THE JOURNAL OF BONE & JOINT SURGERY (BRITISH)

A comparison of early and delayed arthroscopically-assisted reconstruction of the anterior cruciate ligament using hamstring autograft

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Delayed rather than early reconstruction of the anterior cruciate ligament is the current recommended treatment for injury to this ligament since it is thought to give a better functional outcome. We randomised 105 consecutive patients with injury associated with chondral lesions no more severe than grades 1 and 2 and/or meniscal tears which only required trimming, to early (< two weeks) or delayed (> four to six weeks) reconstruction of the anterior cruciate ligament using a quadrupled hamstring graft. All operations were performed by a single surgeon and a standard rehabilitation regime was followed in both groups. The outcomes were assessed using the Lysholm score, the Tegner score and measurement of the range of movement. Stability was assessed by clinical tests and measurements taken with the KT-1000 arthrometer, with all testing performed by a blinded uninvolved experienced observer. A total of six patients were lost to follow-up, with 48 patients assigned to the delayed group and 51 to the early group. None was a competitive athlete. The mean interval between injury and the surgery was seven days (2 to 14) in the early group and 32 days (29 to 42) in the delayed group. The mean follow-up was 32 months (26 to 36).

The results did not show a statistically significant difference for the Lysholm score ($p = 0.86$), Tegner activity score ($p = 0.913$) or the range of movement ($p = 1$). Similarly, no distinction could be made for stability testing by clinical examination ($p = 0.56$) and measurements with the KT-1000 arthrometer ($p = 0.93$).

Reconstruction of the anterior cruciate ligament gave a similar clinical and functional outcome whether performed early (< two weeks) or late at four to six weeks after injury.

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doi:10.1302/0301-620X.92B4.22973 $2.00

J Bone Joint Surg [Br] 2010;92-B:521-6.
Received 23 June 2009; Accepted after revision 14 January 2010

The anterior cruciate ligament (ACL) is the primary stabiliser of the knee against anterior translation of the tibia relative to the femur and is important in counteracting rotational and valgus stresses.[1-3] It is the most commonly torn ligament in the knee and is a more common injury in female patients.[4,5] Reconstruction of the ACL-deficient knee is accepted as standard treatment for young and active patients.

Reconstruction of the ACL allows the patient to resume sporting activities and is reported to delay the onset of osteoarthritis which is associated with loss of meniscal function.[6-11] There is uncertainty regarding the timing of surgery with both early and late reconstruction being advocated. Shelbourne and Patel[12] recommended reconstruction after three weeks to prevent the occurrence of arthrofibrosis, and this view has been expressed by others.[13-15] One report found an increased incidence of arthrofibrosis if surgery was performed within a week and recommended that surgery be delayed for at least three weeks.[14] Post-operative stiffness has been well documented by various studies.[16-18] A number of authors have suggested that early surgery adversely affected the outcomes.[19-24] Two studies using hamstring tendons for reconstruction of the ACL compared the outcome after early or delayed reconstruction.[25,26] Meighal, et al[25] recommended that there was no functional advantage following early reconstruction of the ACL. Botoni et al[26] and did not observe any loss of motion following early reconstruction. Daniel et al[28] have reported a higher incidence of arthritis of the knee after surgical treatment.

We have compared the clinical and functional outcome of arthroscopically-assisted reconstruction of the ACL using a quadrupled hamstring autograft performed early (< two weeks) with that performed late (> four to six weeks) after injury.

Patients and Methods

Our study was approved by the institutional review board and informed consent was obtained from all the patients. We included

patients who presented to the emergency department of our hospital and were diagnosed with a torn ACL as seen on an MR scan. We excluded those with concomitant ligamentous injuries, ipsilateral long-bone injuries and the requirement of an additional procedure such as meniscal repair on the same knee, aged under 18 years, any previous injuries or operations on the same knee, and Outerbridge grade-3 and grade-4 chondral injuries detected intra-operatively. Patients requiring meniscal trimming or trimming of chondral injuries of less than grade 3 on the O'Connors classification system[29] were not excluded.

Between August 2004 and November 2006, 115 patients presented with rupture of the ACL. Of these, ten were excluded because of the presence of grade-3 or grade-4 chondral lesions or repairable meniscal injuries. The remaining 105 patients were randomly allocated into one of two groups using a computer-generated randomisation sequence. The patients who were selected for early surgery had the procedure within one day. Those in the delayed surgery group underwent a pre-operative rehabilitation programme which included range-of-movement exercises on the knee and hamstrings and quadriceps strengthening exercises. Additionally, a hinged brace was applied which was locked in extension for walking, with weight-bearing allowed as tolerated. When not walking they were allowed a full range of knee movement in the brace.

