Clinically Assessed Knee Joint Laxity as a Predictor for Reconstruction After an Anterior Cruciate Ligament Injury: A Prospective Study of 100 Patients Treated With Activity Modification and Rehabilitation

Ioannis Kostogiannis, Eva Ageberg, Paul Neuman, Leif E. Dahlberg, Thomas Fridén and Harald Roos

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Clinically Assessed Knee Joint Laxity as a Predictor for Reconstruction After an Anterior Cruciate Ligament Injury

A Prospective Study of 100 Patients Treated With Activity Modification and Rehabilitation

Ioannis Kostogiannis,*† MD, Eva Ageberg,‡ PT, PhD, Paul Neuman,† MD, Leif E. Dahlberg,† MD, PhD, Thomas Fridén,† MD, PhD, and Harald Roos,† MD, PhD
From the †Department of Orthopaedics and ‡Division of Physiotherapy, Lund University, Lund, Sweden

Background: The association of early knee joint laxity with the need for later reconstruction of the anterior cruciate ligament has not been extensively studied.

Hypothesis: The grade of knee laxity can be used as an early predictor of the need for later reconstruction.

Study Design: Cohort study (prognosis); Level of evidence, 2.

Methods: One hundred consecutive patients with an acute arthroscopically verified total anterior cruciate ligament rupture were followed prospectively for 15 years. Lachman and pivot-shift tests were performed with the patient under general anesthesia before arthroscopy. After 3 months, the tests were repeated in an ordinary clinical setting. All patients underwent rehabilitation as the first choice of treatment. Anterior cruciate ligament reconstruction was performed only in cases of significant reinjuries (n = 16) or reparable meniscal lesions (n = 6) at a mean of 4 years after injury (range, 4 months-11 years). After 15 years, 94 patients were available for follow-up.

Results: Of the later reconstructed patients (n = 18), 82% had a high-grade Lachman test under anesthesia compared with 63% of the nonreconstructed patients (n = 45; *P* = .048). At 3 months, 44% of the nonreconstructed patients (n = 32) had a high-grade Lachman test compared with 82% of the reconstructed patients (n = 18; *P* = .007). Twenty-five patients displayed a normal pivot-shift test at 3 months, of whom 1 underwent later reconstruction (*P* = .009). A high-grade pivot-shift test at 3 months was associated with an 11.4 relative risk for reconstruction.

Conclusion: A positive pivot-shift test at 3 months after injury in an awake patient is the strongest predictor for the future need for reconstruction. Furthermore, a normal pivot-shift test at 3 months indicates a low risk for reconstruction and is characteristic for copers.

Keywords: ACL; predictors; laxity; pivot-shift test; long-term follow-up; copers

There is still great controversy concerning how an anterior cruciate ligament (ACL) injury should be treated, and evidence-based data are limited. Only 1 randomized study comparing surgical repair to nonsurgical treatment algorithm has been published in the literature, and it showed a higher physical activity level after surgery and a lower risk of secondary meniscal injury.[3] A 15-year follow-up of that study has recently been presented, and showed rather similar results in both groups in terms of osteoarthritis, knee function, and activity level, but one third of the nonsurgically treated subjects underwent later ACL reconstruction for instability.[27] A survey among American Academy of Orthopaedic Surgeons (AAOS) members regarding choice of clinical treatment and decision making after ACL injuries shows considerable differences.[26] It is still not known whether a patient with an

*Address correspondence to Ioannis Kostogiannis, MD, Lund University, Margaretav 3B 823, Lund, Sweden 222 40 (e-mail: ioannis.kostogiannis@med.lu.se).

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ACL-deficient knee should be advised to participate in all recreational activities, nor is there any evidence that reconstruction of the ACL reduces the future risk of osteoarthritis.[10,29] The geographical and, in particular, intercontinental variation in the treatment of ACL injuries is also apparent.[20]

The most important factor contributing to the variation in the treatment of ACL injuries is that we cannot, at an early stage, discriminate between patients who can adjust/compensate for the ACL insufficiency (copers) and patients in need of reconstruction (noncopers).[18] Many athletes have little or no functional limitations despite an ACL injury, while others have gross instability even in activities of daily living (ADL).[13] Fithian et al[12] proposed a surgical risk factor (SURF) algorithm based on initial instability, as measured by the KT-1000 arthrometer, together with the preinjury activity level to differentiate between copers and noncopers early after the injury. The same authors concluded in 2002 that the ideal study on ACL insufficiency and its long-term sequelae has yet to be performed.[13]

Our objective was to investigate if there was any association between manually tested laxity, graded using the Lachman and pivot-shift tests, and the need for later ACL reconstruction in a consecutive, initially nonreconstructed cohort. We hypothesized that high-grade positive pivot-shift and Lachman tests are early signs (0-3 months) of the need for later ACL reconstruction.

