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The Effect of Postoperative Mild Varus Deformity on Functional Outcome Scores after Primary Total Knee Arthroplasty in Patients with Varus Osteoarthritis

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ABSTRACT

Introduction: This study evaluated the effect of both postoperative residual varus alignment and the amount of correction in lower limb alignment (LLA) on postoperative functional outcomes of total knee arthroplasty TKAs in patients with preoperative varus deformity.

Methods: Two-hundred and fifty-two knees of 209 patients who underwent a TKA for treating varus gonarthrosis were retrospectively reviewed in the study. Patients were then divided into the three groups according to the postoperative hip-knee-ankle angle (HKAA): the neutral group (NG) (HKAA: 183°-177°); the mild varus group (HKAA: 176.9°-174°); and the severe varus group (HKAA <174°). Patients were also categorized into the three groups based on the amount of correction in LLA; group A (<5); group B (5° to 10°), and group C (>10°). Pre- and post-operative functional outcomes were compared among the groups.

Results: There were no significant differences in the postoperative Knee Society Score (KSS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and visual analog scale (VAS) scores between the mild and NGs (p=0.99, p=0.62, and p=0.33, respectively). The severe group showed lower postoperative KSS, WOMAC, and higher VAS scores compared to other two groups (p<0.001, p<0.001, and p<0.001, respectively). No significant differences were observed in the postoperative knee flexion and extension deficits among the three groups (p=0.79 and p=0.3). Patients with correction in LLA of >10° had higher WOMAC and lower VAS scores than the other patients (p=0.008 and p=0.002, respectively).

Conclusion: Postoperative mild varus deformity is not associated with poorer clinical and functional outcomes; however, a postoperative severe varus deformity following TKA can cause a significant deterioration in postoperative clinical and functional outcomes in patients with preoperative varus osteoarthritis.

Keywords: Total knee arthroplasty, residual varus, mild varus, varus deformity, lower limb alignment, functional outcomes

Introduction

Lower limb alignment (LLA) is one of the critical determinants of successful outcomes after total knee arthroplasty (TKA), and there is a widely accepted opinion that the neutral mechanical axis of the lower limb (0°±3°) in the coronal plane after TKA contributes to good functional outcomes and to implant longevity (1,2). If the neutral alignment is not achieved postoperatively, increased load acting on the tibial insert and component may lead to earlier polyethylene wear, implant loosening, and poorer clinical outcomes (3-6). Otherwise, improvements in the design and manufacture of prostheses have potentially reduced the risk of wear and implant loosening secondary to component malposition and lower limb malalignment (7). Nonetheless, research findings have been inconsistent regarding the effect of postoperative LLA on the clinical and functional outcomes of TKAs (8,9).

In the existing literature, some studies have shown a significant association between lower limb malalignment and poor functional outcomes following TKA (5,6) whereas other studies have reported that a mild postoperative varus alignment in the coronal plane does not adversely affect postoperative outcomes (8,10). Furthermore, previous literature has found that approximately 30% of the Asian population has a constitutional varus deformity (11). Accordingly, neutral alignment after TKA may not be normal in some individuals, and functional results and patient satisfaction may be lower with neutral alignment in such patients. Moreover, a significant number of bone resections and soft tissue releases may be needed to correct the preoperative lower limb deformity back to neutral alignment during TKA (3,11). However, according to our literature review, no consensus exists to date regarding the effect of excessive alteration of the bone stock and ligament balance in the knee joint on postoperative functional outcomes following TKA.

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The aim of the present study was to evaluate the impact of both postoperative residual varus deformity and the amount of correction in LLA on postoperative functional outcomes of TKAs in patients preoperative varus deformity.

Methods

Our study is a retrospective, single center outcome study which was conducted at an education and training hospital and has institutional review board-approval. Signed informed consent form was routinely obtained preoperatively from the patients included in the study. The study was approved by the University of Health Sciences Turkey, Haseki Training and Research Hospital Clinical Research Ethics Committee (approval number: 129-2021, date: 01.12.2021).

