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Original Article

Can isokinetic test be a supportive tool for unilateral knee arthroplasty decision?

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ABSTRACT

Objectives: This study analyzed whether the isokinetic muscle strength of bilateral knee osteoarthritis patients undergoing unilateral total knee arthroplasty (TKA) is a predictor for prior surgery side.

Patients and methods: In the prospective study conducted between April 2021 and December 2021, 58 knees of 29 unilateral TKA candidates (6 males, 23 females; mean age: 66.7±7.4 years; range, 53 to 81 years) were enrolled. The patients were divided into surgical (n=29)and nonsurgical (n=29) groups. The knees of patients with bilateral knee osteoarthritis (Stage III or IV) according to the Kellgren-Lawrence (KL) scale were scheduled for unilateral TKA. An isokinetic testing system was used to assess knee flexor and extensor muscle strength (peak torque) at angular velocities of 60°/sec and 180°/sec (five cycles per velocity). The radiological (X-ray-based KL scale and magnetic resonance imaging-based quadriceps angle) and clinical findings (isokinetic test and Visual Analog Scale pain scores) in both groups were compared.

Results: The mean symptom duration was 10±5.4 years. The KL score and quadriceps angle showed no significant differences (p=0.056 and p=0.663, respectively). Isokinetic test results were in accordance with the clinical results of the surgery group. In the isokinetic evaluation, both the 60°/sec concentric extension (35.00 *vs.* 46.00, p=0.002) and flexion peak torque (18.00 *vs.* 26.00, p=0.001) values were significantly lower in the surgical group than in the nonsurgical group.

Conclusion: Isokinetic testing can be a supportive tool for assessing the prior side of TKA in patients with bilateral knee osteoarthritis. Further studies are required to support these findings.

Keywords: Arthroplasty, knee, muscle strength dynamometer.

Total knee arthroplasty (TKA) is an elective surgical procedure for patients with symptomatic advanced osteoarthritis (OA) of the medial tibiofemoral, lateral tibiofemoral, and patellofemoral knee compartments.[1-6] The only published indications for TKA are those of the American Academy of Orthopedic Surgeons, which developed appropriate use criteria for the surgical treatment of knee OA. These indications include the functional limitations of the patient, pain, the range of motion, instability, the imaging findings of the joint space in the most affected compartment, extremity alignment, other symptoms compatible with meniscal tears or loose bodies, and age.[1,2,5,6] Surprisingly, quantitative clinical indications for TKA are lacking.

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Therefore, orthopedic surgeons tend to have differing opinions regarding the need for TKA.[7-9]

To the best of our knowledge, no studies have evaluated the value of isokinetic knee muscle strength test results as an indicator of TKA. Therefore, this study analyzed the relationship between isokinetic muscle strength, radiological parameters, and clinical parameters in unilateral TKA patients. We hypothesized that isokinetic muscle strength testing may be a supportive tool for assessing the prior side of TKA in patients with bilateral advanced knee OA in this patient cohort.

PATIENTS AND METHODS

Fifty-eight knees of 29 unilateral TKA candidates (6 males, 23 females; mean age: 66.7±7.4 years; range, 53 to 81 years) were included in this prospective study conducted at the Memorial Şişli Hospital between April 2021 and December 2021. All patients had radiographic evidence of advanced (Kellgren-Lawrence Stage III or IV) bilateral knee OA. Knees were divided into surgical (n=29) and nonsurgical (n=29) groups. The knee with pain was selected for surgery based on the decision of the orthopedist and included in the study. Patients with any neurological or rheumatological disease that could affect knee muscle strength or a Kellgren-Lawrence stage below III for a nonsurgical knee and those scheduled for bilateral TKA were excluded. The demographic data of patients were recorded.

In this study, both knees of the patients underwent isokinetic muscle testing before surgery using the Cybex Norm, CSMi (Computer Sports Medicine, Inc., MA, USA). The peak torque (PT) of the bilateral knee flexors and extensors were tested.[10,11] Tests were performed under the guidance of a rehabilitation medicine specialist, and the system was calibrated prior to their commencement. The patients were seated in upright position and were fixed with pelvic and thigh belts. Concentric extension peak torque (EPT) and concentric flexion peak torque (FPT) were measured between the 0° and 90° knee ranges at angular velocities of 60°/sec and 180°/sec (60° EPT, 60° FPT, 180° EPT, and 180° FPT, respectively). The tests were repeated five times at each velocity, and the highest PTs were selected for statistical analysis. The participants performed repeated trials before sets, while a 20-sec rest was provided between sets. The measured muscle contraction variables included the total extensor and flexor PTs, which were compared between groups. Vocal encouragement was provided during the tests.

