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Basic Science

The Change in Posterior Tibial Slope After Cementless Unicondylar Knee Arthroplasty

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ABSTRACT

Background: The posterior tibial slope (PTS) is an important factor in patients undergoing unicondylar knee arthroplasty. It is an area subjected to high shear and compressive forces. Our objective is to investigate the changes taking place on the tibial slope of cementless unicondylar knee arthroplasties and define its relationship with functional scores.
Methods: Patients undergoing a cementless unicondylar knee arthroplasty between January 2011 and July 2019 were selected. Exclusion criteria were lack of at least 1 year of follow up, loss to follow-up for any reason, and revision of a metallic component. Overall, 161 cases were included. Patients were analyzed using standard radiographs for changes in PTS, coronal positioning of the implant, and overhanging. Function was analyzed using Oxford Knee Score, Tegner Activity Scale, and Knee Society Score. Changes of the PTS were analyzed for statistical significance and for correlations with all the other variables.
Results: All postoperative functional scores showed significant improvement ($P < .05$). Compared to the early postoperative values, increases of $\leq 5^{\circ}$ were detected in 79% of all patients. The greater amount of slope change occurred during the first 6 months postoperatively. Statistical analysis revealed no significant relationship with functional scores of the knee, age, body mass index, overhanging, and coronal alignment of the tibial component.
Conclusion: This study showed that, with time, minimal changes take place in the PTS of cementless unicondylar knee arthroplasty. The change mostly takes place during the first 6 months. These changes do not affect functional scores.

Unicondylar knee arthroplasty (UKA) is a viable surgical procedure for patients with anteromedial osteoarthritis (OA) and focal femoral osteonecrosis [1]. Several studies have now shown its advantages over total knee arthroplasty (TKA) which include more normal knee kinematics, reduced blood loss, better postoperative range on motion, and better patient-reported outcome measures [2]. Although both cemented and uncemented components have shown good long-term results when performed correctly, cementless fixation has gained popularity among many surgeons these last years [3].

The Phase 3 cementless Oxford mobile-bearing unicondylar implant (Zimmer Biomet, Swindon, UK) was introduced in 2004 as an alternative to the cemented one. Many advantages of cementless UKA such as shorter surgical time, strong fixation, no cementation errors, and a decrease in radiolucent line incidence have been already pointed out [1]. But just like the cementless TKA, cementless UKA has also been shown to be prone to subsidence over time [4].

The posterior tibial slope (PTS), defined as the posterior inclination of the tibial plateau, is an important factor in patients undergoing mobile-bearing UKA. It is an area subjected to high shear and compressive forces especially during knee flexion [5]. During UKA the native medial tibial plateau is exchanged with a metallic tibial component. This exchange defines the medial compartment's new overall PTS and previous studies have defined normative values according to which the component's slope should be implanted [6]. Many studies have researched the acceptable slope

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values between which a mobile-bearing UKA achieves maximal stability but very few of them have analyzed postoperative change taking place on the slope and possible implant subsidence during follow-up.

The aim of this study is to investigate the potential changes in PTS of uncemented Phase 3 mobile-bearing Oxford implants and to evaluate the effect these changes have on knee functional scores.

Methods

This study was approved by the local ethical committee with the reference number E1-20-435.

Patient Selection

Inclusion criteria for this retrospective study were patients with a diagnosis of anteromedial OA or focal femoral osteonecrosis of the medial condyle and operated with the cementless Oxford unicondylar knee implant (Biomet Orthopedics, Inc, Warsaw, IN) between January 2011 and July 2019 at the Orthopedic and Traumatology Clinic of our hospital. A total of 204 patients were identified.

An informed consent was obtained from all included patients. Indications for surgery included severe-enough pain to justify arthroplasty, a bone-on-bone lesion confined to the medial compartment of the knee, a healthy lateral compartment with or without minor degenerative signs, a correctible varus deformity of a maximum of 15°, a flexion contracture less than 15°, and an intact anterior cruciate ligament (ACL) on physical examination [1]. Exclusion criteria were treatment with a cemented tibial component, a history of proximal tibial osteotomy, lack of at least 1 year of follow-up or incomplete data, loss to follow-up for any reason, and the revision of any of the metallic implants. Patients with an American Society of Anesthesiologists (ASA) score >3 (11-23) and those of age >85 were also not included in the study. Demographic data regarding age, gender, operated side, mobile-bearing size, and body mass index (BMI) were collected from the hospital's medical records. The surgeries were performed by 2 different surgeons with at least 10 years of experience in arthroplastic surgery.

