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Primary Knee

Medial Unicompartmental Knee Arthroplasty After Failed Open-Wedge High Tibial Osteotomy

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ABSTRACT

Background: Controversy exists whether or not a previous high tibial osteotomy (HTO) influences the outcome and survival of a unicompartmental knee arthroplasty (UKA). The aim of this retrospective study was to evaluate clinical, radiological, and functional outcomes of UKA after failed open-wedge HTO compared with UKA with no previous HTO.
Methods: Between 2001 and 2017, 24 post-HTO UKAs (group A) with an average follow-up of 8.1 years (range: 5 to 13) were compared with a control group of 30 patients undergoing simple UKA (group B) with an average follow-up of 9.5 years (range: 2 to 16). All patients were evaluated preoperatively and postoperatively using Knee Society Score, University of California at Los Angeles Activity Score, Western Ontario and McMaster University Osteoarthritis Index, and through objective evaluation. Mechanical coronal alignment and Caton-Deschamps index were measured both preoperatively and postoperatively.
Results: In both groups, Knee Society Score, University of California at Los Angeles Activity Score, and Western Ontario and McMaster University Osteoarthritis Index scores significantly improved at follow-up ($P < .001$). In addition, statistically significant greater improvements in clinical and functional scores were reported in group B compared with group A ($P < .001$). No statistically significant differences concerning postoperative mechanical axis were observed between groups (2.7° and 3.2°, respectively, $P = .27$) and with regard to Caton-Deschamps index (1.0° and 1.1°, respectively, $P = .44$).
Conclusion: This study demonstrated improvements in clinical and functional outcomes compared with preoperatory status in both groups irrespective of a previous HTO. A prior HTO was a determinant for having reduced postoperative clinical and functional outcomes after UKA.

High tibial osteotomy (HTO) is a well-established surgical option for the management of medial osteoarthritis (OA) of the knee, especially in relatively young patients with a varus deformity [1,2]. The goal of this procedure is to avoid or postpone the need for future joint arthroplasties. However, its results commonly deteriorate over time, and with increasing life expectancy, the need for revision surgery is growing [3,4]. In addition, concerns have been raised about the ability of HTO to restore correct limb alignment, as undercorrection and overcorrection are being reported [5,6]. For these reasons, unicompartmental knee arthroplasty (UKA) is gaining popularity compared with the past [7–9], as it has shown better clinical outcomes and survival rate in the long term compared with open-wedge HTO [10–12].

Controversy exists whether or not a previous HTO influences the outcome and survival of a subsequent knee arthroplasty [13–26]. In fact, performing knee arthroplasty after HTO is considered a demanding procedure because of soft tissue scarring, potential loss of bone stock, and altered tibial slope and patella height [17,27,28]. Patients with prior HTO developed OA at an earlier stage of life, and the knee is more susceptible to inferior outcomes and increased complications [17].

Although several studies exist on the outcomes of total knee arthroplasty (TKA) after HTO [13–22], few studies in literature report on UKA after failed HTO.

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The aim of this retrospective study was to evaluate clinical, radiological, and functional outcomes of UKA in knees that had a previous HTO, which failed due to undercorrection, compared with a control group of UKA in knees with no previous HTO.

The aim of this retrospective study was to evaluate clinical, radiological, and functional outcomes of UKA in knees that had a previous open-wedge HTO, which failed due to undercorrection, compared with a control group of UKA in knees with no previous HTO.

Materials and Methods

Between 2001 and 2017, 6827 patients underwent UKA at our Department. Twenty-seven consecutive patients suffering from isolated idiopathic medial OA after a previous HTO and treated with UKA (group A) with a minimum follow-up of 5 years were included in this retrospective single-center study. All patients in group A underwent a previous failed open-wedge correction for varus deformity. The indication for conversion from HTO to UKA was clinical and radiological progressive medial arthritic degeneration caused by persistent varus alignment.

Patients were matched to a control group of 30 consecutive patients taken from a larger cohort of participants who underwent UKA for primary idiopathic OA without previous HTO. The 2 groups were comparable for body mass index (BMI) and absence of comorbidities. Inclusion criteria were those adopted for surgical indication for a UKA at our institution: BMI <30, isolated unicompartmental OA, varus knee deformity less than 10°, tibial slope less than 10°, absence of clinical patellofemoral pathology or ligamentous incompetence, absence of comorbidities such as diabetes, cancer, cardiovascular, neurological, or rheumatic disease.