MATERIALS AND METHODS

A consecutive 100 patients with acute hemarthrosis and arthroscopically verified total ACL rupture were included in the study.[24] All patients were examined by the same knee specialist within 5 days of injury, and patient management followed a specific treatment algorithm and exclusion criteria, which has been reported previously.[24] Professional soccer players (Tegner = 10), as well as patients with partial ACL tears at arthroscopy, were excluded from the study. The cornerstones of this algorithm were rehabilitation and activity modification to cope with the ACL injury. One hundred consecutive patients with complete rupture of the ACL were followed prospectively for a mean of 15 years (range, 12-20 years).

All subjects underwent initial arthroscopy to verify the diagnosis and determine intra-articular injury. The presence of a total ACL tear was verified by probing with an arthroscopic hook. Arthroscopy was performed in all cases by one of the senior authors with profound experience in knee injuries. Before arthroscopy, and with the patient under general anesthesia, manual stability testing was performed by the same doctor. No ligamentous or meniscal repair was performed during the initial arthroscopy. At the time of study initiation, meniscal repair was not performed at our hospital.

An isolated ACL injury was found in 15 subjects, while a combined medial collateral ligament (MCL) and meniscal lesion was observed in 29 subjects, with a total of 10 MCL grade III injuries. Lateral meniscal lesion was the most common meniscal injury, and it was found in 45 of the cases. Twelve of the subjects with an associated meniscal injury had a lesion in both menisci. A chondral lesion was found in 11 of the subjects. No subject had a lateral collateral ligament injury. All meniscal tears were probed with an arthroscopic hook. Stable partial tears and short peripheral tears were left untreated. As much as possible of the meniscus was saved, and only grossly unstable parts were removed.

After arthroscopy, all subjects underwent rehabilitation with the overall aim of regaining joint mobility and restoring muscle function.[37] The majority of the patients underwent neuromuscular training supervised by physical therapists specializing in knee injury training.[38] The detailed rehabilitation protocol, which has been presented earlier, is based on biomechanical and neuromuscular principles with the aim of improving neuromuscular control and achieving compensatory functional stability.[1] Those with associated MCL grade III injuries initially wore a protective brace that prevented varus-valgus instability but did not restrict flexion-extension joint movements. The brace was not used during the training sessions. The aim of the initial treatment was to achieve good knee function without discomfort or lack of confidence in the knee at a satisfactory level of activity from the patient's perspective. A number of different aspects of the cohort have been studied and reported during the 15 years.[2,8,15,16,24,37,38]

The subjects were followed prospectively with physical examination and manual laxity testings at the time of arthroscopy and at 3 months (range, 11-13 weeks) by the same knee specialist, who was directly involved in the treatment of the patients. The 15-year follow-up (range, 12-20 years) was carried out by 2 physicians who were not involved in the primary treatment. During the course of the injury, patients were instructed to contact the treating physician at any time if they had any knee-related problems. Depending on the perceived instability, they were advised to modify their physical activities to cope with the ACL insufficiency. All subjects were advised to avoid contact sports, particularly soccer, basketball, and handball. Those with more than 1 significant reinjury, who would not accept a further prophylactic decrease in activity level (n = 16), and those with a symptomatic reparable meniscal lesion (n = 6) were advised to undergo ACL reconstruction. The mean time from injury to reconstruction was 4 years (range, 4 months-11 years). Six patients were lost to follow-up (3 had moved abroad and the rest could not be located/did not respond to our phone calls). The characteristics of the subjects are presented in detail in Table 1.

Manual Assessment of Laxity

Manual assessment of laxity was performed under general anesthesia within 10 days of injury and after 3 months with the patient conscious. All tests were performed by the same physician.

The Lachman test was performed with the subject in the supine position and the knee at 15° to 25° of flexion. It was graded as normal (0-2 mm), low-grade instability +1 (3-5 mm or <3 mm with soft endpoint), or high-grade instability +2, +3 (>5 mm), compared with the contralateral (noninjured) knee.

