Anterior Knee Pain After Anterior Cruciate Ligament Reconstruction

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Background: Anterior knee pain is a frequent condition after anterior cruciate ligament reconstruction (ACLR), but its origin remains uncertain. Studies have suggested that donor site morbidity in autologous bone–patellar tendon–bone reconstructions may contribute to patellofemoral pain, but this does not explain why hamstring tendon reconstructions may also present with anterior pain.

Purpose: To evaluate the prevalence of anterior knee pain after ACLR and its predisposing factors.

Study Design: Case-control study; Level of evidence, 3.

Methods: We evaluated the records of all patients who underwent ACLR between 2000 and 2016 at a private facility. The prevalence of anterior knee pain after surgery was assessed, and possible risk factors (graft type, patient sex, surgical technique, range of motion) were evaluated.

Results: The records of 438 patients (mean age, 30 years) who underwent ACLR were analyzed. Anterior knee pain was found in 6.2% of the patients. We found an increased prevalence of anterior knee pain with patellar tendon graft, with an odds ratio of 3.4 ($P = .011$). Patients who experienced extension deficit in the postoperative period had an odds ratio of 5.3 of having anterior pain ($P < .001$). Anterior knee pain was not correlated with patient sex or surgical technique.

Conclusion: The chance of having anterior knee pain after ACLR was higher when patellar tendon autograft was used compared with hamstring tendon graft, as well as in patients who experienced extension deficit in the postoperative period.

Keywords: anterior cruciate ligament reconstruction; anterior knee pain; patellar tendon graft; hamstring tendon graft

Anterior cruciate ligament (ACL) injury is the most common ligament injury of the knee and accounts for approximately 50,000 to 105,000 reconstructions per year in the United States alone.[11,17] Greater participation in sports and recreational activities leads to greater exposure to risk of ACL rupture. Surgical treatment through ligament reconstruction is associated with higher quality of life, better function, and better control of symptoms compared with nonoperative treatment.[2] Studies show success rates between good and excellent in >90% of cases.[8]

Despite excellent results, ACL reconstruction is not free of complications. Among these is anterior knee pain, which can range from mild and sporadic to severe pain that limits daily and sports activities. The literature estimates a prevalence of anterior knee pain ranging from 5% to 19%.[1,22] However, the origin of this symptom is unknown. Reconstruction of the ACL using bone–patellar tendon–bone (BPTB) graft demonstrates higher rates of anterior knee pain compared with use of the hamstring tendon (HT) graft.[15,21,25,26,27] Studies have suggested that donor site morbidity in autologous BPTB reconstructions may contribute to patellofemoral pain.[15,28] Gaudot et al[14] and Freedman et al[12] estimated a prevalence of 11.5% and 22%, respectively, of anterior knee pain associated with donor site morbidity.

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Sachs et al[22] were among the first to describe postoperative flexion contracture as a cause of anterior knee pain. Shelbourne and Trumper[23] demonstrated that the incidence of anterior knee pain was related to a failure to obtain complete knee extension in the postoperative period, concluding that this pain could be avoided by early movement and stimulation of knee hyperextension.

Anterior knee pain is related to quadriceps weakness, independent of the type of graft used.[6,19] Studies that assessed quadriceps strength 6 months after ACL reconstruction surgery demonstrated a 10% to 30% deficit in maximal torque of the quadriceps-operated limb compared with the contralateral limb.[4,13] Although most cases are asymptomatic,[9,16] quadriceps deficit may lead to painful patellar syndrome owing to patellofemoral dysfunction.[13]

Despite the knowledge of such predisposing factors, the exact cause of anterior knee pain has not yet been determined. The aim of this study was therefore to define the prevalence of anterior knee pain after ACL reconstruction and to determine any predisposing risk factors. We hypothesized that donor site morbidity is not the main cause of anterior knee pain after ACL reconstruction.

