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ORIGINAL PAPER

Patient-reported outcomes correlate with functional scores after opening-wedge high tibial osteotomy: a clinical study

Seung-Beom Han[1] · Jong-Hee Lee[1] · Seul-Gi Kim[1] · Chun-Guang Cui[1] · Dong-Won Suh[2] · Seung-Yup Lee[3] · Ki-Mo Jang[1]

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Abstract
Purpose The purpose of this study was to assess post-operative patient subjective satisfaction and to analyze associated peri-operative factors following biplanar medial open wedge high tibial osteotomy (OWHTO).
Methods The study cohort consisted of 88 patients with a minimum of two years of follow-up. Patient satisfaction was evaluated with a questionnaire that assessed (1) overall satisfaction, (2) pain relief, (3) daily living functions, and (4) cosmesis. Patients were categorized into two groups (satisfied or unsatisfied) based on overall satisfaction questionnaire. Pre- and post-operative objective clinical statuses were assessed with a knee scoring system based on the American Knee Society (AKS), the Western Ontario McMaster University Osteoarthritis Index (WOMAC), and range of motion.
Results Of the 88 patients, 85.2% were graded as satisfied according to the overall satisfaction estimation. The percentage of patients satisfied with pain relief, daily living functions, and cosmesis were 85.2%, 86.4%, and 86.4%, respectively. Multivariable logistic regression analysis demonstrated that pre-operative Hip-Knee-Ankle angle (HKAA) (odds ratio (OR) = 1.812), post-operative AKS knee score (OR = 1.156), and post-operative HKAA (OR = 0.717) were significantly associated with overall satisfaction. Pre-operative HKAA (OR = 1.436), post-operative WOMAC activity score (OR = 0.865), and post-operative HKAA (OR = 0.505) were significant predictors for satisfaction with pain reduction, daily living functions, and cosmesis, respectively.
Conclusions Biplanar medial OWHTO is an effective treatment for osteoarthritis with varus deformity in terms of subjective satisfactory outcome. Several factors, including pre- and post-operative HKAA, post-operative AKS and WOMAC score, were significant predictors for subjective satisfaction.
Level of evidence: Level III

Keywords Osteoarthritis · Knee joint · Opening-wedge high tibial osteotomy · Patients reported outcomes · Satisfaction · Functional score

✉ Ki-Mo Jang
kimo98@hanmail.net

[1] Department of Orthopaedic Surgery, Anam Hospital, Korea University College of Medicine, 73 Inchon-ro (Anam-dong 5-ga) Seongbuk-gu, Seoul 02841, South Korea

[2] Department of Orthopaedic Surgery, Barunsesang Hospital, Seongnam, Gyeonggi-do, South Korea

[3] Department of Orthopaedic Surgery, Seoul Barunsesang Hospital, Seoul, South Korea

Introduction

High tibial osteotomy (HTO) is a widely performed surgical option for active and young adult patients with isolated medial compartmental osteoarthritis (OA) of the knee joint and varus alignment deformity [1–3]. The main goals of HTO are to reduce knee joint pain by re-distributing the weight-bearing forces from the medial compartment to the relatively unaffected lateral compartment, and to delay the need for a total knee arthroplasty (TKA) by slowing and stopping the destructive changes of the medial compartment. The advantages of HTO include joint preservation, the induction of biological remodeling, the repair of articular cartilage, and reduced synovitis [4–6].

Lateral closing-wedge HTO (CWHTO) has been conventionally performed with excellent clinical outcomes [7–9].

However, lateral CWHTO is technically demanding and requires fibular osteotomy and tibialis muscle detachment. Recently, medial opening-wedge HTO (OWHTO) has become popular through the development of strong plate fixation. It is technically easier and less invasive than lateral CWHTO. Through medial OWHTO, surgeons can avoid several potential complications associated with lateral CWHTO [10–12]. Many studies have already demonstrated excellent clinical and radiological outcomes following medial OWHTO [13–16].