TABLE 1
Subject Characteristics

	No Reconstruction	Later Reconstruction	Total	*P* Value
Mean age at injury, y (range)	25.9 (14-41)	22.7 (15-43)	25.1 (14-43)	.06
Gender, n (%)				
Male	41 (75)	14 (25)	55	.4
Female	31 (80)	8 (20)	39	
Injured knee, n (%)				
Right	40 (83)	8 (17)	48	.08
Left	31 (69)	14 (31)	45	
Activity at injury, n (%)				
Contact sports	37 (71)	15 (29)	52	.06
Non-contact sports	33 (87)	5 (13)	38	
Not sport	2 (50)	2 (50)	4	
Tegner preinjury, median (range)	7 (3-9)	7 (4-9)	7 (3-9)	.9
MCL grade-III, n (%)				
No	63 (75)	21 (25)	84	.3
Yes	9 (90)	1 (10)	10	

The pivot-shift phenomenon was elicited with the Flexion-Rotation Drawer test (FRD) as described by Noyes and Grood.[30] It was performed with the subject in the supine position. A coupled axial compression and valgus stress with simultaneous internal rotation and flexion-extension movement was applied to the knee, and the detectable subluxation/relocation of the lateral femoral condyle against the tibial plateau was estimated. It was graded as normal (equal), low-grade instability (+, glide), or high-grade instability (++, clunk; +++, obvious jerk) compared with the contralateral (noninjured) knee.

The presence of varus-valgus instability was tested with the knee in slight flexion and graded as normal (equal), grade I (<5 mm joint opening), grade II (5-10 mm), or grade III (>10 mm) compared with the contralateral knee.

Subjects assessed their preinjury activity level according to the Tegner activity scale. The scale is graded between 0 and 10. Zero represents sick leave or disability pension and 10 represents competitive soccer on national or international level.[34] Subjects were further stratified into high-demand sports (Tegner ≥7) and low-demand sports (Tegner <7). This stratification, together with their Lachman test under anesthesia, was used to divide the subjects into a high-risk group (high-demand sports with a high-grade Lachman test) and a low-risk group (the remaining subjects) in terms of future need for reconstruction.

Statistics

The statistical analysis was performed with the SPSS for Windows 13.0 software package (SPSS Inc, Chicago, Ill). The descriptive data are presented as arithmetic means and ranges, unless otherwise stated. For unevenly distributed data, the Mann-Whitney *U* test was used for comparisons between subgroups. Differences in the distribution of baseline categorical variables among the nonreconstructed and reconstructed subjects were compared with the use of Fisher's 2-sided exact test. A value of $P \leq .05$ was considered statistically significant. The relative need for ACL reconstruction was calculated by logistic regression analysis, both crude and adjusted for age and gender.

RESULTS

The distribution of subjects in terms of laxity measurements is presented in Table 2. Of the patients who had later reconstruction, 82% (n = 18/22) had a high-grade Lachman test under anesthesia, compared with 63% of the nonreconstructed subjects (n = 45/72; $P = .048$). None of the subjects had a normal Lachman test. At 3 months, 44% of the nonreconstructed knees (n = 32) had a high-grade instability compared with 82% of the reconstructed knees (n = 18; $P = .007$).

No significant differences were found between the reconstructed and nonreconstructed knees in terms of laxity in the pivot-shift test under anesthesia ($P = .9$). However, after 3 months, with the subjects conscious, 25 exhibited a normal pivot-shift test, 1 of who underwent later reconstruction ($P = .009$) The results of the pivot-shift test at 3 months are displayed in Table 2.

Both groups had the same median preinjury activity level of 7, according to the Tegner scale (Table 1). Subjects were also grouped by combining their preinjury activity level with the Lachman test under anesthesia. Subjects with a Tegner activity level of 7 or above, together with a high-grade Lachman (n = 52), were compared with those with an activity level below 7 and low-grade instability (n = 38). No significant differences were observed between these 2 groups in terms of the future need for reconstruction ($P = .6$).

Subjects engaged in noncontact sports at the time of injury (n = 38) were less likely to undergo later reconstruction (n = 5) than subjects injured in contact sports (n = 15), although this difference was not statistically significant ($P = .1$). Among the 10 subjects with an MCL grade III injury, 1 patient later underwent reconstruction, but there was no statistical significance between an MCL grade III injury and the need for reconstruction ($P = .4$).

