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The Effect of Correction Amount of Varus Deformity After Unicompartmental Knee Arthroplasty on Functional and Clinical Outcomes

Unikompartmental Diz Artroplastisi Sonrası Varus Deformite Düzeltme Miktarının Fonksiyonel ve Klinik Sonuçlar Üzerine Etkisi

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ABSTRACT

Objective: The objective was to investigate the effect of the amount of varus deformity correction on functional and clinical outcomes after unicompartmental knee surgery. Material and methods: Seventy-one medial unicompartmental knee arthroplasties (UKA) in 51 patients were enrolled in this study. The knees were grouped based on the amount of correction using standing orthoroentgenograms after the surgery (0-4.9° correction in Group 1, 5-9.9° in Group 2, and 10° or above in Group 3). Range of motion measurements, posterior tibial slope angles, visual analogue score (VAS), Knee Society Score (KSS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and Oxford Knee Score (OKS) questionnaires, which were utilized for functional knee evaluation, were the assessment tools. Results: All of these patient-reported outcome scores, posterior tibial slope angles, visual analogue scores, and measurements of range of motion were significantly improved in all groups after UKA surgery. However, there were no significant differences when the postoperative scores were compared between groups. Conclusion: Selected patients who have varus deformities up to 15 degrees can be operated on safely using UKA without compromising clinical and functional outcomes.

Keywords: *Unicompartmental knee replacement, Varus deformity, Tibial slope*

ÖZ

Amaç: Bu çalışmanın amacı, unikompartmental diz cerrahisi sonrası varus deformite düzeltme miktarının fonksiyonel ve klinik sonuçlar üzerindeki etkisini araştırmaktır. Gereç ve Yöntem: Bu çalışmaya 51 hastada 71 medial unikompartmental diz artroplastisi (UKA) dahil edildi. Dizler, ameliyat sonrası ayakta basarak çekilen ortoröntgenogramlar kullanılarak düzeltme miktarına göre gruplandırıldı (Grup 1'de 0-4.9° düzeltme, Grup 2'de 5-9.9° ve Grup 3'te 10° veya üzeri). Dizlerin fonksiyonel değerlendirilmesi için hareket aralığı ölçümleri, posterior tibial eğim açıları, görsel analog skor (VAS), Diz Cemiyeti Skoru (KSS), Western Ontario ve McMaster Üniversiteleri Osteoartrit İndeksi (WOMAC) ve Oxford Diz Skoru (OKS) anketleri kullanıldı. Bulgular: Tüm diz skorları, posterior tibial eğim açıları, VAS skorlar ve eklem hareket açıklığı ölçümleri, UKA cerrahisi sonrası tüm gruplarda anlamlı bir şekilde iyileşmiştir. Ancak, ameliyat sonrası skorlar gruplar arasında karşılaştırıldığında anlamlı farklılıklar bulunmamıştır. Sonuç: Seçilmiş varus deformitesi olan hastalar, klinik ve fonksiyonel sonuçları riske atmadan UKA kullanılarak güvenli bir şekilde ameliyat edilebilir.

Anahtar Kelimeler: *Unikompartmental diz replasmanı, Varus deformitesi, Tibial eğim*

INTRODUCTION

Unicompartmental knee arthroplasty (UKA) is extensively employed as a surgical intervention when knee arthrosis is limited to a single compartment, especially the medial side. Achieving favorable outcomes in medial UKA relies on accurately restoring lower extremity alignment during surgery (1). Unlike total knee arthroplasty, where bone cuts, osteophyte excisions, and adjustments in polyethylene insert height rectify deformities, in UKA, no additional soft tissue releases are performed to realign the neutral mechanical axis. Inaccurate varus-valgus alignment or malposition of components after UKA surgery can lead to early polyethylene wear, aseptic loosening, arthrosis development in the lateral compartment, and higher revision rates (2-4). Due to disappointing outcomes following first-generation UKA procedures, Kozinn and Scott established selection criteria which included: (1) a low functional level, (2) age over 60 years, (3) a weight less than 82 kg, (4) a flexion arc of 90°, (5) flexion contracture of less than 5°, (6) minimal resting pain, and (7) a passively correctable maximum 10° varus or 15° valgus deformity (5). Enhanced surgical techniques, sophisticated implant designs, and meticulous patient selection based on these criteria have resulted in improved survivorship and revision rates comparable to those of total knee arthroplasty (6) . Nevertheless, the standard criteria have been expanding and evolving due to these factors, and the acceptable threshold for correcting varus deformity in medial UKA remains controversial, with ongoing discussions. Some authors advise against operating on deformities larger than 10° (7,8). In a recent study by Seng CS et al., patients with severe varus deformity exceeding 15° underwent UKA surgery and demonstrated long-term survival (9).

