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The Course of Knee-Ligament Injuries

BY

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MUNKSGAARD . COPENHAGEN

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INTRODUCTION

In the 19th century, studies were made demonstrating the relationship between trauma, ligament injuries to the knee-joint and knee instability (Hyrtl 1847, Hönigschmied 1893). Early in the 20th century each of a number of authors presented a few cases of ligament rupture with suggestions for therapy (Battle 1902, Robson 1903, Pringle 1907). Goetjes (1913) and Jones and Smith (1913) suggested that early surgical repair might be an advantage in cases with injuries of the anterior cruciate ligament. Their observations, however, were mainly based on such cases which had radiologically visible avulsion fractures of the tibial spine. On the whole, conservative treatment was preferred (Smith 1918, Harding 1919). Hey Groves, in his classical paper of 1917, formulated the attitude of his time: "A rigid plaster or leather case to be worn for a year, followed by a hinge apparatus represents the generally accepted method". In 1942, Mauck surveyed a series of 587 cases of acute knee-injuries, encountered over 20 years, and emphasized the importance of early conservative treatment, preferably with a hinged cast.

Palmer (1931, 1937) described repair operations for recent knee-ligament injuries. O´Donoghue (1950) stated that a complete recovery was the goal of treatment of knee-ligament injuries and that this goal could be achieved by early surgical intervention and repair of the ligament. This was particularly important in athletes since cruciate instability was intolerable to those who wanted to participate fully in sporting activities - patients who by successful surgical intervention had stable knee-joints could usually return to full activity (O´Donoghue 1955). Johansson (1954) pointed out that the early diagnosis and repair of cruciate ligament injuries gave good results. Liljedahl et al. (1965) suggested that patients with suspected acute rupture of the anterior cruciate ligament should be examined under anaesthesia and by arthrography. In a series of patients who had been diagnosed by such methods, complete

ruptures were detected and sutured with excellent results. This observation was later confirmed in a larger number of patients and with a longer follow-up (Liljedahl and Nordstrand 1969). Lately, Marshall et al. (1979) presented a series of primary repairs with which a majority of the patients had been able to return to their pre-injury activities. Lysholm et al. (1981) obtained good results in two thirds of repaired ACL-substance ruptures.

Solonen and Rokkanen (1967) found good or excellent results in half of the patients after repair of injuries to the anterior cruciate ligament within 11 days after the accident, and suggested that the strength of the torn ligaments should be safe-guarded by grafts even at the primary repair. Feagin and Curl (1976) and Vidal et al. (1977) concluded that early repair was of little value. Arnold et al. (1979) were unable to demonstrate any difference between patients with and without early repair - extra-articular operative stabilization was more efficient. In these studies, however, the time lapse accident - repair was not presented.

A vast majority of knee-ligament injuries are not being diagnosed or treated in conjunction with the causing accident, and this seems to be particularly true of rupture of the anterior cruciate ligament without or with only minor injuries to other structures of the knee-joint. Most repair procedures presented in the past are therefore concerned with reconstruction of the anterior cruciate ligament using structures such as the patellar retinaculum, the semitendinous, gracilis and patellar tendons and the iliotibial tract. Lindström (1959) presented a series of 34 cases of successful reconstruction using the medial semilunar cartilage. Jones (1963) presented a series of anterior cruciate ligament reconstructions by transposition of part of the patellar tendon. This method, modified by Brückner (1966) and Broström et al. (1968), was used with success in Sweden as presented by Gillquist et al. (1971), Alm and Gillquist (1974) and Eriksson (1976). Also,

extra-articular reconstructions have been suggested, the most commonly used being the pes anserinus transposition (Slocum and Larson 1968), the O´Donoghue procedure (1973), the "five to one" procedure by Nicholas (1973) and the "distal ilio-tibial band transfer" (Ellison 1979).

There are two possible beneficial effects of early repair as well as late reconstruction of knee-ligaments: an immediate effect, permitting the patient to lead, in all respects, a normal life and, a delayed effect, preventing degenerative changes and disability later in life. Controlled studies with a random allocation of cases have not been carried out with regard to either of these two expected beneficial effects. Comparisons between patients with and without early repair have been presented. Fetto and Marshall (1980) concluded that the untreated anterior cruciate ligament rupture follows a course of progressive knee dysfunction and deterioration which can be modified by repair as well as by reconstruction whereas Arnold et al. (1979) failed to demonstrate any difference between patients with repair directly after the accident and untreated patients. In both instances, however, the time of observation was limited.

Today, the decision-making process is difficult when we wish to create a policy for treating knee-ligament injuries, since therapy should always be evaluated against the background of the natural course of the injury itself. Attempts to describe the natural course have been presented by Gudde and Wagenknecht (1973), Arnold et al. (1979) and Fetto and Marshall (1980). In all instances, however, the natural course has been tampered with owing to therapeutic attempts.

It is obvious that the true natural history of knee-ligament injuries will never be available. Nevertheless, from a substantial number of injuries it may be possible by comparison and extrapolation to arrive fairly close to the truth and to provide background data for discussing the treatment.

The aim of the present study was to follow the course of knee-ligament injuries in a consecutive series of patients, who had been diagnosed by arthrotomy and visual inspection of the injured structures, and to examine factors which might possibly contribute to the outcome of such injuries.

MATERIAL

The entrance criteria to this study were:

1) Patients treated in the Orthopedic Department, Malmö General Hospital, 1945 - 1974.
2) Knee-ligament injury diagnosed by arthrotomy and visual inspection of the structures, regardless of the cause of the surgery - recent injury, planned reconstruction or an accidental finding.
3) No intra-articular fractures except for avulsion of ligament attachments. Twenty cases were excluded because of this criterion.

Altogether 413 patients fulfilled the criteria. Of these patients 383 - 339 men and 44 women - were re-examined - 96% of the survivors (Figure 1). The age at accident ranged from 8 - 72 years (28 $\pm$ 12). The distribution of patients over the years is presented in Figure 2. The recording procedure was somewhat unreliable for the first 5 years. During part of that period these patients were also managed in the Department of General Surgery. From 1950 onwards, however, all ligament injury patients were cared for in the Orthopedic Department and all patients in the city of Malmö who fulfilled the criteria were included.

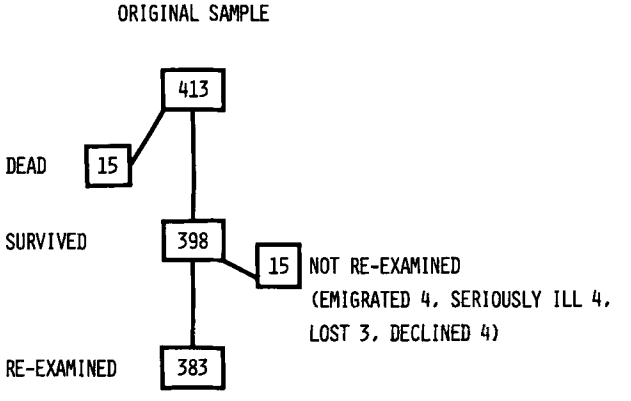

Figure 1. Flow scheme of patients with knee-ligament injuries diagnosed by arthrotomy.

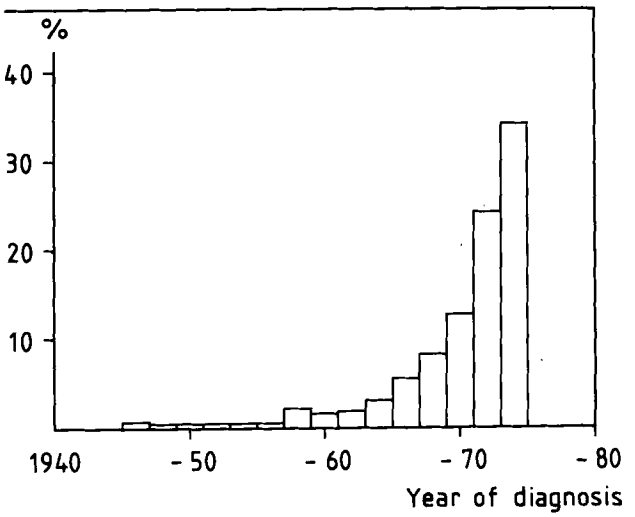

Figure 2. Distribution over the years of knee-ligament injuries diagnosed at arthrotomy in the city of Malmö - per cent of total (N = 389).

The injuries had occurred under a variety of circumstances as listed in Table I, soccer (association football) being the predominant cause contributing almost half of the injuries. The left-right ratio was 0.5 in soccer injuries and 1.1 in other injuries.

The injuries were classified according to Hastings (1979) (Table II). For this classification all additional ligament injuries which had occurred before or after the entrance arthrotomy (= the arthrotomy which revealed the injury that became the criterion for inclusion in the study) were included, so that the 389 joints involved had been subjected to altogether 585 accidents and 507 operations. As many as 89 joints underwent two operations. One patient with altogether 11 accidents was operated on five times. Seventy-nine of the subsequent operations were undertaken without intervening trauma with the purpose of undertaking meniscectomy, ligament

reconstruction or treatment of secondary gonarthrosis. The distribution of injuries and the various combinations are also demonstrated in Figure 3, again using the accumulated injuries.

Table I. Accidents causing the entrance arthrotomy.

	N	
Traffic	62	16%
Fall between levels	36	9%
Fall same level	22	6%
Labour accidents	13	4%
Beatings	5	1%
	138	36%
Soccer	181	47%
Skiing	18	5%
Handball	13	3%
Wrestling	12	3%
Other sports	21	6%
	245	64%

Table II. Classification of injuries according to Hastings.

Abbreviations: Medial collateral ligament (MCL)
Anterior cruciate ligament (ACL)
Posterior cruciate ligament (PCL)
Lateral collateral ligament (LCL)

Injury	N	
ACL	151	39%
ACL + MCL	118	30%
ACL + posterior medial capsule	1	0%
MCL	47	12%
Posterior medial capsule	12	3%
ACL + LCL	7	2%
LCL	2	1%
PCL	19	5%
MCL + PCL	8	2%
MCL + ACL + PCL	17	4%
MCL + ACL + PCL + LCL	1	0%
MCL + PCL + LCL	1	0%
ACL + PCL	2	1%
ACL + PCL + LCL	3	1%

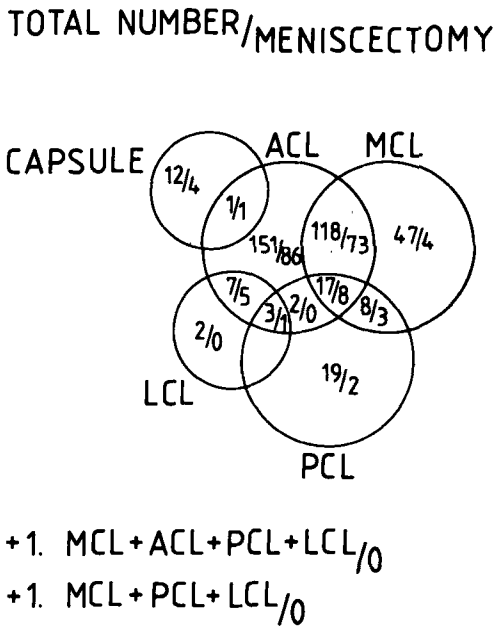

Figure 3. Distribution of injuries among the main types as represented by an extended Venn diagram, injuries combined with meniscectomy presented separately.

The therapy was usually surgical in those patients in whom the diagnosis had been obtained within three weeks after the accident. The most common procedure was suture of the medial collateral ligament but efforts were also made to suture the anterior cruciate ligament. In 42 joints, ACL substance sutures were undertaken, whereas the femoral or tibial attachments were re-attached in 32. Two knees in each group were left without repair. Proximal and distal substance ruptures and attachment ruptures were mostly repaired by the pull out suturing technique described by Palmer (1937). In cases of anterior cruciate ligament injuries which were diagnosed later on, ligament reconstructions were undertaken in 76 joints, in all instances because of instability - 41 in conjunction with the entrance operation. Altogether 99 knee-joints with known injuries to the anterior cruciate ligament - with or

without other concomitant injury - were left without surgical treatment.

The following complications were encountered:

Twelve wound infections - six of which with discharge of suture material.
One streptococcus arthritis.
Six cases of deep vein thrombosis, diagnosed by phlebography, two of which had pulmonary embolism.
Six cases of post-operative peroneal nerve paralysis.

All complications were resolved without any known harmful effects. There was no mortality.

Among the variables recorded in these patients for further analysis were also:

Anatomy of ligamentous rupture: There were 47 ACL ruptures in the substance whereas 34 were attachment ruptures - the anatomy could be established only in 81 joints, failure to do so was usually due to the age of the injury.

The extent of injury: This classification was applied only to ACL injuries not combined with PCL or tibial spine injuries or operated on with reconstruction. Of these, 125 were total whereas 40 had signs of partial rupture and/or elongation, again in old injuries with a resorbed ligament, the extent of damage may not be evaluated.

Type of trauma: Forty per cent of the trauma episodes included abduction, 17% hyper-extension. The remainder were divided among a variety of trauma types or the trauma could not be analysed.

Previous knee-injuries were known to have occurred in 106 joints (27%) - mostly sprains without a diagnosis. Eleven joints were known to have had a meniscus or ligament injury.
In 15 of the patients there was evidence of mental disorder including alcoholism.

Also, the types of treatment were recorded with particular reference to whether the ligaments had been sutured or re-attached or left without surgical repair.

As a special group of treatment were separated the 73 knee-joints which had undergone intra-articular ligament reconstruction. All but three had had a modified Jones procedure (Broström et al. 1968).

Also, there were 35 joints in which extra-articular ligament reconstructions were performed.

The 21 patients who had a fracture of the tibial intercondylar eminence were presented separately. The requirement to be included was that the entire distal attachment including the bony substance should be torn away from the tibial spine and not merely the ligament with tiny bone fragments.

Finally, the 51 cases of posterior cruciate ligament injuries were studied separately, all PCL injuries being included here regardless of combined injuries and treatment.

The time lapse accident - entrance arthrotomy is presented in Figure 4. Even if there are exceptions most of the arthrotomies were undertaken within two weeks after the accident.

