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Lateral Tibial Slope Should Be Considered When Planning Medial Unicompartmental Knee Arthroplasty

Fahri Emre,[1] Murat Bozkurt[2]

[1]Department of Orthopedics and Traumatology, VM Medicalpark Ankara Hospital, Ankara, Türkiye
[2]Department of Orthopedics and Traumatology, Yıldırım Beyazıt University, Ankara, Türkiye

ABSTRACT

Objective: The purpose of this study was to evaluate the effects of medial tibial slope (MPTS) and lateral tibial slope (LPTS) on clinical scores and range of motion (ROM) after unicompartmental knee arthroplasty (UKA).

Materials and Methods: A total of one hundred eighty-two patients with medial compartment osteoarthritis, treated by UKA between January 2011 and May 2017, were retrospectively evaluated. Postoperative MPTS and LPTS were measured using computed tomography (CT). Patients were categorized into four groups based on MPTS and LPTS values: Group 1 had MPTS and LPTS>5°; Group 2 had MPTS>5°, LPTS<5°; Group 3 had MPTS<5°, LPTS>5°; and Group 4 had MPTS and LPTS<5°. Preoperative and postoperative Knee Society Score (KSS) and ROM were compared.

Results: The mean age of the patients was 64.3±5.2 years (range: 52–78) and the mean body mass index (BMI) was 26±1.6 kg/m² (range: 22–29.6). There were no significant differences between the groups regarding age, BMI, follow-up period, and gender (p=0.402, p=0.076, p=0.712 and p=0.787, respectively). The postoperative KSS scores and postoperative maximum flexion in patients with both MPTS and LPTS>5° were significantly higher compared to the other groups (p<0.001 for both).

Conclusion: Sagittal alignment should not be overlooked in UKA. Unlike previous studies that evaluated only MPTS using a lateral radiograph and ignored LPTS, this study demonstrated that LPTS affects postoperative ROM and clinical scores. Therefore, defining MPTS along with LPTS is recommended.

Keywords: Unicompartmental knee arthroplasty, posterior tibial slope, osteoarthritis, range of motion, computed tomography.

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Address for correspondence:
Fahri Emre.
Department of Orthopedics and Traumatology, VM Medicalpark Ankara Hospital, Ankara, Türkiye
Phone: +90 535 409 58 11
E-mail: faemre@gmail.com

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INTRODUCTION

Unicompartmental knee arthroplasty (UKA) is an effective method for treating medial compartment osteoarthritis.[1,2] However, proper surgical technique and optimal implant positioning are crucial for achieving satisfactory results.[3,4] Postoperative range of motion (ROM) is a significant outcome parameter of knee arthroplasty.[5,6] This is especially relevant for the Asian population, which requires deep knee flexion for daily activities, notably during prayer.[6] The posterior tibial slope (PTS) may influence postoperative ROM and clinical scores after UKA.[7,8] Proper component positioning in the sagittal plane is vital to prevent early failures in UKA.[9]

Table 1. Demographic characteristics of the patients (age, body mass index (BMI), follow-up time, and gender)

	Mean±SD	Median (Min–Max)	n
Age (years)	64.3±5.2	63 (52–78)	
BMI (kg/m²)	26.01±1.6	25.7 (22–29.6)	
Follow-up time (years)	6.2±0.8	6 (3–8)	
Gender			
Female			128
Male			54
Group 1			58
Group 2			45
Group 3			42
Group 4			37

SD: Standard deviation; Min: Minimum; Max: Maximum.

