Clinical Outcomes of Revision Total Knee Arthroplasty after High Tibial Osteotomy and Unicompartmental Knee Arthroplasty: A Systematic Review and Meta-Analysis

Gaobo Shen, MD1,2, Danhong Shen, MD3, Yuan Fang, MD1, Xuefei Li, MD1, Longkang Cui, PhD2, Bing Wei, MD1, Lianguo Wu, PhD2

1The Second Clinical Medical College of Zhejiang Chinese Medical University and 2Department of Orthopaedics, The Second Affiliated Hospital of Zhejiang Chinese Medical University, Hangzhou and 3Nanjing University of Science and Technology, Nanjing, China

As more high tibial osteotomy (HTO) and unicompartmental knee arthroplasty (UKA) are performed, orthopaedic surgeons realize that more HTO and UKA failures will require revision to total knee arthroplasty (TKA) in the future. To systematically evaluate the clinical outcomes of TKA after HTO and TKA after UKA, the Embase, PubMed, Ovid, Web of Science, and Cochrane Library databases were searched for studies investigating revision TKA after HTO and UKA published up to June 2021. RevMan version 5.3 was used to perform the meta-analysis. The revision TKA after HTO and revision TKA after UKA groups were compared in terms of operative time, range of motion (ROM), knee score, postoperative complications, postoperative infection, revision, and revision implants used. Nine studies were ultimately included in the meta-analysis. Results revealed that the knee score for the revision TKA after HTO group was better than that of the revision TKA after UKA group (MD 4.50 [95% CI 0.80–8.20]; p = 0.02). The revision TKA after HTO group had a lower revision rate (OR 0.65 [95% CI 0.55–0.78]; p < 0.00001) and fewer revision implants used (OR 0.11 [95% CI 0.05–0.23]; p < 0.00001). There were no statistical differences in operation time (MD -2.00 [95% CI -11.22 to 7.21]; p = 0.67), ROM (MD -0.04 [95% CI 3.69–3.61]; p = 0.98), postoperative complications (OR 1.41 [95% CI 0.77–2.60]; p = 0.27), or postoperative infections (OR 0.89 [95% CI 0.61–1.29]; p = 0.53). To conclude, the revision rate of revision TKA after UKA was greater, and more revision implants were required. It is important for orthopaedic surgeons to preserve bone during primary UKA.

Key words: High tibial osteotomy; Revision; Total knee arthroplasty; Unicompartmental knee arthroplasty

Introduction

Knee osteoarthritis (KOA) is the most common degenerative disease, and is characterized by cartilage degeneration, destruction, and bone hyperplasia. As aging and living standards increase, the prevalence of KOA has increased significantly. Mainstream surgical methods for the treatment of medial KOA include high tibial osteotomy (HTO) and unicompartmental knee arthroplasty (UKA). Both have been used in practice and have yielded satisfactory efficacy. HTO is more suitable for active younger patients, while UKA is more commonly used for elderly patients due its shorter recovery time and faster functional recovery. HTO relieves load on the medial compartment by transferring the lower limb force line to the unaffected lateral compartment, thus delaying degeneration of the articular cartilage of the medial compartment, while UKA replaces the medial compartment. A retrospective study by Bouguennec et al. concluded that there was no significant difference in 10-year survival rate between HTO and UKA, and good survival rates could be obtained. However, both surgical methods may still need to...
be revised for total knee arthroplasty (TKA) due to progressive osteoarthritis, loosening, and wear of the prosthesis. As the number of HTO and UKA surgeries increase, more HTOs and UKAs will need to be revised to TKA in the future. Lee et al. retrospectively analyzed clinical outcomes and survival rates of revision TKA after HTO or UKA; however, most of the studies mainly reported the outcomes of TKA after HTO or UKA compared with those of primary TKA without HTO or UKA. Prompted by current controversy regarding clinical outcomes and survival rates of HTO and UKA revision to TKA, we performed a meta-analysis to compare the outcomes of revision TKA after HTO and revision TKA after UKA.

