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RESEARCH ARTICLE

KNEE FUNCTION AND FLEXION RANGE OF MOTION IN OLDER VERSUS YOUNGER PATIENTS FOLLOWING SIMULTANEOUS BILATERAL TOTAL KNEE ARTHROPLASTY: A TWO-YEAR RETROSPECTIVE FOLLOW-UP STUDY

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ABSTRACT

Purpose: To compare knee function and flexion range of motion between older (≥70 years) and younger patients (<65 years) over a two-year follow-up period following simultaneous bilateral total knee arthroplasty (TKA).
Materials and Methods: A total of 121 patients were divided into older (N = 70) and younger (N = 51) patient groups. The groups were compared for knee function (Hospital for Special Surgery (HSS) knee score) and flexion range of motion. The follow-up period was two years.
Results: In the HSS knee score, no significant differences were found for the group-by-time interaction ($F(5, 573.07) = 1.57$, $p = 0.17$) or the main effect of group ($F(1, 114.78) = 1.55$, $p = 0.22$). For knee flexion range of motion, a significant group-by-time interaction was observed ($F(5, 572.88) = 3.03$, $p = 0.01$). The older patient group had a significantly lower range of motion preoperatively than the younger patient group ($p = 0.02$); however, no significant differences were detected at postoperative follow-up time points ($p > 0.05$).
Conclusion: Patients aged ≥70 years demonstrated postoperative improvements in knee function and flexion range of motion comparable to those observed in patients aged <65 years following simultaneous bilateral TKA.

Keywords: total knee replacement, function, arthroplasty, range of motion, outcome, knee joint

INTRODUCTION

The efficacy of total knee arthroplasty (TKA) in treating end-stage osteoarthritis is well-established, resulting in meaningful clinical improvements in both pain scores and functional status (1). As the global population ages, an increasing number of older adults

undergo TKA to maintain mobility; meanwhile, demand among younger adults is also rising as surgical thresholds expand to support active lifestyles (2,3). Despite these trends, age-related differences in recovery following TKA are not yet fully understood. While the primary goal of TKA is pain relief, older adults often present with reduced physical resilience compared with younger adults, who typically demonstrate higher functional capacity (4,5). This distinction is particularly relevant in bilateral TKA. Unlike unilateral procedures, bilateral TKA requires immediate mobilization with two prosthetic joints, potentially increasing early functional demands. Age-related differences in physiological and musculoskeletal reserve may therefore contribute to variation in postoperative adaptation, posing a particular challenge for older patients compared with younger patients (6,7). Given this unique nature of bilateral TKA, understanding how different age groups navigate this process is essential for optimizing clinical outcomes and managing expectations.

The influence of advanced age on postoperative knee function and range of motion remains debated. The literature presents inconsistent findings regarding the effect of age on TKA outcomes. While some studies report no significant differences in clinical scores across age groups (8,9), others suggest that older patients may experience less favorable outcomes (10–12), whereas some have reported poorer outcomes among younger patients, including higher levels of postoperative pain and worse functional outcomes (13–17). Moreover, many studies evaluating age-related outcomes are based on unilateral TKA (8,9,12,15–17). A study has reported differences in postoperative range of motion and functional outcomes between unilateral and bilateral TKA (18). Since the nonoperated limb may substantially influence overall mobility (19), unilateral designs may not fully reflect functional outcomes. Longitudinal deterioration of the nonoperated limb, including the development of pain and muscle weakness over time, may further affect long-term functional outcomes of the operated limb (20). In this context, bilateral TKA may reduce the influence of the nonoperated limb and require a more symmetrical musculoskeletal adaptation, thereby providing a more appropriate framework for evaluating age-related differences in functional outcomes.

We aimed to compare knee function and flexion range of motion between older patients (≥70 years) and younger patients (<65 years) over a two-year follow-up period following simultaneous bilateral TKA. We hypothesized that the older patients would demonstrate poorer clinical outcomes compared with their younger counterparts.