The cases had been sampled over a period of 30 years with an uneven distribution over that time period (Figure 2). In the early sixties the interest in knee-ligament injuries increased, later examination under general anaesthesia was introduced - from 1973 as a routine method. Later, arthroscopy also improved the diagnostic procedure. The change in rate of diagnosed cases over the years (Figure 2) does not reflect the incidence of injuries in the city of Malmö but rather the diagnostic efforts invested in these cases. Even if a true incidence may never be calculated, not even in Malmö with an Orthopedic Emergency Room available for the entire population, we may at

least be approaching the incidence of patients who present themselves with symptoms.

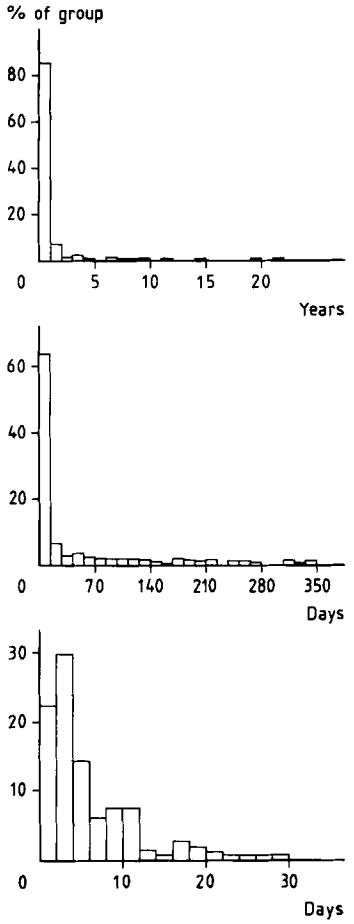

Figure 4. The time elapsed between the accident, which most probably caused the injury and the entrance operation (the diagnosis) presented in relation to the total time period involved, to injuries diagnosed during the first year after the accident and injuries diagnosed during the first month after the accident.

METHODS

In the clinical and roentgenological follow-up examination, which was undertaken after a minimum of 5 years (10 $\pm$ 6) after the first accident supposed to have caused the injury, 160 variables were recorded describing the patients' symptoms and function, subjective and objective joint stability and radiological changes. In the first analysis the following variables were used:

Symptoms and function

None of the patients complained of pain at rest but some claimed they had pain and discomfort with weather changes or that they were able to predict weather - such weather change pain was therefore recorded. The presence or absence of pain or discomfort in conjunction with walking, stair climbing, running, squatting, kneeling and cycling were also recorded.

Those patients, who had retired or had had to change their professions due to their injury, were recorded. Also, the habits with regard to sport and exercise were noted.

Stability

Stability was estimated by traditional methods and by using mechanical measuring devices. The patient's opinion of stability was recorded and classified in three levels: Normal stability, a feeling of instability and the occurrence of "give away" episodes.

The forward drawer sign was estimated by a standard technique - the patient relaxed in supine position with the joint in 90° flexion and the foot fixed. The findings were classified as absence of drawer sign and moderate or obvious drawer sign. The anterior-posterior stability was also tested in slight flexion using the Lachman test (Torg et al. 1976) and graded as negative, moderate and obvious. The pivot shift (Galway et al. 1972), assumed to be in particular an estimate of the antero-lateral instability, was undertaken and the results graded as

absent, moderate and obvious.

Finally, the medial-lateral stability was estimated using the standard method of manipulating the knee in full extension and in 20° of flexion. Medial-lateral instability was graded and classified as none, slight, moderate and obvious. In all instances comparisons with the contra-lateral joint were considered most important for the classification.

Quantitative measurements of knee stability

Anterior-posterior stability

For the purpose of measuring the anterior-posterior stability, a calliper was used (Sylvin 1975) (Figures 5 and 6). The anterior drawer was measured in millimetres with the knee in 90° flexion and the tibia in neutral position, internal rotation and external rotation, separately, each measurement being an average of five repetitions.

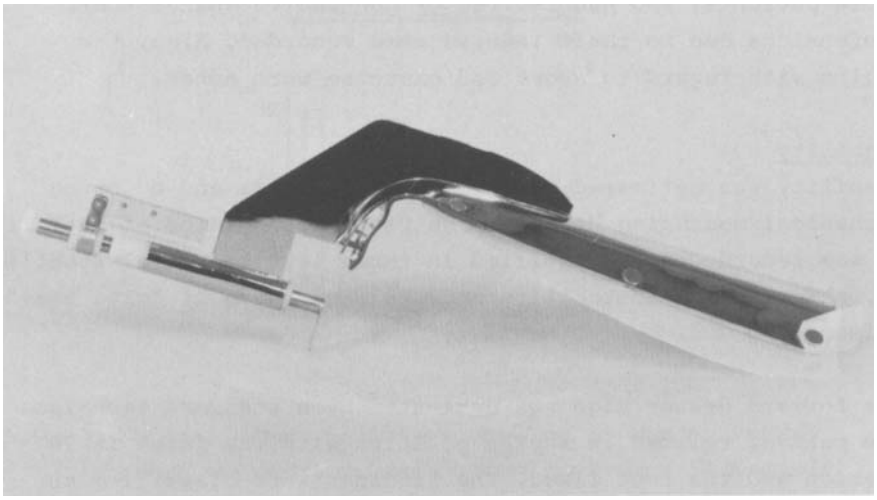

Figure 5. Calliper for measuring anterior-posterior mobility.

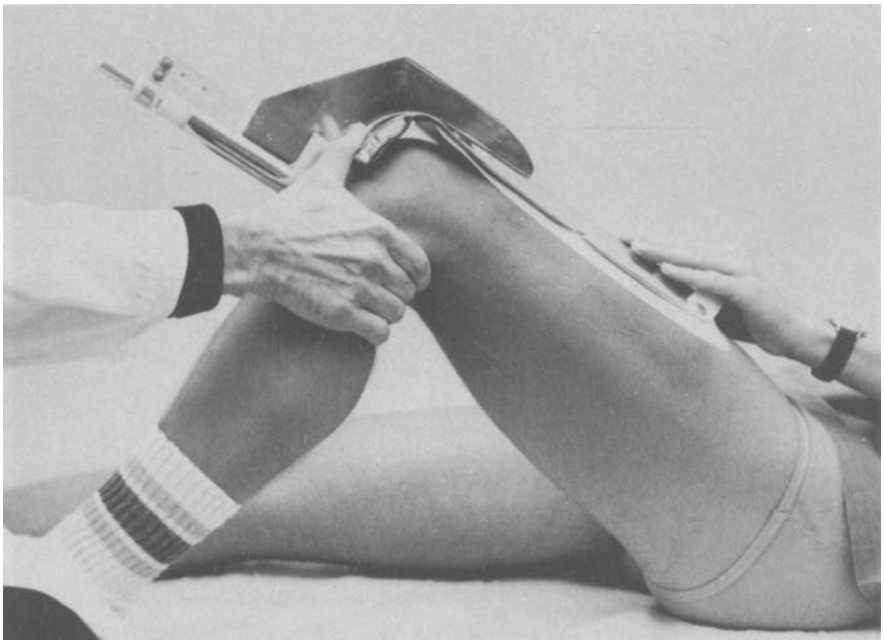

Figure 6. The foundation of the calliper is resting on the thigh and firmly pressed against the patella. Palpation of hamstrings and biceps tendon to control as far as possible relaxation of the thigh muscles before the tibia is pulled anteriorly. The forward movement of the tibial tuberosity is recorded by the movable part of the calliper to an accuracy of 1 mm.

Medial-lateral stability

For measurement of medial-lateral stability, a measuring technique was designed which permitted firm restriction of the distal end of the femur and measurements in various degrees of knee flexion of the medial-lateral movement in the knee-joint using constant forces (Figures 7 and 8).

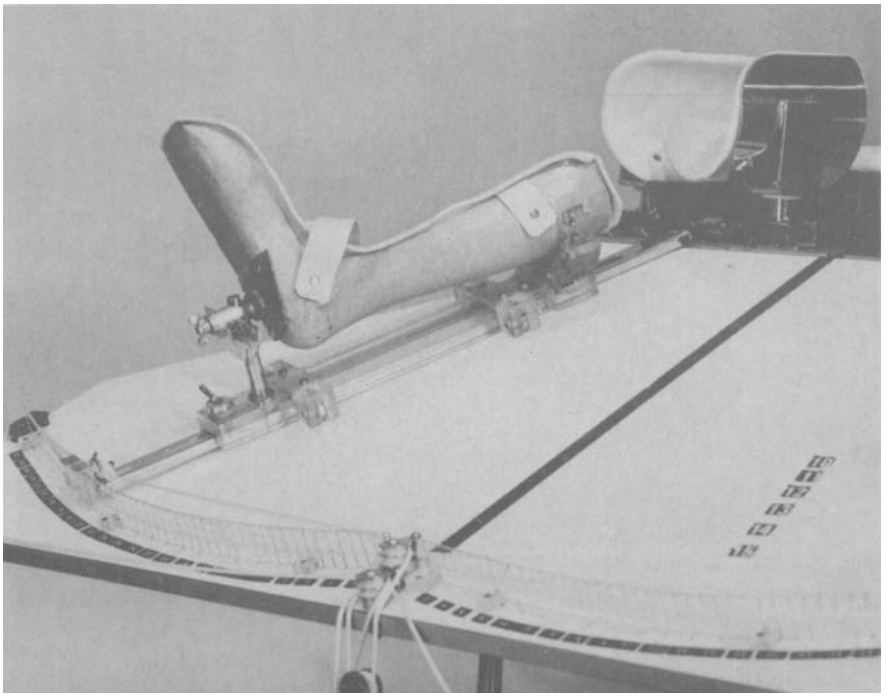

Figure 7. Cradle for attaching the distal end of the femur and the lower leg and foot for measuring medial-lateral stability. The cradle is adjustable for leg length and for rotation and moves freely on ball-bearings. Constant force (90 N at the level of the ankle) (Jacobsen 1976) may be applied forcing the lower leg either laterally or medially.

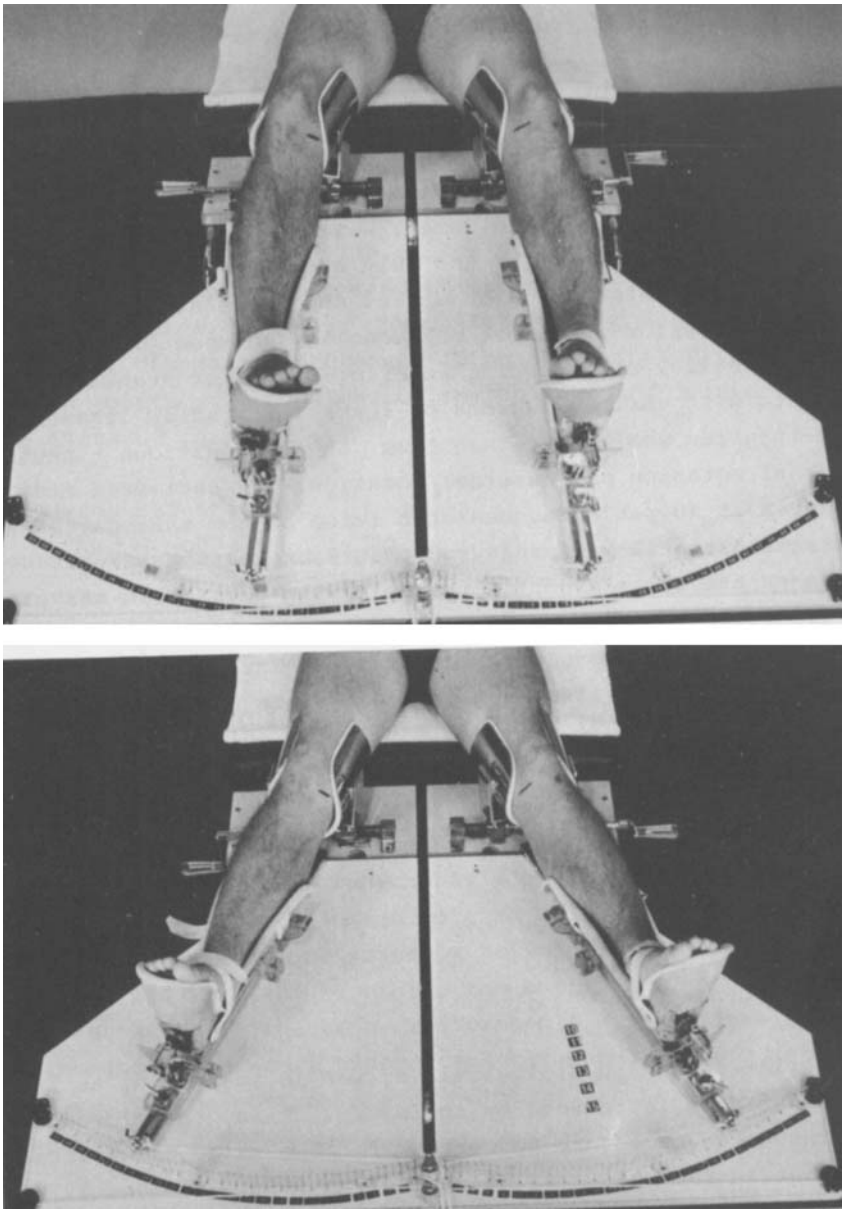

Figure 8. Patient in position. Adduction forces applied to both sides with the knees in 20 degrees of flexion and in inward rotation (upper) and abduction force with straight knees in neutral position (lower).

Studies on the measuring techniques

Anterior-posterior stability

The anterior-posterior stability as measured with the calliper constructed for the purpose of this study also varies considerably in uninjured knee-joints (Table III). There is also a difference between men and women, women having less anterior-posterior mobility. Sex is the only correction factor, parameters of body size being otherwise not correlated with the range of anterior-posterior movement in the knee-joint. The reproducibility of measuring anterior-posterior stability in patients with various degrees of instability after ligamentous knee-injuries was better than 1 mm* in all positions - neutral, internal rotation and external rotation - as estimated from 20 knees in 10 patients, measured twice on the same day. When the same patients were measured under general anaesthesia later on the same day or on the following day, there was still no significant difference as compared with the initial measurement. There was a considerable variation in the anterior-posterior mobility also in uninjured joints (Table III).

