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Younger Patients Are at Increased Risk for Graft Rupture and Contralateral Injury After Anterior Cruciate Ligament Reconstruction

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Background: Graft rupture of the same knee or injury to the anterior cruciate ligament (ACL) in the contralateral knee is a devastating outcome after ACL reconstruction surgery. While a number of factors have been identified as potentially increasing the risk of subsequent ACL injury, the literature is far from definitive.

Purpose: To determine the rates of graft rupture and contralateral ACL injury in a large cohort and to investigate patient characteristics that may be associated with these.

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

Methods: A consecutive cohort of 750 patients who had undergone primary ACL reconstruction surgery with a minimum 3-year follow-up were questioned about the incidence of ACL graft rupture, contralateral ACL injury, family history of ACL injury, and current activity level. Patient databases provided details for age, sex, original injury mechanism, meniscus or articular surface injury, and graft diameter.

Results: Responses were received from 561 patients (75%) at a mean ± SD follow-up time of 4.8 ± 1.1 years. Anterior cruciate ligament graft ruptures occurred in 25 patients (4.5%), and contralateral ACL injuries occurred in 42 patients (7.5%). The highest incidence of further ACL injury occurred in patients younger than 20 years at the time of surgery. In this group, 29% sustained a subsequent ACL injury to either knee. The odds for sustaining an ACL graft rupture or contralateral injury increased 6- and 3-fold, respectively, for patients younger than 20 years. Returning to cutting/pivoting sports increased the odds of graft rupture by a factor of 3.9 and contralateral rupture by a factor of 5. A positive family history doubled the odds for both graft rupture and contralateral ACL injury.

Conclusion: Patients younger than 20 years who undergo ACL reconstruction are at significantly increased risk for both graft rupture and contralateral ACL injury. Whether age per se is a risk factor or age represents a proxy for other factors remains to be determined.

Keywords: risk factors; ACL reconstruction; failure rate; age; graft survival

When planning a return to sport after anterior cruciate ligament (ACL) reconstruction surgery, patients are often concerned about the risk of sustaining the same injury again. A systematic review and meta-analysis of prospective studies with a minimum 5-year follow-up found that graft rupture rates varied from 1.8% to 10.4%, with a pooled percentage of 5.8% (all grafts were autografts).[30] In addition to the rate of graft rupture, it is also relevant to know whether predictors (ie, patient and surgical variables) can be used to identify at risk individuals. Risk factors for ACL graft rupture have been studied with increasing frequency, and patient variables that have been associated with graft rupture include being young,[11,12,23] having a family history of ACL injury,[3] contact mechanism of original injury,[21] and an early return to competition sport.[9] With regard to patient sex, some studies have shown that males are at increased risk,[2,3,10,23] while the rate of revision surgery is reported to be higher in females.[1] Surgical factors that have been indicated include a vertical graft position,[2,7,10] small graft,[12,16] lax graft,[2,20] and hamstring graft.[13] While it is encouraging that so many potential factors have been identified, there is considerable inconsistency in the published literature, and many of the above-listed risk factors have also been shown not to be associated with graft rupture in other studies.

Just as devastating to the patient is an injury to the ACL in the contralateral knee. The systematic review

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data showed the risk of contralateral ACL injury after ACL reconstruction to be double (pooled percentage 11.8%) that of graft rupture.[30] This is clearly something that warrants attention, although, in comparison with risk factors for graft rupture, fewer studies have reported on risk factors for contralateral ACL injury after reconstruction. There are nonetheless some data from US and Australian populations that show being female[23] and young,[3,7,10,20,23] returning to strenuous[21] or preinjury[3] sports, and having a family history of ACL injury[3] to be risk factors. The use of patellar tendon grafts also has been shown to be associated with higher rates of contralateral ACL injury than hamstring grafts.[10,20]

Given the inconsistencies in the literature and the potential importance of being able to determine predictors of graft rupture and contralateral ACL injury after reconstruction, the aim of this study was to add to the existing knowledge base and determine the rates of graft rupture and contralateral ACL injury in a large cohort and determine patient and surgical characteristics associated with these injuries.

MATERIALS AND METHODS

Patient Selection

A consecutive cohort of 750 patients had primary autograft ACL reconstruction surgery between November 2004 and June 2008 by a single experienced knee surgeon. After institutional ethics approval, all were invited to participate in the current study. At the time of follow-up, all patients were a minimum 3 years after reconstruction surgery.

