Acta orthop. scand. *53*, 109–118, 1982

LONG-TERM RESULTS AFTER EARLY TREATMENT OF KNEE INJURIES

JACK LYSHOLM, JAN GILLQUIST & STEN-OTTO LILJEDAHL

Department of General Surgery, University Hospital, Linköping, Sweden

A total of 175 patients were reviewed 1 to 8 years (average 42 months) after treatment of knee ligament injury in the acute stage. Two-thirds were treated operatively because of total ligament tears and the remainder, with minor injuries, were treated non-operatively. In two-thirds of the patients with total substance tear of the anterior cruciate early repair was successful. Repair of the posterior cruciate was generally successful. Functional loss was correlated to the presence of a pivot shift sign and with abduction or adduction instability in extension. An important reason for a poor result was either medial meniscectomy or some component of the injury being missed in the primary diagnosis. Diagnosis based on arthroscopic and clinical findings was more reliable when selecting patients for operative or non-operative treatment than was diagnosis based on clinical examination alone. There was no difference in the results of non-operative treatment between patients immobilized in plaster and those treated with early mobilization without weight-bearing.

Key words: haemarthrosis; knee joint; ligaments

Accepted 22.iii.81

For many years we have asserted that clinical examination combined with arthroscopy is the method of choice in the diagnosis of recent knee injuries (Gillquist et al. 1977). We have found that arthroscopy improves the diagnosis of associated injuries, specially in the lateral compartment, and facilitates the detection of anterior cruciate (ACL) tears in patients with acute knee injuries (Lysholm et al. 1981).

Opinions vary concerning the treatment of substance tears of the ACL. Smillie (1978) has given arguments both for and against suture of the ligament in an acute injury. He concludes: "It is not my practice to make a special point of repair" (Smillie 1978). Kennedy et al. (1974) find the results of both operative and conservative treatment for ACL tear acceptable, although they state that the good result might be temporary. Palmer (1938, 1957), O'Donoghue (1955), and Liljedahl & Nordstrand (1969), on the other hand, advocate early primary suture. Early repair of the ACL was also used by Feagin et al. (1972, 1976) with disappointing results. In the present study the late results of early treatment of acute knee injuries are analysed with special reference to improved diagnosis due to arthroscopy.

PATIENTS AND METHODS

During the period 1971–1978, 192 patients were admitted to this department for acute knee injury. There were 153 men and 39 women, 13 to 62 years of age; 127 were below 30. The predominant cause of the injury was sport (61 per cent). All injuries were less than 4 weeks old. Patients with previous disorder of the same joint and simple torn meniscus were excluded. Most patients showed haemarthrosis, and some acute locking of the joint.

0001-6470/82/010109-10 $02.50/0

Clinical examination combined with arthroscopy was used in 117 patients (61 per cent), clinical examination and exploratory arthrotomy in 58 (30 per cent), and clinical examination alone in 17 (9 per cent). Arthroscopy was performed as described by Gillquist & Hagberg (1976) and Gillquist et al. (1977).

Almost all injured joints showed a combination of several ligament tears. To obtain groups as homogenous as possible the following classification of injuries was used:

Posterior cruciate ligament (PCL) tear: includes all patients with tear of the PCL.

ACL tear: includes all patients with ACL tear except those with injury to both cruciates.

Medial ligament complex (MED) injury or lateral compartment (LAT) injury: both cruciates were normal. The medial ligament complex was regarded as one unit, consisting of not only the medial ligaments but also the medial meniscus.

Total or partial tear of the ACL without injury to the PCL was found in nearly 50 per cent of the patients.

Table 1. Classification of injuries and incidences of different combinations of ligament tears

Group		Associated injury	*n*
ACL	total	isolated	1
		medial compartment	50
		lateral compartment	4
	partial	isolated	6
		medial compartment	24
PCL	total	isolated	4
		anterior cruciate, medial compartment	5
		medial compartment	8
	partial	isolated	1
		anterior cruciate, medial compartment	1
		medial compartment	2
MED		isolated	53
LAT		isolated	16

Abbreviations:

ACL: means rupture of the anterior cruciate ligament with or without associated medial or lateral compartment injury. Patients with rupture of both cruciate ligaments are classified as group PCL.

