INTRA-ARTICULAR PATHOLOGY ASSOCIATED WITH ACUTE AND CHRONIC ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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ABSTRACT

Background: Concomitant meniscal and chondral pathology is common at the time of anterior cruciate ligament reconstruction (ACL-R). The purpose of the present study was to report the prevalence of concomitant intra-articular pathology for patients undergoing acute or chronic anterior cruciate ligament reconstruction.

Methods: This study represents a prospective, consecutively collected cohort of 255 patients undergoing both primary and revision ACL-R between January 2012 and December 2014 at a single institution. The cohort was divided into an acute surgical group, defined as surgery within six weeks of injury, and a chronic surgical group, greater than six weeks removed from injury. The median time from injury to surgery for the entire cohort was 37 days (range: 4 days to 855 days). Variables of interest included patient demographic characteristics, concomitant meniscal and chondral pathology, and meniscus treatment.

Results: Patients treated in the chronic setting were slightly older (28.7 ± 11.6 years vs. 23.1 ± 8.6 years, P=0.001), had a higher prevalence of complex tears of the medial meniscus (37.2% vs. 7.7%, P=0.012) and cartilage injury (16.5% vs. 7.8%, P=0.03). After excluding revision ACL-R procedures, complex medial meniscus tears in chronic ACL-R were higher than in acute ACL-R (medial= 27.3% vs. 3.0%, P=0.022), however when age was considered, these tears were no longer more frequent than in the acute setting (P=0.056). Similarly, the prevalence of cartilage injury was equivalent between groups after correcting for age (P=0.167). Among primary ACL-R, there were more medial meniscus repairs in the acute surgical group compared to the chronic group (60.6% vs. 24.2%, P=0.003). After excluding complex tears, medial meniscus repair rates were no longer performed more frequently in patients undergoing acute ACL-R (59.4% vs. 33.3%, P=0.054).

Conclusions: Data from this prospective cohort suggest that with increasing time from ACL injury to ACL-R, medial meniscus pathology increases, with a lower likelihood of meniscal repair in all patients undergoing ACL-R. However, this finding is no longer statistically significant when considering only patients undergoing primary ACL-R. Age appears to play an important role in whether concomitant pathology develops following ACL rupture. Given these findings, early intervention may increase the ability to repair medial meniscus tears in the setting of ACL-R, but this conclusion is less supported in primary ACL-R.

Level of Evidence: II

Keywords: anterior cruciate ligament, reconstruction, meniscus, acute, chronic

INTRODUCTION

The incidence of anterior cruciate ligament (ACL) rupture is as high as 7% in active, at risk populations.[1-3] ACL injuries predispose the knee to abnormal forces and kinematics that result in subsequent cartilage and meniscal injury that may lead to the development of osteoarthritis.[4,5]

ACL reconstruction (ACL-R) is commonly performed for treatment of ACL tears. The surgery has been shown to decrease the time to return to sport and improve patient reported outcomes.[6] However, the timing of ACL-R remains a topic of debate. One proposed approach promotes delaying surgery, with a focus on early range of motion to reduce the risk of postoperative arthrofibrosis.[7] On the other hand, delayed ACL-R has been associated with increased risk of chondral and meniscal damage.[8-12] The purpose of the present study was to report the prevalence of concomitant intra-articular pathology for patients undergoing acute or chronic ACL-R using prospectively collected data in a consecutively collected cohort of patients. It was hypothesized that chronic ACL-R portends greater intra-articular pathology at the time of surgical intervention.

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Table 1a. Patient Demographics of ACL-R Groups

	<6 weeks	>6 weeks	P value
N	128	127	
Age, yrs	23.1±8.6 24 (14-49)	28.7±11.6 25 (14-60)	0.001
Female	63 (49%)	59 (46%)	0.667
BMI	25.3±4.4 24.5 (15.7-39.9)	27.1±5.5 25.9 (18.6-44.8)	<0.001
Primary ACL-R	118 (92.2%)	89 (70.1%)	<0.001
Graft Type			
Allograft	14 (11.0%)	25 (19.7%)	0.052
Hamstrings	79 (61.7%)	74 (58.3%)	0.570
Bone-patellar-bone	35 (27.3%)	28 (22.0%)	0.333
Noncontact	111 (86.7%)	111 (87.4%)	0.877
Sport	103 (80.4%)	78 (61.4%)	<0.001
Time to surgery, d	25.31±10.29 25 (4-41)	164.0±176.5 88.5 (43-855)	Group

