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Perceived Instability Is Associated With Strength and Pain, Not Frontal Knee Laxity, in Patients With Advanced Knee Osteoarthritis

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Abstract

BACKGROUND: Increased varus/valgus laxity and perceived knee instability are independently associated with poor outcomes in people with knee osteoarthritis. However, the relationship between laxity and perceived instability is unclear.

OBJECTIVE: To assess whether knee extensor strength, pain, and knee laxity are related to perceived knee instability in patients with advanced knee osteoarthritis.

METHODS: This was a secondary analysis of a prospective observational cohort study of 35 patients (24 female; mean $\pm$ SD age, 60 $\pm$ 8 years; body mass index, 33 $\pm$ 5 kg/m²) with knee osteoarthritis awaiting total knee arthroplasty (36 knees). Within 1 month before arthroplasty, we measured isometric knee extension strength and self-reported knee pain (using the Knee Injury and Osteoarthritis Outcome Score pain subscale). Patients rated their perception of knee instability as moderate to severe (n = 20) or slight to none (n = 15 patients, n = 16 knees) using the Knee Outcome Survey. We measured intraoperative varus/valgus knee laxity.

RESULTS: Lower knee extension strength ($P = .01$) and greater pain ($P < .01$) were associated with the perception of moderate to severe knee instability. Laxity was not related to perceived knee instability ($P = .63$).

CONCLUSION: Knee extension strength and pain were associated with perceived instability in people with advanced osteoarthritis. Varus/valgus laxity was not related to perceived knee instability.

Keywords

arthroplasty; function; KOOS; operative

Over 250 million people worldwide live with knee osteoarthritis.²⁶ Up to half have activity limitations, such as decreased mobility at home and in the community.³ People with knee osteoarthritis are often challenged by muscle weakness,¹⁵ perceived instability,^{8,19} increased pain,¹² and reduced function.¹¹

Increased varus/valgus laxity is common in patients with knee osteoarthritis.^{15,19,23} Altered knee motion associated with knee laxity is hypothesized to contribute to development and progression of osteoarthritis.^{1,4} There is a biological rationale for a relationship between varus/valgus motion and functional joint instability. However, the relationship between knee laxity and perceived instability is uncertain.^{9,10}

Measures of knee laxity may be affected by the measurement tool used and by guarding in patients who may fear discomfort or pain.¹⁰ Recording passive knee laxity under anesthesia may be a way to overcome measurement challenges⁹ and accurately quantify the relationship of static knee laxity to knee symptoms (eg, perceived instability).

Recent studies have focused on evaluating the relationship between knee laxity and the development and progression of osteoarthritis.¹ Another relevant clinical question is, what factors influence patients' perceptions of knee instability?⁸ The purpose of this secondary analysis⁹ was to assess whether knee extensor strength, varus/valgus laxity, and pain were related to patients' perceptions of knee instability in people awaiting total knee arthroplasty (TKA).

METHODS

Thirty-nine participants (40 knees; 33 participants from Freisinger et al⁹) were recruited by orthopaedic surgeons at The Ohio State University and participated after providing Institutional Review Board–approved consent. We aimed to enroll 42 participants to examine the relationships between intraoperative, functional, and patient-reported measures before and after TKA.

Participants had been diagnosed with predominantly medial-compartment tibiofemoral osteoarthritis and were scheduled for primary TKA within 30 days. We excluded patients with a body mass index greater than 45 kg/m², those who were unable to walk 10 m unaided, and those with predominantly lateral-compartment osteoarthritis or revision TKA, because the influence of surgical technique on TKA outcomes was the parent study's primary focus. Four participants were excluded due to sterilization error, prohibiting intraoperative data collection (n = 2), or technical difficulties during preoperative testing, resulting in no available strength data (n = 2).

The clinical assessment, self-reported measures, and intraoperative laxity measurement methods are described in detail in a previous publication.⁹ We measured isometric knee extensor strength during a maximal voluntary isometric contraction in a seated upright position, with the knee held at 60° of flexion (System 3; Biodex Medical Systems, Shirley, NY). We normalized the average peak torque from 2 trials by body mass (Newton meters per kilogram). To assess perceived knee instability, we used a question from the Knee Outcome Survey-Activities of Daily Living scale¹³: “To what degree does giving way, buckling, or shifting of the knee affect your daily activity?” Respondents rated their instability on a scale ranging from 0 to 5, with 0 as preventing all activity, 1 as affecting activity severely, 2 as affecting activity moderately, 3 as affecting activity slightly, 4 as not affecting activity, and 5 as no instability. We dichotomized scores of 0 to 2 as a moderate or severe effect on activity and scores of 3 to 5 as slight or no effect on activity. We assessed pain using the pain subscale of the Knee injury and Osteoarthritis Outcome Score (KOOS),¹⁷ where a higher score reflected less pain.

