ORIGINAL PAPER

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Bone-patellar tendon-bone reconstruction of the anterior cruciate ligament

A long-term comparison of early and late repair

Accepted: 12 July 1999

Abstract Ninety-one patients were assessed 5–9 years after an anterior cruciate ligament reconstruction (bone patella-tendon bone autograft). Forty-eight patients had been treated within 6 weeks of the injury (Group I) and 43 patients more than 3 months after the injury (Group II). 73 patients had either a normal or nearly normal final outcome. The mean Lysholm score was 82 and the mean Marshall score was 42. Eighty nine patients had normal or nearly normal stability in the operated knee when compared to the contralateral joint. In none of these results was there any significant difference between the groups. Results of functional and of isokinetic strength tests, as well as the presence of anterior knee pain, were also similar in both groups. However, patients with early reconstruction had fewer degenerative changes in the tibio-femoral joint and were more satisfied with the result. They also returned to their pre-injury level of sports activity more often than those patients in the late reconstruction group.

Résumé Nous avons revu quatre-vingt douze patients ayant eu une reconstruction du ligament croisé antérieur du genou par autogreffe os-tendon rotulien-os, avec un recul de 5 à 9 ans. Quarante-huit patients ont été opérés dans les 6 semaines suivants le traumatisme (groupe I) et quarante-trois patients plus de trois mois après le traumatisme (groupe II). Soixante-trois patients ont un résultat normal ou presque normal. Le score Lysholm a été 82 et le score Marshall a été 42. La stabilité du genou opéré

a été normale ou presque normale dans quatre-vingt neuf cas. Il n'y a pas eu de différence significative dans les deux groupes. Le résultat des tests fonctionnels, la force musculaire isokinétique et la douleur résiduelle dans le genou ont été similaires dans les deux groupes. Cependant, dans la reconstruction précoce il y a eu moins de lésions dégénératives de l'articulation tibio-fémorale, moins de gêne ou de douleurs et le retour à l'activité sportive a été plus fréquent. Nos résultats montrent que la réparation précoce est préférable.

Introduction

The bone patella-tendon bone (BTB) autograft procedure has given good and predictable long-term results [14, 17], and today this reconstruction of the anterior cruciate ligament (ACL) is considered the gold standard procedure [4, 5, 13, 17]. However, the optimal time for the reconstruction remains controversial. Some studies have shown that the risk of stiffness may increase if the reconstruction is done too soon after injury [15]. Other studies have reported no difficulties in obtaining a full range of knee movement after early ACL repair [7, 11]. The aims of this study were to assess the results of the BTB reconstruction (using a mini-arthrotomy technique) 5–9 years after the procedure, and to compare the results between reconstruction within 6 weeks as opposed to surgery after a delay of more than 3 months.

Materials and methods

Between January 1989 and December 1991, 144 patients underwent ACL reconstruction (using the middle-third BTB autograft and a mini-arthrotomy technique). Of these, 130 were contacted and interviewed with a questionnaire; 101 patients were able to attend for examination. In 53 patients, reconstruction had been done within 6 weeks of injury, while in 48 patients reconstruction was performed more than 3 months after injury. In 10 patients an ACL reconstruction was performed on the contralateral knee during the follow-up period, and these patients were excluded from the statistical analysis as it was thus impossible "to compare" the injured

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Table 1 Gender, age, delay between injury and reconstruction, and follow-up time of the 2 analyzed groups. Mean (range)

Group	Sex	No.	Age (years)	Delay	Follow-up (years)
Group I	M	29	}32	}6 days	}7.0
	F	19	}(15–61)	}(0–43)	}(5.9–8.5)
Group II	M	34	}30	}3.7 years	}7.0
	F	9	}(16–46)	}(0.3–20)	}(4.6–8.8)

Table 2 Surgical procedures before ACL reconstruction

Procedure	Group I <i>n</i> =53	Group II* <i>n</i> =48
Diagnostic arthroscopy	2	4
Medial menisectomy (partial or total)	1	6
Lateral menisectomy (partial or total)	0	1
Medial and lateral menisectomy (partial or total)	0	4
Primary repair of the ACL	0	2
ACL reconstruction (failed)	0	4
Other	0	3
Total	3	24

* $P<0.005$ for the group difference

knee. For review, therefore, there were 48 patients with early reconstruction (Group I) and 43 patients with late reconstruction (Group II). Information on these 2 groups can be seen in Tables 1 and 2.

