

Low ceiling effect of Forgotten-Joint Score 12 after anterior cruciate ligament reconstruction: A longitudinal retrospective study

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Research Article

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Abstract

Background: Conventional patient-reported outcome measures (PROMs) are crucial for postoperative evaluation following anterior cruciate ligament reconstruction (ACLR); however, a disadvantage is their high ceiling effect. In contrast, Forgotten Joint Score-12 (FJS) is used for postoperative evaluation after total joint arthroplasty and has a low ceiling effect. We aimed to assess the ceiling effect in FJS, Knee Injury and Osteoarthritis Outcome Score (KOOS), and Lysholm Knee Score (LKS) at 1 and 2 years after ACLR and to predict the factors influencing FJS in the first postoperative year.

Methods: This retrospective observational study included 47 patients who underwent double-bundle primary ACLR. We surveyed the demographic characteristics of the patients and the side-to-side difference of tibial anterior translation and limb symmetry index of the single-leg hop test (SLH-LSI) at 1 year postoperatively. Additionally, we collected the FJS, KOOS, and LKS scores at 1 and 2 years postoperatively using identical predetermined questionnaires. We compared the FJS scores at 1 and 2 years postoperatively using paired t-tests and calculated the ceiling effects of the FJS, KOOS, and LKS scores. In addition, multiple linear regression analysis was performed to predict the factors influencing the FJS score 1 year postoperatively.

Results: The participants included 32 women and 15 men (mean age, 27.2 years; mean body mass index, 22.8 kg/m²). The mean FJS scores at 1 and 2 years postoperatively were 85.0 ± 18.1 and 89.8 ± 13.1, respectively, and had no significant differences ($p = 0.06$). The ceiling effects for the FJS, KOOS, and LKS scores at 1 year postoperatively were 23.4%, 34.0%, and 29.8%, and 36.2%, 43.8%, and 42.6% at 2 years postoperatively. The SLH-LSI score affected the FJS 1 year postoperatively (estimated coefficient 38.183, $p < 0.05$).

Conclusions: The ceiling effect of FJS on ACLR up to 2 years tended to be lower than that of KOOS and LKS. Knee function related to the FJS was similar to that of other PROMs. The FJS may also be useful for assessing the short clinical course after ACLR.

Background

Anterior cruciate ligament (ACL) injury is a common sports injury typically treated with ACL reconstruction (ACLR) surgery. Of professional athletes, 78–98% can return to their pre-injury sports level within 1 year after ACLR surgery, and the post-ACLR outcome is considered good [1]. To assess the clinical course after ACLR surgery, different evaluation methods have been reported [2–4]. Some researchers have evaluated the differences in the side-to-side anterior translation of the tibia to assess knee joint stability. A difference of 5 mm or more from the uninjured side is considered a failure of anterior tibial stability [5]. In contrast, a weak association between anterior stability and the ability to return to athletic activities has been documented [6]. Other researchers have reported a relationship between the hop test and clinical results after ACLR. A cohort study reported that single-leg hop tests

conducted 6 months after ACLR could predict patient-reported outcome measures (PROMs) 1 year after ACLR [4]. Biomechanical evaluation is an important aspect of the clinical outcomes of ACLR.

PROM is also important for evaluating postoperative clinical results. The Knee Injury and Osteoarthritis Outcome Score (KOOS) and Lysholm Knee Scoring Scale (LKS) are the two most commonly used clinical evaluation tools for knee disorders [7]. Numerous authors have examined clinical outcomes after ACLR using KOOS and LKS and reported favorable results [3, 8]. In addition, the KOOS can assess functional limitations of the knee joint in sports and daily activities. KOOS scores are associated with functional assessments after ACLR, such as the HOP test and the ability to return to sports [4]. However, KOOS and LKS have a high ceiling effect in post-ACLR procedure assessments and do not accurately reflect functional improvement over time [9–11]. Therefore, a longitudinal evaluation using PROMs with low ceiling effects is necessary.