MATERIALS AND METHODS

Study design and patients

The clinical records of 352 patients were retrospectively reviewed. Eligible patients included those who underwent simultaneous bilateral TKA for Kellgren-Lawrence grade 3 or 4 osteoarthritis (21). Exclusion criteria were defined as: neurological disease; prior lower limb fractures; revision surgery or postoperative complications; gastrointestinal, endocrinological, or rheumatoid diseases; and malignancy. Of the 352 clinical records reviewed, 153 patients met these criteria. Patients aged 65–69 years were excluded to prevent age group overlap, as population-level evidence indicates that overall health heterogeneity peaks around 70 years of age, representing a highly variable transition period (22). Excluding this transitional stratum ensured clearer between-group contrasts and enhanced internal validity. Consequently, the final study cohort consisted of 121 patients, divided into older patient (≥70 years) and younger patient (<65 years) groups. Data were collected at six time points: preoperatively and at six weeks, three months, six months, one year, and two years postoperatively.

All surgical procedures were performed by a single surgeon at a university hospital using a paramedian approach and a gap-balancing technique. The patients underwent simultaneous bilateral TKA in a single session using the same cemented prosthesis design in both knees and patellar resurfacing. Postoperatively, all patients completed a standardized inpatient rehabilitation program led by a physiotherapist, consisting of range of motion exercises (passive, active-assistive, and active), muscle strengthening (isometric and isotonic), and functional mobility training (gait, transfer, and stair-climbing). Following discharge, the patients were instructed to continue these exercises as part of a home-based program.

The study was approved by the Noninvasive Research Ethics Board of Dokuz Eylül University (Date: 06.04.2026, No: 2026/14-08).

Outcome measures

Assessment of knee function

Knee function was assessed using the Hospital for Special Surgery (HSS) knee score, which incorporates pain, function, range of motion, muscle strength, flexion deformity, instability, and subtractions. Scores range from 0 to 100; higher scores indicate better knee function (23,24). Consistent with established literature, the mean HSS knee score of both knees was utilized for statistical analysis (25).

Measurement of knee flexion range of motion

Active knee flexion was measured with the patient in a supine position, with the hip and knee in extension. A universal goniometer was positioned with its fulcrum over the lateral femoral epicondyle. The proximal arm of the goniometer was aligned with the lateral midline of the femur pointing toward the greater trochanter, while the distal arm was aligned with the lateral midline of the fibula referencing the lateral malleolus. The patients were instructed to perform maximum active knee flexion while maintaining heel contact with the examination table (26). Flexion values were recorded in degrees, and the mean flexion range of motion from both knees was used for statistical analysis.

Sample size estimation

An a priori power analysis was performed with G*Power software (v3.1.9.6, Heinrich-Heine University Düsseldorf, Germany) with the F-test (ANOVA: repeated measures, within-between interaction) (27). A small-to-medium effect size of 0.15 was targeted based on expected group differences. By setting a Type I error rate of 0.05 and a statistical power of 0.95 for two groups with six repeated measurements, and assuming a correlation of 0.50 between the measures with a nonsphericity correction of 1, it was determined that a minimum of 38 patients per group was necessary.

Statistical analysis

Group allocation, statistical analyses, and the generation of figures were conducted using the R language for statistical computing (https://www.r-project.org). Linear mixed-effects models were employed for group comparisons. To address missing data encountered during follow-up, the assumption was made that data were missing at random. Since mixed-model analyses provide valid statistical inferences under this assumption (28), multiple imputation was not performed, and no subjects were removed due to missing observations.