Patients who underwent primary TKA for treating varus knee osteoarthritis between January 2016 and April 2019 were retrospectively reviewed. Preoperative varus knee deformity was defined as hip-knee-ankle angle (HKAA) <177°. Inclusion criteria of our study were 1) a diagnosis of primary knee osteoarthritis, 2) preoperative knee varus deformity, 3) undergoing a posterior cruciate retaining prosthesis, 4) full medical records and radiographic images stored in the hospital Picture Archiving and Communication System (Picture Archiving and Communication System), and 5) being eager to participate in the study. The exclusion criteria of our study were 1) secondary knee osteoarthritis (rheumatologic disorder, trauma, etc.), 2) preoperative valgus knee deformity, 3) a history of previous knee surgery such as high tibial osteotomy or arthroscopic debridement, 4) concomitant chronic disease (chronic renal disease, severe heart disease, severe dementia, etc.), 5) severe preoperative flexion contracture of >20°, 6) lost to follow-up the following surgery, 7) inadequate and unacceptable radiographic imaging for the measurements, and 8) not wanting to participate in the study.

Study Population and Protocol

A total of 228 patients (271 knees) were evaluated on the basis of the above eligibility criteria. After excluding 19 knees of 19 patients (3 were lost to follow-up, 8 underwent previous knee surgery, 2 had unacceptable radiographic imaging for the radiologic measurements, and 6 had concomitant chronic disease), the remaining 252 knees (43 bilateral) of 209 patients (37 males, 172 females) were included in the study.

The study was conducted in two stages. First, to assess the impact of postoperative residual varus deformity on postoperative clinical and functional outcomes of TKAs, patients were divided into one of the three subgroups according to the postoperative HKAA: the neutral group (NG), patients with a neutral HKAA (183°-177°); the mild varus group (MVG), patients with a mild varus deformity (HKAA: 176.9°-174°); and the severe varus group (SVG), patients with a severe varus deformity (HKAA <174°). Second, to determine the impact of the amount of correction in LLA following TKA on ultimate knee functions, patients were also categorized into the three subgroups based on the amount of correction LLA following TKA; group A (<5); group B (5° to 10°), and group C (>10°). Pre- and post-operative functional outcomes were compared among the groups.

Functional Outcome Measures

The Knee Society Score (KSS) (12), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score (13), visual analog scale (VAS) (14), and knee range of motion (ROM) were calculated and measured preoperatively and been recorded in the patient files. Afterwards, the patients included in the study were called for KSS, WOMAC and VAS score calculations and ROM measurements for the final follow-up. The ROM of the knee joints were measured using a universal standard goniometer. All measurements were performed by senior orthopedic surgeons in our department.

Radiographic Outcome Measures

Varus angle was measured using HKAA, which measures the angulation between the mechanical axes of the femur and tibia (3,14), on immediate preoperative and routine postoperative 6-week follow-up orthoroentgenograms (anteroposterior full length, full weight-bearing standing digital radiography) (13) (Figure 1). All the radiographic measurements were performed by two orthopedic surgeons who were blinded to the clinical information of the patients. The measurements were recorded twice on the radiographs over a 2-week period. Intraclass correlation coefficients were used for evaluating the intra- and interobserver reliability of all radiographic assessments. The radiographic measurement was also assessed with one decimal. Orthoroentgenograms were obtained using a well-established, conventional approach that involved taking three radiographic exposures centered over the hip, knee, and ankle joints, then combining them into a single film to reduce magnification error (15).

