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ORIGINAL ARTICLE

Impact of postoperative femorotibial axis on functional outcomes in unicompartmental knee arthroplasty

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ABSTRACT

Objectives: This study aimed to compare the functional outcomes of patients undergoing fixed-bearing medial unicompartmental knee arthroplasty (UKA) classified as either varus or neutral based on their postoperative femorotibial angle (FTA), with the goal of evaluating the impact of FTA on functional results.

Patients and methods: A total of 38 knees of 35 patients (27 females, 8 males; mean age: 63.6±7.1 years; range, 52 to 75 years) were included in this retrospective study. The data was collected between December 15, 2020, and January 15, 2021. Patients were categorized into two groups based on their postoperative FTA. The neutral group consisted of patients with an FTA range of 5.1° to 7.4°, while the varus group included patients with an FTA range of 0.1° to 4.8°. Knee Outcome Osteoarthritis Score (KOOS), Visual Analog Scale (VAS) scores, sit to stand test results, and six minute walk test data were analyzed.

Results: The mean follow-up was 42.0±19.3 months. The postoperative VAS score for the varus group was 0.95±0.99, whereas the neutral group had a VAS score of 2.19±1.83 (p=0.021). The mean KOOS for the varus group was 88.01±7.88, whereas the neutral group had a mean KOOS score of 78.46±13.69 (p=0.006).

Conclusion: In patients undergoing UKA, mild varus alignment could yield superior early and midterm functional outcomes compared to a neutral femorotibial angle.

Keywords: Functional outcomes, medial compartment gonarthrosis, osteoarthritis, unicompartmental knee arthroplasty.

Unicompartmental knee arthroplasty (UKA) in isolated medial gonarthrosis is a long-standing and well-known treatment modality with several advantages over total knee replacement, such as faster recovery time, better range of motion, and reduced blood loss.[1-3] However, the success of UKA is highly dependent on proper alignment. Misalignment can lead to implant failure, resulting in the need for revision surgery.[4] Several factors can affect alignment in UKA, including surgical technique, patient anatomy, and preoperative planning. Therefore, it is essential to have a comprehensive understanding of the factors that influence alignment and the methods used to achieve optimal alignment in UKA.[5]

There is currently no consensus on the optimal alignment technique for achieving the best functional outcome for the knee. While it is conventionally believed that neutral alignment of the lower extremity mechanical axis may prolong the longevity of the implant, clinical reports suggest that such an approach can result in unsatisfactory functional outcomes.[6] The prevailing perception regarding the benefits of neutral mechanical alignment is largely predicated on the assumption that the majority

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of individuals possess such alignment. However, recent research indicates that a significant proportion of the population exhibits varus alignment at the conclusion of skeletal growth. A study conducted by Bellemans et al.[7] found that 32% of males and 17% of females exhibit varus alignment following skeletal maturity. According to the mentioned information, attempting to achieve neutral mechanical alignment through surgery may not be appropriate or natural for individuals with varus alignment.[7,8]

The present study aimed to compare the functional outcomes of patients classified as either varus or neutral based on their postoperative femorotibial angle (FTA) after undergoing fixed-bearing medial UKA. The hypothesis was that patients with varus alignment would exhibit superior outcomes compared to those with neutral alignment following the surgical intervention.

PATIENTS AND METHODS

A retrospective analysis of patients who underwent UKA at the Gazi University Hospital, Department of Orthopedics and Traumatology between March 2014 and January 2020 was performed and the data was collected between December 15, 2020, and January 15, 2021. Patients who underwent UKA and fulfilled the inclusion criteria, which mandated a minimum of one-year follow-up and demonstrated adequate physical capacity, were considered eligible for participation in this study. Functional evaluations were performed at their last follow-up. When the patients were called, they were asked whether they had chronic heart disease, chronic lung disease, and their daily activity, and patients who were less active enough to affect the test results were excluded from the study. Consequently, 10 patients deemed unsuitable for physical testing were excluded from the final analysis. All patients who were excluded from the study had undergone unilateral UKA. A graphical representation of the patient inclusion and exclusion process can be found in Figure 1. In this study, 38 knees were evaluated in 35 patients (8 males, 27 females; mean age: 63.6±7.1 years; range, 52 to 75 years). The participants' age, sex, body mass index (BMI), affected side, follow-up duration, Knee Outcome Osteoarthritis Score (KOOS), pre- and postoperative FTAs, Visual Analog Scale (VAS) scores, sit to stand test results, and six-minute walk test (6-MWT) data were analyzed.

