

# Effects of Total Knee Arthroplasty on Balance and Fall Risk in Elderly Patients with Severe Gonarthrosis: An Age- and Sex-Matched Comparative Study

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## INTRODUCTION

Falls are causes of severe morbidity and mortality in elderly patients, and fall-related injuries impose a heavy burden on the health care system.<sup>[1]</sup> A 13% fall rate has been reported in adults over 65 years of age.<sup>[2]</sup> Accidents and environmental factors are among the main reasons for falling in the elderly population. These are followed by gait/balance disorders and muscle weakness.<sup>[2]</sup> Primary gonarthrosis is a frequent cause of disability in the elderly population. Gonarthrosis causes a predisposition to fall due to lower extremity deformity (especially varus), knee instability,

### ABSTRACT

**Background:** Falls are a severe cause of morbidity and mortality in elderly patients, and gonarthrosis causes a tendency to fall. Total knee arthroplasty (TKA) is a widely used successful surgical procedure for end-stage gonarthrosis. **Aims:** To investigate whether there is a difference in the frequency of falls, balance and fall risk, and clinical and radiological results in patients with end-stage gonarthrosis with and without TKA. **Patients and Methods:** This was a single-center, retrospective, case-control study with age- and gender-matched groups. A total of 100 patients over 60 years of age, with end-stage gonarthrosis and who met the inclusion criteria were included in the study. Fall risk was analyzed using the Berg Balance Scale (BBS), TUG tests, and the ITAKI Fall Risk Test. Knee varus angles were measured using standing long-leg radiographs, and radiological gonarthrosis grading was performed. Pain levels and quality of life were assessed using the VAS and WOMAC. Each patient’s knee extensor muscle strength and range of motion were measured. **Results:** WOMAC, ITAKI, TUG test, and VAS scores were significantly higher in the control group than in the TKA group. BBS scores were significantly lower in the control group. Although the number of falls was high in the control group, there was no statistically significant difference between the two groups. **Conclusion:** The results of this study showed that total knee arthroplasty provided statistically significant improvement in the clinical, radiological, and fall risk results of the patients. Although there was a decrease in the frequency of falls compared to the control group, it was statistically insignificant. In addition, in our study, it was evaluated that the most important risk factor for falling was advanced age.

**KEYWORDS:** Alignment, balance, fall Risk, gonarthrosis, total knee arthroplasty


impaired walking biomechanics, a decreased sense of proprioception, and impaired balance due to muscle weakness, pain, and reduced range of motion.<sup>[3,4]</sup> Because gonarthrosis causes a tendency to fall, it increases the risk of fractures. The annual fall rate among patients with advanced gonarthrosis has been reported to be

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48%.<sup>[5]</sup> Therefore, when planning knee osteoarthritis treatment, it is crucial to determine fall risk and take precautions accordingly.

Total knee arthroplasty (TKA) is a common surgical procedure for end-stage gonarthrosis with severe pain that does not respond to conservative treatment. It improves the patient's quality of life by relieving pain and correcting knee deformities. It not only reduces pain but also enhances dynamic stability by improving proprioception, neuromuscular control, and joint-related stability. The consequent improvement in walking performance and balance can reduce fall risk.<sup>[6-8]</sup> These effects are significant because falling increases the risk of periprosthetic fractures in elderly patients who undergo TKA. It has also been reported that the prevalence of osteoporosis in patients who have undergone TKA is higher than in healthy elderly people.<sup>[9]</sup> Moreover, a decrease in bone mineral density has been observed around the prosthesis in the post-operative period, which is the result of an increase in bone resorption and a decrease in patient motor activity.<sup>[10]</sup>

Many studies have investigated the risk of falling and related factors affecting falls in both patients with gonarthrosis and patients undergoing TKA, studies on the effects of TKA on falls have reported contradictory results.<sup>[11-13]</sup> Some studies have reported that TKA reduces the number of falls and the fear of falling<sup>[5,14,15]</sup>, whereas others have found an increased risk of falling due to impaired proprioception and balance.<sup>[16,17]</sup> However, there are few studies in the literature comparing patient groups with TKA and gonarthrosis in terms of fall incidents and related risk factors.<sup>[13]</sup> Also, the effects of TKA on balance and the risk of falling, especially in elderly patients with functional walking disorders, have not been well established, and there are relatively few studies on falls after TKA.<sup>[18]</sup>

