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JOINT LINE CHANGES AND PATELLA BAJA INFLUENCE CLINICAL OUTCOMES OF REVISION TOTAL KNEE ARTHROPLASTY

EKLEM ÇİZGİSİ DEĞİŞİKLİĞİ VE AŞAĞI YERLEŞİMLİ PATELLA REVİZYON TOTAL DİZ PROTEZİ KLİNİK SONUÇLARINI ETKİLEMEKTEDİR

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ABSTRACT

Objective: The purpose of our study was to determine joint line (JL), posterior condylar offset ratio (PCOR), and patellar height alterations following revision total knee arthroplasty (RTKA) and evaluate the functional results according to the critical limits defined in the literature.

Material and Method: Fifty-one patients with a minimum of two years of follow-up were retrospectively reviewed. Demographic data and operative reports were evaluated. Joint line change was measured according to the method of Figgie. Patellar height was measured using the Insall–Salvati Index and the Blackburn–Peel Index. The effect of JL, patellar height alteration, and PCOR on functional outcomes was analyzed using the Knee Society Score (KSS), knee range of motion (ROM), SF-12, and visual analog scale score as functional results.

Result: Patients whose joint lines were not reconstructed had a lower KSS than those whose JLs were restored in accordance with the crucial limit of 5 mm. The other functional results were similar. Functional outcomes were similar between patients with PCORs under 0.44 and those with PCORs higher than 0.44. There was also no significant difference in functional results for the group of patients whose PCOR was lower than 0.5 and those whose PCOR was higher than 0.5. The patients with patella baja had significantly lower knee ROMs, KSS, and SF-12 PCS scores than those without patella baja (p:0.012,p:0.03, and p:0.01, respectively).

Conclusion: In this study, joint line change >5 mm and patella baja negatively affected clinical outcomes after RTKA.

Keywords: Revision knee arthroplasty, joint line, prognostic factors, functional results, patella baja

ÖZET

Amaç: Çalışmamızın amacı revizyon total diz artroplastisi (RTKA) sonrası eklem hattı (JL), posterior kondiler ofset oranı (PCOR) ve patellar yükseklik değişikliklerini belirlemek ve fonksiyonel sonuçlara etkisini literatürde tanımlanan kritik sınırlara göre değerlendirmektir.

Gereç ve Yöntem: Takip süresi en az iki yıl olan 51 hasta retrospektif olarak incelendi. Demografik veriler ve ameliyat raporları değerlendirildi. JL değişimi Figgie'nin yöntemine göre ölçüldü. Patellar yükseklik hem Insall-Salvati İndeksi hem de Blackburn-Peel İndeksi kullanılarak ölçüldü. JL, patellar yükseklik değişikliği ve PCOR'un fonksiyonel sonuçlar üzerindeki etkisi, fonksiyonel sonuçlar olarak Knee Society Score (KSS), diz hareket açıklığı (ROM), SF-12 ve visüel analog skala skoru kullanılarak analiz edildi.

Bulgular: JL'si kritik sınır olan 5 mm'ye göre yeniden yapılan hastaların KSS'larının, eklem seviyesi rekonstrükte edilemeyen hastalara göre anlamlı derecede yüksek olduğu belirlendi. Diğer fonksiyonel sonuçlar benzerdi. PCOR'u 0,44'ün altında olan hasta grubu ile PCOR'u 0,44'ün üzerinde olan hasta grubunun fonksiyonel sonuçlar benzerdi. Hem PCOR'u 0,5'in altında olan hasta grubu hem de PCOR'u 0,5'in üzerinde olan hasta grubu arasında fonksiyonel sonuçlarda da anlamlı fark yoktu. Patella baja'lı hastaların diz ROM'ları, KSS ve SF-12 PCS skorları patella baja'sız hastalara göre anlamlı derecede düşüktü (sırasıyla p:0,012, p:0,03 ve p:0,01).

Sonuç: Bu çalışmada RTKA sonrası >5 mm eklem seviyesi değişikliği ve patella baja gelişmesinin fonksiyonel sonuçlara olumsuz etkisi bulunduğu tespit edilmiştir.