At the initial evaluation a detailed clinical history was obtained regarding the mechanism of injury. The surgical procedure was standardised for all patients and was carried out by the same surgeon, (GK). All were operated on under bupivacaine epidural anaesthesia.

An examination under anaesthesia was performed before inflation of the tourniquet and included the Lachman, anterior-drawer and pivot-shift tests. Cefuroxime (1 g) was given intravenously as prophylaxis. An initial arthroscopy was undertaken to confirm the diagnosis and to assess any associated injuries with chondroplasty and any meniscal trimming performed as required. A quadrupled hamstring graft was fashioned from harvested semitendinosis and gracilis tendons in all patients. A Biotransfix system (Arthrex, Naples, Florida) was employed for femoral fixation and a Biointerference screw (Arthrex) was used on the tibial side. The rehabilitation protocol was the same in both groups. Non-steroidal anti-inflammatory drugs were not administered for the first two weeks after surgery.

Operative technique. The hamstring autograft was harvested using a tendon stripper through a small incision near the insertions of gracilis and semitendinosis. A quadruple construct was made and held with Ethibond stitches on either side.

After preparing the tibial tunnel using a standard guide, a transtibial technique was used to make the femoral tunnel. This was accomplished using a 7 mm offset guide (Arthrex) with the femoral tunnel made up to a length of 40 mm. The Biotransfix system guide was used to make a slot for the proximal fixation of the graft with a Biotransfix screw. A nitinol wire was passed through this slot and was subsequently pulled out into the tibial tunnel by the standard guide system. This wire was then used to draw the autograft into the femoral tunnel. Once in the tunnel care was taken to make sure that there was a smooth passage of the wire over the graft.

The Biotransfix screw was passed over the nitinol wire and tightened. The graft was pulled distally to ensure that fixation was complete. The nitinol wire was removed and the knee cycled 20 times to eliminate any creep in the graft. Distal fixation of the graft to the tibia was carried out using a Biointerference screw with the knee in 20° of flexion. Placement of the screw was confirmed under arthroscopic guidance, the tension in the reconstructed ligament was checked using a probe and a Lachman test performed. The knee was irrigated and the portals and medial tibial wounds were closed. No drains were used at the site of the tibial incision. The knee was injected with 10 ml of lidocaine (2% plain) and 10 ml of bupivacaine (0.5% plain).

Post-operative analgesia was provided with tramadol for 24 hours. A single dose of subcutaneous fondaparinux (2.5 mg) was given six hours post-operatively. The patient was mobilised and discharged on the first post-operative day.

Post-operative rehabilitation. Post-operatively, the patients were placed in a hinged knee brace and touch weight-bearing was allowed for two weeks, during which time the range of movement was restricted to 0° to 90° of flexion. Subsequently, they progressed to weight-bearing as tolerated with the range of movement no longer restricted, but with wearing of the brace for six weeks.

Rehabilitation consisted of a progression through range-of-movement exercises, patellar mobilisation, electrical stimulation if needed, and proprioceptive and closed-chain strengthening exercises during the first three months after operation. This was followed by straight-line jogging and exercises specific to the patients' preferred sport. The patients were followed up at intervals of two, six and 12 weeks post-operatively, then at six months and thereafter at six-monthly intervals. They were allowed to return to their pre-injury sporting leisure activities at a minimum of six months after reconstruction, using a custom-made brace which was discarded nine months post surgery.

Clinical evaluation of joint function and stability. The range of movement of the knee was measured with a goniometer with the patient supine using fixed anatomical landmarks and taking the mean of three values. The heel was elevated on a support to determine if there was passive hyperextension while active knee extension was measured by asking the patient to perform a straight-leg raise against gravity. The range of movement was recorded for both the involved and normal sides. Examination for laxity included the Lachman, pivot-shift, anterior-drawer, and varus/valgus stress tests. The assessment of clinical function and joint laxity was undertaken by a single blinded observer, who was a physiotherapist with 15 years experience and had not been involved in the surgery.

