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Better clinical results after closed- compared to open-wedge high tibial osteotomy in patients with medial knee osteoarthritis and varus leg alignment

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Abstract

Purpose Studies comparing mid- or long-term outcomes of open- and closed-wedge high tibial osteotomy are limited. Here, the midterm survival rate and clinical and radiographic outcomes were compared for these two techniques. The study hypothesis, based on short-term follow-up, was that after midterm follow-up, the two techniques would not differ.

Methods A prospective follow-up study was conducted for a previously reported randomized controlled trial of an original 50 patients (25 open-wedge osteotomy and 25 closed-wedge osteotomy) with medial knee osteoarthritis and a varus leg alignment. We analyzed patients without knee arthroplasty (mean age 48.7 years, SD 8.0) for clinical and radiographic follow-up.

Results Five patients in each group had undergone conversion to a total knee arthroplasty or unicompartmental knee arthroplasty, leaving 19 patients for analysis in each group. At 7.9 years of follow-up (range 7–9 years), survival did not differ significantly between groups (open-wedge group 81.3 % [95 % confidence interval (CI) 75.2–100], closed-wedge group 82.0 % [95 % CI 66.7–100]). At final follow-up, total Dutch Western Ontario and McMaster Universities Arthritis (WOMAC), Knee Society Score, and visual analog scale (VAS) pain did not differ between groups. However, the results were significantly better in the closed-wedge group for VAS satisfaction and WOMAC pain and stiffness compared to the open-wedge group. Radiographic evaluation did not differ between groups for any outcome at final follow-up.

Conclusion After a mean follow-up of 7.9 years, patients undergoing a closed-wedge osteotomy had favorable clinical results compared to those who underwent an open-wedge osteotomy.

Level of evidence II.

Keywords Open-wedge high tibial osteotomy · Closed-wedge high tibial osteotomy · Osteoarthritis · Knee · RCT

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Introduction

High tibial osteotomy is performed to stop or inhibit progression of osteoarthritis (OA) of the knee joint and to avoid or postpone placement of a knee arthroplasty in patients with medial knee OA. In several studies, different techniques have been evaluated, each with their own advantages, disadvantages, and complications [8, 19, 21, 29]. The techniques most commonly used include closed-wedge osteotomy (CWO) and open-wedge osteotomy (OWO), stabilized by a locking plate [19, 21].

Long-term (10–20 years) survival of CWO is well documented in the literature, varying between 74 and 97.6 % after 10 years [1, 9, 16, 30, 32], 56–93.2 % at 15 years [1, 9, 16, 30, 32], and 66.9–85.1 % at 20 years [9, 32]. The survival rates of OWO are not as well documented, but are reported to be between 88.9 and 97 % at 5 years [3, 26, 31] and 74–89 % at 10 years [5, 26]. For both techniques, good clinical and radiographic results are described [5, 12, 13, 16, 23, 26, 32]. Disadvantages of CWO include the need for a fibular osteotomy, the high rate of tibial neuropathies, bone stock loss, and a more demanding subsequent total knee arthroplasty [19, 21]. OWO has been associated with high nonunion rates, donor site morbidity (if an autograft is used), loss of correction due to unstable fixation, and increased posterior tibial slope [19, 21].

OWO has gained popularity in recent years, but direct comparisons of the two techniques are rare, and mid- and long-term comparisons are almost completely lacking [11, 27]. Because a valgus osteotomy is still an important treatment option for patients with medial knee OA and a varus leg alignment, knowing which technique is superior is relevant. To address these gaps in the literature, this study was conducted as an update of a previous report after a mean follow-up of 7.9 years (range 7–9 years). The current work involved analysis of differences in survival and clinical and radiographic outcomes between patients with medial knee OA and a varus leg alignment who were treated with an open- or a closed-wedge high tibial osteotomy. The study hypothesis, based on short-term follow-up findings, was that after midterm follow-up, the outcomes for the two techniques would not differ.