METHODS

This retrospective study was approved by the ethics committee of our institution. A total of 516 medical records of patients who underwent reconstruction of the ACL between January 2000 and June 2016 in a private clinic were analyzed. All patients underwent surgery by a single surgeon (W.M.A.), who also wrote all of the surgical records, and all patients underwent the same standard protocol of physical therapy for postoperative care. Patients were clinically evaluated postoperatively at 1, 2, and 4 weeks and at 2, 4, 6, 12, 18, and 24 months. The evaluation included characteristics of incisions, range of motion (ROM) measured with a goniometer, presence and location of any pain or discomfort, Lachman test, and presence or absence of swelling and/or effusion. Extension deficit was defined as an extension ROM deficit $>5^{\circ}$.

The inclusion criteria for the study were as follows:

- Patients who underwent primary ACL reconstruction with ipsilateral BPTB autograft or ipsilateral HT autograft
- Age >16 years and <45 years
- 2-year minimum follow-up

The exclusion criteria for the study were as follows:

- Presence of previous anterior knee pain
- Patients undergoing revision ACL reconstruction surgery
- Patients undergoing primary ACL reconstruction with grafts other than the BPTB autograft or HT autograft
- Postoperative follow-up of <2 years
- Patients undergoing other concomitant procedures that altered the standard protocol of rehabilitation, such as posterior cruciate ligament reconstruction, posterolateral corner reconstruction, osteotomy for axis correction, or equal or superior chondral lesion classified as degree 3 according to the International Cartilage Repair Society

After eligibility criteria were assessed, 78 patients were excluded: 50 who had revision ACL reconstruction surgery, 4 who had concomitant posterior cruciate ligament reconstruction, 3 who had concomitant osteotomy for axis correction, 2 who had concomitant posterolateral corner reconstruction, and 19 who had a postoperative follow-up of <2 years. A total of 438 records were included in the final analysis. We included patients undergoing concomitant meniscal repair because these patients followed the same protocol as those undergoing isolated ACL reconstruction.

All patients underwent surgery with a single-bundle technique. Graft choice was according to the surgeon's preference. The BPTB graft was harvested as the central third of the patellar tendon with 2 bone blocks. After graft removal, the tendon gap was not closed. The patellar bone defect was filled with bone graft from the tibial tunnel. The paratendon was closed with No. 2.0 Vicryl (Johnson & Johnson). For the HT graft, the triple semitendinosus tendon or semitendinosus and gracilis tendons were used. Tibial insertion was not preserved. In all earlier cases, the femoral tunnel was drilled with a transtibial technique. In the later cases, an anteromedial portal technique was used (for both grafts). The HT graft was routinely fixed using an Endobutton fixation device (Smith & Nephew) on the femoral side. The BPTB graft was routinely fixed using an interference screw on the femoral side. For both grafts, tibial fixation was achieved using Ethibond No. 2 sutures (Ethicon) tied over an AO (Arbeitsgemeinschaft für Osteosynthesefragen) bicortical screw as a post or using an interference screw. Meniscal repair was performed with an arthroscopic all-inside technique using a Sequent Meniscal Repair Device (ConMed) for tears in the dorsal and middle portions of the meniscus; tears located in the anterior portion of the menisci were repaired using an outside-in technique with PDS No. 0 (Ethicon).

The following 2 main groups were established: patients who underwent reconstruction with the ipsilateral HT graft (cut from tibial insertion), and patients who underwent reconstruction with the ipsilateral BPTB graft.

The objective of the analysis of the medical records was to identify all patients who experienced anterior knee pain 1 year after ACL reconstruction surgery. The primary endpoint was the presence or absence of anterior knee pain in the first year after ACL reconstruction surgery, regardless of pain level or specific pain location.

Statistical Analysis

To compare the characteristics of the patients who had anterior knee pain versus those who did not, we used the Student *t* test to analyze the continuous variable (age) and the chi-square test to analyze the categorical variables (type of graft, type of fixation, ROM deficit, and sex).

