Disability in anterior cruciate ligament insufficiency

An analysis of 19 untreated patients

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We analyzed the knee function in 19 consecutive patients with chronic instability after an anterior cruciate ligament rupture. Muscle strength, standing balance, activity level, functional knee score, and a performance test were evaluated. Reduced quadriceps muscle strength compared with the noninjured limb was associated with reduced performance as measured by the one-leg hop test and the Lysholm knee score. No weakness in the hamstrings was found. The patients had impaired standing balance with increased body sway in the frontal plane when standing on both the injured and noninjured limb.

We have analyzed a number of factors including pain, laxity, muscle strength, and standing balance in patients with old, untreated symptomatic lesions of the anterior cruciate ligament.

Patients

During 1983 and 1984, patients referred to our orthopedic department for chronic traumatic instability of the knee were consecutively selected for this study using the following criteria: 1) time from injury > 6 months; 2) signs of anterior cruciate ligament insufficiency, with at least Lachman 2+ and one pivot-shift test clearly positive; 3) no clinical signs of associated lesions of the posterior cruciate ligament or notable varus/valgus laxity; 4) no disabling signs of a meniscus lesion; 5) no history of other injuries of the affected limb; 6) normal standing radiographs; 7) an uninjured contralateral lower extremity; and 8) no previous attempts to treat the instability with physiotherapy, braces, or surgery.

Twelve men and 7 women fulfilled these criteria. The mean age was 24 (15–41) years, and the mean time from injury was 29 (8–96) months.

All the injuries were sustained during sports activities, especially contact sports: 10 in soccer and two in handball. Before the injury, these patients were involved in recreational sports or competed on a low to moderate level. Three patients had had meniscus surgery after their injury. All the patients complained of "giving way"; they did not trust their injured knee in provocative situations; and most of the patients experienced some discomfort in daily living.

Reference subjects

In the stabilometric investigation, a reference group of 55 healthy volunteers, without any history of major orthopedic lesions, were examined (Fridén et al. 1989). In this group, there were 22 males and 33 females with a mean age of 26 (19–38) years; their level of physical activity was comparable to the injured group of patients.

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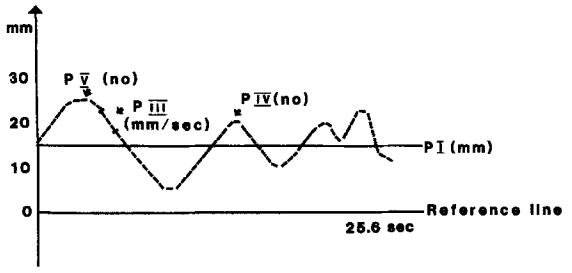

Figure 1. The different parameters used to describe body sway in the frontal plane during the stabilometric measurements.

Methods

Different *symptoms* were analyzed both independently and together in a scoring scale.

Laxity was recorded clinically with the drawer sign at 90° (Sylvin 1975) and the Lachman test (Torg et al. 1976), and was graded according to the American Medical Association (1968). The different pivot-shift tests were graded according to Noyes (1988). Muscular *strength* of the quadriceps and hamstrings were recorded by a Cybex II device (Lumex Inc., N.Y., U.S.A.) isometrically at 60° of knee flexion. The angular velocities used during maximum dynamic contractions of these muscle groups were 30° and 90° per second. The hip abductors and adductors were measured isometrically in a fixed side-lying position. The ratio between the injured and uninjured leg was calculated for each of the different measurements. A one-leg hop test was performed according to Tegner et al. (1986). The modified (Tegner 1985) *knee scoring scale of Lysholm* (Lysholm and Gillquist 1982) was used to evaluate loss of function. The *activity* level was recorded according to Tegner (1985).

The one-leg standing balance was measured with a strain-gauge force plate, and analysis of body sway was restricted to movements in the frontal plane, which has been shown to be sensitive (Fridén et al. 1989). Three recordings on each leg were made. The following variables were measured (Figure 1): *Mean value of the distance* (parameter 1) between the center of pressure and the reference line and its *standard deviation* (parameter 2; in millimeters). The latter describes the effective value of variations around the mean value and reflects the amplitude of the sway movements, but not their frequency. *Average speed* (parameter 3) of frontal oscillations reflects both amplitude and frequency (mm/s). *Number of oscillations* (parameters 4 and 5) exceeding defined amplitude levels (5 and 10 mm, respectively.