Table 1b. Patient Demographics of Primary ACL-R Groups with Complex Tears Excluded

	<6 weeks	>6 weeks	P value
N	118	89	
Age, yrs	23.1±8.9 19 (14-49)	28.9±12.1 25 (14-60)	0.001
Female	58 (49%)	40 (45%)	0.550
BMI	25.3±4.5 24.5 (15.7-39.9)	26.8±5.6 25.9 (18.6-44.8)	<0.001
Graft Type			
Allograft	12 (10.2%)	19 (21.4%)	0.026
Hamstrings	75 (63.6%)	58 (65.2%)	0.811
Bone-patellar-bone	31 (26.3%)	12 (13.5%)	0.025
Noncontact	102 (86.4%)	78 (87.6%)	0.800
Sport	98 (83.1%)	62 (69.7%)	0.023
Time to surgery, d	24.62±10.66 24 (4-41)	147.4±157.9 87.5 (44-768)	Group

METHODS

Prior to patient enrollment, this study was approved by the Institutional Review Board. All patients (n=255) undergoing primary (n=207, 81.2%) or revision (n=48, 18.8%) ACL-R were prospectively and consecutively enrolled from January 2012 to December 2014 at a single institution. All surgical procedures were performed by five sports medicine fellowship trained orthopaedic surgeons. Participating surgeons recorded the presence of meniscal pathology, including tear type and location, as well as the presence, location, and grade of chondral injury, when applicable.

Patients were divided into two groups based on time from injury to surgery. The acute surgical cohort was defined as having surgery within six weeks of the injury while the chronic surgical cohort underwent surgery greater than six weeks after the initial injury. All patients recalled a distinct injury event that was consistent with the mechanism of ACL injury. A time frame of six weeks was selected for the cutoff between acute and chronic surgical intervention based on previous studies which have shown increased risk of developing intra-articular lesions as time from injury to surgery increases.[13-15]

Collected data elements included patient demographics (age, gender, body mass index [BMI]), mechanism of injury (contact vs. non-contact), intraoperative findings (chondral injury, defined by the Outerbridge classification system with grade III or IV being considered significant[16] and meniscal injury, as defined by presence of a complex tear),[17] surgical variables (ACL graft choice [allograft, hamstrings, bone-patellar tendon-bone], ACL graft size, graft fixation methods, and meniscal treatment [repair vs. meniscectomy]).

Statistical Analysis

Demographic, injury and intraoperative data were compared between patients undergoing acute (≤6 weeks post-injury) or chronic (>6 weeks post-injury) ACL-R. Statistical analysis included chi-square and Fisher's exact tests and Student's t-test for categorical and continuous variables, respectively. When non-normal distributions were present, the Wilcoxon rank sum test was utilized. Age-adjusted comparisons were made using logistic regression. A p-value <0.05 was considered statistically significant. All analyses were completed using SAS statistical software version 9.4 (SAS Institute Inc., Cary, NC).

RESULTS

A total of 255 participants were enrolled, of which 122 (47.8%) were women and 207 (81.2%) were primary procedures. The mean patient age was 25.9 ± 10.6 years and mean BMI was 26.2 ± 5.0 kg/m^2. The majority of ACL tears occurred due to a non-contact injury mechanism, as described by the patient (n= 222, 87.1%). A majority also occurred while participating in a sporting event (n=181, 70.9%). Distribution of graft choice was as follows: hamstrings (n=153, 60%), bone-patellar tendon-bone (n=63, 24.7%), and quadriceps (n=39, 15.3%).

