).

Evidence of publication bias was sought using the funnel plot method.

A funnel plot is the simplest scatter plot of the intervention effect estimates from individual studies against some measure of each study's size or precision.

Statistical methods

Outcomes from included trials were combined using the systematic review manager software and manually screened for eligibility to be included. Data were collected in an Excel master sheet, coded, entered, and analyzed using EPI-INFO medical statistical package and computer medical software SPSS version 23 (Chicago, Inc. USA).

Outcomes from included trials were combined using the systematic review manager software and manually screened for eligibility to be included. PRISMA flowchart was produced based on the search results and the inclusion/exclusion criteria. To facilitate the assessment of the possible risk of bias for each study, information was collected using the (Cochrane collaboration tool for assessing the risk of bias). After pooling the collected data from the desired search studies, the relative risk of each of the intended outcome measures of interest was calculated and a comparison between the works of literature was estimated.

The phase of analysis of data

Data were presented as Mean ± SD for quantitative variables and number and percentage for qualitative variables. Data were coded, entered, and analyzed by computer software package (version 10). Categorical data were compared using chi-square and calculated. The significance level was considered at P-value <0.05 for ANOVA and the t-student test was used to differentiate between two different variables.

Results

Studies identification and inclusion

Searches conducted in the PubMed, Medline, Embase, and Cochrane Library, yielded a total of 224 articles. After removing duplicates, 113 works of literature have remained. Based on the titles and abstract review, 111 irrelevant articles were excluded. 113 full-text articles were assessed for eligibility. However, 102 articles were excluded based on the previously established exclusion criteria (one biomechanical study without available data). Finally, 11 observational studies were included in this systematic review and meta-analysis. The detail of the selection process is listed in (Figure 1).

Study characteristics

Eleven retrospective studies were assessed in the current review. The included studies were conducted from 2004 to 2022 and involved 7339 patients (332 patients treated with the DTO technique, 407 patients treated with the PTO technique) aged 30.5 to 63.0 years. The average follow-up duration ranged from 1.5 to 48 months. The clinical outcomes of the studies were evaluated mainly based on the postoperative patellar height, postoperative posterior tibial slope (angle), and postoperative complications. The detailed information on included studies is shown in (Table 1).

Methodological assessment of study quality

- **Newcastle-Ottawa Scale:** Methodological quality assessment of the 11 included studies is presented in (Table 2). Among the observational studies, the Newcastle-Ottawa Scale including the exposed cohort, the non-exposed cohort, ascertainment of exposure, the outcome of interest, comparability, assessment of outcome, length of follow-up, and adequacy of follow-up, was used to assess the risk of bias. The scores of all 11 studies were all 6 to 8, indicating a low risk of bias. The risk of bias was assessed using the Newcastle-Ottawa Scale. A higher overall score indicates a lower risk of bias; a score of 5 or less (out of 9) corresponds to a high risk of bias.

Postoperative outcomes

Comparison of postoperative medial OWHTO versus lateral OWHTO

A comparison of postoperative posterior tibial slope between DTO and PTO treatment was conducted among 7 included studies which contain 507 patients in (Figure 2). A heterogeneity test showed that there was none heterogeneity among studies (P =