Table I. Demographic data

	Early	Delayed	
	< 2 weeks	4 to 6 weeks	p-value
Number of patients	51	48	0.423
Gender			
Male	25	26	
Female	26	22	
Mean age in yrs (range) (SD)	31.6 (5.3)	31.2 (5.3)	0.693
Duration since injury in days mean (range)	7 (2 to 14)	32 (29 to 42)	-
Operative time in mins, mean (SD)	64.9 (7.8)	64.2 (7.8)	0.688
Day of suture removal	14	14	1.0
Number of side			
Left	29	22	-
Right	22	26	
Mechanism of injury			
Self fall	23	15	
Sports injury	21	24	
Traffic accident	7	9	
Sporting activity			
Soccer	12	12	
Cricket	12	15	

The Lachman test was graded as normal if there was side-to-side difference of < 5 mm and abnormal if this was > 5 mm. The pivot-shift test was graded as normal in the absence of a clunk or abnormal if a clunk was felt. Anterior tibial translation was measured using the KT 1000 arthrometer (MEDmetric Corporation, San Diego, California) with the knee positioned in 25° to 30° of flexion. Both knees were measured and the side-to-side difference in anterior tibial translation was determined. The Lysholm and Tegner activity scores[30] were also recorded.

Statistical analysis. Considering the proportion of patients of at least 70% to be significantly different with the primary outcome between the two groups and a null value of 50, it was estimated that 47 patients per group were required with an α-level of 0.05 and a power of 80%. The outcome scores in both the groups were compared using the independent Student's *t*-tests. The Bonferroni[31] correction was used to correct for multiple testing at the different time intervals. The chi-squared test was used for the comparison of categorical data. The data are presented as the mean (SD) and the statistical analysis performed using SPSS version 14 software for Windows (SPSS Inc., Chicago, Illinois). A p-value ≤ 0.05 was considered to be statistically significant.

Results

Of the 105 patients entered into the study, six were lost to follow-up. Of the remaining 99, 51 were in the early and 48 in the delayed group. Their mean age was 31.4 years (19 to 38). The mean period between injury and the operation was seven days (2 to 14) in the early group and 32 days (29 to 42) in the delayed group. The mean follow-up was 32 months (26 to 36). The distribution of age, gender and mechanism of injury for each group is given in Table I. None was a competitive athlete who had participated in sport at state or national level. The sporting activities in both the groups were similar (cricket; early group-12, delayed group-15. Soccer; early group-12, delayed group-14). Of the 99 patients 60 had chondral and 73 had meniscal injuries. The distribution of these injuries in both the early and delayed groups were comparable (Table II). All the meniscal tears identified were either debrided or underwent partial excision. The chondral injuries were either Outerbridge grade 1 or grade 2.

The recovery of the range of movement at various intervals showed no statistical difference between the two groups (Table III). No statistically significant difference was found for the Lysholm score (p = 0.86) and Tegner activity score (p = 0.913). Stability testing by clinical examination (p = 0.56) and measurements on the KT-1000 arthrometer (p = 0.93), were comparable in both groups (Table IV).

Complications. Two patients in the early group had a superficial wound infection around the site of the tibial tunnel, which responded to treatment with oral antibiotics. One patient in the delayed group had pain at the site of insertion of the tibial screw at six weeks which had resolved at the 12-week follow-up.

None of the patients in either group required revision at the last follow-up.

Table II. Associated chondral and meniscal injuries of review for both groups

	Early	Delayed	p-value
Chondral injuries			
Medial femoral condyle	8	9	< 0.05
Lateral femoral condyle	12	10	< 0.05
Patella	6	8	< 0.05
Femoral trochlea	3	4	< 0.05
Meniscal injuries			
Medial	18	13	< 0.05
Lateral	-20	22	< 0.05

Table III. Progession of range of motion (ROM)

	Early	Delayed	
	< 2 weeks (n = 51)	4 to 6 weeks (n = 48)	p value
Mean ROM 4 weeks (°)			
Flexion loss	17 (15 to 19)	15 (14 to 17)	0.542
Extension loss	7 (6 to 8)	5 (6 to 8)	
Mean ROM 8 weeks (°)			
Flexion loss	12 (10 to 13)	10 (8 to 11)	0.752
Extension loss	5 (4 to 7)	3 (0 to 5)	
Mean ROM 12 weeks (°)			
Flexion loss	5 (0 to 7)	5 (0 to 7)	1.0
Extension loss	0	0	
Mean time taken for full ROM			
14 weeks	11 to 16	12 to 17	0.974