The patients were categorized based on the FTAs of the lower extremity, as determined by postoperative FTAs. To increase the reliability and minimize possible measurement errors, all evaluations were performed by two independent orthopedic surgeons separately, and the mean of these measurements was used for the final statistical analysis. The neutral group consisted of 16 patients with an FTA range between 5.1° and 7.4°, while the varus group included 22 patients with an FTA range between 0.1° and 4.8°. The selection of the cutoff point was based on the knee alignment angles considered normal in existing literature.[9]

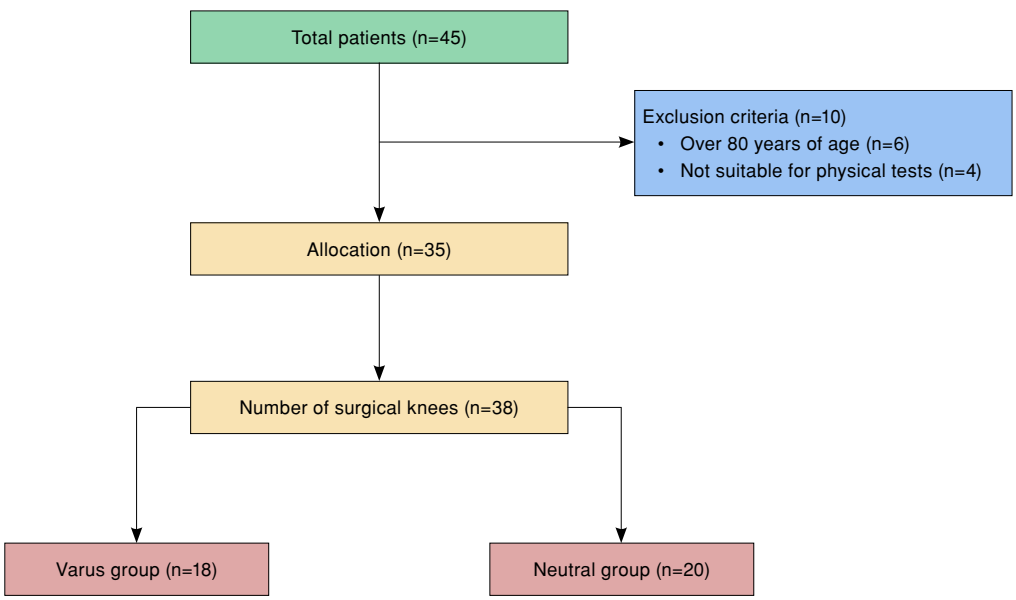

FIGURE 1. The flowchart of inclusion and exclusion of patients.

Surgical procedure

The present study outlines a surgical intervention under general anesthesia, involving the use of a tourniquet to the thigh, and the administration of 2 g of intravenous cefazolin sodium for infection prophylaxis, along with 1 g of intravenous tranexamic acid pre- and postoperatively for each patient. Additionally, patients received oral anticoagulants for 20 days postoperatively. All surgeries were performed by the senior surgeon. The implant was placed to ensure proper soft tissue balance. They were grouped according to postoperative alignment status.

The surgical procedure utilized a medial parapatellar incision, beginning from the upper pole of the patella, crossing the joint line 2 to 4 cm, and terminating medially to the tuberosities tibia. The spacer block method of a fixed-bearing UKA (Zimmer Biomet, Warsaw, IN, USA) was used for all patients, in which bone cuts were initiated from the proximal tibial side. Femoral cuts were made over tibial guides without the usage of an intramedullary femoral guide. Subsequently, alignment and range of motion were assessed through trials, and the final unicompartmental prosthesis components were implanted using bone cement.

