Knee laxity in cruciate ligament injury

Value of examination under anesthesia

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Arthrometry was performed before and during anesthesia in 41 patients with acute or old anterior cruciate ligament injuries and only minor signs of valgus or varus instability. The uninjured contralateral knee served as a control. The influence of anesthesia on the anterior stability was distinct in acute knee injuries. There was also a small, but definite, increase in anterior laxity in uninjured knees. Knees with old injuries were more lax, and the injured-uninjured difference in anterior laxity was more pronounced. Stability examination under anesthesia is of great value for acutely injured knees.

Stability examination of the knee under anesthesia provides reliable information for diagnosis of an anterior cruciate ligament injury (Noyes et al. 1980, Donaldson et al. 1985, Sandberg et al. 1986). Several reports have shown the Lachman test (Torg et al. 1976) to be most accurate for the diagnosis of an acute anterior cruciate ligament injury (Jonsson et al. 1982, Zelko and Abrams 1982), and Markolf et al. (1976) stated that changes in anterior knee stability are best shown with the knee near or at full extension. Arthrometric measurement of anterior knee stability with the knee in 25° of flexion is very similar to the Lachman test, and provides the examiner with numerical values of anterior laxity (Daniel et al. 1985a).

Whereas the Lachman test is highly reliable during examination with and without anesthesia in the acute setting, the pivot shift test (Galway et al. 1972) seems more sensitive during anesthesia (Donaldson et al. 1985).

We report the effect of anesthesia on anterior stability, measured by arthrometry, and on the occurrence of pivot shift.

Patients and methods

Acute injuries. In our department, all adult patients below the age of 40 years with hemarthrosis following knee trauma and without radiographic evidence of fracture are examined for instability under anesthesia and with arthroscopy.

From February 15 to May 15, 1988, 23 consecutive knees (11 men and 12 women) with arthroscopically verified complete anterior cruciate ligament rupture and only minor signs of valgus or varus instability were included in the study. All the contralateral knees were intact. The median age in this group was 27 (14–40) years, and the median duration of symptoms was 6 (2–22) days after the primary knee injury. One patient had an earlier medial meniscectomy. Twenty patients were examined under general anesthesia and 3 patients under epidural anesthesia.

Old injuries. During the same period, 18 patients (9 men and 9 women) with unilateral old anterior cruciate ligament injuries underwent diagnostic arthroscopy and/or reconstruction, and were also included in the study. The median age in this group was 28 (18–47) years, and the median duration of symptoms was 2 (1–9) years.

Fifteen patients were examined under general anesthesia and 3 patients under epidural anesthesia.

The primary knee injury was usually caused by trauma during sport activities – skiing and soccer being the most common cause (Table 1).

The knees were first examined in the anesthesia room before premedication. A clinical examination was performed for straight and rotatory instabilities. Anterior drawer with the knee in 25° of flexion was then measured with an arthrometer (KT-1000, MEDMetrics Corp. San Diego, CA, USA) with a forward pull of 67 and 89 N, and with the use of maximum manual displacement where a high manual force is applied

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Table 1. Data for 41 patients with anterior cruciate ligament injuries examined with arthrometry before and under anesthesia