Table III. Anterior-posterior mobility measured in uninjured knee-joints in 90° of flexion (mm).

	Men		Women	
Forward drawer	N	Av ± SD	N	Av ± SD
Neutral position	307	6.7 ± 2.0	43	5.1 ± 1.3
Internal rotation	307	5.2 ± 1.8	43	4.0 ± 1.1
External rotation	307	7.7 ± 2.1	43	6.2 ± 1.5

The variation in "physiological" drawer is just about as large as the changes introduced by an injury. It is, therefore, in all instances necessary to correct for the range of sagittal movement in the uninjured joint (Sylvin 1975, Jacobsen 1976). Consequently, the measured anterior-posterior mobility in injured joints without an uninjured contra-lateral knee, is of limited value.

**) 1 SD of the difference between repeated measurements.*

Estimations of anterior-posterior instability arrived at by interviewing the patient or using the forward drawer sign, the pivot shift or the Lachman test, were tested for internal correlation (Table IV). The four variables were all closely correlated with each other. The relationship between these parameters of instability and the measured instability is demonstrated in the same Table. The properties which best distinguished degrees of measured instability were an obvious forward drawer sign and an obviously positive Lachman test. Otherwise, the main differences in measured instability were between joints with no signs of instability and joints with some signs of instability.

Medial-lateral stability

Eighteen knee-joints in 9 patients with knee-ligament injuries were measured twice, with a 1 - 3 days interval, using the measuring device described above. The average reproducibility was < 1.5° * with extended knee and < 3° * in 20° flexion.

The measured average medial mobility was about 7° (Table V) and the average lateral mobility about 10° with extended knee-joints, whereas in 20° of flexion the average medial mobility was about 15° and the average lateral mobility 17°. There is, in spite of a reasonably good precision, an enormous variation - in 20° of flexion more than 30° - which is about three times the range observed by Hallén and Lindahl (1965) measuring cadavers and recording the mobility with a measuring device attached to the bone. The probable explanations are deformation of the soft tissues and rotation in the hip-joint. Again, using the contra-lateral joint as a control the method may still be useful.

*) *1 SD of the difference between repeated measurements.*

Table IV. Correlation between symptoms, signs and measured difference in anterior-posterior instability among all injured knees (PCL excluded).

Patient's opinion		Measured difference anterior-posterior instability (mm)		
		External rotation	Internal rotation	Neutral position
Patient's opinion				
N = 194	No instability	1.7 ± 2.1	1.4 ± 1.8	1.6 ± 2.0
N = 58	Moderate instability	2.9 ± 3.0	1.9 ± 2.3	2.7 ± 2.7
N = 50	Give away	3.0 ± 3.4	1.6 ± 2.4	2.3 ± 3.0
p < 0.001		p < 0.001	p < 0.001	
Forward drawer				
N = 337 Forward drawer				
N = 69	None	0.1 ± 1.7	0.1 ± 1.3	-0.4 ± 1.2
N = 140	Slight	1.6 ± 1.9	1.2 ± 1.6	1.6 ± 1.4
N = 73	Moderate	4.0 ± 2.2	2.8 ± 1.7	3.8 ± 2.0
N = 20	Obvious	5.8 ± 3.1	4.1 ± 2.3	5.6 ± 2.4
p < 0.001		p < 0.001	p < 0.001	
Pivot shift				
N = 310 Pivot shift				
N = 162	None	1.6 ± 2.2	1.0 ± 1.8	1.4 ± 2.1
N = 102	Moderate	3.1 ± 2.8	2.1 ± 1.9	2.6 ± 2.4
N = 13	Obvious	2.9 ± 3.4	2.5 ± 3.1	3.4 ± 3.7
p < 0.001				
Lachman test				
N = 310 Lachman test				
N = 137	Negative	1.2 ± 2.2	0.8 ± 1.8	1.2 ± 2.0
N = 128	Moderate	2.9 ± 2.4	2.0 ± 1.9	2.6 ± 2.4
N = 12	Obvious	5.0 ± 4.0	3.3 ± 2.7	4.3 ± 3.2

Table V. Medial - lateral mobility in uninjured knee-joints (degrees).

		Men		Women	
Extension		N	Av ± SD	N	Av ± SD
Medial (valgus)	neutral position	254	5.7 ± 1.3	27	7.6 ± 1.7
	internal rotation	254	6.2 ± 1.4	27	7.8 ± 2.0
	external rotation	254	6.8 ± 1.3	27	7.9 ± 1.4
Lateral (varus)	neutral position	254	9.7 ± 1.7	27	12.0 ± 2.0
	internal rotation	254	8.9 ± 1.7	27	10.8 ± 2.2
	external rotation	243	10.4 ± 2.4	27	12.0 ± 2.8
20 degrees of flexion					
Medial	neutral position	254	14.7 ± 3.2	26	16.6 ± 2.6
	internal rotation	252	13.4 ± 2.9	25	14.9 ± 3.2
	external rotation	253	15.3 ± 3.5	27	17.7 ± 3.3
Lateral	neutral position	208	17.1 ± 3.3	25	19.3 ± 2.6
	internal rotation	238	16.6 ± 3.3	25	18.1 ± 3.8
	external rotation	115	16.5 ± 3.1	17	18.8 ± 1.7

Roentgen

All but 21 injured knee-joints were examined with standard antero-posterior and lateral views and antero-posterior views of both knees with the patient in standing position taking the weight equally on both legs. The film-focus distance was in the standing position 110 cm, otherwise 115 cm. According to the findings of the roentgen examination the patients were classified as follows:

Gonarthrosis: Narrowing of the joint space with a loss of distance between the tibia and the femur in one compartment, of half or more of the distance in the other compartment of the same knee-joint or the same compartment of the other knee, or less than 3 mm (Ahlbäck 1968). (Appendix, Cases 3, 4 5 and 7).

Osteophytosis: Knee-joints with osteophytes observed on the medial and/or lateral edges of the tibia or the femur with at least one osteophyte of a size of at least 2 mm were not accepted as normal knee-joints but classified as osteophytosis. Also, the osteophytes were measured to an accuracy of 1 mm. (Appendix, Case 2).

Normal: All other joints.

Also,in the gonarthrosis and osteophytosis groups, a number of additional radiological changes were recorded, such as sharpening or flattening of the tibial intercondylar eminence, subchondral sclerosis, subchondral cysts and calcifications of ligaments (Table VI).

Table VI. Additional roentgen findings in the osteophytosis and gonarthrosis groups.

	Osteophytosis	Gonarthrosis
Tibial intercondylar eminence		
Sharpening	11	2
Osteophytes	33	7
Flattening	24	11
Healed fracture	9	1
Obliteration	0	1
Tibial subchondral sclerosis		
Medially	11	10
Laterally	2	1
Medially and laterally	1	1
Tibial subchondral cysts	0	1
Subluxation of the tibia		
Medially	0	2 (> 7 mm)
Laterally	1 (< 7 mm)	1 (< 7 mm)
Dome shaped tibia	2	1
Calcification of ligaments	36	13

Comment

The definition of gonarthrosis based entirely on narrowing of the joint space is convenient but not generally accepted - in previous studies on ligamentous injuries it has been rarely used. Similarly, the importance of osteophytosis may still be discussed. In an attempt to evaluate our methods of classification, a radiologist with long experience in the field of orthopedic roentgen diagnostics* was asked to classify the patients without measuring joint spaces (Table VII). There was a fair agreement between the two methods of classification.

Table VII. Comparison between present classification of roentgenological findings and that of a radiologist.

	Radiologist's classification gonarthrosis		
Present classification	No	Slight	Obvious
Normal	219	1	0
Osteophytosis	84	24	14
Gonarthrosis	1+	8	17

+Appendix Case number 4.

Data reduction and statistical analyses

Vital statistics, history, data on entrance operation and follow-up data including roentgen, all patients included, provided altogether 136,000 pieces of information, most of which are not presented in this study. For the data reduction a Hewlett-Packard 9845B desk top computer equipped with HP 9895A flexible disc memory and the NMSP** statistical analysis package was used. Standard statistical methods - Chi-2-test,

*Lars Andrén, M.D., Department of Radiology II, Malmö General Hospital.

**New Mathematical Statistics Package. Tore Persson, Institute of Mathematical Statistics, University of Lund.

t-test and linear correlation coefficient - were applied.

Significance levels better than 95% have in the text been referred to as significant.

Because of the multifactorial properties of the data discriminant analysis was also used. The coefficients of the discriminant functions were estimated according to Van de Geer (1971).

RESULTS

General

For the purpose of analysis of the results the patients were subdivided in the following groups:

Anterior cruciate ligament injuries (ACL)

Included were those anterior cruciate ligament injuries which had been treated by primary repair as well as those that had not. Included were also those with combined injuries including meniscus injuries but excluding injuries to the posterior cruciate ligament. Also, joints which had been treated by reconstruction of the anterior cruciate ligament were excluded from the group.

Fracture of the tibial spine regardless of coinciding injury except for posterior cruciate ligament injury.

Anterior cruciate ligament reconstruction

These patients were treated separately. Included were all knee-joints with intra-articular ACL-reconstruction regardless of whether the reconstruction was undertaken in conjunction with the entrance operation or on a later occasion. Three joints with concomitant PCL-injuries were excluded.

Posterior cruciate ligament injuries (PCL) regardless of combination.

Medial collateral ligament injuries

Major injury of the joint capsule without known concomitant ligamentous injury.

Extra-articular reconstruction

Altogether 35 knees were operated on with extra-articular reconstructions. The most common was the Mauck procedure (1936)

- 17 joints - followed by pes anserinus transfers (Slocum and Larson 1968) - 10 joints. The O'Donoghue procedure (1973) was undertaken in five joints, two of which in combination with other reconstructive measures. Not less than five of the extra-articular reconstructions were undertaken in the group of 12 patients without any other known injury than medial posterior rupture of the capsule. Seventeen of the procedures were undertaken in combination with reconstruction of the anterior cruciate ligament. The remainder were evenly distributed among the various groups - 10 were undertaken on knees with ACL-injuries. The impact of these procedures on the outcome of the various injuries cannot be further analysed.

Two odd cases of isolated injury to the lateral collateral ligament were excluded from the analysis.

Of the 389 knee-joints with ligament injuries, 368 had follow-up roentgen examinations and of these, 26 joints had signs of gonarthrosis as defined above. Osteophytosis was more common in the injured joints - both types of changes were roughly 10 times as frequent in joints with ligamentous injuries as compared with uninjured joints in the same individual (Table VIII).

Table VIII. Summary of the roentgen appearance of 368 knee-joints with ligament injuries and 332 knee-joints from the same sample but without known injuries.

	Injured joints	Uninjured joints
Roentgen normal	220	321
Osteophytosis	122	9
Gonarthrosis	26	2

Of the 26 patients who qualified as having gonarthrosis not less than 22 had had a meniscectomy.

Applying the criteria of retirement from work because of knee complaints (N = 8) or forced physical inactivity because of knee dysfunction (N = 32), 40 patients (11%) were classified as knee-disabled. This classification coincided with the finding of gonarthrosis in 8 patients, but was not related to parameters of instability.

Sixty-six patients (17%) had give away episodes - 6 (2%) frequent, weekly episodes.

Of the 26 patients with gonarthrosis, however, only 6 patients (7 joints) had presented over the years with knee complaints. All but one of these joints had had a meniscectomy. In the remaining joint a reconstruction of the PCL had been undertaken 25 years earlier.

Measurable anterior-posterior instability was a frequent finding whereas medial-lateral instability of importance was an infrequent finding at follow-up. Instability will be presented under the various injuries.

ANTERIOR CRUCIATE LIGAMENT INJURIES

There were altogether 183 ACL injuries in 180 patients in whom the injury was not combined with PCL and who had not been treated with reconstruction of the ACL. Twenty-one of these were women. The frequency of radiological changes, the stability of the knee-joint and the function were compared between subsets:

Primary repair - non repair

Eighty-six joints had been treated by primary repair in conjunction with the entrance operation - 97 had not been repaired. Seven of the gonarthrosis cases were in the repaired group and 10 in the non-repaired; the frequencies of osteophytosis were 29% and 39%, respectively. Subjective symptoms, capacity and the outcome of stability tests did not differ between the two sets (Table A:I*, Figures 9 and 10). There were 11 knee-disabled among the repaired cases and 13 among the non-

* *Appendix Table I.*

repaired. The measurements of sagittal instability did not differ between the two groups.

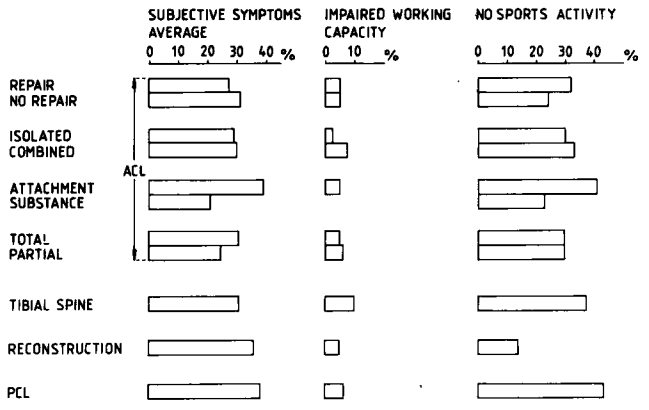

Figure 9. Comparison of subjective symptoms and parameters of function between subsets of ACL-injuries and between other subsets of patients in this study.

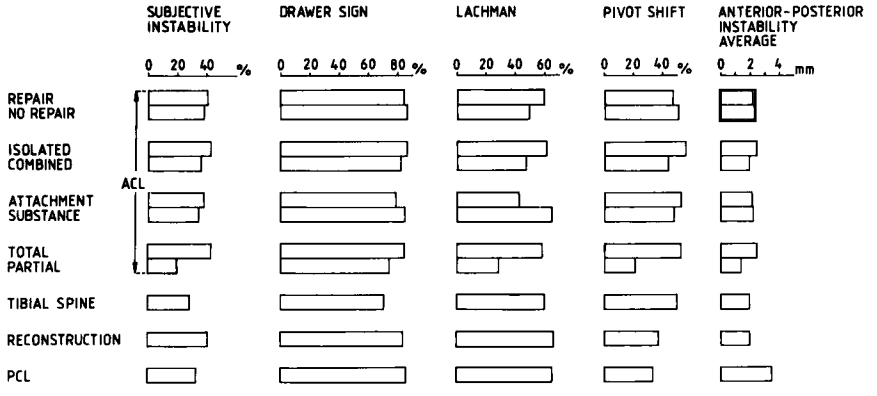

Figure 10. Comparison of parameters of anterior-posterior instability between subsets of ACL-injuries and between other subsets of patients in this study.

