

Second ACL Injury Rates in Younger Athletes Who Were Advised to Delay Return to Sport Until 12 Months After ACL Reconstruction

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Background: Younger patients are at increased risk for anterior cruciate ligament (ACL) graft rupture and contralateral injury after ACL reconstruction (ACLR). Increasing the amount of time between surgery and the resumption of competitive sport may reduce this risk.

Purpose: To determine the rates of graft rupture and injury to the contralateral native ACL at 3- to 5-year follow-up in younger patients who were advised to delay a return to competitive sport until 12 months after surgery and compare this with a nondelayed cohort.

Study Design: Cohort study; Level of evidence, 3.

Methods: The primary study cohort consisted of 142 eligible patients aged <20 years when they underwent their first primary ACLR. All were informed about the risk of further injury and advised not to return to competitive sport before 12 months postoperatively. Return-to-sport status and the number of subsequent ACL injuries (graft rupture or a contralateral injury to the native ACL) were determined at 3- to 5-year follow-up and compared with a historic cohort of 299 patients with ACLR who were not advised to delay their return to sport for a set period. The cohorts were then combined, and injury rates were compared between those who returned to sport before and after 12 months postoperatively.

Results: The follow-up rate was 91% (129/142). In the delayed cohort, 63% returned to competitive sport after 12 months (mean, 14 months). Few patients (n = 10) returned before 9 months. In the delayed group, 33% had a subsequent ACL injury; this was not significantly different when compared with the nondelayed group (31% rate), in which a majority (58%) returned to competitive sport before 12 months. Subsequent ACL injury rates were also similar when compared between patients who returned before and after 12 months postoperatively (33% vs 32%, respectively).

Conclusion: At midterm follow-up, the overall rates of subsequent ACL injury were high, even for patients who delayed their return until 12 months after surgery. More research is required to identify strategies to reduce the high reinjury rate in younger athletes.

Keywords: young athlete; return to sport; ACL injury; reinjury

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A second anterior cruciate ligament (ACL) injury is devastating for any athlete, regardless of whether it is a graft rupture in the reconstructed knee or an ACL rupture in the healthy contralateral knee. Much effort has gone into identifying risk factors for second ACL injury, and of these factors, younger age has been the most consistently reported risk factor for both ACL graft rupture and contralateral ACL injury.^{9,11,13,14,21,24} In cohort studies, the rates of second ACL injury have been reported to be between 25% and 35% for younger athletes.^{3,15,17,26} Large registry studies have also indicated that younger patients have 3 to 4 times the risk for both revision ACL reconstruction (ACLR) and contralateral ACL injury.¹⁹

The reason for an increased risk in younger patients is likely multifactorial, and it is also likely that age represents a proxy for other factors.²⁷ The most salient of these is sport exposure, as younger patients are more likely to resume

high-risk sports that involve jumping, cutting, and pivoting.²⁴ Recent studies have also shown that younger athletes resume these high-risk sports sooner after surgery and may also return with strength and functional deficits.^{2,6,29} Data from a Swedish Rehabilitation Outcome Registry showed that 50% of adolescent patients (aged 15-20 years) had resumed strenuous sports by 8 months postoperatively despite only 29% having achieved satisfactory muscle function.² A similar study by Toole et al²³ reported that only 14% of adolescent patients (mean age, 17 years) met recommended return-to-sport criterion thresholds when cleared to return at 8 months postoperatively.

A consistent finding has been that graft ruptures tend to occur earlier than contralateral ACL ruptures.^{11,26} Registry data show that the incidence of ACL revision surgery tends to peak at 1 to 2 years,¹¹ and in younger athletes, it has also been shown that around 50% of graft ruptures occur within the first postoperative year.²⁶ This raises several issues regarding the timing of return to sport and, more specifically, whether this should be delayed for younger patients. In a cohort of 1415 patients aged between 14 and 58 years with patellar tendon graft ACLR, Shelbourne et al²¹ did not find a difference in further ACL injury rates between patients who returned to sport before and after 6 months postoperatively. However, a recent study, which followed 159 patients aged 15 to 30 years who had mostly hamstring tendon grafts, found that returning to strenuous sports before 9 months after ACLR surgery was associated with a 7-fold increased rate for a second ACL injury compared with returning after 9 months.¹ While these studies show contradictory findings related to the timing of return to sport and subsequent ACL injury, the age range of patients varied, and as such, there may be merit in delaying a return to sport for younger patients. However, there is a paucity of data from which to draw robust conclusions.