For radiological evaluation, the X-ray-based Kellgren-Lawrence grade and magnetic resonance imaging-based quadriceps angle (Q-angle) were used.[12-14] The Visual Analog Scale (VAS) pain score of each individual was also recorded.

Statistical analysis

Based on 95% power, 5% alpha level, effect size of 1.1, and a t-test model, a minimum sample size of 11 participants was calculated for each group by the

TABLE 1
Baseline demographics of TKA candidates

Baseline characteristics	n	%	Mean±SD
Age (year)			66.7±7.4
Symptom duration (year)			10.0±5.4
Height (cm)			159.6±5.7
Weight (kg)			84.7±11.9
Body mass index (kg/m^2)			33.2±4.2
Dominant side			
Right dominant	27	93.1	
Left dominant	2	6.9	
Chronic disease			
HT	10	34.5	
HT + diabetes	1	3.4	
HT + goiter + CAD	1	3.4	
CAD + BPH	1	3.4	

TKA: Total knee arthroplasty; SD: Standard deviation; HT: Hypertension; CAD: Coronary artery disease; BPH: Benign prostatic hyperplasia.

TABLE 2
The comparison of VAS, isokinetic testing, and radiological parameters of the TKA surgery indicated knee group and the nonsurgical knee group

	Surgery indicated knee group			Non-surgical knee group			
Assessment	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	*p*
VAS	7.6±1.0			4.2±1.2			**<0.001***
Radiological evaluation-X-ray based K-L	3.9±0.4			3.7±0.5			0.056*
Radiological evaluation-MRI based Q angle	13.3±2.2			13.5±1.5			0.663*
Isokinetic evaluation- 60 EPT		35.00	12.00-83.00		46.00	16.00-99.00	**0.002****
Isokinetic evaluation- 60 FPT		18.00	1.00-45.00		26.00	9.00-50.00	**0.001****
Isokinetic evaluation- 180 EPT		23.00	9.00-46.00		26.00	0.00-60.00	0.089**
Isokinetic evaluation- 180 FPT		12.00	3.00-23.00		14.00	0.00-27.00	0.052**

VAS: Visual analog scale; TKA: Total knee arthroplasty; SD: Standard deviation; K-L: Kellgren-Lawrence; MRI: Magnetic resonance imaging; Q-angle: Quadriceps angle; EPT: Extension peak torque; FPT: Flexion peak torque; IQR: Interquartile range; * Paired samples t-test; ** Wilcoxon signed-rank test.

G*Power version 3.1.9.6 software (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany). The sample size was chosen to be 29 participants to replace any missing data.

All data were analyzed by the PSPP (GNU General Public License version 3. Descriptive statistics (frequency distributions, percentages, mean, standard deviations, median, minimum, and maximum) were generated, and the Kolmogorov-Smirnov test (normality of the distribution), paired samples t-test, and Wilcoxon signed-rank test were used as appropriate. Receiver operating characteristic (ROC) curve analysis was used to validate the isokinetic test results.[15] The level of statistical significance was set at $p<0.05$.

RESULTS

The mean symptom duration was 10.0±5.4 years (Table 1). In the initial clinical evaluation, the VAS score was significantly higher in the surgical group than in the nonsurgical group (7.59±0.98 *vs.* 4.21±1.15, $p<0.001$, Table 2).