Out of 204 cases, 35 patients had lacked complete data or had radiographs on which measurements could not be performed (taken at other centers, physical X-ray slides, and/or patients who were partially/fully followed up at other centers). Four patients had died at the time the study was performed for reasons unrelated to the arthroplasty. There was a total of 16 revisions (6.5%) performed but none was directly related to migration or to an excessive change in slope; 4 cases were revised because of progression of OA on the lateral compartment (1.6%), 4 others had recurrent bearing dislocations (1.6%), 2 cases were revised because of mechanical instability (cruciate ligament rupture following surgery or unnoticed intraoperative damage to the medial collateral ligament) (0.8%), 3 cases were revised due to infection (1.2%), and 1 case because of an early tibial plateau fracture (0.4%). The last 2 cases were revised in another medical center and data on the reason for the revision could not be reached. Of the remaining 149 patients, 12 had bilateral procedures. The study was conducted on these 161 cases.

Surgical Technique

After spinal anesthesia, all patients were placed supine with the indicated leg on a custom holder to allow for a flexion of 110°. Two grams of cefazolin were administered at approximately 30 minutes before the operation. A medial parapatellar mini approach without patellar dislocation was used for the surgeries. The state of the ACL was checked intraoperatively and only patients with an intact ACL were implanted a UKA. The Oxford Phase III cementless mobile-bearing implant was used in all procedures. A mixture of local anesthetics, prednisolone, and cefazolin was infiltrated throughout the soft tissue of the joint and the periosteum. Immediate full weight bearing with crutches and active knee range of motion exercises were started immediately.

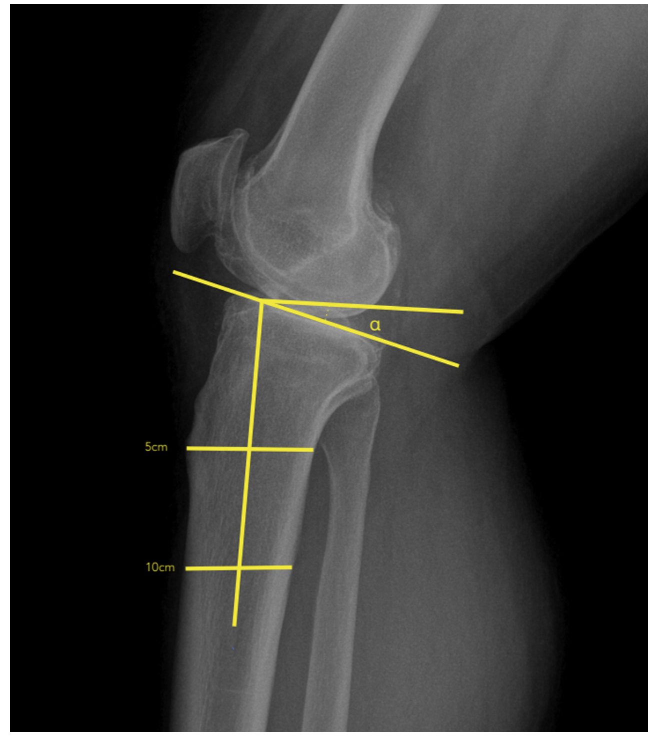

Fig. 1. The posterior tibial slope angle (denoted as "*a*") measured on the lateral radiograph of a native knee.

Radiological Evaluation

Preoperative evaluation started with calibrated leg standing anteroposterior and lateral knee radiographs. Coronal alignment and preoperative PTS was measured on these views. Osteoarthritic levels of the medial and lateral condyle were recorded according to the Kellgren-Lawrence classification [7]. A bone-on-bone lesion was confirmed with a 20° in flexion Rosenberg view. The state of the patella-femoral joint was evaluated with the Merchant view and any leg length discrepancies were ruled out with full length lower extremity radiographs. Finally, the correctability of the varus deformity and the state of the lateral compartment were confirmed with stress varus/valgus radiographs taken at 20° of flexion.

Postoperative follow-up was performed through leg standing anteroposterior and lateral knee radiographs. Radiographs taken with the extremity rotated were repeated. Lateral radiographs were taken according to the implant manufacturer's guidance [1] and with the patient weight bearing and in a "patella-forward" position. The joint space visibility, implant conformity, the relation of the proximal tibia with the fibula, the superposition of the femoral condyles and the tibial condyles (when anatomically possible) were the landmarks used to determine whether the radiograph was acceptable for the study or not. Radiographs with very minor changes were discussed and accepted or retaken with mutual agreement of the 2 observers making the measurements. Radiographical evaluation was performed immediately/early after the operation and routinely thereafter on follow-up intervals at the 3rd