Therefore, the purpose of this study was to audit a consecutive cohort of younger patients (aged <20 years at the time of surgery) who were specifically advised to delay their return to competitive sport until after 12 months postoperatively to determine how many actually delayed their return along with rates of graft rupture and injury to the contralateral native ACL at 3 to 5 years. We then sought to compare this delayed cohort with a prior young patient cohort who were not advised to delay their sport resumption until after 12 months. It was hypothesized that the cohort who delayed return to sport would have a lower rate of graft rupture and contralateral ACL injuries.

METHODS

Patient Selection

The inclusion criteria for participants in this study were patients <20 years (at the time of surgery) who had undergone primary autograft ACLR surgery between January 1, 2014, and December 31, 2016, by the participating knee surgeon (J.A.F.). A consecutive cohort of 157 patients who satisfied these criteria were identified from a surgical audit

database. Patients were not excluded based on meniscal or chondral status. The following exclusion criteria were applied: a previous ACL injury or surgery to the contralateral knee (n = 11); significant collateral ligament damage to the affected knee requiring repair (n = 2); and graft tendon harvest from the contralateral knee (n = 1). One patient had simultaneous bilateral ACLRs and was also excluded, leaving a total of 142 eligible participants. At the time of follow-up, all patients were between 3 and 5 years after ACLR surgery (mean, 3.4 years). This study was approved by hospital and university ethics committees.

Surgical and Rehabilitation Details

ACLR surgery was performed arthroscopically using either a hamstring (semitendinosus and gracilis) tendon (n = 115), quadriceps tendon (n = 14), or patellar tendon (n = 13) graft. Medial meniscal tears were present in 33 patients (23%). Of these tears, 19 were repaired, 8 were partially resected, 1 was both partially resected and repaired, and 5 were stable and not addressed surgically. Lateral meniscal tears were present in 54 patients (38%). Of these, 6 were repaired, 24 were partially resected, 1 was both partially resected and repaired, and 23 were not addressed surgically. Chondral damage was present in 12 patients (International Cartilage Repair Society grade 2, n = 9; grade 3, n = 3), of which 4 were debrided with an arthroscopic shaver. For all graft types, suspensory fixation was used on the femoral side and interference screw fixation on the tibial side, unless the tibial growth plate was still open, in which case fixation was by means of sutures tied to a fixation post. This applied to 13 patients (10 male, 3 female), all of whom had a hamstring graft. Three patients (2 male, 1 female), who were deemed to be at particularly high risk of reinjury due to a combination of factors including positive family history and planning to return to high-risk sport (Australian Rules football, soccer) at an elite level, also had lateral extra-articular tenodesis procedures.

Postoperatively, all patients followed the same rehabilitation protocol, which encouraged immediate full knee extension and the restoration of quadriceps function as soon as possible. Weightbearing was allowed on an as-tolerated basis from the first postoperative day. No braces or splints were used. Progression was guided by the presence and degree of pain and swelling. Typical timing was stationary cycling at 3 to 4 weeks, gymnasium-based strengthening exercises and plyometric exercises at 8 to 10 weeks, running at 12 to 14 weeks with progression to change of direction work after 4 weeks, and sports-specific drills at 5 to 6 months with a gradual resumption of team-based training at 9 to 10 months. A formal return to sport test battery was not used. Provided there was no effusion, an essentially full range of motion, good quadriceps strength, and neuromuscular control of a single-leg squat (as assessed by the treating surgeon), patients were cleared to return to play once they had completed a minimum of 4 weeks of completely unrestricted training.

The treating surgeon made a conscious decision, commencing in January 2014, to advise patients under 20 years of age at the time of their ACLR to delay their return to

competitive sport until at least 12 months from surgery, even if they had met all of the above criteria prior to 12 months. This was based on analysis of outcomes from previous ACLRs by the same surgeon who identified high rates of second ACL injury in younger athletes and the timing of the reinjuries.^{24,26} This information, as well as sport-specific data from our own clinic, was conveyed verbally to the patients and their parents at the time of the initial consultation, along with the advice to delay a return to competitive sport until at least 12 months from surgery. Also, they needed to complete at least 4 weeks, preferably 8 weeks, of completely unrestricted training with their team. The advice was reiterated at the 3- and 6-month follow-up appointments.