A variety of studies have shown outcomes and related factors following HTO [17–20]. Most previous studies have used radiologic results, clinical scores, survivorship, or complications to assess the outcomes. However, there is scant published information regarding patient subjective and self-reported satisfaction following HTO. Because of the well-documented discrepancies between clinicians' and patients' health status ratings, patient subjective satisfaction could be an important outcome measure [21, 22]. Additionally, there is a lack of information about the factors influencing post-HTO subjective satisfaction, such as the pre-operative degree of lower limb varus, OA grade, body mass index (BMI), post-operative correction amount, and post-operative clinical score. Patients' opinions and sense of satisfaction regarding their HTO results are important and should be considered in evaluation studies [23].

The purpose of this study was to assess patient subjective satisfaction (patients reported outcome) following biplanar medial OWHTO. Additionally, we sought to determine which pre- and post-operative factors were correlated with patient subjective satisfaction after biplanar medial OWHTO. We hypothesized that most patients might be satisfied with biplanar medial OWHTO, and pre-operative demographics, pre- and post-operative degree of lower limb varus and objective clinical scores might be associated with subjective satisfaction.

Materials and methods

This study was performed after obtaining approval from the institutional review board of our institution. One hundred twenty consecutive patients who underwent biplanar medial OWHTO between March 2010 and December 2014 were assessed for study eligibility. All patients were diagnosed with medial compartmental OA with varus mal-alignment. The criteria for ineligibility for OWHTO were symptomatic lateral compartmental OA, flexion contracture greater than 10°, age older than 65 years, range of motion less than 100°, lateral collateral ligament laxity more than grade III, and rheumatoid arthritis. Thirty-two patients were excluded due to a diagnosis other than primary osteoarthritis, a follow-up period less than two years, and loss to follow-up, or bilateral HTO cases which have a potential for selection bias. Consequently, the resulting study cohort consisted of 88 patients (88 knees) with a minimum follow-up period of two years. All operations were performed by a single senior surgeon. All clinical and radiological data were prospectively collected. The data, including demographics, pre-operative clinical and radiological data, intra-operative data, and post-operative data, were assessed at six months and one year post-operatively and then yearly thereafter. Pre- and post-operative clinical statuses were assessed using the knee scoring system from the American Knee Society (AKS) [24], the Western Ontario McMaster University Osteoarthritis Index (WOMAC) [25], and range of motion (ROM).

The subjective satisfaction with biplanar medial OWHTO was evaluated using a satisfaction questionnaire at annual follow-up exams according to previous studies which developed and utilized a validated satisfaction scale [26–29]. In addition to three questions in a recent study [29], we included a question regarding cosmesis. Therefore, the satisfaction questionnaire included four questions: (1) Overall, how satisfied are you with the results of your surgery? (2) How satisfied are you with your surgery for reducing your pain? (3) How satisfied are you with your surgery for improving your ability to perform daily living functions (walking, going upstairs, getting in/out of a car, using your bed, performing light domestic tasks), and (4) How satisfied are you with your surgery regarding cosmesis? All patients were asked to provide a response for each question based on a five-point scale (very satisfied, satisfied, neutral, dissatisfied, or very dissatisfied). Patients were categorized into two main groups (satisfied or unsatisfied) based on overall satisfaction. Patients whose answers fell within the very satisfied or satisfied range for overall satisfaction were categorized into the satisfied group, and those who answered neutral, dissatisfied, or very dissatisfied were classified into the unsatisfied group [29]. These two categories (satisfied and unsatisfied) were primary variables used in this study to statistically measure overall satisfaction.

