

Reconstruction of the anterior cruciate ligament

A 5-year follow-up of 89 patients

Rolf Sandberg and Bengt Balkfors

In all, 112 consecutive patients were operated on because of chronic insufficiency of the anterior cruciate ligament. The surgical procedure used was an intraarticular reconstruction using the medial third of the patellar ligament. Eighty-nine patients were reexamined 5 (2-11) years after the reconstruction. Eighty percent of the patients were satisfied, but most of them had discontinued strenuous sports. The best results were observed in individuals with normal demands on their knee function.

We have studied the long-term results of anterior cruciate ligament reconstructions using the patellar tendon (Broström et al. 1968).

Patients and methods (Table 1)

Totally, 112 consecutive patients were treated from 1975 through 1983. Their median age was 25 (14-44) years; 75 were men and 37 women. The interval between injury and reconstruction ranged from 4 months to 27 years, with a median of 2 years. Only patients with disabling anterior cruciate ligament insufficiency, not improved by a 3-month standard period of muscle force exercises and with objective signs of instability, qualified for operation.

The primary injuries were usually caused by sports, mainly soccer (72 percent). Nineteen patients had had a primary repair without augmentation.

Operation

The method has been described by Brückner (1966), Broström et al. (1968), and Eriksson (1976). The medial third of the patellar tendon with patellar periosteum and with the distal attachment retained was pulled through a drill hole in the tibia to emerge at the attachment of the

anterior cruciate ligament, and through the joint into another drill hole far back on the medial aspect of the lateral femoral condyle. A rather wide exposure was used without a drill guide. Nonabsorbable sutures were tied extraarticularly proximal-lateral to the lateral femoral condyle with the knee flexed at 30°. Great care was taken to find the isometric position of the transplant before fixation. Whenever possible (one fourth of the cases) the remnants of the old cruciate ligament were used to reinforce the transplant. In 51 patients a flap of synovial lining was added. When necessary a notch plasty was performed. The synovium and the retinaculum were closed with interrupted, absorbable sutures.

In addition to the anterior cruciate ligament reconstruction, 19 patients had a pes anserinus transposition and 3 had a medial collateral ligament reconstruction.

At the time of reconstruction, 38 medial and 18 lateral semilunar cartilage lesions were treated or had previously been operated on. Between the anterior cruciate ligament reconstruction and follow-up, an additional eight medial and three lateral meniscectomies were performed.

Postoperative care.

A plaster cast was applied with the knee in 30 degrees of flexion for 6 weeks, and full weight bearing was permitted immediately. Isometric muscle exercise of the hamstrings and the quadriceps, supervised by a physiotherapist, was initiated during the first postoperative week. After 2 weeks a new cast was applied for an additional 4

weeks. Dynamic muscle training was introduced when the knee was free from effusion. The patients were permitted to return to physical activity when the pain and the swelling of the joint had subsided, the range of motion was more than 90°, and the force of the thigh muscle was at least 85 percent of that of the other side. No stabilizing braces were used. The patients were advised not to resume soccer or similarly strenuous activities.

Follow-up

Seven patients were lost for follow-up, 11 had sustained new injuries to the same knee, and 5 had bilateral anterior cruciate ligament reconstructions. After exclusion of these patients, 89 patients were examined after a median of 5 (2-11) years. Stability was examined using the anterior drawer sign, the Lachman test, and the pivot shift test. The mediolateral instability was tested in full extension and at 30° of flexion. Instability was classified as Grade 1 – slight, Grade 2 – obvious, and Grade 3 – gross instability. Even a small difference from the uninjured knee in the end-point resilience of the Lachman test or anterior drawer sign was regarded as positive and indicative of instability. The anterior drawer sign was also quantified with the Lindahl caliper (Sylvén 1975).

Range of motion was expressed in degrees, measured with a goniometer; *joint swelling* was measured as the joint circumference at the midpatellar level as compared with the contralateral joint; *muscle atrophy* was measured as the thigh circumference 20 cm proximal to the joint line as compared with the contralateral thigh; *muscle force* was quantified in a Cybex II testing machine, isometrically at 60° of flexion and isokinetically at 180 and 240° degrees of angle speed; *disability time* was expressed as both sick leave and time to full physical activity; *function* was evaluated by the scoring system of Lysholm and Gillquist (1982), with 100 points the maximum and 84 points as the lower limit for good and excellent; and lastly, *subjective satisfaction* was expressed whether or not the outcome had met the expectations of the patients.