The purpose of this study was to evaluate the clinical and functional outcomes of medial UKA and investigate whether varying degrees of preoperative varus deformities affect these results. Our hypothesis was that varus deformities up to 15° would not influence outcomes after UKA surgery if good alignment could be achieved. This study focuses on postoperative knee pain status, functional recovery, and radiological results.

MATERIAL and METHOD

This study was approved by the local ethics committee, and informed consent was obtained from each patient. Seventy-one knees of 51 patients (44 females, 86.3%; 7 males, 13.7%) with arthrosis isolated to the medial compartment underwent unicompartmental knee replacement by a single orthopedic surgeon (AMU) between February 2013 and December 2015. The inclusion criteria were (1) isolated medial unicompartmental arthrosis, (2) at least two years of follow-up, (3) varus deformity less than 15°, and (4) a passively correctable deformity. Patients who did not comply with the questionnaires and those who underwent revision surgery, such as conversion from a high tibia osteotomy or fracture surgery, or experienced loosening or failure due to trauma, were excluded, as were those with missing records or preoperative anterior cruciate ligament deficiency. Seventy-one knees of 51 patients met the selection criteria and were included for further evaluation.

All included knees were implanted with a medial cemented Zimmer Unicompartmental High Flex Knee System (ZUK) (Zimmer Inc, Warsaw, Indiana, USA). All patients underwent surgery using the same minimally invasive surgical approach and technique. The operation was performed under a tourniquet. An anterior midline skin incision and medial parapatellar approach were utilized. Both the femoral and tibial components were cemented in place. The appropriate polyethylene insert was inserted to ensure neutral mechanical alignment under fluoroscopic guidance. No drains were applied at the end of the procedure. Continuous passive range of motion exercises were initiated as soon as possible on the first postoperative day, and patients were encouraged to walk with two crutches, weight-bearing as tolerated.

Radiologic Outcomes

Standing x-rays were obtained from all patients preoperatively and postoperatively at the third-month visit. Preoperative and postoperative full-length standing orthoroentgenograms, as well as

anteroposterior and lateral views of the operated knees, were used for radiological evaluation. Lower extremity alignment was assessed using the hip-knee-ankle angle (HKA), which measures the angle between the mechanical axes of the femur and tibia. These axes form a straight line, with the normal angle specified as 180°. Varus deformity is described when this angle is less than 180°, and valgus deformity when it is greater than 180°. The knees were subdivided according to the amount of varus deformity correction: 0-4.9° correction in Group 1, 5-9.9° in Group 2, and 10° or more in Group 3. The preoperative and postoperative radiographs of a patient are shown in Figure 1.

Figure 1. Preoperative and Postoperative X-Rays of a Patient.

Clinical And Functional Outcomes

All clinical data of the patients were retrospectively analyzed both preoperatively and at their routine second-year follow-up examination. Pain status was assessed using the visual analogue score (VAS), and all range of motion measurements were performed by the senior author (AMU). Participants completed questionnaires including the Knee Society Score (KSS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and Oxford Knee Score (OKS) for functional knee evaluation.

Statistical Analysis

Statistical analysis was conducted using IBM SPSS v23 software (SPSS Inc., Chicago, IL). After determining the frequencies and descriptive statistics of the data, the Shapiro-Wilk and skewness-kurtosis tests were employed to assess the normality of variable distributions. Kruskal-Wallis and Friedman tests were utilized for comparisons among the groups. Quantitative data were presented as mean ± standard deviation. A significance level of $p<0.05$ was considered statistically significant

RESULTS

None of the included patients required revision surgery up to the completion date of this study. The mean age of the patients at the time of surgery was 61.65±7.39 years. Patients were evaluated over a mean period of 47 months (range:24-77 months). There were no significant differences in age, gender, height, weight, or body mass index (BMI) distribution among the groups ($p>0.05$). Twenty out of 51 patients underwent bilateral surgery. Of all replacements, 56.3% (n=40) were performed on the right side, and 43.7% (n=31) on the left side. The distribution of operated sides did not differ significantly among the groups (p:0.171). Demographic data is presented in Table 1.

Table 1: Demographic Data

	All patients (n=51)	Group 1 (n=11)	Group 2 (n=18)	Group 3 (n=22)	P value
Age (years)	61,65±7,39	61,55±8,53	61,44±7,25	61,86±7,27	0,992
Height (cm)	161,51±6,25	160,64±4,63	163,56±8,54	160,27±4,27	0,463
Weight (kg)	80,41±11,73	81,18±9,51	80,11±10,43	80,27±14,01	0,930
BMI (kg/m^2)	30,84±4,27	31,44±3,17	30,05±4,19	31,18±4,85	0,474

*Kruskal-Wallis test is applied.

