Short-term follow-up of bilateral total knee arthroplasty following previous high tibial osteotomy in both knees

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Background
Closing wedge high tibial osteotomy (HTO) as a treatment for medial compartment osteoarthritis has a long history. As a result of improvements in operative methods and in the quality of the implants used for total knee arthroplasty (TKA), the use of HTO has decreased considerably in recent years. The clinical results of HTO deteriorate with time despite the initial satisfactory results. The aim of this study was to assess the clinical and radiological results as well as patient satisfaction following knee arthroplasties for failed HTO and to identify the various variables affecting the results.

Patients and methods
Twenty-eight bilateral TKAs were performed in patients who had previously undergone a closed wedge HTO. Different radiological assessments were performed and the American Knee Society Scores were recorded preoperatively and at the latest follow-up. Moreover, patients were asked whether they were satisfied with their operation. The average follow-up was 2.5 years and the average age of the patients was 60.5 years.

Results
The average femoral–tibial angle was corrected from varus 6.5° to valgus 5.75°. The mean improvement in the postoperative arc of flexion was 25°. Preoperatively, the average American Knee Society Score was 45 points and at the final follow-up, it was 82; the improvement was significant.

Conclusion
In conclusion, TKA after HTO improves knee function, but it is a technically demanding operation with altered anatomy and significant balancing problems, and a meticulous surgical technique may lead to satisfactory results in such cases.

Keywords:
knee arthroplasty, knee prosthesis, osteoarthritis, results, tibial osteotomy

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Introduction

Closing wedge high tibial osteotomy (HTO) as a treatment for medial compartment osteoarthritis has a long history, with numerous studies documenting its efficacy and outcome [1]. The failure of this surgery often results in the onset of osteoarthritis in the other compartments, necessitating conversion to total knee arthroplasty (TKA). Several authors have described patella infra at the time of conversion surgery, leading to technical difficulties not commonly encountered in the primary knee arthroplasty setting [2–5]. As a result of improvements in operative methods and in the quality of the implants used for TKA, the use of HTO has decreased considerably in recent years [6].

Meding *et al.* [7] reported that the outcome of total knee replacement after HTO remains uncertain. They concluded that the results of total knee replacement with or without a previous HTO are similar and that the previous HTO had no adverse effect on the outcome of the subsequent total knee replacement.

Recently, Van Raaij *et al.* [8], in their systemic review, reported that osteotomy does not compromise subsequent knee replacement.

The main objectives of both types of interventions (TKA and HTO) are the same: axis realignment, loading redistribution, mobility recovering, and pain relief, but in different stages of arthritis. The clinical results of HTO deteriorate with time despite the initial satisfactory results and the interval between HTO and TKA varies with indications of HTO [8,9].

TKA after failed HTO is difficult in 20–40% of these patients [10].

This study aims to assess the clinical and radiological results as well as patient satisfaction following knee arthroplasties for failed HTO and to identify the various variables affecting the results.

Patients and methods

A total of 28 bilateral TKA were performed in patients who had previously undergone a closed wedge HTO as

a treatment for knee osteoarthritis that was performed earlier for both knees in separate stages. All patients presented and operated in King Faisal Specialist Hospital and Research Center, Jeddah, Saudi Arabia. Weight-bearing radiographs were taken preoperatively and at the latest follow-up. Alignment was read off the radiographs. Postoperative radiographs were examined for implant alignment, patellar height, tibial tray translation, and any lucency or sign of failure. The American Knee Society Scores (AKSSs) [11] were recorded preoperatively and at the latest follow-up. In addition, patients were asked whether they were satisfied with their operation and whether it had relieved their symptoms.

The average follow-up after TKA was 2.5 years (range 2–4 years) and the average interval to knee arthroplasty after tibial osteotomy was 5.5 years (range 4–8 years). The average age of the patients was 60.5 years (range 52–68 years). Among 28 patients, there were 21 women and seven men (75 and 25%, respectively). All patients underwent closing wedge osteotomy. All patients underwent TKA because of persistent pain even after HTO. Fourteen of the 28 patients in the study underwent TKA in the same sitting for removal of the hardware.

