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Midterm Outcome of Open Wedge High Tibial Osteotomy without Bone Graft with Locking Plate Fixation

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Purpose: The purpose of this study was to assess the midterm outcomes of open-wedge high tibial osteotomy without bone graft (OWHTO) in patients with advanced medial compartment arthritis.
Methods: From January 2014 to December 2020, all patients treated with OWHTO had medial compartmental arthritis. Twenty patients underwent OWHTO. Clinically, we evaluated the Oxford Knee Score (OKS), Knee Society Score (KSS), and range of motion (ROM) at the five years follow-up.
Results: The mean age of the patients was 52.65±4.88 years. All clinical outcomes gradually improved from the postoperative period to the final follow-up period. The mean follow-up duration was 5.05±0.43 years. Pre-operative OKS was 20.85±3.47; Post-operative OKS was 36.70±2.16; P = 0.034. Pre-operative KSS was 35.8±20, Post-operative KSS was 53.2±20.2, and P = 0.02. Pre-operative ROM was 100.59±11.22; Post-operative ROM was 120.57±11.06; P = 0.044.
Conclusions: OWHTO has good clinical outcomes. Thus, the results of this study suggest that OWHTO may be a good alternative treatment for medial unicompartmental arthritis.

Keywords: knee, osteoarthritis, osteotomy, arthroplasty, unicompartmental arthritis

Unicompartmental knee arthroplasty (UKA) and high tibial osteotomy (HTO) have both been used to treat unicompartmental knee osteoarthritis (OA). In terms of the trends of both treatments, the number of UKA performed in the United States between 2007 and 2011 remained unchanged, whereas that of HTO slightly declined[1]. However, the characteristics of the candidates for these treatments and their outcomes are controversial. HTO was introduced to correct angular deformity in the 1960s[2]. The major benefit of HTO is that it preserves the natural knee without affecting physical loading[3]. The patients who underwent HTO were younger and more active; the ideal demographic was less than 60 years of age[1,4]. The patients may have good flexion of the knee, which is higher than 120 °, without any laxity or instability[4]. The survival rate of HTO at 15 years has been reported to be as high as 90.4%[5].

There are several HTO techniques, including dome, closing wedge, and opening wedge[6-8]. Open wedge high tibial osteotomy (OWHTO) provides precise correction by progressive opening while conserving the bone stock and limiting metaphyseal deformity. The drawback to this method is the risk of increasing the tibial slope and reducing patellar height[9-11]. Locking plates enable early weight bearing without bone or bone-substitute grafting[12-15], thereby avoiding the morbidity associated with iliac graft

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harvesting[16]. For planned corrections ≥10°, some authors recommend grafting the osteotomy site to avoid consolidation delay and non-union[17,18]. Other studies, such as the one from Brosset et al. (2011), reported no influence of the degree of correction on consolidation[15]. Numerous theoretical factors lead to complications or delayed consolidation after OWHTO, such as obesity, smoking, age, and osteoporosis, but these have not been explored sufficiently in recent studies. Therefore, we performed a retrospective study of OWHTO with a 10°correction, to determine the patient-reported outcome measure, range of motion (ROM), and radiographic results.

METHODS

Patient Selection

The inclusion criteria were medial compartment OA knee Ahlback grade 3-4, active patients who needed to return to their work (such as farmers and laborers), a normal functioning knee Ligament, and knee flexion > 90°. The exclusion criteria were knee instability, lateral compartment involvement, and severe patellofemoral joint arthritis.

This study was approved by the institutional review board of our hospital. From January 2014 to December 2020, all patients with medial compartmental arthritis were treated by OWHTO. Of the 65 patients in total, we excluded seven patients whose follow-up was <5 years, three with lateral meniscus lesions or lateral compartment arthritis, three with insufficiencies in the anterior or posterior cruciate ligaments, and two with severe patellofemoral OA. No patient with a deformity or history of trauma to any limb was included to evaluate the accuracy of alignment of the lower limbs. Ultimately, 20 patients who underwent OWHTO were included (n=20). The patients decided whether they wanted to undergo OWHTO after a discussion with the surgeon about the prognosis, rehabilitation program, and their expectations of the level of physical activity after surgery. Based on the evaluation of the patient's compliance, ability to reduce weight, and hygiene, we decided on proper treatment. OWHTO was generally recommended for patients with severe labor, such as farming.