TABLE 2
Results of Initial Laxity Testing (Under Anesthesia) and at 3-Month Follow-up (N = 94)

	Under Anesthesia, n (%)		At Follow-up, n (%)	
	ACL Reconstructed	Nonreconstructed	ACL Reconstructed	Nonreconstructed
Lachman				
Normal (equal)	0 (0)	0 (0)	0 (0)	1 (1.4)
Low-grade instability	2 (9)	24 (33)	4 (18)	37 (50.6)
High-grade instability	18 (82)	45 (63)	18 (82)	32 (44)
Not determined	2 (9)	3 (4)	0 (0)	3 (4)
Pivot-shift test				
Normal (equal)	2 (9)	10 (14)	1 (4.5)	24 (33)
Low-grade instability	4 (18)	18 (25)	10 (45.5)	25 (35)
High-grade instability	12 (55)	41 (57)	11 (50)	20 (28)
Not determined	4 (18)	3 (4)	0 (0)	3 (4)

TABLE 3
Relative Risk for Reconstruction, Crude and Adjusted for Age and Gender[a]

		Crude			Adjusted		
		RR	95% CI	*P* Value	RR	95% CI	*P* Value
Activity at injury	Noncontact/contact	0.4	0.12-1.14	.08	0.5	0.14-1.51	.2
MCL grade-III	No/Yes	0.33	0.04-2.79	.3	0.4	0.05-3.74	.4
Lachman							
Under anesthesia	High/Low	4.8	1.03-22.45	.046[b]	4.2	0.88-20.06	.07
At 3 months	High/Low	5.3	1.64-17.41	.005[b]	4.7	1.41-15.56	.01[b]
Pivot-shift test							
Under anesthesia	Low/No	1.1	0.17-7.17	.9	0.99	0.15-6.65	.99
	High/No	1.5	0.28-7.61	.6	1.2	0.23-6.56	.82
At 3 months	Low/No	9.6	1.14-80.83	.037[b]	9.9	11.6-84.26	.036[b]
	High/No	13.2	1.56-111.23	.02[b]	11.4	1.32-98.51	.03[b]

[a]RR, relative risk; CI, confidence interval.
[b]Statistically significant.

The relative risk (RR) of reconstruction for different groups is presented in Table 3. When adjusted for age and gender, the subjects with high-grade Lachman test at 3 months had an RR of 4.7 compared with subjects with low-grade Lachman. The highest relative risk of reconstruction was detected after 3 months in subjects with a positive pivot-shift test. Those with low-grade laxity had an RR of reconstruction of 9.9 (95% confidence interval [CI]: 11.6-84.26; $P = .036$) and those with high-grade laxity a RR of 11.4 (95% CI: 1.32-98.51; $P = .03$). Subjects injured during noncontact sports had an adjusted RR of 0.5, although this difference was not statistically significant (95% CI: 0.14-1.51; $P = .2$).

DISCUSSION

The principal findings of the present study are that a positive pivot-shift test at 3 months after injury on an awake patient is the strongest predictor for the future need for reconstruction. We also found that knee laxity in the acute phase, assessed as positive Lachman and pivot-shift tests, is not a good predictor of the need for later ACL reconstruction. Although the pivot-shift test was positive initially under anesthesia, it may not be possible to demonstrate a positive pivot-shift test after 3 months in a normal clinical setting. Interestingly, the absence of pivot-shift after 3 months seems indicative of a low need for later ACL reconstruction.

Laxity measurements have little predictive value in differentiating copers from noncopers according to a review article by Herrington and Fowler published in 2006.[18] At the same time, all 9 reviewed studies were criticized for being retrospective and not having a clear definition between copers and noncopers, as well as being based on small patient groups. Patients with both chronic and subacute ACL injuries were included.

We used a different approach. A consecutive group of 100 subjects with an acute arthroscopically verified complete rupture of the ACL was followed prospectively for a mean time of 15 years after injury. The intention-to-treat model was based on avoiding reconstruction by rehabilitation and activity modification to cope with the injury. A well-defined group of 22 subjects was subsequently reconstructed because of significant reinjuries, symptoms, and nonacceptance of activity modification, rather than the presence or grade of clinically assessed laxity. The reconstructed subjects

represent a group of noncopers, whereas the rest of the subjects who modified their activities and avoided reconstructive surgery represent a group of copers. It has previously been demonstrated in the same cohort that differences in femoral condyle anatomy can differentiate copers from noncopers.[16] The mean quotient of condyle height to sagittal depth ratio was significantly lower in patients treated with reconstruction than nonreconstructed patients. Other studies have examined proprioception, muscle strength, and biomechanics in copers and noncopers, but these tests often require access to specific instruments, are time consuming, and are not readily available in everyday clinical practice.[5,6,14,18,32,35] In previous studies based on the same cohort, we have demonstrated an acceptable activity level, from the patient's perspective,[24] and good neuromuscular function 15 years after the ACL injury.[1] In the current article we investigated a possible association between early laxity and the need for future ACL reconstruction.

