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ARAŞTIRMA / RESEARCH

The effect of unicompartmental knee arthroplasty on lower extremity axis, tibiofemoral subluxation, and lateral knee joint distance

Unikompartmantal diz artroplastisinin alt ekstremite ekseni, tibiofemoral subluksasyon ve lateral diz eklem mesafesine etkisi

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Abstract

Purpose: The aim of this study was to investigate the corrective effect of Oxford phase 3 medial unicompartmental knee arthroplasty (UKA) on the lower extremity axis, tibiofemoral subluxation and lateral joint distance.

Materials and Methods: The study included 105 knees that had undergone UKA. The Oxford Knee Score, EQ-5D-3LD and visual analog scale, and The Knee injury and Osteoarthritis Outcome Score were evaluated. Radiological evaluation was made of the lower extremity axis, tibiofemoral subluxation, and lateral knee joint distance.

Results: The postoperative mean improvement in the mechanical axis was 1.4° and in the tibiofemoral subluxation distance, 1.59 mm compared to preoperative values. The difference between the preoperative and postoperative lateral joint distance values was on average 0.25 mm lateral inner joint distance, 0.08 mm in the lateral middle joint distance and 0.34 mm in the outer joint distance. There was no significant difference in clinical results between the groups.

Conclusion: There were significant improvements in the postoperative period after cemented, cementless, and hybrid medial UKA in the measurements of lower extremity mechanical axis, tibiofemoral subluxation distance and lateral joint distances compared to the preoperative period.

Keywords:. Unicompartmental; knee arthroplasty; tibiofemoral subluxation; lower extremity axis; joint distance

Öz

Amaç: Bu çalışmanın amacı, Oxford faz 3 medial unikompartmantal diz artroplastisinin (UDA) alt ekstremite ekseni, tibiofemoral subluksasyon ve lateral eklem mesafesi üzerindeki düzeltici etkisini araştırmaktı.

Gereç ve Yöntem: Çalışmaya UDA yapılan 105 diz dahil edildi. Oxford Diz Skoru, EQ-5D-3LD, vizüel analog skalası ve diz yaralanması ve osteoartrit sonuç skorları değerlendirildi. Alt ekstremite aksı, tibiofemoral subluksasyon ve lateral diz eklem mesafesinin radyolojik değerlendirmesi yapıldı.

Bulgular: Preoperatif değerlere göre mekanik eksende postoperatif ortalama düzelme 1.4 ° ve tibiofemoral subluksasyon mesafesinde 1.59 mm idi. Preoperatif ve postoperatif lateral eklem mesafesi değerleri arasındaki fark ortalama 0,25 mm lateral iç eklem mesafesi, lateral orta eklem mesafesinde 0,08 mm ve dış eklem mesafesinde 0,34 mm. Gruplar arasında klinik sonuçlarda anlamlı bir fark yoktu.

Sonuç: Alt ekstremite mekanik aks, tibiofemoral subluksasyon mesafesi ve lateral eklem mesafelerinin ölçümlerinde çimentolu, çimentosuz ve hibrid medial UDA sonrası postoperatif dönemde preoperatif döneme göre anlamlı iyileşmeler vardı.

Anahtar kelimeler: Unikompartmantal; diz artroplastisi; tibiofemoral subluksasyon; alt ekstremite aksı; eklem mesafesi

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INTRODUCTION

In current surgical treatment of end-stage anteromedial knee osteoarthritis, successful results of over 95% are obtained with the application of medial unicompartmental knee arthroplasty (UKA) by following the patient selection criteria[1,2]. One of the most important prerequisites for a successful medial UKA application is intact chondral integrity on the lateral surface of the knee joint[3,4]. In addition to the application technique, the integrity of the lateral knee joint surface is also of great importance for the survival of UKA, because the development of osteoarthritis in the lateral compartment is accepted as one of the most important reasons for revision of UKA in the medium and long term[4-6].