All operations were performed by a single surgeon specialized in knee arthroplasty and tissue-sparing surgery. During the same period, 41 post-HTO knees with multiple compartments affected by OA were converted to TKA. Criteria adopted to choose conversion of HTO to UKA rather than TKA were integrity of the anterior cruciate ligament, varus knee deformity less than 10°, and tibial slope less than 10°.

Surgical Technique

Surgeries were performed in a minimally invasive way under spinal anesthesia with a mini midvastus approach, without a tourniquet, and using a cemented technique. In patients with previous failed HTO, one-stage prosthesis implantation was performed without hardware removal, which consisted in TomoFix locking plates (Synthes, Stratec Medical, Oberdorf, Switzerland) in 9 patients (38%) and Puddu plates (Arthrex, Naples, Florida) in 15 patients (62%). Allegretto unicondylar fixed-bearing prosthesis (Zimmer Inc, Warsaw, IN, USA) was implanted in 31 patients, whereas Zimmer Unicondylar Knee System (Zimmer Inc) was implanted in 23 patients. Implant choice was based on surgeon preference in accordance with preoperatory planning. Because TomoFix locking plates feature 4 proximal locking screws, whose position could have interfered with arthroplasty implantation, to allow the insertion of the tibial base plate, one or more of the proximal screws were removed if needed, and the retained plates were not disturbed. After positioning a drainage system, the wound was closed with bioabsorbable sutures, and a sterile dressing was applied.

Rehabilitation Protocol

Pain management protocols were the same for both groups. In all patients, physiotherapy was started 3 hours after surgery, including regaining of range of motion with continuous passive motion 0-90° and proprioceptive exercises. Patients were instructed to walk with crutches starting the day after the operation, and for the first 4 weeks, partial weight-bearing ambulation was allowed.

Table 1
Patient Demographics and Anthropometric Data.

	UKA After HTO	UKA Without HTO	*P*-Value
No. of patients	24	30	
Gender			
Male	12	17	
Female	12	13	
Mean follow-up (range) (yr)	8.1 (5-13)	9.6 (5-16)	.08
Mean age at surgery (range) (yr)	64.6 (48-77)	74.2 (57-90)	<.001
Mean BMI (range)	25.8 (18.3-44.4)	26.1 (19.2-32.5)	.91

UKA, unicompartmental knee arthroplasty; HTO, high tibial osteotomy; BMI, body mass index.

Outcome Measures

Clinical assessment included clinical and functional Knee Society Score (KSS), University of California at Los Angeles (UCLA) Activity Score, Western Ontario and McMaster University Osteoarthritis Index (WOMAC), and objective examination including range of motion (ROM). Radiographic assessment included standard weight-bearing anteroposterior and lateral view x-rays, axial knee x-ray at 45° of flexion, Rosenberg view, and long-standing x-rays.

The severity of knee OA was determined using Kellgren-Lawrence (K-L) classification for the medial and lateral compartment; patellar height was measured from lateral view films using the Caton-Deschamps (C-D) index. Long-standing x-rays were used to measure lower limbs' mechanical axis. Patients were examined preoperatively and followed up at 1, 3, 6, 12 months after surgery and then each year for 5 years with clinical examination and new x-rays. Between 2018 and 2019, they were recalled for long-term subjective evaluation, clinical examination, and radiographic assessment. An expert observer performed clinical assessment.

All investigations were conducted in conformity with ethical principles of research. The study received institutional ethical approval, and informed consent was obtained.

Statistical Analysis

IBM SPSS Statistics for Windows software, Version 21.0, (IBM Corp., Armonk, NY, USA) was used for data analysis. The Wilcoxon

Table 2
Comparison Between Preoperative and Follow-Up Status.

	UKA After HTO			UKA Without HTO		
	Preoperative	Follow-Up	*P*-Value	Preoperative	Follow-Up	*P*-Value
KSS clinical score (mean, SD)	45.4 (5.7)	84.6 (6.6)	<.001	62.4 (5.9)	93.5 (6.4)	<.001
KSS functional score (mean, SD)	50.7 (10.5)	82.9 (7.8)	<.001	59.5 (8.4)	91.3 (8.1)	<.001
UCLA score (mean, SD)	3.6 (0.5)	5.4 (0.6)	<.001	3.9 (0.4)	6.5 (0.5)	<.001
WOMAC score (mean, SD)	47.5 (5.9)	79.9 (6.8)	<.001	57.3 (6.3)	91.5 (7.1)	<.001

SD, standard deviation; UKA, unicompartmental knee arthroplasty; HTO, high tibial osteotomy; KSS, Knee Society Score; UCLA, University of California at Los Angeles; WOMAC, Western Ontario and McMaster University Osteoarthritis Index.