Materials and methods

This prospective follow-up study was carried out between March 2012 and January 2013. All patients without a knee arthroplasty who participated in the previous randomized controlled trial [11] (2002/181) were invited to visit one of two orthopedic outpatient clinics (Rijnstate Hospital in Arnhem and Radboud University Medical Centre in Nijmegen, the Netherlands) once for questionnaires, physical examination, and radiographs of the knee and of the whole leg. Informed consent was obtained.

The initial inclusion criteria were radiological evidence of medial gonarthrosis, age 18–70 years, and having a hip–knee–ankle varus alignment. Exclusion criteria were rheumatoid arthritis and previous osteotomy of the same knee. Initially, 50 patients (50 knees) were included, between January 2003 and March 2005, and allocated to the medial OWO group (25 patients) or the lateral CWO group (25 patients) using a randomization procedure with sealed opaque envelopes. A four-hole angle stable plate (Numelock II System, Stryker, Switzerland) and screws were used as fixation devices. In the OWO group, an appropriate tricalcium-phosphate (TCP) wedge (Otis, Lourdes, France) was used as a defect filler. In keeping with a standardized operation technique, a TCP wedge was used in all OWO. The preoperative goal of correction was an overcorrection of 4° of the mechanical femur–tibial axis. The surgical techniques have been described in a previous report of Gaasbeek et al. [11].

The survival rate at mean final follow-up was determined based on conversion or not to total knee arthroplasty (TKA) or unicompartmental knee arthroplasty (UKA). The clinical evaluation consisted of the Knee Society Score (KSS) [14], visual analog scale (VAS) for pain and satisfaction, and the Dutch Western Ontario and McMaster Universities Osteoarthritis index (WOMAC) [24]. The KSS [14] assesses pain, range of movement, stability, and ability to walk and climb stairs, with 200 points representing the best possible function. A VAS for pain and satisfaction is a 0–10-point scale to assess pain and satisfaction. In VAS pain, 0 indicates no pain, and 10 is the worst pain the patient can imagine. A VAS satisfaction score of 0 is the lowest score (unsatisfied), and 10 is the highest score (very satisfied). The WOMAC [24] is a disease-specific questionnaire, divided into five questions about pain, two about stiffness, and 17 about function. Scores from 0 to 96 are possible. The optimum score is zero.

In the preoperative period, at 1 year of follow-up, and at final follow-up, radiographs were made of the whole leg (double-limb stance, hip-to-ankle) and the knee (weight-bearing anteroposterior and true lateral views at 30° of flexion). One investigator (NvE) performed the measurements. The radiographic evaluation consisted of grading the severity of OA of the knee, using the Kellgren and Lawrence system [15]. The patellar height was measured according to Caton Deschamps index (CI) [4]. The tibial slope was calculated as the angle determined between the tibial anatomical axis and the tangent to the medial plate [18]. Furthermore, the mechanical axis was measured following the method described by Dugdale et al. [6], in which the angle is calculated between the weight-bearing line (drawn from the center of the femoral head to the center of the tibiotalar joint) and a line drawn from the center of the knee to the center of the ankle.

Approval of the Medical Ethics Committee (Radboud University Medical Centre Nijmegen, ID-number 2011/531) was obtained.

Statistical analysis

Total test scores for continuous and categorical variables (hip–knee angle, WOMAC, KSS, VAS pain, VAS satisfaction, CI, tibial slope, OA severity) at baseline and after 1 year of follow-up from the study by Gaasbeek et al. [11] were used in the current analyses. Total test scores [mean or median, standard deviation (SD) or range, frequencies or percentages] for the same continuous and categorical variables were calculated for both groups at mean final follow-up. To assess normality, we used the Kolmogorov–Smirnov

