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Comparison of outcomes between males and females after anterior cruciate ligament reconstruction

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Abstract Few studies have specifically addressed the potential differences in outcome from ACL reconstruction between males and females. The present study compared patient-reported outcomes between the sexes after a minimum of 2 years following arthroscopic ACL reconstruction using bone–patellar tendon–bone autograft. Patients were also categorized as acute or chronic based on the time from injury to surgery. Outcome questionnaires were mailed to 638 patients, resulting in 151 eligible respondents included in the analysis. The outcome instruments used were the Cincinnati scale, the ACL-Quality of Life scale, and the Tegner activity rating scale. At an average of 5 years following ACL reconstruction no differences were found between males (*n*=74) and females (*n*=77) on the ACL-QOL scale. Females perceived a significantly higher activity level prior to surgery according to the Tegner scale. However, no other differences were identified by gender or stage based on prior, highest, or current Tegner activity levels. Results of the Cincinnati scale for the entire sample showed that females scored an average of 5.7 points lower than males. Analysis of this difference by patient age indicates a trend toward lower scores in females between 12–18 and over 24 years old. Chronicity was not a factor that affected outcome in either males or females. No differences were found in the number of patients who complained of anterior knee pain. We conclude that autogenous bone–patella tendon–bone ACL reconstruction is equally successful in well-matched populations of males and females.

Keywords Outcomes · Anterior cruciate ligament reconstruction · Gender

Introduction

Approximately 50,000 anterior cruciate ligament (ACL) reconstructions are performed annually in the United States [10]. Studies reporting the clinical outcome of these procedures typically include many more male patients than female patients. This is likely a reflection of the greater absolute number of males than females who participate in the recreational and competitive sporting activities in which the majority of ACL injuries occur. However, several studies have reported that in sports in which males and females participate equally, the likelihood of sustaining an ACL injury is greater in females than in males [2, 9, 10, 16]. Since the ultimate goals of operative treatment are to restore normal biomechanics and stability and return patients to the same level of activity as before the injury occurred, it is important to know whether males and females respond similarly to this type of intervention.

A few authors have suggested that females not do as well as males postoperatively. Although gender comparisons were not the specific focus of the study, Aglietti et al. [1] reported that patellofemoral problems are a frequent complication after patellar tendon ACL reconstruction and tend to occur more frequently in females than in males. A recent study by Noojin et al. [19] using ham-

string tendon grafts showed increased laxity, as measured by the KT-1000 arthrometer, increased pain frequency and intensity, and a greater loss of extension range of motion in female than in male patients. In addition, more of the men returned to their preinjury activity level than did the women.

With patellar tendon grafts most previous reports have not demonstrated significant differences in outcome between males and females [3, 4, 5, 7, 22]. However, comparison between the sexes is typically not the main focus of these reports. The most comprehensive gender comparison study to date was reported by Ferrari et al. [8]. These authors reported no clinically significant difference between 137 men and 63 women with respect to complications, functional testing, radiographic examination, arthrometry, or subjective assessment ranging from 2 to 9 years after surgery. Additionally, Barber-Westin, et al. [4] identified no differences in outcome or presence of complications between 47 men and 47 women at an average of 2 years after surgery. Both groups of authors concluded that there was no basis for using sex alone as a selection criterion for ACL reconstruction.

Notwithstanding the important contributions these authors, patients recovering from ACL reconstruction face a unique set of problems that conventional outcome measures may fail to detect. Additionally, these patients tend to be younger and more active than the general population from which many more generic outcome measures were developed [17]. Recently however, Mohtadi [17] revealed the ACL Quality of Life (ACL-QOL) outcome measure that is designed to assess issues and concerns specific to persons with ACL insufficiency. Unlike other knee outcome measures, it has been validated and determined to be sensitive to patients with ACL insufficiency. Despite this development no studies have used this instrument to assess the outcome of ACL reconstruction by gender for postoperative periods longer than 2 years. Therefore the purpose of this study was to further compare patient-reported outcomes between males and females after more than 2 years following arthroscopic autogenous bone–patellar tendon–bone ACL reconstruction using the ACL-QOL outcome measure. For completeness we included the subjective portion of the Cincinnati scale and the Tegner activity rating to compare our results with previous work. As a secondary question we compare the subjective outcome of patients who had ACL reconstruction within 90 days of their injury vs. those who did not. Finally, we describe the outcome of patients by age group to identify trends for future analysis. Prior activity level and the time from injury to surgery are also considered in these comparisons. Based on the available literature, we hypothesized that no difference in outcome would be found between any group as identified by the ACL-QOL score, Tegner scale, or subjective Cincinnati score.