There were, however, initial differences between those patients who had been sutured and those who had not. During the first part of the period under study, suture was somewhat less common (Figure 11).

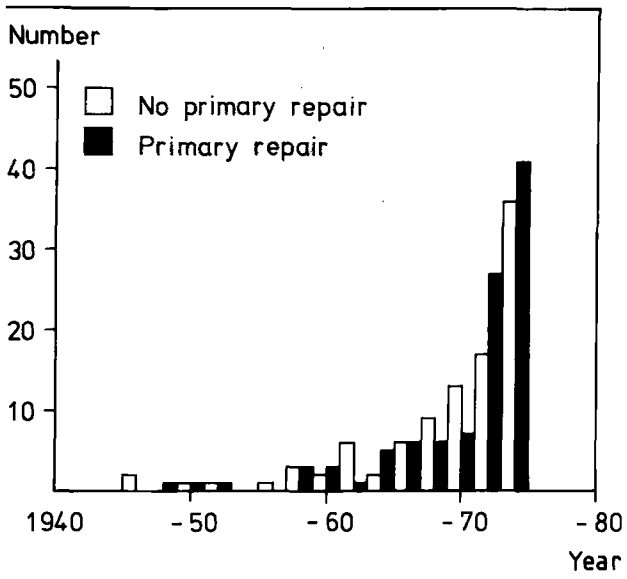

Figure 11. Distribution over the years of joints with ACL-injuries with and without primary repair.

Also, the interval accident - entrance arthrotomy was greater in those patients whose anterior cruciate ligaments had not been sutured. In not less than 61/97 instances the interval exceeded three weeks as compared with 15/86 in sutured ACL. On the other hand, a comparison of measurable instability between non-repaired joints and joints repaired within the first weeks after the injury still failed to reveal any difference (Table IX). Also, excluding those patients who had more than one accident and one operation and including only cases operated on within two weeks, there was still no difference between repair and non-repair (Table A:II).

Table IX. Comparison of difference in measured anterior-posterior instability between ACL non-repair and ACL repaired within the first three weeks (mm). Included are ACL and ACL + MCL injuries.

	Non-repair		Repair within 21 days	
	N	Av ± SD	N	Av ± SD
Neutral position	85	2.4 ± 2.5	51	2.1 ± 2.0
Internal rotation	85	1.9 ± 2.3	51	1.7 ± 1.6
External rotation	85	2.6 ± 2.8	51	2.3 ± 2.2

Another difference was that the non-sutured ACL-injuries were more often isolated. Partial ruptures, however, were equally frequent in the two groups. These differences and the fact that no random allocation was undertaken prevent any final conclusions about the value of early repair of the ACL. However, the findings suggest that such effects in the long run are small and that for the purpose of the present study repaired and non-repaired cases may be pooled in a common analysis.

Isolated - combined ACL-injuries

In 87 knees with ACL-rupture no other ligamentous injuries were found and these injuries have been referred to as isolated. There were six gonarthrosis cases in the isolated ACL-group and 11 in the combined with a frequency of osteophytosis of 40% and 28%, respectively. When symptoms and function were compared between the two groups (Table A:III, Figures 9 and 10) there was no difference. The knee-disabled were distributed with 14 in the group of isolated injuries and 10 in the combined, again, no significant difference. The patient's opinion of instability, the drawer sign and the Lachman and pivot tests did not differ between the isolated and the combined injuries. Similarly, the quantitative evaluation of the sagittal instability did not reveal any differences between the two sets of ACL-injuries.

Partial and total ACL-injuries were equally common in the two sets.

Attachment - substance ACL-injuries.

In this comparison only those 74 joints were included in which a total ACL-rupture had been treated by primary suture. The number of gonarthrosis cases was four among the 32 attachment ruptures and two in the 42 substance ruptures. The frequency of osteophytosis was 28% and 23%, respectively. The symptoms were rather worse in the group of attachment ruptures in that the percentage of pain and discomfort was worse by all evaluations. However, the parameters of instability did not differ significantly between the two subsets and the measurements of anterior-posterior stability yielded almost identical results (Table A:IV, Figures 9 and 10).

Total - partial ACL-injuries

In 165 joints the entrance operation revealed that the injury was total in 125 instances and partial in 40 instances. This study includes only those patients who had had their ACL-diagnosis at the first arthrotomy. Fifteen of the gonarthrosis cases were found among the total injuries and none among the partial injuries - the difference is significant. The frequency of osteophytosis was 34% and 31%, respectively. With regard to subjective pain and discomfort there was no difference between the two groups nor with regard to their function at work or in sport.However, the parameters of stability differed significantly in all instances between the two groups in that instability was more pronounced in the total injuries than in the partial (Table A:V, Figures 9 and 10).

TIBIAL SPINE FRACTURE

Tibial spine fractures were seen in 21 patients, all with unilateral injury. Six were in women and eight in children under 16. All but two had been successfully treated with exact reduction of the bone fragment. None of these patients had gonarthrosis at follow-up whereas 26% had osteophytes.

One had been forced to retire because of his knee injury. Some dysfunction was also noticed in these patients (Table A:VI, Figures 9 and 10). There were patients with signs of persistent instability and furthermore the measurement of anterior-posterior instability did not differ from other groups of ACL-injuries. Even the very youngest of these patients, although they denied all symptoms of instability, still had a measurable difference in anterior-posterior stability between the injured and the uninjured knees. In two cases non-union had developed, one of these being the patient who had retired.

ACL-RECONSTRUCTION

In 73 knees in 71 patients an anterior cruciate ligament reconstruction had been undertaken. In 41 joints the reconstruction was undertaken at the entrance operation, in the remaining cases at a later date. Only three were women. Four had gonarthrosis and 57% had osteophytes. Seven of these patients were classified as knee-disabled. An appreciable number had, in spite of the reconstruction, signs and symptoms of knee instability. Also, the measured instability in comparison with the contra-lateral joint was significantly increased and did not deviate significantly from other ACL-injuries (Table A:VII, Figures 9 and 10).

POSTERIOR CRUCIATE LIGAMENT INJURIES

Posterior cruciate ligament injuries were seen in 51 patients, all unilateral. Isolated posterior cruciate ligament injuries were found in only 19, whereas 32 were combined with other ligamentous injuries as demonstrated in Table X. With regard to treatment of PCL, 39 were sutured in conjunction with the entrance operation, two reconstructed later on and 10 left without surgical treatment of their PCL-injuries. Meniscectomy was performed in 14 of the patients.

Table X. Posterior cruciate ligament injuries - combinations with other injuries.

	N
PCL only	19
MCL + ACL + PCL	17
MCL + PCL	8
ACL + PCL + LCL	3
ACL + PCL	2
MCL + PCL + LCL	1
MCL + ACL + PCL + LCL	1

Gonarthrosis was found in four cases whereas osteophytosis was demonstrated in 30%. Six patients were classified as knee-disabled. The dysfunction of PCL patients is demonstrated in Table A:VIII, Figures 9 and 10. It may be pointed out that even patients with PCL-insufficiency may be able to participate in competitive sports such as wrestling, handball and soccer (10 patients). An appreciable number of patients had instability (Table A:VIII). The contribution of the posterior cruciate ligament to the anterior-posterior instability of the knee-joints is difficult to evaluate particularly since so many of the injuries were combined. The measured anterior-posterior instability deviated only slightly - was somewhat greater - than in ACL-injuries (Table A:VIII, Figure 10). However, a frequent finding in these cases was a posterior subluxation measured with the same device as used for the evaluation of anterior-posterior instability in 90^{o} of flexion. An attempt was made to provoke a posterior drawer sign from the subluxated position - the knee yielded on average 1 mm. However, in a few cases a further posterior drawer of 5 mm:s could be recorded. In many patients the anterior drawer from an estimated neutral position was less than in the uninjured knee (Table XI). In a 26-year-old man with the combination MCL + ACL + PCL - all sutured - a 12 mm posterior subluxation of the tibia was noted. At re-examination after 10 years this patient was still playing team soccer and felt

unrestricted by his knee condition.

Table XI. Relationship between anterior drawer - posterior subluxation in PCL-injuries.

Measured anterior drawer (total mm in comparison with contra-lateral uninjured joints - only in neutral position).

Injured		Uninjured	
N	Av ± SD	N	Av ± SD
49	9.9 ± 3.6	49	6.0 ± 1.8

Posterior subluxation of tibia.

Injured	
N	Av ± SD
43	5.8 ± 3.1

Anterior drawer injured minus subluxation = Av 4.1.

MEDIAL COLLATERAL LIGAMENT INJURIES

Medial collateral ligamentous injuries were seen in altogether 192 knees. Out of these only 47 were isolated whereas 145 were combined with ACL or PCL. PCL-combinations will not be further discussed. It was demonstrated above that the combination of MCL and ACL with regard to function and stability hardly differed from what was found in ACL alone.

Among the patients with isolated MCL not one single case of gonarthrosis was found; there were a few cases with osteophytosis (7%) but these were in all instances also operated on with meniscectomy. One knee-disabled patient was found among the isolated MCL-injuries. There was some dysfunction as described in Table A:IX whereas subjective or objective signs of instability were comparatively rare. There was a highly significant difference between the injured and the uninjured knees with regard to medial - lateral stability (Table XII).

Table XII. Medial-lateral instability in isolated MCL-injuries; difference in degrees between injured and uninjured knees.

	Extended knee		20° of flexion	
	N	Av $\pm$ SD	N	Av $\pm$ SD
Medial neutral position	37	0.2 $\pm$ 0.8	37	0.7 $\pm$ 1.6
internal rotation	37	0.3 $\pm$ 0.6	37	0.3 $\pm$ 1.6
external rotation	37	0.1 $\pm$ 0.7	37	0.4 $\pm$ 2.7
Lateral neutral position	37	0.1 $\pm$ 1.0	30	0.1 $\pm$ 1.3
internal rotation	37	0.2 $\pm$ 1.0	35	-0.4 $\pm$ 1.8
external rotation	36	-0.1 $\pm$ 0.8	14	-0.5 $\pm$ 1.6

However, in spite of its mathematical significance the actual magnitude of the instability measure was very small, consequently there was a fairly constant but very small side difference. When this analysis was repeated on the combined ACL + MCL-injuries the outcome was similar, a very small but constant increase in medial instability (Table XIII).

JOINT CAPSULE INJURIES

In 12 joints there were injuries to the joint capsule, all in the medial posterior aspect of the joint, in which no concomitant ligamentous injury was diagnosed. In this group of patients there was no measurable difference in anterior-posterior stability between the injured and the uninjured joints.

One of these patients had gonarthrosis. This was a soccer-player who had participated in more than 350 National League games. At the time of the entrance operation there were already signs of cartilage injuries in the medial aspect of the joint. This soccer-player was one of the few who had developed gonarthrosis without having had his semilunar cartilage removed.

Table XIII. Measured medial-lateral instability in ACL + MCL-injuries (difference in degrees between injured and uninjured knees).

Extension		N	Av ± SD
Medial (valgus)	neutral	65	0.7 ± 1.1
	internal rotation	65	0.8 ± 1.0
	external rotation	65	0.7 ± 1.1
Lateral (varus)	neutral	65	0.4 ± 1.4
	internal rotation	65	0.3 ± 2.1
	external rotation	62	-0.1 ± 1.1
20^{o} of flexion			
Medial	neutral	65	0.4 ± 1.5
	internal rotation	63	0.7 ± 1.6
	external rotation	65	0.5 ± 1.8
Lateral	neutral	57	-0.2 ± 1.7
	internal rotation	60	-0.3 ± 1.7
	external rotation	39	-0.7 ± 1.4

In one knee there was, at the time of follow-up, osteophytosis but, again, in this knee the semilunar cartilage had been removed. Otherwise, this group did not differ much from the other types of injuries. The average percentage of subjective symptoms was 35.

Only one of the patients in this group - an old lady - did not participate in sports or exercise activities. Two patients deviated slightly in their physical findings, one had positive pivot shift and a positive Lachman test but the signs were positive also in the contra-lateral, completely uninjured knee-joint and the measured anterior-posterior mobility was more than 15 mm on both sides.

One of the patients, a man injured at the age of 46, who had - according to the surgical report - an intact anterior cruciate ligament, had at the time of follow-up "give away" symptoms and anterior-posterior instability.

Not less than 5 of these joints had been treated with extra-articular reconstructions - three pes anserinus transfers, one tightening of the joint capsule and one Mauck procedure.

RADIOLOGICAL APPEARANCE

In collaboration with Fredrik Montgomery.

The patients with the 26 joints which qualified as gonarthrosis according to the criterion of having a decreased joint space were considerably older than those who had not developed gonarthrosis (Table XIV, Figure 12). The gonarthrosis patients had been older at the time of the accident and were older at the time of follow-up, whereas the time interval between the two occasions was only a few years longer (Table XIV). Not less than 22 of the 26 joints with gonarthrosis had had a meniscectomy in the injured knee: in all instances these patients had had their medial semilunar cartilage removed. Except for the high frequency of meniscecomty in the gonarthrosis group, gonarthrosis patients could not be referred to any specific type of ligamentous injury or combination of injuries.

Some of the gonarthrosis cases were borderline cases with regard to the definition of gonarthrosis (Appendix, Case no. 4), but in most instances the diagnosis was obvious (Cases 3, 5 and 7). The joint space - in all instances decreased in the medial compartment of the joint - was 2.7 ± 1.2 mm as compared with 5.5 ± 1.0 in normal joints. Also, there were additional signs of gonarthrosis (Table VI).

Dysfunction was twice as common in joints with gonarthrosis; eight patients were classified as knee-disabled - a significant preponderance. The patients were subdivided into those who participated in sport or physical exercise and those who remained inactive. There was a significant preponderance for gonarthrosis patients among the inactive - half of the gonarthrosis joints were found in this group.