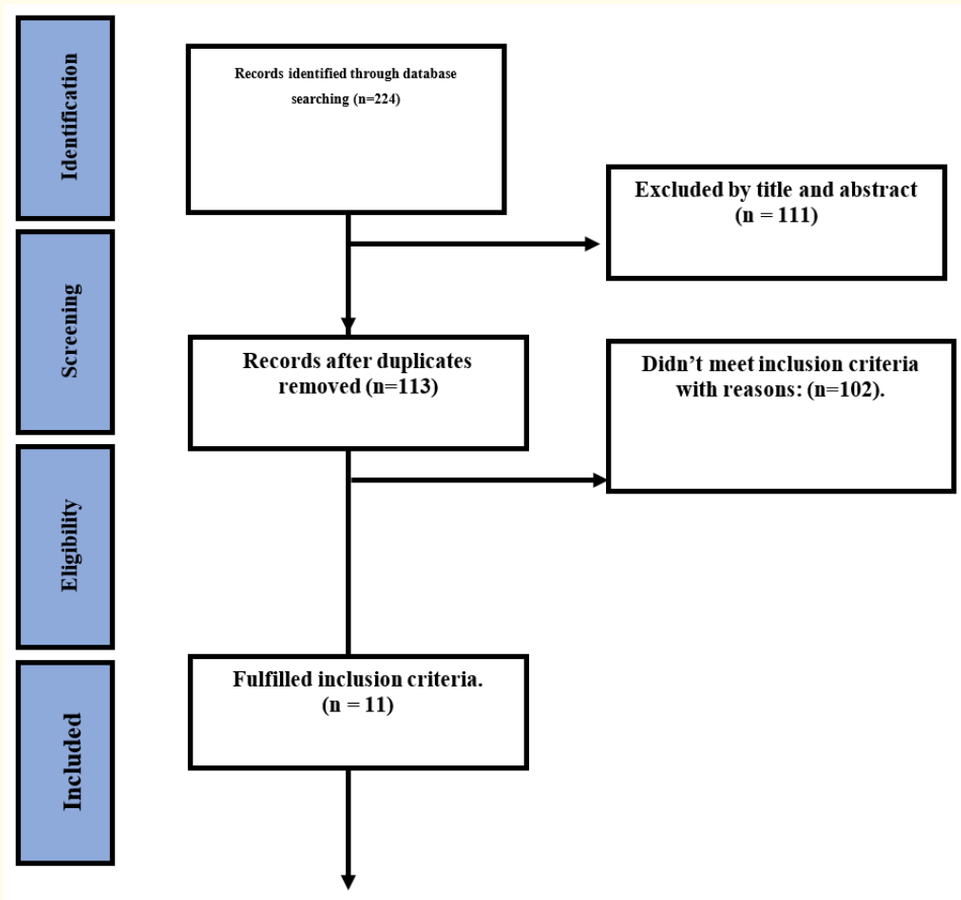

Figure 1: PRISMA diagram for the literature research.

Study	Study design	Sample size (DTO/ PTO)	Mean age(years)	Female (%)	Follow-up (month)	Relevant outcome
Gaasbeek., *et al.* 2004	Retrospective study	17/20	DTO 48 ± 10 PTO 42 ± 11	24.3	1.5	Postoperative patellar height;
Hinterwimmer., *et al.* 2011	Retrospective study	13/12	40.2 ± 8.9	12	NR	Postoperative patellar height; posterior tibial slope
Elmali., *et al.* 2012	Retrospective study	26/21	DTO 55 ± 7 PTO 55 ± 9	78.7	DTO 38 ± 5 PTO 40.6 ± 7	HSS; FTA; postoperative patellar height; posterior tibial slope; postoperative complications
Longino., *et al.* 2013	Retrospective study	29/29	DTO 46 ± 8 PTO 49 ± 6	27.6	DTO 23.1 ± 6.6 PTO 22.7 ± 6.1	Postoperative patellar height; posterior tibial slope
Morsi., *et al.* 2014	Retrospective study	25/25	DTO 48(41-59) PTO 47.7(42-58)	50	DTO 29.1 (12-36) PTO 27.4 (12-34)	Postoperative patellar height; KSS post-operative complication
Gooi., *et al.* 2017	Retrospective study	24/82	48.8 ± 10.8	37.7	NR	Postoperative patellar height; posterior tibial slope
Park., *et al.* 2017	Retrospective study	33/30	DTO 30.5 ± 8.0 PTO 32.8 ± 7.5	66.7	DTO 33.1 ± 2.9 PTO 32.4 ± 8.7	Postoperative patellar height; FTA; posterior tibial slope; postoperative complication
Krause., *et al.* 2017	Retrospective study	32/32	45.2 ± 8.7	37.5	NR	Postoperative patellar height; FTA; posterior tibial slope
Ogawa., *et al.* 2019	Retrospective study	43/41	DTO62.3(40-73) PTO 62.8(48-75)	66.7	DTO 22.2 PTO 33.7	Postoperative patellar height; KSS
Horikawa., *et al.* 2019	Retrospective study	46/65	DTO 62.6 ± 6.2 PTO 63.0 ± 7.1	67.6	12	Postoperative patellar height; FTA; JOA score; posterior tibial slope
Kim., *et al.* 2021	Retrospective study	44/50	DTO 56.83 ± 5.93 PTO 55.88 ± 7.02	66.0	48	Postoperative patellar height; posterior tibial slope; postoperative complications

Table 1: Characteristics of the included studies.