Table IV. Outcome scores at last follow-up

	Early (n = 51)	Delayed (n = 48)	p-value
Lysholm score (range)	83.1 (80 to 90)	84.2 (82 to 90)	0.860
Tegner score (range)	6.1 (5 to 8)	5.9 (5 to 8)	0.913

Discussion

Our findings show that arthroscopically-assisted reconstruction of the ACL using a quadrupled hamstring autograft gives a similar clinical and functional outcome irrespective of the timing of the procedure. Furthermore, no significant differences were found between the groups for the recovery of the range of movement. This finding suggests that reconstruction can be reasonably undertaken at any time within six weeks of injury without compromising the outcomes.

There are no criteria which define the timing of early or late surgery for reconstruction of the ACL. Bottoni et al,[26] classified early as within 21 days and delayed as beyond six weeks. Meighan et al,[25] described early as less than two weeks and delayed between eight and 12 weeks. Majors and Woodfin[23] considered early to be one to 14 days, delayed between 15 and 28 days and late more than 28 days.

Stiffness of the knee is a well-recognised complication after reconstruction of the ACL. Early reconstruction has been associated with an increased incidence of stiffness and prolonged rehabilitation.[13-15] However, the post-operative rehabilitation has varied and in some series there have been associated injuries which have required reconstruction and which may have compromised the ultimate range of movement.[15] Only one prospectiv6 study has supported early reconstruction. Bottoni et al[26] reported an excellent outcome after reconstruction within three weeks of injury and suggested that as long as aggressive rehabilitation was followed the outcome would not be compromised. Meighan et al[25] in a prospective study using hamstring tendons reported that there was no advantage in early reconstruction of isolated tears of the ACL, but found a higher rate of complications. In their study, delayed surgery was reported to give a rapid return of movement and muscle function. However, one year after surgery there was no difference between early and

delayed reconstruction in terms of muscle function, range of movement and the functional outcome.

We found that there was no significant difference in the recovery of the range of movement at any interval (Table III). Additionally, the final follow-up Tegner and Lyshom scores were comparable in both the groups, indicating that the functional outcome was similar in early and delayed reconstruction.

It has been reported that delayed reconstruction of the ACL is associated with an increase in the incidence of associated damage to the menisci and articular cartilage.[27,32-34] Our delayed patients were treated before two months after injury unlike the delayed patients reported elsewhere.[32] However, the increased incidence of meniscal damage with delayed surgery has not been found in every series.[26]

In our study the inclusion criteria were strict so that only isolated injuries of the ACL and meniscal injuries which required only limited debridement were included. Chondral injuries more severe than grade 3 or grade 4 were excluded.

The classical report of O'Donoghue[35] described the association of medial meniscal injury with tears of the ACL. In our study both groups had a greater number of lateral meniscal than medial meniscal tears although this difference was not statistically significant (Table II). The predominance of tears of the lateral meniscal has been observed elsewhere.[36,37]

In our study a goniometer was used by a blinded single observer to measure the range of movement as was described by Meighan et al.[25] Criticism of the goniometer method was made by Austin, Phornphutkul and Wojtys[38] because of the level of the interobserver difference. Readings with a goniometer were taken by an experienced physiotherapist since this is a simple and inexpensive method of measuring the joint angle. A set protocol was followed and the same anatomical landmarks were used.

Accelerated protocols of knee rehabilitation with early movement after reconstruction of the ACL are now common and have not been associated with an increase in complications or morbidity.[39] We believe that the early mobilisation and rehabilitation of our patients accounted for the prompt recovery of movement. Our findings are similar to those of Hunter et al[22] who also concluded that by using modern arthroscopic surgical techniques and an aggressive post-operative protocol of physiotherapy, movement and stability could be restored in a high proportion of patients and that surgical success was independent of the timing of surgery.

The strength of our study is the large number of patients included, the prospective documentation of the data, strict inclusion criteria, and minimal loss to follow-up. We recognise that the exclusion of patients with coexistent grade-3 and grade-4 chondral injuries and meniscal injuries requiring repair, meant we had selected patients who were likely to have a more favourable outcome. Theoretically those injuries might have detracted from the results since the rehabilitation would have had to have been tailored according to these additional injuries.

Supplementary material


A further opinion by Dr C. Frank 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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