European Journal of Clinical Pharmacy

Print ISSN: 2385-409X **Online ISSN**: 3105-0409
Website: https://farmclin.com/

Original Research Article

Long-Term Outcomes After Conversion of High Tibial Osteotomy to Total Knee Arthroplasty

Article History:

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Received: 29-12-2025
Revised: 14-12-2025
Accepted: 23-12-2025
Published: 26-12-2025

Abstract: *Background*: High tibial osteotomy (HTO) is commonly performed as a joint-preserving procedure in younger patients with unicompartmental knee osteoarthritis; however, progression of disease often necessitates conversion to total knee arthroplasty (TKA). Objective: To evaluate long-term functional, radiographic, and implant survival outcomes following conversion of high tibial osteotomy to total knee arthroplasty. Methods: This was a descriptive, retrospective cohort study conducted at Bacha khan medical complex Swabi from June 2024 to June 2025 including 105 patients who underwent conversion of high tibial osteotomy (HTO) to total knee arthroplasty (TKA). The study was designed to evaluate long-term functional outcomes, implant survival, and complication rates following conversion TKA. Results: The mean age at conversion TKA was 58.9 ± 7.6 years, with a mean interval of 9.4 ± 3.1 years between HTO and TKA. Operative time averaged 128.6 ± 22.4 minutes and increased significantly in cases requiring hardware removal. Functional outcomes improved markedly, with the Knee Society Knee Score increasing from 46.8 ± 9.7 preoperatively to 86.2 ± 8.4 at final follow-up, and WOMAC scores decreasing from 62.4 ± 11.6 to 18.9 ± 7.3. Mean range of motion improved by approximately 20 degrees. Radiographic loosening was observed in 4.8% of patients, and revision surgery was required in 7.6% at a mean of 6.1 ± 1.9 years. Implant survival at 10 years was 92.4%. Conclusion: It is concluded that conversion of high tibial osteotomy to total knee arthroplasty results in significant functional improvement and satisfactory long-term implant survival.

Keywords High tibial osteotomy, total knee arthroplasty, conversion knee arthroplasty, long-term outcomes, implant survival.

INTRODUCTION

High tibial osteotomy (HTO) is a long-established joint-preserving surgery procedure usually done on younger and active patients with unicompartmental knee osteoarthritis, especially of the medial compartment [1][2]. HTO targets the offloading of the

diseased compartment, pain relief, and postponement of the necessity of total knee arthroplasty (TKA) by preparing the mechanical axis of the lower limb in a different way (to offload the diseased compartment) [3]. Although osteoarthritis was shown to progress well in short to mid-term results, osteoarthritis progression with time frequently results in HTO failure and subsequent conversion to TKA is inevitable [4]. The transformation of HTO to TKA has both technical and clinical peculiarities with regard to primary TKA. Surgical exposure and component positioning may be complicated by altered anatomy, prior surgical scars and retained hardware, bone loss, ligament imbalance and tibial slope change [5][6]. These reasons cause concern with regards to the alignment of implants, stability, surgery duration, blood loss, and outcome of the conversion TKA over time [7]. As the number of HTO procedures being conducted worldwide, the number of patients who need the conversion to TKA also is constantly increasing [8]. This has made it more critical to learn long-term effects of conversion TKA

policies to both the surgeons and patients. Although primary TKA has been known to offer great pain relief and functional improvement, the question of whether the same can be consistently obtained in the aftermath of previous HTO has remained unclear [9].
Previous researches have given mixed findings on the outcomes of functional performances as well as implant survival following conversion of HTO to TKA. Others have indicated poorer results and increased complication rates over primary TKA, and some others have shown similar results with careful surgical practice applied [10][11]. The nature of the first osteotomy, time delay between HTO and TKA, and whether stemmed or constrained implantation is required have been mentioned as some of the most important outcomes predictors [12]. Follow-up is especially relevant in the long-term follow-up in this patient group since conversion TKA is commonly applied to relatively younger patients with greater functional requirements. The comparison of the

survival rates, revision rates and the long-term functional improvement of the implants offers a good understanding of the long-term durability of conversion TKA [13].