Clinical evaluation

The patients underwent a comprehensive preoperative evaluation consisting of a preoperative VAS score, as well as anteroposterior, lateral, and valgus stress radiographs using the Ahlbäck scoring system to assess the severity of osteoarthritis in the knee. Anteroposterior knee X-rays were taken for all patients after surgery while standing and bearing weight. Postoperative FTAs were measured with these radiographs. The anatomical axes of the femur and tibia are derived from a line centered on the diaphysis of each bone. The angle between these axes was measured.

Postoperatively, the patients were evaluated using the KOOS form, VAS scores, 6-MWT, and sit to stand test. Furthermore, FTA measurements were performed on the hospital PACS (Picture Archiving and Communication Systems) system on preoperative and postoperative direct radiography (Figure 2).

The KOOS is a commonly used patient-reported outcome measure that assesses various aspects of knee function and quality of life in patients with osteoarthritis of the knee. The KOOS questionnaire includes five subscales that evaluate pain, symptoms, function in daily living, function in sports and recreation, and knee-related quality of life. Each subscale includes a set of items that are rated on a 5-point Likert scale, with higher scores indicating better outcomes. The KOOS has been validated and widely used in clinical trials and research studies, as well as in routine clinical practice, to assess the effectiveness of interventions for knee osteoarthritis.[10,11]

Visual analog scale is another commonly used outcome measure in the assessment of knee function and pain in patients with osteoarthritis of the knee. It provides a quantitative measure of pain intensity

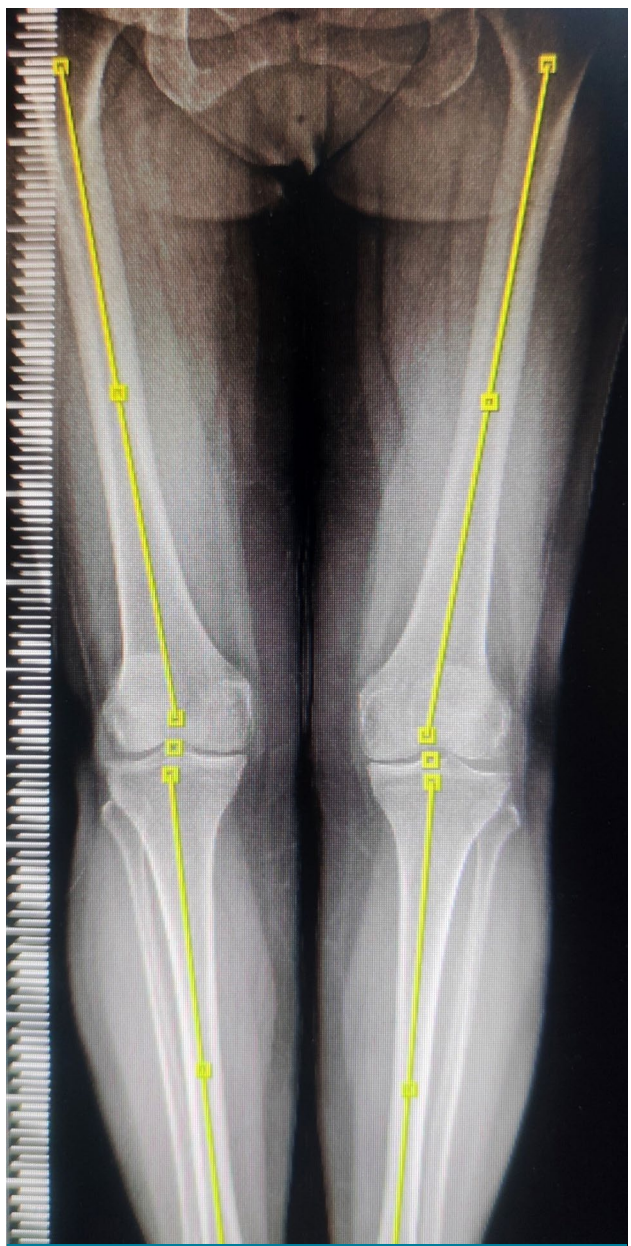

FIGURE 2. Femorotibial angle measurement of mild varus and neutrally aligned patients.