For all these reasons, the questions of our study: ‘1- Is the prevalence of falls similar between the groups of patients with end-stage gonarthrosis who underwent and did not undergo total knee replacement? 2- Are the clinical and radiological results of these patient groups similar?’. Therefore, the purpose of this study was to investigate whether there is a difference in the frequency of falls, fall risk, clinical and radiological results in end-stage gonarthrosis patients with and without TKA.

## MATERIALS AND METHODS

### Study design

This single-center, retrospective, case-control study with age- and gender-matched groups was conducted after obtaining approval from the Ethics Committee of the study was carried out in Balikesir University School of Medicine (approval number: 2018/177).

The case (TKA) group consisted of patients who underwent TKA between April 2016 and September 2018. Data regarding the surgical procedures and post-operative periods were obtained from the patients' medical records. The control group consisted of patients who were referred to the physical therapy outpatient clinic and diagnosed with end-stage primary gonarthrosis.

Patients who applied to the outpatient clinic due to knee pain and were diagnosed with gonarthrosis between April 2016 and September 2018 were scanned retrospectively from the automation system. Medical records were reviewed.

The information of the patients before, after and at the control visits was documented. In addition, patients were called for their final controls by reaching their contact information. KLC stages and knee varus angles of the patients were measured radiologically from the obtained radiological data. Pre-operative and post-operative knee varus angles of the surgical group were measured. For clinical knee pain and functional evaluation of the patients, WOMAC (Western Ontario and McMaster Universities),<sup>[19]</sup> VAS were performed at the last follow-up, and extensor muscle strength and range of motion were measured. The Medical Research Council (MRC) muscle strength scale was used to measure extensor muscle strength. The Berg balance scale,<sup>[20]</sup> The ITAKI Fall Risk Test,<sup>[21]</sup> and The Timed Up & Go Test (TUG)<sup>[22]</sup> were used to analyze fall risk.

In addition, at the last control, the patients were informed that their medical results would be used for scientific purposes, and their consent was obtained.

In our study, the results of 100 patients over 60 years of age with end-stage gonarthrosis, who met the inclusion criteria and were followed up for at least 2 years, were evaluated. The patients were retrospectively divided into two equal groups according to TKA treatment. Group 1: It consisted of 50 patients who received physical therapy and rehabilitation and medical treatment, Group 2 consisted of 50 patients who underwent TKA and received post-operative physical therapy and rehabilitation.

### Patients and controls

The TKA group participants were 84 patients over 60 years old who underwent unilateral TKA. All surgeries were performed by the same orthopedist (SS) using the standard medial parapatellar approach. The NexGen® LPS-Flex Fixed Bearing Knee (Zimmer, USA) was used as an implant in all patients. All patients were mobilized on the first day after surgery and underwent standard inpatient rehabilitation. The early joint

movement was started with a controlled passive-motion device. All obese patients were encouraged to lose weight. The control group was formed according to the inclusion and exclusion criteria, shown in Table 1, from 92 elderly individuals over 60 years old with end-stage primary gonarthrosis. A flow chart of the study is presented in Figure 1. Eventually, 100 patients were included in the study: 50 patients with end-stage primary gonarthrosis and 50 patients who underwent total knee prosthesis.

### Evaluation of knee pain and functional status

Routine radiographs of all patients were evaluated, and radiological gonarthrosis staging was performed according to the Kellgren–Lawrence classification (KLC). A VAS was used to evaluate the patients' pain levels, and the WOMAC was used to assess their quality of life. The WOMAC is a 24-item questionnaire with 3 subscales measuring: pain (5 items), stiffness (2 items) and physical function (17 items). A lower score indicates a better outcome. It has also been used to evaluate many knee OA interventions, both surgical and conservative.<sup>[19]</sup> The patients' knee extensor muscle strength and range of motion were measured.