PFC sigma fixed platform knee replacement (DePuy Orthopaedics Inc.) was used for all patients who were operated for bilateral TKA in the same sitting for both knees.

During surgery, the patient was placed in a supine position, leaving both legs freely mobile on the table. Draping of the legs was performed while elevated, followed by tourniquet inflation with no previous Esmarch application used. All patients received epidural anesthesia and patient-controlled analgesia postoperatively. All patients received identical postoperative pain protocols, through an epidural catheter.

All procedures were performed using a standard technique. The anteromedial parapatellar approach was used for all cases. A midline skin incision measuring 12–15 cm in length with a trial to ensure noninterference with previous skin incisions was performed for previous HTO. In case metal was still in place, plane done to deviate skin incision to be included in the way to enable removal of the previous hard ware, if possible; otherwise two separate skin incisions were performed. Ligament and soft tissue balancing in extension was performed. Proper intraoperative laxity was judged manually. Anterior and posterior femoral cuts were made to ensure a quadrilateral flexion gap, thereby balancing the collateral ligaments in flexion. The femoral cut was performed using an intramedullary guide system providing 3° of external rotation, with the posterior condyles used as a reference. An extramedullary system, with the midpoint of the talus as a reference and with 3° of posterior slope, was used to cut the proximal part of the tibia. The position of the lateral retractor was determined and attention was paid to avoid affecting the lateral peroneal nerve. Care was taken to ensure equal flexion and extension gaps. Resection was performed of the proximal part of the tibia, which was performed perpendicular to the mechanical axis and was posteriorly inclined to mimic the slope of the tibia. A stepwise titrated ligament release was performed until balanced flexion and extension gaps and a properly functioning posterior cruciate ligament were observed with trial implants in place, as most cases had a short and/or a tight patellar tendon that make reflection of the patella a difficult task.

In cases in which removal of the hardware of previous HTO was performed in the same sitting with TKA, the holes left after removal were sealed with bone plugs from the bone cuts to avoid leakage of the bone cement into soft tissue. The intraoperative assessment of patellar tracking was performed with the real components cemented into place. The so-called no-thumbs test was used, in which the patella was reduced into the trochlea and the knee was subjected to a range-of-motion (ROM) test. Appropriate tracking was defined as a patella that remained centered in the trochlea through 90° flexion with no tendency for tilt or subluxation. If there was patellar tilt or subluxation with the no-touch test, a lateral retinacular release was performed. Typically, the lateral retinacular releases were performed from the inside out, with care taken to preserve the superior lateral geniculate vessels. The tourniquet was then deflated, homeostasis was established, and drains were placed.

The patella was not replaced in any patient; however, a patelloplasty was performed in all patients. Both the tibial and the femoral components were cemented. Lavage of the osseous surface was used before cementing the implants.

Routine antibiotic prophylaxis with intravenous cefazolin (2 g given 1½ h before inflation of the tourniquet, followed by 1 g every 8 h for 3 days) and antithrombotic prophylaxis with subcutaneous enoxaparin (40 mg on the night before surgery and 40 mg daily continued through the seventh postoperative day) were used in all patients, followed by oral antithrombotic medication for 3 more weeks, in combination with compression stockings.

All patients received a splint that was applied with the knee in 15° of flexion and was worn for the first

24 h after the operation. Rehabilitation started with continuous passive knee movement started at 60° and continued with a gradual increase. All patients began walking with crutches or a walker and started active and passive ROM exercises on the first day after the operation. The patients used crutches, with full-weight-bearing for 6 weeks under the supervision of a physical therapist.

Outcomes were evaluated using the AKSS (Table 1) [11]. It has a rating system of 100 points, and is simple but more exacting and more objective. The system is subdivided into a knee score that rates only the knee joint itself and a functional score that rates the patient's ability to walk and climb stairs. Three main parameters were assessed: pain, stability, and ROM. A well-aligned knee with no pain, 125° of motion, and negligible anteroposterior and mediolateral instability is assigned 100 points. Fifty points are assigned for pain, 25 for stability, and 25 for ROM.