Table 1 Demographic parameters

Parameter	Open-wedge osteotomy ($n = 25$)	Closed-wedge osteotomy ($n = 25$)	Total group ($n = 50$)	P value
Male/female (n)	15/10	16/9	31/19	n.s.[c]
Age (years)[a]	47.1 (8.5)	50.3 (7.4)	48.7 (8.0)	n.s.[b]
Side L/R (n)	16/9	8/17	24/26	n.s.[c]
Location Rijnstate/Radboud (n)	17/8	19/6	36/14	0.022
BMI (kg/m^2)[a]	29.7 (4.2)	28.4 (3.0)	29.0 (3.7)	n.s.[b]

Gaasbeek et al. [11]

BMI body mass index, *n* number, *n.s.* nonsignificant

[a] Values given as mean (standard deviation)

[b] Student's *t* test

[c] Chi-squared test

Table 2 Baseline parameters

Parameter	Open-wedge osteotomy ($n = 25$)	Closed-wedge osteotomy ($n = 25$)	Total group ($n = 50$)	P value
HKA (°)[a]	4.3 (2.2)	4.1 (2.2)	4.2 (2.2)	n.s.[b]
WOMAC (0–96)[a]	52.0 (18.6)	46.5 (14.9)	49.2 (16.9)	n.s.[b]
KSS (0–200)[a]	111.7 (24.1)	113.6 (15.9)	112.6 (20.2)	n.s.[b]
VAS pain (0–10)[a]	6.6 (1.7)	6.4 (1.3)	6.5 (1.5)	n.s.[b]
VAS satisfaction (0–10)[a]	2.3 (1.8)	2.8 (1.8)	2.6 (1.8)	n.s.[b]
OA classification (n)	I: 8	I: 11	I: 19	n.s.[c]
	II: 9	II: 12	II: 21	
	III: 7	III: 1	III: 8	
	IV: 1	IV: 1	IV: 2	
CI[a]	1.0 (0.2)	1.0 (0.2)	1.0 (0.2)	n.s.[b]
Tibial slope (°)[a]	16.2 (2.7)	14.6 (3.6)	15.4 (3.2)	n.s.[b]

Gaasbeek et al. [11]

HKA hip–knee–ankle, *WOMAC* Western Ontario and McMaster University osteoarthritis index, *KSS* Knee Society Score, *VAS* visual analog scale, *OA* osteoarthritis classification Kellgren and Lawrence, *CI* Caton index, *n* number, *n.s.* nonsignificant

[a] Values given as mean (standard deviation)

[b] Student's *t* test

[c] Fisher's exact test

and Shapiro–Wilk tests. The Levene test was used to check the assumption of equal group variance.

The Student's *t* test or Mann–Whitney *U* test was used to analyze differences in continuous data at final follow-up between treatment groups. The Fisher's exact test or chi-squared test was used in case of categorical variables. A $P < 0.05$ was considered significant. Survivorship analysis was performed using the Kaplan–Meier method with conversion to TKA or UKA as the end point at 5 years and at final follow-up [percentage and 95 % confidence interval (95 % CI)]. Differences between the two treatment groups were calculated with a log-rank test. All data were analyzed with SPSS version 18.0 (SPSS Benelux BV, IBM Company Nieuwegein, The Netherlands).

In the initial report [11], a sample size was calculated based on an expected 30 % difference in the ratio of lateral ligament instability between the two groups. To detect such a difference with $\alpha = 0.05$ and a power of 80 %, 25 patients were required in each group.

Results

Demographic and baseline parameters of the 50 included patients (25 CWO and 25 OWO) are shown in Tables 1 and 2. The results at 1 year of follow-up are shown in Table 3 [11].