Data Collection

Demographic (age at surgery and sex), injury, and surgical information were obtained from prospectively collected patient databases. At our institution, all patients with ACLR are scheduled for a routine 12-month follow-up, and as part of this review, details of sport participation are recorded. Patients are specifically asked whether they have returned to competitive sport and, if so, on what date and at which level (same or lower). If patients have returned to training but not competitive sport, the date they recommenced training is also noted. This prospectively collected information was also accessed for the current study.

Between 3 and 5 years after surgery, all patients were sent an electronic survey and asked to report the number and type (graft rupture, contralateral ACL injury) of any second ACL injury and the date of occurrence. The survey also asked for current sport participation status (returned to competition, returned to training, no return) and, if applicable, the date of return to competitive sport. All patients who did not complete the survey were individually contacted via telephone. This required the patient (or parent) to answer structured questions regarding any further injuries to the ACL-reconstructed knee or the contralateral knee.²⁴ Medical records of the entire cohort were also checked to confirm reinjury details or identify any patient who had attended for consultation where subsequent ACL injury was noted or treatment undertaken but who did not complete the survey/telephone interview.

The proportion of patients who delayed their return to sport was calculated along with the percentages of graft ruptures and contralateral ACL injuries. Descriptive statistics were also calculated for return-to-sport data and the timing of ACL graft rupture and contralateral ACL injury.

Comparison With Nondelayed Cohort

The current delayed cohort was compared with a previous nondelayed cohort treated by the same surgeon. This prior nondelayed cohort initially consisted of 316 younger (aged <20 years at surgery) patients who had a 4-strand hamstring ACLR using the same surgical technique between 2004 and 2012.²⁶ These patients were not advised to delay return to sport until after 12 months from surgery, but they were cleared to return to sport by the surgeon using the

same criteria as the study group.²⁶ Return-to-sport data were available for 299 patients, and these patients comprised the comparison sample for the current study. The follow-up time for this prior cohort was between 3 and 10 years. Data were therefore reanalyzed to include only further ACL injuries that occurred between 3 and 5 years postoperatively, so that a direct comparison could be made with the current delayed cohort. As the prior non-delayed cohort included only patients with hamstring grafts, only those with hamstring grafts in the current delayed cohort were compared.

As it was not expected that all patients in the delayed group would wait until after 12 months to return to sport, further analysis was conducted that was based on the actual time patients took to return to sport. For this analysis, all hamstring patients from both delayed and nondelayed cohorts were grouped together and categorized according to the time taken to return (before or after 12 months), and reinjury rates were calculated. Groups were compared with chi-square analysis using SPSS Version 23 (IBM) software. $P < .05$ was used to indicate statistical significance.

RESULTS

Of the 142 eligible patients in the delayed cohort, there were 13 patients who were not contactable for long-term follow-up to determine further ACL injuries. Therefore, 129 (91%) could be contacted between 3 and 5 years postoperatively. There were 73 male patients and 56 female patients with a mean age of 17 ± 1.9 years (range, 10-19 years) at the time of their primary ACLR. All participated in sports on a weekly basis prior to their ACL injury, of which 91% were cutting and pivoting sports. The most common sports were Australian Rules football, netball, soccer, and basketball, which together accounted for 86% of the sports played. Just over half (54%) played high-level competitions, and 5 (4%) patients played at an elite level.

Return to Sport

Ten patients (8%) reported returning to competitive sport before 9 months, and 38 (29%) returned between 9 and 12 months. A total of 81 patients (63%) waited until at least 12 months, and return-to-sport dates were obtained from 113 patients, which showed a mean return time of 13.6 ± 5.3 months. There were 8 patients who had not returned to sport.

Second ACL Injury

There were 4 second ACL injuries prior to 12 months post-surgically: 1 graft rupture and 3 contralateral. The graft rupture occurred in a female patient at 11 months while playing netball after she had returned to play at 9 months. The early contralateral ACL injuries were sustained by a female patient during tennis at 11.6 months after resuming 3 weeks earlier, a male patient during basketball training at 9 months, and another male patient from a

TABLE 1
Graft Rupture and Contralateral ACL Injury Rates for the Cohort Who Delayed Return to Sport^a

	Graft Rupture	Contralateral ACL
All	20/128 (15.6)	24/128 (18.8)
Female patients	7/56 (12.5)	12/56 (21.4)
Male patients	13/72 (18.1)	12/72 (16.7)

^aData are reported as n (%). Comparisons between graft rupture vs contralateral anterior cruciate ligament (ACL) injury, and female vs male were all nonsignificant.

traumatic nonknee-related workplace accident (collapse of heavy building materials onto the patient resulting in hyperextension injury of the non-operated knee) at 9 months. Due to the nature of the workplace injury, this patient was removed from further summary analysis.