Surgical Technique

In all patients, the skin incision was made at the midline of the knee and medial parapatellar arthrotomy was performed. After the patella

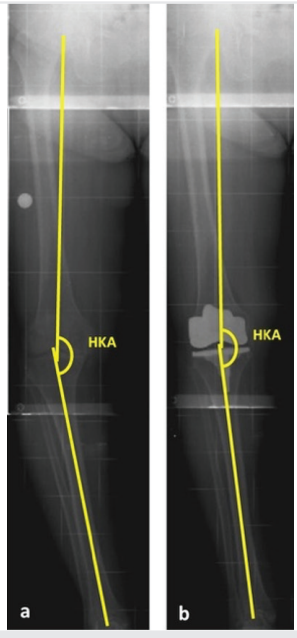

Figure 1. The measurement of hip-knee-ankle angle on full-leg radiographs (a) preoperative measurement, (b) postoperative measurement.
HKA: Hip-knee-ankle

was retracted laterally, hoffa-anterior cruciate ligament and menisci were excised. Femoral bone cuts were first performed, and then osteophytes were removed from the femoral notch. The rotation of the femoral component was identified using anatomical landmarks, as the posterior condylar axis, Whiteside's line (the anteroposterior axis), and the anatomical transepicondylar axis. The intramedullary guide was used for femoral bone cuts with a 6° of valgus angle. After femoral bone cuts and femoral component trials were performed, the proximal tibia was moved anteriorly, and surgery was continued with tibial preparation. The extramedullary tibial guide was centralized using the center of the tibial intercondylar eminence and true center of the ankle-second metatarsal as proximal and distal landmarks. All femoral and tibial components were implanted with a cemented posterior cruciate retaining TKA. None of the patients underwent patellar component implantation; peripatellar osteophytes were removed, and patellar denervation was performed.

Postoperative Rehabilitation Protocol

Postoperative rehabilitation was performed immediately, and a minimum of 90° knee flexion was obtained before discharge. Patients were scheduled for postoperative follow-up at the 3rd week for a wound check, at the 6th week, at 3, 6, 9, and 12 months, and after 1-year intervals, routinely.

Statistical Analysis

Statistical analysis was performed using SPSS ver. 21.0 (IBM Corp, 2011, Armonk, New York). The Shapiro-Wilk test was used for normality check. One-way ANOVA was used to compare the continuous variables among the three groups, and Tukey's multiple-comparison test was used for the post hoc pairwise comparisons if the values were in normal distribution. The Kruskal-Wallis test was used to compare the continuous variables among the three groups, and Tamhane's multiple-comparison test was used for the post-hoc pairwise comparisons if the values were not in normal distribution. P<0.05 was considered as statistically significant.

Results

Baseline Characteristics

Overall, of 209 patients (252 knees; 186 right side and 66 left side), were 29 males and 180 females. Their mean age was 66±7.6 years, and the mean follow-up was 56±9.7 months. The mean pre- and post-operative HKAAs were 169°±4.5° and 177°±2.3°, respectively (Table 1). The mean amount of correction in LLA following TKA was 7.1±5 degrees.

The Impact of Postoperative Residual Varus Deformity

There were 111 knees (92 patients; 12 male, 80 female) in the NG, 114 knees (102 patients; 19 male, 83 female) in the MVG, and 27 knees (27 patients; 10 male, 17 female) in the SVG. The mean age of the patients were 66.1±7.6 years in the NG, 66.4±8.0 years in the MVG, and 66.3±5.6 years in the SVG (p=0.95). The average follow-up period was 54.9±10.6 months in the NG, 57.5±8.8 months in the MVG, and 58.4±9.1 months in the SVG (p=0.21) (Table 2). Within group comparisons revealed a substantial improvement in all clinical outcomes compared to the preoperative baseline scores for all three groups.