Two patients were lost to follow-up because of emigration. A total of nine patients (five OWO, four CWO) were converted to a TKA, and one patient received a UKA (one CWO) before final follow-up, leaving 19 patients in each group for clinical and radiographic analysis. Four patients

Table 3 Results at 1-year follow-up

Parameter	Open-wedge osteotomy ($n = 25$)	Closed-wedge osteotomy ($n = 25$)	Total group ($n = 50$)	Mean difference (95 % confidence interval)	P value
HKA (°)	3.6 (1.6)[a]	3.9 (2.0)[a]	3.8 (0.6–7.4)[b]	0.4 (−1.4; 0.7)	n.s.[c]
Correction angle HKA preoperative and 1 year (°)	7.8 (2.6)[a]	8.0 (2.7)[a]	7.9 (2.6)[a]	0.2 (−1.7; 1.3)	n.s.[c]
WOMAC (0–96)	20.0 (19.4)[a]	14.0 (0–48)[b]	13.5 (0–70)[b]	4.0 (−5.9; 13.9)	n.s.[c]
KSS (0–200)	182 (140–200)[b]	185 (130–200)[b]	185 (130–200)[b]	3.6 (−16.6; 9.4)	n.s.[d]
VAS pain (0–10)	2.5 (1.9)[a]	1.8 (1.5)[a]	2 (0–7)[b]	0.6 (−0.4; 1.6)	n.s.[c]
VAS satisfaction (0–10)	8.5 (3–10)[b]	9.1 (6–10)[b]	8.8 (3–10)[b]	0.9 (−1.8; 0.1)	n.s.[d]
CI	0.9 (0.6–1.3)[b]	1.0 (0.2)[a]	0.9 (0.6–1.3)[b]	0.2 (−0.3;−0.1)	<0.001[c]
Tibial slope	16.3 (2.6)[a]	13.7 (3.9)[a]	15.0 (3.5)[a]	2.6 (0.7; 4.5)	0.009[c]

Gaasbeek et al. [11]

HKA hip–knee–ankle, *WOMAC* Western Ontario and McMaster University osteoarthritis index, *KSS* Knee Society Score, *VAS* visual analog scale, *CI* Caton index, *n* number, *n.s.* nonsignificant

[a] Values given as mean (standard deviation)

[b] Values given as median (range)

[c] Student's t test

[d] Mann–Whitney U test

refused to travel to the outpatient clinics because of distance, and their physical examination (knee score of the KSS) could not be analyzed at final follow-up for this reason. All other questionnaires were sent to these four patients and returned completed. One other patient was not able to complete the WOMAC at final follow-up because of dementia. The median time to follow-up was 8.0 years (range 7–9 years).

Clinical outcomes

At final follow-up, the total WOMAC, KSS, and VAS pain scores were better in the CWO group compared to the OWO group, although the differences were not significant. Patients in the CWO group, however, reported significantly less WOMAC pain and WOMAC stiffness compared with the OWO group at the last follow-up ($P = 0.025$ and $P = 0.036$, respectively). Furthermore, patients in the CWO group were significantly more satisfied than in the OWO group (VAS satisfaction, mean 8.1 vs. 6.1, $P = 0.017$) at the final follow-up. Also, at the final follow-up, a total of nine (18 %) patients had said that they would not go forward with this operation if they had the opportunity to choose again; among these, significantly fewer patients were in the CWO group [one patient (4 %) in CWO vs. eight (32 %) in OWO; $P = 0.018$]. The clinical outcomes at 7.9 years are shown in Table 4.

Radiographic outcomes

Compared to preoperative scores, the grade of OA was progressive in the CWO and total groups, with significantly more patients in classes 3 and 4 together at 7.9 years of follow-up ($P = 0.008$ and $P = 0.001$, respectively). There were no significant differences in mean correction angle, tibial slope, or CI between groups at mean final follow-up and between 1 year and the final follow-up. At the final follow-up, there was a nonsignificant decrease in the CI in the OWO group compared to the preoperative CI (0.9 and 1.0, respectively), but in the CWO group, there was no change (CI 1.0 at both time points). In both techniques, there was no loss of correction angle. The radiographic results at 7.9 years are shown in Table 5.