Anahtar Kelimeler: Revizyon total diz protezi, eklem seviyesi, prognostik faktörler, fonksiyonel sonuçlar, patella baja

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INTRODUCTION

Restoration of the native joint line (JL) is one of the key points in achieving natural knee biomechanics and successful functional results in total knee arthroplasty (TKA) (1, 2). Balancing the collateral ligaments and joint isometry is associated with good outcomes in revision total knee arthroplasty (RTKA) (3-6). Joint line alteration may result in increased component wear, lower survival rates, increased patellofemoral contact forces, patellar malalignment, decreased range of motion, and mid-flexion instability (7-9).

There are different landmarks to determine the native JL in RTKA. Comparing preoperative and postoperative distances according to prominent anatomical structures is one of the most known methods. However, when the surgeon has no pre-TKA X-ray of the affected knee and the patient has bone defects distorting the bony anatomy, it becomes hard to estimate the native JL during surgery, so JL changes may occur.

There needs to be a consensus about the critical limit of JL changes in primary TKA and RTKA. Figgie et al., and Partington et al. showed that a JL change of more than 8 mm was associated with inferior clinical results (8, 10). However, Hoffman et al. found that a ±4 mm critical limit of JL alteration was correlated with inferior clinical results, while Porteous et al. found that the critical limit was ±5 mm (6, 11). In addition to the change in the JL, the patellar height may also change and affect the functional results postoperatively in RTKA (12). Patella baja may occur due to shortening of the patellar tendon following revision surgery. Pseudo-patella Baja can also occur due to joint-level alterations (13, 14). Posterior condylar offset (PCO) is also one of the parameters affecting functional scores in revision surgery, such as JL restoration. It was first described by Bellemans et al. for TKA, and Johal et al. described a ratio for PCO (Posterior Condylar Offset Ratio: PCOR) (15, 16). It is also found that PCOR has the most significant impact on postoperative range of motion after TKA (17).

Our study aimed to determine JL, PCOR, and patellar height alterations in RTKA and evaluate the functional results according to the critical limits in the literature.

MATERIAL and METHODS

The study was found ethically appropriate by the Ethics Committee of Istanbul University, Istanbul Faculty of Medicine (Date: 25.06.2021, No: 2021/1110). In this retrospective study, the principles of the Declaration of Helsinki were applied. Informed consent was obtained from all the patients. Our study included patients who underwent RTKA at a single tertiary referral center from January 2011 to May 2018. Patients were excluded based on the following criteria: (1) having had a tibial insert change only with femoral and tibial stem retained in the revision procedure, (2) having <2 years follow-up period, (3) having missing or ineligible data, (4) having prior knee surgery other than arthroscopic meniscus surgery before primary knee arthroplasty (5) periprosthetic infection following RTKA. Twenty-two patients were excluded because of missing data (radiologic or demographic), unwillingness to participate in the study, and refusal to come to the hospital for their last follow-up because of the COVID-19 pandemic. All revision procedures were performed by one senior surgeon (C.S.). Medical records were analyzed for clinical findings of age, gender, follow-up period, diagnosis requiring revision arthroplasty, operative reports, knee range of motion, and preoperative functional results (Figure 1). The bone loss of the tibia and femur was classified according to the Anderson Orthopaedic Research Institute (AORI) bone defect classification system (18).

The radiographic measurements were performed using a picture archiving and communication system. Radiographic measurements were performed at three time points: 1) on the preoperative radiographs before the primary TKA or the non-operated contralateral knee radiograph if the patient was operated on in another hospital for primary TKA, 2) on preoperative radiographs for the RTKA, 3) at the last follow up following RTKA. The JL was defined as the superior surface of the tibial component, which is, due to the radiolucency of the tibial insert, the most distal part of the femoral component or distal femoral joint surface. Joint line height was measured according to the method of Figgie as the distance between the top of the tibial tubercle and the JL on a lateral X-ray of the knee (10) (Figure 2). The patellar position was evaluated using the Insall–Salvati ratio (ISR) and Blackburne–Peel index (BPI) on lateral radiographs taken at 30° of flexion. ISR was defined as the ratio of the patella tendon length to the length of the patella. BPI was defined as the ratio of the distance between the horizontal line and the inferior aspect of the patellar articular surface and the distance of the patellar articular surface. The patella baja was defined as ISR<0.8, and the pseudo-patella baja was defined as ISR > 0.8 and BPI<0.5 (19-21). PCOR was determined as the ratio between the distance from the femoral diaphysis posterior cortex to the posterior condylar margin and the maximum anteroposterior diameter of the distal femur on the actual lateral knee radiograph (16).

