■ KNEE

Incidence of graft rupture 15 years after bilateral anterior cruciate ligament reconstructions

A CASE-CONTROL STUDY

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Between 1993 and 1994, 891 patients underwent primary anterior cruciate ligament (ACL) reconstruction. A total of 48 patients had undergone bilateral ACL reconstruction and 42 were available for review. These patients were matched to a unilateral ACL reconstruction control group for gender, age, sport of primary injury, meniscal status and graft type. At 15-year follow-up a telephone interview with patients in both groups was performed. The incidence of further ACL injury was identified through structured questions and the two groups were compared for the variables of graft rupture or further ACL injury, family history of ACL injury, International Knee Documentation Committee (IKDC) subjective score and activity level.

There were 28 male and 14 female patients with a mean age of 25 years (13 to 42) at the time of first ACL injury. Subsequent further ACL injury was identified in ten patients (24%) in the bilateral ACL reconstruction study group and in nine patients (21%) in the unilateral ACL reconstruction control group (p = 0.794). The mean time from bilateral ACL reconstruction to further ACL injury was 54 months (6 to 103). There was no significant difference between the bilateral ACL reconstruction study group and the matched unilateral ACL reconstruction control group in incidence of further ACL injury (p = 0.794), family history of ACL injury (p = 0.595), IKDC activity level (p = 0.514), or IKDC subjective score (p = 0.824).

After bilateral ACL reconstruction the incidence of graft rupture and subjective outcomes were equivalent to that after unilateral ACL reconstructions.

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The risk of contralateral anterior cruciate ligament (ACL) rupture and rupture of a reconstructed ACL is reported to be between 10% and 30% over the long term.[1-4] Bilateral ACL injuries are therefore not uncommon. However, the incidence of subsequent ACL graft rupture in patients following bilateral ACL reconstruction has not been extensively reported. Previous studies examining post-ACL reconstruction injuries have focused predominantly on the potential role of intercondylar notch impingement in contributing to any further disruption where the incidence of re-injury is reported to be between 2% and 10%.[5-8] However, the reports have been mainly case-note reviews, which have not been exclusive to patients who had undergone bilateral ACL reconstruction.[5-8] Knowledge of the incidence of further injury in these circumstances would enable better counselling of patients.

The purpose of this study was to determine the incidence of ACL graft rupture at a minimum 15-year follow-up in patients after bilateral ACL reconstruction matched to a cohort of unilateral ACL reconstructions and evaluate whether any patient characteristics increase this risk.

Patients and Methods

Between January 1993 and December 1994, 891 patients underwent primary ACL reconstruction in a private sports medicine clinic performed by the senior author (LAP). All were included in a prospective knee surgery database. Those seeking compensation for their injury or who did not provide consent to participate in a prospective research database of ACL surgery were excluded. There were 48 patients who had undergone bilateral ACL reconstruction, of whom six were lost to follow-up, leaving 42 available at final review. There were 28 male and 14 female patients with a mean age of 25 years (13 to 42) at the time of the first ACL injury.

Within the original cohort of 48, three patients sustained bilateral ACL ruptures at one injury. The remaining 45 patients suffered an isolated ACL rupture and subsequently sustained a contralateral ACL rupture. From

the available 42 patients, 18 patients underwent simultaneous bilateral ACL reconstructions and 24 patients underwent staged reconstruction, having had their initial isolated ACL rupture and ACL reconstruction before establishing the database in 1993. The ACL reconstruction on the second knee was performed during the study period. Patients were individually matched to a unilateral ACL reconstruction control group in terms of gender, age, sport of primary injury, meniscal status, and graft type using the database. Every ACL reconstruction in the control group was also performed by the senior author (LAP) during the same study period.

A detailed history and clinical examination including the Lachman and pivot shift tests confirmed the diagnosis of complete ACL rupture, as well as examination under anaesthesia and the findings at surgery; MRI was not routinely performed in 1993 and 1994. Ligament reconstruction was offered to those patients with repeated episodes of instability despite completing a physiotherapy-based rehabilitation programme, along with those patients who wanted to return to sporting activities that involved twisting, jumping or sidestepping and who had a positive pivot shift test on clinical examination. Any associated injuries were documented at the time of surgery. Ethical approval was granted by a local independent ethics committee.

The operative techniques have been previously described.[9,10] Either autologous ipsilateral middle third patellar tendon (PT) or four strand gracilis and semitendonosus tendons (HT) were used to reconstruct the ACL. Before October 1993 all patients received PT autograft and after March 1994 HT autograft became the exclusive graft choice for all patients. Between these times both graft types were used. Notchplasty of the bone was not performed. Both proximal and distal graft fixation was achieved with standard roundhead 7 mm × 25 mm titanium cannulated interference screws (Round Cannulated Interference (RCI), Smith & Nephew Endoscopy, Andover, Massachusetts).