Graft ruptures occurred in 20 patients (15.6%) at a mean time of 29 months (median, 24 months) from surgery and 15 months (median, 11 months) from return to sport. Graft diameter was not significantly different between patients who ruptured the graft (proximal diameter, 8.2 mm; distal diameter, 8.7 mm) and those who did not (proximal diameter, 8.0 mm; distal diameter, 8.7 mm; $P > .05$). There were 24 (18.8%) contralateral ACL injuries at a mean time of 28 months (median, 28 months) from surgery and 16 months (median, 13 months) from return to sport. No statistically significant differences were found between graft rupture and contralateral ACL injury rates (Table 1), although female patients had a higher rate of contralateral ACL injuries than graft rupture ($P = .2$). There were 2 patients (15- and 18-year-old male patients) in this delayed cohort who sustained both a graft rupture and then a contralateral ACL injury. The total number of patients who had at least 1 further ACL injury subsequent to the primary surgery was 42 (32.8%).

Comparison With Nondelayed Cohort (All Hamstring Tendon Grafts)

In the nondelayed group, rates of return to competitive sport were determined at 12 months, and 174 of 299 patients (58%) had already returned. This was significantly greater than for the delayed group, $\chi^2(1)$, 15.9; $P < .0001$. There were no statistically significant differences in rupture rates or ACL injuries to the native contralateral knee between the delayed and nondelayed groups (Table 2). The total number of patients who had at least 1 further ACL injury subsequent to the primary surgery in the delayed group was 34 (33%) compared with 93 (31%) in the nondelayed group. The greatest between group difference was in the timing of the graft ruptures. The mean time to graft rupture was 32 months (median, 29 months) from surgery in the delayed group and 18 months (median, 12 months) from surgery for the nondelayed group ($P = .001$). For contralateral ACL injuries, the mean time was 27 months (median, 27 months) from surgery in the delayed

TABLE 2
Graft Rupture and Contralateral ACL Injury Rates Between the Study Groups^a

	Delayed Group	Nondelayed Group
Graft rupture		
All	16/102 (15.6)	54/299 (18.1)
Female patients	6/50 (12.0)	12/111 (10.8)
Male patients	10/52 (19.2)	42/188 (22.3)
Contralateral ACL		
All	18/102 (17.6)	40/299 (13.4)
Female patients	12/50 (24.0)	14/111 (12.6)
Male patients	6/52 (11.5)	26/188 (13.8)

^aData are reported as n (%). Comparisons between graft rupture vs contralateral anterior cruciate ligament (ACL) injury and female vs male patients were all nonsignificant.

group and 31 months (median, 30 months) from surgery for the non-delayed group ($P = .4$).

Comparison of Patients Who Returned to Competitive Sport Before and After 12 Months

When the analysis was performed to compare rates between patients who had returned to competitive sport before 12 months ($n = 212$) with those who returned after ($n = 181$), the overall second ACL injury rate was 33% (69/212) in the group who returned before and 32% (58/182) in the group who returned after 12 months.

DISCUSSION

Given the high second ACL injury rates reported in younger athletes and the fact that many graft ruptures occur within the first postoperative year, delaying a return to sport in this group has been suggested. Two key questions that need to be answered are whether younger patients would comply with specific advice to delay their return to sport and whether such a delay would make a difference in reinjury rates. Results of the current study showed that two-thirds of patients observed specific advice to delay their return to competitive sport. However, this did not reduce subsequent ACL injury rates, which were still high. The hypothesis that a delay in return to sport would reduce subsequent ACL injury rates was not supported.