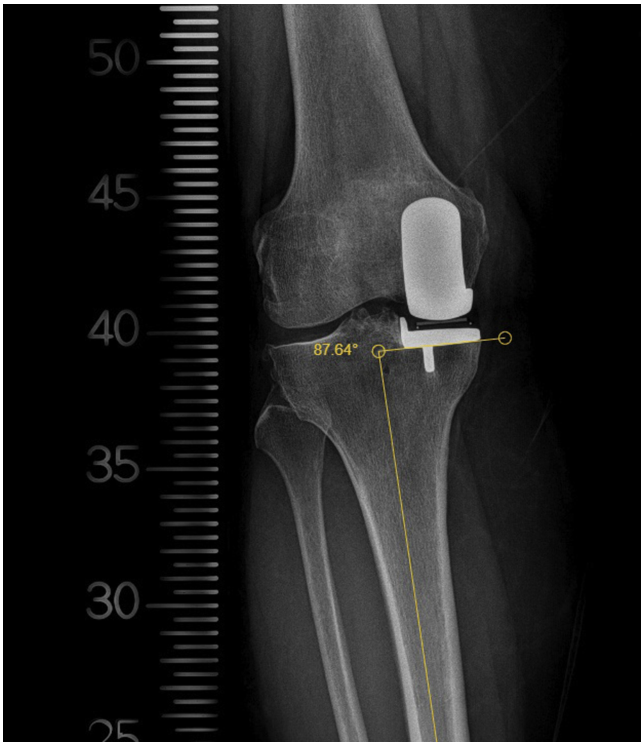

Fig. 2. Measurement of coronal alignment of a cementless Oxford tibial component measured on an anteroposterior knee radiograph.

and 6th month, 1st, 2nd, and 5th year postoperatively. Changes in OA levels of the lateral compartment were also recorded.

The PTS on preoperative radiographs was defined as an angle between the tangent of the medial plateau and the line perpendicular to the longitudinal axis of the tibia (Fig. 1) [8]. Depending on the patient's anatomy, the medial tibial plateau was either superimposed to the lateral one or clearly distinguishable through a shallow concavity. For the superimposed cases a line tangent to the overall plateau was used while for the concavity cases a line tangent to the anterior and posterior rims of the plateau was used to denote the medial tibial plateau [9]. The longitudinal axis (also defined as tibial proximal anatomical axis [10]) was defined as a line passing through 2 points located in the center of the anteroposterior width of the tibia at 5 and 10 cm apart from the proximal diaphysis. All radiographs were standardized and taken under fluoroscopic guidance to avoid mismeasurements. Patients with views taken at other institutions and incompatible with our study design were not included in the study.

Postoperatively, coronal and sagittal measurements were performed according to the original implant designers' guidelines [1].On anteroposterior views, the coronal alignments of the tibial components were measured relative to the long axis of the tibia (Fig. 2). In the postoperative radiographs the angle between the parallel line passing just below the tibial implant and the line perpendicular to the longitudinal axis were used for PTS measuring. Coronal and sagittal tibial implant overhanging was defined as a protrusion of more than 2 mm of the metallic implant over the side of the bony condyle medially or posteriorly respectively. All measurements were performed by 2 different observers using the angle measurement feature found in the local picture archiving and communication system (PACS). The mean value of their measurements was used in the subsequent analysis. The researchers were aware of the study aim but were blinded from each other.

The PTS was measured on all occasions; preoperatively, immediately/early after the operation, on the 3rd and 6th months, on the 1st, 2nd, and for some patients 5th year postoperatively, and on their last follow-up. Changes were recorded as positive values when the slope increased and negative values when it decreased (Fig. 3A-C). The percentage of those whose PTS increased and those whose PTS decreased was calculated. When accounting for change in total, absolute values were calculated when the change was negative (ie, the slope decreased). The potential change was analyzed through time periods: (1) preoperative to early postoperative, (2) early to 3rd month postoperatively, (3) 3rd to 6th month postoperatively, (4) 6th month to 1st year postoperatively, (5) 1st to 2nd year postoperatively, (6) when possible 2nd to 5th year postoperatively, and (7) 5th to more years postoperatively. The percentage of change taking place in-between these periods was analyzed and compared between them for significance. A relationship was also sought between the ultimate change, defined as