### Evaluation of falls and balance

Both groups were asked about the number of falls and fall-related injuries or fractures they had experienced over a period of a year prior to the study. Falls due to reasons such as loss of balance and snagging were defined as falling. Falls due to conditions such as seizure, fainting, or stroke were excluded from the study. The BBS, The TUG test, and The ITAKI Fall Risk Test were used to analyze fall risk.

The BBS was developed for the assessment of postural control. The scale consists of 14 parts. The scale assesses sitting and standing balance, as well as balance during activities commonly performed in daily functions such as transfers, turning, and picking up objects from the ground. Scoring is done on a 5-point scale that considers whether the patient can perform the task safely and independently. Normal performances are rated from 0 (unable to perform) to 4 points (normal performance). The total score is calculated with a maximum of 56 points. 0-20 points as high fall risk, 21-40 points as medium fall risk, and 41-56 points as a low fall risk.<sup>[20]</sup>

The TUG test that evaluates fall risk and mobility in the elderly. A chair and a stopwatch are required to administer the test. The test is done with the shoes that the patient always uses, and it is said that he can use walking aids if he needs them. The distance of 3 meters in front of the chair is determined. The patient is asked

to get up from the chair and walk this distance and sit on the chair again. The elapsed time gives the result of the test. Increased risk of falling over 12 seconds.<sup>[22]</sup>

The ITAKI Fall Risk Scale was developed by reviewing different scales for avoiding falls which are a part of patient safety practices in Turkey. The scale includes 11 minor risk factors (1 point) and 8 major risk factors (5-point) and consists of a total of 19 items. While points lower than 5 signify no fall risk, points higher than 5 signify high fall risk. Maximum 51 points can be obtained from the scale.<sup>[21]</sup>

### Evaluation of alignment

Knee varus angles were measured using standing long-leg radiographs taken during the pre-operative and post-operative periods in order to evaluate the alignment of the patients in the coronal plane.<sup>[23]</sup>

### Evaluation of risk factors for falls

Regression analyzes were conducted to investigate whether age, gender, body mass index, knee varus angles in the coronal plane, total knee prosthesis effect, or symptom duration were fall risk factors.

### Statistical analyses

The SPSS Statistics® 20.0 (IBM Corporation, Armonk, NY, USA) statistical analysis software package was used to analyze the data. To determine the distribution of the data, visual graphs (histograms) and appropriate statistical methods (Kolmogorov–Smirnov and Shapiro–Wilk tests) were used. To compare the two independent groups, Student's t-test, or the Mann–Whitney U test was used depending on the assumption of the normality of the distributions. To compare the related groups, the Wilcoxon sign test was used. For the evaluation of categorical data, cross tables were created, and a Chi-squared test was used.

A binary logistic regression was performed to identify independent risk factors for falls, and the general and surgical factors—including age, sex, body mass index, KLC grade of the knee, symptom duration time, knee varus angle in the coronal plane, and knee replacement— were included in the model. A value of  $P < 0.05$  was accepted as the level of statistical significance.

The G\*Power version 3.1 statistical analysis program (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) was used to compute the study power. There were 50 participants in group 1 and 50 in group 2. If the allocation ratio, effect size (d) and alpha error probability were accepted as 1, 0.55 and 0.05, respectively, hereby, the critical t value would be 1.66 and power was found to be 0.85.

## RESULTS

The patients' demographic data are presented in Table 2. The difference between the two groups in terms of age ( $p = 0.096$ ), gender ( $p = 0.564$ ) and, BMI ( $p = 0.056$ ) was statistically insignificant.

The median, minimum, and maximum values of the two groups are reported in Table 3. TKA was found to have

a statistically significant positive effect on pain, clinical functions, and radiological measurements. WOMAC and VAS scores were found to be statistically significantly lower in the TKA group compared to the control group. The degree of change in knee varus angles before and after surgery in the TKA group was statistically significant. This shows that TKA has an effect on correcting disturbed lower extremity alignment [Table 4, Figure 2].