Table 1. Demographic data of all patients

Number of patients (M/F)	209 (29/180)
Bilateral TKA (M/F)	43 (8/35)
Age (years)	66.3±7.6
The follow - up period (months)	56.4±9.7
Preoperative HKA (degrees)	169.3±4.5
Postoperative HKA (degrees)	176.5±2.3
The angle of alignment correction (degrees)	7.16±5
Preoperative extension deficit (degrees)	6.5±6.5
Preoperative knee flexion (degrees)	100.4±16.7
Postoperative extension deficit (degrees)	0.3±1.3
Postoperative knee flexion (degrees)	107.8±13.5
Preoperative KSS	32.2±8.9
Postoperative KSS	87.6±9.9
Preoperative WOMAC	27.8±9.4
Postoperative WOMAC	84.1±13.1
Preoperative VAS score	8.3±1.2
Postoperative VAS score	0.9±1.2

M: Male, F: Female, HKA: Hip-knee-ankle, KSS: Knee Society Score, WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index, VAS: Visual analog scale

Whereas no significant differences were determined in preoperative KSS, WOMAC, and VAS scores among the three groups, postoperative values significantly varied among the groups (p<0.001 for each outcome measure). In pair-wise comparisons of the subgroups, there were no considerable differences in all outcome scores between groups neutral and mild and groups mild and severe. Otherwise, the mean postoperative KSS and WOMAC were significantly lower and VAS significantly higher in the SVG than in the NG (p<0.001 for each score). While no significant difference was observed in the preoperative HKAA among the three groups, the mean postoperative HKAA significantly differed among the groups, which was 179°±0.9° in the NG, 175°±0.9° in the MVG, and 172°±1.2° in the SVG (p<0.001) (Table 3) (Figure 2-4).

No significant differences were observed in pre-and post-operative knee flexion ROM and extension deficits in neither between groups nor pair-wise comparisons (p>0.05 for each measure).

The Impact of the Amount of Correction in LLA

There were 79 knees (69 patients; 10 male, 59 female) in group A (<5°), 102 knees (87 patients; 13 male, 74 female) in group B (5° to 10°), and 71 knees (61 patients; 8 male, 53 female) in group C (>10°).

No significant differences were found in preoperative KSS, WOMAC, and VAS scores among the three groups (p>0.05 for each outcome measure). In the postoperative assessment, there were significant differences in WOMAC (p=0.08) and VAS (p=0.02) scores among the three groups, but no remarkable difference was observed in KSS (p=0.28) (Table 4).

In pair-wise comparisons of the subgroups, all the outcome scores of groups A and B were statistically similar. There was no significant difference for KSS in pair-wise intergroup comparison. Otherwise, the mean postoperative WOMAC was significantly higher and VAS significantly lower in group C than in the group A (p=0.006 and p=0.002;

Table 2. Comparisons of pre- and postoperative characteristics of the patients in different groups according to postoperative lower limb alignment

	Normal (n=111)	Mild varus (n=114)	Severe varus (n=27)	p-value
Age (years)	66.1±7.6	66.4±8.0	66.3±5.6	0.95
The follow-up period (months)	**54.9±10.6**	**57.5±8.8**	**58.4±9.1**	0.21
Preoperative HKA (degrees)	169.8±4.4	168.9±4.7	169.7±4.2	0.43
Postoperative HKA (degrees)	178.6±0.9	175.4±0.9	172.3±1.2	**<0.001**
The angle of alignment correction (degrees)	8.9±4.4	6.5±4.8	2.7±4.7	**<0.001**
Preoperative extension deficit (degrees)	6.7±6.4	6.2±6.7	7.0±8.0	0.42
Preoperative knee flexion (degrees)	99.8±16.9	100.1±17	104.4±14.2	0.79
Postoperative extension deficit (degrees)	0.1±0.8	0.4±1.7	0.2±1.0	0.53
Postoperative knee flexion (degrees)	108.7±13.6	107.4±13.4	105.7±13.9	0.30
Preoperative KSS	31.1±8.3	33.6±9.9	31.0±6.5	0.9
Postoperative KSS	88.8±8.9	88.7±7.3	77.9±16.0	**<0.001**
Preoperative WOMAC	27.8±9.4	27.6±9.7	28.2±7.9	0.95
Postoperative WOMAC	86.2±11.9	84.6±13.0	73.8±13.9	**<0.001**
Preoperative VAS score	8.4±1.2	8.3±1.2	8.3±0.8	0.85
Postoperative VAS score	0.7±1.0	0.9±1.2	1.7±1.4	**<0.001**