When one or both variables were not measured on a continuous scale, the analyses were made with the Spearman rank correlation or the Wilcoxon rank sum test. All other levels of significance were calculated using paired and unpaired *t*-tests.

Results

General joint laxity (Carter and Wilkinson 1964, Rünow 1983) was noted in 4 patients. After their injury, 13 patients had reduced their sports activities, and an additional 5 patients had given up sports altogether. Six patients were troubled by symptoms of instability most days while at work. Thirteen stated that they avoided turning movements in any direction when the injured leg was weight bearing. Fifteen patients were continuously aware of their knee and protected it, especially on uneven or slippery ground. "Giving way" was experienced by all the patients, but this varied in frequency and direction. There was pain from manual compression of the patella provoked in 9 patients. Fourteen patients had a measurable atrophy of the thigh muscles of more than 1 cm 15 cm above the joint line. Four patients had a pivot-shift grade 1, 13 grade 2, and two grade 3. All patients had Lachman test 2+/3+ and an increased mean sagittal anterior translation (Table 1).

Table 1. Sagittal anterior translation in 90° of flexion, measured with the Lindahl calliper (mm in different degrees of rotation). Mean (range)

	Internal[a]	Neutral[a]	External[a]
Injured	3.7 (2–8)	6.3 (3–12)	6.9 (3–11)
Uninjured	1.8 (0–4)	2.5 (1–4)	2.9 (1–6)

[a] $P < 0.001$.

Table 2. Muscle strength (Nm) and number of patients with a ratio injured /noninjured limb > 0.9. Mean *SD*

	Isometric	Isokin 30°/s	Isokin 90°/s
Knee extension			
injured	153 *70*	154 *51*	131 *40*
uninjured	195 *62*	173 *38*	140 *33*
ratio > 0.9	7/19	7/18	9/17
Knee flexion			
injured	95 *38*	102 *31*	98 *28*
uninjured	103 *39*	109 *22*	105 *23*
ratio > 0.9	10/19	12/19	10/19
Hip abduction			
injured	115 *25*		
uninjured	117 *31*		
ratio > 0.9	15/19		
Hip adduction			
injured	86 *27*		
uninjured	77 *32*		
ratio > 0.9	14/19		

Table 3. The different stabilometric parameters Mean (range)

Parameter	Injured	Uninjured	Reference
1	13.1 (1–23)	11.9 (7–19)	12.7 (4–23)
2	4.0 (3–7)	3.8 (3–5)	3.4 (2–5)
3	18.6 (11–31)	17.7 (11–31)	16.2 (9–29)
4	14.4 (6–31)	13.3 (7–29)	11.3 (3–26)
5	2.1 (0–11)	1.4 (0–8)	0.6 (0–4)

The mean measurements in the one-leg hop test were 144 cm ± 46 cm on the injured side and 175 cm ± 29 cm on the uninjured side ($P < 0.001$). Eight patients had a ratio > 0.9 between the injured and uninjured leg.

The functional knee score was good/excellent (> 83) in 6 patients, fair (65–83) in 6 patients, and poor (< 65) in 7 patients. The median activity level was was 7 (3–9) before injury and 3 (1–6) at the time of testing ($P< 0.001$).

In analyzing whether age at injury affected the outcome, 15 patients older than 19 years were compared with the 4 teenagers, and no differences were found in functional knee score, one-leg hop test, or activity level. The 4 patients with general joint laxity were compared with those without laxity, and no differences were found in the same parameters.

To evaluate the effect of the severity of the pivot shift sign, the patients were divided according to the three different grades, and no differences were seen.

Isometric quadriceps strength on the injured side was reduced ($P < 0.001$) by 22 percent compared with the uninjured limb. Isokinetically at 30°/s and 90°/s the strength values were less reduced: 12 percent ($P < 0.05$) and 8 percent (NS), respectively.

There was a slight, but not significant, reduction in hamstrings strength both isometrically and isokinetically at both 30°/s and 90°/s (Table 2).