Lower extremity axis shift, and tibiofemoral subluxation (TFS) are two of the most important factors affecting the load distribution on the cartilage structure in the knee joint[7]. Excessive valgus or varus correction of the lower extremity after surgery is a risk factor for osteoarthritic progression on the contralateral joint surface[8]. In a lower extremity with normal axis and load distribution, the tibiofemoral joint is in harmony. The knee joint is a hinge-type joint, and its main movement is in the sagittal plane. Therefore, the presence of tibiofemoral angulation together with coronal malalignment geometrically leads to TFS[9]. Studies have shown that a successful medial UKA application should not only restore the damaged medial tibiofemoral joint distance, but also correct the TFS and lateral joint distance. Thus, arthritic progression that may occur in the future can be slowed down or prevented[8,10].

The hypothesis of this study was that medial UKA application will have a corrective effect not only on the lower extremity axis, but also on the TFS and lateral joint distance. The present study is the first study to evaluate and compare cemented, cementless and hybrid unicompartmental knee prostheses according to lower extremity mechanical axis, tibiofemoral subluxation distance and lateral joint distance. The primary aim of the study was to investigate the effects of cement usage in Oxford phase 3 medial UKA on lower extremity axis, TFS and lateral joint distance.

MATERIALS AND METHODS

The study included a total of 105 knees of 105 patients (18 male, 87 female) who underwent an Oxford medial UKA, as 39 cemented, 37 cementless and 29 hybrid (cementless femoral and cemented tibial component), due to isolated anteromedial knee osteoarthritis between May 2014 and February 2018. Ethical approval was obtained from University of Health Sciences Turkey, Dışkapı Yıldırım Beyazıt Training and Research Hospital Local Ethics Board (approval number: 98/10, date: 19.10.2020). All patients provided informed consent.

The mean follow-up period of the patients was 50.3 (34-82) months. Patients with isolated anteromedial osteoarthritis, flexion >90 °, flexion contracture <10 °, varus angulation <15 °, and an intact anterior cruciate ligament were considered to have appropriate indication for medial UKA application. Changes in the lateral tibial-femoral compartment of Kellgren-Lawrence grade ≥3 and inflammatory arthropathy were considered contraindications for UKA [11]. Arthritic changes in the patellofemoral joint, age, height, weight, or body mass index (BMI) were not considered contraindications. The inclusion criteria for this study were having isolated anteromedial osteoarthritis undergoing cemented, cementless or hybrid UKA and receiving appropriate pre- and postoperative radiographs and regular follow-up examinations.

For this present study, 192 knees of 180 patients were examined. 87 knees of 75 patients who did not meet the inclusion criteria were excluded from the study. Eventually, the present study was carried out with 105 knees of 105 patients.

Surgical technique

Surgical interventions were performed by two senior surgeons (H.A, E.D) with a minimally invasive approach. UKA application was performed under tourniquet control in all patients. After cleaning the osteophytes in the medial of the femoral condyle and intercondylar notch, the tibia and femur cuts were made. Stability and mobility control was performed with joint gap measurement and trial components, respectively. In deciding whether the UKA will be applied with or without cement; the "bone hardness test" defined by Stempin et al. was used [12]. If a stability problem was encountered during the placement of trial components following tibial and femoral cuts (if movement of trial components is observed during knee flexion-extension movements), cemented application was preferred in these patients. The femoral component was not cemented in any of the patients who underwent hybrid application. Mobile polyethylene inserts were used in all patients.

Hemovac drains were used in all patients. The drain was withdrawn 24 hours after the surgery, and immediately afterwards the patient was allowed weight-bearing as tolerated. Compressive socks were worn and thromboembolic prophylaxis was applied to all patients. Immediate recovery of full knee extension and flexion was encouraged with quadriceps strengthening exercises.

