



# Impact of Anterior Cruciate Ligament Status on Early Satisfaction and Clinical Outcomes Following Total Knee Arthroplasty

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## Abstract

**Background:** While total knee arthroplasty (TKA) is a successful treatment for debilitating arthritis, up to 20% of patients may be dissatisfied with their outcome. One hypothesis for dissatisfaction is the distortion of native knee kinematics following sacrifice of the anterior cruciate ligament (ACL) during TKA. The purpose of this study was to determine the impact of ACL status at the time of surgery in patients undergoing Posterior Stabilized (PS) TKA for osteoarthritis (OA).

**Methods:** A consecutive prospective series of patients undergoing TKA by a single surgeon underwent prospective intraoperative assessment of their ACL status divided into three different groups: 1) intact, 2) attenuated, or 3) deficient. Demographic, preoperative, intraoperative, and postoperative data were collected for each patient by two blinded, independent observers. Outcomes included patient satisfaction and Knee Society Score for Pain (KSS) and Function (KSF), Kellgren and Lawrence (K&L), UCLA Activity Score (UCLA), Short Form-12 (SF12), EuroQol (EQ5D) and patient satisfaction.

**Results:** Of 116 patients, 33 (28.4%) patients had an ACL deficient knee, 40 (34.5%) patients had an attenuated ACL, and 43 (37.1%) patients had an intact ACL. Those with absent ACL were significantly more likely to have a higher BMI ( $p=.007$ ) and be male ( $p=.003$ ). Patient with a deficient ACL had significantly lower preoperative KSF and higher K&L scores ( $p=.009$ ,  $p=1.26 \times 10^{-7}$ ). Attenuated and deficient groups had the greatest change in SF-

12PCS scores at their one-year follow-up with increases of 9.9 ( $\pm 10.0$ ) and 10.8 ( $\pm 8.0$ ), respectively ( $p=.037$ ). No significant differences in overall postoperative KSS, KSF and satisfaction scores based on ACL status ( $p=.574$  and  $p=.529$ , respectively) were found.

**Conclusion:** In a relatively large series, patient with ACL deficiency were more likely to have worse pre-operative outcome scores and similar or better post-operative outcome scores. This suggests that those with ACL insufficiency may experience more subjective improvement from TKA. ACL status can be used as an additional surgical marker to help orthopaedic surgeons identify which patients would most benefit from TKA.

## Background

Total knee arthroplasty (TKA) is considered a successful treatment for severe osteoarthritis (OA) of the knee, often eliminating an affected patient's pain and discomfort [13]. However, as many as 20% of patients feel neutral, dissatisfied, or very dissatisfied about their TKA post-operatively [4]. This is evident with previously reported average post-operative Knee Society Function (KSF) scores ranging from 66.7-75.7 [1,2,10].

It is theorized that native knee structures such as the

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**Level of Evidence:** III

ACL may play an important role in patients achieving normal knee kinematics and satisfaction following their TKA. Patients undergoing TKA often exhibit variable histopathological changes in their ACL prior to surgery, which is thought to result in impaired knee joint stability and kinematics [11]. Multiple authors have reported degenerative changes being more severe with typically multiple compartment involvement of the knee with ACL deficiency [6,7]. As a result, it has been suggested that pre-operative ACL deficiency may precipitate degenerative patterns due to altered knee kinematics [16], and that lack of an ACL may lead to impaired knee kinematics for patients with end stage degenerative joint disease. Therefore, knowing the status of the ACL in the degenerative knee can be an important indication for TKA [11].

To the author's knowledge, no previous study has directly assessed ACL status and its impact on clinical outcome scores and patient satisfaction following TKA. Therefore, the purpose of this study is to determine the impact of a patient's pre-operative ACL status on post-operative outcomes following TKA. The hypothesis of this study is that a patient's prior ACL status has a significant impact in the pre-operative outcome measures. Specifically, the authors hypothesize that patients with absent or deficient ACLs will have worse pre-operative clinical scores, consistent with more advanced degenerative changes, and postoperatively, will have same or greater increase in their outcome measure scores. The results of this study will prove useful in understanding the role of natural knee kinematics in TKA and help to identify the role of ACL in degenerative joint disease of the knee. In addition, determining the prevalence of an intact ACL shed light on the possible utility of ACL-preserving knee arthroplasties for patients.