Table XIV. Ages and time intervals: Accident - operation - follow-up roentgen in relation to the roentgenological outcome.

		Age		Interval	
	N	At accident	At follow-up	Accident - operation	Accident - follow-up
Roentgen normal	220	29 ± 12	37 ± 13	126 ± 486 (days)	8 ± 5 (years)
Osteophytosis	122	27 ± 10	38 ± 11	429 ± 1049	11 ± 6
Gonarthrosis	26	36 ± 13	48 ± 12	235 ± 489	12 ± 8

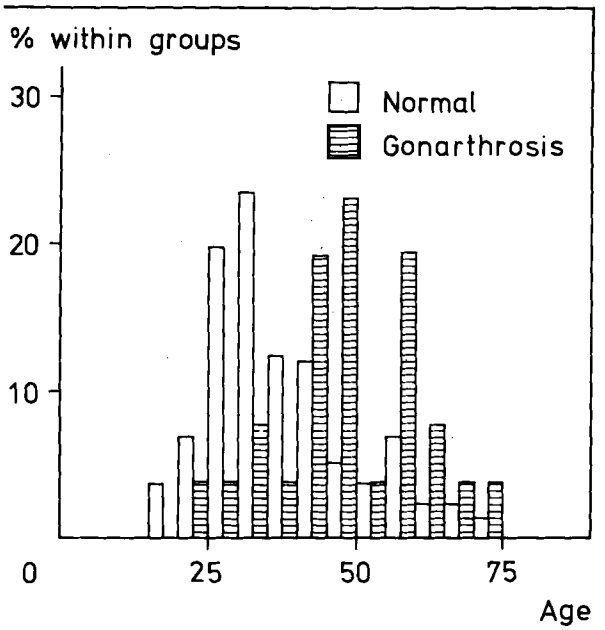

Figure 12. Age distribution in patients with knee ligament injuries; comparison between joints with gonarthrosis and roentgenologically normal joints.

In Table XV the anterior-posterior instability is demonstrated. The gonarthrosis joints were more stable than normal joints and osteophytosis joints. The difference was, however, small and significant only in external rotation. There was no such difference in medial-lateral stability - again this measurement was painful for gonarthrosis patients and could be properly performed in only half of the cases.

The considerably larger subset of joints, those with osteophytes, were in most other aspects similar to the roentgenologically normal knees. The 122 knee-joints with osteophytes did not deviate with regard to the patient´s age but the follow-up time was a few years longer. Also, there were among these joints some that had been waiting extremely long for

the diagnosis (Table XIV).

Table XV. Anterior-posterior instability according to roentgen findings (difference injured - uninjured mm).

	Normal		Osteophytosis		Gonarthrosis	
	N	Av ± SD	N	Av ± SD	N	Av ± SD
Neutral	207	2.2 ± 2.5	101	2.5 ± 3.0	23	1.4 ± 2.0
Internal rotation	207	1.6 ± 2.0	101	1.9 ± 2.7	23	1.2 ± 1.8
External rotation	207	2.3 ± 2.6	101	3.0 ± 3.0	23	1.0 ± 2.6

In one aspect, the osteophyte knee-joints had a background different from those without osteophytes in that they had been subjected more often to meniscectomy. Patients with meniscectomy had significantly more osteophytes than patients with the same injury but without meniscectomy and both types of patients had significantly more osteophytes than were found in contra-lateral uninjured joints (Figure 13). Osteophytes, being the necessary criterion to be included in this roentgenological group, were not the only changes observed in this group of patients (Table VI). Only a few patients were entered into this group on the basis of the minimum criterion that at least one osteophyte should have attained the size of at least 2 mm. In most instances there was multiple osteophytosis and the osteophytes were of a considerable size (Figure 14). The size of the osteophytes did not increase with age but in the lateral aspect of the joint there was a signficant positive relationship between follow-up time and osteophyte size indicating a slow growth of the osteophytes - $\approx$ 0.5 mm per decade. No such tendency was seen in the medial osteophytes.

In Figure 15 a comparison is made between the joint spaces in knee-joints without roentgen changes, joints with gonarthrosis and joints with osteophytosis. There was no difference in joint space between normal and osteophytosis patients but in the latter group there was a slow but significant negative

regression with age for the medial joint space.

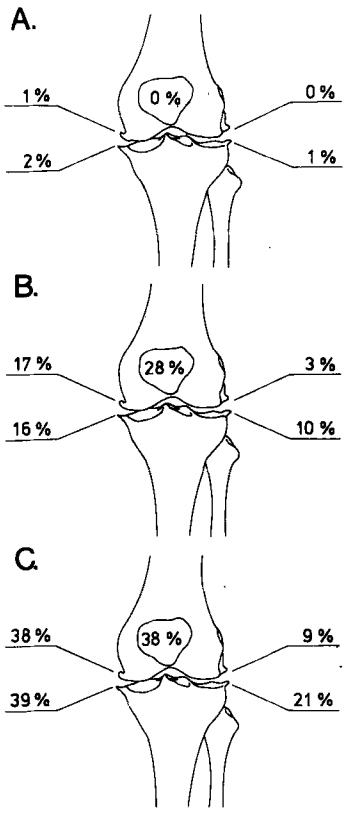

Figure 13. The occurrence of osteophytes in various locations of the knee-joint (patellar osteophytes either on the superior or posterior pole). A. Knee-joints without known injuries. B. Knee-joints with ligamentous injuries. C. Knee-joints with ligamentous injuries plus meniscectomy.

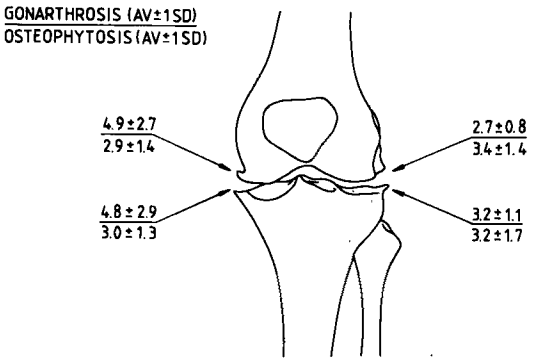

Figure 14. Size of osteophytes (mm) in various locations in knee-joints classified as gonarthrosis or osteophytosis. Only osteophytes of at least 2 mm are included in the calculations.

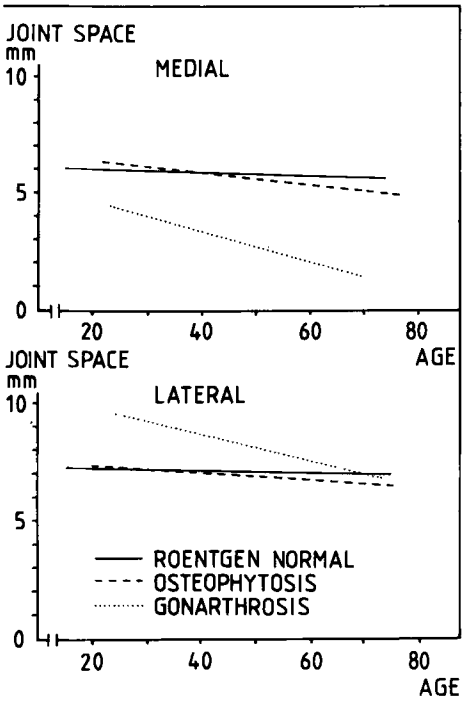

Figure 15. Regression of joint space with age.

The gonarthrosis cases - in all instances medial gonarthrosis - had less joint space which also decreased with age. The lateral joint space - the usually unaffected part of the joint - appears to be greater than normal in gonarthrosis. This may be an artifact in films taken in a standing position - nevertheless also here the joint space decreased with age.

SEMILUNAR CARTILAGE INJURY

More than half of the ligament injuries in this study were combined with meniscus injuries. These patients did not differ in their age from patients with their semilunar cartilages left intact. However, not less than 22 of the 26 gonarthrosis patients had had a meniscus removed and the prevalence of osteophytosis as demonstrated by the distribution of osteophytes in Figure 13 was much greater in those patients who had had a meniscectomy. Anterior-posterior stability did not differ between joints with and without meniscectomy as demonstrated in the example in Table XVI, nor was there any difference in medial-lateral stability. However, when comparing all joints which had been operated on with meniscectomy, with those that had not - even with gonarthrosis joints excluded - there was a tendency of a worse outcome in the former (Table A:X).

AGE AND SEX

In patients with ACL-injuries there was no difference in age between those who had had primary repair and those who had not (Table XVII). The tibial spine fracture patients were younger than average, mostly due to the presence of a few children. The ACL-reconstruction cases were also younger, presumable due to a selection. PCL and PCL-combinations and patients with MCL did not differ from the main group. Patients with attachment injuries were significantly older than patients with substance injuries. In Table XVIII the age at the time of the accident is also demonstrated. The difference was more obvious in women (Table XVIII).

Table XVI. Anterior-posterior instability in relation to meniscectomy, difference in mm between injured and non-injured knees (only ACL, ACL-reconstructions and tibial spine fractures included).

	N	Av ± SD
No meniscectomy		
Neutral	118	2.2 ± 2.6
Internal rotation	118	1.9 ± 2.4
External rotation	118	2.6 ± 2.9
Medial meniscectomy		
Neutral	114	2.5 ± 2.3
Internal rotation	114	1.9 ± 1.9
External rotation	114	2.9 ± 2.6
Lateral meniscectomy		
Neutral	13	2.3 ± 4.1
Internal rotation	13	1.5 ± 2.8
External rotation	13	2.2 ± 3.5
Medial and lateral meniscectomy		
Neutral	22	2.2 ± 2.6
Internal rotation	22	1.4 ± 2.6
External rotation	22	1.8 ± 2.4

Table XVII. Age at follow-up in relation to injury.

	Sex			Age
	Men	Women	Total	Av ± SD
ACL				
No repair	89	8	97	41 ± 12
Repair	72	14	86	39 ± 12
Isolated	80	7	87	39 ± 12
Combined	81	15	96	41 ± 13
Attachment*	25	7	32	45 ± 15
Substance*	35	7	42	36 ± 10
Total	106	19	125	40 ± 12
Partial	40	0	40	40 ± 27
Tibial spine fractures	15	6	21	35 ± 18
Reconstructions	70	3	73	33 ± 7
PCL	47	4	51	39 ± 13
MCL	41	6	47	39 ± 14

*Repaired only

Table XVIII. Age, sex and soccer accidents in ACL-attachments as compared with ACL-substance injuries - repaired and non-repaired included.

	Age				Accident
	Men		Women		Soccer/other
	N	Av ± SD	N	Av ± SD	
Attachment	26	33 ± 14	8	47 ± 17	9/25
Substance	39	27 ± 8	8	32 ± 12	23/24

The finding is consistent with that of avulsion of ankle ligaments which are also more common in older women - possibly as an effect of decreased bone quality (Nilsson 1969). Also, soccer contributed less to attachment injuries owing to age or perhaps special mechanical conditions for the two types of injury. Kennedy et al. (1980) found experimentally that rapidly applied loads caused substance ligament rupture rather than attachment rupture.

DISCRIMINANT ANALYSIS OF FACTORS CONTRIBUTING TO GONARTHROSIS AND INSTABILITY

Only factors known at the time of the entrance operation were used for this attempt to predict the outcome. In order further to simplify the analysis, all variables investigated were dichotomized (Ceder et al. 1980) and only cases with one accident and one operation were included (N = 230). The variables tested were:

Sex
Age
Time interval accident - operation
Follow-up time
Work
Mental disorder
Severity of trauma
Preoperative instability

Preoperative diagnosis
Presence of MCL, ACL, PCL and LCL-injury
Operative findings of cartilage pathology
Operative findings of synovial membrane pathology
Operative findings of synovium fluid pathology
ACL-repair

The discriminant coefficients with a possible ability to discriminate between joints which were to develop gonarthrosis from joints that did not and joints which became subjectively unstable from joints that caused no such problems, were calculated. Discriminant factors for arthrosis were preoperative instability, a peroperative finding of degenerative changes in the lateral tibial or femoral condyles or in the patella,and medial meniscus lesion. Using the discriminant factors added very little to the ability of predicting gonarthrosis.

For prediction of instability, the severity of trauma, injuries to menisci and mental disorder were the best discriminant factors; again the ability to predict using these factors was not satisfactory and the analysis only points out possible relationships.

THE SOCCER PLAYER

Association football (soccer) contributed half of the injuries distributed among 178 joints in 175 patients. PCL-injuries were less frequent (8%) among soccer players than among non-soccer players (18%). Not one single case of tibial spine fracture was found among the soccer players. There was a significant preponderance for right-sided injuries in soccer players. Otherwise the distribution between various anatomical types of injury did not differ in soccer players as compared with other patients with ligament injuries.

Meniscectomies were perforemd in 56% of the soccer players as compared with 42% in other patients - a significant difference. The accumulated number of ligament injury episodes was on

average 2.0 in soccer players as compared with 1.5 in other ligament injury patients - again a significant difference. The frequency of early repair of ACL did not differ between the two groups but ACL-reconstructions were twice as common among soccer players as compared with non-soccer players - 34% and 19%, respectively.

Out of 175 soccer players, 72 were still playing soccer at the time of the re-examination but only 48 on the same level as before the injury and the entrance operation. Nineteen were still playing soccer, but in a lower league or entirely as leisure activities and 13 had retired from soccer as well as from other physical exercise, giving their knee-injury as a reason.

At the time of the follow-up examination 13 patients (7%) were classified as knee-disabled - no significant difference from other knee-ligament injuries. The measurements of stability did not differ significantly from other subsets of the knee-injury patients. Gonarthrosis was noted in 11 joints (6%) and osteophytes in 59 (32%) - again no difference from other ligament injury patients. Gonarthrosis and/or osteophytosis did not occur more often in the uninjured knee-joints of soccer players than in other non-injured knee-joints.