Materials and methods

Outcome questionnaires

The ACL-QOL questionnaire [17] consists of 32 items that address each of five separate quality-of-life domains: symptoms and physical complaints, work-related concerns, recreational activities and sports participation, life-style, and social and emotional concerns. Each item is graded based on the patient's response on a 100-mm visual analog scale. A total score is calculated by summing the scores of individual items and dividing by the total number of points possible yielding a percentage value. The Cincinnati knee rating scale [20] uses a 100-point scoring system that includes evaluation of symptoms (pain, swelling, and giving way) and function (overall, walking, stair climbing, running, and jumping or twisting). The total score is calculated by summing the predetermined point values to the individual responses.

The Tegner activity rating scale [24] uses a 10-level ordinal scale to classify sports participation and occupational activities. Participation in competitive sports corresponds to an activity rating of 7 or higher. Activity ratings of 6 or less represent participation only in recreational sports and work activities. Patients were asked to provide an activity rating corresponding to each of three time periods. Prior activity level refers to the time period just prior to the ACL injury in question. Highest activity level refers to the highest level of activity that patients were able to attain after their ACL surgery. Current activity level describes the patient's activity level at the time the survey was completed. An additional questionnaire was included to gather information about symptoms, injuries, and surgeries prior to or since the ACL reconstruction and to inquire about sports participation at the time of ACL injury.

Subjects

Outcome questionnaires were mailed to 638 patients who underwent unilateral autogenous bone–patella tendon–bone ACL reconstruction between 1991 and 1996. A total of 221 surveys were completed and returned. Of these, 70 were rejected based on exclusion criteria. Reasons for exclusion from the study were: (a) a history of surgery to either lower extremity prior to the ACL reconstruction in question, (b) cases involving workers compensation or litigation, and (c) a history of back surgery. Additionally, subjects who reported significant lower extremity injury subsequent or prior to their ACL reconstruction (for which they missed more than 1 week of work, school or sports participation) were excluded for two reasons. First, it was felt that exclusion of previously injured subjects would allow for comparison of healthy subjects with more similar preoperative activity levels. Second, due to the extended follow-up period, subsequent injuries not necessarily related to their ACL reconstruction may affect the study questionnaire responses. Interestingly, only one male respondent indicated reinjury of his ACL subsequent to his reconstruction.

Of the 151 respondents included in the analysis, 77 were female and 74 were male. An a priori power analysis indicated that this number of subjects would be sufficient to detect a clinically significant (10-point) difference for the ACL-QOL and Cincinnati scales (α=0.05, β=0.20). To assess the effect of chronicity on outcome, patients were also classified according to the time from injury to surgery. Acute reconstructions (55 females, 40 males) were defined as those surgeries performed within 90 days of the ACL rupture. The average time from injury to surgery for patients with acute reconstruction was 38.1 days (range 7–90). Chronic reconstructions (22 females, 34 males) were performed more than 90 days after the ACL rupture. The average time from injury to surgery for patients with chronic reconstruction was 37.3 months (range 3–209). A minimum of 24 months had elapsed from the time of surgery to follow-up for all subjects. Because ACL injuries in females tend to occur earlier in life, we organized the sample into

Table 1 Analysis of age and time to follow-up based on gender and chronicity

	n	Age at injury (years)	Age at surgery (years)	Period from surgery to follow-up (years)
Females				
Acute	55	21.7±8.1	21.8± 8.1	4.8±1.6
Chronic	22	21.7±7.4	25.6±10.3	5.5±1.6
Overall	77	21.5±7.7	22.5± 8.5	5.1±1.6
Males				
Acute	40	27.1±9.7	27.2± 9.7	4.9±1.5
Chronic	34	25.8±8.1	28.3± 7.7	4.8±1.2
Overall	74	26.5±9.0	27.7± 8.8	4.8±1.4

three age groups: 12–18 years (42 females, 20 males), 19–24 years (16 females, 20 males), and over 24 years (19 females, 34 males). Overall the females were significantly younger than the males both at the time of injury and at the time of surgery (Table 1). There were no differences in age at time of injury between acute and chronic groups. Subjects having surgery within 90 days (acute group) were not significantly younger than their chronic counterparts. No differences were found in the number of years from surgery to follow-up based on either gender or chronicity.