## Methods

Following Institutional Review Board (15092303-IRB01) approval, a consecutive series of 466 patients undergoing TKA by the senior investigator between September 1, 2013 and August 1, 2016 were queried using CPT code (27447). Patients under this code were considered for our prospective study. Inclusion criteria included patients over the age of 18 years who underwent Posterior Stabilized (PS) TKA and had their ACL status determined by the senior author intra-operatively. Exclusion criteria included patients that underwent a revision TKA, patients with a previous ACL reconstruction surgery, any patient with a prior open surgical procedure on the affected knee and any patient with missing or incomplete outcome scores at their one-year follow-up. A total of 116 patients out of

466 were deemed eligible. All patients undergoing TKA had their ACL status determined using a standard physical exam, as well as direct intra-operative visualization by a single surgeon. ACL statuses were categorized as: 1) intact, 2) present and weak in the case of fraying, partial tear or mild/moderate degenerative changes, or 3) deficient in the case of full thickness tear or severe degenerative changes. Preoperative, intraoperative, and postoperative data was collected from medical charts by blinded, independent observers. Data gathered included: ACL status, physical exam findings, age at the time of surgery, BMI, sex, medical comorbidities, surgical history, surgery laterality, and patient reported outcomes (PROs). PROs included Knee Society Score for Pain (KSS) and Function (KSF), UCLA Activity Score (UCLA), Short Form-12 (SF12), and EuroQol (EQ5D). Patient reported satisfaction was documented as: very satisfied (1), satisfied (2), satisfied with complaints (3), and unsatisfied (4).

## Statistics

Statistical analyses were conducted using Stata version 13.1 (StataCorp, CollegeStation, TX). First, baseline and operative characteristics were compared between patients in the absent, attenuated, and intact ACL groups using Pearson's chi-squared test (for categorical outcomes) or ANOVA (for continuous outcomes). Second, clinical outcomes were compared between patients in the absent, attenuated, and intact ACL groups using ANOVA. These clinical comparisons were conducted for findings at the preoperative time point, for findings at the 1-year postoperative time point, and for the change between the preoperative and 1-year postoperative time point. All clinical comparisons were adjusted for age, sex, and BMI. The level of significance was set at  $p < 0.05$ .

## Results

A total of 466 patients were enrolled, of which 116 met the inclusion criteria and had complete pre-operative and one-year follow-up data and represented the study population. Of these, 33 (28.4%) had an ACL deficient knee, 40 (34.5%) had an attenuated ACL, and 43 (37.1%) had an intact ACL. ACL status was associated with male sex and higher BMI ( $p=0.003$  and  $p=0.007$ , respectively; Table 1).

Subsequent results are adjusted for age, sex, and BMI (Table 2). Patients with an absent or attenuated ACL were more likely to have a lower pre-operative KSF score than other patients ( $p=0.009$ ). In addition, ACL absent group had a higher Kellgren and Lawrence (K&L) score ( $P=1.26 \times 10^{-7}$ ). ACL absent and attenuated groups expe-

Table 1. Baseline and operative characteristics.\*

	Absent (33 patients)	Attenuated (40 patients)	Intact (43 patients)	P-value
Age (years)	67.6 ± 10.1	69.4 ± 8.0	65.5 ± 8.5	0.140
Male sex	<b>11 (33.3%)</b>	<b>6 (15.0%)</b>	<b>15 (37.7%)</b>	<b>0.003</b>
Body mass index (kg/m <sup>2</sup> )	<b>38.8 ± 10.6</b>	<b>35.6 ± 9.7</b>	<b>32.0 ± 7.1</b>	<b>0.007</b>

\***Bolding** indicates statistical significance.