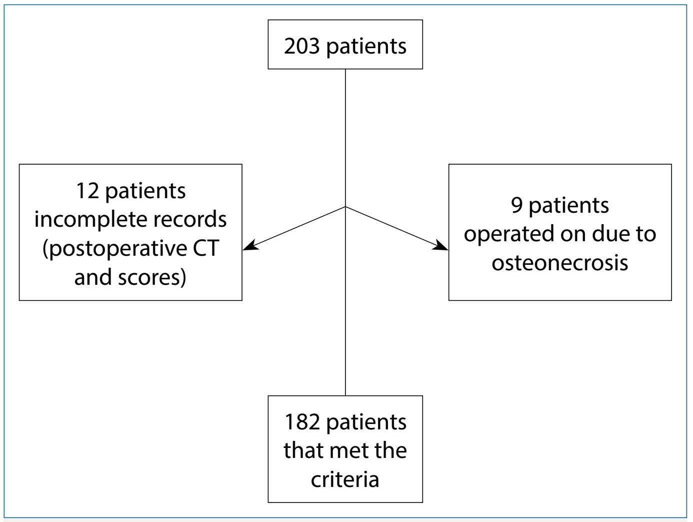

Figure 1. Flow chart.

During UKA, the medial tibial slope (MPTS) can be adjusted, but the lateral tibial slope (LPTS) cannot. Numerous studies have evaluated MPTS after UKA using radiography; however, few have investigated the effect of LPTS (10–12). We hypothesize that LPTS also impacts clinical scores in UKA. This study aimed to assess the influence of both MPTS and LPTS on clinical scores and ROM post-UKA.

MATERIALS AND METHODS

We retrospectively evaluated two hundred and three patients with medial compartment osteoarthritis who underwent UKA between January 2011 and May 2017. This study included patients treated with a primary unilateral fixed-bearing UKA (ZIMMER®, Warsaw, Indiana, USA) for osteoarthritis, those with a minimum three-years follow-up, patients who mobilized without complications, had no wound issues, and had no inflammatory diseases. The Clinical Research Ethics Committee of Ankara Yıldırım Beyazıt University approved this study (Decision number: 2015/210). All participants had varus knees affected by osteoarthritis. We excluded patients who received UKA for reasons other than osteoarthritis (like osteonecrosis) and those without postoperative computed tomography (CT). Twelve patients with incomplete records (postoperative CT and scores) and nine patients who underwent surgery due to osteonecrosis were excluded. In total, 182 patients meeting our criteria were recalled for a final evaluation (Fig. 1). MPTS and LPTS were measured using computed tomography (CT) for each patient. The study group included 128 females (70.3%) and 54 males (29.7%), with an average follow-up period of 6.2 years (ranging from 3–8 years). Patients were categorized into four groups based on MPTS and LPTS values: Group 1 had both MPTS and LPTS>5°; Group 2 had MPTS>5° and LPTS<5°; Group 3 had MPTS<5° and LPTS>5°; and Group 4 had both MPTS and LPTS<5° (Table 1).

Clinical evaluations included the Knee Society Score (KSS) preoperatively and postoperatively at the last follow-up. Both preoperative and postoperative ROM were recorded. All parameters measured preoperatively and at the last follow-up were compared between the groups.

Surgical Technique

The surgical procedure was consistent for all patients. Both femoral and tibial components were affixed using bone cement. Every patient underwent patelloplasty and patellar denervation; there was no need for patellar implant in any case. Initially, the tibial cut was executed perpendicular to the mechanical axis. Efforts were made to position the tibial component to maximize cortical contact in both anteroposterior and mediolateral planes. A distal femoral cut was made using the femoral cutting block. The knee was positioned at 90° flexion, and the chamfer and posterior femoral cuts were executed with cutting guides.

Postoperative Rehabilitation

The rehabilitation protocol was uniform for all patients. Drains were removed 24 hours after the operation. ROM and walking exercises commenced soon after. The postoperative rehabilitation was concluded within three weeks, with evaluations conducted by physiotherapists.