The majority of ACL ruptures (71%) occurred in athletes participating in one of five sports: basketball (n=61), skiing (n=14), football (n=11), soccer (n=11), and softball (n=10). A noncontact mechanism of injury was identified in 70.3% (n=52) of male athletes and 88.3% (n=68) of female athletes.

All patients underwent arthroscopic unilateral autogenous bone–patella tendon–bone ACL reconstruction. All surgeries were performed using similar techniques by one of three orthopedic surgeons. The central one-third of the patella tendon was harvested to yield a graft that was 9–11 mm in width. Notchplasty was performed to ensure that graft impingement did not occur. All grafts were passed into the joint and fixed at the femoral site with an interference screw. Tibial fixation was accomplished with either an interference screw or tied over a post. Arthroscopic procedures performed concurrently with the ACL reconstruction are summarized in Table 2.

Patients who had a meniscal repair or trephination were kept non-weightbearing for 6 weeks after surgery, and motion was limited to 90° flexion. All other patients were allowed weightbearing, and motion as tolerated immediately following surgery. Once full weightbearing was achieved, patients were progressed according to a standard rehabilitation protocol that encouraged full range of motion by 4 weeks and return to sports activities by 4–6 months.

Data analysis

For the entire sample a series of two-factor ANOVAs (gender×chronicity) were performed to test for differences in the following variables: age at injury, age at surgery, time from surgery to follow-up, Cincinnati scale scores for the involved side, and scores for the ACL-QOL scale by gender and chronicity. Separate nonparametric Kruskal-Wallis tests were performed on the ordinal data from activity rating scales to compare prior, current, and highest activity levels by gender and chronicity. The rate of complications associated with surgery was compared using independent t tests for binomial proportions.

Results

Entire sample

Results for the ACL-QOL scale showed no differences between males and females (P=0.42) or between acute and chronic reconstructions (P=0.65; Fig. 1). The breakdown of ACL QOL scores by age group is presented in Fig. 2a. Although power limitations prevent appropriate statistical analysis, inspection of these figures indicates that young males generally scored higher than any other group.

Scores on the Cincinnati scale for the surgical leg were lower in females than in males (P=0.032). This difference

Table 2 Concurrent arthroscopic procedures during ACL reconstruction

	Females				Males			
	Acute		Chronic		Acute		Chronic	
	n	$\%$	n	$\%$	n	$\%$	n	$\%$
Medial meniscus								
Meniscectomy (partial or total)	5	9	5	23	7	18	13	38
Repair	8	15	5	23	6	15	4	12
Trephination	1	2	0	0	1	3	0	0
Débridement	1	2	0	0	1	3	1	3
Lateral meniscus								
Meniscectomy (partial or total)	8	15	7	32	15	38	7	21
Repair	4	7	2	9	2	5	0	0
Trephination	1	2	0	0	2	5	1	1
Débridement	1	2	0	0	1	3	2	6
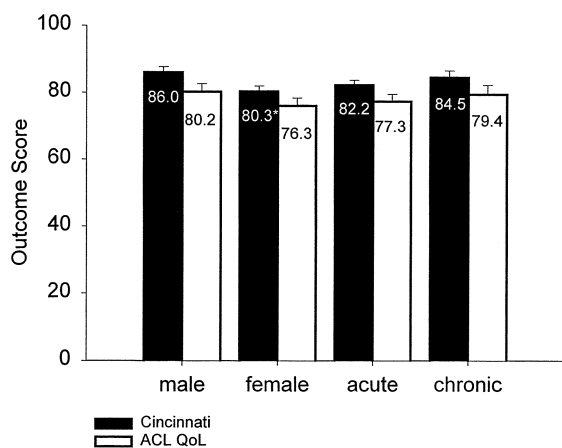
Fig. 1 Comparison of scores on the ACL-QOL scale and Cincinnati scale for subjects divided by gender and chronicity. *Error bars* Standard error of the mean. *P=0.032

was not found between acute and chronic groups (P=0.63; Fig. 1). The breakdown of Cincinnati scores by age group for the involved leg in is presented in Fig. 2b. Inspection of these figures indicates a definite trend toward lower Cincinnati scores among females in the youngest and oldest age groups. No differences were found by gender (P=0.59) or chronicity (P=0.75) for Cincinnati scores for the uninvolved leg.