Objective

To evaluate long-term functional, radiographic, and implant survival outcomes following conversion of high tibial osteotomy to total knee arthroplasty.

METHODOLOGY

This was a descriptive, retrospective cohort study conducted at Bacha khan medical complex Swabi from June 2024 to June 2025, including 105 patients who underwent conversion of high tibial osteotomy (HTO) to total knee arthroplasty (TKA). Patients over the age of 40 who had undergone either a medial opening-wedge or a closing-wedge high tibial osteotomy and were later converted to primary total knee arthroplasty were included in the study. Eligible patients included those who had undergone conversion TKA for at least five years and had complete clinical and radiographic records. Patients were excluded if they underwent uni-compartmental knee arthroplasty following their osteotomy, had inflammatory or post-infectious arthritis, or had any history of revision knee arthroplasty. Those with a documented periprosthetic joint infection before the conversion procedure or with incomplete follow-up or missing outcome data were also excluded from the study.

Data Collection

Data were collected using a structured proforma. Age, gender, body mass index, and side involved were demographic variables. The type of osteotomy, the length of time between the HTO and the conversion TKA, and the presence of retained hardware were all aspects of the index HTO. The surgical approach, need for hardware removal, implant type, utilization of stemmed components, operating time, and intraoperative blood loss were all operational variables for conversion TKA. At the conclusion of the follow-up period, range of motion measurements, the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and the Knee Society Score (KSS) were used to evaluate the clinical outcomes. Radiographic outcomes included component alignment, presence of radiolucent lines, and signs of loosening. Complications such as infection, stiffness, instability, aseptic loosening, and need for revision surgery were recorded.

Statistical Analysis

Data were analyzed using SPSS version 24.0. Quantitative variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Pre- and post-operative functional scores were compared using paired t-tests. Implant survival was analyzed using Kaplan–Meier survival analysis, with revision surgery as the endpoint. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS

A total of 105 patients were included, with a mean age of 58.9 ± 7.6 years. Patients who had previously undergone opening wedge HTO were slightly younger (57.8 ± 7.2 years) than those with closing wedge HTO (60.6 ± 7.9 years). Males constituted 63.8% of the cohort. The mean body mass index was 27.6 ± 4.3 kg/m², with a higher BMI

observed in the closing wedge group (28.7 ± 4.4 kg/m²) compared to the opening wedge group (26.9 ± 4.1 kg/m²). The mean interval between HTO and conversion TKA was 9.4 ± 3.1 years, and preoperative varus deformity averaged 6.8 ± 2.5 degrees. Retained hardware was present in 68.6% of patients. Preoperative knee function was poor, with a mean Knee Society Score of 46.8 ± 9.7, reflecting advanced symptomatic disease at the time of conversion.

Table 1. Baseline Demographic and Preoperative Characteristics (n = 105)

Variable	Overall	Opening Wedge HTO	Closing Wedge HTO
Age at conversion TKA (years), mean ± SD	58.9 ± 7.6	57.8 ± 7.2	60.6 ± 7.9
Male gender, n (%)	67 (63.8%)	41 (64.1%)	26 (63.4%)
Female gender, n (%)	38 (36.2%)	23 (35.9%)	15 (36.6%)
Body mass index (kg/m²), mean ± SD	27.6 ± 4.3	26.9 ± 4.1	28.7 ± 4.4
Interval HTO → TKA (years), mean ± SD	9.4 ± 3.1	8.7 ± 2.9	10.6 ± 3.3
Preoperative varus deformity (degrees), mean ± SD	6.8 ± 2.5	6.4 ± 2.3	7.4 ± 2.7
Retained hardware present, n (%)	72 (68.6%)	46 (71.9%)	26 (63.4%)
Pre-op Knee Society Score, mean ± SD	46.8 ± 9.7	48.1 ± 9.2	44.9 ± 10.3

The overall mean operative time was 128.6 ± 22.4 minutes, increasing to 142.3 ± 20.7 minutes in patients who required hardware removal compared to 103.8 ± 18.9 minutes in those without. Mean intraoperative blood loss was 462 ± 118 mL, rising to 512 ± 121 mL when hardware removal was performed. Tourniquet time followed a similar pattern, averaging 92.3 ± 18.6 minutes overall. Stemmed tibial components were used in 37.1% of cases, and constrained implants in 17.1%, reflecting the need for additional stability.