Surgical technique

Pre-operative planning was conducted using a method previously described by Miniaci et al. [30]. Arthroscopic examination was performed in all cases to assess intra-articular status. If necessary, meniscal procedures such as a meniscectomy or repair were performed. Cartilage repair procedures such as microfracture or subchondral drilling were not performed in any enrolled patients. Subsequently, a 5-cm anteromedial longitudinal incision was made approximately two fingerbreadths medial to the tibial tuberosity. The sartorial fascia was exposed by a soft tissue dissection, and the pes anserinus was retracted distally with a retractor. The distal part of the medial collateral ligament was released distally with a periosteal elevator. Two guide pins were inserted along the planned plane under fluoroscopic guidance, and the

osteotomy was performed just distal to the guide pins. Under fluoroscopic guidance, sharp osteotomes were advanced carefully to approximately 1 cm from the lateral cortex. Then, a vertical osteotomy of the biplanar osteotomy was performed at the posterior aspect of the tibial tuberosity. The bony insertion of the patellar tendon was preserved and attached to the distal tibial fragment. The opening of the osteotomy site was carried out carefully to the planned width with caution to avoid lateral cortical breakage. When the planned osteotomy width was achieved, the mechanical axis of the lower extremity was assessed under fluoroscopic guidance using a metal rod. The osteotomy site was stabilized using a fixed angle plate with locking screws (TomoFix plate, Synthes, Bettlach, Switzerland). The anterior and posterior opening widths were checked and recorded after the plate fixation in every case. To avoid an increased posterior tibial slope, we followed previous recommendations [31, 32]. First, the anterior gap was restricted to one-half to two-thirds of the posterior gap. Second, a complete osteotomy was performed on the posterior tibial aspect, and third, a spreader was positioned as posterior as possible. Lastly, the plate was fixed with the knee joint fully extended, and the posterior slope was also checked under fluoroscopic guidance.

The drain was removed on the day after surgery, and post-operative rehabilitation including isometric quadriceps exercises, straight leg raising exercises, and active ankle exercises were started gradually. Patients were educated to perform a toe-touch weight-bearing gait with crutches during first two weeks after surgery and a partial weight-bearing gait for the next four weeks. A full weight-bearing gait was usually permitted by six to eight weeks. Post-operative casts or braces were not applied.

Radiographic evaluation

Pre- and post-operative standing AP lower leg radiographs were taken to assess the hip-knee-ankle angle (HKAA) of the lower limb before and after biplanar medial OWHTO in all patients. Patients were instructed to place their weight on both feet with their patella facing forward and knee extended. The HKAA, defined as the angle between a line from the centre of the femoral head to the centre of the knee joint and a line from the centre of the ankle joint and to the centre of the knee joint, was calculated on the standing AP lower leg radiographs using a Picture Archiving and Communication System (PACS) workstation (STARPACS, INFINITT Healthcare, Seoul, South Korea).

Statistical analysis

The data were recorded using Microsoft Excel 2010 (Microsoft Corp., Redmond, WA, USA). The Kolmogorov-Smirnov test was carried out to test the normality of the distributions. Means and standard deviations were calculated for normally distributed variables, and frequencies were measured for categorical variables. All knees were divided into two groups: the satisfied group (very satisfied and satisfied responses) and the unsatisfied group (neutral, dissatisfied, and very dissatisfied responses). Statistically significant differences in demographic and pre-/post-operative data were determined between the two groups. A chi-square test was used for categorical variables, Student's t-test for continuous variables, and the Mann-Whitney U-test for non-parametric analyses. To determine predictors for patient satisfaction, multivariable logistic regression analyses were used with a backward stepwise method. Multivariable logistic analyses were performed for the variables with p-values <0.1 in the univariable analyses. Odds ratios and 95% confidence intervals (CIs) were calculated. All statistical analyses were performed using SPSS 20.0 (SPSS Inc., Chicago, IL, USA), and a P-value <0.05 was considered statistically significant.