The Forgotten Joint Score-12 (FJS) was developed by Behrend et al. in 2012 for clinical evaluation after arthroplasty [12]. The FJS consists of 12 questions regarding knee joint awareness during daily activities to achieve a “forgotten knee” after surgery and is considered an evaluation method after total knee arthroplasty with a low ceiling effect [13]. However, few studies have utilized FJS as an evaluation method after ACLR, particularly those that follow changes over time [2, 14].

This study aimed to assess the FJS after ACLR at 1 and 2 years postoperatively and compare the ceiling effects of the FJS with those of the KOOS and LKS. We also investigated the predictive factors for the FJS 1 year after ACLR. We hypothesized that FJS would have a lower ceiling effect than that of KOOS and LKS if used to evaluate short-term clinical results in ACLR.

Methods

This study was a retrospective, observational, two-center examination of postoperative patients utilizing existing data and a questionnaire-based survey. We included patients who underwent primary ACLR using a standardized surgical technique between August 2017 and June 2020 at a university and affiliated hospitals. We excluded patients with multiple ligament injuries, a second ACL injury within 2 years, and deficiencies in data (Figure 1.).

The ethics committee of the institution approved the study (M10379) and all data were collected anonymously to prevent further treatment of specific patients. The use of anonymous data waived the need for informed consent from the patients. This study was conducted following the STROBE guidelines.

[Surgical Techniques]

All the patients underwent anatomical double-bundle reconstruction using hamstring autografts and fixation devices: TightRope-RT (Arthrex, Naples, Florida, USA) or Ultrabutton (Smith and Nephew, Andover, Massachusetts, USA) on the femoral side and 1.3 mm TapeLoop (Arthrex, Naples, Florida, USA) on the

tibial side. The hamstring tendon was harvested after arthroscopic examination of the anteromedial and anterolateral portals. A bone tunnel was created in the anatomical position. Two guidewires were inserted from outside the lateral cortex of the femur to the footprints of the anteromedial (AM) and posterolateral (PL) bundles of the ACL using the ACL femoral drill guide. Initially, the ACL guide was set to 100° to insert the guidewire into the AM position, and subsequently, the drill guide was adjusted to 95° to insert the guidewire into the PL position. After confirming that the two tips of the wires were placed in the desired positions, two bone tunnels were drilled over the guidewires from outside the lateral femoral cortex to allow the passage of a retrograde drill to create sockets of 21 mm in length. The tibial tunnel was established by adjusting the ACL tibial drill guide to 60° to create the anteromedial tunnel and 55° to form the posterolateral tunnel [15, 16]. After passing the graft, the knee joint was pre-tensioned by flexing the knee 10 times from 0° to 90°, while applying manual tensile force [17]. The anteromedial bundle was affixed at 20° of knee flexion, whereas the posterolateral bundle was secured in full extension by applying a traction force of 40 N onto the transplanted tendon. The tibial aspect of the graft was fixed using TensionLoc (Arthrex, Naples, Florida, USA).

[Rehabilitation Protocol]

All the patients underwent an identical postoperative rehabilitation protocol. Static quadriceps strengthening exercises were initiated immediately after surgery. Weight-bearing was limited to 30 kg for the first 2 weeks postoperatively and was unrestricted at 3 weeks post-surgery. The range of motion of the knee joint was restricted from 0° to 90° for 4 weeks postoperatively. Jogging was initiated 3 months postoperatively, and sports training was progressively resumed starting 7 months postoperatively to return to sports activities within 10 months.

[Data collection]

The following demographic data were extracted from electronic medical records: age, sex, and body mass index (BMI). At 1 year postoperatively, orthopedic experts specialized in knee assessed knee stability, such as the side-to-side difference in anterior tibial translation measured using KS Measure (NipponSigmaCo, Tokyo, Japan) in an outpatient awake state and the limb symmetry index of the single-legged hop test (SLH-LSI) [18]. The FJS, KOOS, and LKS were surveyed 1 and 2 years postoperatively using identical predetermined questionnaires.