A	B	C	D	E	F	P_1	P_2	I_1	I_2	U_1	U_2	$I\text{-}U_1$	$I\text{-}U_2$	Compl I1	Compl I2	Compl U1	Compl U2	Compl $I\text{-}U_1$	Compl $I\text{-}U_2$	MMD I_1	MMD I_2	MMD U_1	MMD U_2	MMD $I\text{-}U_1$	MMD $I\text{-}U_2$
ACUTE INJURIES																									
1	M/20	10	14d		1	(+)	+	8.0	9.0	5.0	7.0	3.0	2.0	2.5	2.5	1.0	1.0	1.5	1.5	10.0	13.0	6.0	7.5	4.0	5.5
2	F/26	10	10d		1	-	(+)	11.0	12.0	8.0	10.0	3.0	2.0	2.5	3.0	1.5	2.0	1.0	1.0	14.0	16.0	8.5	10.5	5.5	5.5
3	F/40	9	2d		1	(+)	+	14.0	15.0	10.5	10.0	3.5	5.0	3.5	2.5	2.5	2.0	1.0	0.5	16.0	17.0	11.0	13.0	5.0	5.0
4	F/37	9	6d		1	-	+	10.0	12.5	7.5	7.5	2.5	5.0	2.5	3.5	1.0	1.0	1.5	2.5	13.0	17.0	8.0	10.0	5.0	7.0
5	F/27	9	2d		1	(+)	+	6.5	9.0	5.0	5.0	1.5	4.0	2.5	2.0	1.0	1.0	1.5	1.0	9.0	15.0	6.0	6.0	3.0	9.0
6	F/36	9	4d		1	(+)	+	15.0	16.0	8.0	8.0	7.0	8.0	3.0	3.0	1.0	1.0	2.0	2.0	18.0	20.0	10.0	11.0	8.0	9.0
7	M/18	9	6d		1	(+)	+	9.0	10.5	7.0	7.0	2.0	3.5	2.0	2.5	1.0	1.0	1.0	1.5	12.0	16.0	10.0	9.0	2.0	7.0
8	F/14	3	5d		1	(+)	+	9.0	11.0	5.0	5.0	4.0	6.0	2.5	3.0	1.5	2.0	1.0	1.0	10.0	12.0	6.0	6.5	4.0	5.5
9	F/34	9	2d		1	(+)	+	6.5	11.0	5.5	7.0	1.0	4.0	1.5	3.0	1.0	1.5	0.5	1.5	9.0	16.0	7.0	8.0	2.0	8.0
10	F/33	9	11d		2	(+)	+	12.0	13.0	6.0	5.5	6.0	7.5	2.0	1.0	1.0	1.0	1.0	0.0	16.0	18.0	8.5	6.0	7.5	12.0
11	F/30	9	4d		1	(+)	+	7.0	11.5	5.5	7.0	1.5	4.5	1.0	3.0	1.5	1.0	-0.5	2.0	10.0	18.0	6.0	9.0	4.0	9.0
12	F/27	9	8d		2	(+)	+	10.5	14.0	7.5	9.0	3.0	5.0	1.5	5.0	2.0	2.0	-0.5	3.0	14.0	18.0	8.0	10.0	6.0	8.0
13	M/33	2	4d		1	+	+	8.0	14.0	6.0	7.0	2.0	7.0	2.0	4.5	1.0	1.0	1.0	3.5	11.0	17.5	7.5	8.0	3.5	9.5
14	M/22	9	21d		1	(+)	+	12.5	15.0	9.0	8.0	3.5	7.0	3.5	4.0	1.0	1.0	2.5	3.0	18.0	20.0	9.0	9.0	9.0	11.0
15	M/29	10	22d		1	-	-	10.0	11.5	6.5	7.0	3.5	4.5	2.5	3.0	1.5	2.0	1.0	1.0	14.0	16.0	8.0	8.0	6.0	8.0
16	M/37	9	2d		1	-	-	6.0	9.0	7.0	8.5	-1.0	0.5	1.0	1.0	1.0	0.5	0.0	0.5	8.0	11.0	8.0	9.5	0.0	1.5
17	M/23	10	18d		1	-	(+)	7.5	9.0	3.5	4.0	4.0	5.0	1.5	1.5	0.5	1.0	1.0	0.5	10.0	13.0	5.0	5.0	5.0	8.0
18	M/20	4	13d		1	+	+	9.5	12.0	7.0	7.0	2.5	5.0	2.5	2.0	1.5	2.0	1.5	0.0	11.0	13.0	8.5	9.0	2.5	4.0
19	F/15	10	5d		1	(+)	+	9.5	11.0	5.5	6.0	4.0	5.0	2.0	2.0	1.5	1.0	0.5	1.0	13.0	16.0	6.5	7.0	6.5	9.0
20	M/28	15	16d	1	2	-	-	12.5	12.0	7.5	6.5	5.0	5.5	3.0	2.5	0.5	1.0	2.5	1.5	15.0	15.0	9.0	8.0	6.0	7.0