Radiological evaluation

Radiographs of all patients were taken for standardization, as defined by Lyon-Schuss, with the patient standing, and the x-ray beam taken from the back at 20º-30º of knee flexion[13]. Radiographic evaluations were performed immediately postoperative, then in the 2nd week, 6th week, 3rd month and 6th month follow-up examinations and annually thereafter. In addition, lower extremity axis radiography was performed in all patients at 6 weeks[14]. In order to minimize rotational variations, attention was paid to the centralization of the patella, and the centralization of the tibial eminence according to the intercondylar notch.

Clinical evaluation

At the final clinical follow-up visit, evaluations were made of knee range of motion, the Oxford Knee Score (OKS)[15], the EQ-5D-3LD (EuroQol five-dimensional three level descriptive system), the EQ-VAS (EuroQol-visual analogue scales) and the KOOS (The Knee injury and Osteoarthritis Outcome Score) pain, symptom, activity of daily life (ADL), sports and quality of life (QoL) scores[16]. All the evaluations were made by two independent orthopedic surgeons. The scales used have Turkish validity and reliability.

Measurement of the mechanical axis of the lower extremity

In all patients, the mechanical axis was measured preoperatively and in the 6th postoperative week using standing radiographs including the hip and ankle. The femoral mechanical axis creates a line drawn from the midpoint of the femoral head to the midpoint of the femoral notch. The line drawn from the midpoint of the tibial eminence to the midpoint of the tibial plafond forms the tibial mechanical axis. The angle formed by the intersection of both lines is called the lower extremity mechanical axis.

Measurement of the TFS

Tibiofemoral subluxation was determined on anteroposterior lower extremity axis radiography using the measurement method defined by Nam et al [17]. According to this method, the tibial mechanical axis is determined primarily on the lower extremity axis radiograph, which includes hip to ankle while standing. A second line is drawn parallel to this axis with the femur intercondylar notch as the center. The length of the line joining the two parallel lines perpendicularly gives the amount of tibiofemoral subluxation (Figure 1). If the parallel line drawn from the intercondylar notch is located in the medial of the tibial mechanical axis, it is accepted as positive (+), and if lateral, negative (-). The measurements in this study for tibiofemoral subluxation were performed separately on preoperative and postoperative radiographs by 3 independent observers.

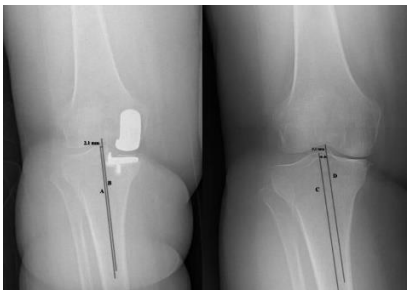

Figure 1. Radiograph demonstrating measurement of the tibiofemoral subluxation.

The tibial mechanical axis is first drawn (A; C), and a line parallel to the tibial mechanical axis is drawn from the apex of the intercondylar notch (B; D). The distance between these two, parallel lines (double headed arrow) was measured, and recorded as the tibiofemoral subluxation. The tibiofemoral subluxation of a patient is 2.1 mm in preoperative and 6.1 mm in postoperative radiograph.

Measurement of the lateral knee joint distance

The technique described by Buckland-Wright et al was used in the measurement of the lateral knee joint distance on anteroposterior lower extremity axis radiography[18]. The lateral knee joint was divided into 3 equal parts on the knee radiographs taken while standing. Measurements were made from the outer, middle and inner thirds. A control group could not be formed because of difficulties of matching similar age, weight and BMI, and the presence of arthritis in most of the contralateral knees. Preoperative and postoperative lateral inner, middle and outer knee

joint distances were compared with each other. Our hospital electronic picture archiving system was used for the preoperative and postoperative measurements of the mechanical axis, TFS and lateral knee joint distances of the knee radiographs of all patients. All the measurements were taken separately by 3 independent observers.