PCL: means rupture of the posterior cruciate ligament with or without associated anterior cruciate ligament or medial compartment injury.

MED: means single medial compartment tears.

LAT: means single lateral compartment tears + miscellaneous injuries (tears of the plica lata, etc.).

Most patients with ACL tear also had injury of the medial ligaments (Table 1). The incidence of total isolated ACL tear was only 1.5 per cent.

Total or partial tear of the PCL was found in 12 per cent of the patients in the series. One-third of them also had injury to the ACL, and three-fourths tear of the medial ligaments (Table 1). Injury to the medial ligaments without cruciate tear was found in 29 per cent of the patients.

Patients with complete ligament tears were treated by operation and the remainder were treated conservatively in plaster for 4 to 6 weeks or by early mobilization without weight-bearing. As patients with late primary repair of the ACL run a greater risk of re-rupture (Liljedahl & Nordstrand 1969), operation was performed as soon as possible, and 71 per cent were treated within 1 week of the injury. For cruciate tears u-sutures were used, pulled out through drill holes in the femoral condyle, or in the tibia in patients with avulsion of the ligament from the tibia. A drill guide was used to place the drill holes as close as possible to the anatomical insertion of the ligament. The technique was originally described by Palmer (1938). Bone fragments were usually re-attached with screws or pins. In 7 late repairs of total tears of the ACL primary reconstruction was used – in 4 patients a pes anserinus transfer (Slocum & Larson 1968), in 2 a modified patellar tendon reconstruction (Broström et al. 1968, Gillquist et al. 1971), and in one a modified Ellison procedure (Ellison 1979). In 2 patients with posterior cruciate ligament tear reconstruction was done – in one case using the medial head of the gastrocnemius and in one the medial meniscus. Reconstruction of the ACL was used in 4 per cent of early operations; after the second week reconstruction was used in 43 per cent ($P < 0.05$). The different sites of injury to the medial ligament complex were identified by thorough dissection, and primary repair was done. The same technique was used for lateral injuries. Meniscus tears were treated by meniscectomy in most cases, but in some patients with avulsion of the meniscus, this was sutured back with Dexon®. In a few patients an associated condylar fracture of the tibia or femur was treated according to the ASIF principles (Müller et al. 1979). All operations were done in a bloodless field. Vacuum wound drainage was used for 24 to 48 hours in all cases. Immobilization in plasters was used for 5 to 6 weeks after the operation.

There were no infections. A few patients having a lengthy operation were given prophylactic antibiotic therapy. Two developed uncomplicated lower leg thrombosis. At follow-up one patient had a loss of extension of 7°, 7 showed maximum flexion under 130°, 2 of them under 115°.

The patients were reviewed 1 to 8 years (mean 42 months, median 40 months) after the injury. A total of 164 patients were re-examined by a surgeon not involved in the primary operations (JL), and 11 answered a questionnaire. Three patients had died and 14 could not be traced. The follow-up study thus came to include 91 per cent of the patients. The history was recorded

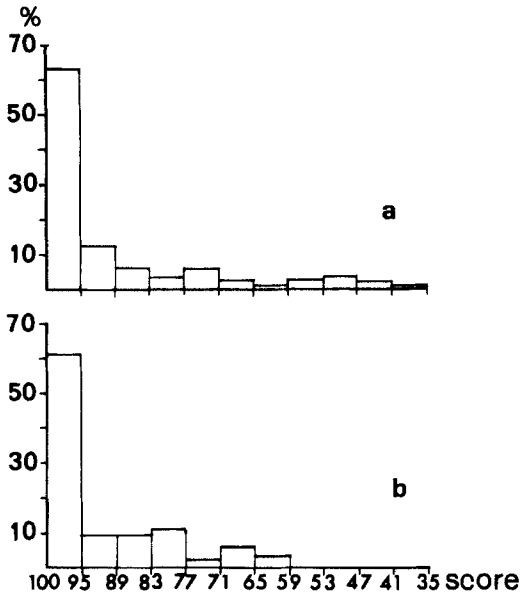

Figure 1. Distribution of scores among patients treated operatively (a; n=112) and non-operatively (b; n=51). Values are given as a percentage of the total number of patients. Patients assessed by questionnaire are not included.