DISCUSSION

For decision-making as to treating knee-ligament injuries two questions demand an answer:

A. What is the natural course of knee-ligament injuries?
   In the present study the natural course has been tampered with by various therapeutic measures and individual patients have been withdrawn from the main group leaving a series of untreated patients from whom only limited conclusions may be drawn. Also, from our experience in the past of secondary gonarthrosis we have reason to believe that not only do we need a follow-up time of decades rather than years, but we must also follow our patients into old age.

B. What are the effects of surgical treatment?
   This set of data is not very well suited to answer this question since random allocation has not been used, and since a retrospective analysis of the indications for surgery in individual patients is difficult or impossible.

Now, is the problem insurmountable? If so, there is no way of approaching the questions any further, since impeccable data are not available and may well never become available. It is therefore a sine qua non to use the type of data available from this study and to attempt to control interaction and variance as far as possible.

What is the natural course of knee-ligament injuries?
In the present study the patients and their injuries have in many instances not been permitted to develop along the natural course. Nevertheless, in the long perspective the importance of treatment appears to be small and with a limited effect on the final outcome. Therefore the data of the present study may, to some extent, be used to form an opinion on the natural history, in particular with regard to the development of gonarthrosis. The prevalence of gonarthrosis according to our

criterion of a decreased joint space is not known in the population at risk nor in any other population. In the present study there were two uninjured contra-lateral joints that qualified as gonarthrosis whereas among the injured joints there were altogether 26. This indicates that gonarthrosis according to our criterion is increased by a factor of about 10 in patients with knee-ligament injuries. Even if the prevalence of gonarthrosis is unknown, the incidence of patients presenting with symptoms and roentgenological gonarthrosis has been estimated (Danielsson and Hernbqrg 1970). Assuming the same incidence in our patients with knee-ligament injuries, none should have presented as a gonarthrosis patient. In fact, six patients were seen over the years indicating that gonarthrosis also as a clinical entity is more frequent among patients with knee-ligament injuries than in the population at risk.

Removal of menisci and/or transection of knee-ligaments is a reliable method of producing arthrosis in rabbits (Hulth et al. 1970, Moskowitz et al. 1973, Bohr 1976 and others) - in man the effect appears to be rather inconsistent.

The gonarthrosis patients were older both at the time of the accident and at the time of the follow-up examination. It is not possible to decide which is the most unfavourable circumstance; being old at the time of the accident causing the injury; or having reached a certain age at the time of the follow-up.

In previous studies various risks of gonarthrosis following knee-ligament injuries have been estimated. High prevalences of roentgenological gonarthrosis after ligament injuries were found by Palmer (1957), Gudde and Wagenknecht (1973), McDaniel and Dameron (1980) and Fetto and Marshall (1980). Alm (1974) and Jacobsen (1977) found frequent cartilage changes when visually inspecting joints operated on for old knee-ligament injuries. The most common roentgenological finding in our patients with knee-ligament injuries was, however, osteophytes frequently combined with

other signs of degeneration or, perhaps rather, repair. Osteophytes are very rare in healthy joints of the male population, also in old age they are more common in women (Hernborg and Nilsson 1973). It has been demonstrated that patients with knee-ligament injuries have an increased prevalence of osteophytes (Hernborg and Nilsson 1973). The presence of osteophytes does not permit any prediction about gonarthrosis later in life (Hernborg and Nilsson 1973). In the present study it was not possible to demonstrate any relationship between osteophytosis and gonarthrosis - the joint space was not decreased in patients with osteophytes as compared with patients with roentgenologically normal joints. There was a slight tendency of a continuing slow growth of osteophytes with time after the injury but only in the lateral aspect of the joint. Even if there was no difference between the joint space in normal joints and joints with osteophytes there was in the latter group a slight negative age regression which is difficult to interpret but which may indicate that some of the osteophytosis patients will perhaps with time fulfil the criterion of gonarthrosis.

Meniscectomy appears to be the most important factor with regard to radiological changes following knee-ligament injuries - very few injuries developed gonarthrosis if they were not combined with a meniscus lesion and a meniscectomy. Also, the osteophytosis cases had much more often been operated on with meniscectomy. An osteophyte on the medial tibial condyle is common following meniscectomy (Fairbank 1948, Jackson 1968, Johnson et al. 1974).

Except for age and meniscectomy it appears as if the presence of cartilagenous injuries or degeneration already at the time of the first arthrotomy and possibly also the preoperative

stability are of some importance for the outcome.

Defining gonarthrosis from arthrotomy findings rather than the roentgen appearance, Jakobsen (1977) found a relationship between meniscectomy and gonarthrosis in unstable joints. Gudde and Wagenknecht (1973) found a high rate of roentgenological gonarthrosis following ACL injury plus meniscectomy. Meniscectomy in itself may also, indeed, result in gonarthrosis (Fairbank 1948, Appel 1970, Dietschi 1973).

In conclusion, gonarthrosis may be the consequence of the meniscectomy whereas osteophytosis is the typical roentgen appearance of an unstable knee-joint.

The various measures of instability were fairly evenly distributed among the subsets of knee-ligament injuries. Therapeutic measures seem to be of little importance but in ACL injuries partial ruptures appear to be more favourable and to produce less instability. However, it must be taken into account that the classification partial/total is fairly inaccurate. The group of partial injuries may include total ruptures and also ligaments without rupture. To make this distinction it is necessary to open the synovial membrane and to dissect the ligament carefully, something which in many instances was not done in this series (Smillie 1978, Kennedy et al. 1980).

Avulsion of the ACL attachments was expected to have a better prognosis than substance injuries, particularly since the latter types of injuries appear to be easier to repair. However, the attachment rupture may include distension of the ligament with serious injuries to the substance structures (Kennedy et al. 1976, 1980). A similar conclusion may be drawn from the persistent instability following tibial spine fractures. These fractures were almost all reduced to an anatomically good position which should have ensured stability - the residual instability may be due to injury to the ligament substance itself and the outcome of the tibial spine fractures was

not particularly favourable. Also, avulsion of the femoral attachment may cause irreparable impairment of the blood supply in the ligament (Smillie 1978).

The patients selected for reconstruction may, indeed, deviate from the rest of the patients in this study. The causes for reconstruction may have been either very serious injuries with an obvious pre-operative instability or particular demands of the patients on knee-function, or a combination of both. Also, the reconstructed patients were younger. The fact that reconstructed patients more often continued their sports activities may not necessarily imply a better function. With regard to stability the outcome of these operations was very similar to that of other ACL injuries, repaired or not. This does not mean that the procedure did not serve its purpose for several years and that these patients may have been worse off without their reconstruction.

In the 51 PCL-cases the injuries were in many instances multiple. In spite of this the PCL-injuries did not differ with regard to stability or function from other injuries, not even the rate of gonarthrosis was particularly high; besides, all four patients with gonarthrosis in this group had also been operated on with meniscectomy. Most authors agree (Brantigan and Voshell 1941, Kennedy and Grainger 1967, Hughston 1969, Meyers 1975, Trickey 1968, 1980, Cain and Schwab 1981) that PCL-rupture is a serious injury which causes disability and should be dealt with by surgical repair. From the data in the present study these injuries do not appear to be more serious than other knee-ligament injuries.

The MCL-injuries, whether in combination with ACL or not, do not appear to be a serious clinical problem - the prognosis is good. In this case we are, however, hardly dealing with the natural history since all injuries included in this study were either partial, and therefore not in need of repair, or were indeed repaired. Good results of conservative treatment of MCL-

injuries have been presented by Godshall and Hansen (1974), Ellsasser et al. (1974),Fetto and Marshall (1978) and Hastings (1980).

For the patient the most important symptom is usually the feeling of instability. Episodes of "give away" prevent the patient from participating in sport and exercise and are usually the symptom that brings the patient to an orthopedic surgeon and also the indication for surgical procedures (O´Donoghue 1963, Nicholas 1973, Alm and Gillqvist 1974, Galway et al. 1980). It is very difficult to predict such subjective instability from the case history even after the patient has been operated on - not even mental factors can be ruled out.

Otherwise, with regard to subjective symptoms, the comparison between the various groups of injury and treatment are inconclusive. The subjective symptoms are per se not necessarily related to the knee-ligament injury, the prevalence of such symptoms, many of which may be of a patello-femoral origin, is not known in the population. A common complaint was discomfort in the kneeling position which could be frequently referred to the loss of superficial sensation in the pre- and infrapatellar area caused by peroperative lesion of the infra-patellar branch of the saphenus nerve (Huckell 1965, Chambers 1972, Johnson et al. 1974).

Will there be a further deterioration of the joints with ligament injuries? Except for the causing agent, known or unknown, the development of gonarthrosis will require time before the condition becomes possible to diagnose with a roentgen examination. Lindén (1976) studying the natural course of osteochondritis dissecans found an approximatively 20-year delay of roentgenological gonarthrosis in those cases who developed this condition. Meniscectomy appears to be an almost necessary prerequisite for gonarthrosis in patients with knee-ligament injuries. However, in 10 of the 22 gonarthrosis joints which had had their meniscus removed,the operation was not closely

related to an accident and in seven of these the arthrotomy revealed degenerative changes in the joint cartilage. Such changes were not seen in those joints in which the meniscectomy was undertaken in conjunction with an accident. In some instances the meniscectomy may be a consequence of early gonarthrosis rather than the opposite. Also, the trauma causing the injury to the meniscus may be the important factor and not the meniscectomy. Appel (1970) found that gonarthrosis after meniscectomy becomes apparent only after decades. In the present study those patients who had gonarthrosis were older at the time of follow-up but they were also older at the time of the injury and the time that elapsed between injury and follow-up did not differ much from that of patients without gonarthrosis.

There is little evidence that joints with osteophytes will develop into gonarthrosis later in life. The joint space decreased slightly with age in these patients but on the whole was not different from the joint space of patients who were classified as normal - the data from the follow-up study suggest a steady state or, possibly, a very slow progress. It remains to be seen if there is a "second wave" of joint deterioration in decades to come.

Are there groups with a particularly poor prognosis? Jones (1946) in a study of 200 consecutive knee-injuries, encountered by soldiers in the Second British Army as they advanced through Northern Germany towards the end of the Second World War, found knee-injuries which were caused by traffic accidents and battle injuries but the most common single cause of knee-injury was still soccer! American football has by providing injuries as well as funds, become one of the corner-stones in the clinical development of knee-ligament surgery. The two sports contribute the largest single number of patients in most series of ligament injuries presented, the American variety probably being the worst offender (Hughston et al. 1961, Peterson 1970, Ellsasser et al. 1974, Del Pizzo et al. 1977).

In the present study, however, there is no support for the suspicion that soccer-players have a less favourable course than other patients with knee-ligament injuries in spite of the fact that they have significantly more accidents. In no respect could the soccer players be demonstrated to have more severe symptoms of their injuries. In fact, many went on playing soccer with or without accidents for many years or maintained by some other means a higher than average degree of physical activity.

What is the effect of repair of knee-ligaments?
Only in one group - the ACL-injuries - may an attempt be made to evaluate the effect of early repair of the ligament. In spite of the shortcomings of these data, the repair procedure should have left some measurable beneficial effects. Every surgeon who is treating knee-ligament injuries will be able to present cases such as Case number 6 (Appendix) with excellent results after suture. Several investigators have recommended early suture as the best means of dealing with knee-ligament injuries (O´Donoghue 1955, Liljedahl and Nordstrand 1969) whereas others have found less rewarding results (Lam 1968). The lack of similarity in results between various studies may be due to differences in skill and technique. In dealing with the earliest cases in this study when the diagnosis was rare and few ACL were repaired, the surgeons must obviously have been inexperienced. Later on, when the procedure became more common we must assume that the skill and technique improved. The re-attachment of an avulsed ligament and the reposition and fixation of an avulsed tibial spine were usually very satisfactory from a technical point of view. Nevertheless, these joints have developed along the same line as joints with other injuries.

The early results of repair cannot be estimated from the data of the present study. The records often have notes about good stability in the operated joint and there may well have been differences between the groups of treatment during the first

years after surgery. The course may also, in both groups, have been interfered with by further accidents, known or unknown. However, in the discriminant analysis, which included only patients with one injury and one operation, the treatment of ACL was not a factor able to discriminate for future gonarthrosis or instability.

Early repair of knee-ligaments is an expensive and time-consuming process. The surgical procedure in itself is not the main problem, it is the screening procedure with a liberal application of diagnostic methods such as examination of stability under general anaesthesia and arthroscopy which is consuming substantial resources. During a 30-month period 1979-1981 the screening procedure in the city of Malmö involved 678 cases with 513 examinations under general anaesthesia and 93 arthroscopies with 137 ACL sutures as a result.

The most impressive finding in the present study was not that patients treated with repair - or reconstruction - were doing poorly but rather that the untreated patients were doing so well.

What other alternatives are there? From the present study as well as from other studies it seems as if repair of the anterior cruciate ligament is not a satisfactory procedure. Early repair, when undertaken, should possibly be combined with some reinforcement procedure as suggested by Solonen and Rokkanen (1967) and Kennedy et al. (1980). Recently Althoff et al.(1981) (personal communication) were able to produce - at least initially - stability in joints with ACL injuries by reinforcing the sutured ligament with a retinaculum strip. Another possibility is to leave those patients untreated who have a ruptured ACL with a moderate instability as their only sign and to perform reconstruction in those patients who so require.

As for the prevention of gonarthrosis later in life it is possible that modifications of treatment should concern the

meniscus ruptures. Perhaps procedures such as re-suturing of menisci (Price and Allen 1978, Hamberg and Gillquist 1981, Wirth 1981) or partial meniscectomy (Hargreaves and Seedhom 1979) may be of value.

SUMMARY AND CONCLUSIONS

A consecutive series of 389 knee-ligament injuries in 383 patients were re-examined 5 - 35 years (mean 10 years) after the accident causing the injury. The diagnosis had been arrived at by visual inspection in conjunction with an arthrotomy. The re-examination included symptoms, function, parameters of joint instability and roentgen. The following conclusions may be drawn from the data:

1. Gonarthrosis, defined as a decreased joint space, was found in 7% of the joints whereas there were osteophytes in additional 33%.

2. Gonarthrosis was found almost only in joints which also had been operated on with a meniscectomy; osteophytes were also more common in joints after meniscectomy but were a frequent find also in other cases of knee-ligament injuries.