Statistical methods. Paired and independent *t*-tests, the Mann-Whitney test for discontinuous variables, and the linear correlation coefficient were used for analysis.

Results (Table 1)

One superficial infection and one staphylococcal arthritis were encountered. Both infections healed without serious consequences.

Altogether, 11 of the originally 112 reconstructions had ruptured – four within 1 year. Eight of the ruptures occurred from adequate trauma during sports. In four knees a new reconstruction was done with an allogeneic transplant – in one a synthetic implant was used.

Even those knees that were grossly unstable preoperatively had improved their stability at follow-up (Table 2). The greatest changes were with the pivot shift test, which was positive in only 11 of 67 knees. Most of the patients, however, had a positive Lachman test, and 53 out of 69 had an abnormal end-point resilience. The pivot shift and the end-point resilience were initially not consistently recorded preoperatively. The sagittal instability was reduced ($P < 0.001$) in comparison with preoperative observations (Table 3).

The range of motion was reduced by an average of 5° ($P < 0.001$), whereas only one knee had a reduction in extension of more than 10°.

Even after 5 years, the midpatellar circumference was approximately 0.5 cm greater ($P < 0.001$) on the injured side. The muscle

Table 2. Preoperative and postoperative instability grade^a after reconstruction of the anterior cruciate ligament

Pre-operative	Postoperative											
	Anterior drawer				Pivot shift ^b				Lachman ^b			
	0	1	2	3	0	1	2	3	0	1	2	3
0	1	0	0	0	1	0	0	0	0	0	0	0
1	8	11	1	0	15	2	0	0	3	4	4	0
2	14	24	13	3	32	3	3	0	5	16	14	1
3	1	5	6	0	8	2	1	0	1	6	10	0

^a For definition, see text.
^b Preoperative pivot shift and Lachman tests not undertaken in 20 cases.

Table 3. Anterior drawer sign measured by caliper. Values are difference from the uninjured knee, mean (mm) SD

Position of lower leg	Preoperative ^a	Follow-up ^a	112 knees at follow-up
Inward	2.9 2.4	0.9 1.4	0.9 1.5
Neutral	3.7 2.7	1.3 1.8	1.4 1.9
Outward	4.2 3.1	1.0 2.0	0.9 2.2

^a 50 knees where both preoperative and postoperative studies were performed.