All patient-reported outcome scores, visual analogue scores, and range of motion measurements significantly improved in all groups after UKA surgery. However, there were no significant differences when comparing postoperative scores between groups (Tables 2 and 3).

Table 2: Results of Range of Motion

	All knees (n=71)	Group 1 (n=15)	Group 2 (n=28)	Group 3 (n=28)	P value
Pre-flexion	128,73±11,45	123±11,62	128,75±9,68	131,79±12,19	
Post-flexion	128,38±9,96	127±9,60	128,21±9,35	129,29±10,95	0,176
Pre-extension	6,06±4,22	6±3,87	5,54±4,38	6,61±4,31	
Post-extension	0,25±1,29	0±0	0±0	0,64±2,02	0,103

*Friedman test is applied.
*Pre-: preoperative
*Post-:postoperative

Table 3: Clinical Results

	All knees (n=71)	**Group 1 (n=15)**	**Group 2 (n=28)**	**Group 3 (n=28)**	P value
VASpre	7,52±1,34	8,07±1,22	7,11±1,29	7,64±1,37	0,296
VASpost	0,35±0,48	0,42±0,51	0,32±0,48	0,36±0,49	
KSSpre	48,62±6,62	48,60±4,69	48,11±7,17	49,14±7,09	0,426
KSSpost	97,48±3,21	98,00±2,54	98,04±2,78	96,64±3,80	
KSSfuncpre	56,20±9,24	52,33±11,93	58,57±9,01	55,89±7,21	0,108
KSSfuncpost	98,87±3,18	98,67±3,52	98,93±3,15	98,93±3,15	
WOMAC pre	43,98±8,76	40,21±12,51	44,27±8,00	45,70±6,54	0,112
WOMAC post	97,98±2,36	98,19±1,75	97,86±2,35	97,97±2,70	
OKSpre	12,80±3,18	12,40±4,08	13,43±3,06	12,39±2,74	0,316
OKSpost	47,50±6,49	46,80±1,15	46,74±1,29	48,61±10,17	

*Pre: Preoperative
*Post: Postoperative
*Func: functional
*Friedman test is applied.

The average preoperative hip-knee-ankle (HKA) angle was measured as 170.40±3.96 and increased to 179.19±3.29 after UKA. In Group 1, which included 15 knees, the average preoperative HKA was 175.68±4.55, and it improved to an angle of 178.46±3.44. For Group 2, consisting of 28 knees,

the average preoperative HKA was 172.20±2.58, which improved to an angle of 179.92±2.65. In Group 3, including 28 knees, the average preoperative HKA was 165.78±3.42, and it improved to an angle of 178.86±3.51. Radiological results of the patients are shown in Table 4.

Table 4: Radiologic results

	All knees (n=71)	Group 1 (n=15)	Group 2 (n=28)	Group 3 (n=28)	P value K-W
Preop HKA	170,40±3,96	175,68±4,55	172,20±2,58	165,78±3,42	0,001* a
Postop HKA	179,19±3,29	178,46±3,44	179,92±2,65	178,86±3,51	0,004*b
P value W		0,001*	0,001*	0,001*	
Preop slope	8,55±3,49	8,39±2,84	7,37±3,55	9,85±3,46	0,014*c
Postop slope	5,14±2,88	5,39±2,78	4,71±3,51	5,55±1,97	0,128
P value W		0,011*	0,009*	0,001*	

Friedman test is applied. *: p value is accepted significant below 0,05. a: Group 2 and Group 3 is significantly different on mechanic-pre values (p=0,038), b: Group 1 and Group 3 is significantly different on slope-pre values (p=0,041).

DISCUSSION and CONCLUSION

The mechanical axis is one of the most critical factors influencing the clinical outcomes and survival of all types of knee arthroplasties. Unlike total knee arthroplasty, where the mechanical axis target is well-defined and typically aimed at achieving neutral alignment (HKA angle of 180°), the optimal mechanical axis following medial UKA surgery remains less clear. While some authors advocate for achieving a neutral mechanical axis, particularly with fixed-bearing design implants, others argue that a slight varus alignment may be preferable (10,11). Our preference is to aim for a neutral mechanical axis, although a slight varus alignment is also acceptable to avoid overcorrection of the deformity and potential iatrogenic progression of lateral compartmental arthrosis. None of the knees exhibited excessive varus deformity, but five knees in Group 1 and four knees in Group 2 developed valgus alignment after surgery in the present study. The mean HKA angle postoperatively was calculated as 179.19±3.29 degrees, indicating a slight varus alignment, using medial fixed-bearing UKA in this cohort. It is a well-known fact that any form of valgus alignment (HKA >180°) or severe undercorrection of varus deformity (HKA <170°) postoperatively is not preferred due to the risk of high revision rates (2). There is no consensus on the amount of residual varus alignment to be achieved. Vasso et al. reported higher International Knee Society knee and functional scores, albeit with a lack of longer follow-up, when the postoperative axis is in varus below 7 degrees (10). Zuiderbaan et al. suggested a narrower range for postoperative alignment, specifically between 1-4° (12).