Radiological Evaluation

Digital assessments of the MPTS and the LPTS were conducted using CT scans taken during the final follow-up. The CT images had a thickness of 0.6 mm and were taken with metal artifact reduction software on a 256-slice multidetector scanner (Siemens®, Erlangen, Germany). A radiologist with expertise in musculoskeletal imaging used the Leonardo Dr/Dsa Va30a software

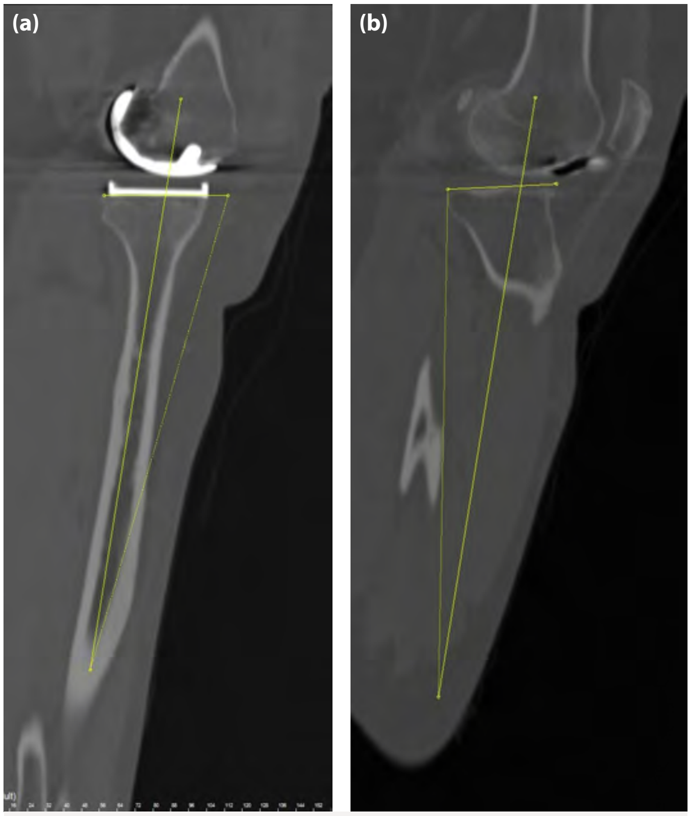

Figure 2. (a) Demonstration of the slope angle of the medial tibial plateau in relation to the diaphysis of the tibia as shown in computed tomography. **(b)** Demonstration of the slope angle of the lateral tibial plateau in relation to the diaphysis of the tibia as shown in computed tomography.

(Siemens®, Erlangen, Germany) to evaluate each CT image. To minimize both interobserver and intraobserver errors, two orthopedic surgeon, who were double-blinded, selected the images. Initially, the mechanical axis of the tibia was delineated to measure the MPTS and the LPTS (Fig. 2). Subsequently, the longest lines connecting the anterior and posterior cortices of the related compartment were drawn. The MPTS and the LPTS are defined as the angles formed between the mechanical axis of the tibia and the lines connecting the cortices of the related compartment.[13]

Statistical Analysis

Descriptive statistics for continuous variables included mean, standard deviation, median, minimum, and maximum values, while percentages were used for categorical variables. For normally distributed data, Analysis of Variance (ANOVA) was employed to compare groups, and the Tukey test identified differences between these groups. For data that were not normally distributed, the Kruskal-Wallis Variance Analysis was used to compare groups, and the Kruskal-Wallis multiple comparison tests were utilized to determine differences between the groups. The Wilcoxon test was employed to compare preoperative and postoperative scores. Correlations among parameters were assessed with Spearman's Correlation coefficient. IBM's Statistical Package for the Social Sciences (SPSS) Statistics 20 software was used for all statistical analyses, with statistical significance set at $p<0.05$.

RESULTS

The mean age of the patients was 64.3±5.2 years (range: 52–78), and the average body mass index (BMI) was 26±1.6 kg/m^2 (range: 22–29.6). There was no statistically significant difference between the groups concerning age, BMI, follow-up period, and gender (p=0.402, p=0.076, p=0.712, and p=0.787, respectively). Further demographic details are provided in Table 1.

Postoperative flexion and KSS scores were significantly higher than preoperative scores (both p<0.001) (Table 2). The preoperative KSS and the preoperative maximum flexion degrees were comparable, but the postoperative maximum flexion degree was significantly higher in Group 1 (p<0.001) (Table 3). No significant difference existed between Groups 2, 3, and 4 (p>0.05).