3. The femuro-tibial joint space in relation to age and time suggests progress of the gonarthrosis. Analysis of osteophyte size and joint space in patients with osteophytes suggests that some of these patients may in time fulfil the criteria of gonarthrosis; however, the progress is very slow.

4. Ten per cent of the patients were incapacitated to the effect that they had retired from work or were completely incapable of physical exercise.

In the analysis of the various types of injuries, special attention was paid to the anterior cruciate ligament injury:

5. Serious disability following anterior cruciate injuries was comparatively rare in spite of frequent residual instability.

6. Early repair of anterior cruciate ligament injuries cannot be demonstrated to alter significantly the course.

7. Anterior cruciate ligament injuries combined with medial collateral injury which had been repaired, did not differ in their course from isolated anterior cruciate ligament injuries.

8. Anterior cruciate ligament injuries involving avulsion of the proximal or distal attachment which frequently had been repaired with a technically satisfactory result, did not deviate with regard to symptoms or stability from rupture in the substance, similarly avulsions of the tibial spine which had usually been reduced to an anatomically good position had residual symptoms and instability just as other ligament injuries.

9. Partial ACL-injuries appear to have a more benign course with less instability.

10. Intra-articular anterior cruciate ligament reconstructions using the patellar ligament led to results similar to those of other anterior cruciate ligament injuries with regard to instability and symptoms, in spite of the fact that these cases were selected because of a more severe instability.

As for other groups the following observations were made:

11. Posterior cruciate ligament injuries had symptoms, function and stability similar to that of other knee-ligament injuries. Posterior subluxation of the tibia was a frequent finding.

12. Medial collateral ligament injuries rarely left any disability, and did not contribute to the production of gonarthrosis. There was at the time of re-examination a small but significant medial instability. Since these injuries almost always had been repaired, the effect of repair cannot be studied.

13. Association football is the most common cause of knee-ligament injuries in the city of Malmö; however, the outcome in soccer players was not - in the longer perspective - any worse than in other knee-ligament injury patients.

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APPENDIX

Tables and case reports

Table A:I. Function and stability after ACL-injuries - comparison between non-repair and primary repair.

A) Symptoms

Symptoms on:	Non-repair Pain/discomfort Yes	No	% Yes	Repair Pain/discomfort Yes	No	% Yes
Weather changes*	13	73	15%	24	56	30%
Walking*	18	68	21%	11	69	14%
Stair climbing*	26	60	30%	17	63	21%
Running*	24	53	31%	21	54	28%
Squatting*	31	53	37%	41	38	52%
Kneeling*	42	44	49%	54	26	67%
Biking*	6	78	7%	5	70	7%

B) Work and sports

	Non-repair Impaired capacity Yes	No	% Yes	Repair Impaired capacity Yes	No	% Yes
Working*	4	82	5%	4	76	5%

	Non-repair Level of practising None	Less vigorous	More vigorous	Repair Level of practising None	Less vigorous	More vigorous
Sports and exercise*	24	34	28	27	22	33

C) Stability

	Non-repair None	Moderate	Give away	Repair None	Moderate	Give away
Subjective instability	59	18	20	52	19	15
			Obvious			Obvious
Forward drawer sign	14	77	6	14	65	6
Positive Lachman test	45	44	1	32	42	6
Positive Pivot shift	44	42	4	42	35	3

D) Measured anterior-posterior instability (mm difference from contra-lateral knees)

	Non-repair N	Av ± SD	Repair N	Av ± SD
Neutral*	86	2.3 ± 2.5	80	2.3 ± 2.1
Internal rotation*	86	1.9 ± 2.3	80	1.8 ± 1.9
External rotation*	81	2.6 ± 2.8	80	2.5 ± 2.4

*) Only knees with an uninjured contra-lateral joint included.

Table A:II. Function and stability after ACL-repaired in the first 14 days after the accident. One injury only.

A) Symptoms

Symptoms on:	Pain/discomfort Yes	No	% Yes
Weather changes*	12	36	25%
Walking*	6	42	13%
Stair climbing*	7	41	15%
Running*	12	31	28%
Squatting*	23	24	49%
Kneeling*	31	17	65%
Biking*	1	43	2%

B) Work and sports

	Impaired capacity Yes	No	% Yes
Working*	1	47	2%

	Level of practising None	Less vigorous	More vigorous
Sports and exercise*	18	14	16

C) Stability

	None	Moderate	Give away
Subjective instability	33	12	6
			Obvious
Forward drawer sign	11	38	2
Positive Lachman test	21	23	3
Positive Pivot shift	25	21	1

D) Measured anterior-posterior instability (mm difference from contra-lateral knees)

	N	Av	±	SD
Neutral*	48	2.1	±	2.0
Internal rotation*	48	1.7	±	1.6
External rotation*	48	2.3	±	2.2

*) Only knees with an uninjured contra-lateral joint included.

Table A:III. Function and stability after ACL-injuries - comparison between isolated and combined.

A) Symptoms

Symptoms on:	Isolated Pain/discomfort Yes	No	% Yes	Combined Pain/discomfort Yes	No	% Yes
Weather changes*	22	54	29%	24	66	26%
Walking*	13	63	17%	16	74	18%
Stair climbing*	22	54	29%	21	69	23%
Running*	25	47	35%	20	60	25%
Squatting*	25	50	33%	47	41	53%
Kneeling*	41	35	54%	55	35	61%
Biking*	6	67	8%	5	81	6%

B) Work and sports

	Isolated Impaired capacity Yes	No	% Yes	Combined Impaired capacity Yes	No	% Yes
Working*	2	74	3%	6	84	7%

	Isolated Level of practising None	Less vigorous	More vigorous	Combined Level of practising None	Less vigorous	More vigorous
Sports and exercise*	23	28	25	28	28	34

C) Stability

	Isolated None	Moderate	Give away	Combined None	Moderate	Give away
Subjective instability	50	18	19	61	19	16
			Obvious			Obvious
Forward drawer sign	11	69	7	17	73	5
Positive Lachman test	31	49	2	46	37	5
Positive pivot shift	36	40	5	49	37	2

D) Measured anterior-posterior instability (mm difference from contra-lateral knees)

	Isolated N	Av ± SD	Combined N	Av ± SD
Neutral*	76	2.5 ± 2.4	90	2.2 ± 2.3
Internal rotation*	76	2.0 ± 2.4	90	1.7 ± 1.8
External rotation*	76	3.0 ± 2.7	89	2.2 ± 2.2

*) Only knees with an uninjured contra-lateral joint included.

Table A:IV. Function and stability after ACL-injuries - comparison between ruptures in attachments and substance (only complete repaired ligaments included).

A) Symptoms

Symptoms on:	Attachments Pain/discomfort Yes	No	% Yes	Substance Pain/discomfort Yes	No	% Yes
Weather changes*	13	18	42%	7	32	18%
Walking*	8	23	26%	2	37	5%
Stair climbing*	10	21	32%	5	34	13%
Running*	10	17	37%	8	30	21%
Squatting*	17	13	57%	20	19	51%
Kneeling*	20	11	65%	10	29	26%
Biking*	5	23	18%	0	38	0%

B) Work and sports

	Attachments Impaired capacity Yes	No	% Yes	Substance Impaired capacity Yes	No	% Yes
Working*	3	28	10%	0	39	0%

	Attachments Level of practising None	Less vigorous	More vigorous	Substance Level of practising None	Less vigorous	More vigorous
Sports and exercise*	13	10	8	9	11	19

C) Stability

	Attachments None	Moderate	Give away	Substance None	Moderate	Give away
Subjective instability	19	7	6	28	10	4
			Obvious			Obvious
Forward drawer sign	6	24	2	7	32	3
Positive Lachman test	17	12	2	12	24	3
Positive pivot shift	15	16	0	21	15	3

D) Measured anterior-posterior instability (mm difference from contra-lateral knees)

	Attachments N	Av	± SD	Substance N	Av	± SD
Neutral*	31	2.2	± 2.1	39	2.3	± 2.2
Internal rotation*	31	1.7	± 1.8	39	1.8	± 1.6
External rotation*	31	2.8	± 2.4	39	2.5	± 2.4

*) Only knees with an uninjured contra-lateral joint included.

Table A:V. Function and stability after ACL-injuries - comparison between total and partial.

A) Symptoms

Symptoms on:	Total Pain/discomfort Yes	No	% Yes	Partial Pain/discomfort Yes	No	% Yes
Weather changes*	32	85	27%	9	26	26%
Walking*	22	95	19%	5	30	14%
Stair climbing*	28	89	24%	9	26	26%
Running*	32	77	29%	7	24	23%
Squatting*	54	61	47%	12	23	34%
Kneeling*	72	45	62%	15	20	43%
Biking*	8	104	7%	1	33	3%

B) Work and sports

	Total Impaired capacity Yes	No	% Yes	Partial Impaired capacity Yes	No	% Yes
Working*	6	111	5%	2	33	6%

	Total Level of practising None	Less vigorous	More vigorous	Partial Level of practising None	Less vigorous	More vigorous
Sports and exercise*	36	37	44	11	11	13

C) Stability

	Total None	Moderate	Give away	Partial None	Moderate	Give away
Subjective instability	71	29	25 Obvious	32	4	4 Obvious
Forward drawer sign	19	95	11	11	29	0
Positive Lachman test	48	64	6	24	10	0
Positive pivot shift	55	56	7	27	7	0

D) Measured anterior-posterior instability (mm difference from contra-lateral knees)

	Total N	Av ± SD	Partial N	Av ± SD
Neutral*	117	2.5 ± 2.4	35	1.5 ± 2.1
Internal rotation*	117	2.1 ± 2.1	35	1.1 ± 2.1
External rotation*	116	2.9 ± 2.6	35	1.7 ± 2.5

*) Only knees with an uninjured contra-lateral joint included.

Table A:VI. Function and stability after fracture of the tibial spine.

A) Symptoms

Symptoms on:	Pain/discomfort Yes	No	% Yes
Weather changes*	7	14	33%
Walking*	3	18	14%
Stair climbing*	7	14	33%
Running*	4	14	22%
Squatting*	7	14	33%
Kneeling*	14	7	67%
Biking*	3	17	15%

B) Work and sports

	Impaired capacity Yes	No	% Yes
Working*	2	18	10%

	Level of practising None	Less vigorous	More vigorous
Sports and exercise*	8	9	4

C) Stability

	None	Moderate	Give away
Subjective instability	15	3	3
			Obvious
Forward drawer sign	6	14	1
Positive Lachman test	7	10	1
Positive pivot shift	9	6	3

D) Measured anterior-posterior instability (mm difference from contra-lateral knees)

	N	Av	±	SD
Neutral*	21	2.0	±	2.9
Internal rotation*	20	2.0	±	1.7
External rotation*	21	2.0	±	2.2

*) Only knees with an uninjured contra-lateral joint included.

Table A:VII.Function and stability after ACL-reconstructions.

A) Symptoms

Symptoms on:	Pain/discomfort Yes	No	% Yes
Weather changes*	16	43	27%
Walking*	11	43	19%
Stair climbing*	12	47	20%
Running*	21	37	36%
Squatting*	36	23	61%
Kneeling*	46	12	79%
Biking*	6	53	10%

B) Work and sports

	Impaired capacity Yes	No	% Yes
Working*	3	56	5%

	Level of practising None	Less vigorous	More vigorous
Sports and exercise*	8	30	21

C) Stability

	None	Moderate	Give away
Subjective instability	43	17	13
			Obvious
Forward drawer sign	11	55	7
Positive Lachman test	24	43	3
Positive pivot shift	43	23	4

D) Measured anterior-posterior instability (mm difference from contra-lateral knees)

	N	Av	±	SD
Neutral*	58	2.0	±	2.3
Internal rotation*	58	1.5	±	1.9
External rotation*	58	2.5	±	2.7

*) Only knees with an uninjured contra-lateral joint included.

Table A:VIII. Function and stability after PCL-injuries.

A) Symptoms

Symptoms on:	Pain/discomfort Yes	No	% Yes
Weather changes*	17	32	35%
Walking*	8	41	16%
Stair climbing*	15	34	31%
Running*	16	30	35%
Squatting*	29	20	59%
Kneeling*	32	17	65%
Biking*	11	37	23%

B) Work and sports

	Impaired capacity Yes	No	% Yes
Working*	6	43	12%

	Level of practising None	Less vigorous	More vigorous
Sports and exercise*	19	20	10

C) Stability

	None	Moderate	Give away
Subjective instability	34	7	10
			Obvious
Forward drawer sign	7	35	9
Positive Lachman test	13	24	3
Positive pivot shift	27	11	2

D) Measured anterior-posterior instability (mm difference from contra-lateral knees)

	N	Av	±	SD
Neutral*	49	3.9	±	3.4
Internal rotation*	49	2.7	±	3.0
External rotation*	49	3.9	±	3.2

*) Only knees with an uninjured contra-lateral joint included.

Table A:IX. Function and stability after isolated MCL-injuries.

A) Symptoms

Symptoms on:	Pain/discomfort Yes	No	% Yes
Weather changes*	8	35	14%
Walking*	2	41	5%
Stair climbing*	5	38	12%
Running*	0	34	0%
Squatting*	11	32	26%
Kneeling*	22	21	51%
Biking*	0	40	0%

B) Work and sports

	Impaired capacity Yes	No	% Yes
Working*	1	42	2%

	Level of practising None	Less vigorous	More vigorous
Sports and exercise*	15	6	22

C) Stability

	None	Moderate	Give away
Subjective instability	38	7	2
			Obvious
Forward drawer sign	27	20	0
Positive Lachman test	37	3	0
Positive pivot shift	37	3	0

D) Measured anterior-posterior instability (mm difference from contra-lateral knees)

	N	Av	±	SD
Neutral*	43	0.7	±	1.8
Internal rotation*	43	0.7	±	1.5
External rotation*	43	0.6	±	1.9

*) Only knees with an uninjured contra-lateral joint included.

Table A:X. Function and stability after knee-ligament injury - comparison between non-meniscectomized and meniscectomized. Gonarthrosis cases excluded.