The HSS knee score and knee flexion range of motion were defined as the dependent variables. The Kenward-Roger approximation was employed to estimate denominator degrees of freedom via a Type III Wald F-test. In each model, group, time, and the interaction between group and time were included as fixed effects, while patients were treated as the random effect. Additionally, body mass index, gender, prosthesis brand, and prosthesis design were included as covariates and modeled as fixed effects. The primary focus of the analysis was the interaction between group and time. In cases where the interaction effect was not significant, the interaction term was removed, and the model was refitted to evaluate main effects only. Within these refitted models, Type II tests were performed to assess the main effect of the group for significant differences. Pairwise comparisons were conducted using estimated marginal means with a Bonferroni adjustment. Estimated marginal means were presented with Bonferroni-corrected 95% confidence intervals, using an adjusted threshold of $p < 0.05$ to determine statistical significance.

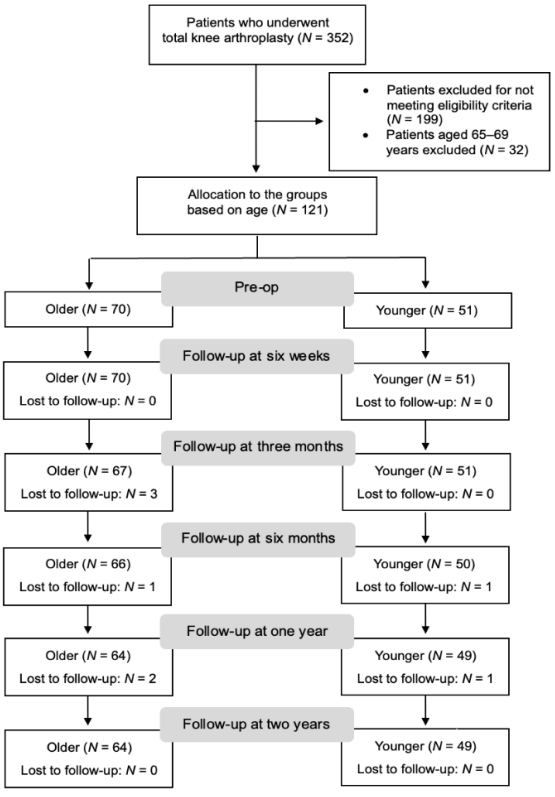


Figure 1. Flow chart of the study.

RESULTS

Baseline characteristics for both groups are presented in Table 1. Table 2 shows the changes in HSS knee scores and knee flexion range of motion across the follow-up period for both groups. The flow chart of the study is shown in Figure 1.

For the HSS knee score, no significant differences were found for the group-by-time interaction ($F(5, 573.07) = 1.57$, $p = 0.17$) or the main effect of group ($F(1, 114.78) = 1.55$, $p = 0.22$) (Figure 2). For knee flexion range of motion, a significant group-by-time interaction was observed ($F(5, 572.88) = 3.03$, $p = 0.01$). Post-hoc analysis revealed that the older patient group had a significantly lower range of motion preoperatively than the younger patient group ($p = 0.02$); however, no significant differences were detected at any of the postoperative follow-up time points ($p > 0.05$) (Figure 3).

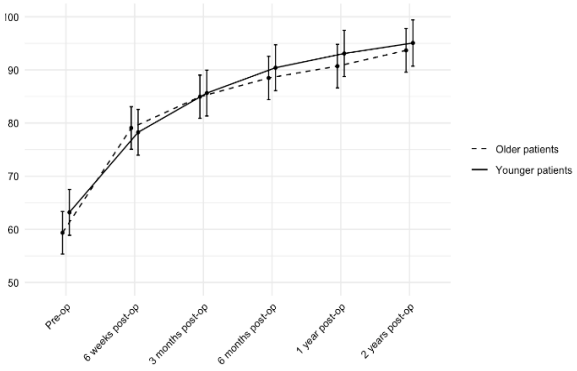


Figure 2. Hospital for Special Surgery knee scores across the two-year follow-up period by group. Values are presented as estimated marginal means, with error bars representing adjusted 95% confidence intervals. There was no significant group-by-time interaction or main effect of group ($p > 0.05$).

Table 1. Demographic and clinical characteristics of the groups, mean ± standard deviation or *N*.