Survivorship

The number of and reasons for re-operations are described in Table 4. The survival after 5 years of follow-up for the total group was 93.7 % (95 % CI 87.1–100); after 7.9 years of follow-up, it was 81.6 % (95 % CI 74.7–95.9). For the OWO group, survival after 5 years was 91.7 % (95 % CI 81.3–100); after 7.9 years, it was 81.3 % (95 % CI 75.2–100). For the CWO group, survival at 5 years was 95.8 % (95 % CI 88.2–100) and was 82.0 % (95 % CI 66.7–100) at 7.9 years (Fig. 1). The two groups did not differ significantly in survival.

Discussion

The most important finding of this study was the favorable clinical result for the CWO technique compared with the OWO technique after 7.9 years of follow-up, in contrast to

Table 4 Clinical results at 7.9 years follow-up

Parameter	Open-wedge osteotomy ($n = 19$)	Closed-wedge osteotomy ($n = 19$)	Total group ($n = 38$)	Mean difference (95 % confidence interval)	P value
KSS	155.5 (34.9)[a]	181.5 (102–200)[b]	170.0 (89–200)[b]	−13.1 (−36.9; 10.7)	n.s.[c]
VAS pain	4.1 (2.6)[a]	2.8 (2.7)[a]	3.4 (2.7)[a]	1.3 (−0.5; 3.0)	n.s.[c]
VAS satisfaction	6.1 (2.9)[a]	8.0 (3–10)[b]	8.0 (0–10)[b]	−1.95 (−3.5; −0.4)	0.017[c]
WOMAC	36.2 (26.8)[a]	21.1 (22.3)[a]	28.9 (25.5)[a]	15.2 (−1.4; 31.6)	n.s.[c]
WOMAC pain	7.3 (5.4)[a]	2.5 (0–12)[b]	5.0 (0–16)[b]	3.7 (0.5; 6.8)	0.025[c]
WOMAC stiffness	3.3 (2.5)[a]	1.0 (0–6)[b]	2.0 (0–8)[b]	1.6 (0.1; 3.1)	0.036[c]
WOMAC ADL	25.7 (20.1)[a]	15.8 (17)[a]	20.9 (19.1)[a]	9.9 (−2.6; 22.3)	n.s.[c]
Removal OSM	12	10	22		n.s.[d]
Re-operation other reasons (n)	1	3	4		n.s.[d]
Debridement tuberositas tibiae	1	1	2		
Infection	0	1	1		
Arthroscopy persisting complaints	0	1	1		

KSS Knee Society Score, *VAS* visual analog scale, *WOMAC* Western Ontario and McMaster University osteoarthritis index, *ADL* activities of daily living, *n* number, *OSM* osteosynthesis material, *n.s.* nonsignificant

[a] Values given as mean (standard deviation)

[b] Values given as median (range)

[c] Student's *t* test

[d] Chi-squared test

Table 5 Radiographic results at 7.9 years follow-up

Parameter	Open-wedge osteotomy ($n = 18$)	Closed-wedge osteotomy ($n = 18$)	Total group ($n = 36$)	Mean difference (95 % confidence interval)	P value
OA classification (n)	I: 2	I: 3	I: 5		n.s.[c]
	II: 8	II: 6	II: 14		
	III: 5	III: 7	III: 12		
	IV: 3	IV: 2	IV: 5		
HKA (°)	3.1 (2.4)[a]	3.6 (2.3)[a]	3.3 (2.3)[a]	−0.5 (−2.1; 1.0)	n.s.[b]
Correction angle HKA preoperative and 7.9 years (°)	7.3 (2.3)[a]	7.6 (3.2)[a]	7.5 (2.8)[a]	−0.3 (−2.2; 1.6)	n.s.[b]
CI	0.9 (0.2)[a]	1.0 (0.2)[a]	1.0 (0.2)[a]	−0.1 (−0.2; 0.0)	n.s.[b]
Tibial slope (°)	17.0 (4.5)[a]	15.5 (3.9)[a]	16.2 (4.2)[a]	1.6 (−1.3; 4.4)	n.s.[b]