**Data and Methods**

**Search Strategy**
The Embase, PubMed, Ovid, Web of Science, and Cochrane Library databases were searched for studies investigating revision TKA after HTO or UKA published up to June 2021. Keywords and medical subject heading (MeSH) terms included the following: high tibial osteotomy, unicompartmental knee arthroplasty, total knee arthroplasty, total knee replacement, HTO, UKA, TKA, and TKR. These keywords and the corresponding MeSH terms were combined with the Boolean operators “AND” and “OR.”

**Eligible Criteria**
Potentially eligible studies were required to fulfill the following criteria: (i) patients diagnosed with KOA requiring revision after HTO or UKA treatment; (ii) case-control and cohort studies published domestically and abroad, with TKA as the final treatment method; (iii) results from conversion TKA after HTO and UKA groups, sample size ≥10, with a mean follow-up of at least 2 years; (iv) and clinical results that could be compared with other studies (e.g. operative duration, ROM, complications, and revision rate). Exclusion criteria were as follows: (i) studies of cadavers or artificial models are excluded, (ii) letters, reviews, editorials, practice guidelines, and other studies with insufficient data are excluded.

**Risk of Bias Assessment**
All articles retrieved in the literature search were screened by two analysts, in accordance with the inclusion criteria, and differences were resolved by discussion with a third analyst. The quality of the retrospective case-control studies was assessed using the Newcastle-Ottawa scale (NOS), which is divided into three components: selection, comparability, and exposure or outcome. The NOS allocates up to four stars for “selection,” up to two stars for “comparability,” and up to four stars for “exposure or outcome,” with one star representing one point and a total score of 10 points. Studies with an NOS score >7 are classified as high-quality, 5–7 as medium-quality, and ≤5 as low-quality.

**Data Extraction**
Data regarding general information and clinical outcomes were extracted from the included studies by two independent analysts. General information included author, year of publication, study design, age, sex ratio, and mean follow-up times. Clinical data included mean operative time, knee ROM, knee function score (Knee Society Score [KSS] and Oxford Knee Score [OKS], etc.), postoperative complications, postoperative infections, revision, and the use of revision implants. All documents and data were analyzed and reviewed by two analysts, and any disagreements were resolved by a third analyst.

**Statistical Analysis**
Data were analyzed using Revman version 5.3 (Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014). The efficacy statistic for dichotomous variables is expressed as odds ratio (OR) and corresponding 95% confidence interval (CI), and mean difference (MD) and 95% CI.
for continuous variables. Tests for heterogeneity were performed using the \( I^2 \) test. When heterogeneity was not statistically significant (\( p > 0.1, I^2 < 50\% \)), the fixed-effect model was used. When heterogeneity was statistically significant (\( p \leq 0.1, I^2 \geq 50\% \)), the source of heterogeneity was analyzed, and the random-effects model was used for analysis. Differences with \( P < 0.05 \) were considered to be statistically significant.

**Results**

**Literature Search Results**
A total of 463 articles were initially retrieved in the literature search, of which 224 were duplicates, while 214 were excluded after screening the titles and abstracts. After reading the full text of 25 articles, nine were ultimately included in the systematic review and meta-analysis\(^7\)\(–\)\(^15\) (Fig. 1). A total of 7328 patients, comprising the HTO-TKA group (\( n = 4031 \)) and the UKA TKA group (\( n = 3297 \)) were included. General information regarding the nine included studies is summarized in Table 1. Two evaluators read the titles, abstracts, or full texts of the articles and strictly performed screening in accordance with the inclusion and exclusion criteria. In the process of extracting data, the two researchers repeated the check and, if there were any discrepancies, a third evaluator was consulted.

**Quality Assessment**
Nine studies, all of which were retrospective in design, fulfilled the inclusion criteria. The NOS was used for evaluation. Three studies scored 8 points, two scored 7, and four scored 6. None of the studies were of low-quality, as shown in Table 2.