To analyze the factors that affect anterior knee pain after ACL reconstruction, we conducted a binary logistic regression model using the forward selection method. Independent

TABLE 1
Characteristics of Patients[a]

Variable	All Patients (N = 438)	Patients With Anterior Pain (n = 27)	Patients Without Anterior Pain (n = 411)	*P* Value
Age, y, mean ± SD	30 ± 12.6	30.6 ± 11.0	30 ± 12.7	.859[b]
Sex				.103[c]
Women	63 (14.4)	1 (1.6)	62 (98.4)	
Men	375 (85.6)	26 (6.9)	349 (93.1)	
Type of graft				.002[c]
Bone–patellar tendon–bone	216 (49.3)	21 (9.7)	195 (90.33)	
Hamstring tendon	222 (50.7)	6 (2.7)	216 (97.3)	
Surgical technique				.007[c]
Interference screw	218 (49.8)	21 (9.6)	197 (90.4)	
Endobutton + interference screw	90 (20.5)	4 (4.4)	86 (95.6)	
Endobutton + cortical screw and washer	130 (29.7)	2 (1.5)	128 (98.5)	
Range of motion deficit				<.001[c]
Presence	34 (7.8)	8 (23.5)	26 (76.5)	
Absence	404 (92.2)	19 (4.7)	385 (95.3)	

[a]Values are expressed as n (%) unless otherwise noted.
[b]*P* value for Student *t* test.
[c]*P* value for chi-square test.

variables (ie, predictor variables) included in the model were graft type (HT and BPTB), type of fixation, ROM deficit (present vs absent), sex (male vs female), and age. The dependent variable (ie, predicted variable) was anterior pain. Type of fixation was treated as a dummy variable, with the following categories being considered for the analysis: interference screw/other, Endobutton + cortical screw with washer/other, and Endobutton + interference/other. To evaluate how well the chosen model fit the data, Hosmer and Lemeshow tests were applied, and to analyze the significance of the coefficients of each variable in the model, Wald tests were applied. The effect of each variable in the model for pain prediction was presented by odds ratios (Exp B) and 95% CIs. Additionally, an influence analysis was performed to verify the overall effect of each case in the model as a whole over the Cook distance.[7] Afterward, an association analysis was conducted through chi-square tests between the significant predictors identified by the binary logistic regression model. All cases had a Cook distance of <0.03. Cook's distance is a measure of the influence of an observation when performing a least squares regression analysis. All analyses were conducted using PASW statistics 18.0 software (SPSS Inc), with a significance level (α) of 5% ($P < .05$).

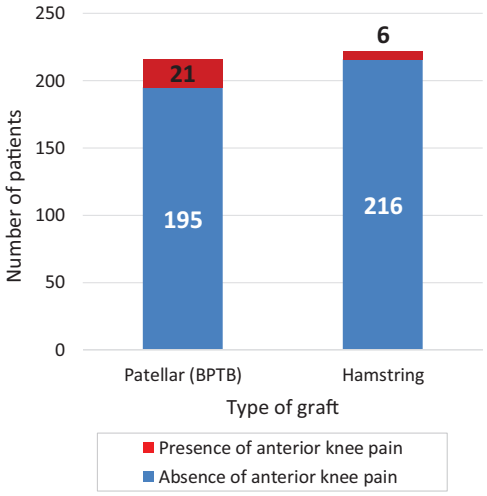

Figure 1. Prevalence of anterior knee pain in bone–patellar tendon–bone (BPTB) graft reconstructions was significantly higher than in hamstring tendon graft reconstructions ($P < .011$).

RESULTS

The characteristics of the 438 study patients are shown in Table 1. There was a significantly higher occurrence of anterior knee pain in the BPTB group (9.7%) compared with the HT group (2.7%) (odds ratio, 3.4; $P = .011$) (Figure 1). Patients who experienced knee extension deficit in the postoperative period had a higher prevalence of anterior knee pain compared with patients who had normal ROM (23.5% vs 4.7%; odds ratio, 5.3; $P < .001$) (Figure 2).

