Timing of reconstruction of the anterior cruciate ligament in athletes and the incidence of secondary pathology within the knee

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We reviewed a single-surgeon series of 300 athletic patients who had undergone reconstruction of the anterior cruciate ligament in order to establish the relationship between the timing of the reconstruction and the incidence of meniscal and chondral pathology. The patients were divided into five groups according to the time from their injury to surgery as follows: less than two months, two to six months, six to 12 months, 12 to 18 months and more than 18 months. The presence of meniscal tears was recorded and chondral pathology was scored according to the system of the French Society of Arthroscopy.

There was a significantly higher chance of a medial meniscal tear occurring in patients undergoing reconstruction after one year from their injury (odds ratio (7.99, $p = 0.004$). The odds of having a lateral meniscal tear did not change significantly with an increasing interval to reconstruction. The chance of patients developing degenerative changes was found to be significantly higher in the groups operated on after six months from injury (odds ratio 4.04, $p = 0.005$).

We advocate that patients with deficiency of the anterior cruciate ligament should be counselled that there is a significant relationship between the duration of the instability of their knee and the subsequent incidence of both chondral changes and meniscal tears. In order to minimise these risks, we recommend that reconstruction be performed within the first year from injury.

Reconstruction of the anterior cruciate ligament (ACL) is one of the most common operations in sports injury with an estimated 100 000 procedures performed per year in the United States alone.¹ Despite this, the optimal timing for reconstruction remains uncertain. There has been debate as to the earliest time that it can be carried out safely without compromising the results.² It appears that some consensus has been reached on this issue with most surgeons waiting for the resolution of the acute haemarthrosis and the restoration of normal gait and range of movement. It has also been suggested that any undue delay in surgery may lead to an increase in meniscal pathology from recurrent episodes of instability which could potentiate the risk of developing damage to the articular surface.³ However, there is limited and conflicting evidence to guide the surgeon on the intra-articular consequences of a delayed reconstruction. This is of importance in the counselling of patients on the outcome of surgery and is of particular interest to the patients treated within a health system of finite resources. It may help surgeons to prioritise individuals on a waiting list.

Our aim was to correlate the incidence of medial and lateral meniscal tears and damage to the articular surface with the time from the initial injury to reconstruction of the ACL in an exclusively sporting population. From this, a guideline has been produced as to the acceptable interval from injury to surgery to avoid the development of preventable secondary intra-articular injuries.

Patients and Methods

We reviewed a series of 446 consecutive patients who had undergone reconstruction of their ACL by a single surgeon (RM) between July 2007 and October 2008. Medical notes were retrospectively reviewed to determine the patients' age and gender, the mechanism of injury, the time from injury to reconstruction and whether there was a history of prior knee injury or surgery and evidence of injury to multiple ligaments. The operating notes were analysed for the type of graft, documentation of meniscal pathology on probing and chondral damage scored according to the system of the French Society of Arthroscopy (SFA).⁴

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Table I. Details of the patient groups

Group	Time from injury (mths)	Number	Male	Female	Mean (SD) age (yrs)
A	0 to 2	62	46	16	22.9 (6.4)
B	2 to 6	142	110	32	25.4 (6.6)
C	6 to 12	44	39	5	25.6 (5.2)
D	12 to 18	21	20	1	23.4 (4.6)
E	> 18	31	22	9	30.6 (7.1)
Total		300	237	63	

Table II. The incidence and severity of chondral pathology in the groups, by number and percentage

Group	Grade 0 (%)	Low-grade (1 to 2) changes (%)	High-grade (3 to 4) changes (%)
A	46 (74.2)	12 (19.4)	4 (6.5)
B	93 (65.5)	42 (29.6)	7 (4.9)
C	21 (47.7)	18 (40.9)	5 (11.4)
D	7 (33.3)	10 (47.6)	4 (19.1)
E	6 (19.4)	5 (16.1)	20 (64.5)
Total	173 (57.7)	87 (29.0)	40 (13.3)

Patients were excluded if they had a history of previous ipsilateral knee surgery or injury, a non-sport-related injury, were > 40 years of age or if they had a multiple-ligamentous injury. A total of 146 patients was excluded leaving the remaining 300 for inclusion in our study.