Activity levels, as determined by the Tegner scale, showed that females in this study perceived a significantly higher activity level prior to surgery than men (P=0.02). This difference did not exist between acute and chronic groups prior to surgery (P=0.18). Further, organization of the sample by gender or chronicity identified no other differences at any time following surgery. Prior, highest, and current activity levels for the entire sample are summarized in Table 3.

Complications

Pain in the anterior aspect of the knee was reported by 29 females (37.7%) and 30 males (40.5%; P=0.81). Pain related to hardware was reported by 22 females (28.6%) and 18 males (24.3%; P=0.41). Tibial hardware had been removed from 7 females and 3 males because of pain complaints. Two females and no males had had their femoral hardware removed at the time of the survey.

Discussion

This study was designed to determine whether males and females do equally well after autogenous bone–patella tendon–bone ACL reconstruction. Based on the results of this study we support the recommendation of Ferrari [8]
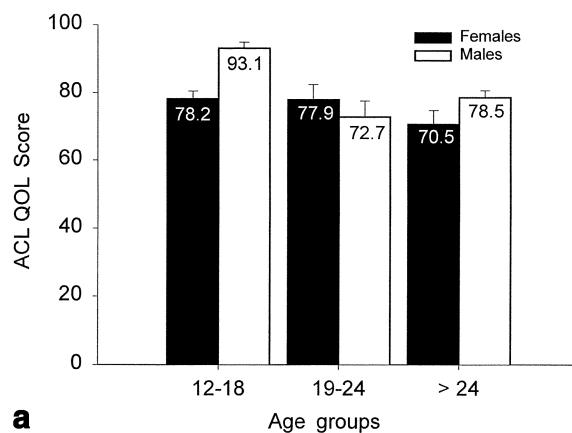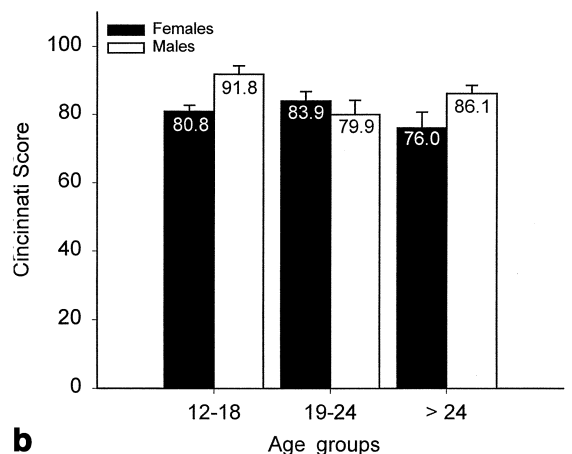
Fig. 2a,b Comparison of scores in the three age groups; *error bars* standard error of the mean. **a** ACL-QOL scale. **b** Cincinnati scale

and Barber-Westin et al. [4] that gender alone should not be the basis for selection regarding surgical intervention. No differences between males and females were found in the analysis of scores from the ACL Quality of Life scale. This suggests that the two sexes perceived similar functional outcomes with respect to physical, mental, and social determinants of satisfaction for patients with ACL insufficiency. Although only recently introduced, this scale has demonstrated adequate validity, reliability, and responsiveness to change in the population of patients for which it was designed [17].

Using the subjective portion of the Cincinnati scale, a significant difference in outcome was found between males and females. On average females scored 5.7 points lower than males for the entire sample. This was true in spite of the fact that the females were younger overall and more active than their male counterparts. The different conclusions reached based on the Cincinnati scale and the ACL-QOL scale reinforces the findings of others that different outcome rating systems do not produce interchangeable results [12, 23]. These two instruments likely

Table 3 Tegner activity levels based on gender and chronicity

| | Gender | | | | | Chronicity | | | | |
| | Male (n=74) | | Female (n=77) | | P | Acute (n=95) | | Chronic (n=56) | | P |
	Mean	Range	Mean	Range		Mean	Range	Mean	Range	
Prior	6.6	3–10	7.1	3–10	0.02	7.0	3–10	6.6	3–9	0.18
Highest	5.8	1–10	6.2	1–10	0.23	6.2	1–10	5.6	2–9	0.06
Current	5.4	3–9	5.0	1–10	0.08	5.3	1–10	5.0	2–9	0.64

measure somewhat different aspects of patient outcome. The Cincinnati scale focuses only on symptoms and activities of daily life/sports function, whereas the ACL-QOL scale considers a broader range of health status specific to ACL insufficiency. The fact that individual patient responses overall were slightly lower for the ACL-QOL scale than for the Cincinnati scale may reflect the different constructs of interest for each survey.