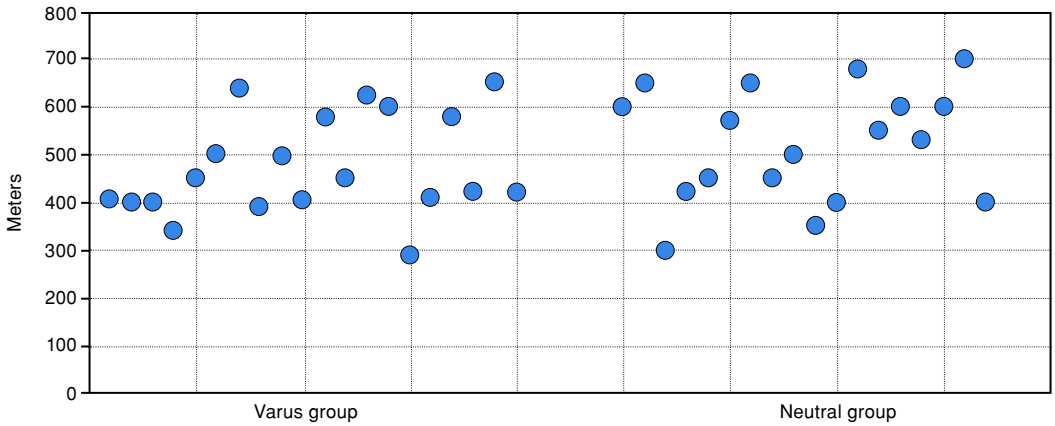

FIGURE 3. Scatterplot of the results of the six-minute walk test in both group.

on a continuous scale, ranging from 0 (no pain) to 10 (worst imaginable pain). Patients are asked to indicate the level of pain they are experiencing at the time of the assessment by marking a point on the scale. Visual analog scale is a simple and easy-to-use tool that has been widely used in clinical practice and research to assess pain intensity and monitor changes in pain over time.[12]

The 6-MWT and the sit to stand test are commonly used clinical measures of functional capacity in patients with knee osteoarthritis. The 6-MWT is a simple, practical, and reliable test that evaluates the walking capacity of the patient. During the test, the patient is instructed to walk as far as possible in 6 min on a premeasured, flat surface. The distance covered in this time period is then recorded and used to assess the patient's functional capacity (Figure 3).[13] The sit to stand test assesses the patient's lower limb strength and functional mobility. During the test, the patient is instructed to sit in a chair and then stand up 10 times as quickly as possible, without the use of their hands. The time taken to complete this task is recorded, and this is used to assess the patient's functional capacity.[14]

Statistical analysis

The sample size was calculated using the IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA) considering a 20% difference between the two groups, using an alpha level of 5% and a power of 80%. Consequently, a minimum of seven to nine participants in each group was required.[15-17] To enhance the study's statistical power, all eligible patients within the specified time interval were included in the study, ensuring a more comprehensive and robust analysis.

Data were analyzed using IBM SPSS version 26.0 software (IBM Corp., Armonk, NY, USA). Categorical variables were presented as numbers and percentages, while continuous variables were expressed as mean ± standard deviation (SD) or as median (min-max) for descriptive analyses. The distribution of variables was examined through both visual (e.g., histograms and probability plots) and analytical methods (e.g., Kolmogorov-Smirnov/Shapiro-Wilks tests) to determine whether they conformed to a normal distribution. Upon reviewing the analysis results and sample size, it was concluded that the data did not follow a normal distribution, thus nonparametric analyses were conducted. To compare categorical variables across independent groups, the chi-square test was employed. For nonnormally distributed variables, the Mann-Whitney U test was performed to compare the data sets. The evaluation employed the interclass correlation coefficient to assess absolute agreement, factoring in the mean of the ratings from two reviewers. Across all measurements, a consistently strong interrater consensus was evident, with interclass correlation coefficient values surpassing 0.8. A p-value <0.05 was considered statistically significant.

RESULTS

The demographic data and baseline characteristics of the patients did not exhibit any statistically significant differences. No complications such as revision, reoperation, loosening, or death were encountered during the follow-up of the patients. Ahlbäck scores, follow-up periods, and BMI values were also comparable among the patients, as presented in Table I. The mean follow-up was 42.0±19.3 months.