At presentation the ACL ($n=130$) was found to be totally torn and functionless in all patients. Sixteen also had medial collateral ligament (MCL) instability, 4 lateral collateral ligament (LCL) instability, 5 a meniscal rupture, 3 rupture of the posterior cruciate ligament (PCL), and 3 an unhappy triad of injury to the ACL, MCL and medial meniscus. Fifteen of the 16 MCL ruptures, all 4 LCL ruptures, and 2 of the 3 PCL ruptures were treated surgically (primary repair). Two of the 35 meniscal ruptures were sutured, and the remaining 33 were treated by partial or complete meniscus resection. The three “unhappy triad” cases were treated surgically (primary repair of the MCL, resection of the medial meniscus and BTB reconstruction of the ACL).

Surgical technique and rehabilitation

A mini-arthrotomy surgical technique was employed using a BTB autograft with screw fixation as previously described [5]. After surgery the knee was immobilised in 35° of flexion by a brace for the first 2 weeks, and non weight-bearing was allowed. After 2 weeks the hinges of the brace were adjusted to allow movement from 30° to 60° and weight-bearing was gradually increased. Isometric quadriceps muscle exercises were started on the first operative day, and these were followed by isotonic quadriceps training. The brace was removed 5–7 weeks after surgery. Full weight-bearing was allowed when there was full extension of the knee. Running was allowed 12–16 weeks after surgery but ball games were prohibited until 6 months after reconstruction.

Complications

Post-operatively there were 4 wound infections (1 in Group I and 3 in Group II), and 2 venous thromboses (both in Group I). In Group I, 2 manipulations under anaesthesia and 7 arthroscopic divisions of adhesions were required, while 5 arthroscopic divisions for adhesions were done in Group II because of stiffness. Four patients sustained further injury to the reconstructed knee (2 in Group I and 2 in Group II) but only 1 re-reconstruction of the ACL was needed (in Group I).

Clinical follow-up was done by one surgeon (TJ) who had not operated on any of the patients. Assessment was performed using the standard knee ligament evaluation form of the International Knee Documentation Committee (IKDC), and the Lysholm (0–100 points) [6] and the Marshall (0–50 points) [9] knee scores.

The knee laxity measurements (antero-posterior stability) were made with the KT-1000 arthrometer (MEDMetric, San Diego, California) as described by Daniel et al. [3] at 30° of knee flexion using a force of 89 Newtons. The laxity was measured twice in the injured and uninjured knees, and an average value was recorded including the side-to-side difference. The result of the test was graded as normal (0–2 mm laxity), nearly normal (3–5 mm laxity), abnormal (6–10 mm laxity) and severely abnormal (>10 mm laxity).

Isokinetic extension and flexion strength assessment of the knees (Cybex 6000, Lumex Inc, Ronkonkoma, New York) was performed with the knee angle velocities of 60°, 180° and 240° per second, and the inter-limb differences were recorded. The circumference of the thighs was measured 15 cm proximal to the joint line and the difference between the thighs was noted.

The knee radiographs were assessed by an experienced radiologist (TP) and the follow-up radiographs of the injured knee were compared to those of the uninjured knee, as well as to those of the injured knee taken before the ACL reconstruction.

Statistics

Statistical analysis was done using the SPSS 7.5 software package (SPSS Inc, Chicago, Illinois). Calculations between the differences of means were done by analysis of variance (ANOVA) and those of the frequencies by the chi-square test. The significance level was chosen to be $P<0.05$.