There were 128 (50.2%) patients who underwent acute ACL-R and 127 patients (49.8%) who underwent chronic ACL-R. The chronic group differed from the acute group

Table 2a. Intra-articular Pathology at Time of ACL-R

	<6 weeks	>6 weeks	P value
Meniscus tears	84 (65.6%)	77 (60.6%)	0.41
Medial meniscus tear	39 (30.5%)	44 (34.9%)	0.45
Lateral meniscus tear	60 (40.9%)	51 (40.2%)	0.28
Medial meniscus tear length, mm	11.5	17.5	0.74
Lateral meniscus tear length, mm	8.4	10.6	0.68
Medial, complex tear type	3 (7.7%)	16 (37.2%)	0.012*
Lateral, complex tear type	8 (13.3%)	11 (21.2%)	0.922*
Cartilage injury	10 (7.8%)	21 (16.5%)	0.03

*adjusted for age

Table 2a. Intra-articular Pathology at Time of ACL-R. (Excluding Revision ACL-R)

	<6 weeks	>6 weeks	P value
Meniscus tears	78 (66.1%)	60 (67.4%)	0.843
Medial meniscus tear	33 (28.0%)	33 (37.1%)	0.164
Lateral meniscus tear	58 (49.2%)	41 (46.1%)	0.660
Medial meniscus tear length, mm	12.1±6.1	17.5±16.3	1.00
Lateral meniscus tear length, mm	8.4±4.2	8.2±2.2	0.964
Medial, complex tear type	1 (3.0%)	9 (27.3%)	0.056* (0.022 if unadjusted)
Lateral, complex tear type	7 (12.1%)	9 (22.0%)	0.561*
Cartilage injury	9 (7.6%)	12 (13.5%)	0.167

*adjusted for age

in that they were slightly older (28.7 years vs. 23.1 years, P=0.001), had higher BMI (27.1 kg/m^2 vs. 25.3 kg/m^2, P<0.001), and more frequently underwent revision ACL-R procedures (29.9% vs. 7.8%, P<0.001) (Table 1a). No graft type was used disproportionately between the acute and chronic groups (P>0.05 for all comparisons). The mechanism of injury was more commonly due to a sports injury in the acute surgical group compared to the chronic group (80.4% vs. 61.4%, P<0.001). The median time from injury to surgery for the entire cohort was 37 days (range: 4-855 days). The median time to acute surgical reconstruction was 25 days (range: 4-41 days) and to chronic ACL-R was 88.5 days (range: 43-855 days).

After excluding patients undergoing revision ACL-R and those with complex meniscus tears, there were 118 patients in the acute group and 89 patients in the chronic group (Table 1b). The demographic trends in this group were similar to those in the entire cohort except that allograft (21.4% vs. 10.2%, P=0.026) and bone-patellar tendon-bone graft (26.3% vs. 13.5%, P=0.025) were more commonly used in the acute group compared to the chronic group. The difference in age between patients with complex tears in chronic ACL-R was also greater than those with complex tears in the acute ACL-R group (36.7±3.4 vs. 24.6±1.4). The median time to acute ACL-R was 24 days (range: 4-41 days) and to chronic ACL-R was 87.5 days (range: 44-768 days) for those undergoing primary surgery.

Does the timing of surgical intervention influence intra-articular pathology at the time of ACL-R?

Meniscal pathology was evaluated at the time of ACL-R for the entire cohort (Table 2a). There were similar numbers of meniscal tears in the acute and chronic surgical groups (65.6% vs. 60.6%, P=0.41) with no differences between the medial (30.5% vs. 34.9%, P=0.45, respectively) and lateral sides (40.9% vs. 40.2%, P=0.28, respectively). Although the tear lengths were longer in the chronic group, the difference was not significant (medial- 17.5 vs. 11.5 mm, P=0.74; lateral- 10.6 vs. 8.4 mm, P=0.68). Complex tears, however, were more frequently observed in both the medial and lateral compartment for patients undergoing chronic ACL-R (medial- 37.2% vs. 7.7%, P=0.003; lateral- 21.2% vs. 13.3%, P=0.022). After correcting for patient age, complex medial meniscus tears were still identified more frequently in patients undergoing chronic ACL-R (P=0.012), although this difference was no longer appreciated for complex tears in the lateral compartment (P=0.922). Chondral injury also occurred more frequently for patients undergoing chronic ACL-R with more areas of Outerbridge grade III and IV chondromalacia noted in the chronic group (16.5% vs. 7.8%, P=0.03).

After revision ACL-R procedures were excluded (Table 2b), complex tears in the medial compartment in chronic ACL-R were higher than in acute ACL-R (27.3% vs. 3.0%, P= 0.022). After this was adjusted for age, chronic complex medial meniscus tears observed in primary ACL-R did not significantly outnumber those observed in acute primary ACL-R (P=0.056). Chondral injury in the chronic surgical group was no longer significantly greater than that in the acute surgical group (13.5% vs. 7.6%, P=0.167).