21	M/30	9	10d		1	-	(+)	7.0	7.5	5.0	5.0	2.0	2.5	2.0	2.0	1.0	1.0	1.0	1.0	14.0	14.0	8.0	8.0	6.0	6.0
22	M/19	2	8d		1	-	(+)	11.0	11.0	7.0	6.5	4.0	4.5	3.0	2.0	1.0	1.0	2.0	1.0	16.0	19.0	11.0	12.0	5.0	7.0
23	F/17	10	4d		1	-	+	8.0	12.0	5.0	5.0	3.0	7.0	2.5	2.0	1.0	1.0	1.5	1.0	13.0	15.5	6.0	6.0	7.0	9.5
OLD INJURIES																									
24	M/35	10	5y	1	1	(+)	+	10.5	12.0	5.5	5.0	5.0	7.0	2.0	2.0	0.5	1.0	1.5	1.0	13.0	15.0	6.0	6.5	7.0	8.5
25	M/33	4	1.5y		1	+	+	10.0	14.0	8.5	8.0	1.5	6.0	1.0	2.0	0.5	0.5	0.5	1.5	12.0	18.5	9.0	10.0	3.0	8.5
26	F/25	6	5.5y	4	1	+	+	14.5	13.0	6.0	6.0	8.5	7.0	2.0	2.0	1.0	1.0	1.0	1.0	17.0	18.0	7.0	8.0	10.0	10.0
27	F/27	3	2.5y		2	+	+	12.0	13.5	7.0	7.0	5.0	6.5	3.0	2.5	1.0	1.5	2.0	1.0	14.5	16.0	8.0	8.0	6.5	8.0
28	M/32	10	7.5y	1	2	+	+	15.0	16.0	9.0	7.0	6.0	9.0	6.0	6.0	3.0	2.0	3.0	4.0	16.5	18.0	6.0	8.0	10.5	10.0
29	F/18	10	0.5y		1	+	+	11.0	12.0	8.0	7.0	3.0	5.0	3.0	4.0	1.0	1.0	2.0	3.0	13.0	14.0	9.5	8.5	3.5	5.5
30	F/34	9	1y		1	-	-	9.0	9.0	6.0	6.0	3.0	3.0	2.0	2.0	2.0	2.0	0.0	0.0	11.0	11.0	7.0	7.0	4.0	4.0
31	F/30	4	9y	2	1	+	+	18.0	18.0	9.0	8.0	9.0	10.0	3.0	3.0	2.0	2.0	1.0	1.0	20.0	22.0	9.0	11.0	11.0	11.0
32	M/29	10	1.5y		1	+	+	12.0	13.0	7.0	8.0	5.0	5.0	4.5	4.0	2.0	2.0	2.5	2.0	16.0	17.0	9.0	10.0	7.0	7.0
33	M/23	9	1y		2	+	+	15.0	19.0	5.0	7.0	10.0	12.0	3.0	3.0	1.0	1.5	2.0	1.5	19.0	24.0	6.5	9.0	12.5	15.0
34	M/23	7	1y	1	1	(+)	+	11.0	16.0	5.0	6.0	6.0	10.0	3.0	3.0	1.5	2.0	1.5	1.0	17.0	20.0	6.0	7.0	11.0	13.0
35	F/22	6	5y	1	1	+	+	10.5	14.5	6.0	6.0	4.5	8.5	2.5	3.5	2.0	2.0	0.5	1.5	15.0	19.0	7.0	6.5	8.0	12.5
36	M/19	10	1y		1	+	+	13.5	13.5	5.5	5.5	8.0	8.0	2.5	2.0	1.0	1.0	1.5	1.0	17.0	18.0	7.0	6.5	10.0	11.5
37	F/22	9	2y		1	+	+	11.0	12.5	5.5	5.5	5.5	7.0	3.5	3.5	1.0	1.5	2.0	2.0	14.0	16.0	7.0	7.5	7.0	8.5
38	M/47	15	1.5y	3	1	-	-	7.0	10.0	5.0	7.5	2.0	2.5	1.5	2.0	2.0	1.5	-0.5	0.5	10.0	12.5	6.0	9.0	4.0	3.5
39	F/25	10	7y	2,4	1	-	+	10.5	14.5	8.0	8.0	2.5	6.5	1.5	2.0	1.5	1.0	0.0	1.0	15.0	20.0	9.0	9.5	6.0	10.5
40	M/28	10	12y	1,2,4	1	+	+	17.0	17.0	5.0	5.5	12.0	11.5	2.0	2.0	1.5	1.0	0.5	1.0	17.5	18.0	6.5	6.5	11.0	11.5
41	F/33	9	1y	3	1	+	+	11.0	11.0	7.0	7.0	4.0	4.0	1.0	1.0	1.0	1.0	0.0	0.0	15.0	15.5	9.0	10.0	6.0	5.5