Data Collection

Prospectively collected patient databases were searched for demographic, injury, and surgical information. Demographics included age at surgery, sex, and history of contralateral ACL injury. The mechanism of original injury was recorded as contact or noncontact. Surgical details included the measurement of graft diameter and the presence of meniscus or articular surface injury.

All patients were sent the link to an online survey (using SurveyMonkey; www.surveymonkey.com) in which they answered structured questions regarding any further injuries to the ACL-reconstructed knee or the contralateral knee. While patients provided details about all subsequent injuries, ACL graft rupture and contralateral ACL injury were the two that were the focus of this study. For patients who reported ACL graft rupture or contralateral ACL injury, the medical record was checked to confirm the diagnosis and details of any further surgery noted. The questionnaire also sought details regarding the family history of ACL injuries and the type of sport to which the patient had returned. Family history was considered positive if the patient reported a first-degree relative (parent or sibling) who had sustained an ACL injury. The type of sport to which patients returned was categorized as either strenuous (ie, sport that involves cutting/pivoting) or not.

Analysis

Random effects logistic regression was attempted, but, owing to the relative scarcity of cases (graft ruptures or contralateral ACL injuries), model convergence was compromised and reliable parameter estimation was impossible. Odds ratios were therefore calculated to assess the association between each measured variable and the risk of ACL graft rupture and contralateral ACL injury. Analysis was performed using STATA (version 12; StataCorp, College Station, Texas, USA) and ratios were considered significant if $P \leq .05$. For age, patients were grouped according to whether or not they were younger than 20 years at the time of surgery. For graft diameter, patients were grouped according to whether their graft measured $\leq$7 mm or greater.

RESULTS

Of the 750 patients in the cohort, 561 (75%) could be contacted and followed up at a mean ± SD of 4.8 ± 1.1 years. There were 370 males and 191 females. For 368 (66%) patients, the mechanism of ACL injury was noncontact. The mean ± SD age at operation was 28.5 ± 9.9 years, and hamstring tendon autografts were used in 547 (97.5%) patients. The patients who were followed up were representative of the entire cohort for these demographic features (entire cohort: age 28 years; 70% male; 97% hamstring autograft).

Graft Rupture Rate and Risk Factors for Rupture

Graft ruptures occurred in 26 (4.5%) patients at a mean of 80 weeks (range, 14-182 weeks), half of which (13/26) occurred within the first postoperative year. Factors significantly associated with graft rupture included age, mechanism of original ACL injury, family history, and the type of sport to which the patient returned (Table 1). As can be seen from the odds ratios in Table 1, patients who were younger than 20 years at the time of surgery were 6 times more likely to sustain a graft rupture than patients 20 years and older. In addition, a contact mechanism for the original injury and returning to a cutting/pivoting sport each led to a 3-fold and an almost 4-fold increase respectively, and a positive family history a 2-fold increase, in the odds for sustaining a graft rupture.

The variables of sex, chondral damage or meniscectomy at the time of surgery, graft diameter, or having a previous contralateral ACL injury did not affect the odds of sustaining a graft rupture. Since all of these variables other than graft diameter are categorical (ie, have a yes/no response), a frequency distribution table was constructed (Table 2) to further investigate the relationship between graft diameter size and rupture. From this table, it can be seen that the smallest graft size is overrepresented, with 20% of patients sustaining graft ruptures; however, this was only 2 patients, since only 10 patients received grafts of this size. There was no systematic decrease in rupture rates with increasing graft size. Patients who had graft ruptures within the first postoperative year had similar graft sizes to patients who sustained later ruptures (mean graft size of 8.8 vs 8.3 mm, respectively; $P = .2$).