Table 2. Clinical outcomes

	Absent	Attenuated	Intact	P-value
KSS (mean points)				
Preoperative	48.1±13.2	52.5±12.9	54.0±14.4	0.248
1 year postoperative	86.3±14.1	85.4±15.7	84.2±14.2	0.574
Pre- to 1-year postoperative change	+34.0±18.1	+34.2±17.3	+28.6±19.9	0.226
KSF (mean points)				
<b>Preoperative</b>	<b>35.3±18.3</b>	<b>44.51±11.9</b>	<b>50.3±15.3</b>	<b>0.009</b>
1 year postoperative	60.4±27.3	64.7±21.5	71.5±23.4	0.529
Pre- to 1-year postoperative change	+6.7±15.9	+15.5±21.7	+15.2±19.6	0.199
UCLA (mean points)				
Preoperative	3.7±1.2	3.7±1.5	4.0±1.9	0.916
1 year postoperative	3.9±1.8	4.5±1.7	5.4±1.9	0.198
Pre- to 1-year postoperative change	+0.7±1.2	+1.2±1.6	+0.6±2.0	0.719
SF12PCS (mean points)				
Preoperative	28.0±7.6	29.8±7.7	32.4±8.6	0.219
1 year postoperative	36.9±11.5	36.8±10.3	40.4±10.4	0.571
<b>Pre- to 1-year postoperative change</b>	<b>+9.9±10.0</b>	<b>+10.8±8.0</b>	<b>+3.7±10.5</b>	<b>0.037</b>
SF12MCS (mean points)				
Preoperative	53.5±11.6	53.2±11.4	51.8±10.4	0.900
1 year postoperative	54.5±11.2	55.1±9.5	55.0±8.0	0.715
Pre- to 1-year postoperative change	-1.1±8.3	+0.6±14.3	+0.8±11.6	0.578
ED5D (mean points)				
Preoperative	0.64±0.20	0.62±0.19	0.67±0.20	0.707
1 year postoperative	0.71±0.23	0.80±0.16	0.78±0.23	0.617
Pre- to 1-year postoperative change	+0.14±0.20	+0.18±0.22	+0.08±0.17	0.404
Extension (mean degrees)				
Preoperative	4.0±8.2	2.5±4.7	3.0±4.5	0.620
1 year postoperative	0.2±0.9	0.3±1.6	0.8±2.8	0.169
Pre- to 1-year postoperative change	-2.5±5.0	-2.3±4.9	-2.4±4.5	0.890
Flexion (mean degrees)				
Preoperative	108.0±13.5	113.0±9.8	111.0±11.9	0.290
<b>1 year postoperative</b>	<b>109.3±10.8</b>	<b>116.5±10.9</b>	<b>115.2±11.1</b>	<b>0.027</b>
Pre- to 1-year postoperative change	+1.4±13.4	+1.6±11.8	+3.0±12.9	0.985
Kellgren and Lawrence				
<b>Pre-operative score</b>	<b>3.56±0.32</b>	<b>3.02±0.33</b>	<b>3.02±0.30</b>	<b>1.26x10<sup>-7</sup></b>
Overall satisfaction (mean score)				
1 year postoperative	2.64±0.81	2.51±1.04	2.51±0.90	0.660

\* Adjusted for age, sex, and body mass index.

rienced greater improvement in SF12PCS from pre-operative to 1-year postoperative than patients with intact ACLs ( $p=0.037$ ). ACL-deficient patients had a decreased post-operative flexion at 1-year than other patients ( $p=0.027$ ). However, the pre- to post-operative change in flexion did not show any difference across the three groups ( $p>0.05$ ). All other clinical outcome assessments did not differ between the three groups. The mean satisfaction for all groups corresponded to satisfied, with no observed difference in patient satisfaction based on ACL status ( $P=0.660$ ).