**Primary Outcomes**

**Knee Score Scales**
Six studies reported knee scoring scales between revision TKA after HTO and revision TKA after UKA\(^8\)\(–\)\(^10,12\)\(–\)\(^14\). Knee scoring scales included the KSS, Knee Society Function Score (KFS), and OKS. Therefore, subgroup analysis was used to analyze postoperative knee scores of revision TKA after HTO or UKA. There was a statistical difference in heterogeneity among the studies (\( p < 0.00001, I^2 = 96\% \)); as such, the random-effect model was used for meta-analysis. Results

---

**Table 1 Basic information of the included studies**

| Study   | Year | Study design | Comparison       | Number | Age (years) | Female/Male | Outcomes | Follow-up (years) |
|---------|------|--------------|------------------|--------|-------------|-------------|----------|-------------------|
| Jackson | 1994 | CCT          | HTO to TKA       | 20 (21 knee) | 70.5 (53–91) | 15/5 | BDE   | 2.8               |
| Gill    | 1995 | CCT          | HTO to TKA       | 23 (24 knee) | 68 (56–82)   | 17/6 | 3.8               |
| Peerse  | 2012 | CCT          | HTO to TKA       | 27 (30 knee) | 65 (54–80)   | 13/14 | CDF   | >3.8              |
| Cross   | 2014 | CCT          | HTO to TKA       | 27 (30 knee) | 67 (57–87)   | 13/14 |        |                   |
| Lee     | 2015 | CCT          | HTO to TKA       | 711     | 62.4 (34–89) | 201/510 | CEFG  | unclear          |
| Lee     | 2016 | CCT          | HTO to TKA       | 205     | 66.4         | 103/102 |        |                   |
| Lee     | 2017 | CCT          | HTO to TKA       | 205     | 66.4         | 103/102 |        |                   |
| Lee     | 2020 | CCT          | HTO to TKA       | 205     | 66.4         | 103/102 |        |                   |

---

**Table 2 Quality evaluation form of the included retrospective studies**

| Study | Selection | Comparability | Exposure or Outcome | Total score |
|-------|-----------|---------------|---------------------|-------------|
| Jackson | ☆☆☆ | ☆ | ☆☆ | 6 |
| Gill   | ☆☆☆ | ☆ | ☆☆ | 6 |
| Peerse | ☆☆☆ | ☆ | ☆☆ | 6 |
| Cross  | ☆☆☆ | ☆ | ☆☆ | 6 |
| Robertson | ☆☆☆ | ☆ | ☆☆ | 6 |
| Pailhe | ☆☆☆ | ☆ | ☆☆ | 6 |
| Lim    | ☆☆☆ | ☆ | ☆☆ | 6 |
| El-Galah | ☆☆☆ | ☆ | ☆☆ | 6 |
| Lee    | ☆☆☆ | ☆ | ☆☆ | 6 |

Note: The quality of the studies was assessed using the Newcastle-Ottawa scale (NOS), and one star represents one point.
revealed that the knee score of the HTO-TKA group was better than that of the UKA-TKA group (MD 4.50 [95% CI 0.80–8.20]; \( p = 0.02 \)) (Fig. 2). Subgroup analysis indicated that the KFS score in the HTO-TKA group was significantly better than that in the UKA-TKA group, with a statistically significant difference (MD 7.41 [95% CI 3.09–11.73]; \( p = 0.0008 \)).

**Postoperative Complications**

Seven studies addressed postoperative complication rate of revision TKA after HTO and reversion TKA after UKA.\(^7^8^9^1^0^1^2^1^3^1^4^1^5\). Heterogeneity among the studies was statistically significant (\( p = 0.03, I^2 = 57\% \)); as such, the random-effect model was used for meta-analysis. Results indicated no statistical difference in the incidence of postoperative...
complications between the HTO-TKA and the UKA-TKA groups (OR 1.41 [95% CI 0.77–2.60]; p = 0.27) (Fig. 3).

**Revision**

Seven studies investigated the revision rate between revision TKA after HTO and reversion TKA after UKA. There was no statistical difference in heterogeneity among the studies (p = 0.15, I² = 37%), and the fixed-effect model was used for meta-analysis. Results indicated that the revision rate for the HTO-TKA group was significantly lower than that of the UKA-TKA group (OR 0.65 [95% CI 0.54–0.78]; p < 0.00001) (Fig. 4).