JOA: Japanese Orthopedic Association; KSS: Knee Society Score; HSS: Hospital for Special Surgery Knee Score; Index; FTA: Femur-Tibia Angle; NR: Not Reported

Study	Exposed Cohort	No exposed Cohort	Ascertainment of Exposure	Outcome of Interest	Comparability	Assessment of Outcome	Length of Follow-Up	Adequacy of Follow-Up	Total Score
Gaasbeek., *et al*. 2004 [1]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	7
Hinterwimmer., *et al*. 2011 [2]	Yes	Yes	Yes	Yes	Yes	Yes	-	-	6
Elmali., *et al*. 2012 [3]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8
Longino., *et al*. 2013[4]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8
Morsi., *et al*. 2014 [5]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8
Gooi., *et al*. 2017 [6]	Yes	Yes	Yes	Yes	Yes	Yes			6
Park., *et al*. 2017 [7]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8
Krau se., *et al*. 2018 [8]	Yes	Yes	Yes	Yes	Yes	Yes	-	-	6
Ogawa., *et al*. 2020 [9]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8
Horikawa., *et al*. 2020 [10]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8
Kim., *et al*. 2021 [11]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8

Table 2: Newcastle-Ottawa Scale of observational studies.

0.93, I^2 = 0%), so the fixed-effect model was used. The overall estimate showed that the difference between the two groups was not statistically significant (MD = -0.43, 95%CI = -1.00-0.15, P = 0.14).

Postoperative complications

Comparison of postoperative complications medial OWHTO versus lateral OWHTO for knee osteoarthritis (KOA) In (Figure 3), five included studies consisting of 255 OA patients (130 patients received medial OWHTO and 125 patients received lateral OWHTO technique) reported postoperative complications. Overall, 12 (9.2%) complications under medial OWHTO surgery were reported and 2 (1.6%) complications under lateral OWHTO surgery were reported in 5 included studies. The major complications reported after lateral OWHTO surgery included fracture of the lateral tibial plateau, tibial tuberosity fracture, delayed healing, superficial infection, and lower extremity deep venous thrombosis. No heterogeneity among studies (P = 0.72, I 2 = 0%) was found, so the fixed-effect model was used. The overall estimate indicated that the pooled OR was 3.63 (95%CI = 1.16-11.39, P = 0.03), suggesting that the difference was statistically significant between medial OWHTO intervention and lateral OWHTO intervention.

Sensitivity analysis and publication bias

A sensitivity analysis was performed to assess the stability of the pooled results. Among most studies, the heterogeneity results were not altered after sequentially omitting each study, indicating that the current results were statistically reliable. The funnel plot of the included studies is shown in (Figure 4). The points in the funnel plot were almost symmetrically distributed, and the Egger test P = 0.817 indicates that the publication bias was not apparent.

Figure 2: Forest plot of comparison: postoperative posterior tibial slope between medial OWHTO versus lateral OWHTO for knee osteoarthritis (KOA) for knee osteoarthritis (KOA).

Figure 3: Forest plot of comparison: postoperative complications between medial OWHTO intervention and lateral OWHTO for knee osteoarthritis (KOA).

Figure 4: Funnel plot to test for publication bias. Each point represents a separate study for the indicated association. The vertical line represents the mean effect size. MD = Mean Difference; SE = Standard Error.

Discussion

High tibial osteotomy (HTO) surgery is currently considered suitable for the following patients: (1) young (generally less than 65 years old), with a large amount of activity, and (2) symptomatic single compartment osteoarthritis of the knee joint, with the presence of a bony internal valgus deformity (mainly extra-articular deformity). The deformity angle is less than 20°; (3) the knee joint activity is good, and the flexion activity is ≥ 100 [9].

The principal finding of the current study was that MOWHTO contributes to the progression of osteoarthritis of the patellofemoral joint regardless of the preexisting cartilage status, but this was not considered to be directly associated with clinical outcome. In addition, the clinical outcome of MOWHTO in patients with preexisting cartilage lesions of the patellofemoral joint was not inferior to those with normal cartilage. This study could suggest that the preexisting focal cartilage lesions on the patellofemoral joint, less than ICRS grade 4, would not be a hindrance to performing MOWHTO [10].

MOWHTO has been known to negatively affect the patellofemoral joint as a result of the change of patellar position. Decreased patellar height and an altered patellofemoral alignment increase patellofemoral contact pressure, subsequently increasing the risk of osteoarthritis progression. Several preceding studies performed an arthroscopic assessment of the progression of patellofemoral osteoarthritis resulting from MOWHTO [11].