**Table 1: Inclusion and exclusion criteria**

Inclusion criteria	Exclusion criteria
<ul style="list-style-type: none"> <li>• 60–75 years old</li> <li>• End-stage primary gonarthrosis according to the KLC</li> <li>• TKA performed at least six months prior to the study</li> </ul>	<ul style="list-style-type: none"> <li>• Secondary gonarthrosis (posttraumatic, inflammatory, postinfectious, etc.)</li> <li>• Advanced auditory, visual, or cognitive impairment (Alzheimer's disease, etc.)</li> <li>• Motor and sensory deficits due to radiculopathy or polyneuropathy</li> <li>• Advanced vascular pathology</li> <li>• Condition that could cause balance problems (Parkinson's disease, cerebrovascular disease, multiple sclerosis, stroke, etc.)</li> <li>• Falls due to seizures or fainting</li> <li>• Symptomatic lumbar and/or foot or ankle problems</li> </ul>

KLC: Kellgren–Lawrence classification; TKA: total knee arthroplasty

**Table 2: Patients' demographic data by group**

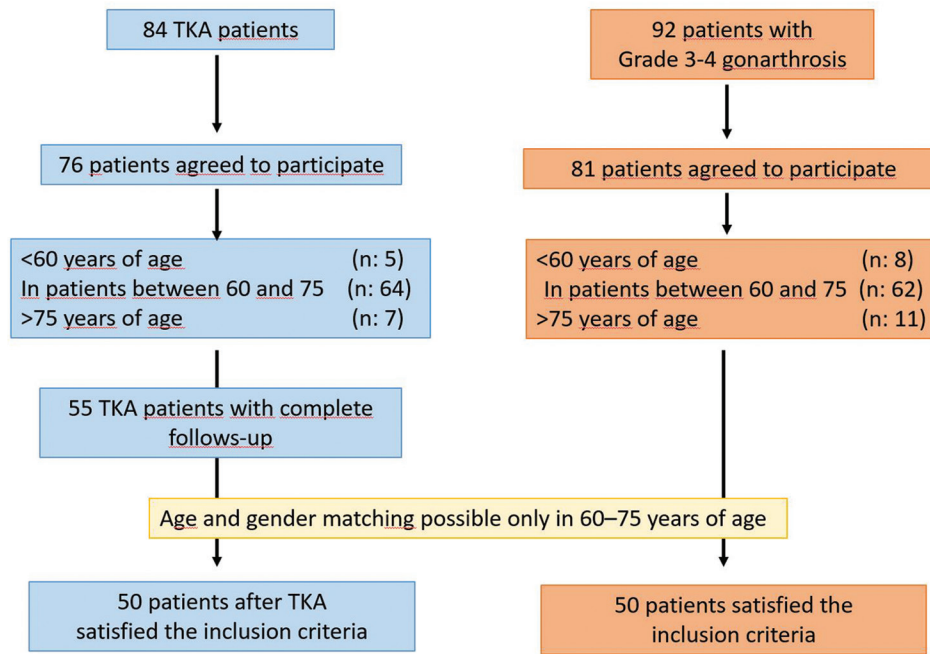
		Control	TKA	p
Gender	Male	6 (12)	8 (16)	0.564
N (%)	Female	44 (88)	42 (84)	
Age (years)		66.06±3.08 (60–73)	67.10±3.11 (60–74)	0.096
mean±SD (min–max)				
BMI (kg/m <sup>2</sup> )		30.77±4.64 (19.94–43.56)	29.10±4.01 (22.58–37.11)	0.056
mean±SD (min–max)				
Duration of symptoms	<3 months	5 (10)	0 (0)	0.001
	3–6 months	2 (4)	8 (16)	
	6–12 months	6 (12)	27 (54)	
	>12 months	37 (74)	5 (30)	
KLC grading	Grade 3	34 (68)	0 (0)	0.001
n (%)	Grade 4	16 (32)	50 (100)	
Pre-operative Knee Angle	Varus	14.81 5.2	14.52±4.75	0.772
mean±SD	Valgus	-	-	