It seems that the indications for unicompartmental arthroplasty have expanded since Kozinn and Scott established the selection criteria. Preoperative coronal alignment is one of the criteria that is currently being questioned. Recently, Kleeblad et al. conducted a study involving 200 patients with preoperative varus alignment ranging between 7° and 18° (13). This study demonstrated that there were no significant differences in clinical outcomes and radiologic results among patients with preoperative mild varus, moderate varus, or advanced varus deformities. We believe that this was facilitated by achieving successful alignment independently from preoperative deformity following UKA surgeries. Deformity correction was achieved through medial osteophyte excisions and bone cuts guided by the manufacturer's recommendations, with no additional soft tissue releases performed during the procedure. Our aim was to achieve a neutral or slightly varus mechanical axis in all patients, irrespective of the degree of deformity, to mitigate the risk of implant wear, lateral compartment arthrosis, and recurrence (2,14). All study groups exhibited similar postoperative range of motion, visual analogue scale (VAS), Oxford Knee Score (OKS), Knee Society Score (KSS), and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores,

which can be attributed to the achieved alignment, despite Group 3 having a statistically significant preoperative varus deformity compared to the others. In line with the findings of the present study, Kennedy et al. reported similar outcome scores and equivalent revision rates in knees with 5° varus and 10° varus alignment in a cohort of 891 mobile-bearing medial UKA surgeries (11). Gulati et al. similarly concluded that an increase in varus deformity is associated with higher postoperative OKS scores in UKA surgeries (15). A group of authors demonstrated that postoperative alignment is not correlated with the outcomes of UKA surgeries (16).

The preoperative mean tibial slope of Group 1 was significantly higher than that of Group 3, however, postoperative tibial slopes were similar among the groups and did not impact the outcomes. This study also demonstrated that both tibial slope and varus deformity could be improved with the appropriate surgical technique.

There is a general belief that UKA yields more favorable results when the patient has a slight varus or close to neutral alignment of the lower extremity (10,17). As far as we know, it hasn't been investigated whether preoperative slight varus, moderate varus, or advanced varus subtypes result in better outcomes after UKA. According to the results of this study, if the preoperative varus deformity is within 15°, the patient could be safely operated on without compromise. Moreover, there appears to be no difference in survivorship after UKA in the mid-term. None of the included knees were revised during our follow-up. It is a well-known fact that high-volume surgeons and centers have better survival rates than low-volume surgeons and centers (18). This may explain our high survival rate despite including advanced varus deformities in the study. The emergence of newer implant designs and such successful results suggest that the selection criteria for UKA should be reconsidered.

This study had several limitations. Firstly, it utilized a small sample size, including only 28 knees with advanced varus deformity. While the study yielded successful outcomes and survivorship, the limited number of patients in this subgroup diminishes the ability to draw definitive conclusions. Additionally, the study design was retrospective, and the patients were followed up for a relatively short duration. Another limitation is that larger varus deformities exceeding 15° were not evaluated in this study. In cases of advanced varus knee deformities, an alternative surgical option is total knee arthroplasty (TKA), and it may be beneficial to include a comparison group undergoing TKA in future studies to determine whether UKA provides superior outcomes in such cases.

In conclusion, this study refutes the notion that unicompartmental knee arthroplasty (UKA) should not be performed and would yield inferior results in cases of advanced varus deformity. Satisfactory clinical outcomes, high knee functional scores, and improved quality of life can be achieved if a neutral or slight varus alignment is attained following UKA, regardless of the degree of varus deformity up to 15°. Future studies with larger sample sizes should further investigate the correlation between lower limb alignment and clinical outcomes to validate these findings. Additionally, including a group with varus deformities larger than 15° in such research would be beneficial for comprehensive analysis.

Declaration of Ethical Code: In this study, we undertake that all the rules required to be followed within the scope of the "Higher Education Institutions Scientific Research and Publication Ethics Directive" are complied with, and that none of the actions stated under the heading "Actions Against Scientific Research and Publication Ethics" are not carried out.

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