Table 3
Comparison Between Groups.

	UKA After HTO	UKA Without HTO	*P*-Value
KSS clinical score (mean, SD)	84.6 (6.6)	93.5 (6.4)	<.001
KSS functional score (mean, SD)	82.9 (7.8)	91.3 (8.1)	<.001
UCLA score (mean, SD)	5.4 (0.6)	6.5 (0.5)	<.001
WOMAC score (mean, SD)	79.9 (6.8)	91.5 (7.1)	<.001

SD, standard deviation; UKA, unicompartmental knee arthroplasty; HTO, high tibial osteotomy; KSS, Knee Society Score; UCLA, University of California at Los Angeles; WOMAC, Western Ontario and McMaster University Osteoarthritis Index.

signed-rank test for related samples was used to compare the preoperative and follow-up status. To compare the differences between the 2 groups, the Mann-Whitney U test for independent samples was used. Differences with a *P* value <.05 were considered statistically significant.

Results

Three patients in group A were not available for clinical assessment: 1 patient died of lung cancer in 2011, 1 patient suffered from dementia since 2009, and one patient was lost to follow-up. Therefore, 24 patients in group A were available at follow-up after an average time of 8.1 years (range: 5 to 13). No patient was lost at follow-up in group B after an average time of 9.5 years (range: 2 to 16) from primary surgery. Mean interval between failed HTO and UKA was 6.5 years (range: 1 to 11). Mean age at surgery was 64.6 years (range: 48 to 77) in group A and 75 years (range: 57 to 90) in group B. Patient demographics are reported in Table 1. The preoperative and postoperative outcome scores for each group are reported in Tables 2 and 3. Mean KSS clinical and functional scores significantly improved from preoperatory status in both groups ($P <$ .001), and similar results were observed concerning UCLA and WOMAC scores ($P <$ .001). Postoperative KSS clinical and functional scores were 84.6 (range: 65 to 95) and 82.9 (range: 65 to 95), respectively, in group A, compared with 93.5 (range: 80 to 100) and 91.3 (range: 70 to 100), respectively, in group B ($P <$ .001). A statistically significant difference between groups was also observed concerning the postoperative mean UCLA score which reached 5.4 (range: 5 to 6) in group A and 6.5 (range: 4 to 9) in group B ($P <$ .001) and concerning WOMAC which in group A scored 79.9 (range: 70 to 90) and in group B scored 91.5 (range: 66 to 100; $P <$ .001). The preoperative ROM averaged 102° (range: 80 to 125) for patients in group A and 100° (range: 80 to 120) for group B. Postoperatively, mean ROMs significantly improved (121° and 120°, respectively, $P <$

Fig. 1. The preoperative X-ray of a patient with previous failed open-wedge correction for varus deformity.

Fig. 2. The postoperative X-ray showing UKA implantation in a patient with previous failed open-wedge correction. UKA, unicompartmental knee arthroplasty.

.001). No statistically significant differences were observed between groups ($P = .97$).

Concerning radiographic assessment, in group A, mechanical axis changed from a preoperative mean value of 3.2° (range: 1.5° to 5.6°) to a postoperative mean value of 2.1° (range: −2.5° to 7.4°) ($P < .001$). The C-D index changed from 1.0 (range: 0.6 to 1.4) to 1.0 (range: 0.6 to 1.3) ($P = .45$).

Similarly, group B showed at latest follow-up a change in mechanical axis from a mean preoperative value of 5.7° (range: 3.0° to 12.0°) to 3.2° (range: 1.5° to 5.6°; $P < .001$), whereas the postoperative C-D index did not significantly change from preoperative values (preop: 1.1 (range: 0.7 to 1.5); postop 1.1 (range: 0.7 to 1.5); $P = .38$). No statistically significant differences concerning postoperative mechanical axis were observed between group A and group B (2.7° and 3.2°, respectively, $P = .27$) and with regard to the C-D index (1.0° and 1.1°, respectively, $P = .44$). No radiographic signs of implant loosening or evidence of pathologic radiolucent lines was observed at latest follow-up (Figs. 1-3).