We measured intraoperative varus/valgus knee laxity after exposing the distal femur and proximal tibia, but prior to any bone, ligament, or meniscal alterations associated with performing a standard TKA. Kinematics were collected with retroreflective marker clusters rigidly attached to the distal femur and proximal tibia with cortical bone screws.^{9,24} Using a custom testing device,²⁴ the surgeon applied varus and valgus torques with the knee fully extended, and the resulting varus and valgus motions and torques were recorded without any feedback provided to the surgeon. The combined varus/valgus range of motion under ± 10 Nm of torque was calculated as the varus/valgus laxity. Surgeons were blind to strength, laxity, and other clinical data.

We used 2-sample Student *t* tests to compare knee extension strength, varus/valgus laxity, and KOOS pain scores between patients who reported moderate to severe knee instability and patients who reported slight to no knee instability. We used backward selection binary logistic regression to identify predictor variables that were significantly associated with the dichotomous perceived knee instability outcome variable. We initially included knee extension strength, varus/valgus laxity, and KOOS pain scores, plus all 2-way interaction terms, as continuous candidate variables for the backward selection process. Statistical analyses were performed in Minitab 17 (Minitab, LLC, State College, PA).

RESULTS

The study included 35 participants (36 knees) (TABLE 1). Clinical assessments and self-report measures were completed a median of 16 days prior to surgery (interquartile range, 28 days; range, 2–117 days). Of 35 participants, 20 reported moderate or severe perceived instability and 15 (16 knees) reported slight to no perceived instability (FIGURE 1). There was no difference in varus/valgus knee laxity between those who did and did not report instability. Patients who reported moderate or severe instability were weaker and reported more pain than those who reported slight or no instability (TABLE 2).

The final binary logistic regression model included knee extension isometric peak torque ($\beta = 13.5$ Nm/kg, $P = .010$), KOOS pain ($\beta = 0.323$, $P = .006$), and the interaction between

knee extension maximal voluntary isometric contraction and KOOS pain ($\beta = -0.215$, $P = .031$). Varus/valgus laxity was not associated with perceived knee instability ($P > .25$). FIGURE 2 shows the distributions of KOOS pain, varus/valgus laxity, and knee extension strength.

DISCUSSION

Among patients with symptomatic knee osteoarthritis, knee extensor weakness and limitations due to knee pain were associated with a greater likelihood of perceiving moderate to severe knee instability. Varus/valgus laxity was not associated with perceived knee instability.

These results may support knee extensor strength training as a focus of treatment for patients with symptomatic knee osteoarthritis. Participants had inferior knee extension strength relative to age-matched controls.² However, participants with stronger quadriceps may have greater ability to develop a neuromuscular control strategy to stabilize the knee, even in the presence of lax passive restraints. For individuals who perceive excessive tibiofemoral motion as instability, activating the quadriceps could lessen excessive frontal plane motion because the line of action of the quadriceps-patella-patellar tendon complex has a moment arm that acts to resist opening of the lateral compartment.¹⁸ Our previous results are consistent with this theory, as greater varus/valgus laxity was associated with greater knee extension strength.⁹ Muscle-related dynamic stabilization is possible in knees with high laxity, though using the quadriceps as a dynamic stabilizer does result in higher joint reaction forces and a higher risk of osteoarthritis progression.²²

While greater passive laxity could theoretically lead to a greater likelihood of “giving way, buckling, or shifting of the knee,”¹³ perceived as an unstable joint, no such relationship has been observed in individuals with either mild to moderate osteoarthritis²⁰ or end-stage osteoarthritis.⁹ Many factors potentially influence the perception of instability in individuals with knee osteoarthritis. Pain and arthrogenic inhibition,¹⁶ followed by inadequate eccentric quadriceps activation, may contribute to a giving-way or buckling sensation. Therefore, our finding of a relationship between pain and perceived instability might warrant further study.

The significant positive interaction coefficient between pain and strength suggests that together, they do more than the sum of their parts in contributing to a perception of instability. Because we only collected data at 1 time point, we cannot determine whether strength training could have reduced pain or reduced perceived instability. However, a dual focus on treating weakness and pain may be beneficial. Addressing knee instability through a comprehensive treatment approach that targets muscle strength, pain, and sensory deficits (such as proprioception and vibratory acuity), with a focus on neuromuscular and stabilization training, may promote favorable outcomes.^{5–7,14,21} However, controlled trials are needed to inform intervention development.

Limitations

Due to large variances, we could not perform subgroup analyses of strength or pain. The desired sample size for the study ($n = 42$) was chosen a priori by identifying correlations

between intraoperative and functional measures, not for the secondary subgroup analyses mentioned here. The decision to perform TKA was made between patient and clinician, and thus presents a risk of selection bias. Osteoarthritis severity was based on the patient's and clinician's judgment. Therefore, our results may not apply to all patients with knee osteoarthritis.

