Persistent stability 3 years after reconstruction of the anterior cruciate ligament

A radiostereometric analysis (RSA) of 20 patients

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We measured, by radiostereometric analysis (RSA), the sagittal knee laxity in 20 consecutive patients with chronic anterior cruciate ligament injuries before, 1 year and 3 years after reconstruction with a free bone-patellar tendon-bone graft. The grafts had been perioperatively tensioned, using a 10–15 N load.

An increased displacement with increasing load was present before reconstruction, but we found no differences between 100 and 150 N stress load 1 and 3 years after the operation. The total anteroposterior displacement decreased from 12.7 mm before the reconstruction to 5.1 mm 1 year and 5.6 mm 3 years postoperatively, using a stress load of 150 N. Thus, we found both a definite end-point of joint displacement and persistent stability without elongation of the graft with time, when care was taken not to overconstrain the knee by a high initial graft tension.

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Submitted 96-09-06. Accepted 97-05-12

It is generally agreed that long-term follow-up is required to assess the sagittal laxity after anterior cruciate ligament reconstructions, but to our knowledge no studies have evaluated patients longitudinally with measurements at different intervals and with more than one load applied.

In a previous study, we used radiostereometric analysis (RSA) (Selvik 1989) to evaluate initial graft fixation (Fridén et al. 1992). In the present study we investigated a possible graft elongation over the years, as well as the quality of resistance to anterior displacement. The study is purely mechanical, with no attempts to analyze the histological appearance of the graft or the functional outcome of the patients.

Patients and methods

20 consecutive patients having chronic anterior cruciate ligament lesions and recurrent instability symptoms were studied before, 1 year and 3 years after an anterior cruciate ligament reconstruction. The 6 women and 14 men had a mean age of 25 (16–37) years at surgery. For the RSA measurements, tantalum markers were implanted during the arthroscopic evaluation of the joint prior to the reconstruction. This prospective study was approved by the Ethics Committee at Lund University Hospital.

The reconstructions were performed through a small anteromedial arthrotomy with a free bone-tendon-bone graft from the patellar tendon. A trial ligament was used to check for impingement through the full range of motion. Isometry and tension were measured, using a dynamometer placed on the tibial side, and the trial tunnels were redrilled, if not properly placed. The graft was fixed by heavy nonresorbable sutures tied over a steel button on both sides. The grafts were tensioned with a 10–15 N load in the position where the distance between the insertion points was longest. Physiotherapy aimed at full rehabilitation after 8–10 months.

Preoperatively, 1 and 3 years after reconstruction, the total anterioposterior displacement was measured, using RSA. The leg was placed in the Lachman position, flexion 25° ± 5°, with the thigh fixed in a brace. A posterior load of 40 N in addition to gravity was used to define the posterior reference position and 100 and 150 N loads were subsequently applied perpendicular to the tibia in the anterior direction by free-hanging weights in a pulley system (Figure 1). Rotations were unrestricted. Simultaneous radiographs in the frontal and lateral projections were taken 20–30 sec. after application of the various loads (Figure 2). The marker images on all radiographs were digitized using a precision digitizing table (Hasselblad Engineering, precision 10 μm). The total motion of the tibia relative to the femur was calculated using the KINEMA routine based on rigid body kinematics (Fridén et al. 1992). Statistical analysis was done with the paired Student's t-test.

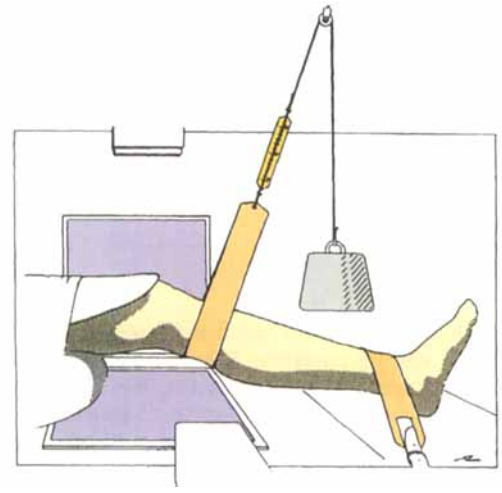

Figure 1. The patient rested in a comfortable position during application of the different forces by free hanging weights. Rotations were not constrained, and measurements were made on simultaneous radiographs in the frontal and lateral projections, using three-dimensional radiostereometry.

Figure 2. Tantalum markers in the femur and tibia. Arrows indicate two markers in the bone blocks of the bone-patellar tendon-bone graft.

Results

Before surgery, an increased anteroposterior displacement with increasing load was found, having a mean value of 9.5 (SD 3.6) mm at 100 N, and 12.7 (4.3) mm at 150 N load ($p = 0.001$, Table, Figure 3). 1 year after the reconstruction, a reduced displacement was found, with a mean value of 4.8 (4.2) mm at 100 N ($p = 0.001$) and 5.1 (4.6) mm at 150 N ($p = 0.001$). At the 3-year examination, the displacements were still reduced and the mean value 5.3 (2.2) mm at 100 N ($p = 0.001$) and 5.6 (2.4) mm at 150 N stress load ($p = 0.001$). No increase in displacement was found with increasing loads, either 1 or 3 years postoperatively.