All the procedures were carried out by or directly supervised by the senior author (RM) using a bone-patellar-ligament-bone reconstruction which was only performed once the acute swelling had resolved and the normal range of movement had been restored. Reconstruction was offered to athletic patients who presented with symptomatic instability and who wished to continue their existing level of sporting activity. The mean time from injury to surgery was 42.4 weeks (3 weeks to 13 years). The patients were subdivided into five groups according to this interval as follows: group A, 0 to two months; group B, two to six months; group C, six to 12 months; group D, 12 to 18 months and group E, more than 18 months. The mean age and gender distribution within these groups is given in Table I.

Statistical analysis. Data were analysed using the Stata version 10 software package (StataCorp, College Station, Texas). In order to identify possible confounding factors, a Wilcoxon ranked sum (for age) Pearson's chi-squared test for gender were used to examine the relationship between age and gender and the incidence of secondary changes for the entire group. An equality-of-population test (Kruskal-Wallis one-way analysis of variance) showed an unequal age distribution between the groups and therefore odds ratios (OR) with their 95% confidence interval (CI) for the risk of meniscal tears and chondral pathology were adjusted for age using the Mantel-Haenszel method.⁵

A sample-size calculation was performed based on the findings of Church and Keating³ who demonstrated a rate

of medial meniscectomy of 20.4% within 12 months of injury compared with 40% after 12 months. With prior knowledge that at least two-thirds of our data related to surgery within 12 months, a total sample of approximately 300 was sought. This size ensured a power of 90% to detect a difference at the 5% level.

A p-value of ≤ 0.05 for all tests was considered to be significant.

Results

Chondral pathology. The number of patients with chondral changes found at arthroscopic assessment is shown in Table II. In order to avoid groups with relatively low numbers of subjects, the chondral changes were stratified as follows: normal appearance (SFA 0), low-grade change (SFA grade 1 and 2) and high-grade change (SFA grade 3 and 4). No relationship was found between the incidence of chondral pathology and gender (chi-squared test, $p = 0.651$). However, using the Kruskal-Wallis test, a positive relationship was identified between increased age and the incidence of degenerative change ($p = 0.035$). The number of patients without changes in the articular cartilage fell progressively with an increasing interval to reconstruction (Table II). On the assumption that any acute damage to the articular surface associated with rupture of the ACL would be represented by group A, it was found that the number of patients with intact articular surfaces decreased from 46 (74.2%) to six (19.4%) by 18 months.

The Mantel-Haenszel age-adjusted test showed that there was a significant increase in the odds ratio (OR, 4.04, 95% CI 1.41 to 11.58) of patients having chondral changes after an interval of six months (chi-squared test, $p = 0.005$; Table III). There was also a significantly increased change

Table III. Mantel-Haenszel odds ratios (ORs) for chondral pathology with adjustment for age

Group	No-wear vs grade 1 to 4 wear			Grade 0 to 2 wear vs grade 3 to 4 wear		
	OR	95% CI*	p-value	OR	95% CI	p-value
A	1.00			1.00		
B	1.39	0.68 to 2.83	0.361	0.55	0.15 to 2.00	0.352
C	4.04	1.4 to 11.59	0.005	0.377	0.70 to 20.28	0.096
D	3.99	1.23 to 2.95	0.012	1.6	0.19 to 3.57	0.660
E	12.84	2.40 to 68.77	< 0.001	46.19	2.30 to 970.62	< 0.001
chi-squared for trend of odds = 28.54, chi-squared for trend of odds = 38.32, p-value < 0.001						

* CI, confidence interval

Table IV. Incidence of meniscal tears in the group, by number and percentage

Group	No meniscal tear (%)	Medial tear (not excluding lateral tear) (%)	Lateral tear (not excluding medial tear) (%)	Both torn (%)
A	24 (38.7)	9 (14.5)	33 (53.2)	4 (6.5)
B	55 (38.7)	21 (14.8)	72 (50.7)	6 (4.2)
C	14 (31.8)	11 (25.0)	21 (47.7)	2 (4.5)
D	4 (19.0)	11 (52.4)	12 (57.1)	6 (24.6)
E	3 (9.7)	22 (71.0)	19 (61.3)	13 (41.9)
Total	100 (33.3)	74 (28.6)	157 (52.3)	31 (10.3)