Functional results were evaluated by Knee Society Score (KSS) and SF-12 (Short Form-12; both physical [PCS] and mental scores [MCS]) preoperatively before RTKA and at the final follow-up postoperatively following RTKA (22, 23). A goniometer measured the knee range of motion (ROMs). The degree of pain was evaluated using a visual

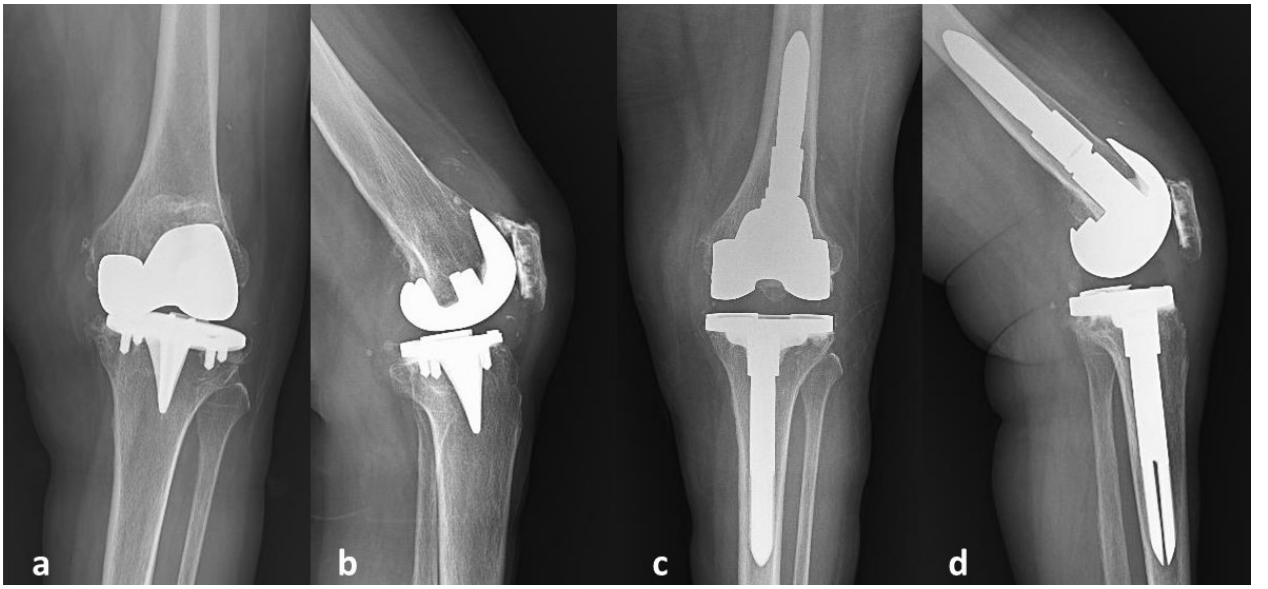

Figure 1: Preoperative (a and b) and postoperative (c and d) X-rays of a patient who underwent revision total knee arthroplasty