Results

The mean age was 57.2 ± 5.1 years (range, 47–65 years) at the time of surgery. The enrolled cohort was composed of 67 females and 21 males. Mean patient height and weight were 160.3 cm (SD = 7.8) and 66.7 kg (SD = 8.6). Mean BMI was 26.0 kg/m^2 (SD = 2.6). The mean follow-up period was 38.5 months (range, 24–80 months). Pre-operatively, the mean HKAA of each lower extremity was varus 7.1 ± 2.8°. The mean AKS knee score and WOMAC total score were 64.8 ± 8.8 and 44.7 ± 11.7, respectively. The mean flexion contracture (FC) and full flexion (FF) angles were 3.1 ± 4.2° and 139.3 ± 3.6°, respectively (Table 1). Post-operatively, the

Table 1 Pre-operative patients' demographics

Parameter	Value
Male: Female	21: 67
Age	57.2 ± 5.1 (47–65)
Height (cm)	160.3 ± 7.8
Weight (kg)	66.7 ± 8.6
BMI (kg/m^2)	26.0 ± 2.6
Pre-operative K-L grade (knees)	I (3) / II (55) / III (22) / IV (8)
Pre-operative FC (°)	3.1 ± 4.2
Pre-operative FF (°)	139.3 ± 3.6
Pre-operative HKAA (°)	varus 7.1 ± 2.8
Pre-operative AKS knee score	64.8 ± 8.8
Pre-operative WOMAC total	44.7 ± 11.7

AKS American knee society, *FC* flexion contracture, *FF* full flexion, *K-L* Kellgren-Lawrence, *HKAA* hip-knee-ankle angle, *BMI* body mass index, *WOMAC* Western Ontario McMaster University Osteoarthritis Index Scales

mean HKAA changed significantly to valgus 3.3 ± 3.2° ($P < 0.001$). The mean AKS knee score increased significantly to 92.1 ± 5.5 ($P < 0.001$), and the WOMAC total score decreased significantly to 10.9 ± 7.3 ($P < 0.001$). Post-operative mean FC and FF angles changed to 0.6 ± 2.6° ($P < 0.001$) and 139.3 ± 6.5° ($P = 0.372$), respectively.

Of the 88 knees, 75 (85.2%) were graded as satisfied (very satisfied or satisfied), and 13 (14.8%) were graded as unsatisfied (neutral, dissatisfied, or very dissatisfied) according to the overall satisfaction estimation, which was used as a proxy for satisfaction outcome. The number of patients satisfied with pain relief, daily living functions, and cosmesis were 75 (85.2%), 76 (86.4%), and 76 (86.4%), respectively.

In the comparisons between the satisfied and unsatisfied patients regarding pre-operative variables, there were statistically significant differences in BMI and HKAA. The satisfied group had significantly lower pre-operative BMI ($P = 0.026$) and significantly more varus pre-operative lower limb alignment ($P < 0.001$). The satisfied group also had significantly better post-operative clinical outcomes, including AKS knee score ($P = 0.004$) and WOMAC activity score ($P = 0.039$). Additionally, the satisfied group showed significantly less valgus post-operative limb alignment ($P = 0.007$) (Table 2).

Several pre-operative factors (BMI and HKAA) and post-operative factors (HKAA, AKS knee score, WOMAC total score, and WOMAC activity score) were found to be significant predictors for overall satisfaction following biplanar OWHTO in univariable analyses. Multivariable logistic regression analysis demonstrated that the pre-operative HKAA (odds ratio = 1.812), post-operative AKS knee score (odds ratio = 1.156), and post-operative HKAA (odds ratio = 0.717) were significantly associated with overall satisfaction. Pre- and post-operative HKAA were assessed using the absolute value; thus, patients were more satisfied after their operation when the pre-operative varus was greater, whereas less satisfied as the overcorrection (valgus) of HKAA increased after their operation (Table 3).

BMI, pre- and post-operative HKAA, and pre- and post-operative WOMAC pain scores were statistically significant factors for predicting successful pain relief in univariable analyses. Among these factors, pre-operative HKAA was the only significant predictor in multivariable logistic regression analysis (odds ratio = 1.436) (Table 4). Post-operative WOMAC activity score was the only significant predictor for daily living function satisfaction (odds ratio = 0.865) in multivariable logistic regression analysis (Table 5). Only post-operative HKAA (odds ratio = 0.505) was found to be a statistically significant negative predictor for cosmetic satisfaction (Table 6).