No intraoperative or postoperative complications, including fractures, infections, thromboembolism, were reported. A progression of symptomatic and radiological OA in the patellofemoral compartment (K-L grade 2-3) led to implantation of patellofemoral prosthesis in 1 patient 2 years after surgery in group A, whereas the progression of OA in the lateral compartment was treated with additional lateral UKA in 1 patient in group B (K-L grade 3). Cumulative survival rate at follow-up was excellent, as additional unicompartmental arthroplasty was needed in 1 patient (4%) in group A and 1 patient in group B (3%), with no statistically significant difference between the 2 groups ($P = .83$). In all patients, single-stage conversion to UKA was performed without hardware removal. To allow the insertion of the tibial base plate, one of the proximal screws was removed if needed. No symptoms related to hardware retention were observed.

Discussion

The main finding of this study is that UKA improves clinical and functional outcomes irrespective of a previous HTO, thus demonstrating that performing UKA with previous HTO is a safe and effective procedure. However, a HTO was a determinant for having reduced postoperative clinical and functional outcomes after UKA. No significant differences concerning postoperative mechanical axis and patellar height variations were reported between the 2 groups.

Both groups showed a postoperative improvement in clinical and functional KSS, UCLA, and WOMAC scores compared with preoperatory status, thus confirming the proved long-term efficacy of UKA in patients suffering from severe unicompartmental knee OA, allowing short hospital stay and quick recovery [7].

Performing knee arthroplasty after a previous failed HTO is a challenging procedure because of increased potential intraoperative and postoperative complications brought by previous HTO; for these reasons, the outcomes reported in literature are variable.

Batailler et al did not report significant differences in functional outcomes, complication and survival rate, or radiological outcomes between 41 uncemented TKAs after HTO and a control group of 82 uncemented primary TKAs at a mean follow-up of 8 years. The survival rate was 97.6% in the group TKA after HTO versus 100% in

Fig. 3. The preoperative and postoperative long-leg standing anteroposterior X-ray showing UKA implantation in a patient with previous failed open-wedge correction for varus deformity. UKA, unicompartmental knee arthroplasty.

the control group [13]. Similarly, Paredes-Carnero et al did not report significant differences between 41 patients who underwent TKA after HTO and 41 matched patients who underwent TKA without prior HTO [20]. Conversely, Parvizi et al investigated the outcomes of patients who underwent TKA after HTO in a comparative study with patients undergoing bilateral TKA after a mean follow-up time of 15 years. Authors observed that TKA provided improvement in function and pain relief, although outcomes were worse for patients who have had a previous HTO [21]. Preston et al did not report differences in clinical outcomes or survivorship of TKA in patients having previously undergone medial open-wedge and lateral closed-wedge HTOs [18].

Previous HTO has long been considered a contraindication to UKA implant in patients with unicompartmental OA, and performing UKA after a previous HTO has limited indication. Patients must have a residual varus of the lower limb with degenerative changes limited to the medial compartment of the knee, an intact anterior cruciate ligament (ACL) with no lateral thrust, and an acceptable patellar tracking. Surgeons during operation have to cope with tissue scarring, an altered tibial slope, poor bone stock, and a potentially altered patellar height [17]. For these reasons, few studies in literature report on UKA after HTO.

Presence of retained hardware could make knee arthroplasty particularly challenging. On the other hand, both staged and concurrent hardware removal before knee arthroplasty have shown relatively high complication rates [29]. In fact, performing concurrent hardware removal may increase the risks of bone fracture and weakness, and surgical scars may not be in optimal position for both procedures, thus leading to wound complications and infections [30]. Similarly, a staged procedure carries the drawbacks of prolonged hospital staying, the need for 2 major surgical procedures, and additional perioperative complications [29].

For these reasons, in our case series, to avoid these shortcomings, in all patients, single-stage conversion to UKA was performed without hardware removal. The use of a Zimmer Unicondylar Knee arthroplasty, whose design features femoral pegs and tibial keel, may enhance implant stability and ultimately improve implant fixation especially in patients with reduced bone quality. On the other hand, the use of an Allegretto knee prosthesis, whose resurfacing design allows greater preservation of bone stock and whose tibial component has no fins, keels, or pegs, may allow the UKA to be performed without interfering with hardware [31].