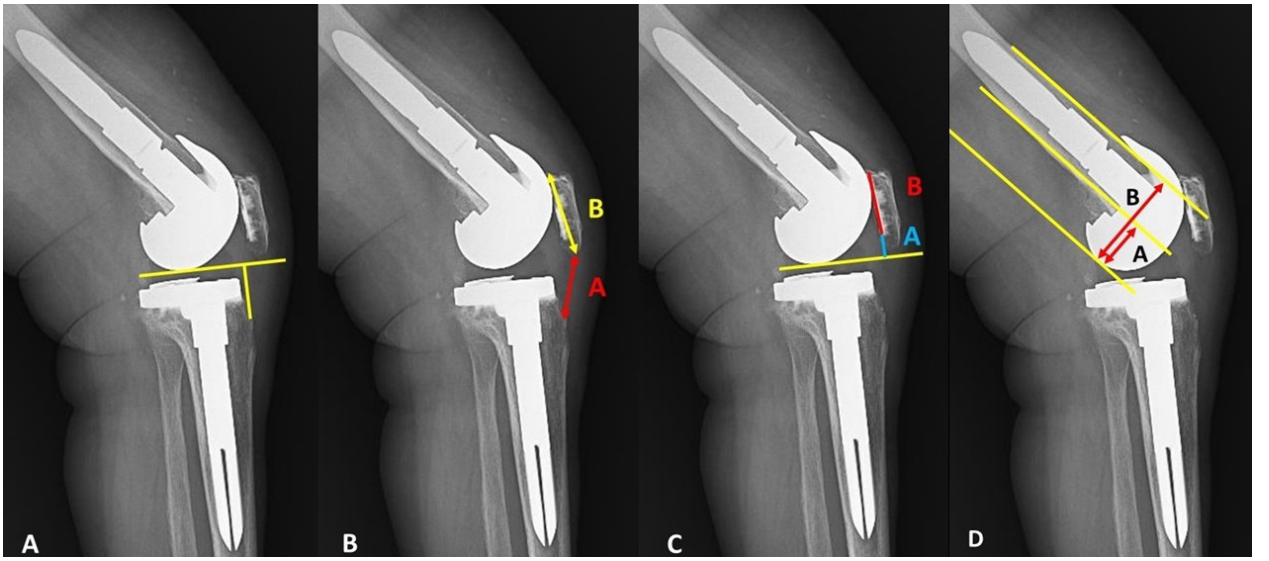

Figure 2: Demonstration of the radiographic measurements, A: Patients joint line height according to the method of Figgie (the distance between the top of the tibial tubercle (TT) and the joint line (JL) on a lateral X-ray of the knee), B: Patellar height measurement according to Insall-Salvati method (A/B), C: Patellar height measurement according to Blackburn-Peel index(A/B), Posterior condylar offset ratio measurement (A/B)

analog scale (VAS). Functional knee scores were calculated by independent orthopedic surgeons both preoperatively and at the final visit.

Joint line change was the difference between the measurements performed before primary TKA or contralateral knee and the last follow-up following RTKA. After calculating the changes in the patient's knee joint level using the Figgie method, patients were divided into two groups in different ways (10). Threshold values previously defined in the literature were used for grouping patients according to the change in joint level. The most accepted of these were 4 mm and 5 mm (6, 11). First, the patients were divided into two groups: those with JL change of more than 4 mm and those with less than 4 mm. Functional scores of the patients (postoperative ROM, KSS, SF-12 PCS, and MCS, and VAS scores) were compared between these two groups. Then, the same categorization and grouping procedure was performed again, considering the JL change with the limit of 5 mm.

Hence, two different comparisons were performed considering the JL alteration.

Since functional scores of patients with a PCOR value of less than 0.44 were reported in the literature, the patients were divided into two groups: those with a PCOR value of less than 0.44 and those with a PCOR value greater than 0.44 (15, 16). Functional scores were also compared between these two groups. Comparisons of functional scores were also performed, grouping the patients by considering the critical limit of 0.5 for PCOR, based on the critical limit of 0.5 for PCOR in the literature (24).

The statistical analysis was performed using SPSS software version 23.0 (IBM SPSS Corp., Armonk, NY, USA) for Windows. A p-value of <0.05 was considered statistically significant. The Shapiro-Wilk test was employed to determine the distribution's normality. Paired samples t-test and independent samples t-test were used to evaluate normally distributed data. The Wilcoxon signed-rank test was used to study dependent variables that were not normally distributed, whereas the Mann-Whitney U test was used to analyze independent variables. The Friedman Test was used to assess the significance of changes in non-normally distributed variables at different time points. Inter- and intraobserver reliability for radiographic classifications was assessed using the intraclass correlation coefficient (ICC). Each group was evaluated twice with repeat classifications on all radiographs with at least a one-week interval for each measurement by three independent observers (ME, KS, and SK). The agreement was excellent for ICC values >0.80.

RESULTS

Seventy-three patients had undergone revision knee surgery in our institution. Finally, 51 patients (40 women, 11 men; mean age 69.9±5.94 [range 56–82]) were included in the study. The mean follow-up period was 40.58±15.32 (24-68) months. The diagnosis for primary TKA was primary degenerative osteoarthritis for 48 knees (94%) and rheumatoid arthritis for three knees (6%). The diagnoses for RTKA were aseptic loosening (n:12, 23.5%), periprosthetic infection (n:37, 72.5%), and periprosthetic fracture (n:2, 4%) (Table 1).