Table 2. Intraoperative Characteristics of Conversion TKA (n = 105)

Variable	Overall	With Hardware Removal	Without Hardware Removal
Operative time (minutes), mean ± SD	128.6 ± 22.4	142.3 ± 20.7	103.8 ± 18.9
Blood loss (mL), mean ± SD	462 ± 118	512 ± 121	349 ± 97
Tourniquet time (minutes), mean ± SD	92.3 ± 18.6	101.4 ± 17.2	74.6 ± 15.9
Stemmed tibial component, n (%)	39 (37.1%)	32 (41.0%)	7 (26.9%)
Constrained implant used, n (%)	18 (17.1%)	14 (17.9%)	4 (15.4%)
Medial soft-tissue release, n (%)	66 (62.9%)	44 (56.4%)	22 (84.6%)
Patellar resurfacing, n (%)	81 (77.1%)	63 (80.8%)	18 (69.2%)

The Knee Society Knee Score increased from 46.8 ± 9.7 preoperatively to 86.2 ± 8.4 at final follow-up, representing

a mean improvement of 39.4 points. The Knee Society Function Score improved from 49.5 ± 10.2 to 82.9 ± 9.1, while the WOMAC total score decreased from 62.4 ± 11.6 to 18.9 ± 7.3, indicating substantial pain relief and functional recovery. Range of motion improved from 98.6 ± 14.9 degreespreoperatively to 118.4 ± 11.7 degrees, with 63.8% of patients achieving flexion of at least 120 degrees. Patient satisfaction scores also improved significantly, increasing from 3.4 ± 1.2 to 8.2 ± 1.1.

Table 3. Functional Outcomes at Final Follow-up (n = 105)

Outcome Measure	Preoperative Mean ± SD	Final Follow-up Mean ± SD	Mean Improvement
KSS – Knee Score	46.8 ± 9.7	86.2 ± 8.4	+39.4
KSS – Function Score	49.5 ± 10.2	82.9 ± 9.1	+33.4
WOMAC total score	62.4 ± 11.6	18.9 ± 7.3	−43.5
Range of motion (degrees)	98.6 ± 14.9	118.4 ± 11.7	+19.8
Patients achieving ROM ≥120°, n (%)	18 (17.1%)	67 (63.8%)	+46.7%
Patient satisfaction score (0–10)	3.4 ± 1.2	8.2 ± 1.1	+4.8

The mean mechanical axis alignment was 1.8 ± 2.3 degrees, indicating near-neutral alignment. Tibial and femoral component alignments averaged 89.4 ± 2.1 degrees and 90.6 ± 1.9 degrees, respectively. Radiolucent lines were observed in 13.3%of patients, with progressive radiolucency in 5.7% and radiographic loosening in 4.8%. Loosening was less frequent in patients with stemmed implants (2.6%) compared to non-stemmed implants (6.1%), suggesting a stabilizing effect of stemmed components in selected cases.

Table 4. Radiographic Outcomes at Final Follow-up (n = 105)

Parameter	Overall	Stemmed Implant	Non-stemmed Implant
Mechanical axis alignment (degrees), mean ± SD	1.8 ± 2.3	1.6 ± 2.1	2.0 ± 2.4
Tibial component alignment (degrees), mean ± SD	89.4 ± 2.1	89.1 ± 2.0	89.7 ± 2.2
Femoral component alignment (degrees), mean ± SD	90.6 ± 1.9	90.4 ± 1.8	90.8 ± 2.0
Radiolucent lines present, n (%)	14 (13.3%)	4 (10.3%)	10 (15.2%)

Progressive radiolucency, n (%)	6 (5.7%)	2 (5.1%)	4 (6.1%)
Radiographic loosening, n (%)	5 (4.8%)	1 (2.6%)	4 (6.1%)

Superficial infection occurred in 5.7% of patients, while deep periprosthetic infection was observed in 2.9%. Postoperative stiffness and instability were noted in 8.6% and 6.7% of patients, respectively. Aseptic loosening occurred in 4.8%, with higher rates beyond 10 years of follow-up (10.7%). Revision surgery was required in 7.6% of patients at a mean of 6.1 ± 1.9 years after conversion.