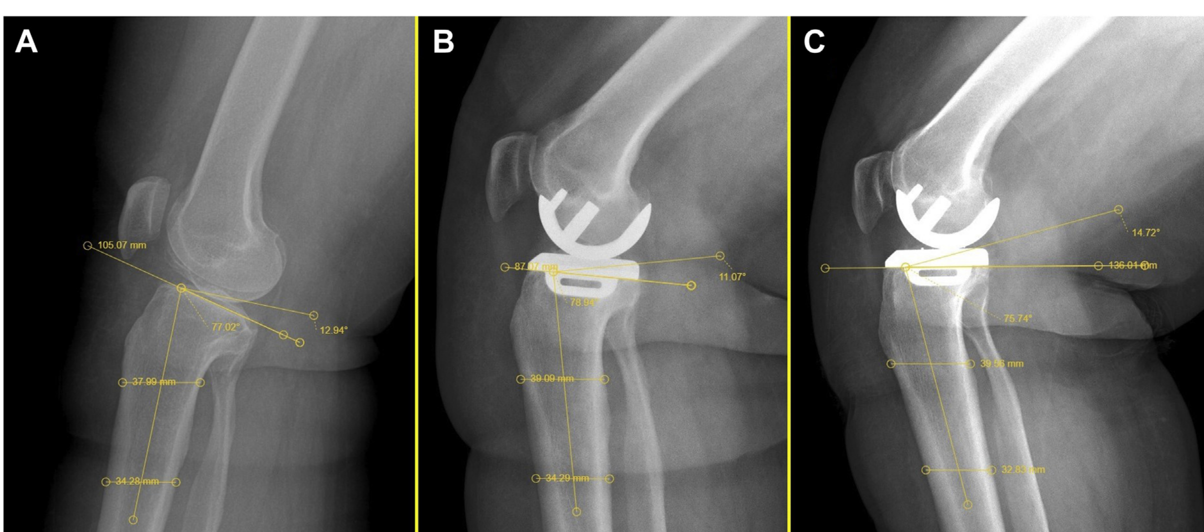

Fig. 3. Change in posterior tibial slope over time on the lateral knee radiograph of the same patient: preoperative lateral radiograph (A), postoperative day 2 (B), and 3.5 years postoperatively (C). The ultimate change was 3.6°, corresponding to a 33% change.

the change between the slope on the final follow-up visit and the early postoperative slope, and the functional scores. The ultimate change was also analyzed for relationships with the other variables in this study: gender, BMI, side, mobile-bearing size, coronal alignment of the tibial component, preoperative native slope, and overhanging.

Clinical Evaluation

All patients scheduled for arthroplasty in our clinic are preoperatively assessed using Visual Analog Scale, Oxford Knee Score (OKS) [11], Tegner Activity Scale [12], and Knee Society Score (KSS) [13]. The assessments are also carried out during the postoperative follow-up period. For practical purposes, in this study the preoperative scores were only compared with those of the last follow-up visit and analyzed for statistical significance.

Statistical Analysis

Statistical analysis was carried out using SPSS 22.0 (Chicago, IL) software. In the descriptive analyses, categorical variables are stated as number (n) and percentage (%), and continuous variables as mean ± standard deviation and median (minimum-maximum) values.

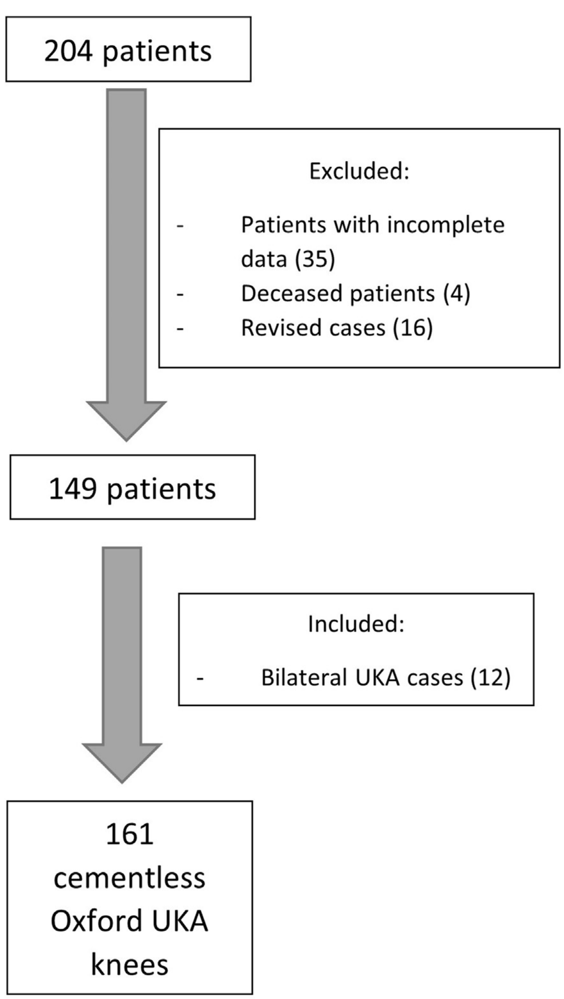

Fig. 4. Diagram depicting inclusion and exclusion criteria for the current study. UKA, unicondylar knee arthroplasty.

For values not showing normal distribution in the Shapiro-Wilk test (such as KSS, OKS, Tegner, etc.), non-parametric tests were used. Repeated-measures analysis of variance, nonparametric alternative of dependent two-sample *t*-test, Wilcoxon rank-sum test, and Spearman's rho correlation analysis were used to determine the relationships between slope parameters. The time periods of the study did not show a global distribution in the Mauchly's test of sphericity of the repetitive-measures analysis of variance; therefore, the Greenhouse-Geisser value was used to analyze the presence and the possible significance of a relationship between the time periods and the percentage of slope change. Chi-squared test was used in the analysis of categorical data. Interobserver reliability was analyzed and an intraclass correlation coefficient was calculated. The results were evaluated at a 95% confidence interval and a P value of <.05 was considered significant.