The values for hip abduction and adduction did not demonstrate any deficits on the injured side compared with the uninjured side (Table 2).

When comparing the patients with a ratio > 0.8 in quadriceps strength with those who had a ratio < 0.8, we found 1) no difference in pain; 2) no difference in activity level before injury, but a higher ($P < 0.01$) activity at the time of testing in the group with a ratio > 0.8; 3) no difference in laxity as measured by both the drawer test and the different pivot-shift tests; 4) no difference in the stabilometric parameters; 5) a reduced ($P < 0.05$) functional knee score in the group with reduced strength; 6) a shorter ($P < 0.05$) one-leg hop performance test in the group with strength reduction.

In the stabilometric investigation, the mean distance between the point of force application and the reference line did not differ between the injured and the uninjured leg. When the values were compared with the healthy reference group, there were no differences.

The standard deviation related to the point of force application showed no difference between injured and uninjured leg, but compared with the reference group, both the injured ($P < 0.001$) and the uninjured ($P < 0.01$) leg deviated.

The average speed of frontal oscillations did not differ between injured and uninjured leg. When compared with the reference group, this parameter revealed an increase ($P < 0.05$) in body sway on the injured, but not on the uninjured side.

The number of frontal oscillations exceeding 5 mm was not increased on the injured side when compared with the uninjured side. Also, here the injured side differed ($P < 0.05$) from the reference group, whereas the uninjured side showed no difference. When analyzing the number of frontal oscillations exceeding 10 mm, both the injured ($P < 0.001$) and the uninjured ($P < 0.01$) side differed from the reference group. No difference was found between injured and uninjured leg (Table 3).

Discussion

Reduction in activity level was not enough for relief from symptoms, and functional instability was experienced by most patients during day-to-day activi-

ties. General joint laxity was more common than in a normal population (Carter and Wilkinson 1964, Rünow 1983), which might suggest that this condition is a predisposing factor to an anterior cruciate ligament rupture. No correlation between general joint laxity and an increased functional disability after the injury was found. McDaniel and Dameron (1980) could not correlate the functional outcome with age, which was also the case in our series.

No reduction of the strength in knee flexion could be found. This is contrary to Giove (1983), but accords with several authors (Elmquist 1988, Gerber 1985, Tibone 1986).

Our study confirms earlier findings regarding the importance of the knee-extension strength (Elmquist 1988, Gerber 1985, Tegner et al. 1984, Tegner 1985, Tibone 1986). The patients with reduced quadriceps strength had a reduced functional knee score and performance in the one-leg hop test. On the other had, 7 patients had a knee-extensor strength reduction of less than 10 percent, but still with substantial functional disability. Mechanoreceptors have been found in the intact anterior cruciate ligament (Schutte 1987) and a reflex activity in the hamstrings when sagittal translation/subluxation in the anterior cruciate ligament-deficient knee or tension in the intact anterior cruciate ligament is provoked (Solomonow et al. 1987). In some recent studies, electromyography, muscle biopsies, and strength analysis have been indicative of disturbed neuromuscular function in these patients (Elmquist 1988), and this disturbance has been suggested to be caused by defects in proprioceptive sensory input (Elmquist 1988, Solomonow 1987).

Defective standing balance in both the symptomatic and the nonsymptomatic limb has been found in patients with unilateral functional instability of the ankle where the mechanical stability was not affected (Tropp 1985), and a bilateral disturbance of the standing balance has been found in patients with unilateral acute ankle ligament lesions (Fridén et al. 1989).

From the stabilometric measurements in this study, we found an impaired standing balance when standing on both the injured and the uninjured limb when compared with a control group. This might, to some extent, be due to the long-standing reduced physical activity as a consequence of the knee injury, but the injured side had a difference in four of the stabilometric parameters when compared with the reference group, whereas the uninjured side only differed in two parameters and on a lower level of significance. Recent animal studies have shown afferent proprioceptive impulses from the anterior cruciate ligament with reflex gamma-motor activity in both the ipsilateral and the contralateral limb (Sjölander 1989), and this is a mechanism that might explain these findings. The patients with minor or no strength reduction have been found to have little to gain from a conventional strength training program (Tegner 1985), and perhaps therapy with emphasis on training also of coordination could be of value.

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