One of the proposed factors that contributes to the increased risk for further injury in younger athletes is that of sport exposure.²⁹ For the current study cohort, the aim was to delay this exposure by advising patients not to return to competitive sport until at least 12 months from surgery. Despite receiving this advice, one-third of patients returned to sport before the recommended time. Reasons for this were not documented and could be explored in future research. It is possible that patients who sustained an in-season injury may have been attempting to return for the beginning of the following season. Of the group who returned between 9 and 12 months, it is worth noting that most returned at closer to 12 months than 9 months, with

more than half of this group returning at around 11 months. As such, it may be feasible to get younger athletes to delay their return to competitive sport, at least until 9 months, as 90% of the current delayed cohort were prepared to wait until this time. This is positive given that previous studies have shown a marked increase in risk for further injury in athletes who return to sport before 9 months.^{1,5}

The delay in return to competitive sport did not reduce overall graft rupture or contralateral ACL injury rates at between 3 and 5 years postoperatively, and 33% of patients sustained at least 1 further ACL injury (graft rupture or contralateral ACL injury). Even when patients were categorized according to the actual time taken to return to competitive sport (before versus after 12 months), 32% who returned after 12 months sustained a subsequent ACL injury. These high rates are of concern but consistent with what has previously been reported as regards patients with hamstring tendon grafts.³¹ One difference between the delayed and nondelayed cohorts was in the timing of graft ruptures. In the nondelayed group, many of these occurred within 1 year of surgery, and the mean time of occurrence was 18 months. In contrast, there was only 1 early graft rupture in the delayed group, and this occurred at 11 months, with the overall mean time to graft rupture time being 27 months for all patients and 31 months for the subgroup with hamstring tendon grafts. Therefore, although the incidence of graft rupture was not reduced by delaying sport resumption, the time it took for patients to sustain a graft rupture was markedly extended and by more than just the length of time by which return to sport was delayed.

The reasons for this finding are not clear, but one could speculate that it implies something about the mechanism of graft rupture. In patients who return to sport early, one would expect the graft to be less mature than in those who return to sport later. There may be individuals who, for whatever underlying reasons, perhaps their landing biomechanics,^{7,18} are fundamentally at increased risk of ACL injury. In this group, less force may be required to rupture a graft in the earlier time frame. Returning to sport at a later time may be associated with greater graft maturation and therefore a greater force required to rupture the graft, but the individual continues to be considered at risk and eventually suffers a graft rupture. However, this is purely speculative, and further work is required to better understand the impact of the timing on further ACL injuries.

Although the results of this study showed that a wait-and-delay approach did not reduce further ACL injury rates in younger patients between 3 to 5 years postsurgically, this should not be interpreted as advocating for an early return, as many factors contribute to second injuries. Return-to-sport testing continues to be explored, and the premise for this is that patients who meet criterion thresholds should have a lower risk of reinjury than patients who do not but nonetheless return to sport.⁴ However, the overall validity for such testing is currently limited.^{12,30} Some work has identified clinical factors that may predict second ACL injuries in younger athletes, but these have not been validated on an individual patient basis.^{16,25} Further work has also not shown any relationship between various knee

function and strength tests and second ACL injury in young athletes.⁸ One potential complicating factor for return-to-sport testing in young athletes is that this age group is more likely to meet criteria thresholds, which may limit the sensitivity of such testing approaches and alternative methods may need to be considered.²⁸

It has been demonstrated that younger patients are more likely to make a return to sport and strenuous activities than their older counterparts.^{24,29} Despite this, it was possible that asking patients to delay their return to sport in the short term may have negatively influenced their future return rates. However, this did not appear to occur, as 94% of the delayed cohort made a return, with only 8 patients never returning at the 3- to 5-year follow-up. These rates are highly consistent with a systematic review, which showed that 92% of children and adolescents returned to some form of sport after ACLR.¹⁰

A limitation of the current study was that only hamstring grafts could be compared between groups (as this was the most frequently used graft). Some studies have shown reinjury rates to be higher with hamstring grafts compared with patellar tendon grafts for all age groups^{19,20} as well as for younger athletes,²² so future studies should compare timing of return to sport and second ACL injury rates for all graft types, with a potential subgrouping for lateral extra-articular tenodesis. A further limitation of the study was that return-to-sport data were collected by self-report measures, and as such, the total sport exposure of the delayed cohort is unknown. A formal return-to-sport test battery was not utilized, and the study also involved only 1 surgeon from a metropolitan specialist clinic where hamstring grafts are predominantly performed. While this may serve to limit numerous selection biases and differences in surgical technique, it may also limit the generalizability of the findings.

In conclusion, a majority of young patients delayed their return to competitive sport; however, at midterm follow-up, the overall rates of graft rupture and contralateral ACL injury were high even for those who delayed their return until 12 months after surgery. Continued effort needs to be made on reducing the high reinjury rates in younger athletes, and alternative approaches for the same should be explored.

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