However, it is difficult to conclude that MOWHTO contributes to the progression of patellofemoral osteoarthritis. The increased contact pressure of the patellofemoral joint may theoretically lead to the progression of osteoarthritis in the affected joint, there are many variables to be considered. The progression of cartilage degeneration might be attributable to normal age-dependent joint degeneration, as noted in preceding studies.

Moreover, preexisting cartilage lesions on the patellofemoral joint, which were frequently encountered during surgery, should be considered. Focal articular cartilage defects have been known to be a predisposing factor for osteoarthritis. To determine whether MOWHTO affects the progression of patellofemoral osteoarthritis, the effect of articular cartilage status of the patellofemoral joint at the time of initial operation on the surgical outcomes should be clarified first [12].

Thus, the authors compared the surgical outcome of the two groups according to the cartilage status of the patellofemoral joint observed in the arthroscopic assessment performed during the initial operation. Although the two groups were classified according to the preexisting cartilage status, the proportion of the degree of

patellofemoral joint osteoarthritis was not different between the two groups [13].

This was observed not only in preoperative comparison but also at the time of the second-look operation. However, osteoarthritis of the patellofemoral joint showed a tendency to progress in both groups, which was consistent with the arthroscopic assessment results. The size of cartilage lesions increased after MOWHTO in both groups, whereas the degree of change over time between the two groups was not different. The severity of cartilage lesions according to the ICRS grading system also seemed to deteriorate in both groups, but, interestingly, it was not statistically significant in the patients with preexisting cartilage lesions. It can be assumed that there was little room for arthritis progression in group 1, compared to group 2.

Summary of Main Results

A previous systematic review and meta-analysis that included 11 studies discussed whether bone grafting is necessary in OWHTO, but 11 included studies were single-arm case series and non-controlled comparative studies.

In this study, we identified Among the observational studies, the Newcastle-Ottawa Scale including the exposed cohort, the non-exposed cohort, ascertainment of exposure, the outcome of interest, comparability, assessment of outcome, length of follow-up and adequacy of follow-up, was used to assess the risk of bias. The scores of all 11 studies were 6 to 8, indicating a low risk of bias.

The risk of bias was assessed using the Newcastle-Ottawa Scale. A higher overall score indicates a lower risk of bias; a score of 5 or less (out of 9) corresponds to a high risk of bias.

As regards the Caton-Deschamps index (CDI) of OWHTO Heterogeneity testing showed that there was no heterogeneity among the studies (P = 0.71, I 2 = 0%), so the fixed effect model was used to pool the data from the 6 studies (MD = 0.05, 95% CI = 0.02-0.07, P = 0.0006).

Regarding the comparison of the Blackburn-Peel index between medial and lateral OWHTO: four included studies consisting of 315 patients investigated BPI. No heterogeneity among studies (P = 0.43, I 2 = 0%) was found, so the fixed-effect model was used to pool the data. The overall estimate showed that the difference was statistically significant for the medial OWHTO group (MD = 0.06, 95% CI = 0.03-0.09, P = 0.0003).

For the postoperative of medial OWHTO versus lateral OWHTO: The postoperative posterior tibial slope between DTO and PTO treatment was conducted among 7 included studies which contain 507 patients in Fig. 4. A heterogeneity test showed that there was no heterogeneity among studies (P = 0.93, I 2 = 0%), so the fixed-effect model was used. The overall estimate showed that the difference between the two groups was not statistically significant (MD = -0.43, 95%CI = -1.00-0.15, P = 0.14).

The postoperative complications medial OWHTO versus lateral OWHTO for knee osteoarthritis (KOA): Five included studies consisting of 255 OA patients (130 patients received medial OWHTO and 125 patients received lateral OWHTO technique) reported postoperative complications.

Overall, 12 (9.2%) complications under medial OWHTO surgery were reported and 2 (1.6%) complications under lateral OWHTO surgery were reported in 5 included studies. The major complications reported after lateral OWHTO surgery included fracture of the lateral tibial plateau, tibial tuberosity fracture, delayed healing, superficial infection, and lower extremity deep venous thrombosis. No heterogeneity among studies (P = 0.72, I 2 = 0%) was found, so the fixed-effect model was used. The overall estimate indicated that the pooled OR was 3.63 (95%CI = 1.16-11.39, P = 0.03), suggesting that the difference was statistically significant between medial OWHTO intervention and lateral OWHTO intervention.