The Kruskal-Wallis test was used for comparisons. HKA: Hip-knee-ankle, KSS: Knee Society Score, WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index, VAS: Visual analog scale

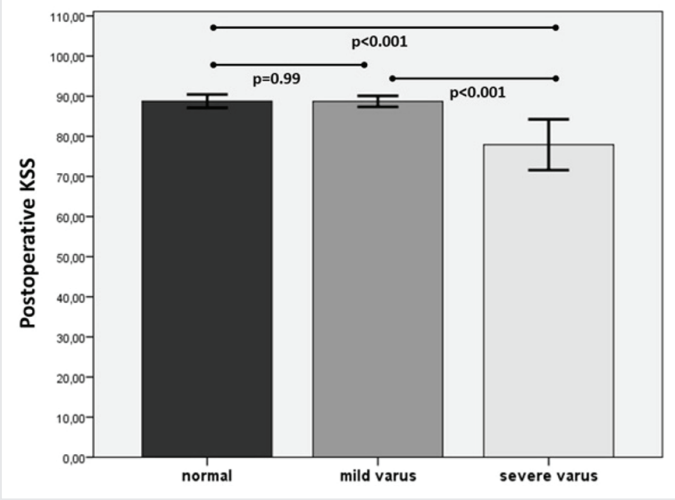

Figure 2. Graph showing differences in postoperative KSS scores between the three groups categorized according to postoperative hip-knee-ankle. The severe varus group showed significantly lower values compared with mild varus and neutral group. Values are shown as mean ± standard deviation
KSS: Knee Society score

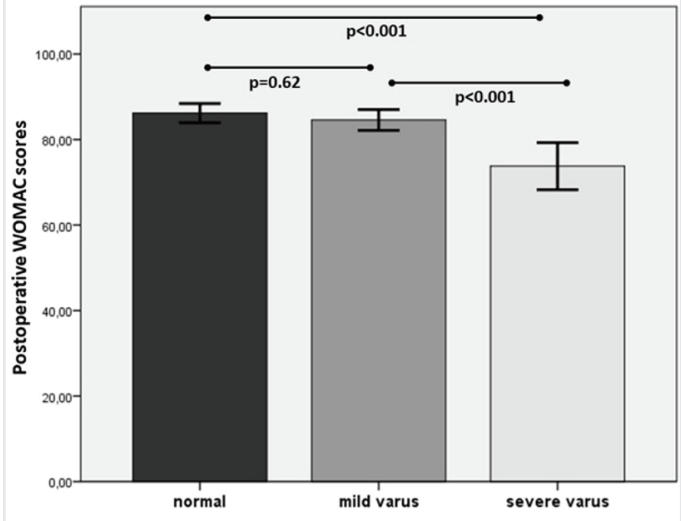

Figure 3. Graph showing differences in postoperative Western Ontario and McMaster Universities Osteoarthritis Index scores between the three groups categorized according to postoperative hip-knee-ankle. The severe varus group showed significantly lower values compared with mild varus and neutral group. Values are shown as mean ± standard deviation
WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index

respectively), but we could not detect any significant difference between groups C and B for WOMAC and VAS scores (p=0.09 and p=0.27; respectively). The ICCs for intra- and interobserver reliability were >0.85 (range: 0.86-0.97) for all radiographic measurements.

Discussion

The most important finding of the current study was that patients with postoperative severe varus alignment (HKA: <174°) following TKA had significantly lower functional outcomes compared to patients with postoperative neutral (HKA: 180±3°) and mild varus (174°≤ HKA: <177°) alignment. Nonetheless, similar favorable clinical outcomes were observed between patients with neutral and those with mild varus alignment. Another important finding was that the correction in LLA of >10° following TKA is associated with better clinical outcomes based on the data indicating higher WOMAC and lower VAS scores compared to patients with <10° of LLA corrections.