Table 2. Comparison of preoperative and postoperative maximum flexion, maximum extension, and Knee Society Score (KSS score)

	Preoperative Mean±SD Median (Min–Max)	Postoperative Mean±SD Median (Min–Max)	Test statistics	p
Maximum flexion	119.1±4.7 120 (110-128)	125.4±5.7 125 (110-135)	Z=-10.296	<0.001
Maximum extension	2.8±3.3 0 (0-10)	1.5±2.4 0 (0-7)	Z=-6.607	<0.001
KSS score	33.2±5.1 32 (24-47)	82.3±7.9 82 (68-99)	Z=-11.702	<0.001

SD: Standard deviation; Min: Minimum; Max: Maximum.

Table 3. Comparison of preoperative and postoperative maximum flexion, maximum extension, and Knee Society Score (KSS score) between groups

	Group 1 (n=58) Mean±SD Median (Min–Max)	Group 2 (n=45) Mean±SD Median (Min–Max)	Group 3 (n=42) Mean±SD Median (Min–Max)	Group 4 (n=37) Mean±SD Median (Min–Max)	p*	Groups
Preoperative maximum flexion	119.22±4.66	119.67±4.22	119.24±5.41	118.32±4.98	0.619	1–2 p<0.001
	120 (110–128)	120 (112–126)	120 (110–128)	120 (110–127)		1–3 p<0.001
Postoperative maximum flexion	131.77±2.54	124.49±2.77	123.43±4.35	123.27±3.83	<0.001	1–4 p<0.001
	130 (128–135)	125 (120–130)	120 (110–128)	120 (115–128)		2–3 p<0.001
Preoperative maximum extension	2.84±2.95	3.11±3.59	2.95±3.50	2.38±3.34	0.794	2–4 p<0.01
	4 (0–10)	0 (0–10)	0 (0–10)	0 (0–10)		3–4 p>0.05
Postoperative maximum extension	1.62±2.45	1.42±2.41	1.48±2.38	1.54±2.41	0.969	1–2 p<0.001
	0 (0–7)	0 (0–7)	0 (0–7)	0 (0–6)		1–3 p<0.001
Preoperative KSS score	33.24±5.38	34.02±4.84	32.10±3.73	33.65±6.31	0.452	1–4 p<0.001
	32 (26–47)	33 (25–40)	32 (25–44)	33 (24–46)		2–3 p<0.001
Postoperative KSS score	88.86±2.41	79.02±2.34	79.00±4.78	78.84±2.80	<0.001	2–4 p<0.001
	91 (85–99)	82 (72–89)	76 (68–91)	74 (68–88)		3–4 p>0.05

*: Kruskal-Wallis Analysis of Variance; SD: Standard deviation; Min: Minimum; Max: Maximum.

The postoperative KSS scores for Group 1 were significantly higher than those of the other groups (p<0.001) (Table 3).

DISCUSSION

Our study's most significant finding underscores the importance of considering both MPTS and LPTS in the planning of UKA. We found that increasing MPTS, when LPTS is near zero, did not influence clinical scores and ROM. Group 1, which exhibited the highest clinical scores and ROM, had elevated levels of both MPTS and LPTS. Conversely, reducing MPTS in patients with a high native LPTS had a detrimental effect on clinical scores and ROM.

MPTS and LPTS may differ in a single knee. Meier et al.[13] demonstrated that the average difference between MPTS and LPTS ranged from a minimum of 2.6° (SD 2.0) to a maximum of 9.5°, a statistically significant difference. In Chiu et al.'s[14] cadaveric study, MPTS and LPTS were measured at 14.8° (range 5°–25°) and 11.8° (range 4°–23°), respectively. Haddad et al.[15] identified no significant difference between MPTS (average 5.7°) and LPTS (average 5.3°). In total knee arthroplasty, both slopes could be aligned. In contrast, in medial UKA, only MPTS is adjustable. After UKA there may be a difference between MPTS and LPTS, akin to the native knee. Kuwano et al.[16] advised that LPTS serve as a reference during the preoperative planning for total knee arthroplasty and tibial cut.