Table V. Mantel-Haenszel odds ratios (ORs) for meniscal tears with adjustment for age

Group	Medial meniscus		Lateral meniscus		Both menisci torn	
	OR (95% CI)*	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
A	1.00		1.00		1.00	
B	1.04 (0.43 to 2.50)	0.86	0.89 (0.25 to 3.16)	0.84	0.89 (0.25 to 3.16)	0.85
C	1.20 (0.33 to 4.47)	0.83	0.81 (0.11 to 5.62)	0.98	0.81 (0.11 to 5.62)	0.83
D	7.99 (1.48 to 43.06)	0.02	8.74 (1.05 to 72.94)	0.90	8.74 (1.05 to 72.94)	0.02
E	12.10 (2.82 to 51.7)	0.001	12.11 (1.44 to 101.60)	0.80	12.1 (1.44 to 101.60)	0.00
chi-squared for trend of odds = 31.88, chi-squared for trend of odds = 1.21, chi-squared for trend of odds = 23.82, p-value < 0.001						

* CI, confidence interval

(OR 46.19, 95% CI 2.20 to 960.62) of patients developing high-grade as opposed to low-grade changes by 18 months (chi-squared test, $p < 0.0001$). Table III also shows that with increasing time from injury to surgery there was an increased likelihood of the development of articular surface wear (SFA grade 1 to 4) (chi-squared test, $p = 0.0000$) and that this was likely to be high-grade damage (SFA grade 3 to 4) (chi-squared test, $p < 0.0001$).

Meniscal tears. We found no significant relationship between the presence of a meniscal tear and age or gender (Wilcoxon ranked sum test, $p = 0.117$, chi-squared test, $p = 0.806$). The incidence of medial and lateral meniscal tears within the groups is shown in Table IV with a higher proportion of tears in the medial meniscus occurring with increasing time from injury. Taking group A as a reference for the incidence of meniscal tears associated with the acute rupture of the ACL, the calculated OR for the likelihood of developing a secondary meniscal tear showed that there was a statistically significant trend for the development of

medial (chi-squared test, $p < 0.0001$), but not lateral (chi-squared test, $p = 0.270$), pathology (Table V). Using the Mantel-Haenszel age-adjusted chi-squared test a significantly higher relative odds of medial meniscal pathology (OR 7.99, 95% CI 1.48 to 43.06) was found if the duration of time from injury to reconstruction exceeded one year (chi-squared test, $p = 0.004$).

The mean interval to reconstruction for patients older than 30 years at the time of surgery was 54.6 weeks (4 to 412) compared with 33.4 weeks (3 to 206) for those under 30 years of age. This difference was statistically significant (Fisher's exact test, $p = 0.001$).

Discussion

Our results suggest that most lateral meniscal tears occur at or around the time of injury to the ACL, whereas medial meniscal tears tend to appear later possibly due to instability of the knee. We feel that the association between a delayed reconstruction and an increased chance of a medial

meniscal tear is clinically important. A tear will alter the ability of at least part of the meniscus to transmit load and it has been shown that an abnormal meniscus alters the biomechanics of the knee resulting in accelerated degenerative arthritis.⁶ There is also evidence that patients with reconstruction of the ACL combined with a meniscectomy have an increased risk of arthritis compared with those who have an isolated injury to the ACL.⁷⁻¹²