BMI: Body Mass Index; KLC: Kellgren–Lawrence classification; TKA: total knee arthroplasty

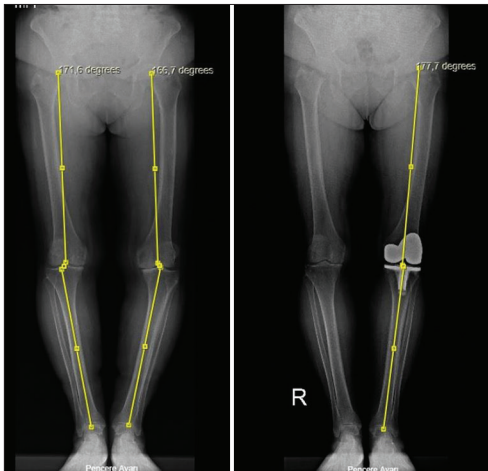
**Table 3: Pain and quality of life assessment and balance and fall risk assessment by group**

	Control		TKA		p
	Median	Min–max	Median	Min–max	
Pain and quality of life assessment					
WOMAC	53.10	8.33–98.95	11.01	6.25–20.80	0.001
VAS	7.5	1–10	3	1–4	0.001
Balance and fall risk assessment					
BBS	48.50	30–56	51.50	17–56	0.001
Itaki test	7	1–19	3	1–6	0.001
TUG test	15.00	8.50–56.00	11.00	7.10–19.80	0.001

TKA: total knee arthroplasty; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index; VAS: visual analog scale; BBS: Berg Balance Scale; TUG: Timed Up and Go



**Figure 1:** Study flow chart (TKA: total knee arthroplasty)



**Figure 2:** Picture showing improvement in lower extremity alignment before and after surgery

TKA was found to have a statistically significant positive effect on balance and fall risk. ITAKI and TUG test scores were significantly higher in the control group, whereas the BBS scores were significantly higher in the TKA group [Table 3]. The number of falls in the TKA group was lower than in the control group. But there was no statistically significant difference between the two groups in terms of the number of falls ( $p = 0.470$ ) [Table 4].

A regression model was created to evaluate the effects of age, gender, body mass index, knee varus angle [Table 5], KLC stage, symptom duration, and surgery on falling. In the model created, it was observed that a one-unit

		Number of falls		
		None	One	Two or more
TKA	N (%)	32 (64)	9 (18)	9 (18)
Control	N (%)	27 (54)	9 (18)	14 (28)

TKA: total knee arthroplasty

	Pre-operative	Post-operative	P
Frontal Knee Varus Angle	14.52±4.75	2.27±1.04	0.001

increase in age increased the fall risk by 1.17 times (95% confidence interval: 1.01–1.35,  $P = 0.031$ ).

## DISCUSSION

The main results of this study show that Total knee arthroplasty has a statistically significant positive effect on fall risk and stability, and consistent with these results, the number of falls was lower in the TKA group than in the control group. However, the difference between the two groups in terms of the number of falls was not statistically significant. In line with the relevant literature, TKA had a statistically significant positive effect on pain, quality of life, alignment, functionality, and mobilization in patients with end-stage gonarthrosis. Finally, among the risk factors investigated in this study—such as age, gender, knee varus angle, symptom duration, and CLC stage—we found that age alone increased fall risk by 1.17 fold.

TKA has been reported to reduce fall risk. Si *et al.*<sup>[11]</sup> found that TKA reduced the incidence of falling and improved functions requiring balance. However, they emphasized that grade  $\geq 3$  gonarthrosis in the contralateral knee is an independent risk factor for falling, and thus the contralateral knee should be considered in fall prevention strategies. Tsonga *et al.*<sup>[12]</sup> reported that TKA improves patients' quality of life and reduces the risk of falling, especially one year after surgery.

In a review regarding the effects of TKA on falling, Moutzouri *et al.*<sup>[3]</sup> found that 54.2% of the patients who had fallen pre-operatively did not fall after surgery, and there was a decrease in fear of falling. They also found a positive effect on balance for up to one year after surgery.<sup>[3]</sup> In our study, we observed a statistically significant difference between the groups according to the fall and balance scales. We think that this positive effect of TKA is due to the improvement in the range of motion of the joint.