Table 1. Data for 89 patients with reconstructed anterior cruciate ligament

No.	Age	Sex	Side	Operation	Time	Follow-up	Result	Complication	Remarks	Ref.
1	21	M	R	ACL	1985	1987	Good			
2	22	M	L	ACL	1985	1987	Good			
3	23	M	R	ACL	1985	1987	Good			
4	24	M	L	ACL	1985	1987	Good			
5	25	M	R	ACL	1985	1987	Good			
6	26	M	L	ACL	1985	1987	Good			
7	27	M	R	ACL	1985	1987	Good			
8	28	M	L	ACL	1985	1987	Good			
9	29	M	R	ACL	1985	1987	Good			
10	30	M	L	ACL	1985	1987	Good			
11	31	M	R	ACL	1985	1987	Good			
12	32	M	L	ACL	1985	1987	Good			
13	33	M	R	ACL	1985	1987	Good			
14	34	M	L	ACL	1985	1987	Good			
15	35	M	R	ACL	1985	1987	Good			
16	36	M	L	ACL	1985	1987	Good			
17	37	M	R	ACL	1985	1987	Good			
18	38	M	L	ACL	1985	1987	Good			
19	39	M	R	ACL	1985	1987	Good			
20	40	M	L	ACL	1985	1987	Good			
21	41	M	R	ACL	1985	1987	Good			
22	42	M	L	ACL	1985	1987	Good			
23	43	M	R	ACL	1985	1987	Good			
24	44	M	L	ACL	1985	1987	Good			
25	45	M	R	ACL	1985	1987	Good			
26	46	M	L	ACL	1985	1987	Good			
27	47	M	R	ACL	1985	1987	Good			
28	48	M	L	ACL	1985	1987	Good			
29	49	M	R	ACL	1985	1987	Good			
30	50	M	L	ACL	1985	1987	Good			
31	51	M	R	ACL	1985	1987	Good			
32	52	M	L	ACL	1985	1987	Good			
33	53	M	R	ACL	1985	1987	Good			
34	54	M	L	ACL	1985	1987	Good			
35	55	M	R	ACL	1985	1987	Good			
36	56	M	L	ACL	1985	1987	Good			
37	57	M	R	ACL	1985	1987	Good			
38	58	M	L	ACL	1985	1987	Good			
39	59	M	R	ACL	1985	1987	Good			
40	60	M	L	ACL	1985	1987	Good			
41	61	M	R	ACL	1985	1987	Good			
42	62	M	L	ACL	1985	1987	Good			
43	63	M	R	ACL	1985	1987	Good			
44	64	M	L	ACL	1985	1987	Good			
45	65	M	R	ACL	1985	1987	Good			
46	66	M	L	ACL	1985	1987	Good			
47	67	M	R	ACL	1985	1987	Good			
48	68	M	L	ACL	1985	1987	Good			
49	69	M	R	ACL	1985	1987	Good			
50	70	M	L	ACL	1985	1987	Good			
51	71	M	R	ACL	1985	1987	Good			
52	72	M	L	ACL	1985	1987	Good			
53	73	M	R	ACL	1985	1987	Good			
54	74	M	L	ACL	1985	1987	Good			
55	75	M	R	ACL	1985	1987	Good			
56	76	M	L	ACL	1985	1987	Good			
57	77	M	R	ACL	1985	1987	Good			
58	78	M	L	ACL	1985	1987	Good			
59	79	M	R	ACL	1985	1987	Good			
60	80	M	L	ACL	1985	1987	Good			
61	81	M	R	ACL	1985	1987	Good			
62	82	M	L	ACL	1985	1987	Good			
63	83	M	R	ACL	1985	1987	Good			
64	84	M	L	ACL	1985	1987	Good			
65	85	M	R	ACL	1985	1987	Good			
66	86	M	L	ACL	1985	1987	Good			
67	87	M	R	ACL	1985	1987	Good			
68	88	M	L	ACL	1985	1987	Good			
69	89	M	R	ACL	1985	1987	Good			

Key to data

1. Sex: 1 male, 2 female
2. Age at injury, years
3. Injured knee: 1 right, 2 left
4. Type of accident: 1 soccer, 2 downhill skiing, 3 other sports, 4 other
5. Diagnosis at preliminary examination: 1 no ligamentous injury, 2 ACL injury, 3 ACL+MCL injury, 4 ACL+other, 5 meniscus lesion, 6 ACL+meniscus lesion
6. Primary surgery: 1 none, 2 plaster cast, 3 arthroscopy without repair, 4 ACL repair, 5 ACL+MCL repair, 6 meniscectomy, 7 meniscectomy+4 or 5, 8 arthroscopy
7. Additional treatment: 1 none, 2 meniscectomy, 3 repair of rupture, 4 secondary reconstruction, 5 arthroscopy, 6 repair of collateral ligament, 7 explorative arthroscopy
8. New trauma injured knee: 1 no, 2 yes
9. Preoperative instability, subjective: 25 no giving way, 20 rarely, during athletics or other heavy exertion, 15 frequently, during athletics or other heavy exertion (or unable to participate), 10 occasionally in daily activities, 5 often, in daily activities, 0 at every step
10. Indication for reconstruction: 1 instability during work, 2 instability at ordinary keep fit exercises, 3 instability during competitive sports, 4 instability during soccer, 5 pain
11. Age at reconstruction
12. Time laps injury - reconstruction, months