Table 5. Complications, Revisions, and Implant Survival (n = 105)

Outcome	Overall	≤10 Years Follow-up	>10 Years Follow-up
Superficial infection, n (%)	6 (5.7%)	4 (4.9%)	2 (7.1%)
Deep infection, n (%)	3 (2.9%)	2 (2.5%)	1 (3.6%)
Postoperative stiffness, n (%)	9 (8.6%)	6 (7.4%)	3 (10.7%)
Instability, n (%)	7 (6.7%)	4 (4.9%)	3 (10.7%)
Aseptic loosening, n (%)	5 (4.8%)	2 (2.5%)	3 (10.7%)
Revision surgery, n (%)	8 (7.6%)	3 (3.7%)	5 (17.9%)
Time to revision (years), mean ± SD	6.1 ± 1.9	5.2 ± 1.4	7.3 ± 2.1
Implant survival at 10 years	92.4%	96.3%	82.1%

DISCUSSION

This paper assessed the outcome of high tibial osteotomy to total knee arthroplasty conversion in the long term, and showed that, although it is technically challenging, conversion TKA could be used to achieve a significant functional benefit and satisfactory implant survival. The results indicate that proper planning of surgery and selection of implants is important in ensuring good results in such a difficult population of patients. The demographic characteristics of the cohort represent the average population experiencing conversion TKA, as the average age of the group is 58.9/7.6 years, and the period of length between HTO and TKA is 9.4/3.1 years. Preoperative functional status was low based on the mean Knee Society Score of 46.8 ± 9.7, stressing on the development of osteoarthritis after HTO. Essentially the same patient characteristics and a long period between procedures are found in other studies, highlighting the importance of HTO as a temporising procedure, but not an ultimate solution [15][16]. Conversion TKA was also linked to longer operative time and more bleeding intraoperative especially in patients who needed removal of hardware. The amount of time spent on surgery operation was 103.8 ± 18.9 in patients without hardware removal and 142.3 ± 20.7 in patients who needed hardware removal, and the blood loss improved correspondingly (349 vs. 512). These results indicate the surgical complexity increment of conversion surgeries, and it is not the first study that reported the increased duration of operation time and intraoperative requirements than primary TKA [17][18].

These difficulties notwithstanding, functional outcomes improved significantly after conversion TKA. The Knee Society Knee Score improved by almost 40 points, with a mean of 46.8 ± 9.7 at preoperative and 86.2 ± 8.4 at final follow-up, which is a significant result of reduction in pain and improvement of functioning. The range of motion had also increased by a factor of about 20 degrees with almost two out of three patients flexing 120 degrees or more. Similar gains in the functional scores and range of motion have been previously reported, indicating that conversion TKA can produce results similar to results of primary TKA when performed correctly [19]

[20]. Radiographic results in this paper were overall good with almost neutral mechanical alignment (1.8 ± 2.3 degrees) and low radiographic loosening (4.8%). The occurrence of loosening was lower with the usage of stemmed elements (2.6% vs 6.1% in non-stemmed implants), which reflects their selective application in the situations when the bone stock or the alignment problem occurs. Other studies in the past have also made an emphasis on the use of stemmed implants in improving the stability and mechanical failure in conversion TKA [21]. In the current study, the rates of complications were satisfactory, but there was a little bit higher compared to the commonly reported rates of primary TKA. The mean implant survival was 92.4% at 10 and 82.1% past 10 years and 7.6% of patients needed overall revision surgery with the mean of 6.17 years. These results agree with other studies that have documented high complication and revision rates in conversion TKA than regular procedures and especially in long-term follow-up periods.

CONCLUSION

It is concluded that conversion of high tibial osteotomy to total knee arthroplasty provides significant long-term functional improvement and acceptable implant survival despite increased surgical complexity. Patients demonstrated marked gains in knee function, pain relief, and range of motion, with a 10-year implant survival of 92.4%. Although operative time, blood loss, and complication rates were higher than those typically seen in primary total knee arthroplasty, these outcomes were largely attributable to the technical challenges inherent to prior osteotomy

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