Results

Out of 204 cementless UKAs retrieved from the registry, only 161 were included in the final analysis (Fig. 4). Of them, 142 were females (88.2%). Mean age was 57.9 years (36-78) and 52.2% of the operations were performed on a left knee. Mean follow-up time was 44.1 months (12-114). All patients had a minimum follow-up of 1 year, 111 had a minimum of 2 years, and only 41 patients had a follow-up of 5 years or more. All demographic data are shown in Table 1.

Size 3 (3-8) was found to be the median mobile-bearing size. The varus degree of the tibial component was found to be within normal values in most of the patients. The mean varus degree was 1.03 (−6 to 6.5). The tibial component was found overhanging in 11 cases (6.8%). All overhanging cases were detected on the coronal plane, with no tibial implant overhanging on the sagittal plane. Of all cases 42.2% showed progression of OA on the lateral side. A subanalysis was performed on all progression differences (late postoperative lateral compartment OA grade to preoperative lateral compartment OA grade) and 93.7% of all changes were found to be of 1 grade or less (mean value 0.48). Six cases had a progression of 2 or 3 grades according to the Kellgren-Lawrence classification. They showed lower functional scores compared to the other patients but refused to undergo another surgery. All relevant data are shown in Table 2.

Interobserver reliability for radiological measurements was calculated and an intraclass correlation coefficient of 0.971 was obtained showing an excellent reliability level. The mean preoperative PTS value was found to be 10.7° (1.0-17.4). Although 56.5% of cases (n = 91) showed a decreased slope in the immediate postoperative period compared to preoperative, 68 cases (42.2%) had increased slopes and 2 cases showed no change (1.2%). Although unintentional, we detected a clear pattern toward decreasing the slope. The overall mean change was found to be −0.9°. When absolute values were calculated in order to detect the total amount of change in degrees, the mean value was 3.4°. The analysis of ultimate change (last follow-up to early postoperative change) revealed that no slope remained unchanged during time. Independent of the implantation degree, 78.8% of all slopes increased with time.

The mean value of overall change was 1.4° while the mean value of absolute change was 1.7°. A subanalysis was performed to explore the extent of this change. Given that the optimal slope implantation range is widely accepted as 5°-7° (maximum 8) [1] and ACL rupture has been associated with slopes starting from 13° [1,14], we decided to consider a change of 5° as a threshold for significant PTS change. In our study, most of the patients had a change of ≤5° (93.7% of all increases, n = 119) and only 8 cases

Table 1
Demographic Data.

	Total (n = 161)
Age (y)	
Mean ± SD	57.91 ± 6.746
Median (min-max)	56 (36-78)
Gender, n (%)	
Female	142 (88.2%)
Male	19 (11.8%)
Side, n (%)	
Right	77 (47.8%)
Left	84 (52.2%)
Follow-up time (mo)	
Mean ± SD	44.1 ± 28.4
Median (min-max)	42 (12-114)
BMI (kg/m^2)	
Mean ± SD	32.36 ± 4.949
Median (min-max)	31 (21-48)

BMI, body mass index; min, minimum; max, maximum; SD, standard deviation.

showed an increase of more than 5° (6.3%). All relevant data are presented in Table 3.

In terms of change in degree during the studied time periods, the majority of change was observed during the first 3 postoperative months. The mean value of total change was found to be of 1° (minimum-maximum: −2.8 to 9.8), while the mean value of absolute change was found to be 1.2° (minimum-maximum: 0.0-9.8). This change was substantially less on the following time periods and was almost nonexistent after 2 years. Data regarding change in degrees are shown in Table 4.

We also analyzed the radiographs of the revised cases. Out of 16 total revisions we gathered data regarding 14 of them (2 were operated at other centers) and analyzed 13. Six patients (4 because of recurrent bearing dislocation and 2 for mechanical instability) were revised within 6 months of the index surgery. Two patients had progression of OA on the lateral compartment within 1 year and 2 other cases were revised for the same reason at the 2nd and 4th year respectively. Three cases were revised due to late infection and 1 due to an early tibial plateau fracture. For practical reasons we evaluated only the overall absolute change as the difference between the last slope before revision and the early postoperative slope. We found an overall change of 1.3°, similar to the overall change of the study. We concluded that slope change was not a reason leading to revision for our cases.

Table 3
Changes in Posterior Tibial Slope.