Findings at arthroscopy

13. Synovitis: 1 none, 2 light-moderate, 3 severe, 4 no information
14. Anterior cruciate remnants: 1 none, 2 remnants usable at reconstruction
15. Cartilage lesion, medial femoral condyle: 1 none, 2 no information, 3 grade 1, 4 grade 2, 5 grade 3, 6 grade 4, 7 grade 5, 8 grade 6 (Bauer et al 1988)
16. Size of lesion: 1 small, 2 medium, 3 extensive
17. Age of lesion: 1 recent, 2 old
18. Cartilage lesion, medial tibial condyle: Compare no. 15
19. Size of lesion: See no. 16
20. Age of lesion: See no. 17
21. Cartilage lesion, lateral femoral condyle: Compare no. 15
22. Size of lesion: See no. 16
23. Age of lesion: See no. 17
24. Cartilage lesion, lateral tibial condyle: Compare no. 15
25. Size of lesion: See no. 16
26. Age of lesion: See no. 17
27. Cartilage lesion: Patella: 1 none, 2 no information, 3 circumscript chondromalacia, 4 extensive chondromalacia, 5 old chondral fracture
28. Medial meniscus: 1 intact, 2 no information, 3 rupture in the periphery, 4 flap tear, 5 previous total extirpation, 6 previous partial extirpation
29. Lateral meniscus: See no. 28
30. Type of reconstruction: 1 medial third of ligamentum patellae, 2 1+pes anserinus transp, 3 medial collateral ligament, 4 other

31. Synovial covering of transplant: 1 none, 2 no information, 3 with synovial membrane, 4 with anterior fat pad
32. Complications: 1 none, 2 superficial wound infection, 3 deep infection with septic arthritis, 4 deep venous thrombosis, 5 other or combination
33. Additional surgery after secondary injury: 1 reconstruction, 2 medial meniscectomy, 3 lateral meniscectomy, 4 medial+lateral meniscectomy, 5 other
34. Age at follow-up
35. Follow-up time, months

Lysholm knee scoring scale

36. Limp: 5 none, 3 slight and/or periodical, 0 severe and/or constant
37. Support: 5 none, 3 cane or crutch, 0 weight-bearing impossible
38. Locking: 15 no locking and no catching sensations, 10 catching sensations but no locking, 6 locking occasionally, 2 locking frequently, 0 locked on examination
39. Stair-climbing: 10 no problems, 6 slightly impaired, 2 one step at a time, 0 impossible
40. Squatting: 5 no problems, 4 slightly impaired, 2 not beyond 90°, 0 impossible
41. Subjective instability: Compare no. 9
42. Pain: 25 none, 20 inconstant and slight, during heavy exertion, 15 marked, during heavy exertion, 10 marked, on or after walking more than 2 km, 5 marked, on or after walking less than 2 km, 0 constant
43. Swelling: 10 none, 6 on heavy exertion, 2 on normal exertion, 0 constant
44. Lysholm score
45. Kneeling: 1 not current for the patient because of age or other reasons, 2 no problems, 3 unpleasant due to loss of sensation, 4 impossible - pain, 5 impossible - reduced range of motion
46. Biking: 1 not current for the patient because of age, 2 no problems, 3 some problems, 4 impossible
47. Work after reconstruction: 1 same, 2 changed due to the injury, 3 changed of other reasons, 4 retired because of the injury, 5 student or in military service
48. Kind of work: 1 extremely heavy, 2 heavy, walks and stands, 3 easy labour, 4 easy work mostly sitting, 5 youngsters, students, in military service, 6 retired
49. Sports after reconstruction: 1 unchanged, 2 given up all sports, 3 reduced intensity, same discipline, 4 changed discipline, 5 given up or changed not depending on the knee injury
50. Sporting intensity: 1 competitive sports, national or international level, 2 competitive sports, 3 frequent keep fit exercise, 4 moderate keep fit exercise, 5 low
51. Time lap reconstruction to full activity, months
52. Patients satisfaction: 1 satisfied, i.e., function without limitation, 2 satisfied but not able to perform as prior to the injury, 3 not satisfied