There are only a limited number of published studies which have investigated the relationship between a delay in reconstruction and the incidence of secondary pathology. Church and Keating³ reviewed 187 patients divided into those who had reconstruction early (less than 12 months) or late (more than 12 months). They found a significant increase in degenerative changes of grade 1 to 4 (31.3% *vs* 10.7%) and also in the overall incidence of meniscal tears in the late group (71.2% *vs* 41.7%). This was attributable, in the main, to medial but not lateral pathology. Papastergiou et al¹³ retrospectively studied 451 patients who had undergone reconstruction and who were divided into six groups according to the time from injury. They examined the incidence of meniscal tears, but did not study changes in the articular surface. They found an increased overall incidence of meniscal tears (medial and lateral) when treatment was delayed beyond three months. Compared with our results, they found an increased incidence of medial and a reduction in lateral meniscal tears in their baseline study group. These differences may arise from the application of different exclusion criteria. We included only patients without a history of previous knee injury or surgery under the age of 40 years. In doing so, we hoped to have removed the factor of the presence of pre-existing structural changes within the knee which would have confounded the data. In addition, 10.9% of their population had non-sporting injuries and 14.1% had a co-existing medial collateral injury. The higher recorded incidence of lateral tears in our group is because we included all tears found on probing and specifically those deemed to be stable and left *in situ*. These tears are a common finding and have been shown to do well with conservative treatment.¹⁴

While in broad terms our results support the previously published literature,^{3,13} there are some differences in the suggested interval during which surgery should be performed. The larger numbers of patients in our study relative to that of Church and Keating³ allowed us to examine the early patients in narrower time-bands, without compromising statistical power and in so doing to exclude significant differences in the incidence of secondary meniscal tears earlier than 12 months. Papastergiou et al¹³ found a significant increase in meniscal tears at an interval to reconstruction of greater than three months. However, increases in either medial or lateral meniscal tears alone were not found to be significant before this time. Considering their medial meniscal tears separately, this broadly supports our finding of a significant difference occurring after a delay of more than six months when differences in exclusion criteria are

reconciled. Consideration of medial and lateral tears separately is justified, since in our data we found a large proportion of lateral meniscal tears to be partial or stable and if found in isolation would be of questionable clinical significance.¹⁴

In our late group (E) we found a higher incidence of both meniscal tears and degenerative changes. All patients were regular participants in pivoting sports such as football, rugby and Gaelic games and those who had a prolonged interval to reconstruction had all attempted to return to their pre-injury activity, but subsequently became dissatisfied with the stability of their knee. This desire to return to activity despite instability is reflected in the high incidence of medial meniscal pathology in this group (71%/22 patients) and grade 3 to 4 changes (64.5%/20 patients).

We noted that older patients delayed reconstruction longer than younger patients possibly because they had other considerations which caused them to defer surgery. This may become particularly important since it has been shown that older patients with meniscal injuries demonstrate a more rapid progression of degenerative change.¹⁵ We feel that the finding of a positive relationship between increased age and the incidence of degenerative change is to be expected, and reflects the vulnerability of these patients to developing degenerative wear secondary to meniscal damage.¹⁵ We therefore suggest that these older and yet still active patients should, in fact, be prioritised for early reconstruction of the ACL.

A considerable strength of our study is that we have been able to examine a large group of patients with all procedures being performed by a single surgeon (RM). This is important since the identification of pathology during knee arthroscopy has been shown to be prone to interobserver error^{16,17} and may limit the conclusions of previous studies.¹⁸ Applying strict exclusion criteria we have examined the results of isolated ACL injuries occurring in an exclusively sporting population and assessed the potential benefits of reconstruction at less than a year from injury compared with those when surgery was delayed. Our findings indicate that delayed reconstruction is strongly associated with an increased likelihood of both medial meniscal tears and degenerative changes in the articular surface. We found that there was a significant reduction in the number of patients with normal articular surfaces after a delay of six months. It is possible that these macroscopic low-grade changes have evolved from the damage to the articular surface caused by the major initial episode of femorotibial subluxation. These areas would then be at risk of further deterioration to high-grade changes if subjected to subsequent instability and made even worse by the additional insult of meniscal tears and dysfunction. While we acknowledge that reconstruction alone does not remove the threat of the future development of arthritis,^{9,11,19-21} we advocate that reconstruction should be performed before 12 months from injury to reduce the chance of the occurrence of instability-induced medial meniscal tears. We feel

that this approach may confer a longer-term benefit in reducing late degenerative change.

Supplementary material

A further opinion by Mr Sam Church is available with the electronic version of this article on our website at www.jbjs.org.uk

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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