Average knee ROM was 81.82±17.64 degrees before RTKA and significantly improved to 99.17±12.27 degrees (p<0.001) after revision surgery. KSS, SF-12 PCS, and SF-12 MCS scores also increased significantly (all p<0.001). The ICC for all functional outcomes and radiological data was more than 0.80 (range 0.86 to 0.94), showing strong agreement on all parameters evaluated by the three independent observers.

Table 1: Demographic and clinical data of 51 revision total knee arthroplasties

Age (years)	69.9±5.94 (56-82)	
Gender (Male/ Female)	11/40	
Age at primary TKA (years)	63.23±5.83 (48-74)	
Age at revision TKA (years)	66.6±5.9 (52-77)	
Follow-up period (months)	40.58±15.32 (24-68)	
Interval primary-revision TKA (months)	40.88±21.44 (34-46)	
Diagnosis for revision TKA		
Aseptic loosening	12 (23.5%)	
Periprosthetic infection	37 (72.5%)	
Periprosthetic fracture	2 (3.9%)	
Bone defect (AORI)		
Femur (1/2a/2b/3)	23.5%/41.2%/ 35.3%/0%	
Tibia (1/2a/2b/3)	19.6%/52.9%/ 27.5%/0%	
Range of motion (ROM)		p<0.001*
Pre-Revision TKA ROM	81.82±17.64	
Post-Revision TKA ROM	99.17±12.27	
Knee Society Score (KSS)		p<0.001*
Pre-Revision TKA KSS	46.25±4.78	
Post-Revision TKA KSS	72.39±6.82	
SF-12 PCS		p<0.001*
Pre-Revision TKA	31.03±7.48	
Post-Revision TKA	49.09±9.18	
SF-12 MCS		p<0.001*
Pre-Revision TKA	38.92±9.35	
Post-Revision TKA	52.15±9	

TKA: Total Knee Arthroplasty, AORI: Anderson Orthopaedic Research Institute, ROM: Range of motion, *: Statistically significant

In the last follow-up X-rays, patella baja was observed in 4 (7.8%) patients according to the Insall–Salvati index and 13 (25.5%) according to the Blackburn–Peel index. The incidence of pseudo-patella baja was 24% (n:12). The patients with patella baja had significantly lower knee ROM, KSS, and SF-12 PCS than the patients without patella baja (p:0.012, p:0.03, and p:0.01; respectively). Howev-

er, the functional results were similar for both groups of patients when patients were grouped according to the pseudo-patella baja (Table 2, 3).

Twenty-two knees (43.1%) showed a JL change of more than 4 mm, and 16 knees (31.4%) showed a JL change of more than 5 mm. When knee JL was reconstructed within the limit of 4 mm according to the method of Figgie, all postoperative functional results (ROM, KSS, SF-12 PCS, MCS, and VAS score) were similar for both the group where JL was reconstructed within the limit of 4 mm and the group where it was not. When the critical limit in JL reconstruction after RTKA was accepted as 5 mm, it was found that the KSS of the patients whose JLs were reconstructed according to this limit were significantly higher than the patients whose JL change was more than the limit of 5 mm (p:0.02). The other functional results were similar (Table 4). The patients whose JL changed more than 5 mm had higher pain and less knee ROM clinically. There was a trend, but it was not significant.

However, functional results were similar for the group of patients whose PCOR was lower than 0.44 and the group of patients whose PCOR was higher than 0.44. There was also no significant difference in functional results for the patients whose PCOR was lower than 0.5 and those whose PCOR was higher than 0.5 (Table 5).

DISCUSSION

Restoration of the JL in knee arthroplasty is one of the important factors affecting post-op functional results. In RTKA surgery, after bone loss that may occur for various reasons, it may not always be possible to maintain the joint level to the native JL, and alterations may occur in the JL (5, 25, 26). In our study, we aimed to evaluate the critical limit values of the JL change and PCOR affecting the functional results in RTKA, previously described in the literature. The main finding of the present study was that JL alteration of more than 5 mm is significantly associated with poorer KSS following RTKA. Although functional results were reported to be poor in patients with a PCOR below 0.44 in the literature, our findings showed similar