OA osteoarthritis classification Kellgren and Lawrence, *HKA* hip–knee–ankle, *CI* Caton index, *n* number, *n.s.* nonsignificant

[a] Values given as mean (standard deviation)

[b] Student's *t* test

[c] Chi-squared test

the results after 1 year of follow-up. The clinical outcomes (WOMAC, KSS, VAS pain) suggest a trend toward superior results (approximately 15 %) for patients treated with CWO compared to patients treated with OWO (Table 4). In addition, the other clinical results (VAS satisfaction, WOMAC pain, and stiffness) were significantly better in the CWO group. Also, significantly fewer patients from the CWO group expressed that they would elect not to go forward with this operation if they had the opportunity to choose again ($P = 0.018$). A possible explanation could be that there was a patella baja after OWO, which could lead to patellofemoral complaints and a negative influence on clinical results. At the final follow-up, there was a decrease in the CI in the OWO group compared to the preoperative CI values (0.9 vs. 1.0), which is comparable to the literature [7, 28]. The CI remained unchanged from preoperative

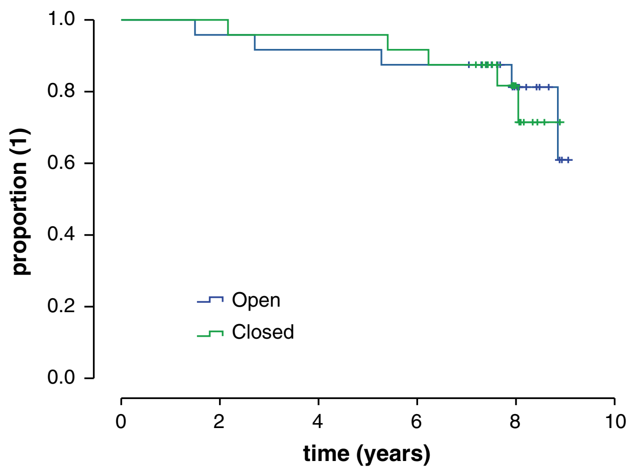

Fig. 1 Survivorship analysis

to final follow-up in the CWO group (both 1.0). Increases and decreases in this index following CWO have been described [7, 28]. In a biomechanical study, Gaasbeek et al. [10] investigated the differences in dynamic patellar tracking after open- and closed-wedge high tibial osteotomy with the same operative techniques used here. They concluded that patellar height significantly decreased with OWO and increased with CWO. Unfortunately, a patellofemoral questionnaire such as the Kujala score was not used in the current study [17]. Future research is needed to confirm the results and to evaluate the hypothesis that patella baja after an OWO causes patellofemoral complaints and therefore may negatively influence clinical results.

The current study did not involve standard MRIs to evaluate a greater degeneration of the cartilage of the patellofemoral joint after OWO compared with CWO. On the radiographs, in fact, the results were more the reverse: There was a greater progression of total OA in the knee in the CWO group compared with the OWO group. No indications were observed for some of the other potential disadvantages of OWO (e.g., high nonunion rates) [19, 21]. One possible disadvantage of the OWO technique is the use of a TCP wedge. At the time of the initial 1-year report, a TCP wedge had been used in all patients who underwent OWO, which could become a serious problem in revision surgeries in the future. Concerns persist about their resistance to compressive loads and biological degradability [2], and the use of a TCP wedge in a correction <10° is not advised [2]. The reason the TCP wedge was used in these procedures was to follow a standardized operative technique intended to promote perioperative maintenance of the precise correction made.