### Secondary Outcomes

**Operation Time (min)**

Among the four studies for which operative time of revision TKA after HTO and revision TKA after UKA were
compared 10,12–14, there was a statistical difference in heterogeneity ($p < 0.00001$, $I^2 = 91\%$); as such, the random-effect model was used for meta-analysis. Heterogeneity was attributed to one of the articles, and a subgroup analysis was performed. Results revealed that there was no significant difference in operative duration between the HTO-TKA and UKA-TKA groups ($MD = -2.00$ [95% CI $-11.22$ to $7.21$]; $p = 0.67$). Except for the study by Cross et al., the operative duration of the HTO-TKA group was significantly shorter than that of the UKA-TKA group ($MD = -9.15$ [95% CI $-11.97$ to $-6.33$]; $p < 0.00001$) (Fig. 5). The article by Cross et al. did not describe specific surgical procedures; as such, it was inferred that operative duration may have been affected by the surgeon’s skills.

**Range of Motion**

Three studies compared the ROM between revision TKA after HTO and revision TKA after UKA 7,10,12, and there was no statistical difference in heterogeneity among the studies ($p = 0.46$, $I^2 = 0\%$). Therefore, the fixed-effect model was used for meta-analysis. Results revealed no statistical difference in ROM between the HTO-TKA and UKA-TKA groups ($MD = -0.04$ [95% CI $-3.69$ to $3.61$]; $p = 0.98$) (Fig. 6).

**Postoperative Infections**

Six studies investigated the postoperative infection rate of revision TKA after HTO and revision TKA after UKA 7,9,10,12,13,15. Because some studies did not distinguish between superficial and deep infections, this distinction was disregarded in the present analysis. There was no statistical difference in heterogeneity among the studies ($p = 0.22$, $I^2 = 28\%$), and the fixed-effect model was used for meta-analysis. Results revealed no statistical difference in the incidence of postoperative infections between the HTO-TKA and UKA-TKA groups (OR $0.89$ [95% CI $0.61$–$1.29$]; $p = 0.53$) (Fig. 7).

**Revision Implants Used**

Five studies compared the use of revision implants between revision TKA after HTO and revision TKA after UKA 9–11,13,14. There was no statistical difference in the heterogeneity among the studies ($p < 0.00001$, $I^2 = 90\%$), and the random-effect model was used for meta-analysis. Results indicated that the utilization rate of revision implants in the HTO-TKA group was significantly lower than that in the UKA-TKA group (OR $0.11$ [95% CI $0.05$–$0.23$]; $p < 0.00001$) (Fig. 8).
Bias Analysis
The funnel plots were used to detect publication bias in the clinical outcomes of the included studies. The funnel plot for revision rate (Fig. 9A) was symmetric with all studies included, indicating no publication bias. However, funnel plots for postoperative complications (Fig. 9B) and infections (Fig. 9C) were asymmetric, and some studies were not included, indicating the presence of publication bias.

Discussion
The present study was a systematic review and meta-analysis of clinical outcomes of revision TKA after HTO and revision TKA after UKA. Nine retrospective studies, including a total of 7328 patients, were included. Existing clinical evidence reveals that the Knee Society Function Score of the HTO-TKA group was better than that of the UKA-TKA group. The HTO-TKA group demonstrated a lower revision rate and required fewer revision implants. Most studies reported that the operative duration of the UKA-TKA group was longer than that of the HTO-TKA group, which is consistent with higher surgical complexity and the need to use complex revision implants. There was no significant difference in ROM, postoperative complications, and incidence of postoperative infections between the two groups. A study by Pailhe \(^{12}\) compared clinical outcomes of computer-assisted TKA after HTO and UKA without considering revision rates. In the present study, we found that the UKA-TKA and HTO-TKA groups appeared to experience fewer postoperative complications and demonstrated better knee function scores. Currently, it is acknowledged that computer-assisted TKA can reduce operative duration, improve radiographic alignment, and possibly improve knee function, although it may have little impact on long-term survival rates \(^{16,17}\). However, few studies have compared computer-assisted and traditional revision TKA, which may have influenced our results.