Table 2: Radiographic measurements

Insall-Salvati Index	
Pre-TKA	1.19±0.15
Pre-revision TKA	1.14±0.2
Post-revision TKA	1.1±0.22
Blackburn-Peel Index (BPI)	
Pre-TKA	0.84±0.15
Pre-revision TKA	0.66±0.18
Post-revision TKA	0.63±0.21
Joint line level according to Figgie	
Pre-TKA	24.54±2.49
Pre-revision TKA	26.12±6.77
Post-revision TKA	26.14±6.82
Posterior condylar offset ratio (PCOR)	0.46±0.06
Patella baja following RTKA (ISI<0.8) n (%)	4 (7.8%)
Pseudo-patella baja following RTKA n (%) (BPI<0.5 and ISI>0.8)	12 (24%)

TKA: Total Knee Arthroplasty, ISI: Insall-Salvati Index, BPI: Blackburn-Peel Index, PCOR: Posterior condylar offset ratio, RTKA: Revision total knee arthroplasty

Table 3: Functional results according to the patellar height

	Patella baja (ISI<0.8) Yes n (%) 4 (7.8%) No n (%) 47 (92.2%)		**p**	**Pseudo Patella baja (ISI≥0.8 and BPI<0.5) Yes n (%) 12 (24%) No n (%) 39 (76%)**		**p**
Post-RTKA ROM	Yes	90.21±12.2	**0.012***	Yes	91.25±13.25	0.5
	No	102.5±6.45		No	91.25±8.82	
Post-RTKA KSS	Yes	66.82±6.65	**0.03***	Yes	66.41±6	0.47
	No	74±5.48		No	67.69±7.1	
Post-RTKA SF-12 PCS	Yes	42.19±8.8	**0.013***	Yes	42±5.64	0.31
	No	53.75±7.22		No	43.43±10.1	
Post-RTKA SF-12 MCS	Yes	51.61±9.1	0.097	Yes	52.12±9.81	0.78
	No	52.63±8.08		No	52.25±5.92	
Post-RTKA VAS	Yes	2.93±1.07	0.266	Yes	3.16±0.7	0.31
	No	2.25±1.25		No	2.79±1.17	

RTKA: Revision Total Knee Arthroplasty, ISI: Insall-Salvati Index, BPI: Blackburn-Peel Index, ROM: Range of motion, KSS: Knee Society Score, SF-12: Short form-12, PCS: Physical score, MCS: Mental score, VAS: Visual Analogue Scale, *: Statistically significant

Table 4: Evaluation of the knees according to different levels of joint line alterations

	Joint line changing >4 mm Yes n (%) 22 (43.1%) No n (%) 29 (56.9%)		p	Joint line changing >5 mm Yes n (%) 16 (31.4%) No n (%) 35 (68.6%)		p
Post-RTKA ROM	Yes	89.82±14.3	0.41	Yes	89.57±13.46	0.20
	No	92.95±8.9		No	94.68±8.45	
Post-RTKA KSS	Yes	65.68±7.45	0.66	Yes	65.82±6.9	**0.02**
	No	69.63±5.25		No	70.81±5.38	
Post-RTKA SF-12 PCS	Yes	41.68±9.56	0.27	Yes	42±9.72	0.31
	No	44.95±8.51		No	45.5±7.61	
Post-RTKA SF-12 MCS	Yes	51.79±9.75	0.91	Yes	51.37±9.84	0.52
	No	52.63±8.08		No	53.87±6.75	
Post-RTKA VAS	Yes	3.06±1	0.15	Yes	3.08±1.01	0.64
	No	2.64±1.17		No	2.43±1.15	

RTKA: Revision Total Knee Arthroplasty, ROM: Range of Motion, KSS: Knee Society Score, SF-12: Short Form-12, PCS: Physical score, MCS: Mental score, VAS: Visual Analogue Scale

Table 5: Evaluation of functional results according to the posterior condylar offset ratio