TABLE I
Baseline demographics and information about patients

Groups	Varus group (n=22) n	Varus group (n=22) Mean±SD	Neutral group (n=16) n	Neutral group (n=16) Mean±SD	*p*
Age (year)		66.2±7.8		63.1±7.4	0.217
Sex of the operated knee					0.547
Female	17		13		
Male	5		3		
Side					0.171
Right	12		12		
Left	10		4		
Ahlbäck score					0.852
1	4		4		
2	16		11		
3	2		1		
Mean body mass index		30.02±4.1		31.14±2.7	0.181
Mean follow-up time (month)		40.64±16.6		43.75±23.1	0.455

SD: Standard deviation.

Upon examination of preoperative FTA values, it was found that the varus group had a mean value of 0.11±1.05 (range, 1.4 to 2.4), while the neutral group had a mean value of 1.09±1.77 (range, 1.5 to 5.7; p=0.064). In the postoperative period, the mean value for the varus group was 3.15±1.55 (range, 0.1 to 4.8), and for the neutral group, it was 6.40±0.75 (range, 5.1 to 7.4; p<0.001).

The preoperative VAS scores for the varus and neutral groups were 8.5±1.14 and 9.0±1.16, respectively, and the difference between the two groups was not statistically significant (p=0.171). Postoperatively, the varus group had a VAS score of 0.95±0.99, whereas the neutral group had a VAS score of 2.19±1.83. This difference was found to be statistically significant (p=0.021). The mean KOOS score for the varus group was 88.01±7.88, while the neutral group had a mean KOOS score of 78.46±13.69. A statistically significant difference was observed between the two groups (p=0.006, Table 2).

The postoperative 6-MWT result for the varus group was 486.14±109.83 m, while the neutral group had a result of 509.38±119.92 m. No significant difference was observed between the two groups (p=0.549). The sit to stand test score for the varus group was 25.41±6.25 sec, while the neutral group had a score of 25.0±8.6 sec. No significant difference was observed between the two groups (p=0.827), as shown in Table II.

DISCUSSION

One of the most pressing dilemmas faced by orthopedic knee surgeons in recent years is whether

TABLE II
Comparison of varus and neutral group according to clinical outcomes

	Varus group Mean+SD	Varus group Median	Varus group 1Q-3Q	Neutral group Mean+SD	Neutral group Median	Neutral group 1Q-3Q	*p*
KOOS score	88.01+7.88	89.6	85.1-93.62	78.46+13.69	82.90	67.72-89	0.006
Preoperative VAS	8.50+1.14	8.5	8-9.25	9.00+1.16	9	8-10	0.171
Postoperative VAS	0.95+0.99	1	0-1.25	2.19+1.83	1	0-2.75	0.021
10 times sit to stand test (second)	25.41+6.25	25.50	19.5-30	25.0+8.60	25	18.5-30	0.827
Six minute walk test	486.14+109.83	450	403.75-600	509.38+119.92	515	405-600	0.549

KOOS: Knee Injury and Osteoarthritis Outcome Score, VAS: Visual Analog Scale; SD: Standard deviation; Q: Quartile.

to perform lower extremity alignment mechanically or based on the patient's specific needs.[12] While some proponents argue in favor of neutral alignment yielding superior results, the findings of the present study align with those advocating for implant placement in a mild varus position. In the current study, the clinical and functional status of patients with mechanically neutral alignment and patients with varus alignment were evaluated. After the analysis, it was determined that the KOOS and VAS values measured from the last control evaluation of the patients with varus alignment were statistically significantly better than the patients with neutral alignment.

The number of authors advocating for less correction following UKA surgery has increased in recent years, citing the acceleration of arthritis in the opposite compartment with overcorrection.[18-20] However, excessive varus alignment can lead to component wear. Argenson et al.[21] recommended maintaining a postoperative mechanical axis of 3° to 5° varus. Nevertheless, Zambianchi et al.[22] found higher revision rates among 134 patients who remained in varus after 8 to 12 years of follow-up. Similarly, Ridgeway et al.[23] found similarly high revision rates among 150 patients who remained in varus after at least five years of follow-up. In the study conducted by Gulati et al.,[15] patients who underwent UKA surgery were categorized into three groups based on their postoperative alignment: neutral, mild varus, and varus. The evaluation of these groups was done using the Oxford Knee Score and the American Knee Society Score. The findings of the study indicated that as the degree of varus alignment increased, there was a corresponding deterioration in the clinical scores. It was found that the deterioration of AKSS with increasing varus alignment was due to the fact that AKSS included alignment as a parameter. The outcome with OKS after removal of alignment was reported to be similar.[15]