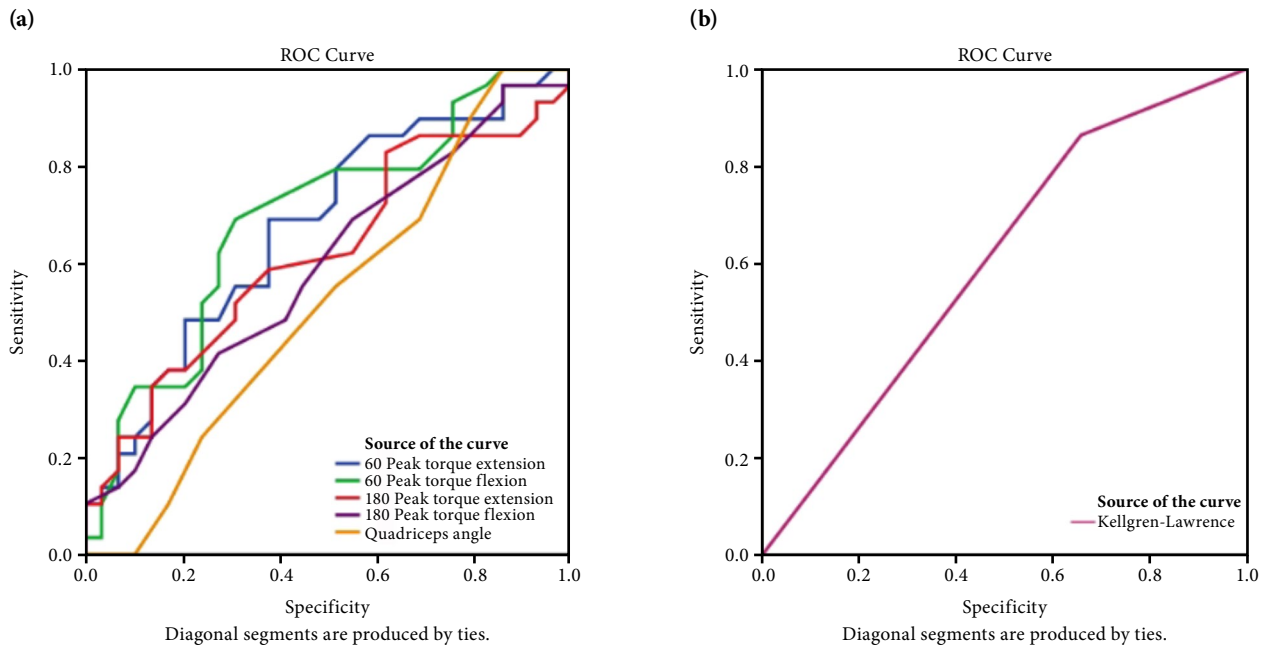

Figure 1. Receiver operating characteristic curve of isokinetic testing and radiological parameters. **(a)** State variable: Nonsurgical knee group. **(b)** State variable: Surgical knee group.

TABLE 3
The area under ROC curve values of isokinetic evaluation and radiological evaluation

Test result variable(s)	AUC±SD	*p*	95% CI (lower-upper)
Isokinetic evaluation-60 EPT NS	0.671±0.071	0.025	0.532-0.811
Isokinetic evaluation-60 FPT NS	0.690±0.07	0.013	0.552-0.828
Isokinetic evaluation-180 EPT NS	0.616±0.075	0.129	0.47-0.762
Isokinetic evaluation-180 FPT NS	0.590±0.075	0.240	0.443-0.737
Radiological evaluation-X-ray based K-L^{S}	0.603±0.75	0.176	0.457-0.750
Radiological evaluation-MRI based Q angle^{NS}	0.517±0.077	0.822	0.366-0.668

ROC: Receiver operating characteristic; AUC: Area under the curve; SD: Standard deviation; CI: Confidence interval; EPT: Extension peak torque; FPT: Flexion peak torque; NS: State variable/nonsurgical knee group; KL: Kellgren-Lawrence; MRI: Magnetic resonance imaging; Q-angle: Quadriceps angle; S: State variable/surgical knee group.

In the isokinetic evaluation, both 60° EPT (35.00 *vs.* 46.00, p=0.002) and 60° FPT (18.00 *vs.* 26.00, p=0.001) were significantly lower in the surgical group than the nonsurgical group. However, 180° EPT (23.00 *vs.* 26.00, p=0.089) and 180 FPT (12.00 *vs.* 14.00, p=0.052) did not differ significantly between the surgical and nonsurgical groups. Table 2 shows the results of isokinetic evaluation.

The radiological outcomes, the Kellgren-Lawrence score (3.86±0.35 *vs.* 3.66±0.48, p=0.056) and the Q-angle (13.34±2.18 *vs.* 13.48±1.50, p=0.663), did not differ significantly between the surgical and nonsurgical groups. The outcomes are summarized in Table 2.

The area under the ROC curve provides a measure of discrimination; the AUCs (state variable: Nonsurgical knee group) for EPT and 60° FPT, indicating the need for surgery in advanced OA cases, were 0.671 (p=0.025) and 0.690 (p=0.013), respectively (Figure 1 and Table 3).