The comparison organized by age group confirms that homogeneity of the samples is a very important factor to consider when comparing outcome between the sexes. The difference by gender in Cincinnati scale score may be a reflection of the preexisting difference in age between males and females in this study. Indeed, females in the middle age group, between 19 and 24 years of age, scored slightly higher than males.

Several important differences between our study and the one by Barber-Westin et al. [4] may help to explain the different results in the Cincinnati scale. First of all, the average time interval from surgery to follow-up in our study was 60 months and included 151 questionnaires completed through the mail. The follow-up period in the study by Barber-Westin et al. [4] was 26 months, and the data were collected from 94 patients through personal interview. The presence of an interviewer has been shown to positively influence patient responses to a knee outcome survey [11].

The design of this study more closely parallels that of Ferrari et al. [8] who also reported no significant differences between males and females, including Cincinnati score, at an average of 4–5 years after surgery. Similar to the study by Ferrari et al., all questionnaires in our study were self-administered at an average of 5 years after surgery. Further, the sample for Ferrari et al. also included females who were significantly younger at surgery and at follow-up than their male counterparts. However, in contrary to the results of Ferrari at al., our results indicate significantly lower Cincinnati scores among females than males. While this difference may be statistically significant, we feel that the 5.7 point average difference between males and females identified in this study has little clinical significance, especially in light of preexisting activity and age differences between the two groups. Indeed, the effect size (d=0.38) for this variable in our study would generally be classified as small to moderate [6]. It is in-

teresting to note that Barber-Westin also reported a five-point lower average Cincinnati score among females. However, in their study this difference was determined not to be statistically significant.

The rate of patellofemoral pain and/or crepitus after ACL reconstruction has been reported between 1.5% and 60% [1, 3, 4, 15]. Due to the varying procedures used to evaluate these complaints as well as the various rehabilitation protocols that have been employed it is difficult to make generalizations across studies. The study by Aglietti et al. [1] was the only one to suggest that patellofemoral complaints are a more common complication in women than in men. Overall 39% of the patients in our study reported some pain in the anterior aspect of the knee, but there was no evidence of a difference between men and women. Because our patients were not examined directly, we are unable to specifically determine what proportion of these complaints represent true patellofemoral problems.

Previous studies have reported a poorer outcome in patients with chronic injuries than those with acute injuries, particularly in active populations [3, 21]. Presumably this is because of an increased risk of meniscal and articular cartilage injury with delays in surgery leading to irreversible degenerative changes [18]. Karlsson et al. [13] further reported decreased Tegner activity levels among competitive athletes with chronic injuries 2–5.5 years after ACL reconstruction. In the present study of predominantly recreational athletes no differences in ACL-QOL score, subjective Cincinnati score, or Tegner activity rating were found between acute and chronic subjects. Similar to the results of previous authors, however, a greater number of meniscal procedures were performed overall in patients with chronic insufficiency [13, 14].

A limitation of this study is the 35% response rate obtained from the mailed questionnaires. We believe this low response rate was due to a number of factors. The orthopedic practice that performed the ACL reconstructions specializes in musculoskeletal injuries of athletes and serves as a referral center for a large geographic region. Therefore many of the patients were followed elsewhere and did not provide a current address to the center. Further, nearly 65% of the subjects were between the ages of 12 and 24 years at the time of surgery. Over the period of follow-up many of these patients presumably moved from high school to college or from college to a new permanent address.

Despite this limitation the purpose of this study was to investigate gender differences with respect to ACL reconstruction. While a low response rate is often associated with an increased risk of selection bias, we have no reason to believe that this selection bias would be different between the sexes. That is, males and females are equally likely to respond to a questionnaire regardless of their satisfaction with the outcome of their reconstruction. Therefore any bias that exists from the low response rate should not affect the research question or subsequent conclusions drawn from the data.

Conclusions

This study found that patient-reported outcomes following autogenous bone-patella tendon-bone ACL reconstruction are similar between well-matched samples of males and females, suggesting that the sexes recover equally well. In addition, there was no evidence to suggest that any differences should be expected in the incidence of postoperative complications. However, a trend toward lower Cincinnati scores for females in the younger and older age groups may warrant further investigation.

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