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CLINICAL RESEARCH

High Satisfaction Yet Decreased Activity 4 Years After Transphyseal ACL Reconstruction

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Abstract

Background ACL injuries in preteens and teens are common occurrences. Reconstruction is believed to be optimum treatment for those wishing to return to running, cutting, and jumping sports. Rates of reoperation, satisfaction, and long-term return to and maintenance of preinjury activity after ACL reconstruction in young athletes are important information for physicians, patients, and parents.

Questions/purposes The purposes of this study were to address the following questions in this skeletally immature patient population undergoing ACL reconstruction: (1) What is the reinjury rate and the need for subsequent surgeries? (2) How do patient satisfaction and function as assessed by patient and physician correlate with return to sport? (3) What factors contribute to failure to return to preinjury activity levels?

Methods This is a retrospective review of 29 patients who underwent transphyseal ACL reconstruction using soft tissue grafts passed through open physes and followed to skeletal maturity, and at least 2 years from their index surgery, who were invited and returned for a study interview and examination. Pre- and postinjury activity levels were assessed via the Tegner activity score, satisfaction was determined using a 10-point Likert scale, function was assessed via the Lysholm score and IKDC grade, and an open-ended questionnaire was used for explanations of changes in activity levels. Reoperations were classified as major or minor, determined from a review of the medical records conducted after interview and examination.

Results At a minimum followup of 2 years (mean, 4 years; range, 2–8 years), four revision reconstructions and seven minor operations were performed for a reoperation rate of 11 of 29 (38%). Eight of 29 patients (28%) sustained contralateral ACL ruptures. The mean satisfaction score was 9 (range, 4–10) and mean Lysholm score was 91 (range, 61–100). Only 12 of 29 (41%) patients returned to and maintained their preinjury level of sport. High satisfaction correlated with return to prior level of sports, although there was no relationship between function and activity level. Reoperation on the index knee or contralateral ACL tear did not correlate with a change in activity level; rather, most patients who were less active indicated a change in interest with advancing age.

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.
This work was performed at the Seattle Children's Hospital and the University of Washington School of Medicine, Seattle, WA, USA.

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Conclusions Despite high satisfaction and function, less than 50% of patients maintained their preinjury level of play 4 years after ACL reconstruction. Satisfaction correlated significantly with knee function; highly satisfied patients were more likely to return to and maintain their prior level of participation in sports. Contributing factors to decreased activity include changes in lifestyle with increasing age. Reoperation did not correlate with lower activity scores or failure to return to sports.

Level of Evidence Level IV, therapeutic study. See the Instructions for Authors for a complete description of levels of evidence.

Introduction

ACL disruptions in skeletally immature athletes are common occurrences [18, 19, 32]. Although many advocate reconstruction of all ACL-deficient knees in youth because of the high risk of subsequent meniscal injury and/or early arthritis in unstable knees [12, 23, 29], others have shown that after an activity modification program while waiting until skeletal maturity before reconstruction may avoid the risk of a poor outcome from an unstable knee [38]. Numerous clinical studies showed high functional outcome scores and high rates of return to play when treating ACL disruptions in adolescent patients with varying reconstruction techniques [9, 17, 20, 24, 26]. Some studies suggest that rates of participation at preinjury levels of sport after surgical reconstruction are high, corresponding to patient- and physician-derived assessments of function [5, 13, 24, 31].

The relationships between preoperative factors and success or failure of ACL reconstruction, function, and return to activity have been reported in adults, yet not in patients who were preteens or teens when undergoing ACL reconstruction [35]. Patient-centered evaluations of satisfaction are considered an important element of assessments of surgical outcomes [10, 22], yet reports of patient satisfaction are rarely included in reports of outcomes of pediatric sports procedures [18]. In addition, the relationships among reoperation, patient satisfaction scores, patient- and physician-generated evaluations of function, and return to sports after ACL reconstructions in active adolescent patients would be important information for counseling and treating physicians, patients, and parents.

We, therefore, asked the following questions regarding this skeletally immature patient population undergoing ACL reconstruction: (1) What is the reinjury rate and the need for subsequent surgeries after ACL reconstruction in youth? (2) How do patient satisfaction and function as assessed by patients and physicians correlate with return to sport? (3) What factors contribute to failure to return to prior activity levels?