All patients followed an accelerated rehabilitation programme that has been previously described.[10] Patients were allowed to full weight-bear immediately and protective braces were not used. Patients were permitted to begin straight-line jogging at six weeks, progressing to side-stepping activities at three months, with full return to sporting activity allowed at six to nine months if rehabilitation targets were met.

All patients, including the control group, were assessed by means of a detailed telephone interview by an independent observer at a minimum of 15 years (mean 16.5 years (15.3 to 18.7)). Patients were questioned about the history and incidence of further injury and ACL graft rupture in either knee, including rupture of the native ACL in the contralateral knee of those patients who had been matched controls with an initially isolated unilateral ACL rupture. Further ACL injury or graft rupture was defined as a previously stable knee becoming subjectively unstable following

a traumatic event to the knee, or a history of revision ACL reconstruction having taken place.

The mechanism of any further injury, any swelling, as well as further knee surgery, symptoms of instability and family history of ACL injury was noted. Family history was considered to be positive if the patient had a first degree relative who had sustained an ACL rupture at any time. Symptoms of knee function were assessed with the International Knee Documentation Committee (IKDC) Subjective Assessment.[11] Activity levels were classified according to the IKDC grades of: 5) very strenuous (e.g., basketball, soccer); 4) strenuous (e.g., skiing, tennis, heavy physical work); 3) moderate (e.g., running, jogging); 2) light (e.g., housework, yard work); or 1) unable to perform any of the above activities.

Statistical analysis. This was performed using SPSS software (SPSS Inc., Chicago, Illinois). The bilateral ACL group and the matched case controls were compared using the Mann-Whitney U test for continuous measurements (mean IKDC subjective score, mean time periods) and ordered categorical variables (IKDC categories, activity level). Chi-squared tests were used for dichotomous variables (family history of ACL injury, further knee injury). Fisher's exact test was use for dichotomous variables if any subgroup count dropped below n = 5. Statistical significance was set at a p-value < 0.05.

Results

The groups were matched for the variables of age (mean 30 years (17 to 48), graft type (19 HT graft and 23 PT graft), gender (28 males, 14 females) and intact menisci (n = 20). The two groups were compared for the variables of further ACL injury, family history, mean IKDC Subjective Score and activity level. The results are shown in Table I. There was no significant difference in IKDC activity levels between the bilateral ACL reconstructions study group and the matched unilateral ACL reconstruction control group (Mann-Whitney, p = 0.514).

Of the 42 patients, 23 received PT autograft in both knees, eight patients received an HT autograft in both knees, and 11 patients received a PT graft in one knee and an HT autograft in the other.

Of 42 patients reviewed, ten patients (24%) suffered further ACL graft ruptures of whom seven were male and three female. One patient who had undergone simultaneous bilateral ACL reconstructions using autologous HT graft suffered bilateral ACL graft ruptures, to the right knee at 36 months and the left at 103 months. The other nine patients suffered one ACL graft rupture each. Of the ten, four patients suffering a further ACL injury re-injured their first injured knee. The mean time from ACL reconstruction to ACL graft rupture was 54 months (6 to 103) and six patients proceeded to revision ACL reconstruction following their ACL graft rupture.

The incidence of further ACL injury in each group is shown in Figure 1. The mean time to further ACL injury

Table I. Subjective outcomes at a minimum follow-up of 15 years (ACL, anterior cruciate ligament; IKDC, International Knee Documentation Committee)