## Discussion

Despite the success of TKA as a means for alleviating severe arthritis, a large number of patients remain dissatisfied with their outcomes. The role of patients' pre-operative ACL status has been hypothesized to affect both the post-operative outcome and satisfaction of patients. This study aimed to investigate whether patients with deficient ACLs had different post-operative outcomes compared to those with intact ACLs. We hypothesized that ACL pathology is associated with degenerative knee arthritis and patients with deficient ACLs experience similar or better outcomes at their 1-year follow-up.

The majority of the patients in this study (62.9%) had an attenuated or deficient ACL, which is consistent with previously reported histologic studies. Cushner et al. and Mont et al. both demonstrated histologically that the ACL is part of the degeneration process that occurs in arthritic knees with abnormalities being present in 47% and 85% of knees undergoing TKA respectively [5,11].

Our study results indicated that ACL-deficient knees had worse pre-operative KSF scores and a higher K&L score, suggesting further clinical and radiological significance to the observed histological and radiographic findings in degenerative joint disease. Berend et al. demonstrated increased chondral and meniscal damage with more extensive osteophyte formation in ACL deficient knees [3]. In addition, Berend et al. discovered that ACL deficient knees were found to require more deformity correction and had lower pre-operative ROM [3]. These combined findings suggest that ACL deficiency is closely correlated with worsened degenerative joint disease both in terms of the patient's perspective as well as radiographic and clinical exam findings.

This study is one of the first studies that examined the role of ACL status in post-operative outcome measures of patients undergoing TKA. It was discovered that those with deficient ACL status exhibited similar or greater improvement across all their post-operative outcome measures up

to one year. This can possibly be attributed to the abnormal knee kinematics that patients with deficient ACLs experience prior to their TKA, allowing for more subjective improvement post-operatively. Overall, ACL derangement can be used as one of the surgical markers of degenerative joint disease of the knee and can help orthopaedic surgeons identify potential candidates whom will benefit from a TKA.

Strengths of this study include 1) Visual inspection of ACL. The ACL of each patient was assessed intra-operatively by a single surgeon, 2) Blinded data collection. Observers collecting post-operative outcomes were blinded to the intra-operative ACL status of subjects, 3) Prospective nature of the study which allowed enough time for 1-year follow-up and inclusion of all the relevant outcome scores, and 4) Inclusion of multiple outcome scores. Nine total outcome scores were included in the study for a comprehensive assessment.

Limitations to this study include a relatively short, 1 year, follow-up period. Longer term follow-up may have revealed further changes in functional status following TKA between the three groups. However, 1 year is generally adequate to allow for a subsidence of residual pain and swelling caused by the surgery. Postoperatively, a 0-10 scale satisfaction survey may have yielded better estimation of patients' satisfaction compared to 1-4 scale that was used in this study. Lastly, having administrative measures placed to track patients and reduce the number of patients lost to follow-up would have minimized the possibility of attrition bias. However, 116 patients is still an adequate number in terms of sample size and overall power of the study.

## Conclusion

In a relatively large series, over 60% of patients had a deficient or attenuated ACL at the time of TKA for OA. Compared to patients with an intact ACL, patients with ACL deficiency are more likely to have worse preoperative KSF and radiological K&L scores, indicative of a more severe degenerative disease. However, those with ACL deficiency experience similar or possibly more relief from arthroplasty as demonstrated in SF12PCS outcome scores suggesting that abnormal knee kinematics prior to TKA may lead to more subjective improvement from arthroplasty compared to patients with intact ACLs prior to surgery. This indicates that natural knee kinematics and its alteration during surgery may play a role in clinical outcomes following TKA. As a result, ACL status can be used as an additional surgical marker to help orthopaedic surgeons

identify which patients would most benefit from TKA.

### List of abbreviations

TKA - Total Knee Arthroplasty  
 ACL - Anterior Cruciate Ligament  
 KSS – Knee Society Score  
 KSF – Knee Society Function  
 SF-12- Short Form 12  
 EQ5D - EuroQol

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