In the preoperative surgical evaluation, the sole reliance on a lateral X-ray does not facilitate the independent detection of MPTS and LPTS.[13] This does not provide sufficient information about posterior tibial slope (PTS) during the planning of UKA, and LPTS is frequently ignored. However, when considering alignment, both MPTS and LPTS are integral to the tibial geometry's three-dimensional structure.[17] This study emphasizes that LPTS should also be considered during the planning for UKA. Kang et al.[18] reported that increasing MPTS in UKA decreases the load on the components, thereby reducing polyethylene wear. Nunley et al.[19] stated that a 5–7° slope is less than the native slope and recommended a slope greater than 5–7° slope during UKA. Our findings suggest that an increase in MPTS in patients with higher LPTS positively influences clinical scores and ROM. Conversely, decreasing MPTS in such patients negatively has a negative impact on clinical scores and ROM. This might result from the increased load on the medial compartment, specifically on the components. We advise maintaining MPTS above 5 degrees when LPTS exceeds 5 degrees.

Chatellard et al.[10] proposed that PTS in UKA should not exceed 5 degrees. Another study posited that PTS in UKA should be under 4 degrees, warning that a slope greater than 10 degrees could lead to tibial translation and failure.[20] Weber et al.[21] advocated for a steeper slope in fixed insert UKA. However, their study was *in vitro* and overlooked ligament balance. A pronounced slope can induce anterior tibial translation, potentially overloading the anterior cruciate ligament (ACL). This strain on the ACL and potential rupture may cause knee instability. Additionally, load transfer on the tibial component without ACL strain could result in tibial component loosening.[10] Hernigou et al.[12] found that an increased PTS in UKA did not improve clinical scores and ROM. They advised a slope between 3–7 degrees to minimize strain on the ACL and relied on radiography for measurements without considering LPTS. In their study, Kang et al.[18] demonstrated that increasing MPTS in UKA elevates the load on the lateral tibial plateau. They suggested that this may contribute to the progression of osteoarthritis. In our study, we used CT images and took LPTS into account. We found that LPTS also impacts the clinical scores and ROM in UKA. While increasing MPTS in patients with lower LPTS does not influence clinical scores and ROM, it can intensify the strain on the ACL and the load on the lateral compartment. Over time, potential wear of the components and loosening could precipitate osteoarthritis in the lateral compartment. To mitigate the risk of ACL strain and osteoarthritis in the lateral compartment for patients with LPTS less than 5 degrees, MPTS should similarly be kept below 5 degrees.

The limitations of our study include a relatively low number of patients and a limited follow-up period. Secondly, we did not obtain preoperative knee CT scans that would indicate preoperative slopes. As a result, we could not evaluate the difference between preoperative and postoperative MPTS. Thirdly, CT scans may not accurately depict the actual thickness of the cartilage, potentially leading to errors in the calculation of tibial slopes.

CONCLUSION

Sagittal alignment should not be overlooked in UKA. Contrary to prior studies that assessed only MPTS using lateral radiographs and disregarded LPTS, our findings indicate that LPTS plays a role in postoperative ROM and clinical scores, Therefore, determining MPTS following LPTS may be advisable.

Peer-review: Externally peer-reviewed.

Ethics Committee Approval: The Ankara Yıldırım Beyazıt University Clinical Research Ethics Committee granted approval for this study (date: 16.09.2015, number: 2015/210).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Author Contributions: Concept – FE; Design – FE; Supervision – FE; Resource – MB; Materials – MB; Data Collection and/or Processing – FE; Analysis and/or Interpretation – MB; Literature Search – FE; Writing – MB; Critical Reviews – FE.

Conflict of Interest: The authors have no conflict of interest to declare.

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