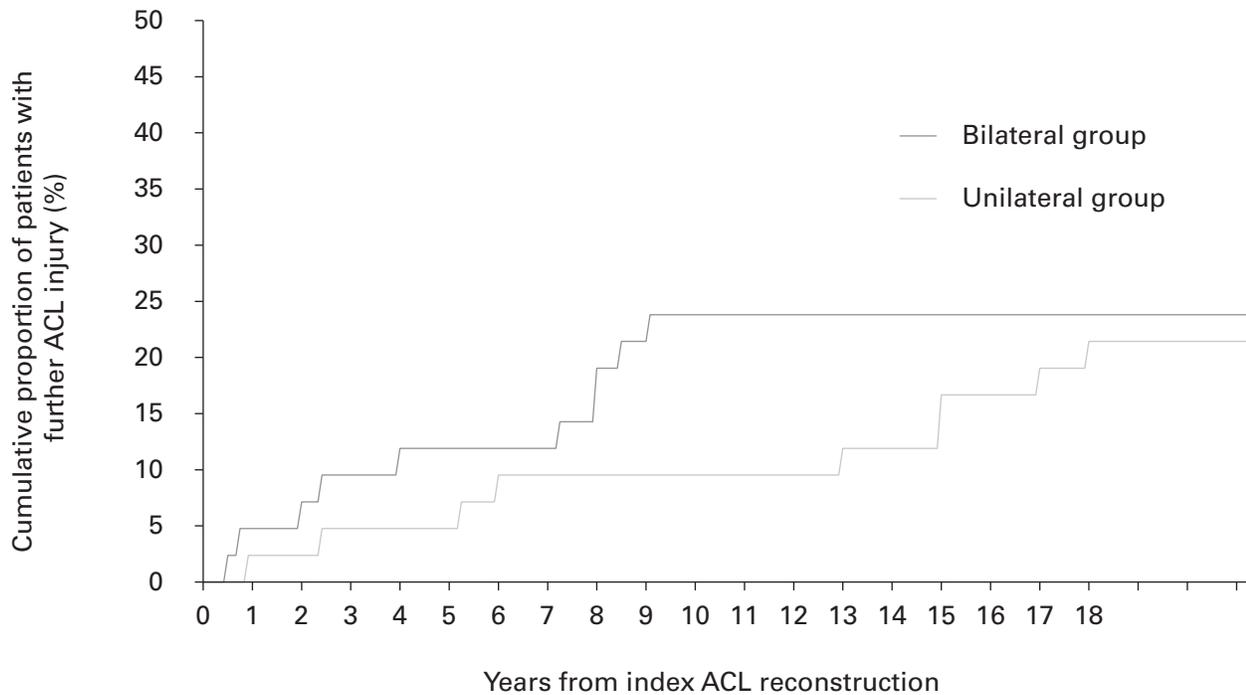| Outcome	Bilateral ACL reconstruction group	Control group (unilateral ACL reconstruction)	p-value
Patients (n)	42	42	
Family history of ACL injury[†] (n, %)	10 (*24*)	8 (*19*)	0.595[*]
Further ACL injury (n, %)	10 (*24*)	9 (*21*)	0.794[*]
IKDC activity level (n, %)			0.514[†]
2	9 (*21*)	11 (*26*)	
3	10 (*24*)	12 (*28.5*)	
4	10 (*24*)	7 (*17*)	
5	13 (*31*)	12 (*28.5*)	
Mean IKDC subjective score (median; range)	85.8 (90; 45 to 100)	84.22 (92; 40 to 100)	0.824[†]
Mean time to graft rupture (mths) (range)	54 (6 to 103)	124 (11 to 216)	0.043[†]

* chi-squared test
† Mann-Whitney U test
‡ considered to be positive if the patient had a first degree relative with an ACL rupture

Fig. 1

Graph showing cumulative proportion of patients with further anterior cruciate ligament (ACL) injury over time.

was 124 months (11 to 216) in the matched unilateral ACL reconstruction control group and 54 months (6 to 103) in the bilateral ACL reconstruction study group (Mann-Whitney, p = 0.043). The incidence of further ACL injury at five, ten and 15 years is shown in Table II.

Table III shows the time between each ACL injury and ACL reconstruction, as well as the time between each ACL injury. The mean time between first and second ACL injury was 58 months (0 to 244).

We were unable to detect a significant effect of gender (p = 0.78), family history (p = 0.60), graft type (p = 0.197)

or meniscal status (p = 0.73, all chi-squared tests) on the incidence of further ACL rupture in the bilateral ACL study group.

Discussion

We found that ten (24%) of the 42 patients who had bilateral ACL reconstruction sustained at least one further ACL injury over the minimum 15-year follow-up period. The ACL graft rupture occurred on the first knee to undergo ACL reconstruction in four of the ten patients. There was no significant difference in the incidence of

Table II. Incidence of further anterior cruciate ligament (ACL) injury in the bilateral ACL reconstruction study group and matched unilateral ACL reconstruction group

Further ACL injury within…	Bilateral ACL reconstruction group	Control group (unilateral ACL reconstruction)	p-value
5 years (n, %)	6 (14)	2 (5)	0.236*
10 years (n, %)	10 (24)	4 (10)	0.07*
15 years (n, %)	10 (24)	9 (21)	0.794†

* Fisher's exact test
† chi-squared test

Table III. Mean time in months (range) between each injury and anterior cruciate ligament (ACL) reconstruction, and time between each ACL injury