Patients and Methods

This is a retrospective review of ACL reconstructions performed by two surgeons (GS and RL) on all adolescent and preadolescent patients with knee instability from an acute tear of the ACL at two urban tertiary referral institutions during a 9-year period between 1998 and 2007, approved by the institutional review boards of each institution. Medical records and radiographic reviews identified 50 patients who were skeletally immature, having open physes at the distal femur and proximal tibia just before ACL reconstruction, judged by plain radiographs and MRI; preoperative Tanner staging and hand radiographs for bone age were not routinely performed for assessment of skeletal maturity before surgery. All patients underwent arthroscopically assisted ACL reconstruction for gross instability of the knee interfering with activity and were skeletally mature at the time of most recent followup, at least 2 years from surgery, with a mean followup of 4 years (range, 2–8 years). Only patients who underwent a first-time primary isolated transphyseal ACL reconstruction at our institutions were included. Patients treated for meniscal injury at the time of this surgery also were included. Patients with tibial eminence fracture, multiple ligamentous injury, or closed physes about the knee at the time of surgery were excluded. Of the 50 potential study patients identified, all 29 patients contacted living locally agreed to return for a weekend interview, physical examination, skills test, and radiographs, and were given a $25 inducement for participation. Eleven patients could not be contacted, and 10 patients had moved out of area and were unable to return for either of the two weekend sessions, and thus were excluded from the study.

Surgical Procedure

All patients underwent a similar procedure: soft tissue grafts were fixed on the femoral side with an Endobutton (Smith & Nephew, Memphis, TN, USA) and to the tibial metaphysis with a 6.5-mm Linvatec screw and washer (Conmed, Utica, NY, USA). This technique involved drilling centrally through the tibial physis, avoiding the tibial tubercle apophysis medially, and drilling across the femoral physis through a transtibial approach in a more vertical fashion [33]. An offset guide was used to preserve a 0.5- to 1-mm back wall. The femoral physis typically was visible when viewing up the femoral tunnel. No interference screws were used. The recommended postoperative rehabilitation was similar to that recommended for our adult patients, consisting of a 9- to 12-month program of graduated activity emphasizing closed chain exercises before return to sports [21]. Tests of strength, coordination,

and agility [3] were not routinely performed before release for full return to sports.

Grafts consisted of quadruple-stranded hamstring autograft or a double-stranded fresh-frozen nonirradiated tibialis anterior allograft, depending on patient and family preference. Concomitant meniscal repairs were performed for tears with healing potential; unstable meniscus tears with poor healing potential were trimmed and stable tears were not treated.

Patients completed a questionnaire at the invited session that asked them to describe the circumstances of their injury, dates of injury and reconstruction, current activity, and activity levels pre- and postinjury. The IKDC subjective and symptom rating scales were used to determine grades for current self-assessment of function [14] (A, normal; B, nearly normal; C, abnormal; and D, severely abnormal). A Likert scale was used to determine patient satisfaction with the reconstructed knee [11, 16, 18, 22]. A Lysholm score also was used for self-assessment of current function [27], and a Tegner activity score was used to establish activity levels [36]. Interviews were conducted by a blinded research assistant (SH). Return to sports was determined by comparing the preinjury Tegner score with the most recent score; those whose most recent Tegner score was equal to or greater than their preoperative Tegner score were deemed to have a positive value for return to sports. One blinded examiner (CP), trained in use of the KT-1000 unit (MEDmetric Corporation, San Diego, CA, USA) using standard protocols (89 N force at 25° knee flexion [2]) collected KT-1000 arthrometry results for both knees. One examiner (GS), blinded to the medical histories of 23 of the 29 patients, performed the physical examinations for tabulation of the IKDC physical examination score, taking the lesser of the two ROM and ligament examination scores [14]. A final IKDC score for each patient was the lowest of all ratings [14]. Radiographs of affected and unaffected knees were obtained by one blinded technologist (CK) to confirm closure of physes and to detect any gross growth abnormalities after surgery, and were evaluated by one examiner (GS).