	Posterior condylar offset ratio <0.44 n (%) 14 (27%) >0.44 n (%) 37 (73%)		p	Posterior condylar offset ratio <0.5 n (%) 37 (73%) >0.5 n (%) 14 (27%)		p
Post-RTKA ROM	<0.44	90.13±13.71	0.26	<0.5	90.54±12.06	0.62
	>0.44	93.92±6.84		>0.5	92.85±13.11	
Post-RTKA KSS	<0.44	67.18±6.8	0.65	<0.5	67.32±6.54	0.62
	>0.44	68±7.1		>0.5	67.57±8.42	
Post-RTKA SF-12 PCS	<0.44	42.69±9.28	0.79	<0.5	42.37±9.36	0.25
	>0.44	43.57±9.25		>0.5	45±8.73	
Post-RTKA SF-12 MCS	<0.44	51.18±9.48	0.36	<0.5	52.05±9.4	0.84
	>0.44	54.71±7.21		>0.5	52.42±8.12	
Post-RTKA VAS	<0.44	3±1.17	0.51	<0.5	3±1.3	0.54
	>0.44	2.83±1.06		>0.5	2.83±1	

RTKA: Revision Total Knee Arthroplasty, ROM: Range of Motion, KSS: Knee Society Score, SF-12: Short Form-12, PCS: Physical score, MCS: Mental score, VAS: Visual Analogue Scale

functional results when the patients were grouped according to the PCOR with the critical limit of 0.44 and 0.5.

There are different opinions regarding the effect of JL restoration on functional results in RTKA. Clave et al. and Hoffman et al. found that significantly lower functional outcome scores were associated with the JL change of more than 4 mm (5, 11). Partington et al., declared that the cut-off value of JL elevation in which functional scores are worse was 8 mm, while Porteous et al., stated the limit as 5 mm in RTKA (6, 8). However, Clement et al. and Seon et al. stated that the change in the JL did not significantly affect the functional scores following RTKA (27, 28). In our study, the critical limit of JL change is 5 mm. While there was no significant difference in clinical results when there was a 4 mm limit of JL change, the KSS of the patients was significantly poorer when the JL change was more than 5 mm.

Patella baja is one of the complications after RTKA and may cause inferior clinical results (6, 29). It can occur because of patellar tendon shortening with scar tissues with multiple operations. Additionally, JL elevation can cause pseudo-patella baja without patellar tendon shortening in RTKA (6, 14, 27). Our study observed patella baja and pseudo-patella baja after RTKA in 4 cases (7.8%) and 13 cases (24%), respectively. Patella baja incidence is lower

than in the study of Han et al. (14). In our study, no significant difference was found in the functional scores of patients with pseudo-patella baja and those without pseudo-patella baja, contrary to the study of Vandeputte et al. (30). However, the knee ROM and postoperative KSS of patients with patella baja was found to be significantly lower (p:0.012 and p:0.03, respectively). These results are consistent with the literature (6, 8).

There are several studies about PCOR and its effect on the functional results following knee arthroplasty (17, 26, 31). While Clement et al. and Malviya et al. suggested that PCO is one of the factors significantly influencing functional scores after knee arthroplasty, Ishii et al. reported that PCO does not affect functional scores (17, 26, 31). In the present study, we defined the critical limit of PCOR as 0.44 and 0.5 based on the literature (16, 24). When the patients were divided into two groups according to the PCOR of 0.44 and 0.5, no significant difference could be found in functional results between the two groups in our study. Our results are consistent with the study of Ishii et al.; however, Benazzo et al. did not evaluate the functional results according to the PCOR in their study (24, 31).

In the present study, the mean knee ROM was increased to 99 degrees from 82 degrees following RTKA. RTKA aims to restore native knee kinematics and joint level, and changes in these parameters can affect postoperative functional results (14, 32). Although the mean knee ROM increased after revision surgery in our study, knee ROM was lower, and the pain was higher in patients whose joint level was more than 5 mm.

Our study has several limitations, mostly due to the heterogeneous patient population and the retrospective design. Also, the reason for revision surgery in the present study was mostly periprosthetic joint infection (72.5%). Due to the higher probability of bone loss in the revision surgery after periprosthetic joint infection, restoration of the JL may be more difficult in this patient group and may cause bias in the results. The low number of patients in our study was another limitation. Lastly, all the radiological measurements performed on standard X-rays and measurement errors may be present because of the rotational position of the knee.

CONCLUSION

In this study, JL change >5 mm and patella baja were the prognostic factors affecting functional results after RTKA. The patients with patella baja had significantly lower knee ROM, KSS, and SF-12 PCS than those without patella baja.

Ethics Committee Approval: The study has ethical approval from the Istanbul University, Istanbul Faculty of Medicine (Date: 25.06.2021, No: 2021/1110).

Informed Consent: Informed consent was obtained from all the patients included in our study.

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