DISCUSSION

This study found that isokinetic knee flexion and extension strengths were significantly lower in knees requiring surgery than in nonsurgical knees. The radiological findings, the Kellgren-Lawrence score and Q-angle, did not differ significantly between the groups. The results of the isokinetic tests were correlated with the clinical parameters of the surgically treated knees. This suggests that while radiographic and clinical parameters can be used to determine TKA candidates, isokinetic measures may be useful for deciding whether patients with end-stage knee OA should undergo elective TKA.

It is desirable to assess muscle strength and physical function before and after surgical interventions. Isokinetic knee flexion, extension strength, and endurance can be measured using isokinetic test systems.[10,11,16] Using isokinetic tests, Berman et al.[17] identified marked preoperative muscular deficits in both flexion and extension in the knees of 68 patients with degenerative joint disease who were scheduled for unilateral TKA. Similarly, in our study, knee flexor and extensor strength decreased significantly in TKA candidate knees based on 60° EPT and 60° FTP, respectively.

In a recent study of 300 patients with knee OA, Klasan et al.[18] concluded that the proportion of knees considered as TKA candidates was inflated when the assessment was based only on radiological parameters. We showed that the radiological parameters were similar between surgical and nonsurgical knees, whereas the isokinetic scores differed significantly. We think that isokinetic muscle testing can be an important objective measure to improve the accuracy of the TKA candidate selection besides other clinical parameters. Despite the interest in TKA screening tools, there is limited evidence of their usefulness.[19] Our study supports the use of isokinetic muscle testing with other clinical parameters to optimize patient selection for TKA.

Using isokinetic tests, Wang et al.[20] investigated the changes in muscle strength before and after knee replacement in 200 patients with advanced knee OA undergoing TKA. Isokinetic muscle strength was tested one, three, and six months before and after the operation. They concluded that knee muscle strength and function improved significantly after TKA compared to preoperative function and advocated that these tests be performed in cases of knee OA. This study also supports the importance of isokinetic tests for deciding TKA as they are easy to use, accurate, and safe. Cavanellas et al.[21] compared

quadriceps and hamstring strength in patients with knee OA before and after TKA using the CSMI HUMAC NORM instrument. They noted reduced quadriceps and hamstring strength in patients with more advanced OA, even after knee replacement. In this study, although both knees of the patients were in advanced stages of OA, the isokinetic muscle strength scores were lower in the knees selected for surgery; the weakness of the muscles increased the severity of symptoms and informed the decision to operate.

In the current American Physical Therapy Association guidelines, knee OA, which often leads to elective TKA surgery, is ranked as the 11th leading cause of disability among almost 300 health conditions.[22] The isokinetic evaluations in our study revealed that the candidates for surgery were significantly weaker than those with nonsurgical knees. One of the clinical criteria in determining the knee that will go to surgery is pain, but this criterion needs some supportive objective measures in bilateral knee patients to select the priority for the surgical side. However, while pain was present in both the tests performed at 180° and 60° during the isokinetic test, the strength difference was only significant at high resistance velocities (60° EPT and FPT, but not 180° EPT and FPT). This means that the resulting weakness in muscle strength may not occur while the patient is carrying out activities of daily living, except for strenuous activities. Therefore, it was stated that the isokinetic test can be considered a clinical supportive criterion for the surgical side selection. Whether or not isokinetic testing is used to evaluate muscle strength before surgery or to make a decision for surgery, the main point is the detection of muscle weakness, objective documentation of the situation, and accurate follow-up of the progression.

This study has some limitations. First, although the radiological stage was the same, the more painful knee was selected for surgery. The lower PTs may be due to pain, fatigue, or prolonged immobilization and may result in a decrease in isokinetic muscle testing. This limitation also suggests that if the patients selected for surgery can be included in an isokinetic test and exercise program before the operation, the clinical symptoms can be decreased, and functional recovery after surgery can be faster. Furthermore, postsurgical outcomes were not evaluated, and it remains unclear whether isokinetic testing improves these outcomes. Finally, the small sample size is a major limitation of our study.

In conclusion, isokinetic muscle testing may provide valuable information regarding the need for knee arthroplasty in patients with advanced bilateral knee OA and can be a supportive tool for assessing the prior side of TKA. We suggest that screening for potential TKA candidates include isokinetic muscle tests. In addition to subjective clinical parameters, objective isokinetic muscle test findings can inform the decision to perform TKA in knees with advanced OA, and it can be an important guide to the rehabilitation program planned after the surgery. However, further studies are required to support this finding.

Ethics Committee Approval: The study protocol was approved by the Istanbul Medipol University Ethics Committee (date: 05.04.2021, no: E-10840098-772.02-1615). 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.

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