TABLE 1
Incidence and Odds Ratios for ACL Graft Rupture[a]

	Graft Ruptures/ Total	Incidence of Graft Rupture, %	Odds Ratio (95% CI)	*P* Value
Mechanism of injury			3.2 (1.5-7.1)	.005
Contact	16/193	8		
Noncontact	10/368	3		
Sex			1.4 (0.6-3.2)	.44
Male	19/370	5		
Female	7/191	4		
Age, y			6.3 (2.8-13.9)	.0001
<20	15/110	14		
≥20	11/451	2		
Family history			2.4 (1.1-5.3)	.04
Yes	10/123	8		
No	16/438	4		
Chondral injury			1.3 (0.6-2.9)	.61
Yes	9/169	5		
No	17/392	4		
Meniscectomy			0.6 (0.3-1.5)	.29
Yes	7/207	3		
No	19/354	5		
Graft diameter, mm			0.7 (0.2-2.9)	.60
≤7	2/30	7		
>7	24/525	5		
Strenuous activity[b]			3.9 (1.3-9.9)	.01
Yes	22/335	7		
No	4/226	2		
Prior contralateral ACLR			0.5 (0.1-2.7)	.45
Yes	1/44	2		
No	25/517	5		

[a]The graft diameter variable includes only single-bundle hamstring grafts (n = 555). ACLR, anterior cruciate ligament reconstruction; CI, confidence interval.
[b]Strenuous activity refers to sports that involve cutting/pivoting.

TABLE 2
Frequency Distribution of Graft Size and Incidence of Graft Rupture[a]

Graft Diameter, mm	No. of Patients	No. of Ruptures	% Rupture
<7	10	2	20
7	20	0	0
7.5	91	0	0
8	138	5	4
8.5	151	9	6
9	83	6	7
>9	62	4	7

[a]Single-bundle hamstring grafts (n = 555).

Contralateral ACL Injury Rate and Risk Factors for Contralateral ACL Injury

Contralateral ACL injuries occurred in 42 patients (7.5% of the entire cohort or 8.0% excluding the 44 patients with prior contralateral ACL injury). Three factors were significantly associated with contralateral ACL injury. Patients who had returned to a cutting/pivoting sport had an almost 5-fold increase in the odds for sustaining a contralateral ACL injury (Table 3). Being young and having a positive family history also led to 3- and 2-fold increases, respectively, in the odds for sustaining a contralateral ACL injury.

TABLE 3
Incidence and Odds Ratios for Contralateral ACL Injury[a]

	Graft Ruptures/ Total	Incidence of Graft Rupture, %	Odds Ratio (95% CI)	*P* Value
Mechanism of injury			1.2 (0.6-2.3)	.60
Contact	15/171	9		
Noncontact	26/346	8		
Sex			1.9 (0.9-3.9)	.09
Male	32/340	9		
Female	9/177	5		
Age, y			3.1 (1.6-5.9)	.001
<20	17/107	16		
≥20	24/410	6		
Family history			2.2 (1.2-4.4)	.02
Yes	15/114	13		
No	26/403	7		
Strenuous activity[b]			4.9 (2.0-12.2)	.001
Yes	36/310	12		
No	5/207	2		

[a]Excludes patients with prior contralateral anterior cruciate ligament (ACL) reconstruction. CI, confidence interval.
[b]Strenuous activity refers to sports that involve cutting/pivoting.

TABLE 4
Patients With Subsequent ACL Injuries to Either Knee and Patients Who Returned to Strenuous Sport Grouped According to Age[a]

	Age Group, y		
	<20 (n = 110)	≥20 (n = 451)	Total
Subsequent ACL injury to either knee	32 (29)	35 (8)	67 (12)
Returned to strenuous sport	97 (88)	238 (53)	335 (60)

[a]Values are expressed as number (%). ACL, anterior cruciate ligament.

Combined Graft Rupture and Contralateral ACL Injury Rates

Table 4 combines graft rupture and contralateral injury rates. Age group and the type of sport patients returned to are shown separately. For the patients younger than 20 years at surgery, 29% had a subsequent graft rupture or contralateral ACL injury (Table 4). This equates to 1 in every 3.4 patients in the young group. There is also a clear association between age and returning to cutting/

TABLE 5
Risk Factors for ACL Autograft Rupture[a]