Certain characteristics of end-stage disease, such as the presence of osteophytes, could have influenced perceptions of instability. The use of passive varus/valgus laxity under anesthesia also limits the applicability of the results to all patients with knee osteoarthritis, or to other forms of laxity. Passive laxity was only measured at full extension due to time limitations. Perceived instability could be related to laxity of the joint at other flexion angles. We included a greater proportion of women—who have greater varus/valgus laxity—than men.^{10,23,25}

Perceived instability was only assessed by a single item from the Knee Outcome Survey. While this approach was consistent with our previous work examining instability in patients with medial knee osteoarthritis,^{19,20} other assessments of perceived instability may result in different relationships to laxity, strength, and pain. With the exception of sample size, these limitations are unlikely to have significantly affected the internal validity of the study, because these participants are representative of people living with significant pain and physical limitations due to knee osteoarthritis.

CONCLUSION

Knee extension strength and pain were independently associated with perceived instability in people awaiting TKA. There was no relationship between varus/valgus laxity and perceived instability.

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KEY POINTS**FINDINGS:**

Knee extension strength and pain were associated with perceived knee instability in people awaiting total knee arthroplasty. Varus/valgus laxity measured under anesthesia was not associated with perceived instability. Weakness and pain significantly interacted in their association with perceived instability.

IMPLICATIONS:

An intervention that focuses on both strengthening and pain reduction may improve perceived instability in individuals with advanced osteoarthritis.

CAUTION:

The study sample included patients with advanced osteoarthritis; therefore, the findings are not generalizable to individuals with other conditions or with osteoarthritis at other levels of severity.

FIGURE 1.

Distribution of perceived instability among the participants in the study, based on the response to the question, “To what degree does giving way, buckling, or shifting of the knee affect your daily activity?” from the Knee Outcome Survey.¹³ A score of 0 indicated that instability prevented all activity, 1 indicated that instability affected activity severely, 2 indicated that instability affected activity moderately, 3 indicated that instability affected activity slightly, 4 indicated that instability did not affect activity, and 5 indicated no instability. Scores on the Knee Outcome Survey instability question were then grouped into 2 categories: those who perceived a moderate or severe effect on activity (0, 1, or 2; n = 20 knees) and those who perceived a slight or no effect on activity (3, 4, or 5; n = 16 knees).

FIGURE 2.

Self-reported pain as indicated by the (A) KOOS¹⁷ pain subscale (higher values indicate less pain) and (B) varus/valgus laxity with the knee fully extended and ± 10 Nm of torque applied under anesthesia, versus normalized knee extension maximum voluntary isometric contraction of the involved limb. Orange squares indicate participants who reported slight to no perceived instability, and blue circles indicate participants who reported moderate to severe perceived instability. Abbreviation: KOOS, Knee injury and Osteoarthritis Outcome Score.

TABLE 1

Demographics of Involved Knees of Study Participants

Characteristic	Value*
Sex, n	
Female	24
Male	11
Age, y	59.9 ± 8.0
Body mass, kg	92.2 ± 15.8
Height, m	1.67 ± 0.10
Perceived instability (IKOS)	2.4 ± 1.2
Varus/valgus laxity, deg	5.4 ± 3.0
Knee extension strength, Nm/kg	1.00 ± 0.44

Abbreviation: IKOS, Knee Outcome Survey instability question.

* Values are mean ± SD unless otherwise indicated.

TABLE 2

Group Differences, Univariate Test Results, and Binary Logistic Regression Model for Knee Extension MVIC, Varus/Valgus Laxity, and the KOOS Pain Subscale*

	Moderate to Severe [†]	Slight to None [‡]	Univariate Student <i>t</i> Test <i>P</i> Value	Binary Logistic Regression	
				Coefficient (SE)	<i>P</i> Value
KOOS pain (0–100)	38.6 ± 16.4	59.9 ± 17.8	.001	0.323 (0.162)	.006
Knee extension MVIC, Nm/kg	0.79 ± 0.42	1.26 ± 0.33	.001	13.54 (6.73)	.01
Varus/valgus laxity, deg	4.9 ± 3.1	6.0 ± 2.9	.310	NA	NA
Knee extension MVIC-KOOS pain interaction	NA	NA	NA	−0.215 (0.120)	.031

Abbreviations: KOOS, Knee injury and Osteoarthritis Outcome Score; MVIC, maximum voluntary isometric contraction; NA, not applicable; SE, standard error.

* Values are mean ± SD unless otherwise indicated.

[†] Scores of 0 to 2 on the Knee Outcome Survey instability question.

[‡] Scores of 3 to 5 on the Knee Outcome Survey instability question.