Table 1 American knee society score

	Point
Pain	
None	50
Mild or occasional	45
Stairs only	40
Walking and stairs	30
Moderate	
Occasional	20
Continual	10
Sever	0
Range of motion	
5° = 1 point	25
Stability	
Anteroposterior (mm)	
<5	10
5–10	5
10	0
Mediolateral	
<5°	15
6–9°	10
10–14°	5
>15°	0
Subtotal	[]
Deductions points (minus)	
Flexion contracture	
5–10°	2
10–15°	5
16–20°	10
>20°	15
Extension lag	
<10°	5
10–20°	10
>20°	15
Alignment	
5–10°	0
0–4°	3 points each degree
11–15°	3 points each degree
Other	20
Total deductions	[]
Total knee score	[]

Results

The problems encountered at knee arthroplasty after a HTO included significant soft tissue balance, and altered slope of the tibial plateau as well as the patellar height.

The mean peroperative arc of motion was 71.16 (range 50–100). The mean improvement in postoperative arc of flexion was 25.12. The average length of physiotherapy before going back to near- normal activities was 28 days (range 22–50 days).

Preoperatively, the average AKSS was 45 points (range 35–70) and the score at the latest follow-up was 82 points (range 55–90); this improvement was significant.

Radiological evaluation shows that the average femoral–tibial angle was corrected from varus 6.5° before TKA to valgus 5.75° at the last follow-up. The ratio LP/LT was measured; however, it was not significantly compromised in this series. There was no tibial tray translation or any signs of lucency or failure of the prosthesis.

There were no deep infections or any thromboembolic complications in this group of patients. Blood transfusion was performed postoperatively in most cases; 25 of 28 patients required transfusion of two units of packed RBCs.

One patient developed rupture of the patellar tendon 1 month postoperatively, which repaired and showed improvement with some delay with physiotherapy and good improvement 4 months postoperatively (case in Fig. 2).

General outcome in terms of patient satisfaction indicated that 26 (92.8%) patients were satisfied and two (7.2%) patients were dissatisfied.

Figures 1–4 show an example of preoperative and postoperative radiological studies of four patients.

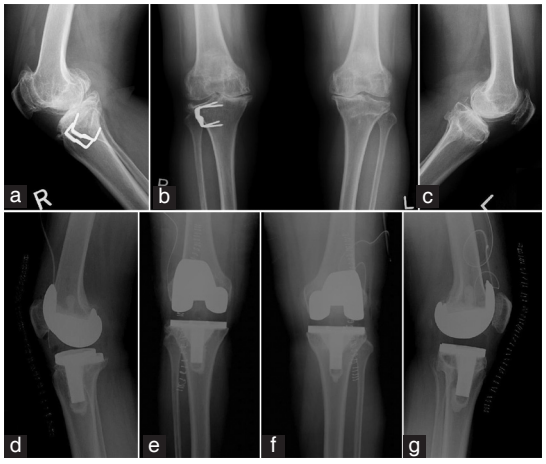
Discussion

HTO is an extra-articular operative therapeutic approach to the treatment of osteoarthritis of the knee that does not lead to improvement in quadriceps muscle function. Knee function may be worsened by HTO in some patients [12]. The reasons for performing TKA after HTO were pain caused by recurrence of the varus deformity and progression of the osteoarthritis to the

Figure 1

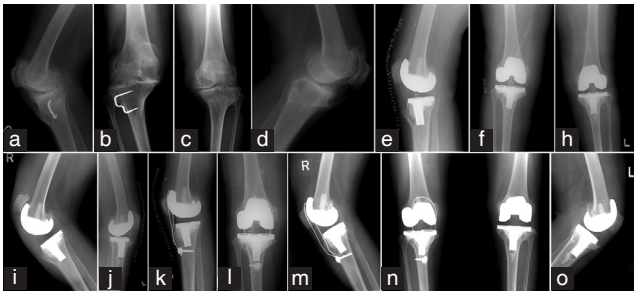
Radiographs of a 62-year-old man, who underwent high tibial osteotomy 4 years back for the right knee and 5 years back for the left knee, in whom hardware was removed earlier (a–c); postoperative radiographs are shown in (d)–(g).