Combined arthroscopic procedures were performed in 35 patients (39.8%). Arthroscopic partial meniscectomy was performed in 31 patients, subtotal meniscectomy in one patient, and arthroscopic meniscus repair in three patients. However, none of the combined arthroscopic procedures were found to have statistically significant correlation with post-operative subjective satisfaction ($P > 0.05$).

Discussion

The most important finding of this study was that most of the patients were satisfied with their biplanar medial OWHTO, which coincided with better objective clinical outcomes over a short to mid-term follow-up period. Overall, 85.2% of enrolled patients showed subjective satisfaction with their surgeries. This overall satisfaction was positively related to pre-operative HKAA and post-operative AKS knee score and negatively related to post-operative HKAA.

Objective assessment is important after surgical treatment. However, objective outcomes cannot be the only representative measurements for surgery results. In addition to the objective outcome, a patient's subjective satisfaction following surgery should be estimated as part of the overall post-operative outcome. There have been several studies regarding post-operative satisfaction after HTO, showing consistently relatively high ratings [9, 33–37]. However, these previous studies mostly only estimated overall satisfactory outcomes using a simple satisfaction index, without further evaluating specific categories of satisfaction. Additionally, analyses of factors related to post-operative satisfaction were not sufficient. In this study, we attempted to investigate specific satisfaction items such as pain reduction, daily living function, and cosmesis, as well as overall satisfaction using previously validated methods [26–29]. Unlike previous studies, we enrolled only patients who underwent biplanar medial OWHTO, which has become a common method.

Overall satisfaction following biplanar medial OWHTO was estimated as 85.2% in this study. Schallberger et al. reported that the median satisfaction index was 80% after opening and closing wedge osteotomies without a statistically significant difference between the two surgical methods [9]. In another study, Miller et al. demonstrated that the mean satisfaction score was 7.6 of 10, and there was a positive correlation observed between the satisfaction score and the objective Lysholm score after medial OWHTO using an external fixator and Puddu plate [33]. Therefore, although the measurement methods were somewhat different, the degree of overall satisfaction in our study was consistent with that found in previous studies. Clinical outcomes, as measured by the AKS knee score and WOMAC score, were better among the satisfied group compared with the unsatisfied group, and the mean AKS knee score was a significant positive predictor for overall satisfaction. Thus, it seems that biplanar medial OWHTO can be an efficient surgical option for treating degenerative varus knees in terms of both objective and subjective assessments.

Table 2 Comparison of pre- and post-operative variables between the satisfied and unsatisfied groups

Pre-operative variables	Satisfied	Unsatisfied	p-value
Gender	M:18 / F:56	M:3 / F: 11	0.827
Age (years)	57.0 ± 6.3	55.9 ± 6.1	0.287
Height (cm)	160.6 ± 8.1	158.4 ± 6.2	0.356
Weight (kg)	66.2 ± 8.8	69.6 ± 7.0	0.187
BMI (kg/m²)	25.6 ± 2.5	27.7 ± 2.6	***0.015***
Pre-operative AKS knee score	65.3 ± 9.0	61.8 ± 6.8	0.167
Pre-operative WOMAC (total) score	44.4 ± 11.8	46.1 ± 11.5	0.605
Pre-operative WOMAC (pain) score	9.0 ± 3.2	9.6 ± 3.1	0.562
Pre-operative WOMAC (stiff) score	3.0 ± 1.9	2.7 ± 1.9	0.545
Pre-operative WOMAC (activity) score	32.3 ± 9.1	33.9 ± 9.1	0.558
Pre-operative FC (°)	3.1 ± 4.2	3.2 ± 4.2	0.898
Pre-operative FF (°)	139.2 ± 3.5	138.9 ± 4.0	0.771
Pre-operative HKAA (°)	varus 8.7 ± 3.0	varus 4.1 ± 0.7	***<0.001***
Pre-operative K-L grade	I (2) / II (44) / III (21) / IV (7)	I (1) / II (11) / III (1) / IV (1)	0.357
Post-operative variables	Satisfied	Unsatisfied	p-value
Post-operative FU period (month)	37.2 ± 15.6	44.3 ± 20.6	0.165
Post-operative HKAA (°)	valgus 2.9 ± 3.3	valgus 5.3 ± 1.3	***0.007***
Post-operative FC (°)	0.6 ± 2.5	0.7 ± 2.7	0.908
Post-operative FF (°)	139.0 ± 4.0	138.6 ± 3.6	0.739
Post-operative AKS knee score	92.8 ± 5.6	88.3 ± 2.8	***0.004***
Post-operative WOMAC (total) score	10.3 ± 6.9	14.4 ± 8.5	0.054
Post-operative WOMAC (pain) score	2.0 ± 1.7	2.8 ± 2.3	0.138
Post-operative WOMAC (stiff) score	0.9 ± 1.1	0.9 ± 0.9	0.778
Post-operative WOMAC (activity) score	7.3 ± 5.0	10.6 ± 6.8	***0.039***