	All patients	Staged	Simultaneous	p-value*
Patients	42	24	18	
Mean time from 1st injury to 1st reconstruction (mths) (range)	50 (0 to 245)	14 (0.3 to 58)	97 (1 to 245)	0.001
Mean time from 1st injury to 2nd reconstruction	58 (0 to 244)	50 (6 to 93)	72 (0 to 244)	0.75
Mean time from 1st reconstruction to 2nd injury	-	35 (-52 to 84)†	-	-
Mean time from 2nd injury to 2nd reconstruction	14 (0 to 157)	5.4 (0.3 to 21)	24 (1 to 157)	0.287
Mean time from 1st reconstruction to 2nd reconstruction	26 (0 to 86)	46 (5 to 86)	0 (0)	0.001

* Mann-Whitney U test
† negative range as some patients had already ruptured their contralateral ACL before having had the first side reconstructed

further ACL injury between the bilateral ACL reconstruction study group (24%) and the matched unilateral ACL reconstruction control group (21%) in this series at 15 years (p = 0.794).

Wright et al[3] in their systematic review at minimum five years follow-up reported an ACL graft rupture rate of 6% and contralateral ACL injury rate of 12%, with an overall rate of further injury to either knee of 18%. Bourke et al[1] performed a 15 year survival analysis of unilateral ACL reconstruction and reported a graft rupture rate of 11%, a contralateral knee rupture rate of 14%, with an overall rate of further injury to either knee of 25%. When considered as a mean annual incidence, we found that 1.6% of patients sustained an ACL graft injury per year, which is similar to the incidence of ACL injury after single ACL reconstruction in other series.[1-4,12]

The mean time to further ACL injury occurred significantly earlier in the bilateral ACL reconstruction study group compared with the unilateral ACL reconstruction group (p = 0.043). At ten years there was a trend towards a higher incidence of further ACL injury in the bilateral ACL reconstruction study group (p = 0.07) but by 15 years this difference had resolved (p = 0.794). We were unable to attribute this difference to activity level, as at 15 years no significant difference in activity was evident (p = 0.514). The earlier timing of repeat ACL injury in the bilateral ACL reconstruction study group may reflect differences in the activity level in the first ten years, which was not recorded in this study. Alternatively this finding may reflect a potential for inherent susceptibility to injury in the bilateral ACL reconstruction study group.

Return to sports is one of the major patient objectives following ACL reconstruction. However this increases the exposure to activities with the potential to rupture the graft. In our study there was no significant difference in the final IKDC subjective scores between the bilateral ACL reconstruction study group and the matched unilateral ACL reconstruction control group (p = 0.824). In the bilateral ACL reconstruction study group the IKDC subjective scores were encouragingly high (mean 85.6) and 23 of 42 patients (55%) were still participating in strenuous or very strenuous activities (IKDC grades 4 and 5) at 15 years follow-up. This suggests that patients presenting with bilateral ACL injuries can be counselled in the same way as unilateral ACL injuries with regard to risk of further injury, subjective outcomes, and return to sport following bilateral ACL reconstruction.

Other authors have described gender differences in re-injury rates after primary ACL reconstruction.[1,2,4] Two studies have suggested a familial tendency to primary ACL rupture[5,13] as well as collagen gene defects in patients who sustain ACL injuries compared with a control group,[14] although further studies are required to evaluate the true influence and importance of this gene defect. This reflects the multifactorial nature of ACL rupture.

The ability to detect significant differences between groups of a relatively rare event such as further ACL injury in patients having undergone bilateral ACL reconstruction is a challenge. For example, sample size calculations have determined that to be able to conclude a statistically significant difference in rates of re-injury between the bilateral ACL reconstruction study group at 24% and the matched unilateral ACL reconstruction control group at 21%, with a power of 0.8, would require more than 2300 patients in each group. Therefore not surprisingly we were unable to detect a significant effect of gender (p = 0.78), family

history (p = 0.60), graft type (p = 0.197) or meniscal status (p = 0.73) on ACL graft rupture. This study is only effective in assessing the overall incidence of further injury.

We acknowledge that this study has other limitations. Firstly it is questionable if the results of a study from a single surgeon series can be generalised due to the possibility of selection bias. Secondly graft rupture and further ACL injury were determined only by telephone interview. We relied on the patient's answer to questions to the best of their ability in the absence of objective mechanical testing.

Further ACL injury after bilateral ACL reconstructions occurred in one in four patients over 15 years, which represents an annual incidence of 1.6% per year. However, after bilateral ACL reconstructions the incidence of graft rupture and subjective outcome were equivalent to those after unilateral ACL reconstruction. This information is helpful in counselling patients before surgery.

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