Figure 3



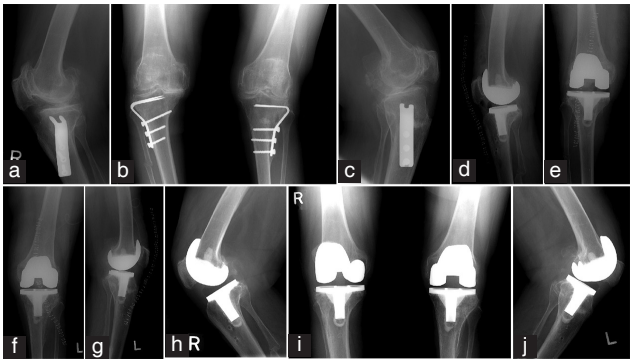
Radiographs of a 60-year-old woman, who had undergone high tibial osteotomy 6 years back for the right knee and 8 years back for the left knee, in whom hardware was removed earlier (a–c); postoperative radiographs shown in (d)–(g).

Figure 2



Radiographs of a 66-year-old woman, who had undergone high tibial osteotomy 5 years back for the right knee and 7 years back for the left knee, in whom hardware was removed earlier (a–d); postoperative radiographs are shown in (e)–(h); (i)–(l) show 1 month after the operation with rupture of the patellar tendon; and (i)–(j) show the postrepair radiographs, a follow-up 2 years is shown in (m)–(o).

Figure 4



Radiographs of a 53-years-old woman, who had undergone high tibial osteotomy 6 years back for the right knee and 5 years back for the left knee (a–c); postoperative radiographs shown in (d)–(g); 3-year follow-up radiographs shown in (h)–(j).

other compartments. Knee function improved after TKA in the group of patients in this series, which may be because of improvements in pain and balance; this may have also been because of improvement in the quadriceps.

Conflicting results have been reported in the literature on the results of TKR performed after a previous HTO. Cameron [13] reported 17.5% poor results in 131 knee arthroplasties performed after failed high tibial osteotomies at 2–15 years' follow-up and an overall complication rate of 11.2%. These findings were also obtained by Insall *et al.* [14], who reported poor results in 14% of cases in a 3.6-year follow-up of 22 knees. However, Takai *et al.* [15], in a 6-year follow-up of 12 knees, found results that were comparable with a control group of 12 patients who had undergone primary knee arthroplasties. Toksvig-Larsen *et al.* [16] in a comparison of 40 matched knees, found no difference between primary and post-tibial osteotomy knee arthroplasties after a 3-month, 6-month, 1-year, 2-year, 5-year, and 10-year follow-up. However, these authors provided data for only five of their patients at the 10-year interval.

Bergenudd *et al.* [17] evaluated 113 patients, of whom 14 had undergone HTO; they concluded that there was no difference in the final result after follow-up periods of 4–9 years with respect to degree of knee flexion, later knee revisions, and operative time, but significantly greater blood loss and other postoperative complications were noted among the previously osteotomized group of patients. The current study had a shorter follow-up period of 2–4 years and greater blood loss was observed in these cases than in the usual TKA.

The problems encountered on performing knee arthroplasty after a HTO included significant soft tissue imbalance and altered slope of the tibial plateau. Soft tissue imbalance at the long-term follow-up following HTO was also observed by Bettin *et al.* [18]. They found that after valgus osteotomy, a stretching of the medial collateral occurred. They found that the lateral collateral ligament remained lax in the long term, perhaps because of a functional adaptation process to the postoperative loading in valgus angulation on the medial collateral ligament.

The posterior cruciate ligament is often scarred and shortened after HTO. Therefore, adequate balancing may require resection of the PCL and the use of a PCL substituting component. This was found in all cases in this series and a PCL substituting component was used for all cases.