		Older patients (≥70 years)	Younger patients (<65 years)
N		70	51
Age (years)		74.4 ± 4.0	58.6 ± 4.1
Body mass index (kg/m^2)		30.9 ± 5.2	34.2 ± 5.7
Gender			
	Male	7	6
	Female	63	45
Prosthesis brand			
	NexGen®, Zimmer	49	27
	Scorpio®, Stryker	21	24
Prosthesis design			
	Cruciate-retaining	44	39
	Posterior-stabilized	26	12

Table 2. Hospital for Special Surgery knee scores and knee flexion range of motion of the groups, estimated marginal mean (adjusted 95% confidence interval).

	Older patients (≥70 years)	Younger patients (<65 years)	Estimated mean difference
Hospital for Special Surgery knee scores			
Pre-op	59.4 (55.3 to 63.4)	63.2 (58.9 to 67.5)	–3.8 (–8.3 to 0.7)
Six weeks post-op	79.1 (75.1 to 83.1)	78.3 (74.0 to 82.6)	0.8 (–3.7 to 5.3)
Three months post-op	85.0 (80.9 to 89.0)	85.6 (81.3 to 89.9)	–0.7 (–5.2 to 3.8)
Six months post-op	88.5 (84.4 to 92.6)	90.4 (86.1 to 94.7)	–1.9 (–6.5 to 2.6)
One year post-op	90.7 (86.6 to 94.8)	93.1 (88.7 to 97.4)	–2.4 (–7.0 to 2.2)
Two years post-op	93.7 (89.6 to 97.8)	95.1 (90.7 to 99.4)	–1.4 (–6.0 to 3.2)
Knee flexion range of motion			
Pre-op	98.9 (93.5 to 104.3)	105.7 (99.9 to 111.4)	–6.8 (–12.7 to –0.8)
Six weeks post-op	103.5 (98.1 to 108.8)	103.0 (97.2 to 108.7)	0.5 (–5.5 to 6.5)
Three months post-op	108.9 (103.4 to 114.4)	110.2 (104.4 to 115.9)	–1.3 (–7.3 to 4.8)
Six months post-op	111.6 (106.1 to 117.1)	112.9 (107.1 to 118.7)	–1.3 (–7.4 to 4.7)
One year post-op	115.2 (109.7 to 120.7)	114.3 (108.4 to 120.1)	1.0 (–5.1 to 7.1)
Two years post-op	117.2 (111.7 to 122.7)	117.0 (111.2 to 122.9)	0.1 (–6.0 to 6.2)

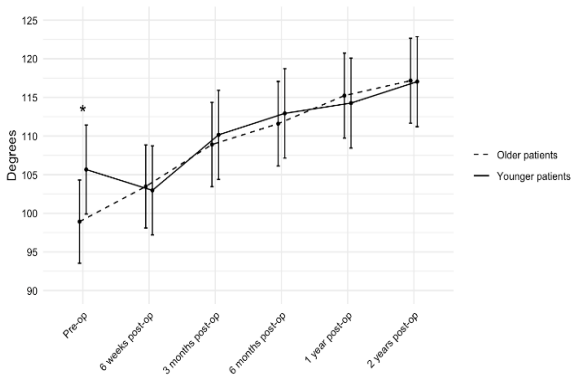


Figure 3. Knee flexion range of motion across the two-year follow-up period by group. Values are presented as estimated marginal means, with error bars representing adjusted 95% confidence intervals. The group-by-time interaction was significant (p = 0.01). The older patient group had a significantly lower range of motion preoperatively than the younger patient group (p = 0.02).

DISCUSSION

Our findings show that patients aged 70 years and older achieve similar improvements in knee function and flexion range of motion compared to those younger than 65 years over the two-year period following simultaneous bilateral TKA. Contrary to our initial hypothesis, both groups exhibited comparable clinical outcomes. By the end of the follow-up period, each group demonstrated satisfactory results. These findings suggest that advanced age alone may not be a limiting factor for favorable functional outcomes after bilateral procedures.