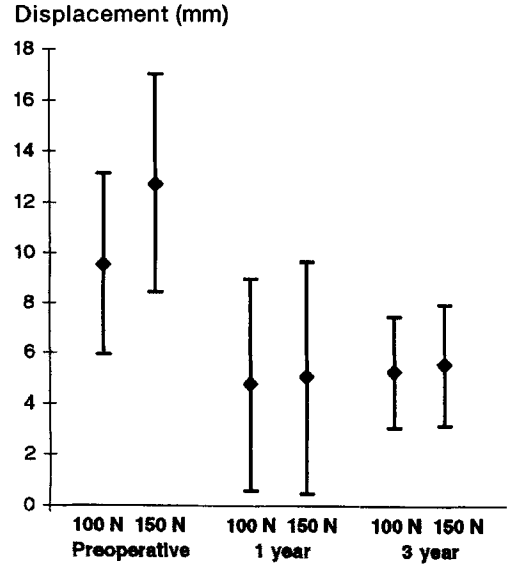

Figure 3. The mean total anteroposterior displacement at 2 loads before, 1 year and 3 years after an ACL reconstruction in 20 consecutive patients.

Individual values in 20 patients of the total anteroposterior displacement before, 1 year and 3 years after an ACL reconstruction

Patient no.	100 N Preop	150 N Preop	100 N 1 year	150 N 1 year	100 N 3 years	150 N 3 years
1	8.7	11.4	2.4	1.9	6.2	6.3
2	7.3	6.1	0.3	0.0	3.1	3.2
3	16.7	20.5	9.5	12.8	7.6	8.3
4	8.1	9.8	2.4	3.0	3.7	4.0
5	4.3	8.1	2.6	3.7	3.6	3.5
6	10.3	12.5	7.4	7.3	5.9	5.6
7	9.5	12.3	0.5	0.0	3.8	4.9
8	9.0	14.6			5.9	6.3
9			14.9	15.6		9.3
10			3.3	2.6	3.4	2.9
11			5.0	6.0	4.0	3.7
12	10.7	14.2	0.8	0.0	5.3	5.1
13	13.0	19.4	8.4	8.9	6.6	5.2
14	10.9		2.7	2.9	3.4	3.6
15	9.2	13.7	3.9	3.8	8.9	9.2
16	15.3	15.0	8.4	8.7	9.3	10.3
17	6.5	14.7	11.6	11.5	5.2	5.0
18			5.3	5.4	8.9	9.0
19	3.7	5.9	0.2	0.5	3.0	2.7
20			1.1	1.6	2.2	3.0

Discussion

We considered the follow-up period of 3 years to be sufficient for the processes of tissue healing, remodeling and possible graft elongation. Jonsson et al. (1992) examined the laxity of 32 cases 2 years after ACL reconstruction using an over-the-top technique with RSA measurements, and found a gradual increase, restoring the laxity to preoperative levels after 2 years. However, they reported no data on peroperative tension, and the operative technique did not achieve an anatomic positioning of the graft. Good et al. (1994) followed 24 patients up to 2 years after an ACL reconstruction, using an operative technique similar to ours, although all grafts were fixed under the higher tension of 40 N in 20° of flexion. Tibial anteroposterior displacement, as measured with the Stryker knee laxity tester, demonstrated successively increasing laxity over the years. This was most marked when the 20° flexion angle, which was used at the time of graft fixation, coincided with the flexion angle, where the distance between the tibial and femoral ligament insertion locations was at a minimum. These findings indicate the importance of not overconstraining the joint at the time of graft fixation, in order to avoid graft elongation over the years.

Only a few clinical studies demonstrate the effect of peroperative tension (Andersen and Amis 1994), and to our knowledge none with a follow-up longer than 2 years (Nabors et al. 1995). Tension in the graft is difficult to measure with precision, and in well-controlled experimental studies individual variations has been shown after a standardized procedure in different knees (Lewis et al. 1989). Revascularization of autogenous grafts may be adversely affected by a high tension of the graft, as demonstrated by Yoshiya et al. (1987). In our study we chose to tighten the sutures with only a 10–15 N load, in order to mimic the physiological low tension of the normal unloaded ACL in the semiflexed knee (Bylski-Austrow et al. 1990, Markolf et al. 1990), thereby avoiding to overconstrain the joint.

We found a definite end-point resistance, since increasing the testing loads from 100 N to 150 N did not increase the displacement after either 1 or 3 years.

The measured displacements did not increase between the 1- and the 3-year follow-ups, which indicates good function of the graft over prolonged periods.

Acknowledgements

This study was supported by grants from Medicinska Forskningsrådet, Project 09509, Stiftelsen för bistånd åt vanföra i Skåne, Syskonen Perssons Donations Fond, Svenska Sällskapet för Medicinsk Forskning, Thyr och Thure Stenemarks Fond, Ruth Trossbecks Minnes Fond och Albert Hellströms Fond, Centrum för Idrottsforskning, Faculty of Medicine, University of Lund.

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