Surgical Techniques

Open Wedge High Tibial Osteotomy without bone graft: The patient was kept in a supine position with a tourniquet at the root of the limb. A 6 cm longitudinal incision was made halfway between the anterior tibial tuberosity and medial collateral ligament (MCL), 1 cm from the joint. A TomoFix plate (DePuy Synthes) was inserted as per the manufacturer's instructions, and the alignment was checked by fluoroscopy. The sartorius fascia was incised and the hamstring tendons were released subperiosteally toward the posterior region. A Hohmann retractor was used to retract posterior neurovascular elements. Two K-wires were positioned under fluoroscopic control from the medial to the lateral, up to the fibular head. Osteotomy using an oscillating saw was performed along the K-wires with respect to the lateral cortex. A second osteotomy was performed obliquely on the anterior tibial tuberosity in the coronal plane, parallel to the anterior tibial cortex. The opening was progressive until the desired correction was achieved using the manufacturer's instrumentation. Finally, a TomoFix locking plate (Depuy Synthes, Saint Priest, France) was fitted with at least three locking screws on either side of the osteotomy. The target correction angle was measured at the point at which the mechanical axis of the lower limb passed through the Fujisawa point, which was 62.5% from the medial tibial articular margin and created a medial gap of less than 12.5 mm[19,20]. Partial (contact) weight bearing was authorized postoperatively on day 1, and full weight bearing was authorized at six weeks.

Assessment of outcomes

Two types of outcome assessment were collected in this study. The primary outcome was the patient-reported outcome measure, including the Oxford Knee Scores (OKS) and Knee Society Scores (KSS). The secondary outcomes were range of motion (ROM) and radiographic results. We compared the pre-operative and post-operative

five-year follow-up. Statistical significance was set than 0.05.

Statistical Analysis

Descriptive statistics were presented as the means and standard deviations for continuous variables, and frequencies with percentages for categorical variables. Student's unpaired t-test was used to compare the quantitative variables of the cohorts. Categorical data, such as sex and OKS, were analyzed using either Fisher's exact test or chi-squared test. Statistical analyses were performed using SPSS Statistics (version 23; SPSS Inc., Chicago, IL, USA) at a significance level of 0.05.

RESULTS

Twenty patients with OWHTO were included in this study after screening. The mean age was 52.65 ± 4.88 years. The mean follow-up duration was 5.05±0.43 years, and the patient characteristics are shown in Table 1. Pre and postoperative KSS, OKS, and ROM scores are shown in Table 2, and Table 3 lists the radiographic results.

Table 1 Patient characteristics.

Description	HTO (n = 20)
Mean Age (y)	52.65±4.88
Gender	
Female (n, %)	18 (90%)
BMI (kg/m2)	20.02±2.50
Affected side	
Left	10
Right	10
Bilateral	0
Follow-up duration (y)	5.05±0.43

Table 2 Pre-operative and Post-operative KSS scores, Oxford scores and ROM.

Description	Preoperative	Postoperative	p-value
Oxford Knee Scores	20.85±3.47	36.70±2.16	0.034
Knee Society Score	35.80±20.00	53.20±20.20	0.020
Range of motion	100.59±11.22	120.57±11.08	0.044

Table 3 Radiographic Results.

Description	Preoperative	Last follow up	p-value
Femoro-tibial angle	-4.00±2.50	8.00±3.50	<0.001
Posterior tibial slope	8.04±1.30	8.20±1.80	0.437
Medial joint space	3.05±1.20	4.80±1.40	0.092
Insull-Savati ratio	1.09±0.11	1.03±0.11	0.100

Fig. 1. Pre-operative standing radiograph.

Fig. 2. Post-operative follow-up four years standing radiograph.

The femoral tibial angle was defined as the angle between the anatomical axis of the femur and tibia in the anteroposterior (AP) view of the knee joint. The posterior tibial slope was measured using the proximal tibial anatomical angle. The left preoperative lateral radiograph in Fig 1 shows the posterior tibial slope. The medial joint space was defined as the joint space distance, and measured as follows: A line was drawn parallel to both femoral condyles, and a second line drawn parallel

to both tibial condyles in the anteroposterior (AP) standing view of the knee joint.

No complications or failures were noted. Both groups had complete survival. No revisions were conducted for any reason.