BMI body mass index, *AKS* American Knee Society, *FC* flexion contracture, *FF* full flexion, *K-L* Kellgren-Lawrence, *HKAA* hip-knee-ankle angle, *WOMAC* Western Ontario McMaster University Osteoarthritis Index Scales, *FU* follow-up

Data are presented as mean ± standard deviation. Statistically significant *p*-values (< 0.05) are shown in *italics*

Pre- and post-operative limb alignment (HKAA) was another significant predictor for overall satisfaction in the present study. Patients with more varus deformities in pre-operative HKAA reported greater satisfaction with their surgeries. However, post-operative HKAA was a negative predictor. There is still debate regarding alignment correction in HTO. Traditionally, approximately 62% of the weight bearing line ratio or a femoro-tibial angle of 170° was the post-operative alignment target [38–40]. Some authors have suggested that an over-correction of alignment would be optimal [41, 42]. However, post-operative HKAA was shown to be negatively associated with overall satisfaction, i.e., patients were less satisfied as alignment overcorrection increased. Furthermore, a recent study demonstrated that no significant

Table 3 Significant predictors associated with overall satisfaction

Variable	*p*-value (univariable)	Odds ratio (95% CI for odds ratio, *p*-value)
BMI	0.032	Not significant
Pre-operative HKAA	0.003	1.812 (1.155–2.842, $p = 0.01$)
Post-operative HKAA	0.012	0.717 (0.54–0.951, $p = 0.021$)
Post-operative AKS knee score score	0.011	1.156 (1.024–1.305, $p = 0.02$)
Post-operative WOMAC total score	0.064	Not significant
Post-operative WOMAC activity score	0.049	Not significant

BMI body mass index, *HKAA* hip-knee-ankle angle, *AKS* American Knee Society, *WOMAC* Western Ontario McMaster University Osteoarthritis Index Scales

The p-value was determined with multivariable logistic regression analysis

Table 4 Significant predictors associated with satisfaction for pain relief

Variable	*p*-value (univariable)	Odds ratio (95% CI for odds ratio, *p*-value)
BMI	0.051	Not significant
Pre-operative HKAA	0.041	1.436 (1.026–2.008, $p = 0.038$)
Pre-operative WOMAC pain	0.096	Not significant
Post-operative HKAA	0.064	Not significant
Post-operative WOMAC pain	0.087	Not significant

BMI body mass index, *HKAA* hip-knee-ankle angle, *WOMAC* Western Ontario McMaster University Osteoarthritis Index Scales

The p-value was determined with multivariable logistic regression analysis

differences were found in cartilage regeneration between over- and moderate correction [43]. Thus, the optimal target for alignment correction should be investigated further, considering subjective satisfactory outcomes as well as objective clinical assessments.