[Statistical Analysis]

Summary statistics for each variable were created using frequencies and proportions for categorical data, and means and standard deviations (SDs) for continuous variables. To evaluate temporal changes in PROMs, we compared the mean FJS, KOOS, and LKS scores 1 and 2 years postoperatively using a paired t-test. In addition, the ceiling effect of each PROM was calculated at 1 and 2 years postoperatively. To identify factors affecting the FJS at 1 year postoperatively, multivariate linear regression analysis was performed with age, BMI, side-to-side differences in anterior tibial translation, and SLH-LSI score. The variance inflation factor was < 4 for all variables, and no collinearity was detected for each variable.

Correlation analyses with the KOOS and LKS and calculation of Cronbach's alpha coefficients were conducted to validate the FJS. Statistical analysis was performed using EZR R (version 4.1.2), and a p-value < 0.05 was considered statistically significant.

Results

A total of 97 patients underwent primary ACLR reconstruction. Patients with multiple ligament injuries (n = 3), a second ACL injury within 2 years (n = 4), and/or missing PROM data at 1 or 2 years or hop test data at 1 year postoperatively (n = 43) were excluded; thus, 47 patients were included in this study (Fig. 1).

[Participant Demographics]

Table 1 shows the demographic characteristics of the participants. Thirty-two participants were women, with an average age of 27.2 ± 10.8 years at surgery and a BMI of 22.8 ± 5.3 kg/m². Meniscal injuries requiring treatment were observed in 32 patients.

[FJS, KOOS, LKS]

Mean FJS at 1 and 2 years postoperatively was 85.0 ± 18.1 and 89.8 ± 13.1 , respectively. The FJS improved from the first to the second year; however, no significant difference was observed ($p = 0.06$). Only Question-12 items significantly improved from the first to second year postoperatively (1.72 ± 1.50 vs 1.13 ± 1.30 at 1 year vs. 2 years, respectively; $p < 0.01$). The other items tended to improve; however, no significant differences were observed (Table 2).

Table 3 shows the mean KOOS and LKS at 1 and 2 years postoperatively. Statistically significant improvements were observed from the first to the second year for both the KOOS and LKS.

[Ceiling effect]

The ceiling effect for the FJS was 23.4% at 1 year and 36.2% at 2 years postoperatively. The ceiling effect of KOOS was 26.5% for symptoms, 27.7% for pain, 51.1% for ADL, 21.3% for sports, and 25.5% for Quality of life (QOL) at 1 year postoperatively, and 44.7% for symptoms, 40.4% for pain, 59.6% for ADL, 36.2% for sports, and 31.9% for QOL at 2 years postoperatively. The ceiling effect of LKS was 29.8% at 1 year and 42.6% at 2 years postoperatively. The FJS had the lowest ceiling effect at both 1 and 2 years postoperatively.

[Factors Influencing FJS]

According to the multivariate linear regression analysis, the SLH-LSI score affected the FJS at 1 year postoperatively (estimated coefficient = 38.1, $T = 2.47$, $p < 0.05$) (Table 4).

[Validation]

Table 5 presents the validation analysis of the FJS 1 and 2 years after ACLR surgery. At both 1 and 2 years postoperatively, the FJS correlated with the KOOS subgroups and LKS.

As measured by Cronbach's alpha, the internal consistency was 0.88 for the first year and 0.91 for the second year postoperatively.

Discussion

The FJS is often used as a PROM to assess clinical results after total knee arthroplasty, and few studies have utilized the FJS as an evaluation method after ACLR. Previously, cross-sectional studies have been conducted to determine the FJS scores after ACLR.[2, 14, 19, 20] We assessed the time-dependent changes in the FJS up to 2 years postoperatively. The most important finding of our study was that the FJS score improved from the first to the second year and the ceiling effect of the FJS was lower than that of the other PROM at 1 and 2 years postoperatively. Our results suggest that the FJS may also be useful for assessing the short clinical course after ACLR.