Furthermore, a previous HTO may produce extra-articular deformities affecting soft tissue tension [26]. In case of persistence of varus deformities after failed HTO, a contracture of the medial collateral ligament or the pes anserinus may be present. While performing UKA, caution should be given to avoid excessive soft tissue release to achieve satisfying soft tissue balance. Similarly, the presence of increased tibial slope can lead to greater anteroposterior translation and thus ACL loading. For these reasons, to allow UKA implantation, deformities should be minimal and tibial slope should be less than 10°. In addition, the use of a fixed-bearing prosthetic design could allow the possibility to cope with residual medial laxity without resulting in postoperative valgus alignment, more effectively compared with mobile-bearing designs which carry risks of inlay dislocation or overcorrection in the setting of increased medial laxity [26].

Vorlat et al showed the effect of previous HTO on the outcome of mobile-bearing UKA at 10 years after surgery: survival rate was 35.7% in 8 patients with previous HTO, compared with a survival rate of 83.7% in 31 patients without previous HTO [23], although these results should be interpreted with caution because of the very small sample size of the post-HTO group. Similarly, Jamali et al [24] compared UKA after HTO with UKA in primary OA. They showed poor survivorship of UKA after HTO (69%) in relation to primary UKA (96%) at 10 years of follow-up. Schlumberger et al retrospectively reviewed 27 mobile-bearing UKAs after failed prior HTO after an average follow-up of 4.3 years. The survival rate was 93%. Clinical and radiological assessment was performed in 21 patients: average Oxford Knee Score was 42.7, mean WOMAC was 7.9, whereas clinical and functional KSS were 82.9 and 93.3, respectively [26]. Valenzuela et al [25] reported no statistically significant differences in clinical and radiological outcomes between UKA and TKA after lateral closing-wedge HTO as well as after primary UKA after 6 years of follow-up. However, a lower survival rate at 10 years after UKA after HTO was reported (66%) compared with primary UKA (96%).

Our study points out a larger number of patients enrolled with similar results in relation to postoperative scores for post-HTO UKAs, while the control group showed statistically significant better outcomes in all point scales considered. The excellent survival rate reported in our case series may be justified by the strict criteria for patient selection adopted. Strict indications for surgery should be adopted to maximize the outcomes in a possibly technically demanding procedure. Improved surgical techniques in a high-volume center and surgeons specialized in such procedures are also possible explanations for improved functional results.

Concerning radiographic outcomes, an improvement in mechanical alignment compared with preoperative status was reported in both groups, whereas the postoperative C-D index did not significantly change from preoperative values. Valenzuela et al reported a higher incidence patella infra in knees post–closing-wedge correction HTO (6/22, 27%) compared with knees without previous HTO (2/22, 9%). These differences among studies may be related to the increased incidence of patella infra observed after lateral closing-wedge HTO [25].

To our knowledge, this is one of the few studies in literature about UKA after HTO, the first for number of patients enrolled and length of follow-up.

Limitations of the present study include the relatively small sample size and the retrospective nature. This is due to strict indication for patient selection. The limited study population may not have allowed for detection of small differences between groups, and a greater number of patients in each group could have enhanced the power of the results obtained. Another potential limitation was that patients were not matched in accordance with age; patients in the HTO group developed OA at an earlier stage of life and were more likely to be younger than the control group. However, to limit bias, the 2 groups were comparable for BMI and absence of comorbidities.This study demonstrated excellent outcomes in terms of clinical, radiological, and functional outcomes when performing UKA after previous failed HTO. Although inferior results were observed compared with the control group of patients treated with UKA without previous HTO, the satisfying outcomes reported allow considering medial UKA a reliable treatment option in selected patients with medial OA and prior HTO. Further prospective comparative studies with larger cohort are needed to validate these results.

Conclusions

This study demonstrated improvements in clinical and functional outcomes compared with preoperative status in both groups irrespective of a previous HTO, thus demonstrating that performing a UKA after HTO can be a safe and effective procedure in the setting of a high-volume UKA surgeon, but these outcomes will need to be generalized in larger studies. A previous HTO was a determinant for having reduced postoperative clinical and functional outcomes after UKA.

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