Descriptive statistics (means, SDs, ranges) were used to summarize the outcome variables. A paired t-test was used to compare preinjury and postinjury Tegner activity scores and to compare function (Lysholm score) for those who had a decrease in Tegner score of 2 or more points with those who did not. Associations among patient satisfaction, function (IKDC assessments), and return to sports were explored using Spearman's rank order correlation. Pearson's chi-square test was used to analyze associations between return to sports and IKDC scores. The effects of having an ipsilateral rerupture or contralateral ACL rupture on Tegner activity scores and return to sports were explored using logistic regression models controlling for age and sex. The determination of factors contributing to failure to return to prior level of activity was performed through an open-ended questionnaire. To determine the odds ratio of allograft versus autograft failure, we used Fisher's exact test with nonparametric confidence limits. Fisher's exact test also was used to examine whether a relationship between sex and reoperation existed. Double-sided p values are reported. Stata Version 12.0 (StataCorp, College Station, TX, USA) was used for statistical analysis.

Results

Twenty-nine patients, 23 girls and six boys with a mean age of 14 years at the time of index surgery were included in the study (Table 1). There were four reruptures at a mean of 39 months (range, 8–66 months). Eight patients sustained contralateral ACL ruptures at a mean of 28 months (range, 6–50 months). Eleven of 29 patients (38%) underwent additional surgeries on the index knee: four for revision ACL reconstruction, one for arthrodébridement of scar tissue, three for removal of symptomatic hardware, one for combined removal of symptomatic hardware and arthrodébridement of scar, and two for arthrodébridement of scar and further partial medial meniscectomy (Table 2). Although 10 girls and one boy underwent reoperation on the index knee, the higher reoperation rate in girls (for major, minor, or overall reoperations) was not statistically significant (Fisher's exact test, $p > 0.2$). There were no reoperations for growth abnormalities, and no angular malalignments or radiographic anomalies were appreciated by clinical or radiographic examination at the study followup. Classifying reoperations as major (revision ACL reconstruction) or minor (partial meniscectomy, arthrodébridement of scar tissue, or removal of symptomatic hardware) yielded four major and seven minor reoperations. Of the four patients who had revision ACL reconstruction, two were the result of failed autografts and two had initial fresh-frozen, nonirradiated tibialis anterior allografts (odds ratio, 7.3; exact nonparametric 95% CI, 0.7–73; $p = 0.13$).

Table 1. Demographic data

Sex	Number of patients	Age at surgery (years) (± SD)	Number of patients with overall growth from surgery to maturity (n = 24)*	
			< 3 cm	> 3 cm
Female	23	14 (± 1)	10	8 (mean, 6 cm growth)
Male	6	14 (± 1)	2	4 (mean, 13 cm growth)

* Preoperative heights were unavailable for five patients.

Table 2. Complications

Type of complication	Number of patients	Sex of patients F/M
Rerupture of index ACL	4	3/1
Opposite knee rupture of ACL	8	7/1
Repeat arthroscopy for arthrofibrosis	4 total	4/0
With hardware removal	1	
With partial meniscectomy	2	
Isolated debridement	1	
Isolated hardware removal	3	3/0
Total reoperations on index knee	11	10/1

Table 3. IKDC scores for subjective assessment, symptoms, physical examination, radiographic assessment, and overall*

IKDC subsection	A	B	C	D
Subjective score	9	12	4	
Symptom score	14	6	4	1
Physical examination score	5	15	5	
Radiographic imaging score	17	7	1	
Overall IKDC score†	3	12	9	1

* Patients having undergone revision of their primary ACL reconstruction were not included; †overall scores are the lowest of the three subjective, symptom, and physical examination assessments for each patient.

Table 4. Correlations between level of satisfaction and IKDC scores

Assessment	Overall score	Symptom score	Subjective score	Physical examination score
Level of satisfaction	−0.67 (0.0001)*	−0.68 (0.0001)*	−0.73 (0.0001)*	−0.22 (0.2887)

* $p < 0.05$.