Study	Follow-up, y (Range)	Younger Age	Sex	Family History	Contact Injury	Return to Preinjury Sport	Early Return to Sport	Activity Level/Type of Sport/ Athletic Status	Height and Weight	Femoral Notch Width After ACLR	Small Graft	Graft Type	Vertical Graft	Lax Graft	Chondral Damage	Meniscal Damage/ Meniscectomy
Shelbourne et al[22]	—	—	N	—	—	—	—	—	—	N	—	—	—	—	—	—
Salmon et al[21]	5	—	N	N	Y	—	—	Y (moderate/ strenuous)	—	—	—	N	—	—	N	N
Pinczewski et al[20]	10	N	N	—	—	—	—	N	—	—	—	N	—	Y (laxity at 2 y)	—	—
Shelbourne et al[23]	5	Y	Y (young male)	—	—	—	N	—	—	—	—	—	—	—	—	—
Laboute et al[9]	3.5 (3-4)	N	N	—	—	—	Y	N		—	—	N	—	—	—	—
Hui et al[7]	15	N	N[b]	—	—	—	—	—	—	—	—	—	Y	—	—	—
Leys et al[10]	15	N	Y (male)	—	—		—	—	—	—	—	N	Y	—	—	—
Bourke et al[3]	15	N	Y (male)	Y	—	N	—	—	—	—	—	N	—	—	—	N
Bourke et al[2]	15	Y[c]	Y (young male)	—	—	—	—	—	—	—	N	N	Y[c]	Y (laxity at 1 y)	—	—
Magnussen et al[12]	14 mo (6-47 mo)	Y	N	—	—	—	—	—	N	—	Y	—	—	—	—	—
Maletis et al[13]	1.5 (0-5)	#	#	—	—	—	—	—	#	—	—	Y (HS)	—	—	—	—
Park et al[16]	2+	N	N	—	—	—	—	N	N	—	Y (<8 mm)	—	—	—	—	—
Kamien et al[8]	2+	Y	—	—	—	—	—	N	—	—	N	—	—	—	—	—
Current study	5	Y	N	Y	Y	—	—	Y (strenuous)	—	—	N	—	—	—	—	N

[a]ACLR, anterior cruciate ligament reconstruction; HS, hamstring; #, study combined autograft and allograft procedures; —, variable not reported.
[b]Only male patients sustained ruptures.
[c]Significant for univariate but not multivariate analysis.

pivoting sports, whereby 88% of the under 20 group returned to these types of activities compared with only 53% of the older group.

DISCUSSION

In this large cohort study, the rates of graft rupture (4.5%) and contralateral ACL injury (7.5%) were generally consistent with the rates reported in the literature. The rate of contralateral ACL injury was greater than that of graft rupture, which is similar to the meta-analysis data of more than 5 years' follow-up.[30] It has been suggested that the risk for contralateral ACL injury increases with time, but it is currently unclear why this should be the case, and overall there are relatively few prospective studies with long-term follow-up.[30] A recent large-scale multicenter study showed little difference between the percentage of revision ACL procedures (7.7%) and contralateral ACL ruptures (6.4%) at a 6-year follow-up,[6] although in both knees, rates had doubled since a 2-year follow-up.[31] It is difficult to know how population characteristics influence graft rupture and contralateral ACL injury rates and whether this may account for the differences seen between studies. The current literature body does, however, clearly show that, at a minimum, the contralateral knee is just as at risk of ACL injury as the reconstructed side.

The current data showed age to be a significant risk factor for further ACL injury. Specifically, 1 in every 3.4 patients (29%) younger than 20 years at their primary ACL reconstruction surgery had a graft rupture or contralateral ACL injury within the follow-up period of just less than 5 years. Combined ACL rupture and contralateral injury rates for young patients have previously been reported as 17.4% in an under 18-year-old group at 5 years,[23] 25% in a 10- to 25-year age group (average age 16 years) at 1 year,[18] and 12% and 16% in an under 19-year-old group at 5 and 15 years, respectively.[3] Data from the Swedish National ACL registry also show that 22% of female and 9.8% of male soccer players aged 15 to 18 years have further ACL reconstructive surgery within 5 years.[1] Since the Swedish registry only notes further surgery, the reinjury rates are likely to be higher.