In our subdivided assessments of post-operative satisfaction, 85.2% of enrolled patients were satisfied with their pain relief, 86.4% with daily living functions, and 86.4% with cosmetic changes. Patient satisfaction with pain relief significantly correlated with pre-operative HKAA, satisfaction with daily living functions was significantly positively correlated with post-operative WOMAC activity score, and satisfaction with cosmetic change was negatively associated with post-operative limb alignment (HKAA). The subdivided assessments of post-operative satisfaction also roughly corresponded to objective radiologic and clinical assessments; thus, an exact assessment of objective radiologic and clinical outcomes might be necessary to recognize and predict subjective satisfactory outcomes. Regarding satisfaction with cosmetic change, the greater was the alignment correction, the less satisfied was the patient with cosmetic outcome, and increased overcorrection was associated with cosmetic dissatisfaction in patients. Overcorrection was also a negative predictor for overall post-operative satisfaction. Thus, cosmetic dissatisfaction with alignment overcorrection might have influenced patients' overall dissatisfaction. Meanwhile, neither gender nor age was significantly correlated with cosmetic or overall satisfaction. These findings are consistent with previous studies and suggest that gender might not play a significant role in patient selection in HTO [33, 44, 45].

This study has several limitations. First, the number of enrolled knees was relatively small. Nevertheless, the measurements were normally distributed. Second, we enrolled patients who underwent short to mid-term (at least two year) follow-up; our mean follow-up duration was 38.5 months, and 68.2% (60/88) of enrolled patients had only a two- or three-year follow-up period. Patient subjective satisfaction and objective clinical outcome may change with long-term follow-up [29]. Accordingly, the described correlations may change over time. Therefore, further studies with larger numbers of patients and a longer follow-up duration are necessary to clarify post-operative satisfactory outcomes and related findings following biplanar medial OWHTO. Third, we investigated and analyzed post-operative outcomes only from the population of a single Asian country. Patient activities and expectations for their surgeries may differ from country to country. Thus, a study with patients from different countries could suggest findings that are more generalized. Lastly, there is still no available satisfaction assessment method specified for HTO. Thus, we referred to satisfaction questionnaires in previous studies to measure patient satisfaction [29]. To achieve more refined results for post-operative satisfaction

Table 5 Significant predictors associated with daily living function satisfaction

Variable	*p*-value (univariable)	Odds ratio (95% CI for odds ratio, *p*-value)
BMI	0.049	Not significant
Pre-operative AKS knee score	0.064	Not significant
Post-operative AKS knee score	0.031	Not significant
Post-operative WOMAC total score	0.008	Not significant
Post-operative WOMAC pain score	0.034	Not significant
Post-operative WOMAC activity score	0.006	0.865 (0.692 to 0.926, $p = 0.006$)

BMI body mass index, *AKS* American Knee Society, *WOMAC* Western Ontario McMaster University Osteoarthritis Index Scales

The p-value was determined with multivariable logistic regression analysis

Table 6 Significant predictors associated with cosmetic satisfaction

Variable	*p*-value (univariable)	Odds ratio (95% CI for odds ratio, *p*-value)
Pre-operative HKAA	0.093	Not significant
Post-operative HKAA	0.004	0.505 (0.294–0.868, $p = 0.013$)
Post-operative AKS knee score	0.048	Not significant

HKAA hip-knee-ankle angle, *AKS* American Knee Society

The p-value was determined with multivariable logistic regression analysis

analyses, a validated scale or scoring system for satisfaction assessment specified for HTO would be necessary for future studies.

Conclusion

Despite its limitations, this study demonstrated that biplanar medial OWHTO is an effective treatment for OA with varus deformity in terms of subjective satisfactory outcomes. Several peri-operative factors, including pre- and post-operative HKAA, post-operative AKS knee score, and post-operative WOMAC score, were significant positive or negative predictors of post-operative subjective satisfaction. Findings from this study should be taken into consideration for pre- and post-operative patient consultations and management when surgeons perform biplanar medial OWHTO.

Compliance with ethical standards

Conflict of interest statement The authors have no financial or personal relationship with other people or organizations that could inappropriately influence this study, including consultancies, employment, stock ownerships, paid expert testimony, honoraria, patient applications/registrations, and grants or other funding.

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