Fig. 9 (A) Funnel plot of revision between the two groups. (B) Funnel plot of postoperative complications between the two groups. (C) Funnel plot of postoperative infections between the two groups.
Revision Factors of HTO and UKA

The surgical indication for HTO and UKA is unicompartmental osteoarthritis. HTO is especially recommended for younger patients with high mobility needs, while UKA is recommended for patients with lesser mobility needs. Studies have shown that HTO yields good clinical outcomes and survival rates; however, the symptoms of osteoarthritis will gradually worsen with the progression of the disease. According to literature reports, the 10-year survival rate of HTO is approximately 75%–96%, with a 15-year survival of 55% to 92%. The number of UKA applications in clinical practice is increasing annually. A systematic analysis of survival rate for UKA, including 26 studies, reported 5- and 10-year survival rates of 95% and 91%, respectively. The reasons for revision include aseptic loosening of the prosthesis, periprosthetic fractures, wear of the prosthesis, progression of osteoarthritis, and infection. All studies included in our analysis excluded the revision of HTO and UKA to TKA due to infection. Although both HTO and UKA yield good survival rates, a considerable proportion need to be revised for TKA. With the increasing number of HTO and UKA surgeries, the number of TKAs that eventually need to be revised has also increased.

Survival Rates of Revision HTO and UKA

Presently, controversy persists as to whether previous HTO affects the outcomes and survival rate of TKA. Some scholars believe that previous HTO does not affect the function and survival rate of TKA. Badawy et al. used data from the Norwegian Arthroplasty Register to compare revision TKA after HTO and initial TKA. The 10-year survival rate was 92.6% in the TKA after HTO group and 93.8% in the primary TKA group, with no significant difference in survival rate. A systematic analysis by Chen suggested that, compared with primary TKA, TKA after HTO has greater complication and revision rates, and greater surgical complexity. Currently, the clinical application of UKA is increasing. It is generally believed that UKA is more minimally invasive and has fewer early complications; however, it may have a higher revision rate than TKA. Many scholars believe that UKA is a preoperative strategy that can delay the time to final TKA. In this regard, some researchers believe that the revision of UKA to TKA has worse clinical outcomes and a higher revision rate than primary TKA. This revision surgery is more complicated and requires greater surgical skill. However, Lombardi et al. found that the revision rate of UKA to TKA was similar to that of primary TKA. Similar to revision TKA after HTO, revision TKA after UKA is also controversial.

Challenge

We found that the revision rate of TKA after UKA was higher than that after TKA after HTO, and more revision implants were required during revision surgery. Challenges in revision HTO include the unclear anatomy of the proximal tibia, difficult surgical approaches, and the need to balance ligaments. The challenges of revision UKA is high bone loss, which may be related to aseptic loosening and excessive osteotomy during UKA. Lewis et al. used the Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR) database to analyze the survival rate of implants after revision of UKA to TKA and found that when a tibial extension stem was used, the risk for repeat revision was lower. Orthopaedic surgeons should be aware that revising UKA to TKA may require the use of revision implants, and that intraoperative management of bone loss should be a top priority.

Conclusion

Results of the present analysis demonstrated that revision TKA after HTO had a lower revision rate than revision TKA after UKA, the use of revision implants was lower, and the Knee Society Function Score was better. However, there were no significant differences in ROM, postoperative complications, and postoperative infection rates. Although previous UKA has a higher revision rate compared with HTO, the indications for HTO and UKA are not entirely the same. It also takes into account the benefits of delaying ultimate TKA, and both HTO and UKA have excellent survival rates; as such, it cannot be inferred from this which is better or worse. It should be considered in the initial UKA that it may eventually need to be revised to TKA, and bone should be preserved as much as possible during the operation.

The present study had some limitations, the first of which was that all nine included studies were all retrospective in design; moreover, two were not novel, and one investigated computer-assisted revision TKA. Orthopaedic surgeons have different clinical experience, surgical skills, and follow-up times, which will also contribute to greater heterogeneity. The included studies did not distinguish between the medial opening-wedge and the lateral closed-wedge HTO, and the UKA did not distinguish between cemented and uncemented components, and fixed and mobile bearings. In the future, it will be necessary to conduct larger-scale and multi-center studies to draw more reliable conclusions.