DISCUSSION

In this study, we conducted a retrospective review of patient data. Functional outcomes were evaluated in terms of OKS, KSS, ROM pre- and post-operatively, and radiographic results pre-operative and last follow-up. According to the results, midterm follow-ups for OWHTO were found to have good outcomes. OWHTO has attracted increasing interest in recent years because it avoids incurring neurological complications, such as peroneal nerve palsies, and can overcome the difficulties associated with total knee arthroplasty after closed wedge osteotomy[21,22]. The advantages of an open wedge over a closed wedge osteotomy include realignment of the anatomy with the addition of bone to the diseased medial side, the ability to achieve a predictable correction in the coronal and sagittal planes, the ability to intraoperatively adjust the correction, the requirement for only a single bone cut, and the relative ease of combining this technique with other procedures such as anterior cruciate ligament (ACL) reconstruction[23]. Koshino et al. (2003) examined 21 knees treated with OWHTO using a hydroxyapatite wedge as a bone graft substitute[24]. The mean Hospital for Special Surgery score of knees treated with OWHTO was superior to that in a previous study of knees treated with a closed wedge procedure[25]. The tibial slope is an important parameter that influences knee biomechanics. The proximal anteromedial tibial cortex has an oblique or triangular shape when viewed cross-sectionally, whereas the lateral tibial cortex is almost perpendicular to the posterior margin of the tibia. Because of this configuration, an open-wedge osteotomy with an anterior tibial tubercle gap equal to the gap at the posteromedial crest increases the tibial slope, alters the femorotibial contact point, decreases knee extension, and potentially increases the ACL tensile load[26-28]. However, there is considerable controversy regarding the ideal valgus correction angle. Insall et al. (1984) reported that a postoperative valgus position ranging from 5° to 14° was acceptable[29]. It is probably better to err on the valgus side of this spectrum, even though a noticeable valgus position might be cosmetically unacceptable to the patient, particularly if the varus angulation of the contralateral knee creates a so-called "wind-blown" appearance. Coventry and Bowman (1982) recommended that overcorrection of a normal 5° anatomical valgus to improve long-term results[30]. The precise effects of various degrees of overcorrections have not yet been reported. However, excessive valgus angulation may not only overload the lateral compartment but also be cosmetically undesirable. Over the years, surgeons and researchers have reached a compromise of a valgus angulation between 7° and 10 °. When performing univariate analysis of the risk factors for failure related to angular correction, Coventry et al. (1993) confirmed that knees with less valgus correction had a higher risk of failure, with a lower risk of failure for knees with more correction[31]. Agneskirchner et al. (2007) reported that by simulating a varus deformity (0% offset from the loading axis with the medial border of the knee joint), the intra-articular pressure in the medial compartment exceeded that in the lateral compartment by approximately 45%[32]. Gradual shifting of the loading vector laterally decreased the medial pressure and increased the lateral pressure. Interestingly, in the neutral position (50%, straight leg), somewhat higher pressures were recorded laterally than they were medially, which corresponds well with existing data. In valgus positions (62% and 75%), the lateral pressure exceeded the medial pressure by 30-40%. In our study, the knees were overcorrected by 4-5° to achieve a normal femorotibial angle of approximately 6°. Thus, the femorotibial angle was set to 10-11°. Wright et al. (2001) reported that the height of the patellar bone decreased in all patients who underwent proximal tibial osteotomy[33]. This was explained by the articular surface being remote from the tibial tubercle owing to an open osteotomy. Noyes et al. (2006) also reported that the decreased height of the patellar bone was observed

at an incidence of 80%, but they noted that the corrective angle did not affect the height of the patellar bone[26]. This was explained by the fact that the degree of anterior distraction at the osteotomy site was not higher than that of anterior distraction. In addition, in our series, there were no cases of a decreased IS ratio associated with patella infra syndrome. Deltoni et al. (2008) reported that both HTO and UKA showed satisfactory results and survival rates at mid- and long-term follow-ups. A few studies have attempted to compare the two procedures and generally showed slightly better results for UKA in terms of survivorship and functional outcome[4]. However, the differences were not remarkable, and the quality of these studies was insufficient to draw definitive conclusions. However, there are numerous patients for whom knee arthroplasty cannot be performed owing to the risk of infection and difficulty in management.

Although there were no major complications in the OWHTO group in our study, the occurrence of arthroplasty complications, such as component loosening or infection, is disastrous for young patients because revision operations are more difficult. Therefore, we suggest that OWHTO might be a good alternative strategy for medial unicompartmental arthritis in young, borderline patients, when considering the risk of arthroplasty. Performing OWHTO without a bone graft was effective in obtaining a satisfactory correction angle for osteoarthritis treatment accompanied by a varus deformity. In addition, this procedure recovered the joint space and enhanced the knee joint function. Furthermore, it allowed early stage joint movement and weight-bearing after early bone union and was effective in preventing the posterior tibial slope.

Limitations

The number of patients was small, and these results need to be confirmed by conducting a long-term follow-up study.

CONCLUSION

OWHTO without a bone graft showed good clinical outcomes and fewer complications in patients with unicompartmental osteoarthritis. Thus, the results of this study suggest that OWHTO might be a feasible treatment alternative for medial unicompartmental arthritis and is safe and effective for treating patients with knee OA. Although UKA achieves slightly better results than OWHTO, OWHTO remains the treatment of choice for younger, heavier, and more active patients with medial knee arthrosis.

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