Was the operative decision influenced by time from injury?

Operative decisions with respect to meniscus treatment were analyzed in the setting of acute and chronic primary ACL-R (Table 3a). Medial meniscus repair rates

Table 3a. Operative Decisions in Acute and Chronic Primary ACL-R

	<6 weeks	>6 weeks	P value
Medial			
Meniscectomy	7 (21.2%)	15 (45.5%)	0.037
Repair	20 (60.6%)	8 (24.2%)	0.003
Lateral			
Meniscectomy	19 (32.8%)	19 (46.3%)	0.171
Repair	17 (29.3%)	9 (22.0%)	0.412

Table 3b. Operative Decisions in Acute and Chronic Primary ACL-R with Complex Tears Excluded

	<6 weeks	>6 weeks	P value
Medial			
Meniscectomy	7 (21.9%)	7 (29.2%)	0.533
Repair	19 (59.4%)	8 (33.3%)	0.054
Lateral			
Meniscectomy	15 (29.4%)	15 (46.9%)	0.107
Repair	16 (31.4%)	7 (21.9%)	0.347

were higher in the acute surgical group compared to the chronic surgical group (60.6% vs. 24.2%, P=0.003). Meniscectomy rates were higher in the chronic reconstruction group relative to the acute surgical group (45.5% vs. 21.2%, P=0.037). When complex tears were excluded from analysis (Table 3b), medial meniscus repair rates in the acute surgical group were no longer different than those in the chronic surgical group (59.4% vs. 33.3%, P=0.054). Additionally, meniscectomy rates showed no difference (P=0.533).

DISCUSSION

This study examines the differences in intra-articular concomitant pathology for patients undergoing acute or chronic ACL-R. The key findings of this study include a higher prevalence of complex medial meniscus tears in the chronic ACL-R group and a higher rate of medial meniscus repair in the acute ACL-R group. However, these differences diminish when the effect of age is considered and revision ACL-Rs are excluded.

The demographic characteristics of the acute and chronic surgical cohorts were compared to better understand potential factors contributing to increased pathology with delayed surgical reconstruction. Although the overall age of the cohort was relatively young, the chronic surgical group was older than the acute surgical group by over five years. Moreover, the average age of the primary ACL-R group with chronic complex tears was greater than 10 years older than that of the acute ACL-R cohort with complex tears, suggesting that age may play a significant role in predicting complex tear development. As has been previously noted, age alone may serve as a risk factor for meniscal pathology and chondral injury.[17] These demographic trends illustrate the difficulty in isolating the effect of acute or chronic ACL-R because patients in the chronic surgical cohort are often older and have lower activity levels than those in the acute surgical cohort.

Additionally, the number of revision ACL-R procedures included in the delayed surgical group was higher than in the acute surgical group. Knees undergoing revision ACL reconstructions more frequently have concomitant intra-articular injuries than knees undergoing primary reconstruction.[19-21] We subsequently performed a subgroup analysis in which we excluded revision procedures to mitigate any selection bias towards increased intra-articular pathology in the chronic group and demonstrated a greater incidence of medial meniscus complex tears in chronic ACL-R compared to acute ACL-R.

In regard to the frequency of concomitant pathology, there was a greater prevalence of complex medial and lateral meniscus tears in patients undergoing chronic ACL-R. The increased incidence of complex medial meniscus tears persisted when correcting for age. Moreover, when subgroup analysis was performed with revision procedures excluded, a statistically significant higher rate of complex medial meniscus tears was observed for patients undergoing primary ACL-R in the chronic setting (P= 0.022). However this was no longer observed after correcting for patient age (P=0.056). Although this did not reach significance, the difference should be at least considered in this specific cohort of primary ACL-Rs. This finding suggests that patient age plays an important role in predicting development of intra-articular pathology following ACL rupture. Further studies with larger sample size are required in order to properly evaluate this relationship. There was no difference in the prevalence of complex tears observed in the lateral meniscus between the acute and chronic surgical groups when revision procedures were excluded. Our findings are supported by Church et al., who demonstrated an association between delayed surgical intervention, defined as taking place 12 months after an injury, and an increased frequency of medial meniscus tears.[22] Our study suggests that intra-articular pathology in the knee develops in chronic ACL injuries. However, this may in part be due to the higher frequency of revision ACL-R procedures being performed in the chronic setting, as suggested by subgroup analysis.