A) Symptoms

Symptoms on:	Non-meniscectomy Pain/discomfort Yes	No	% Yes	Meniscectomy Pain/discomfort Yes	No	% Yes
Weather changes*	48	124	30%	36	101	26%
Walking*	22	150	13%	22	115	16%
Stair climbing*	37	135	22%	32	105	23%
Running*	31	119	21%	41	91	31%
Squatting*	67	104	39%	73	63	54%
Kneeling*	103	69	60%	95	41	70%
Biking*	10	154	6%	13	122	10%

B) Work and sports

	Non-meniscectomy Impaired capacity Yes	No	% Yes	Meniscectomy Impaired capacity Yes	No	% Yes
Working*	6	166	3%	11	126	8%

	Non-meniscectomy Level of practising None	Less vigorous	More vigorous	Meniscectomy Level of practising None	Less vigorous	More vigorous
Sports and exercise*	56	55	61	28	61	48

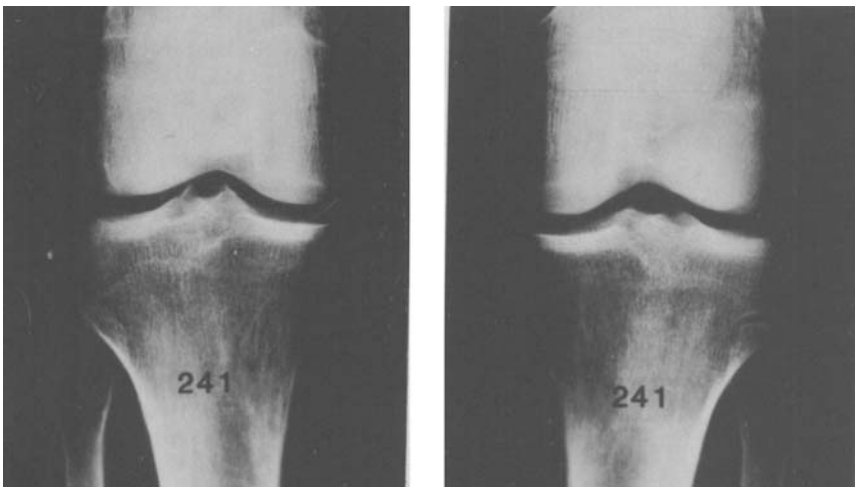
C) Stability

	Non-meniscectomy None	Moderate	Give away	Meniscectomy None	Moderate	Give away
Subjective instability	135	24	24	89	69	31
			Obvious			Obvious
Forward drawer sign	50	119	14	21	122	15
Positive Lachman test	87	67	8	55	87	7
Positive pivot shift	110	46	6	77	61	11

D) Measured anterior-posterior instability (mm difference from contra-lateral knees)

	Non-meniscectomy N	Av ± SD	Meniscectomy N	Av ± SD
Neutral*	172	2.1 ± 2.7	136	2.5 ± 2.7
Internal rotation*	172	1.7 ± 2.3	136	1.8 ± 2.2
External rotation*	172	2.3 ± 2.8	135	2.8 ± 2.7

*) Only knees with an uninjured contra-lateral joint included.



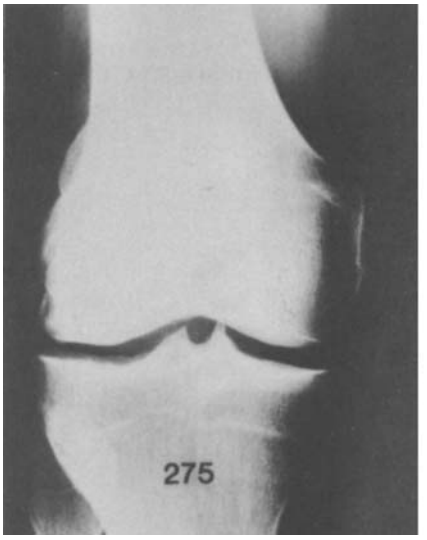
Case No. 1.

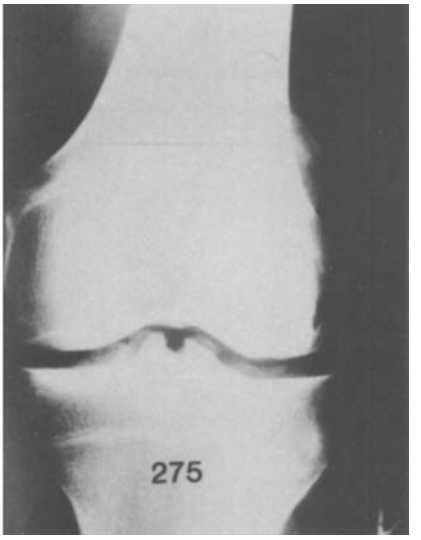
1955. Man, aged 20, injured his right knee playing soccer. Over the years intermittent feeling of instability and episodes of joint effusion.

1970. Owing to these symptoms, 15 years after the accident, the patient sought medical advice. Arthrography and arthrotomy were performed and a torn medial semilunar cartilage with its anterior part interposed between the condyles was removed. The injury appeared to be old at the time of the entrance operation. Also, the ACL was resorbed.

1980. At follow-up the patient had experienced five episodes of give away over the last 10 years but had no other complaints. Unrestricted golf, badminton and walks. The follow-up examination revealed anterior drawer sign corresponding to an increase in the measured anterior-posterior instability of 5 mm in the neutral position and positive Lachman test and pivot shift. The roentgen examination revealed no pathological changes.*

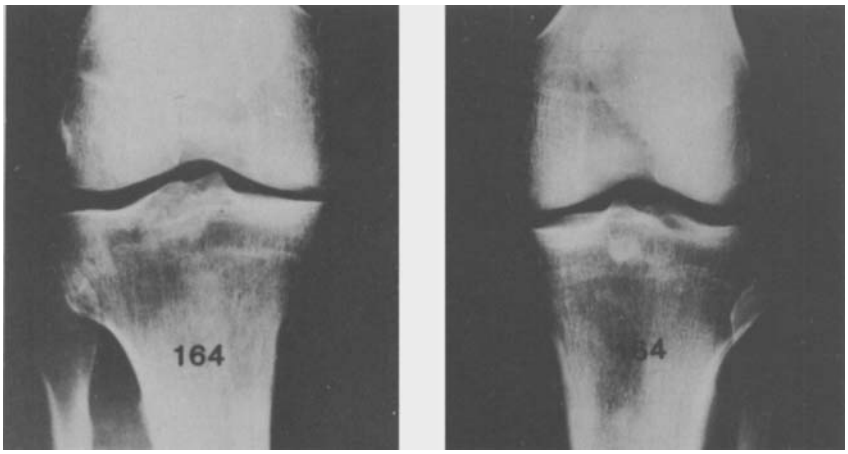
* *All films presented in case reports are weight-bearing.*





Case No. 2.
This patient participates in the study with both knees.
Right knee
1955. Rupture of the lateral semilunar cartilage which was removed.
1971. Soccer injury - valgus hyperextension trauma to the knee. The arthrotomy revealed a total rupture of the femoral attachment of the ACL and total rupture of both layers of the MCL just proximally of the femoral-tibial articulation. The ACL was re-attached and the MCL sutured.
1977. Discomfort in conjunction with weather changes - no other symptoms. Fireman on active duty. Unrestricted physical activity including soccer. The range of flexion motion was 10^{o} less than in the left knee and there was a slight anterior drawer sign corresponding to the measured difference in the neutral position of 2 mm. There was no medial-lateral instability and Lachman and pivot tests were negative. Roentgen demonstrates small osteophytes and sharpening of the tibial spine.
Left knee
1959. External rotation-flexion trauma. Arthrotomy revealed an uninjured medial semilunar cartilage and a completely ruptured

ACL which was left without attempts at repair.
1977. (compare above) No symptoms from his knee. The roentgen examination revealed obvious osteophytosis.



Case No. 3.

1973. 58-year-old undertaker who fell during work and sustained an external rotation-abduction-flexion trauma to his right knee-joint. Arthrotomy revealed an avulsion of the femoral attachment of the ACL, a ruptured and impacted medial semi-lunar cartilage and a rupture of both layers of the MCL just distal to its femoral attachment. The meniscus was removed, the MCL sutured and the ACL re-attached.

1977. No symptoms. The patient is mobile to the same extent as before the injury and still working. The range of flexion motion was decreased by 15° as compared with the left knee-joint. There was a slight drawer sign in the right knee and the measured anterior-posterior instability was 3 mm. Also, there was a positive pivot shift.

This patient has a slight but obvious gonarthrosis with narrowing of the medial joint space.

Case No. 4.

1973. 40-year-old shipyard worker, fell from his moped and had a trauma to his right knee. Arthrototomy two days after the accident revealed an avulsion of the femoral attachment of the ACL, rupture of both layers of the MCL and a ruptured, impacted medial semilunar cartilage. The ACL was re-attached, the MCL sutured and the meniscus removed.

1979. Symptoms on walking stairs and biking, "predicts weather", the symptoms are episodical. Positive pivot shift and Lachman test. Positive drawer sign corresponding to a measured difference of approximatively 2 mm.

The roentgen examination reveals medial gonarthrosis, the diagnosis is in this case based only on a slightly decreased joint space.

Case No. 5.

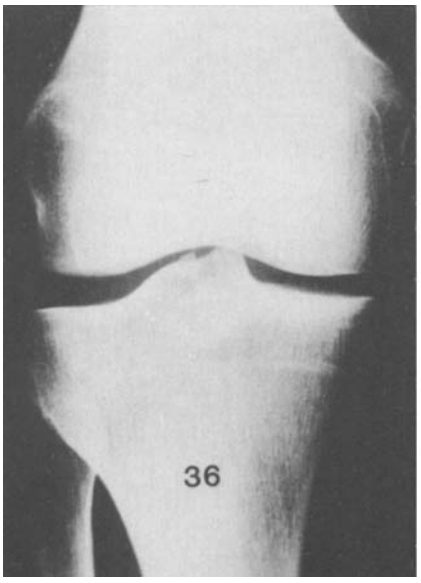
1943. 21-year-old man who fell off a truck during his militarv service and sustained an unspecified injury to his right knee-joint.

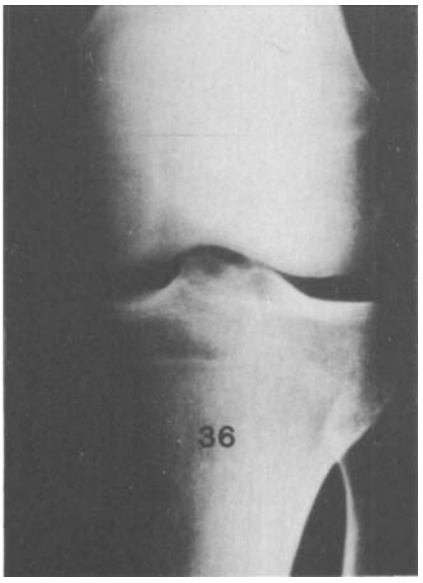
1954. Soccer injury. Kicked on his knee. Swelling, no diagnosis obtained.

1956. The patient sought advice for pain in his right knee. After arthrography which disclosed a medial meniscus rupture he was operated on. A medial bucket-handle meniscus was removed but it could also be seen that the patient had no ACL.
No attempts were made to reconstruct the ACL.

1974. He fell from his bicycle and developed hemarthrosis. Examination under general anesthesia immediately after the injury revealed no instability.

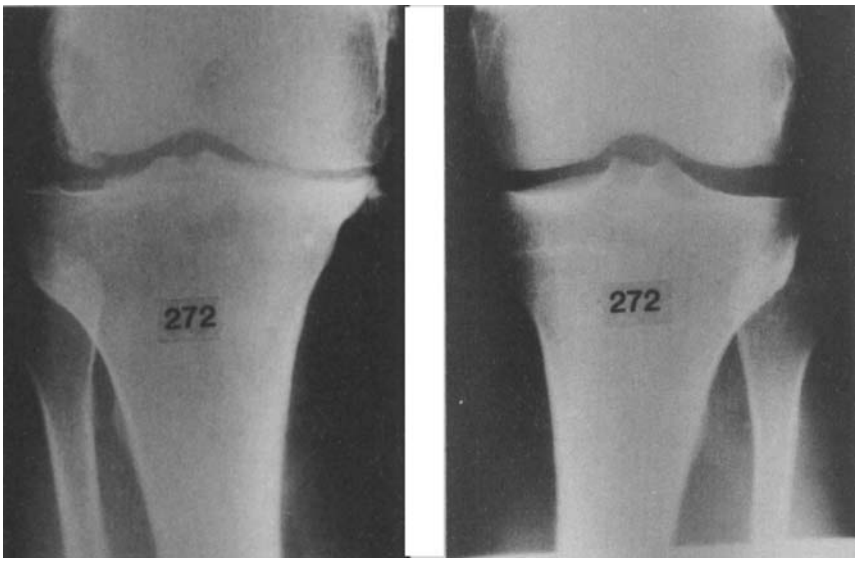
1978. Pain and discomfort, episodically and moderately when walking stairs and running and weekly "give away" episodes. There was an obvious anterior drawer sign in the right knee corresponding to a measured stability difference of 3 mm, the pivot and the Lachman tests were both positive. Medial-lateral stability was difficult to estimate because of pain. A slight varus deformity could be seen in the right knee.
Roentgen revealed an obvious medial gonarthrosis.





Case No. 6

1974. 21-year-old soccer player who sustained a rotational trauma to his right knee-joint. Operated on within a week, a ruptured medial meniscus was removed and total rupture in the femoral attachment of the ACL repaired by a re-attachment.
1980. Plays Swedish National League soccer. Lacks 15^{o} in full flexion as compared with the uninjured side and has a minimal hardly measurable drawer sign with Lachman and pivot shift tests negative and a normal roentgen finding.



Case No. 7.

1954. Man, aged 18, playing soccer, was kicked on the outside of his right knee and fell to the ground. Surgery nine days later revealed rupture of MCL, ACL, PCL, posterior medial capsule and the medial meniscus. ACL was sutured and reinforced, all other structures repaired and the meniscus removed.

1978. Clerk. Episodic"give away".Lacks 45^{o} of flexion. Plays badminton regularly. Eight mm posterior subluxation of the tibia but no difference in measured anterior-posterior stability. Some medial instability and a positive Lachman test. Roentgen: Obvious medial gonarthrosis.