The favorable results for CWO reported here have not been previously described. A few short-term—and therefore not fully comparable—randomized controlled trials found no significant difference in clinical outcomes comparing OWO and CWO after 1 year of follow-up [11, 33]. Song et al. [29] performed a retrospective comparison of 50 patients who underwent OWO or CWO. After a minimum follow-up of 3 years, the mean Hospital for Special Surgery Knee scores were similar in the two groups. Schallberger et al. [27] found no significant differences between OWO and CWO for Knee injury and Osteoarthritis Outcome Score or WOMAC after a median of 16.5 years (range 13–21). A possible explanation for the divergent results is that other groups did not use the same fixation technique applied here of a rigid plate fixation and locking screws, complicating comparisons.

Survival in the present study with conversion to UKA or TKA was comparable to values reported in the literature [1, 3, 5, 9, 16, 26, 30–32]. In Schallberger et al. [27], survival after 10 years was 92 % (95 % CI 86–99), and it was 71 % (95 % CI 58–85) after 15 years, with TKA as an end point. These authors concluded that there was no significant difference between OWO and CWO in survival and functional outcome, but that their results must be approached with caution because the number of included patients with OWO was small (16) compared to those with CWO (56).

Today, it is recognized that changes in the tibial slope may have a profound influence on the biomechanics and kinetics of the knee joint. OWO is suggested to increase the tibial slope, while CWO decreases it [7, 29], but these assertions are debated [20]. In the current study, both groups had a slight but nonsignificant increase in the tibial slope at the last follow-up compared to the preoperative values. The tibial slope at the final follow-up was also not significantly different between the two groups, suggesting that a correct osteotomy was performed also in the lateral plane in both groups.

The best correction angle is a matter of debate. Rudan et al. [25] found that a correction to a femorotibial angle between 6° and 14° of femorotibial valgus is associated with an optimal clinical result. Hernigou et al. [13] concluded that an overcorrection of more than 6° femorotibial valgus is associated with progressive degeneration of the lateral compartment and that an undercorrection of <3° femorotibial valgus is associated with a poorer result and reappearance of the medial compartment OA. Odenbring et al. [22] found that overcorrected (>7° femorotibial valgus) knees had clinically and radiographically better results than normal-corrected (1°–7° femorotibial valgus) and undercorrected (<1° femorotibial valgus) knees. In the current study, both techniques resulted in a stable correction with locked plate fixation and good clinical results. The mean postoperative femorotibial angle at 1 year for the osteotomies that were converted to a TKA or a UKA was 3.3° valgus; for the osteotomies that survived, it was 3.9° valgus. Thus, no association was found between femorotibial angle and failure rate at follow-up. Also, there appeared to be no association between severe correction (>6°) and worse clinical results, but the number of patients (three) with such a correction was very small.

This study had some limitations. At final follow-up, the data were not complete: Two patients were lost, and the data for five patients at last follow-up were incomplete. At almost 8 years after the surgery, however, this level of loss seems reasonable. Also, no new power analysis was performed, and a small number of patients were evaluated (38 in total). If more patients were included, the trend to better clinical results and a difference in CI for the CWO group compared to the OWO group might become significant. The surgeries were performed in two hospitals. Because of the standardized operation technique (the use of a TCP wedge in all patients who underwent an OWO), use of the same instruments, and the same standardized postoperative management, the use of two separate institutions should not have had an influence on the outcomes.

This study was the first prospective study to investigate the midterm results (7.9 years) of OWO compared to CWO. The favorable clinical results for the CWO technique have not been described previously. Results from the 1-year follow-up report led to the conclusion that the OWO technique was preferable. The current midterm findings, however, suggest the need to reconsider these conclusions or to recalibrate the surgical technique so that a patella baja does not occur, for example, by using an undercutting technique in case of an OWO.

Conclusion

In summary, patients who underwent a closed-wedge osteotomy had favorable clinical results compared with patients who underwent an open-wedge osteotomy after a mean follow-up of 7.9 years. The survival rates and radiographic results were similar for both techniques. A possible explanation could be the development of a patella baja after OWO, which can lead to patellofemoral complaints and worse results.

Conflict of interest The authors declare that they have no conflict of interest.

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