Abbreviations

Index number 1: Measurement values obtained by examination *without* anesthesia.
Index number 2: Measurement values obtained by examination *with* anesthesia.
A: Case number.
B: Age and sex.
C: Cause of knee injury: 2 = indoor bandy, 3 = basketball, 4 = falling, 6 = handball, 7 = motorcycle, 9 = skiing, 10 = soccer, 15 = orienteering.
D: Duration of symptoms prior to examination. Days for acute, years for old injuries.
E: Previous surgery in injured knee: 1 = Med. meniscus; 2 = Extraart. stabilization; 3 = Med. coll. lig. sut; 4 = Ant. cruciate lig. reconstruction.
F: Anesthesia method: 1 = Gen. anesthesia, 2 = Epidural.
P: Pivot shift + = Clearly positive; (+) = Uncertain; – = Clearly negative.
I: Anterior displacement (mm) injured knee during 89 N pull.
U: Anterior displacement (mm) uninjured knee during 89 N pull.
I-U: injured — uninjured difference (mm) at 89 N pull.
Compl. I: Compliance injured knee.
Compl U: Compliance uninjured knee (mm).
Compl. I-U: Compliance difference (mm).
MMD I: Maximum manual displacement (mm) injured knee.
MMD U: Maximum manual displacement (mm) uninjured knee.
MMD I-U: Maximum manual displacement difference (mm).

to the proximal part of the calf as described by Daniel et al. (1985a). The patients were then anesthetized, and the measurements were repeated by the same examiner (LD).

The uninjured contralateral knee was measured in the same way. The difference between the injured and uninjured knee of each patient was calculated for the different loads.

Compliance was calculated as the difference between the 67 and 89 N pull values in the same knee. The difference in compliance between the injured and uninjured knee of each patient was also calculated.

For statistical analysis, the Student's t-test and chi-square test were used, and $P < 0.05$ was considered significant.

Results

The Lachman test was positive in all acute knees even before anesthesia, but it became easier to demonstrate under anesthesia. Before anesthesia, there was a pivot shift in two of 23 knees, and under anesthesia this test was clearly positive in another 14 knees (Table 2). Arthrometric measurements showed that the influence of anesthesia on the anterior stability is profound in acute injured knees. The mean increase in injured knees for anterior displacement during an 89 N pull was 2.1 ± 1.6 mm (mean ± SD), whereas maximum manual displacement increased by 3.1 ± 2.1 mm. There was no increase in compliance.

In all the knees with old anterior cruciate ligament

Table 2. Sagittal stability: Frequency of a positive pivot shift symptom and arthrometric measurement values for injured knees (I) and contralateral uninjured knees (U) examined without (EWA) and under (EUA) anesthesia. Mean (mm), *SD*, and *P*-values

	EWA		EUA		*P*
Acute injuries (n 23)					
Pivot shift pos. (n)	2		16		< 0.001
AD I	9.6	*2.5*	11.7	*2.2*	< 0.001
AD IU	3.1	*1.7*	4.8	*1.9*	< 0.001
Compl. I	2.3	*0.7*	2.6	*1.0*	NS
Compl. IU	1.1	*0.8*	1.4	*0.9*	NS
MMD I	12.8	*2.9*	15.9	*2.4*	< 0.001
MMD IU	4.8	*2.1*	7.4	*2.6*	< 0.001
Old injuries (n 18)					
Pivot shift pos. (n)	13		16		NS
AD I	12.1	*2.8*	13.8	*2.7*	< 0.001
AD IU	5.6	*2.9*	7.1	*2.7*	< 0.001
Compl. I	2.6	*1.2*	2.8	*1.2*	NS
Compl. IU	1.2	*1.0*	1.3	*1.0*	NS
MMD I	15.1	*2.7*	17.4	*3.2*	< 0.001
MMD IU	7.7	*3.0*	9.2	*3.1*	< 0.002
Contralateral uninjured knee (n 41)					
AD U	6.5	*1.5*	6.8	*1.3*	< 0.05
Compl. U	1.3	*0.5*	1.3	*0.5*	NS
MMD U	7.7	*1.5*	8.4	*1.8*	< 0.001

AD: Anterior displacement at 89 N pull force.
AD IU: Anterior displacement difference, injured-uninjured knee at 89 N pull force.
Compl.: Compliance.
Compl. IU: Compliance difference injured-uninjured knee.
MMD: Maximum manual displacement.
MMD IU: Maximum manual displacement difference injured-uninjured knee.

injuries, the Lachman test was positive before and under anesthesia. Before anesthesia, there was a pivot shift in 13 of 18 knees and under anesthesia in another 2 knees. In knees with old injuries, there was a mean increase of 1.7 ± 1.9 mm in anterior displacement during the 89 N pull and an increase in maximum manual displacement of 2.2 ± 1.8 mm. There was no increase in compliance.