Daniel et al[10] demonstrated that KT-1000 arthrometer measurements in the first 3 months after injury are important in predicting the need for late meniscal or ligamentous surgery. In this study, we found a positive association between initial high-grade instability determined by the Lachman test (performed under anesthesia, as well as after 3 months) and the need for reconstruction. When adjusted for age and gender, the relative need for reconstruction of subjects with high-grade instability evidenced by the Lachman test was 4.7 at 3 months.

The pivot-shift test has been shown to be a positive predictor of osteoarthritis after surgery[21] and correlates better with the functional instability perceived by the patient.[4,23] Thus, it is often used in clinical practice as a means of identifying subjects in need of reconstruction. During the initial phase after the injury, pivot-shift testing may be inappropriate. It may be difficult to perform and grade due to both pain and general patient tension, leading to resisting muscle tension. It may also be inappropriate when torn ligament fibers are in the process of healing. To decrease this effect, we chose to perform and grade the postinjury laxity at 3 months. Contrary to our hypothesis, we could not find any association between high-grade pivot-shift during anesthesia in the subacute phase and the future need for reconstruction. However, we found that the majority of the subjects with a normal pivot-shift test at 3 months (96%, 24 of 25 subjects) managed without later reconstruction.

It has previously been demonstrated that the injured ACL ligament may heal with fibrous tissue at a different insertion point or against the posterior cruciate ligament (PCL) providing additional stability.[7,17] Such scar formation may in fact be responsible for the elimination of the pivot-shift phenomenon in 25 of our subjects at the 3-month follow-up. Another explanation of the higher specificity of the pivot-shift test at the 3-month follow-up in detecting patients who can manage without reconstruction may be that the pivot-shift test in conscious patients correlates better with the dynamic instability of the knee. Patients who are able to control the knee by reflectory contraction of the muscles are more likely to cope without reconstruction.[25,36] Walla et al[36] described the presence of an active hamstring control that reduced the pivot-shift in 95% of a selected group of copers.

Thus the pivot-shift test under anesthesia in the early phase must be questioned as an indicator for early ACL reconstruction. On the other hand, the pivot-shift test after 3 months seems to be valuable in decision making after an ACL injury. The adjusted relative risk for reconstruction of subjects with high-grade laxity at pivot-shift testing was 11.4 compared with subjects with no laxity. On the basis of these findings, we recommend an initial 3-month period of rehabilitation after an ACL injury to identify patients who are able to cope with the injury without reconstruction.

Many authors propose reconstruction of the ACL in knees with combined MCL grade II or III injuries.[19,28,31] In our study, a combined ACL and MCL grade III injury does not appear to predispose the patient to need ACL reconstruction. Although there was no statistically significant difference between reconstructed and nonreconstructed patients with an MCL grade III injury, we cannot dismiss the fact that just 1 subject among 10 MCL grade III injuries needed later reconstruction. Despite the fact that concomitant MCL grade III ruptures occur more often in noncontact injuries and thus constitute a more complex ligamentous defect, patients with ACL reconstruction more often engaged in contact sports at the time of the injury (15 of 22). It has also been speculated that individuals with higher preinjury activity levels and higher demands on knee function have a higher risk of reinjury and should undergo reconstruction.[9,11,22] We found no significant differences between patients with high and low Tegner activity levels in coping with the injury, but this may be explained by the fact that our study excluded patients with Tegner level 10, who are often treated with early reconstruction.

In our study, a cohort of consecutive patients was treated without reconstruction for a long period of time and followed at regular intervals. Patients with recurrent giving-way episodes and/or those with significant reinjuries or reparable meniscal injuries were treated with reconstruction. This approach is as close to the natural course of the injury as possible[13] within ethical boundaries. The follow-up rate of 94% after 15 years must be considered high. All laxity testing was performed by the same orthopaedic surgeon with considerable experience in knee injuries, thus minimizing intraobserver and eliminating interobserver variations.

A possible flaw of our study is that we have not used any objective measurements of laxity, such as KT-1000 arthrometer or Stryker, since their use at the time the study started was limited. However, a study by Sernert et al[33] has demonstrated good correlation between the Lachman test and KT-1000 arthrometer. Other limitations include that the indications for surgery were subjective, as they relied on the patient's nonacceptance of knee disability, and that follow-up initially and at 3 months were undertaken by the same physician who performed the initial arthroscopy.

CONCLUSION

A positive pivot-shift test at 3 months after injury on an awake patient is the strongest predictor for the future need of reconstruction. Furthermore, a normal pivot-shift test at 3 months indicates a low risk for reconstruction and is characteristic for copers.

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