In a study conducted by Slaven et al.,[24] which reported on the results of at least 10 years of follow-up of UKA patients, it was found that approximately four degrees of varus alignment in patients who underwent medial fixed-bearing UKA had a favorable impact on both functional outcomes and implant survival. In a study that examined the functional outcomes and revision rates of patients who underwent Oxford Medial Unicompartmental Knee Replacement and evaluated 891 knees, patients with varus and neutral alignment were compared.[25] The study reported that there was no statistically significant difference between the groups, but the Oxford Knee Score increased in correlation with the degree of varus alignment.

In cases where a neutral alignment (within a range of 5° to 7° valgus) is maintained, lateral compartment arthritis is hypothesized to potentially result from neutral alignment. This is in line with the view that intentionally placing the implant in mild varus alignment, as opposed to neutral alignment, may yield superior functional and clinical outcomes. The results of the current study also support the view that varus alignment leads to better clinical outcomes. In the current study, which presented early and midterm results, it was observed that the difference in KOOS scores between patients with varus alignment and those with neutral alignment was approximately 10 points. The mentioned difference was not only statistically significant but also considered to be significant according to the clinically important level in the literature.[26]

A clinically significant change of 1.1 cm is reported for VAS, a commonly used scale for pain assessment, for mild pain levels.[27] When the pain values of the patients participating in the current study were examined, it was found that the mean pain scores of the varus alignment group were 1.24 cm lower.

The 6-MWT and sit to stand test are functional tests that are frequently used to demonstrate functional recovery after knee arthroplasty surgeries.[13,28] Ten times sit to stand test is a test that measures the function of the lower extremity and is directly related to lower extremity muscle strength and body balance.[14] In healthy individuals, the mean distance covered in the 6-MWT was 581.4±66.5 m (range, 383 to 800 m) for females and 608.7±80.1 m (range, 410 to 875 m) for males.[28] Upon examination of the data from the current study, it was found that the distances walked during the 6-MWT ranged from 290 to 700 m and that the mean distances walked by both groups fell within the range of distances that healthy individuals were able to walk. While no significant differences were observed between the two groups based on the 6-MWT data, both groups demonstrated a walking capacity that was close to that of healthy individuals.

Regarding the evaluation of the ten times sit to stand test, a study conducted on non-disabled older females reported a mean time of 13.6±3.2 sec.[14] In another study involving individuals who underwent total hip arthroplasty and had similar BMI measurements to the current study, the mean time

was reported to be 20.6±7.5 sec.[29] In the current study, however, the averages were calculated to be around 25 sec, which was longer compared to the data reported in the literature.

The current study had strengths, including the fact that all surgical interventions were performed at the same center using the same implant and that there were no significant differences between groups in terms of BMI, age, and osteoarthritis stages. However, this study was limited by its retrospective nature, limited sample size, limited follow-up period, and the fact that the follow-up periods were different from each other. Additionally, we were unable to compare pre- and postoperative scores due to a lack of preoperative KOOS data. Another limitation is that only patients currently using UKA were evaluated. Thus, other UKA patients who went on to revision were not determined during this analysis, which may have altered the results. Finally, sagittal measurements were not conducted in the study.

In conclusion, a mild varus alignment of the lower extremity after UKA surgery may have a positive impact on clinical and functional outcomes in the early and midterm. The preservation of soft tissue balance and elimination of the reason of the pain at the medial compartment may contribute to the observed differences in clinical outcomes.

Ethics Committee Approval: The study protocol was approved by the Gazi University Clinical Research Ethics Committee (date: 14.12.2020, no: 032). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Idea/concept, design, data collection and/or processing, literature review, writing the article, materials: A.K.; Analysis and/or interpretation, writing the article, materials: M.A.T.; Data collection and/or processing, literature review, references and fundings: N.B.C.; Control/supervision, critical review: G.B.; Control/supervisin, critical review, materials: H.Ö.

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