The logistic regression model was able to correctly predict 93.7% of patients without anterior knee pain and 29.6% of patients with anterior pain, so that the use of BPTB graft and the presence of ROM deficit (extension deficit) explained 12.1% (r^2, Nagelkerke) of pain after ACL reconstruction ($P < .05$) (Table 2). Type of fixation, sex, and age did not contribute significantly to explain the occurrence of anterior pain after ACL reconstruction.

Patients with a BPTB graft were 3.4 times more likely to report anterior knee pain than those who received HT graft ($P = .011$), while the presence of extension ROM deficit increased the chance of occurrence of anterior pain by 5.3 times ($P < .001$) in relation to the absence of a deficit (Table 2).

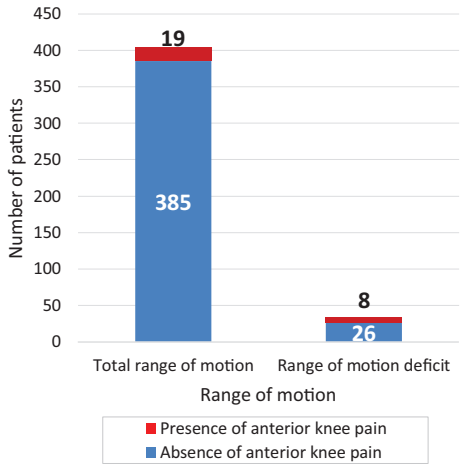

Figure 2. Prevalence of anterior knee pain was significantly higher in patients who experienced postoperative knee extension deficit versus those with normal range of motion ($P < .001$).

TABLE 2
Logistic Regression Model
for the Prediction of Anterior Pain[a]

Variable	B	*P* Value	OR (95% CI)	r^2
Included in the model[b]				0.121
Type of graft[c]	1.23	.011	3.4 (1.3-8.76)	
Range of motion deficit[d]	1.66	<.001	5.3 (2.1-13.47)	
Constant[e]	–2.31	<.002	0.1 (—)	

[a]B, beta coefficient; OR, odds ratio (chance ratio that indicates the probability of occurrence of an individual with anterior knee pain for the reference predictor); r^2, variance explained according to Nagelkerke. —, not applicable.

[b]Patient sex and surgical technique were excluded from the model; excluded variables indicate absence of significant effect for prediction of anterior pain after anterior cruciate ligament reconstruction.

[c]Reference to patellar tendon graft.

[d]Reference to range of motion deficit.

[e]Constant is a step in the statistical analysis when performing binary logistic regression. The constant within a regression model represents a fixed value within the model that corresponds to the crossing of the regression line on the *y* axis when *x* is zero. It allows the reproduction of the regression model.

Finally, a significant association was observed between graft type and ROM deficit ($P < .032$). Patients who received a BPTB graft were 2.3 times more likely to have an ROM deficit compared with patients who received an HT graft (Table 3).

The mean time to onset of symptoms was 7.5 months postoperatively. All 27 patients who experienced anterior knee pain underwent nonoperative treatment, consisting of rest, symptomatic medication, and physical therapy. Physical therapy included analgesic interventions and extensor ROM gain if needed. Of these patients, 22 (81%) experienced good results after nonoperative treatment. A further 5 patients (19%) needed to undergo knee arthroscopy with resection of cyclops lesion. The mean duration of symptoms was 6.5 months.

TABLE 3
Association Between Graft Type
and Range of Motion Deficit[a]

Deficit	Bone–Patellar Tendon–Bone	Hamstring Tendon
Presence	23 (67.6)	11 (32.4)
Absence	193 (47.8)	211 (52.2)

[a]Values are expressed as n (%). Statistical analysis: odds ratio, 2.3; 95% CI, 1.1-4.8; $P < .032$.

DISCUSSION

Studies on the prevalence of anterior knee pain after ACL reconstruction surgery usually relate to the type of graft used. Our study demonstrated that in addition to the use of a BPTB autograft, an extension deficit is also a predisposing factor for a higher prevalence of such pain.