Acknowledgement

The study was supported by a grant from the Zhejiang Provincial Administration of Traditional Chinese Medicine.

Authorship declaration

All authors listed meet the authorship criteria according to the latest guidelines of the International Committee of Medical Journal Editors and all authors have approved the manuscript and agree with submission to Orthopaedic Surgery.
1. Kolasiński SL, Neogi T, Hochberg MC, Qato D, Guyatt G, Block J, et al. 2019 American College of Rheumatology/Arthritis Foundation guideline for the Management of Osteoarthritis of the hand, hip, and knee. Arthritis Rheumatol. 2020;72:220–33.

2. Vina ER, Kwoh CK. Epidemiology of osteoarthritis: literature update. Curr Opin Rheumatol. 2018;30:160–7.

3. Cao Z, Mai X, Wang J, Feng E, Huang Y. Unicompartmental knee arthroplasty vs high Tibial osteotomy for knee osteoarthritis: a systematic review and meta-analysis. J Arthroplasty. 2018;33:962–9.

4. Santos MB, Wu L. Unicompartmental knee arthroplasty, is it superior to high tibial osteotomy in treating unicompartmental osteoarthritis? A meta-analysis and systemic review. J Orthop Surg Res. 2017;12:50.

5. Bouguennec N, Mergenthaler G, Gicquel T, Bryand C, Nadau E, Pailhé R, et al. Medium-term survival and clinical and radiological results in high tibial osteotomy: factors for failure and comparison with unicompartmental arthroplasty. Orthop Traumatol Surg Res. 2020;106:5223–30.

6. Lee YS, Kim HJ, Mok SJ, Lee OS. Comparison of outcome following primary proximal tibial osteotomy or unicompartmental arthroplasty. J Arthroplasty. 1994;9:539–42.

7. Gill T, Schemitsch EH, Brick GW, Thomlll TS. Revision total knee arthroplasty after failed unicompartmental knee arthroplasty or high tibial osteotomy. Clin Orthop Relat Res. 1995;321:10–8.

8. Pearson AJ, Hooper GJ, Rothwell AG, Frampton C. Osteotomy and unicompartmental knee arthroplasty converted to total knee arthroplasty: data from the New Zealand joint registry. J Arthroplasty. 2012;27:1829–34.

9. Cross MB, Yi PY, Moric M, Sporer SM, Berger RA, Della Valle CJ. Revising an HTO or UKA to TKA: is it more like a primary TKA or a revision TKA? J Arthroplasty. 2014;29:229–31.

10. Robertson O, W-Dahl A. The risk of revision after TKA is affected by previous high tibial osteotomy and unicompartmental knee arthroplasty. J Knee Surg. 2019;32:686–700.

11. Jackson M, Sarrangili PP, Newman JH. Revision total knee arthroplasty: a comparative study of computer-assisted total knee arthroplasty after high tibial osteotomy and unicompartmental knee arthroplasty; a meta-analysis. J Knee Surg. 2013;26:112–23.

12. Cao Z, Mai X, Wang J, Feng E, Huang Y. Unicompartmental knee arthroplasty vs high Tibial osteotomy for knee osteoarthritis: a propensity-score weighted mid-term cohort study. Bone Joint J. 2020;102-B:220–7.

13. Lin JBT, Chong HC, Pang LN, Tay KD, Chia SL, Lo NN, et al. Revision total knee arthroplasty for failed high tibial osteotomy and unicompartmental knee arthroplasty have similar patient-reported outcome measures in a two-year follow-up study. Bone Joint J. 2017;99-B:1329–34.

14. El-Galaly A, Nielsen PT, Kappel A, Jensen SL. Reduced survival of total knee arthroplasty after previous unicompartmental knee arthroplasty compared with previous high tibial osteotomy: a propensity-score weighted mid-term cohort study based on 2,133 observations from the Danish knee arthroplasty registry. Acta Orthop. 2020;91:177–83.