Findings at follow-up

53. Local tenderness: 1 none, 2 medial joint line, 3 lateral joint line, 4 medial+lateral joint line, 5 MCL's proximal attachment, 6 tender neuroma, 7 other or combinations
54. Pain at testing motion: 1 none, 2 max. extension, 3 max. flexion, 4 at both end points, 5 all the range of motion
55. Range of motion, injured side
56. Range of motion, uninjured side
57. Limitation of extension, degrees
58. General joint laxity according to Carter Wilkinson: 1 yes, 2 no
59. High circumference, difference in mm
60. Mid-patellar circumference, difference in mm
61. Muscle force isometric extension, difference uninjured-injured, preop. (Cybex torque Nm)
62. Muscle force isometric extension, difference uninjured-injured, follow-up
63. Muscle force isometric flexion, difference uninjured-injured, preop.
64. Muscle force isometric flexion, difference uninjured-injured, follow-up
65. Muscle force isokinetic extension 180°/s, difference uninjured-injured, preop.
66. Muscle force isokinetic extension 180°/s, difference uninjured-injured, follow-up
67. Muscle force isokinetic flexion 180°/s, difference uninjured-injured, preop.
68. Muscle force isokinetic flexion 180°/s, difference uninjured-injured, follow-up
69. Medial instability, preop: 1 +, 2 ++, 3 ++++, 4 none
70. Medial instability, follow-up: 1 +, 2 ++, 3 ++++, 4 none
71. Forward drawer, preop: 1 +, 2 ++, 3 ++++, 4 none
72. Forward drawer, follow-up: 1 +, 2 ++, 3 ++++, 4 none
73. Lachman, preop: 1 +, 2 ++, 3 ++++, 4 none
74. Lachman, follow-up: 1 +, 2 ++, 3 ++++, 4 none
75. End point: 1 normal, 2 soft, 3 distinct
76. Pivot shift, preop: 1 +, 2 ++, 3 ++++, 4 none
77. Pivot shift, follow-up: 1 +, 2 ++, 3 ++++, 4 none
78. Forward drawer, inward rotation, measured difference, mm preop
79. Forward drawer, inward rotation, measured difference, mm follow-up
80. Forward drawer, neutral position, measured difference, mm preop
81. Forward drawer, neutral position, measured difference, mm follow-up
82. Forward drawer, outward rotation, measured difference, mm preop
83. Forward drawer, outward rotation, measured difference, mm follow-up

wasting in the thigh was minor, approximately 1 cm ($P < 0.001$).

In 23 patients who had 3 months of preoperative exercise and who also had preoperative muscle force measurements, there was no side-to-side difference. When these same patients were measured again after 5 (2-11) years, there was again no difference. Nine patients not satisfied with their reconstruction had less isometric extension force ($P < 0.05$) compared with the contralateral leg than the others.

The sick-leave period was 14 (0-40) weeks. Only 3 patients had changed their occupation because of the injury. The median time required for regaining full physical activity was 24 (8-172) weeks. Thirty-one out of 85 had quit sports entirely. Twenty of the 54 who were still physically active did participate in competitive sports, and the others were active doing keeping-fit exercises. Only 24 of 68 soccer players returned to their original sport.

The mean Lysholm score was 89 ± 13 points (median 94 points, q_1 - q_3 84-99 points). Sixty-nine patients exceeded 84 points and 22 had the maximum score. There was no difference in mean score between patients with and without meniscectomy. Those patients who had had their menisci removed prior to or at the time of the ligament reconstruction did not differ in any of the variables. However, not less than 8 of the 9 patients who were dissatisfied with their operations had this combination.

Preoperatively, all the patients had frequent and disabling give-way symptoms. At follow-up the number of patients with this problem was reduced to 12. Twenty patients had pain during vigorous activity and 19 had swelling episodes. Six patients had a combination of give-way and pain; 5 had give-way and swelling, and 4 had give-way, pain, and swelling.

In 9 out of 89 patients, the results did not meet their expectations. However, only 2 of them had a positive pivot shift and give-way sensation. The remainder who had minor complaints had had a meniscectomy or had chondral lesions.

The measured stability was not related to the surgical technique – synovial lining, reinforcement or additional medial stabilization. The combined anterior cruciate/medial collateral ligament procedures did not differ in their outcome from the single anterior cruciate ligament reconstruction.

The time lapse from injury to reconstruction was not related to symptoms or signs.

Discussion

Because the patients operated on with an anterior cruciate ligament reconstruction are selected or, rather, in cooperation with their surgeon, select themselves to be operated on, comparison and evaluation of results are difficult – the selection process usually cannot be reconstructed in retrospect. For the same reason, randomized, controlled studies seem to be impossible. In Sweden more than 200 reconstructions have been presented by Alm and Gillquist (1974) and Johnson et al. (1984). Improvement was observed in approximately 70 percent of the patients; stability was improved, but complete stability was rarely obtained. Many patients could return to their sports activities at least for some time. In both of these studies the same surgical procedure, an intraarticular transplant from the patellar tendon, was used.