We found a significant decrease in activity comparing preinjury (mean, 8) and most recent Tegner activity scores (mean, 7; paired two-tailed t-test; p = 0.0026); only 12 of 29 maintained their preinjury level of sports activity. The mean Likert satisfaction score was 9 (range, 4–10). The average Lysholm score was 91 (range, 61–100). The IKDC subjective, symptom, physical examination, and overall scores were generally good (A or B in 15 patients, C in 9 patients, D in 1 patient) (Table 3). Satisfaction was highly correlated with the Tegner activity score ($r_s = 0.56$; p = 0.0015) and return to prior level of sports ($r_s = 0.44$; p = 0.019) (Table 4). Overall IKDC scores were not correlated with return to sports (chi-square = 2.6; p = 0.45). There was a negative correlation between overall IKDC scores and satisfaction, which was statistically significant ($r_s = -0.67$; p = 0.0001), that is, patients who were satisfied had a better overall IKDC score. This correlation was maintained when comparing satisfaction with IKDC symptom ($r_s = -0.68$; p = 0.0001) and subjective scores ($r_s = -0.73$; p = 0.0001). However, we did not find a significant association between satisfaction and IKDC physical examination score ($r_s = -0.22$; p =0.29). Comparing Lysholm scores for patients who returned to sports or whose most recent Tegner score decreased by only one level with those whose scores decreased by two or more levels revealed no significant differences in scores (mean Lysholm scores 93 and 90, respectively; paired two-tailed t-test = 0.7; p = 0.5).

Having a contralateral ACL tear in the period since the index ACL surgery was not predictive of lower Tegner activity score (p = 0.64) or return to sports (p = 0.59) controlling for sex and age. Similarly, having a reoperation on the index knee, either major or minor, was not associated with lower activity scores (p = 0.85) or return to sports (p = 0.36) controlling for sex and age. For patients with depressed levels of sports participation (nine patients with decreases in Tegner scores of two or more levels), there was also a negative, statistically significant correlation between overall IKDC score and satisfaction ($r_s = -0.83$; p = 0.01) but no correlation between function (as summarized by Lysholm score) and return to sports, as noted previously. Reasons given by patients not currently participating at their preinjury level of activity (17 of 29; 60% overall) included "I lost interest in sports and decided to take up something new", "I no longer want to participate in dangerous activities" (giant swings on the horizontal bar; downhill ski racing), "I fell behind my peers and now enjoy recreational sports", and for one patient, a feeling that the knee was not as stable as it was preinjury.

Discussion

ACL injuries in active preteens and teens are common occurrences. Many believe that surgical reconstruction of the torn ACL is the preferred treatment for active youth [12, 23, 26, 29, 33], yet surgical outcomes and their relationship to function and patient satisfaction have not been routinely reported for this group of patients. We invited all patients who were skeletally immature and underwent ACL reconstruction by either of two surgeons at related institutions during a 9-year period to return for a study interview and examination, to assess reoperation rates, return to and maintenance of preinjury levels of sports activity, satisfaction, and function, and to determine relationships between these assessments. We found high rates of reoperation, major and minor; return to and maintenance of preinjury level of sports activity for less than 50% of patients; high satisfaction correlating with return to prior level of sports, although no relationship between function

and activity level; and reoperation on the index knee or contralateral ACL tear not correlating with a change in activity level. Rather, most patients who were less active indicated a change in interest with advancing age.

Limitations to this study were many. The retrospective design required reliance on background data (eg, height at the time of surgery) that were not available for all patients. Growing patients with ACL tears who had instability interfering with activities were recommended to undergo transphyseal ACL reconstruction, although we do not have a count on the number recommended to have surgery who chose to not undergo reconstruction or to delay until their physes about the knee were obviously closed. Although we did not enroll patients prospectively, all patients living locally who were contacted chose to participate. Further, this study has a small sample size, and a comparison group of patients treated for an ACL disruption by a different technique was not available. Assessment of preoperative radiographs and MR images revealed 50 patients with open physes, 29 of whom returned and were included in the study, yet at least 12 of these 29 patients grew less than 3 cm in height from the time of their index surgery to the invited followup session, suggesting that they were approaching skeletal maturity at the time of their index procedure. We detected no evidence of growth abnormalities or angular malalignments at the study followups, although radiographs were limited to the knee and did not include hip-knee-ankle radiographs. Although our interviewer and KT-1000 examiner were blinded to the patient histories, the surgeon performing physical examinations for determination of one element of the IKDC score and who evaluated radiographs had previously treated six of the 29 patients, and so was not uniformly blinded to patient histories. Patient interviews and assessments were performed at one of two invited weekend study visits by the same team of examiners; no data from telephone interviews or routine clinic followups were included in this study. Medical record reviews for surgical details of index and additional surgeries were performed after the invited study sessions were completed.