Whether age per se is a risk factor or represents a proxy for other factors is not known. There is a clear relationship between being young and returning to strenuous sports that involve cutting and pivoting movements. In this study, 88% of the under 20-year-old group returned to such activities, and therefore this high level of exposure may be related to the high rate of ACL injuries in this group. Shelbourne et al[23] also reported that their younger patient group (<18 years) participated in more strenuous activities both before and after surgery than older patients,

TABLE 6
Risk Factors for Contralateral ACL Injury After Autograft ACL Reconstruction Surgery[a]

	Time of Follow-up	Younger Age	Sex	Family History	Contact Injury	Return to Preinjury Sport	Early Return to Sport	Activity Level	Muscle Strength	Femoral Notch Width	Graft Type	Lax Graft	Meniscal Damage/ Meniscectomy	Chondral Damage
Shelbourne et al[22]	—	—	N	—	—	—	—	—	—	Y	—	—	—	—
Salmon et al[21]	5	—	N	N	N	—	—	Y (moderate/ strenuous)	—	—	N	—	N	N
Pinczewski et al[20]	10	Y	N	—	—	—	—	N	—	—	Y (PT)	N	—	—
Shelbourne et al[23]	5	Y	Y (young female)	—	—	—	N	—	—	—	—	—	—	—
Hui et al[7]	15	Y	N	—	—	—	—	—	—	—	—	—	—	—
Leys et al[10]	15	Y	N	—	—	—	—	—	—	—	Y (PT)	—	—	—
Bourke et al[3]	15	Y[b]	N	Y	—	Y	—	—		—	N	—	N	—
Nakase et al[15]	At reinjury (mean, 22 mo)	N	—	—	—	—	—	N	N	—		N	—	—
Current study	5	Y	N	Y	N	—	—	Y (strenuous sports)	—	—	—	—	—	—

[a]ACL, anterior cruciate ligament; PT, patellar tendon; —, variable not reported.
[b]Significant for univariate but not for multivariate analysis.

and Brophy et al[4] similarly showed that younger patients were more likely to return to soccer after surgery. Greater risk-taking behaviors may also be present in a younger age group, but this has not been extensively studied in sport populations. Recent reports have indicated that neuromuscular impairments are predictive of a second ACL injury in young athletes,[19] and therefore incomplete neuromuscular maturation may also be an age-related risk factor.

A number of patient and surgical factors have been investigated for their association with graft rupture in previous studies, and these factors are summarized in Table 5. For comparison with the present study, the table is limited to studies that only used autografts for the primary ACL reconstruction or reported separately on an autograft group. From this table, it can be seen that other than age and sex, which have been reported on in most studies, many of the other variables have been investigated only by a limited number of studies, so there is clearly more work to be done to confirm the current findings. Risk factors that have been investigated in previous studies for their association with contralateral ACL injury after ACL reconstruction are similarly listed in Table 6. Again, few studies have investigated factors other than age and sex. When interpreting both tables, it is important to note that while an extensive search was conducted for studies that report risk factors of graft rupture or contralateral ACL injury after reconstruction, it was not the intent to conduct a systematic review search strategy. In addition, the statistical approach used by the individual studies varied and, as such, some of the risk factors identified are as a result from univariate models and others from multivariate models.

Studies that have investigated patient sex as a risk factor for graft rupture have either shown no influence or have shown that male patients, particularly young males, are at greater risk (Table 5). In contrast, if there is a sex effect for subsequent contralateral ACL injury, female patients appear to be at greater risk. While this was noted in only one of the studies that specifically investigated risk factors after an autologous graft procedure (Table 6), further studies that report reinjury rates also show an increased incidence of contralateral ACL injuries in females.[4,18] Data published from the Danish ACL registry report no effect of sex on the risk for ACL revision but do report young patients (<20 years) to be at greater risk.[11] Data published from the Swedish ACL registry reveal higher rates of both revision and contralateral ACL reconstruction in young female patients (15-18 years) compared with males.[1] It is therefore reasonable to conclude that, to date, there is not a definitive relationship between sex and the risk for further ACL injury.

Given the limited number of studies, it is difficult to draw firm conclusions about the influence a positive family history has on graft rupture or contralateral ACL injury. While the current data did show that having a positive family history doubled the odds of both graft rupture and contralateral ACL injury, which is similar to the data of Bourke et al,[3] it is not known whether this represents a true genetic risk or rather an active family lifestyle. The current findings are also consistent with previous work, which has shown that people who injure their ACL are twice as likely to have a relative with an ACL tear.[5] Therefore, a family history of ACL injury may well influence the risk of both first and subsequent ACL injuries.