Biau et al[3] stated that donor site morbidity in the use of a patellar tendon graft is one of the major factors leading to symptoms of anterior knee pain. Once the patellar tendon graft is extracted from the contralateral knee, there is a tendency for decreased anterior pain in the reconstructed knee.[18] A meta-analysis[24] compared the clinical results of ACL reconstruction with a patellar tendon graft versus HT graft and reported that anterior knee pain and pain when kneeling are more prevalent symptoms after patellar tendon reconstruction. Because a patellar tendon defect is created with the removal of the central third of the patellar tendon, the closure of that defect can cause lowering of the patella and, consequently, can lead to increased sensitivity and pain when the anterior compartment is directly pressed during kneeling or squatting.

A systematic review of 9 clinical trials[26] found 4 trials that indicated increased anterior pain and pain when kneeling after ACL reconstruction with a patellar tendon autograft. Another systematic review[21] of 12 trials found similar results, advising clinicians to avoid using BPTB for ACL reconstruction in patients who are prone to anterior knee pain or kneeling pain, such as athletes and workers who squat or kneel repetitively. The median incision required for removal of the graft from the central third of the patellar tendon may injure the infrapatellar branch of the saphenous nerve, which is one of the factors that would contribute to a higher prevalence of anterior pain.[15] Most studies, including literature reviews, have shown a higher prevalence of anterior knee pain in ACL reconstruction with the use of a patellar tendon autograft.[25] Chee et al[5] showed a lower occurrence of anterior knee pain and extension deficit in patients who underwent ACL reconstruction with HT graft. These facts should be considered when deciding which graft to use in ACL reconstruction surgery.

In our study, we found that the postoperative extension ROM deficit was related, as a sole factor, to an increase

in the prevalence of anterior knee pain (odds ratio, 5.3; $P <$ .001). In addition to scar formation after surgical damage and improper postoperative rehabilitation, there is a direct correlation between graft positioning and extension capacity. A study by de Abreu e Silva et al[10] found a higher prevalence of extension deficit after ACL reconstruction with the transtibial technique compared with an anteromedial portal group.

In a study of 602 patients who underwent ACL reconstruction with a patellar tendon graft and a specific rehabilitation protocol with an emphasis on obtaining complete hyperextension postoperatively, Shelbourne and Trumper[23] evaluated the incidence and severity of anterior knee pain through questionnaires of reported function during sports and activities of daily living and through objective measurement of ROM. They compared these patients with 122 control patients without prior knee injury and found that neither group experienced changes in the incidence of anterior knee pain during sports or activities of daily living. The authors concluded that rehabilitation with an emphasis on early hyperextension of the knee is fundamental to prevent the occurrence of anterior pain after ACL reconstruction with a patellar tendon graft, which is not an inherent complication of patellar tendon graft use.

In contrast, Noyes et al[20] related the use of a patellar tendon graft to the occurrence of extension limitation and arthrofibrosis. Removal of the middle third of the patellar tendon weakens the extensor mechanism. Limited extension is also related to the lack of flexibility (ie, stiffness) of the patellar tendon graft, which is approximately 4 times greater than that of the HT graft. The combination of extensor mechanism weakness and graft stiffness would significantly limit extension when a patellar tendon graft is used compared with HT graft.

Our study has some limitations. First, this was a retrospective study based on the analysis of medical records, which allowed us to investigate only the associations between risk factors and disease. Second, we could analyze only ROM and symptoms. Probably a more profound functional analysis including dynamic tests and strength tests could give more insight. Third, we evaluated only the presence or absence of pain and did not assess pain via an analog scale. Fourth, we did not analyze other risk factors associated with anterior knee pain, such as body mass index, preinjury activity level, existence of patellar femoral arthritis, or postoperative rehabilitation protocol.

CONCLUSION

In the current study, the chance of having anterior knee pain after ACL reconstruction surgery was increased in patients who received ipsilateral BPTB autograft compared with those who received ipsilateral HT autograft; further, the chance of experiencing pain increased in patients who had a postoperative extension ROM deficit compared with those who did not (regardless of the technique). Therefore, site morbidity is not the only risk factor for the occurrence of anterior pain in the knee after ACL reconstruction.

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