Virolainen and Aro [19] reported that subperiosteal exposure of the proximal tibia and eversion of the patellar mechanism are more difficult in the postosteotomy knee because of soft tissue scarring. This was observed during surgery in most cases in this series and one patient developed avulsion of the patellar tendon and repair was performed. Although this was in a later stage and not during surgery, it can be attributed to scarring of the tissue after HTO.

Studies reported that more lateral ligamental releases were necessary for the postosteotomy patients, and found that more tibial tuberosity osteotomies were performed. These additional procedures may contribute toward a significantly prolonged operation time for patients receiving TKA after a previous osteotomy [20,21]. No patient required this osteotomy; rather, a longer operative time than usual was reported for TKA.

The patellar height as measured by the ratio LP/LT was, however, not compromised in this series. This is in contrast to the experience of Insall *et al.* [14]; they reported shortening and more patella infera.

Conversion of a failed HTO into a TKR presents technical challenges not generally encountered in primary arthroplasty. The operative time for revision of an osteotomy to a TKR is generally more than the time taken to perform a primary arthroplasty. Medial scarring from osteotomy can be more challenging while exposing and soft tissue balancing at the time of TKR. A closing wedge HTO shortens the distance of the tibial tubercle from the joint line, making exposure of the proximal part of the tibia and lateral dislocation of the patella more difficult, which increases the risk of avulsion of the tibial tubercle [14,22]. Generally, 8–14 mm of bone is removed from the lateral side of the proximal tibia at the time of HTO. Thus, resection of this amount of bone during TKR results in excessive bony resection medially, and even more resection laterally. This may result in difficulties with excessive laxity and soft tissue imbalance and also necessitates the use of a very thick prosthesis on the tibial side to restore the joint line.

Karabatsos *et al.* [23] carried out a retrospective matched cohort study with a mean follow-up of 5 years, comparing 20 patients who underwent TKA after HTO and 20 matched patients who received a primary TKA. Surgical difficulties were more frequently encountered in the TKA after HTO group, with longer operative times, more difficult exposure, and an increased number of lateral releases. The authors concluded that TKA after HTO is a more challenging procedure, technically, than primary TKA and that functional outcomes after TKA after previous HTO tended to be inferior, even though differences were not significant.

In the last few years, several authors have reviewed the results of TKA after a HTO. The literature includes contradictory results as some papers report results comparable with those of a primary TKA whereas others report poorer results in patients who had received a previous tibial osteotomy. Flórez *et al.* [24] and Staeheli *et al.* [25] reported good result in their cases. In contrast, Ragab and El-Sayed [26] and Windsor *et al.* [27] reported worse results and concluded that the evolution of TKAs is poorer in patients who have been subjected to a previous proximal tibial osteotomy. This study was in agreement with the first two studies.

Several studies that have evaluated the effect of HTO on the tibial inclination angle have reported the importance of tibial inclination angle on knee stability [28,29]. Kaper *et al.* [30] concluded that an increase in the tibial inclination angle would result in posterior translation of the femur on the tibia, which would also induce an increase in the severity of arthrosis, compromising future TKA operations by causing a tibial bone defect that necessitates TKA at a later stage.

Recently, Haslam *et al.* [20], in a long-term follow-up with an average of 12.6 years of TKA after HTO in comparison with another matched group of TKA without HTO, showed that there were more failures after HTO, thus emphasizing the importance of long-term follow-up. In this study, no comparison was made as the aim was to report the results and difficulties encountered with TKA following HTO. Moreover, this study had a short-term follow-up period. Thus, long-term follow-up should also be part of a study.

Conclusion

Major complications such as prolonged surgery duration, greater blood loss, and technical difficulties associated with conversion of HTO into TKA suggest that tibial osteotomy should be reserved for a very narrow group of patients in whom primary arthroplasty is unsuitable.

TKA after a HTO improves knee function, but it is a technically demanding operation, with altered anatomy and significant balancing problems. Results of knee arthroplasty after HTO are inferior to those of a primary knee arthroplasty.

A meticulous surgical technique may yield satisfactory results in TKA after HTO, considering the correction of the deformity, the re-establishment of joint line height, and the amount of tibial bone resection.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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