Statistical analysis

Statistical evaluation of the data was made using the Statistical Package for the Social Sciences (SPSS) for Windows version 22.0 software. In the analysis of numerical data, conformity to normal distribution was examined with the Kolmogrov Simirnov and Shapiro-Wilk tests. In the comparisons of two groups of independent variables with normal distribution, the Student's t-test was used and for more than two groups, the One-Way Anova test was applied. For independent variables not showing normal distribution, the median difference between the two groups was examined using the Mann-Whitney U-test, and the median difference between more than two groups was examined using the Kruskal-Wallis H-test. Analysis of normally distributed dependent variables was performed using the Paired Samples T test, and analysis of dependent variables not showing normal distribution with the Wilcoxon test. The data were examined at a 95% confidence level and tests and a value of $p< 0.05$ was considered statistically significant.

RESULTS

The demographic characteristics of the patients are given in Table 1. The mean postoperative knee flexion in patients was 112° and extension was 0.5°. Postoperatively, the mean OKS was 40.88, mean EQ-5D-3LD was 0.80, mean EQ-VAS was 82.71, KOOS-pain score mean 82.58, KOOS-symptom score mean 85.1, KOOS-ADL score mean 85.28, KOOS sports score mean 68.16, and KOOS-QoL score was 80.86.

The lower extremity mechanical axis of the patients was mean 4.99° varus preoperatively, and 3.59° varus postoperatively. The mean improvement in the mechanical axis was 1.4° ($p <0.05$). The mean TFS distance was measured as 4.10 mm preoperatively, and 2.51 mm postoperatively. The mean improvement in TFS distance was found to be 1.59 mm ($p <0.05$).

Table 1. Demographic properties of the patients

Variable	
Mean age (Range)	59 (47 - 79)
Gender (M/F)	18 / 87
Side (Right/Left)	49 / 56
Mean height (m) (Range)	1,63 (1,50 - 1,86)
Mean weight (kg) (Range)	80.6 (55 - 112)
Mean BMI (Range)	30,13 (23 - 40)

In the evaluation of the lateral joint distance, the lateral inner joint distance was mean 4.71 mm preoperatively and 4.96 mm postoperatively. The difference of mean 0.25 mm was statistically significant ($p = 0.004$). The lateral middle joint distance was found to be 5.30 mm preoperatively and 5.22 mm postoperatively. The difference was 0.08 mm ($p = 0.364$). The lateral outer joint distance was mean 5.96 mm preoperatively and mean 5.62mm postoperatively. The difference was mean 0.34 mm and statistically significant ($p = 0.002$). No correlation was determined between preoperative TFS distance and mechanical axis values. The improvement in the postoperative TFS distance and the degree of improvement in the mechanical axis were observed to be independent of each other ($p >0.05$). BMI, age and gender were not found to have any significant effect on TFS distance ($p >0.05$).

The patients were separated into 3 groups according to the postoperative mean lower extremity mechanical axis values of 1°-4°, 5°-7° and >7°. Postoperatively, 37 (35.2%) patients were in the 1°-4 ° varus mechanical axis range, and the mean lower extremity mechanical axis values was 2.74 °. In the 5°-7° varus mechanical axis range, 47 (44.8%) patients had a mean lower extremity mechanical axis value of 5.06°. A total of 21 (20%) patients were determined with lower extremity mechanical axis >7°, with a mean value of 8.76 °. When the relationship between mechanical axis values and clinical scores was investigated in all three groups, no significant relationship was found.

The mean operation time was 39.27 minutes in the patient group who underwent cementless UKA (n = 37) and 50.31 minutes in the cemented group (n = 39) ($p <0.05$). The average insert thickness used in patients was found to be 4.07 mm.