Intra-articular cartilage injury was noted to be greater in the chronic group when revision procedures were included. However, this trend did not persist when revision

procedures were excluded. This finding is supported by Borchers et al, who showed that there is an increased odds ratio of Outerbridge grade III or IV articular cartilage injury at the time of revision ACL-R compared with primary ACL-R in the lateral and patellofemoral compartments.[20] Our findings, along with this study, suggest that there is likely progression of chondral damage following failed primary ACL-R. Moreover, Krutsch et al. published a study that showed no significant difference in chondral pathology between early and delayed ACL repair, using a time point of six months as a cutoff.[23] Our findings further support the idea that chondral injury may not be exacerbated by delayed intervention, although it does appear to occur more frequently in the revision setting.

Our study reported that meniscal treatment decisions differed between the acute and chronic primary ACL-R surgical cohorts. We found that the medial meniscus was more frequently repaired in the acute group compared to the chronic group while meniscectomy rates were higher in the chronic surgical cohort. After complex tears were excluded, which are historically considered irreparable by many surgeons, meniscal repair rates and meniscectomy rates were no longer different between the acute and chronic surgical groups. Differences in medial meniscus repair rates between the acute and chronic groups did not achieve statistical significance when complex tears were excluded (P=0.054), but were noted to be higher in the acute surgical cohort. Krutsch et al reported that medial meniscus lesions had significantly higher repair rates in early intervention, defined as undergoing surgery within six months of injury, compared to delayed ACL-R.[22] Meniscectomy rates were no longer higher in the acute ACL-R group compared to the chronic group after excluding complex tears. This is most reasonably explained by the fact that complex tears are indicated for treatment with meniscectomy and were more prevalent in the chronic ACL-R cohort. Age was not stratified in this group, however it is likely that the younger age of the acute surgical cohort influenced the surgeon's decision to repair the meniscus rather than perform a meniscectomy. As previously discussed, age, BMI, and revision ACL procedures may serve as risk factors for increased intra-articular pathology in this cohort, and further study into these potential risk factors is warranted.

There are several important limitations to consider. First, the paucity of follow-up data in this cohort makes it difficult to speculate about the utility of different treatment decisions. The time-zero analysis elucidates a number of interesting findings about meniscal pathology as it relates to injury chronicity, but it fails to provide information on outcomes of surgical intervention. Long-term follow-up data is required in this cohort in order to suggest further benefit to acute surgical intervention. The results of this single-institution study make for a smaller sample size than a large, multicenter study. A higher-powered study may reveal an increased prevalence of complex tears in the medial meniscus and lower medial meniscus repair rate associated with chronic ACL-R. Additionally, this study was performed at a single institution, thus the results are less generalizable. Moreover, the treatment decisions in this study were not randomized. Activity level of patients has been shown to influence outcomes. While subjective activity levels were not reported in the present study, injuries were characterized as sporting or non-sporting injury, which may at least suggest the activity level of the patients. While our study cannot identify all risk factors for development of chondral damage following primary ACL-R, it emphasizes the importance of further study on the effect of surgical timing on chondral injury in the ACL deficient knee. Finally, the five surgeons involved in the study controlled the graft selection as well as the decision to repair the meniscus or perform meniscectomy. While treatment decisions were not randomized, the ability of surgeons to classify meniscal pathology and render potential treatment decisions is reported to be relatively consistent.[17]

CONCLUSIONS

The present study identified a greater prevalence of complex medial meniscus tears and chondral injury associated with chronic ACL-R. These findings diminished when primary ACL-Rs were exclusively examined and corrected for age. Despite the inability to fully randomize treatment decisions at the time of ACL-R, the present study found that medial meniscus tears were more frequently considered reparable in patients undergoing acute ACL-R. However, when complex tears were excluded from analysis, this trend was no longer found to be significant. While further follow-up of these treatment decisions is warranted, consideration should be given to early surgical intervention for patients undergoing operative treatment of ACL injuries in order to allow for meniscal preservation.

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