	Total (n = 161)
Native/preoperative slope (°)	
Mean ± SD	10.7 ± 3.24
Median (min-max)	11.1 (1.0-17.4)
Change pattern of preoperative to early postoperative values, n (%)	
No change	2 (1.2%)
Increased PTS	68 (42.3%)
Decreased PTS	91 (56.5%)
Frequencies of overall values	
Mean ± SD	−0.9 ± 3.38
Median (min-max)	−1.4 (−8.6 to 9.4)
Frequencies of absolute values	
Mean ± SD	3.4 ± 2.16
Median (min-max)	3.1 (0-9.4)
Ultimate change pattern of early postoperative to last follow-up values, n (%)	
No change	0 (0%)
Increased PTS	127 (78.8%)
Decreased PTS	34 (21.2%)
Frequencies of overall values	
Mean ± SD	1.4 ± 2.30
Median (min-max)	1.0 (−3.2 to 11.1)
Frequencies of absolute values	
Mean ± SD	1.7 ± 2.06
Median (min-max)	1.1 (0.1-11.1)

PTS, posterior tibial slope; min, minimum; max, maximum; SD, standard deviation.

The percentage of change taking place between these periods, whether increasing or decreasing, was significantly greater compared to the other analyzed periods. Although it was not found to be statistically significant, minimal change continued to occur even after the 3rd to 6th month period. All data are presented in Table 5.

A correlation analysis was performed in order to understand what leads to the changes in PTS (data not shown here). The main focus was on the ultimate change (early to late postoperative) PTS change. A statistical significance was sought with preoperative to early postoperative slope change values, native slope values, age, side, BMI, gender, presence of overhanging, coronal tibial implant alignment, and most importantly functional scores. Although statistical significance was reached for 3 variables, the correlation was very weak. No significant correlation could be found with any of the other variables, therefore no regression analysis to investigate for

Table 2
Distribution of Technical Data.

	Total (n = 161)
Mobile bearing (size)	
Mean ± SD	3.65 ± 0.9
Median (min-max)	3 (3-8)
Varus of tibial component (°)	
Mean ± SD	1.03 ± 2.26
Median (min-max)	2 (−6 to 6.5)
Overhanging, n (%)	
Yes	11 (6.8%)
No	150 (93.2%)
OA progression on the lateral side (KL grades), n (%)	
Yes	68 (42.2%)
No	93 (57.8%)
Change of ≤1 grade	155 (93.7%)
Change >1 grade	6 (3.7%)
Mean ± SD	0.48 ± 0.65
Median (min-max)	0.0 (0-3)

OA, osteoarthritis; min, minimum; max, maximum; SD, standard deviation; KL, Kellgren-Lawrence classification grades.

Table 4
Angular Change of Slope During the Defined Periods.

Period Analyzed	Average Slope Change (°)	Absolute Slope Change (°)
Early postoperative to 3rd month (%)	n = 161	n = 161
Mean difference ± SD	1.0 ± 1.84	1.2 ± 1.71
Median (min-max)	0.6 (−2.8 to 9.8)	0.6 (0.0-9.8)
3rd month to 6th month (%)	n = 161	n = 161
Mean difference ± SD	0.3 ± 0.46	0.4 ± 0.40
Median (min-max)	0.1 (−1.1 to 1.8)	0.2 (0.0-1.8)
6th month to 1st year (%)	n = 161	n = 161
Mean difference ± SD	0.1 ± 0.23	0.1 ± 0.21
Median (min-max)	0.0 (−0.5 to 1.6)	0.1 (0.0-1.6)
1st year to 2nd year (%)	n = 111	n = 111
Mean difference ± SD	0.0 ± 0.14	0.1 ± 0.11
Median (min-max)	0.0 (−0.3 to 0.6)	0.1 (0.0-0.6)
2nd year to 5th year (%)	n = 31	n = 31
Mean difference ± SD	0.0 ± 0.11	0.1 ± 0.08)
Median (min-max)	0.0 (−0.2 to 0.3)	0.0 (0.0-0.3)
5th year to more than 5 years (%)	n = 22	n = 22
Mean difference ± SD	0.0 ± 0.06	0.0 ± 0.06
Median (min-max)	0.0 (0.0-0.2)	0.0 (0.0-0.2)

SD, standard deviation; min, minimum; max, maximum.

Table 5
Percentile Change of Slope During the Defined Periods.