Table 2. Pre- and post-operative lower extremity mechanical axis, tibiofemoral subluxation, and lateral joint inner-middle and outer distance values of the patients

	Pre-operative	Post-operative
Lower extremity mechanical axis	4.99°±2.46°	3.59°±2.56°
Tibiofemoral subluxation (mm)	4.10±1.57	2.51±1.41
Lateral knee joint distance-Inside (mm)	4.71±0.88	4.96±0.88
Lateral knee joint distance-Middle (mm)	5.30±0.94	5.22±0.90
Lateral knee joint distance-Outside (mm)	5.96±1.17	5.62±1.04

DISCUSSION

The most important finding of this study was the detection of significant improvement in the postoperative period after cemented, cementless or hybrid medial UKA in the measurements of lower extremity mechanical axis, TFS distance and lateral joint distances compared to the preoperative period.

The average postoperative lower extremity mechanical axis of 3.59 ° varus determined in this study was within the range of angle values recommended for better functional and clinical scores in the literature. Vasso et al. reported that postoperative mild varus angulation ≤7 ° was associated with a better outcome in UKA and better survival in the mid-long term[19]. Zuiderbaan et al. found that the best WOMAC, pain, function, and total scores were observed in patients with 1°-4° varus alignment in patients applied with UKA[10]. In the current study, no significant correlation was observed in terms of Oxford, EQ-5D, EQ-VAS and KOOS scores when the lower extremity mechanical axis values of the patients were classified as mean 1°-4°, 5°-7° and >7° in the postoperative period. However, the lack of statistical significance may have been due to the low number of 21 (20%) patients with an average of more than 7° mechanical axis.

It is important that TFS can be corrected after surgery in patients undergoing UKA. It has been reported that in the postoperative period, TFS may lead to instability and compression of the tibial spine, leading to persistent pain and failure of UKA[20]. Similarly, in this study, it was found that the improvement in TFS was independent of the amount of improvement in the lower extremity mechanical axis, and BMI, age and gender were not related to these improvement amounts. The average amount of 1.59 mm correction observed in the postoperative period in TFS in this study was not observed to have a positive effect on the clinical results. However, since the mean follow-up period in this study was less than 5 years, it is unclear whether the clinical scores will still remain at the same level or change negatively in the future in patients with high TFS. Therefore, long-term follow-up of the patients in this study may be a more accurate guide in this regard. Nam et reported an average 2.2 ± 2.6 mm improvement in TFS and also stated that this was not correlated with the amount of improvement in the mechanical axis and was independent of the patient's age, gender and BMI values[17].

As a result of correction of varus deformities of the patients in this study within certain degrees, the increase in the postoperative lateral joint distance and the decrease in the lateral outer joint distance were found to be consistent with similar studies in the literature. Khamaisy et al. compared the pre- and postoperative radiographs of medial UKA patients with a control group, and reported that the preoperative lateral joint distance was significantly narrower in the patients than in the control group, and the lateral joint distance increased significantly postoperatively, resulting in the elimination of the significant difference from the control group[9]. As a result, it was stated that medial UKA application corrected the knee joint compliance and restored the lateral joint distance.

This study has several limitations, primarily that it was retrospective in design. Second, the measurements were evaluated on coronal plane radiographs, and no evaluation was made of sagittal plane deformities. Third, as all the surgeries were performed by 2 senior surgeons (H.A, E.D), these results may not be reproducible in small centers or clinics with fewer cases. Finally, because of the difficulty in matching, a control group was not formed for comparison of the inner, middle and outer lateral joint distance measurements, and therefore the improvement in the

lateral joint distance could not be compared with values that could be considered normal.

Despite the limitations of this study, its major strength was that it is one of the few studies showing that UKAs have a corrective effect on TFS, lateral joint distance, and lower extremity axis. In addition, the investigation of the effect of TFS, lateral joint distance and lower extremity axis changes on clinical scoring can also be considered a strength of the study. Further studies using standardized methods for the measurement of TFS and lateral joint distances will enable better understanding of how the improvements in TFS following UKA application affect the clinical scores of the patients. Unicompartmental knee prostheses correct lower extremity axis, TFS and lateral joint distance, unrelated to the use of cement.

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