We found that the FJS score was 85–89 up to 2 years after ACLR. The FJS is often used for clinical evaluation after total joint arthroplasty. The short-term FJS scores after total knee arthroplasty (TKA) were 51. However, few reports of FJS refer to ACLR. One cross-sectional study showed that the FJS scores in the ACLR from 3 to 7 years postoperatively were 70.1–71.6 [20]. FJS in mid- to long-term post-ACLR surgery has been reported to be around 20 points higher than that in post-TKA surgery; however, in the present study, it was even higher, at 85–89 points. In this study, we performed double-bundle reconstruction, surveyed early term after ACLR, and patients were younger than in the past study, so these factors may have influenced the clinical outcomes.

One observational study compared FJS to KOOS and LKS in mid- and long-term post-ACLR and showed a lower ceiling effect for FJS than for LKS [14]. Other cross-sectional observational studies after ACLR have also compared the FJS to the Tegner Activity Scale, KOOS, Western Ontario and McMaster Universities Osteoarthritis Index WOMAC , LKS, and International Knee Documentation Committee subjective knee scores and reported a ceiling effect lower than that for the LKS and WOMAC [2, 14, 19, 21]. A cohort study has reported the ceiling effect of FJS to be 3.9% at 1 year after TKA, and an observational study has reported it to be 8.4%–21.9% in the mid- to long-term after ACLR [13, 22]. A prospective study reported a ceiling effect of 9.3% for FJS at 2 years after ACLR surgery [21]. Here, we report a ceiling effect of 23.4% 1 year after ACLR. The ceiling effect of FJS in the short term after ACLR surgery appears to be similar to that in the mid- to long-term after ACLR surgery, but higher than that after TKA. We believe that the higher ceiling effect of the FJS in this study compared to previous prospective studies may be due to selection bias caused by high dropout rates. The present study also found a lower ceiling effect for FJS than for LKS at 1 and 2 years postoperatively. FJS has a lower ceiling effect than other PROMs in the short term after ACLR and may be useful for evaluation.

SLH-LSI has previously been reported as a factor influencing the return to sports after ACLR [23–25]. In a study involving patients who had not returned to their pre-injury sports level 1 year post-ACLR, SLH-LSI

was better in the group that returned to sports 2 years postoperatively [1]. In this study, patients with good SLH-LSI at 1 year postoperatively also had good FJS following other PROMs. The SLH-LSI can be used to measure dynamic stability and reflect the actual functional status of the knee of a patient. As such, the SLH-LSI has been reported to correlate with the LKS and KOOS, and the present study showed that it is also relevant to psychological assessments [11].

However, no correlation was found between the side-to-side differences in anterior tibial translation and FJS, which is consistent with the findings of previous studies comparing other PROMs and functions [3, 26, 27].

Our study is one of the few to investigate the association between ACLR and FJS. Furthermore, to the best of our knowledge, this is the first study to track the longitudinal changes in the FJS after ACLR. It must be noted that this study had some limitations, including a possible selection bias because of a high dropout rate during the follow-up, and a small sample size that does not show a statistically significant difference in improvement from the first to the second year postoperatively for the FJS. Further studies with larger patient sample sizes and longer follow-up periods are required to validate these findings.

Conclusions

The FJS improved over time, up to 2 years postoperatively, with a lower ceiling effect than that of the LKS. The SLH-LSI related to FJS was similar to that of the other PROM. Thus, the FJS may be useful for assessing the short clinical course after ACLR.

Abbreviations

ACL, anterior cruciate ligament

ACLR, anterior cruciate ligament reconstruction

AM, anteromedial

FJS, Forgotten Joint Score-12

KOOS, Knee Injury and Osteoarthritis Outcome Score

LKS, Lysholm Knee Score

SLH-LSI, limb symmetry index of the single-legged hop test

TKA, total knee arthroplasty

PROM, patient-reported outcome measures

PL, posterolateral

QOL, quality of life

SD, standard deviation

WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index

Declarations

Ethical approval and consent to participate: All methods were carried out in accordance with relevant guidelines and regulations. The Institutional Review Board of Chiba University approved (M10379) the research protocol for this retrospective study. Owing to the anonymous nature of the study and absence of any new data invasion, individual informed consent from the patients was not required.