The neutral LLA has been considered the gold standard of TKA (15). Malalignment could cause an imbalance of contact forces on the tibial component, accelerated wear of the polyethylene insert, an increased risk of osteolysis, and further implant loosening (16). Furthermore, previous research found poorer clinical and functional results

secondary to malalignment of TKAs (5,9,17). 3° deviations from the neutral alignment were suggested as the critical point in TKA affecting the postoperative clinical outcomes (2,5). However, recent studies have reported that revision rates and clinical outcomes were similar between patients with neutral LLA and those with mild varus malalignment after TKA (18-20), supporting the findings we present here.

Salzman et al. (21) included 172 TKAs in their study and showed that postoperative residual varus alignment did not adversely affect the functional scores of TKA in patients with varus-type osteoarthritis. A study by Nishida et al. (3), which included 220 TKAs, found that postoperative mild varus and neutral mechanical alignment of the lower limb both led to excellent functional outcomes, and the researchers emphasized that postoperative mild varus LLA is acceptable following TKA for varus-type osteoarthritis. Moreover, Schiffner et al. (10) stated that leaving a residual varus alignment after TKA in patients with varus osteoarthritis leads to better functional outcomes than postoperative neutral alignment. Additionally, Vanlommel et al. (20) concluded that if the alignment is retained in the mild varus after TKA, the functional scores could be better than patients with an alignment correction to neutral. Our findings support the notion that postoperative residual varus alignment does not compromise clinical and functional outcomes following TKA as long as severe varus alignment is avoided.

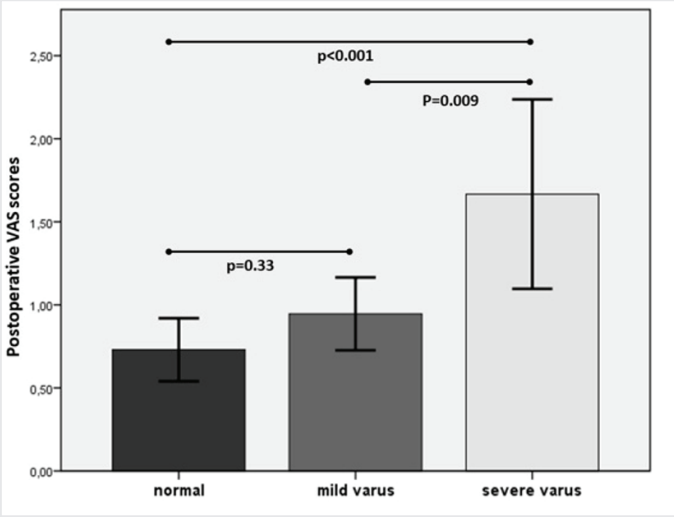

Figure 4. Graph showing differences in postoperative visual analog scale scores between the three groups categorized according to postoperative hip-knee-ankle. The severe varus group showed significantly higher values compared with mild varus and neutral group. Values are shown as mean ± standard deviation
VAS: Visual analog scale

LLA correction is also performed during TKA, and the amount of correction in LLA has been shown to be correlated with the severity of preoperative varus deformity (22). The current study has shown that the correction in LLA of >10° following TKA is associated with better clinical outcomes in terms of postoperative WOMAC and VAS scores, but not KSS. Actually, postoperative KSS showed higher trend in the patients with LLA correction of >10° but was not statistically significant. The reason for this absence of statistical difference could be that the KSS evaluates the pain, knee stability, and ROM. However, WOMAC primarily considers the knee functions according to the daily living activities. The knee ROM is taken into account once in KSS, despite several considerations in the WOMAC scoring system, as several daily activities are highly associated with knee ROM. Thus, the knee ROM affects the WOMAC score many times over KSS. In contrast to our findings, Vanlommel et al. (20) found that the amount of deformity correction has no significant impact on the clinical scores of TKAs.