using a knee scoring scale protocol (Lysholm & Gillquist, in press). The score consists of eight items: limp (5 points), support (5), muscle atrophy (5), instability (30), pain (30), swelling (10), stair climbing (10), and squatting (5). The maximum score is 100 points. Clinical examination of the joint was done by the AAOS technique and classification and was supplemented in 26 cases with symptoms of internal derangement by arthroscopy under local anaesthesia. The results were treated statistically by the usual methods (Snedecor & Cochran 1967) and by cross-tabulation using standard averages (Wallis & Roberts 1956).

RESULTS

The mean score at follow-up in 112 patients with total ligament tears treated by operation was 90.1±14.6 (Figure 1). One patient had to be excluded from the score evaluation as he was drunk at the time of the follow-up. The mean score in 51 patients treated non-operatively for minor injuries was 91.2±11.7 (Figure 1). There was no difference in score between conservatively treated patients immobilized in plaster (93.7±9.9) and those treated with early mobilization without weight-bearing (90.0±12.8).

Eleven patients who answered a questionnaire had a score of 79.6±19.8 (maximum score 95 points).

Eighty-four (48 per cent) patients noted excellent function (function equal or nearly equal to that in the normal leg), 58 (34 per cent) good (some but not incapacitating functional loss), 25 (14 per cent) acceptable (significant but acceptable functional loss), and 7 (4 per cent) poor (unacceptable impairment of function).

Ninety-five patients were active in athletics before the injury. There was a significantly lower incidence of return to athletics after treatment in patients complaining of instability than in pa-

Table 2. Return to sport after knee injury in patients taking part in athletics before the injury (n=95)

	Total	Active at follow-up	Given up total	Because of injury	Other reason
1. Free from symptoms	63	49 (78%)	14 (22%)	6	8
2. Slight and occasional pain	12	8	4	4	0
3. Pain more than above	6	4	2	1	1
2 + 3	18	12 (67%)	6 (33%)	5	1
4. Feeling of instability, pivot shift neg.	5	1	4	4	0
5. Feeling of instability, pivot shift pos.	9	1	8	7	1
4 + 5	14	2 (14%)	12 (86%)	11	1

Group 4 + 5 ≠ 1 (P <0.001) and ≠ 2 + 3 (P <0.005). Group 2 + 3 = group 1.

tients with no instability or in patients with pain but no instability ($P < 0.001$ and $P < 0.005$; Table 2). There was no difference in the incidence of return to sport between patients with pain and patients with no symptoms. Statistical analysis revealed that a number of factors determined the final result of treatment:

(i) Sex. The results in women (conservative treatment 84.6±7.0, operation 85.2±11.2) were worse than in men (96.0±7.0 and 93.2±11.2; $P < 0.001$ and $P < 0.005$).

(ii) Arthroscopy. The value of arthroscopy was studied in terms of the differences between the primary (at the injury) and the secondary (at the follow-up or re-operation) diagnosis. In most patients the primary and secondary diagnoses were the same, but in some a new secondary diagnosis was made depending on the history and findings at the follow-up examination. The difference between the primary and secondary diagnosis is shown in Figure 2. An incorrect primary diagnosis was almost nine times more common with clinical examination alone compared to clinical examination combined with arthroscopy (11/68 and 2/108; $P < 0.001$).