Period Analyzed	Percentage Change	*P* Value
Early postoperative to 3rd month (%)	n = 161	**<.001**[a]
Mean difference ± SD	9.45 ± 1.73	
95% CI for difference	5.26-13.65	
3rd month to 6th month (%)	n = 161	**<.001**[a]
Mean difference ± SD	11.48 ± 1.81	
95% CI for difference	7.09-15.87	
6th month to 1st year (%)	n = 161	<.218[a]
Mean difference ± SD	0.56 ± 0.26	
95% CI for difference	−0.15 to 1.29	
1st year to 2nd year (%)	n = 111	<1.000[a]
Mean difference ± SD	0.38 ± 0.45	
95% CI for difference	−0.98 to 1.75	
2nd year to 5th year (%)	n = 31	<1.000[a]
Mean difference ± SD	−0.009 ± 0.30	
95% CI for difference	−0.97 to 0.95	
5th year to more than 5 years (%)	n = 22	<1.000[a]
Mean difference ± SD	0.37 ± 0.33	
95% CI for difference	−0.70 to 1.45	

ANOVA, analysis of variance; CI, confidence interval; SD, standard deviation. Bold indicates statistically significant.
[a] Repetitive-measures ANOVA - adjustment for multiple comparisons: Bonferroni.

Table 6
Correlation Data Regarding the Ultimate Change in Slope.

	Ultimate Slope Change (Absolute Value of Early-to-Late Postoperative Change)	
	Correlation Coefficient *R*[a]	Significance *P* Value
Age	−0.011	.888
Gender	0.073	.36
Side	0.044	.575
BMI	0.083	.296
Overhanging	**−0.185**	**.019**
Coronal implant alignment degree	−0.07	.379
Native slope values	**−0.201**	**.01**
Preoperative to early postoperative slope change values	−0.120	.129
Postoperative KSS	0.121	.127
Postoperative KSS - Functional score	0.0	.997
Postoperative OKS	0.146	.065
Postoperative Tegner	0.126	.111
Postoperative VAS	**−0.181**	**.022**

BMI, body mass index; KSS, Knee Society Score; OKS, Oxford Knee Score; VAS, Visual Analog Scale.
Bold indicates statistically significant.
[a] Spearman's rho.

possible risk factors was possible. All correlation data are presented in Table 6.

Independent of change in slope, outcome functional scores showed significant improvement in the majority of the patients with a mean KSS score of 92.5 (59-100), a mean OKS of 43(17-48), and a mean Tegner score of 2.6 (1-5). All the relevant data are shown in Table 7.

Discussion

This study showed that slope change after cementless unicondylar arthroplasty is a widespread phenomenon affecting the majority of cases. A total of 161 cases were followed up for a mean of 44.1 months. Of all cases in this study 78.8% showed an increase in PTS over time. The change was for the most part ≤5° and apparently did not affect functional scores.

The success of cementless mobile-bearing Oxford unicondylar implant depends on the experience of the surgeon and the established soft tissue balance [2]. Previous studies have shown that it has a 10-year survival rate of up to 94% and a 15-year survival rate of up to 91% [2]. Experience with cementless fixation in total knee replacement surgery has generally yielded less favorable results [15]. Historically, the cementless tibial components of TKA tended to loosen and shear forces at the bone/implant interface tended to eccentrically load the implant. This leads to stress on the unloaded side of the interface [16]. These disadvantages have been addressed in newer generations with better results. These new generations of uncemented TKA implants are now routinely used in many centers worldwide [17–19]. Likewise, uncemented UKA implants have shown results and survival rates that are as good or even better than cemented implants [2,20].

Cementless tibial component subsidence and slope changes in TKA has been reported before in many studies [3–5,21] but very few studies exist on cementless unicondylar component subsidence. Due to its mobile-bearing design, unlike TKA implants, cementless Oxford unicondylar implants are subjected to compressive forces rather than shear forces. This creates a favorable environment for fixation but also for a different pattern of migration [14]. Kendrick et al [4] performed a randomized controlled study on 43 patients undergoing cemented and uncemented Oxford implants. A radiostereometric analysis (RSA) was used to study and compare migration of both femoral and tibial components on both implant types. The study had a follow-up of 2 years. They found that in the first 3 months the tibial component of the cementless implant would migrate more that the cemented one. Migration would continue during the second year too but both implant types were found to have a similar and slow migration rate thereafter [4]. They concluded that the reason of this early migration of the cementless component could be incomplete seating or bedding-in of the component before fixation occurs. Migration was measured in millimeters and the change in slope angles was not measured. Other studies have also shown that cementless tibial component migration during the first 12 months can be expected [22] but stabilization during the second year has been found to be important for overall implant survival [23]. Our results are compatible with these previous studies. We found that an increase of ≤5° could be observed in most of the patients (78.9% of cases) and this change, though small, happened in the first 6 months. Although minimal changes continued to occur in the following years, the amount was far from what was observed on the first 6 months.