A sensitivity analysis was performed to assess the stability of the pooled results. Among most studies, the heterogeneity results were not altered after sequentially omitting each study, indicating that the current results were statistically reliable. The points in the funnel plot were almost symmetrically distributed, and the Egger test P = 0.817 indicating that the publication bias was not apparent.

Clinical Outcome Assessment

Although the OWHTO technique maintains patellofemoral joint alignment, no difference in clinical outcome was detected. The RT-OWHTO has an increased risk of tuberosity fracture, delayed union, and prominent tibial tuberosity. The surgeon should consider these negative aspects of the technique and consider adjusting additional stabilization [14].

Horikawa T., *et al*, 2020 concluded that medial OWHTO maintained the preoperative patellar height, which could help prevent the progression of cartilage degeneration in the PF joint after surgery. In respect of the biplanar osteotomy direction in OW-HTO, the medial OWHTO is the preferred technique for the treatment of varus knee osteoarthritis to avoid the progression of PF cartilage degradation [15].

Medial OWHTO is associated not only with reduced deterioration but also with increased improvement of cartilage status in the trochlear groove and better KSS as compared with PTO.

Krause M., *et al*, 2018 concluded that Compared to the biplanar ascending medial open-wedge HTO, the descending HTO did not influence patella height or increase the posterior tibial slope. To respect patellofemoral and slope-related knee kinematics, a biplanar

descending medial open-wedge HTO has proven useful to control patella height and posterior tibial slope. These findings underscore the importance of the preoperative patella height assessment in the osteotomy planning and subsequent choice of the biplanar osteotomy direction [16].

Open-wedge high tibial osteotomy can be performed without significant changes in patellar height or posterior tibial slope if specific intraoperative methods are used to prevent their occurrence. Analysis and control of sagittal changes in valgus open-wedge high tibial osteotomy should reduce the incidence of unwanted changes in patellar height and posterior tibial slope [18]. It is a safe technique that can prevent the lowering of the patella following OWHTO, especially in patients who need a major degree of valgus correction for medial compartment osteoarthritis of the knee [19].

Failure and complications

In the present study, failure was defined as construct failure nonunion, and a loss of correction 4° between immediate postoperative and final follow-up radiographic findings. No median loss of correction 4° was reported; additionally, the loss of angular correction has previously been regarded as a critical factor in early failure and nonunion [20].

The overall loss of correction at 2 years in the latter group (2.0°-2.7°) was higher than that in the medial group (0.3°-3.3°). The majority of loss of correction occurred in the first year, without any correlation between the degrees of loss of correction and subject characteristics.

Both the medial and lateral groups demonstrated a progressive loss of correction following 6 months of surgery and a follow-up of >4 years, but the loss was equal in both groups. Following our pooled results, no loss of correction was observed, and no nonunion or delayed clinical bone unions were observed in either group [21].

The lateral tibial cortex was fractured in four cases and two of those presented delayed clinical bone union and loss of correction, suggesting that lateral cortical breach may increase the loss of correction and result in the delayed clinical bone union [22].

Complications in procedures should also be noted. In Porn., *et al.* study, one knee developed a superficial wound infection, and another patient suffered a lateral tibial plateau fracture in the knee after a postoperative fall in the BG group. one knee exhibited screw penetration in the posterolateral portion of the knee joint and the other two knees exhibited local irritation that required the removal of the implanted hardware [24].

In Gassbeek and his collages, five patients exited bone resorption around the metal; five patients had superficial infections; ten patients developed hematomata; and four patients developed deep venous thrombi. In El mali., *et al*. study, the most frequent complication was a hematoma, which occurred in two patients, one patient presented sciatic nerve palsy, and one presented recidivated patellar dislocation 3 months postoperatively [25].

Limitations of the Study: First, the small sample size may have affected the significant difference. Second, based on the results of the funnel plot, it is difficult to rule out publication bias. Also, different fixing plates (Arthrex plate, Puddu plate, and T-plate) were used in the evaluated studies, which may add to clinical heterogeneity. Lastly, the included studies were mostly observational studies and not RCTs, and they largely relied on retrospectively collected data resulting in a high risk of selection bias. Further large-sample, multicenter, high-quality RCTs are warranted to verify the outcomes of this meta-analysis.

Conclusion

The results of this study suggest that MOWHTO, increases posterior tibial slope after operation; the former is more likely to cause postoperative patella infra than the latter, but its safety is higher than the latter. Clinically, for patients with serious patellofemoral osteoarthritis, MOWHTO can prevent the complication of the patella and be preferred. OWHTO does not affect the results of postoperative complications.

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