Informed Consent: The need for informed consent was waived by Chiba University Hospital Observational Research Ethics Review Committee.

Consent for publication: Not applicable.

Availability of data and materials: The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Competing Interests: The authors declare that they have no competing interests.

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Authors' contribution: All authors contributed to the conception and design of the study. TS, RI, KT, and SW performed material preparation, data collection, and analysis. RA and TS performed the surgery and provided the data from the institution for analysis. TS wrote the first draft of the manuscript, and all authors commented on previous versions. MH, SK, SY, SO, and TS provided constructive comments and revised the manuscript. All authors read and approved the final version of the manuscript.

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Code availability: Not applicable

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Tables

Table 1: Demographics of participants.

Number	48
Sex	
Female	33 (70.2)
Male	15 (29.8)
Age (y)	27.2 ± 10.8
BMI (kg/m ²)	22.8 ± 5.3
Affected side	
Left	29 (61.7)
Right	19 (38.3)
Meniscus injuries requiring treatment	32 (68.1)

Data were represented as a number (prevalence) and mean ± standard deviation.

BMI: body mass index

Table 2: Mean and standard deviation of FJS score at 1 and 2 year after ACLR

Postoperative	1 year	2 year	<i>p</i> -value
Total FJS	85.0 ± 18.1	89.8 ± 13.1	0.06
Subscale			
FJS 1	0.28 ± 0.77	0.11 ± 0.37	0.12
FJS 2	0.47 ± 0.88	0.23 ± 0.67	0.13
FJS 3	0.45 ± 0.93	0.23 ± 0.60	0.14
FJS 4	0.26 ± 0.79	0.09 ± 0.35	0.16
FJS 5	0.32 ± 0.81	0.15 ± 0.55	0.21
FJS 6	0.57 ± 0.97	0.45 ± 1.00	0.35
FJS 7	0.64 ± 1.05	0.49 ± 0.86	0.36
FJS 8	0.77 ± 1.09	0.55 ± 0.93	0.18
FJS 9	0.79 ± 1.08	0.55 ± 1.00	0.08
FJS 10	0.34 ± 0.76	0.32 ± 0.84	0.88
FJS 11	0.60 ± 1.14	0.49 ± 0.89	0.38
FJS 12	1.72 ± 1.50	1.13 ± 1.30	< 0.01

Data were represented as mean ± standard deviation. The FJS consists of 12 questions with 5 choices (from 1 to 4) and is scored using a format with the raw scores transformed onto a 0–100 point scale.

FJS: Forgotten Joint Score-12

Table 3: Mean and standard deviation of KOOS and LKS score at 1 and 2 year after ACLR.

Postoperative	1 year	2 year	<i>p</i> -value
KOOS			
ADL	96.6 ± 5.5	98.1 ± 3.3	0.03
Pain	91.2 ± 11.1	94.3 ± 8.0	0.35
Symptoms	87.1 ± 13.2	93.8 ± 8.6	< 0.01
Sports	82.6 ± 18.0	88.4 ± 14.3	< 0.01
QOL	80.2 ± 18.9	86.6 ± 14.3	< 0.01
LKS	91.1 ± 10.0	94.5 ± 8.3	< 0.01

Data were represented as mean $\pm$ standard deviation. KOOS: knee injury and osteoarthritis outcomes score, ADL: activities of daily living, QOL: quality of life, LKS: lysholm knee scoring scale