15. Lee SH, Seo HY, Lim JH, Kim MG, Seon JK. Higher survival rate in total knee arthroplasty after high tibial osteotomy than that after unicompartmental knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2021. https://doi.org/10.1007/s00167-021-06641-5.

16. Atto P, Zara A, Notarfrancesco D, Maffulli N. Computer assisted total knee arthroplasty: 2.5 years follow-up of 200 cases. Surgery. 2011;149:394–401.

17. Antonios JK, Kang HP, Robertson D, Oakes DA, Lieberman JR, Heckmann ND. Population-based survivorship of computer-navigated versus conventional Total knee arthroplasty. J Am Acad Orthop Surg. 2020;28:857–64.

18. van Wulffen-Palthe AFY, Clement ND, Temmerman OPP, Burgi BJ. Survival and functional outcome of high tibial osteotomy for medial knee osteoarthritis: a 10-20-year cohort study. Eur J Orthop Surg Traumatol. 2018;28:1381–9.

19. Sasaki E, Akimoto H, Ito K, Fujita Y, Saruga T, Kakizaki H, et al. Long-term survival rate of closing wedge high tibial osteotomy with high valgus correction: a 15-year follow-up study. Knee Surg Sports Traumatol Arthrosc. 2021;29:3221–8.

20. Heaps BM, Blevins JL, Chiu YF, Konopka JF, Patel SP, McLawhorn AS. Improving estimates of annual survival rates for medial unicompartmental knee arthroplasty, a meta-analysis. J Arthroplasty. 2019;34:1538–45.

21. Rodriguez-Merchan EC. Does a previous high Tibial osteotomy (HTO) influence the long-term function or survival of a Total knee arthroplasty (TKA)? Arch Bone Joint Surg. 2018;6:19–22.

22. Niinimäki T, Eskelinen A, Ohtonen P, Puhto AP, Mann BS, Leppilahki J. Total knee arthroplasty after high tibial osteotomy: a registry-based case-control study of 1,036 knees. Arch Orthop Trauma Surg. 2014;134:73–7.

23. Badawy M, Fenstad AM, Indrekvam K, Havelin LI, Furnes O. The risk of revision in total knee arthroplasty is not affected by previous high tibial osteotomy. Acta Orthop. 2015;86:734–9.

24. Chen X, Yang Z, Li H, Zhu S, Wang Y, Qian W. Higher risk of revision in total knee arthroplasty after high tibial osteotomy: a systematic review and updated meta-analysis. BMC Musculoskelet Disord. 2020;21:153.

25. Ode Q, Gaillard R, Batailler C, Herry Y, Neyret P, Servien E, et al. Fewer complications after UKA than TKA in patients over 85 years of age: a case-control study. Orthop Traumatol Surg Res. 2018;104:955–9.

26. Murray DW, Parkinson RW. Usage of unicompartmental knee arthroplasty. Bone Joint J 2018;100-B:432–5.

27. Craik JD, El Shaifee K, Singh VK, Twyman RS. Revision of unicompartmental knee arthroplasty versus primary total knee arthroplasty. J Arthroplasty. 2015;30:592–4.

28. Sun X, Su Z. A meta-analysis of unicompartmental knee arthroplasty revised to total knee arthroplasty versus primary total knee arthroplasty. J Orthop Surg Res. 2018;13:158.

29. Lombardi AV Jr, Kolich MT, Berend KR, Morris MJ, Crawford DA, Adams JB. Revision of Unicompartmental knee arthroplasty to Total knee arthroplasty: is it as good as a primary result? J Arthroplasty. 2018;33:S105–9.

30. Lo Presti M, Costa GG, Grassi A, Agro G, Cialdiella S, Vascio C, et al. Bearing thickness of unicompartmental knee arthroplasty is a reliable predictor of tibial bone loss during revision to total knee arthroplasty. Orthop Traumatol Surg Res. 2020;106:429–34.

31. Lewis PL, Davidson DC, Graves SE, de Steiger RN, Donnelly W, Cuthbert A. Unicompartmental knee arthroplasty revision to TKA: are Tibial stems and augments associated with improved survivorship? Clin Orthop Relat Res. 2018;476:854–62.