One reason for poor results was new injury episodes. In the study of Johnson et al. (1984), the pivot shift remained positive in 25 percent. The outcome of the reconstruction was similar in our study: 77 percent of the patients became good or excellent; only 13 percent had a residual positive pivot shift. About 20 percent still experienced some pain when subjected to vigorous strain. The soccer players were advised to discontinue their sport. However, 24 of 68 patients nevertheless went back to playing soccer.

Is the present method, then, the best method for dealing with sagittal instability due to an anterior cruciate ligament injury? Hefti et al. (1982) compared four methods – extraarticular stabilization, carbon-fiber implant, intraarticular transplant “over the top,” and intraarticular transplant – with the method we used. The last method gave the best results, but the study was not randomized. Some hope has been attached to new synthetic implant materials; so far, the documentation and the time of observation are insufficient.

Is it possible at all to select suitable patients for the intrarticular transplant procedure? The patients who most eagerly ask for a repair operation, namely those with a high level of physical activity, in particular soccer players, seem to have the

worst results subjectively and are usually unable to continue their sport. It has become gradually apparent that soccer players with serious knee ligament injuries can seldom be reconstructed to the extent that they can resume playing soccer. The most successful results can probably be

achieved in a patient with normal demands of their knee function, the regular keep-fit exerciser, who has a give-way phenomenon and a positive pivot shift being an example, because that type of patient will improve stability and remain free from symptoms in most instances.

References

- Alm A, Gillquist J. Reconstruction of the anterior cruciate ligament by using the medial third of the patellar ligament. Treatment and results. *Acta Chir Scand* 1974;140(4):289-96.
- Bauer M, Jackson R W. Chondral lesions of the femoral condyles. *Arthroscopy* 1988. In press.
- Broström L, Gillquist J, Liljedahl S O, Lindvall N. Behandling av invetererad ruptur av främre korsbandet. *Läkartidningen* 1968;65(45):4479-87.
- Brückner H. Eine neue Methode der Kreuzbandplastik. *Chirurg* 1966;37(9):413-4.
- Eriksson E. Reconstruction of the anterior cruciate ligament. *Orthop Clin North Am* 1976;7(1):167-79.
- Felsenreich F. Über die Technik der vorderen Kreuzbandplastik mittels gestielter Fascienstreifen. *Zentralbl Chir* 1934;61:1223-7.
- Hefti F, Gächter A, Jenny H, Morscher E. Replacement of the anterior cruciate ligament. A comparative study of four different methods of reconstruction. *Arch Orthop Trauma Surg* 1982;100(2):83-94.
- Johnson R J, Eriksson E, Häggmark T, Pope M H. Five to ten year follow-up evaluation after reconstruction of the anterior cruciate ligament. *Clin Orthop* 1984; (183):122-40.
- Lysholm J, Gillquist J. Evaluation of knee ligament surgery results with special emphasis on use of a scoring scale. *Am J Sports Med* 1982;10(3):150-4.
- Sylvin L E. A more exact measurement of the sagittal stability of the knee joint. *Acta Orthop Scand* 1975; 46(6):1008-11.

Acknowledgements

Financial support was obtained from the Herman Järnhardt, Greta and Johan Kock, and Alfred Österlund Foundations.

Editor's note

An example of the information content of Table 1 is provided by the following transcript of Case 66.

A 28-year old male ruptured the anterior and medial ligaments of his right knee playing soccer football. He had primary repair of both ligaments. Without additional trauma he had developed instability both in his daily activities and during work, and at age 42 he had ligament reconstruction.

At the operation he had no synovitis, and there were no remnants of the anterior cruciate ligament. There were medium size Type 5 femoral and tibial cartilage lesions on both sides. There were no complications after the operation.

At follow-up 6 years postoperatively he did not limp, he walked without support, had no locking and no problems stair-walking but could not squat beyond 90°. He rarely experienced instability, heavy exertion caused but slight pain, and he had no swelling for a total Lysholm score of 87 points. He had slight difficulties kneeling, none biking, and he had retained his mostly sitting work but he had changed to less demanding sports activity, focused on keeping fit which he started 5 months after the operation; he was satisfied with the results.