The PTS is known to be an important factor for successful UKA [24]. Intraoperative objectives of Oxford UKA include a restoration of the native slope or a slope very close to that [5,14]. A PTS of 5°-7° is the widely accepted safe interval [24], with some researchers suggesting even 4°-20° [25] and others advocating for individualized slopes according to every patient's anatomy. Hernigou and Deschamps [14] showed that a postoperative tibia slope of more than 13° frequently led to a rupture of the ACL. Aleto et al [24] in their series of unsuccessful UKAs showed that of 32 cases, 15 had failed due to an increased (mean 12.8°) or decreased (mean 4.8°) postoperative PTS. The changes in slope in our study were mostly less than 5° with 3 cases of 5°-10° and 1 case of 11.2°. A minority of the cases showed a decrease in PTS with the maximum decrease bearing of −3.2°. None of them required a revision due to slope changes and their overall functional scores improved significantly.

The PTS is a 2-dimensional approximation of the often asymmetric, complex, and 3-dimensional surface of the tibial plateau [26]. Measuring the PTS on direct radiographs can be a challenging topic and different methods have been suggested [27–29]. Although many studies have defined computed tomography (CT) and magnetic resonance imaging (MRI) as standard measurement

Table 7
Functional Score Results.

Score (n = 161)	Preoperative Follow-Up, Mean ± SDMedian (Min-Max)	Last Postoperative Follow-Up,[a] Mean ± SDMedian (Min-Max)	*P* Value
KSS	55.4 ± 12.6 56 (16-93)	92.5 ± 9.04 95 (59-100)	**<.001**[b]
KSS - Functional score	49.2 ± 16.11 50 (0-90)	86.0 ± 15.24 90 (40-100)	**<.001**[b]
OKS	18.4 ± 6.31 18 (5-33)	43.0 ± 6.26 44 (17-48)	**<.001**[b]
Tegner Activity Scale	0.95 ± 0.025 1 (0-2)	2.6 ± 0.91 2 (1-5)	**<.001**[b]
VAS - Pain	5.5 ± 1.24 5 (4-8)	0.7 ± 1.35 0 (0-7)	**<.001**[b]

KSS, Knee Society Score (KSS score max value 100; KSS Functional score max value 100); OKS, Oxford Knee Score (OKS max value 48); Tegner Activity Scale (0-10); VAS, Visual Analog Scale (0 no pain; 10 worst pain imaginable); SD, standard deviation; min, minimum; max, maximum.
Bold indicates statistically significant.
[a] All postoperative scores were recorded on the patient' last follow-up visit.
[b] Wilcoxon singed-rank test.

devices, other studies have found strong correlations between direct radiographical measurements and CT or MRI measurements with good interobserver and intraobserver reliabilities [30]. On direct radiographs, different reference longitudinal axes have yielded different margins of error, with some being as high as 4.64° [28,30]. The tibial proximal anatomical axis described by Dejour and Bonnin [10] has shown good correlation with CT and MRI measurements in previous studies and is independent from variables such as age, gender, weight, and height. For this longitudinal axis an error of ±1° has been described [29,31–34].

This study shows that although changes in PTS do occur with time overall, knee functional scores are not affected. As per the reason these changes take place, we analyzed a series of variables trying to find a correlation. Mobile-bearing size, coronal tibial implant alignment, preoperative to early postoperative slope changes, native slope values, and most importantly functional scores were also analyzed for significant relationship with the PTS, but no such relation could be proven. Overhanging, despite a weak correlation, was found to be statistically significant. Although minimal overhanging (1-2 mm) may represent a protective support to minimize cancellous settling that can increase movement, we suggest this finding is interpreted cautiously since previous studies have shown that medial overhanging of the tibial component leads to irritation of soft tissues, pain, and increased medial collateral ligament load [35,36].

This study has its limitations. First, our conclusions may be limited to this implant only. We used and studied the cementless Oxford unicondylar knee which is made of cast cobalt chromium molybdenum alloy. Further studies will be needed to understand if the same results apply to other materials. All our measurements were performed on plain radiographs and this could have led to errors during data gathering. To minimize this risk, we standardized the radiograph taking process and excluded patients with oblique and inappropriate radiographs on which measurements could not be performed and our interobserver reliability was good. Had our study been performed using an RSA or CT scans, the results would have been more accurate. Despite the relatively good number of patients, ours was a gender-biased study. Although all consecutive patients undergoing a UKA were included and the indications were kept identical for both genders, 88% of them were females. Osteoporosis is a common characteristic of this gender and age group (mean 57 years) and implant subsidence tends to be more frequent in osteoporotic bone. Another limitation of this study is the lack of data regarding additional radiographic measurements, such as coronal plane changes. These measurements would provide a more comprehensive assessment of implant migration in the initial postoperative period.

Conclusion

This study shows that PTS of cementless Oxford UKA changes minimally with time. This change does not affect functional or clinical results. A possible reason for this may be incomplete seating or bedding-in of the tibial component during the procedure. Larger cohorts with longer follow-ups, analyzed with RSA or CT scans will be needed to reveal risk factors and long-term effects of PTS change in cementless UKA.

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