In this study, returning to a sport that involved cutting and pivoting also significantly increased the risk of both graft rupture and contralateral ACL injury. Overall, the findings across the literature are mixed with respect to the association between graft rupture or contralateral ACL injury and activity level. This may in part relate to how activity has been defined. Some studies, like ours, have recorded activity level to reflect the demands of the sport that the patient returns to (ie, strenuous or

not),[20,21] while others have specifically referred to returning to preinjury sport[3] or athletic status.[9] A review by Swärd et al,[26] which includes studies in which not all patients had reconstructive surgery, concluded that a return to high-level sport was the most important risk factor for sustaining a contralateral injury. Studies do not typically account for the amount of athletic exposure, and it is possible that a patient may still return to a strenuous sport but with a reduction or increase in the weekly participation time, and the effect this has on reinjury risk is unclear. In one of the few studies to account for athletic exposure, Paterno et al[18] showed that the ACL injury rate was 15 times greater in people with a past ACL injury compared with a control group. Only 2 studies have investigated whether an early return to sport is associated with graft rupture with contrasting results.[9,23] Given that activity level and the timing of return to sport is a modifiable factor, this needs further evaluation.

Other sport-related factors such as an aggressive playing style may also affect the risk of further ACL injury, but this has not been investigated. Interestingly, more highly skilled female soccer players were reported to have a greater risk for any injury than less skilled players, and it was suggested that this was due to their greater involvement in the game.[24] A reconstruction on the nondominant limb has also been shown to place the dominant limb at risk for future ACL injury in soccer players.[4] Abnormal movement strategies when performing sports-related tasks have been identified in patients who have returned to sport after ACL reconstruction and have been suggested as another potential factor that may increase the risk of subsequent ACL injury.[14,17,19,25,29]

Graft diameter has received recent attention after the publication by Magnussen et al,[12] which showed that small hamstring grafts were a predictor of early graft failure. Park and colleagues[16] also showed greater graft rupture rates in patients with a graft size of less than 8 mm in a mostly nonathletic population at an average 4.5-year follow-up. Interestingly, the same association between graft size and rupture rate was not found when a cutoff of 7.5 mm was used instead of 8 mm. In the current study, there was no statistically significant relationship when a 7-mm or less cutoff was used, which is the same result as recent studies by Bourke et al[2] and Kamien et al.[8] The frequency distribution between graft size and rupture rates did, however, show that the smallest graft size (<7 mm) was overrepresented for graft failure (20% ruptures). However, given that only 10 patients received grafts of this size and that this percentage is based on only 2 graft ruptures, it is difficult to draw robust conclusions. The different length of follow-up times may contribute to the different results observed between studies. However, the patients who ruptured the graft early (within 12 months) in this study did not have significantly different graft sizes than patients who ruptured later.

Although not extensively studied, there is no evidence that the amount of chondral or meniscal damage recorded at surgery, or having a meniscectomy, is a risk factor for graft rupture.[3,21] A group of studies from the same institution has shown that a lax graft[2,20] and vertical graft placement[2,7,10] increase the risk for graft rupture, and careful consideration of the effect of different surgical techniques is therefore required. While the focus of the current study was ACL reconstruction with autografts, it has been suggested that allografts have a higher failure rate both in primary[13,28] and revision[11] ACL reconstruction. Risk factors that have been identified for allograft failure also include younger age as well as earlier return to sport.[27]

The primary limitation of the current study was the inability to conduct multivariate analyses because of the relatively small number of ruptures. Even though the cohort was large, from a statistical viewpoint, there were not enough rupture cases to run a valid multivariate model. Odds ratios, however, were calculated, and these give a good indication of important risk factors. Nonetheless, there is likely to be some overlap between the factors that were investigated in the current study, such as age and physical activity level, and the relative importance of one factor over another cannot be determined. Future studies should be cautioned to check the validity of any multivariate analyses conducted. We also collected radiographic data as part of a routine clinical assessment at 1 year and could have used this to quantify tunnel position. However, since 50% of the ruptures occurred before 1 year and these patients did not return for routine assessment, these radiographic data unfortunately could not be used as they were not representative of the cohort. Finally, it is possible that some patients may have sustained further ACL injury but failed to report this in the survey.

In summary, the results of this study showed that 1 in every 3.5 patients who underwent ACL reconstruction and were younger than 20 years sustained a further ACL injury to either knee within a 5-year period. This high reinjury rate is of concern and has implications for the preoperative advice that is given to younger patients regarding the risk of further injury after ACL reconstruction and postoperative management.

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