Knee function, as assessed by the HSS knee score, improved in both age groups, with no meaningful between-group differences throughout the follow-up period. This finding aligns with several previous studies reporting that advanced age does not necessarily compromise postoperative knee function after TKA (8,9).

However, other studies have reported less favorable outcomes in either older or younger patient populations (10–17). In this context, comparisons across studies should be interpreted with caution, as the definition of “younger” and “older” patients varies substantially in the literature, with thresholds ranging from <50 to <65 years for younger cohorts and ≥60 to >80 years for older cohorts (8–17). In addition, discrepancies between our findings and some previous reports may be partly explained by differences in outcome measures. Many studies reporting inferior outcomes in younger patients have relied predominantly on patient-reported outcome measures (13–16), which may be influenced by patient expectations after TKA (29). Younger patients may have higher functional demands and expectations, which potentially attenuate perceived postoperative gains despite similar objective improvements, whereas older patients may report comparable or more favorable outcomes due to more modest expectations (15–17). In contrast, the HSS knee score incorporates objective clinical parameters, providing a more performance-based assessment of knee function. This distinction is important, as patient-reported outcome measures and objective functional measures following TKA are complementary, capturing different aspects of recovery (30). Therefore, differences reported in the literature between age groups are likely to reflect the type of outcome measures used rather than true differences in knee function.

We found that flexion range of motion improved over time in both age groups, with no statistically significant between-group differences observed at any postoperative follow-up point. Although older patients demonstrated lower preoperative range of motion compared to younger patients, this difference did not persist postoperatively. These findings are partially consistent with the existing literature. Elmallah et al. reported that patients younger than 55 years had a lower preoperative range of motion compared to those older than 55 years; however, they similarly found no differences at postoperative follow-up (31). Likewise, Yun et al. compared patients aged 65–70 years with those aged ≥ 80 years and reported no statistically significant differences in range of motion preoperatively or postoperatively (9). The apparent differences in preoperative range of motion across studies may be explained by the degree of overlap in age distributions between cohorts. In our study, the lower preoperative range of motion observed in older patients may be attributable to cumulative joint degeneration, soft tissue stiffness, and reduced physical activity (32). The lack of preoperative differences in the study by Yun et al. may stem from the fact that both their groups (65–70 years vs. ≥80 years) consist of geriatric patients (9), similar to our older patient group (≥70 years). However, we could not reach a clear explanation regarding the lower preoperative range of motion observed in the younger patient group in the study by Elmallah et al. (31). Taken together, the observed

discrepancies in preoperative range of motion between studies may be explained not only by differences in age cut-off definitions, but also by variations in baseline disease severity, degree of deformity, and timing of surgical intervention across study populations.

This study has several limitations. First, the retrospective design may have introduced selection bias, as the study population may not fully represent the general bilateral TKA population. Second, although demographic and implant-related factors were included as covariates in the statistical models, certain other potentially influential confounders—such as comorbidities and preoperative mental health status—could not be incorporated into the models due to data unavailability (33,34). Finally, variations in postoperative rehabilitation protocols and patient adherence were not fully controlled, which may have influenced the functional outcomes. A major strength of this study is the inclusion of only patients undergoing simultaneous bilateral TKA. By eliminating the influence of the nonoperated limb—such as pain or muscle weakness that may affect functional outcomes in unilateral cases—this design enables a more balanced and reliable assessment of age-related differences in postoperative function (18,20). In addition, all procedures were performed by a single surgeon at a single center, which enhances internal validity by ensuring procedural consistency and minimizing inter-surgeon and inter-institutional variability (35).

CONCLUSION

Patients aged ≥70 years demonstrated postoperative improvements in knee function and flexion range of motion comparable to those observed in patients aged <65 years following simultaneous bilateral TKA. Advanced age alone may not act as a barrier to achieving successful functional outcomes.

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Conflict of Interests: None
Ethical Approval: The study was approved by the Noninvasive Research Ethics Board of Dokuz Eylül University (Date: 06.04.2026, No: 2026/14-08).
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