Knees with old as compared with acute anterior cruciate ligament injuries were laxer, and the difference between the injured and contralateral uninjured knee was also more pronounced.

There was a profound difference between injured and uninjured knees both before and under anesthesia (Table 3). There was no difference between males and females concerning anterior knee stability for acute and old injuries and for uninjured contralateral knees. For uninjured knees examined under anesthesia, there was an increase in anterior drawer of 0.3 mm and maximum manual displacement of 0.7 mm. There was no change in compliance (Table 2).

Table 3. Mean differences between injured and uninjured knees when examined with an arthrometer under anesthesia. Mean differences (mm) and *t* values

	Mean difference	*t*
Acute injuries		
Anterior displacement[a]	4.8	12.3
Compliance	1.4	7.1
Maximum manual displacement	7.4	14.8
Old injuries		
Anterior displacement[a]	7.1	11.2
Compliance	1.3	5.8
Maximum manual displacement	9.1	12.2

[a] Displacement with 89 N pull force.

Discussion

The Lachman test is highly accurate for diagnosing acute anterior cruciate ligament injuries. It has the best diagnostic specificity for this lesion with the patient awake, and if the examination is performed under anesthesia, the diagnosis can be correct in almost all cases (Torg et al. 1976, Jonsson et al. 1982, Donaldson et al. 1985, Sandberg et al. 1986). However, the Lachman test is difficult to quantify. Arthrometric measurement with the knee in 25° of flexion is similar to the Lachman test and gives a numerical value of anterior knee laxity (Daniel et al. 1985a).

Malcolm et al. (1985) have pointed out that anesthesia can falsely influence the measurement due to wrong tracking of the patella during the examination or due to rotation of the lower leg. In uninjured contralateral knees, we found a mean increase of less than 1 mm during anesthesia (Table 2), indicating that these errors are of minor importance; arthrometric measurement of anterior drawer is a valid method with good reproducibility.

Our observations confirm those of Malcolm et al. (1985). They found in 24 patients with acute anterior cruciate ligament injuries a mean increase in injured-uninjured difference from 4 to 6 mm; and in 19 patients with old anterior cruciate ligament injuries, the values were 6.8 mm and 6.4 mm, respectively, i.e., no change.

During anesthesia, we found an increase in anterior drawer in 25° of flexion in both injured and uninjured knees. There was also a marked increase in maximum manual displacement under anesthesia for both types of injury. Our results confirm the opinion of Daniel and Stone (1988) that the maximum manual displacement test is the best diagnostic test for an anterior cruciate ligament injury. The fact that chronic anterior cruciate-deficient knees may show higher anterior displacement values corresponds to the easiness with which the Lachman and pivot shift tests can be provoked in these cases. It is probably a manifestation of weakened secondary restraints to anterior laxity.

Daniel et al. (1985b) consider an injured-uninjured difference at 89 N pull of 3 mm or more as indicative of an anterior cruciate ligament injury. We found such a difference in 13 of 23 acute injuries without and in 19 of 23 with anesthesia, and for old injuries in 15 of 18 knees without and in 17 of 18 with anesthesia.

Torg et al. (1976) introduced the concept of end point in the Lachman test. Donaldson et al. (1985) explained the end point as a sensation of sudden increase in ligament stiffness as the load is applied. The concept of compliance was described by Daniel et al. (1985) as a measure of sagittal stiffness. Although there was a difference in compliance between injured and uninjured knees, the clinical value of compliance can be questioned (Table 3).

We believe that examination under anesthesia is of great value in acutely injured knees, but in most cases unnecessary in old injuries. Anesthesia influences the results; and when comparing reports, it is important to know whether or not anesthesia has been used.

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