Results

Subjective overall assessment can be seen in Table 3. The group difference, in favour of Group I, was significant ($P<0.05$). Evaluation of symptoms is shown as “normal” (absence of pain, swelling and giving way); “nearly normal” (ability to perform moderate activity without producing any of these symptoms); “abnormal” (ability to perform only light activity without symptoms), and “severely abnormal” (no activity possible without symptoms). Although patients in Group I had less knee symptoms than patients in Group II, the difference between the 2 groups was not statistically significant.

When compared to the unaffected knee, movement was considered to be “normal” (lack of extension <3°, flexion <5°); “nearly normal” (lack of extension 3–5°, flexion 6–15°); “abnormal” (lack of extension 6–10°, flexion 16–25°), and “severely abnormal” when these deficits were found to be much greater. There was a significant difference in favour of Group II ($P<0.05$).

Results of the arthrometric antero-posterior laxity measurements are shown in Table 4. The difference be-

Table 3 Subjective overall assessment, symptoms and range of motion (ROM) of the knee between the two groups

	Subjective overall assessment		Symptoms		ROM	
	Group I	Group II	Group I	Group II	Group I	Group II
Normal	25	12	31	17	26	29
Nearly normal	20	24	13	20	16	12
Abnormal	3	7	4	6	6	–
Severely abnormal	–	–	–	–	–	2

Table 4 The AP laxity measured with the KT-1000 arthrometer and with a force of 89 Newtons

	Group I <i>n</i> =48	Group II <i>n</i> =43
Injured knee	3.1 mm (SD 1.5)	3.2 mm (SD 1.7)*
Uninjured knee	2.5 mm (SD 1.1)	2.9 mm (SD 1.3)*
Difference	0.5 mm (SD 1.6)	0.3 mm (SD 1.4)*

SD=standard deviation

* No significant difference between the early and late reconstruction groups

Fig. 1 Stability evaluation of the knee by the IKDC rating system**Table 5** Crepitation, anterior knee pain, degenerative changes and “single leg hop” test between Group I and Group II

	Group	Normal	Nearly normal	Abnormal	Severely abnormal
Crepitation:					
– patello-femoral	I	33	15	–	–
	II	19	23	1	–
– lateral compartment	I	46	2	–	–
	II	36	2	–	–
– medial compartment	I	47	1	–	–
	II	38	5	–	–
Anterior knee pain:					
	I	21	25	2	–
	II	19	22	2	–
Degenerative changes:					
– patellofemoral	I	25	20	3	–
	II	24	13	6	–
– lateral compartment	I	46	2	–	–
	II	41	5	2	–
– medial compartment	I	44	4	–	–
	II	32	8	3	–
Single leg hop test					
	I	36	7	1	–
	II	29	4	–	–

tween the injured and the uninjured knee averaged 0.5 mm in Group I, and 0.3 mm in Group II (NS). The IKDC stability rating can be seen in Fig. 1.

The presence of crepitation, anterior knee pain, degenerative changes in the knee and the results of the “single leg hop” test, when compared between the two groups, are shown in Table 5.

In the case of patello-femoral crepitation, the difference between the two groups was significant ($P<0.05$), whereas there was no significant difference between the two groups with the presence of lateral and medial compartment crepitation. Anterior knee pain was similar in both groups. The only significant degenerative change in the knee appeared in the medial tibio-femoral joint. No significant difference between the two groups was found on the “single leg hop” test, though 14 patients (4 in Group I, 10 in Group II) were unable to complete this test either because of other injuries, pain or pregnancy. Testing isokinetic strength and measuring thigh atrophy showed that there were no significant differences between the two groups. Overall assessment of the knee by the IKDC rating system is shown (Fig. 2). In Group I the mean Lysholm score was 84 (SD 18, range 28–100), and in Group II it was 79 (SD 18, range 33–100). The mean Marshall score was 43 in Group I (SD 5, range 30–49), and 41 in Group II (SD 5, range 30–50). Neither of these scores are statistically significant (NS).