Table 4: A multiple linear regression analysis to predict FJS 1 year after ACLR

	Estimated coefficient	Standard deviation	t value	95% CI	p-value
Intercept	61.92	22.42	2.77	16.41 - 107.43	< 0.01
Age	-0.43	0.27	-1.57	-0.98 - 0.13	0.13
BMI	0.01	0.52	0.02	-1.04 - 1.06	0.98
Side-to-side difference of tibial translation	-0.58	1.29	-0.45	-3.19 - 2.04	0.66
SLH-LSI	38.18	15.43	2.48	6.73 - 69.51	0.02

FJS: Forgotten Joint Score-12 BMI: body mass index SLH-LSI: Limb Symmetry Index of Single Leg Hop

Table 5: Correlation coefficient of KOOS and LKS for FJS at 1 and 2 year after ACLR

Postoperative	1 year		2 year	
	Correlation Coefficient	p-value	Correlation Coefficient	p-value
KOOS				
Pain	0.51	< 0.01	0.66	< 0.01
Symptoms	0.76	< 0.01	0.74	< 0.01
ADL	0.89	< 0.01	0.81	< 0.01
Sports and Rec	0.68	< 0.01	0.77	< 0.01
QOL	0.65	< 0.01	0.82	< 0.01
LKS	0.59	< 0.01	0.63	< 0.01

KOOS: knee injury and osteoarthritis outcomes score, ADL: activities of daily living, QOL: quality of life, LKS: lysholm knee scoring scale

Figures

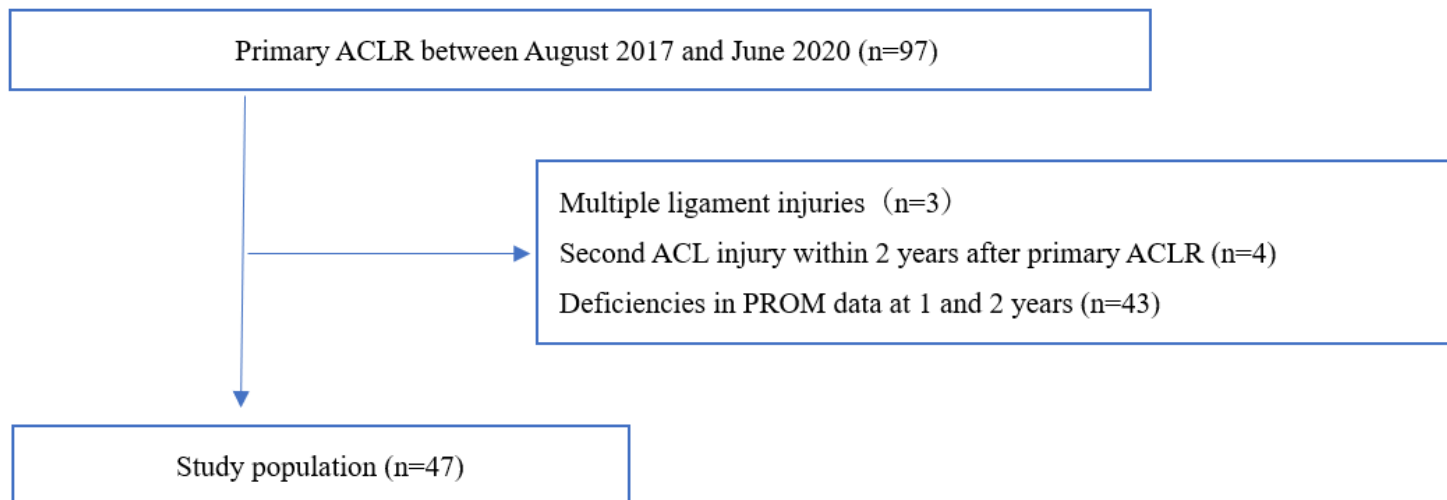


Figure 1

Flowchart of patients included in the study

A total of 97 knees of 97 patients were included in the study. Three knees of three patients with multiple ligament injuries were excluded. Four knees of four patients who suffered from graft rupture or contralateral ACL injury and 43 knees of 43 patients who did not respond to the questionnaire in the first or second postoperative year. Finally, 47 knees of 47 patients were included in this study.