Study Limitations

Our study has some limitations. First, the study had a relatively small number of TKAs, and the patients counted in the study did not have a long-term follow-up. Second, this study was a retrospective nature,

Table 3. Intergroup comparisons of postoperative clinical outcome values according to postoperative lower limb alignment

	Neutral vs mild	Mild vs severe	Neutral vs severe
Postoperative KSS	0.99	<0.001	**<0.001**
Postoperative WOMAC	0.61	0.002	**<0.001**
Postoperative VAS score	0.33	0.009	**<0.001**
Postoperative extension deficits	0.28	0.72	0.98
Postoperative knee flexion	0.73	0.84	0.56

KSS: Knee Society Score, WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index, VAS: Visual analog scale

Table 4. The comparisons of pre- and postoperative clinical scores for different amounts of deformity correction

	<5 degrees (n=79)	5-10 degree (n=102)	>10 (n=71)	p-value	<5° vs 5-10°	<5° vs >10°	5-10° vs >10°
Preoperative KSS	32.0±8.5	32.8±10.4	31.6±6.9	0.9	0.84	0.95	0.67
Postoperative KSS	86.2±10.3	87.9±9.1	88.7±10.4	0.28	0.48	0.28	0.87
Preoperative WOMAC	26.3±5.4	28.3±10.7	28.5±10.5	0.95	0.32	0.34	0.98
Postoperative WOMAC	81.3±12.8	83.7±15.2	87.9±8.6	**0.008**	0.43	**0.006**	0.09
Preoperative VAS score	7.9±1.2	8.7±1.1	8.4±1.1	0.85	0.63	0.78	0.89
Postoperative VAS score	1.3±1.3	0.9±1.1	0.6±1.0	**0.002**	0.06	**0.002**	0.27

The Kruskal-Wallis test was used for comparisons. KSS: Knee Society Score, WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index, VAS: Visual analog scale

and thus patients' data were collected from the registry. Third, the knee ROMs were measured using a hand-goniometer, a digital and calibrated goniometer could be more accurate for measurements of knee ROM with decimals. Fourth, implant survival of the patients counted in this study was not assessed. Finally, there are several factors that affect postoperative clinical outcome scores after TKA, and only postoperative LLA and correction in LLA were analyzed. The other factors such as bone resection flexion-extension-ligament balance, important clinical (e.g., BMI, comorbidities, preoperative opioid use, smoking, etc.), and psychologic (e.g., resilience, pain catastrophizing, depression, etc.) factors were not analyzed. Despite these limitations, analyzing the postoperative clinical results of the patients in the study is strength, by grouping according to both postoperative HKAA and the amount of deformity correction. Studies with long-term follow-up, homogenous patient groups, and assessing implant survival are warranted for future research.

Conclusion

Postoperative residual mild varus alignment does not compromise clinical and functional outcomes following TKA in patients with preoperative coronal-plane varus deformity. Nonetheless, postoperative severe varus deformity could cause poor clinical and functional outcomes following TKA in such patients.

Ethics Committee Approval: The study was approved by the University of Health Sciences Turkey, Haseki Training and Research Hospital Clinical Research Ethics Committee (approval number: 129-2021, date: 01.12.2021).

Informed Consent: Signed informed consent form was routinely obtained preoperatively from the patients included in the study.

Peer-review: Externally peer-reviewed.

Authorship Contributions: Surgical and Medical Practices - M.E., M.Er., M.Y.; Concept - M.E.; Design - M.E., M.Er.; Data Collection or Processing - M.E., M.D.; Analysis or Interpretation - M.E.; Literature Search - M.E., M.Er.; Writing - M.E., M.D., M.Y.

Conflict of Interest: No conflict of interest was declared by the authors.

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