Fig. 2 Final evaluation of the knee by the IKDC rating system

Of the 101 patients in our study, 9 (3 in Group I, 6 in Group II) played no sports before the injury. Among the remaining 49 patients (1 missing information) in Group I, 44 (90%) returned to their pre-injury level of sporting activity, while in the remaining 39 in Group II (information missing in 3 cases), 31 (79%) were able to play sports as well as they did before their injury (NS).

Discussion

This study demonstrates that a bone patellar-tendon bone autograft is effective for reconstruction of both an acutely ruptured as well as an chronically insufficient ACL. In our study, most patients considered their knees normal or nearly normal 5–9 years after surgery. These results are comparable with many previous studies [1, 2, 8, 10, 11, 17]. Patients who had undergone early reconstruction were more satisfied with their knees than those who had had a late reconstruction; they had less pain, less loss of function and were able to return to more strenuous athletic activities than those with late ACL reconstruction. In addition, only 10% of the patients with early ACL reconstruction could not return to previous sports activity level while this number was 21% in the chronic group. Noyes et al. [11] reported similar results. These findings are not really surprising as patients with late reconstruction had suffered from pain, giving way, and instability-induced degenerative changes for an average of nearly 4 years *before* reconstruction, and the number of previous surgical procedures was significantly higher in this group than those who had early ACL reconstruction (Table 2). These findings thus support the concept that ACL reconstruction should be performed before degenerative changes develop in the knee, and this may particularly affect those who are athletically active.

In our study only 2 patients had obvious instability of the knee at follow-up. Otto et al. [12] reported similarly good 5-year stability results from their recent study in which the reconstruction was done arthroscopically.

We found that the range of knee motion was satisfactory in most of our patients. Some patients who had undergone early ACL reconstruction developed post-operative stiffness and 9 required knee manipulation under anaesthesia or division of adhesions. The brace and immobilisation that we used after reconstruction, when com-

pared to the accelerated rehabilitation advised by Shelbourne et al. [17], probably caused some of our post-operative knee stiffness. We have now abandoned brace immobilisation after ACL reconstruction.

One of the major problems with the patellar tendon autograft procedure is post-operative anterior knee pain [2, 15, 16]. In our study about half the patients had mild anterior knee pain at follow-up and in 4% this pain was “moderate”. Shelbourne [16] suggested that extension deficit of the knee is the main reason for this anterior knee pain and therefore recommended that full knee extension should be allowed immediately after surgery. Our patients’ knees were immobilised in a brace and full movement was not allowed until 5–7 weeks after surgery. If full extension of the knee immediately after reconstruction does, in fact, prevent the appearance of post-operative anterior knee pain, our current treatment protocol without using a brace (and limiting movement) should improve our results.

Degenerative changes in the lateral tibio-femoral joint were noted in 10% of our patients, and degenerative changes in the medial tibio-femoral joint were noted in 17%, while almost half of the patients had some degenerative changes and crepitation in the patello-femoral joint. However, these changes were mild in most cases and only one patient experienced pain and crepitation of the patello-femoral joint at follow-up. Despite these rather encouraging results at 5–9 years, only time will reveal the final incidence of post-operative osteoarthritis among patients following ACL reconstruction.

In the final evaluation of the knee with the IKDC rating system, 80% of our patients achieved satisfactory results. This is in line with Otto et al. [12] who recently reported similar results in their retrospective study of 68 patients.

In conclusion, our results show that an ACL reconstruction using a bone-patellar tendon-bone autograft and a mini-arthrotomy technique generally leads to good ligamentous stability and knee function. Patients who undergo early ACL reconstruction are more satisfied with the end result, have fewer symptoms and can return to sports activities more often than patients with late ACL reconstruction. Therefore, this surgery should be carried out before the onset of any late phase symptoms (such as those of osteoarthritis). The most typical long-term problems after an ACL reconstruction with a BTB graft are anterior knee pain and degenerative changes of the patello-femoral joint. Further studies are needed to solve these problems.

Acknowledgements This study was supported financially by the Medical Research Fund of Tampere University Hospital, Finland.

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