Susceptibility to falling due to imbalance is known to increase in advanced gonarthrosis. The literature has reported mechanical axle deformity, decreased muscle strength, impaired proprioception, pain, and reduced joint range of motion as the reasons for this imbalance.<sup>[3,4]</sup> TKA reduces fall incidents and improves balance by reducing pain, correcting mechanical axis deformity, and improving the joint range of motion. The results of this study are similar to these data in the literature.

In contrast, a recent systemic review found that patients with TKA had a high risk of falling, which continued after surgery, albeit at a reduced rate.<sup>[24]</sup> Similarly, Levinger *et al.*<sup>[5]</sup> reported an increased risk of falling in patients who had undergone TKA within four months post-operatively, attributing this change to a decrease in knee extension strength and lower extremity proprioception. Moreover, Matsumoto *et al.*,<sup>[1]</sup> although reporting reduced knee pain and improved functionality after TKA, observed inadequacy and functional limitations in their TKA group compared to the control group. They found that TKA patients were more likely to fall than the general Japanese population, especially in the first six months after surgery, and they reported that kyphosis was the factor most strongly associated with falling. In our study, functionality was significantly improved and pain levels were significantly lower in the TKA group. In our study, contrary to these studies, the number of falls was found to be statistically insignificantly lower in the TKA group and the risk of falling was found to be statistically significantly better in the TKA

group. We believe that the most important reason for BBS demotion in the control group is a decrease in muscle strength, pain and a loss of proprioception. Therefore, both orthopedists and physiatrists should be aware that the risk of falling does not decrease in end-stages gonarthrosis patients. For these patients with additional musculoskeletal pathologies, such as kyphosis, it may be appropriate to take preventive measures and plan exercise and rehabilitation programs accordingly.

Various fall rates after TKA have been reported in the literature. Matsumoto *et al.*<sup>[15]</sup> found that 32.9% of patients fell at least once during a six-month observation period of elderly patients who had undergone TKA. Following 99 TKA patients for one year, Swinkels *et al.*<sup>[14]</sup> reported that 24.2% of them fell at least once. In a total of 87 fall cases, 50 (57.5%) resulted in injury, and 15 (17.2%) required medical care. In our study, the number of falls was lower in the TKA group than in the control group. We hypothesize that this difference is due to decreased speed and degree of motion in patient activities combined with a disproportional improvement in the factors that affect balance. Women have been found to have a higher risk of falling and associated harm than men,<sup>[25]</sup> which can be attributed to the fact that various musculoskeletal diseases, such as gonarthrosis and osteoporosis, are more common in women.

One of the limitations of our study is that it included unequal numbers of men and women in both groups, which prevented an examination of differences between the genders. Because of the higher incidence of musculoskeletal diseases such as obesity, osteoarthritis, and osteoporosis in women, the majority of our participants were female. Other limitations include the fact that we did not measure muscle strength with isokinetic devices, the fact that we did not evaluate the TKA group both pre- and post-operatively, and insufficient follow-up time and the number of cases in the groups.

In conclusion, most studies performing pre- and post-op evaluations of patients undergoing TKA have reported a reduced risk of falling after surgery. In our study, we compared the risk of falling in patients with TKA and patients with end-stage primary gonarthrosis and found that all parameters, were more favorable in the TKA group than in the control group. In line with previous studies, we found that TKA reduces pain, improves the quality of life and decreases fall risk and falling numbers for patients with end-stage primary gonarthrosis. In end-stage gonarthrosis patients who do not want TKA surgery, patients' balance and proprioception should be supported by physical therapy.

### Authors' contributions

NSG reviewed the patient records, posted the questionnaires and interviewed the patients. SS participated in the collection of patient data and interpretation of results and analyzed the data, and drafted the manuscript. NS participated in the planning and design of the study. AA participated in the data interpretation and critically revised the manuscript. All authors have read and approved the final manuscript.

### Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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