Eleven of 29 patients underwent additional surgery, most commonly for symptomatic scar tissue blocking motion or painful hardware, and four reruptures of the ACL occurred. The observed rerupture rate (four of 29 [14%]) was higher than rates reported in other studies [1, 2, 17, 20, 24, 25, 31] although similar to the rate of Courvoisier et al. (five of 38 [13%]) [6]. Whether this is a function of the procedure performed, the age of the patients at the time of surgery, or the behavior of these patients during the postoperative period cannot be determined. However, many patients admitted to stopping formal rehabilitation and returning to sports because their knee "felt good" despite warnings of increased risk of reinjury with early cessation of therapy. The contralateral rupture rate (eight of 29 [28%]) was greater than that seen in adult populations (up to 16%), although being twice that of the reconstructed side was similar to the two times ratio of contralateral ACL rupture to ipsilateral rerupture seen in adults [39]. Studies suggest higher failure rates in young active patients undergoing allograft ACL reconstruction [4, 30, 34, 35, 37]. Although our findings did not reveal a statistically significant association between allograft and increased risk of failure, we suspect a trend toward increased failure with allograft reconstruction. Therefore, we no longer routinely offer allograft for primary ACL reconstruction in adolescents.

This series of active adolescent patients treated with transphyseal ACL reconstruction showed good function and high patient satisfaction at a mean of 4 years from their primary surgery; however, our rate of return to and maintenance of preinjury activity (12 of 29 [40%]) is lower than rates reported in similar studies in adolescents [2, 5, 17, 20, 24, 25, 28, 31] and adults [7, 8, 42]. We found that highly satisfied patients were more likely to return to and maintain their preinjury level of sport, and that patients with better function were more likely to be highly satisfied. However, we found no correlation between function (IKDC or Lysholm scores) and return to prior intensity of sports participation; that is, it was not necessarily the case that the patients with the best functioning knees were the most likely to return to sports. In contrast, Kocher et al. [18] found that patients with less than a 50% tear of the ACL treated nonoperatively were significantly more satisfied, more functional in activities of daily living, and more active on assessment of sports activity than those with a greater than a 50% tear of the ACL with an unstable knee, suggesting that satisfaction, function, and activity level went hand in hand.

Although one of our patients reported knee instability, most expressed a change in interest and a desire to no longer practice and compete at prior levels, although perhaps a lack of confidence in the knee may have contributed to a decrease in intensity of play. A decrease in activity level 2 to 6 years after ACL reconstruction in adults was noted by Spindler et al. [35], although patient self-assessments of function through IKDC scores remained essentially unchanged during that interval. Surprisingly, neither ipsilateral rerupture or reoperation nor contralateral ACL rupture and surgery were associated with a decrease in Tegner activity score. Patients who had a substantial decrease in activity, or two or more levels on the Tegner activity scale, did not have a significantly lower Lysholm score, suggesting that for many, the choices made were not dictated by knee function. Reasons for not returning to sports were varied, with only one of 29 stating that poor knee function was the reason she was not participating at her prior level of intensity.

Our techniques have evolved. We now place our ACL graft in a more anatomic position [40, 41], our postoperative protocol now includes early motion to limit arthrofibrosis, a series of hop tests are now routinely required before clearing patients for return to sports [3], with testing beginning at 6 months and the average return to sports occurring at 7 to 12 months, and participation in an ACL injury prevention program [15] is recommended during the last few months of rehabilitation to limit the likelihood of contralateral ACL rupture. Serial long, standing radiographs and a hand film for bone age are now routinely obtained preoperatively, and serial long, standing films are obtained at 3-, 6-, and 12-month intervals until skeletal maturity is reached to monitor for growth abnormalities.

Despite these modifications and apparent decreases in our primary failure and contralateral rupture rates, we still routinely see patients who no longer participate at their preinjury level of sports long after their index surgery.

Transphyseal ACL reconstruction in young, active patients may lead to only moderate rates of sustained return to sports at preinjury levels despite high satisfaction and generally good function. Contributing factors include changes in lifestyle with increasing age. The probability of not continuing to participate at preinjury levels of sport should be discussed when counseling parents and young patients undergoing transphyseal ACL reconstruction. Given the relatively small numbers of skeletally immature patients undergoing ACL reconstruction each year at our two centers, multicenter studies examining surgical techniques, rehabilitation protocols, and using universal followup assessments of satisfaction, function, and activity should be conducted.

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