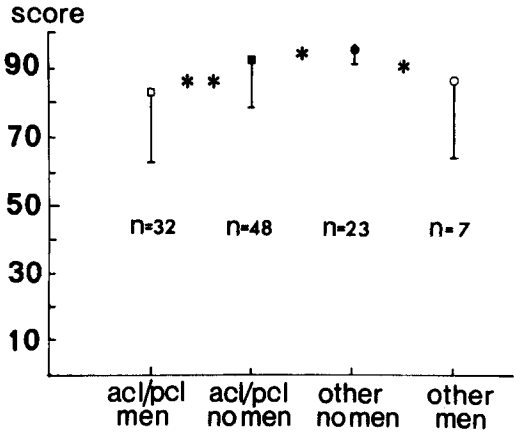

*Figure 3. Score (mean and standard deviation) in 100 cases operated on with or without medial meniscectomy. Patients with lateral meniscectomy are not included. Statistically significant differences are indicated**, $P < 0.01$; *, $P < 0.05$. Abbreviations: acl – anterior cruciate ligament; pcl – posterior cruciate ligament; men – medial meniscectomy; inj – injuries.*

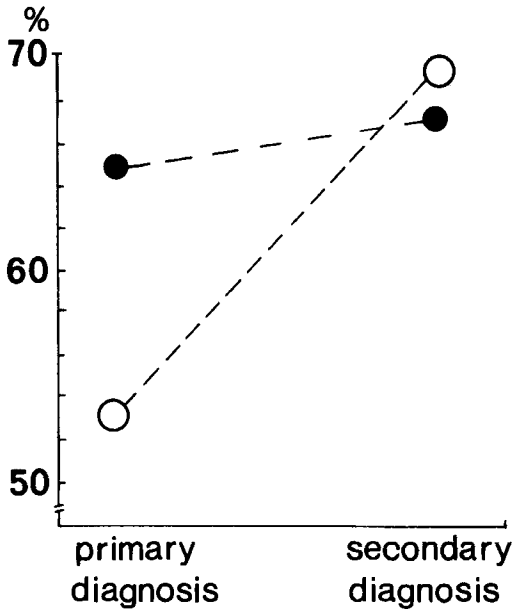

Figure 2. Differences between primary (at the injury) and secondary (at the follow-up) diagnoses of cruciate injury (per cent of total). In most patients the primary and the secondary diagnoses were the same but in some patients a new secondary diagnosis was made depending on symptoms and signs at the follow-up examination. ○---○ primary diagnosis was established by clinical examination; n=68. ●---●, primary diagnosis by clinical examination and arthroscopy; n=108.

The final result was better when arthroscopy was used in non-operatively treated patients (92.6±11.9 compared to 83.9±11.9; $P < 0.005$).

(iii) Medial meniscectomy. Patients who had undergone medial meniscectomy generally showed a worse result at follow-up than patients treated by operation without meniscectomy (score 84.3±11.2 and 94.3±11.2; respectively $P < 0.001$). Lateral meniscectomy (97.7±11.2) did not influence the result in this way. The results in comparable types of injury with and without medial meniscectomy are shown in Figure 3.

Anterior cruciate ligament (ACL; n=85). The mean score was 88.5±14.7. The score distribution is shown in Figure 4. Sixty-four patients with ACL injury noted no giving way of the knee (76 per cent). About half of the patients (11/20) with symptoms of instability noted giving way only during vigorous activity.

Sixteen showed a pivot shift sign on clinical examination (20 per cent; Table 3).

Table 3. Symptoms of instability and clinical findings at follow-up in patients with cruciate tears. The AAOS nomenclature was used.

	ACL, $n=85$	PCL, $n=21$
No symptoms or signs of instability	42 (49%)	6 (29%)
Symptoms of instability (questionnaire)	6	0
ALRI	16 (19%)	0
AMRI (+)	8	1
AMRI (++/+++)	3	1
Anterior drawer sign with the tibia in neutral position	9	2
Abduction or adduction instability in extension	1	1
SPI	0	10 (48%)

ACL – anterior cruciate ligament.
PCL – posterior cruciate ligament.
AMRI – antero-medial rotatory instability (anterior drawer sign in external rotation of the tibia).
ALRI – antero-lateral rotatory instability (pivot shift sign). All patients with pivot shift sign are given in this group, although the majority of them also showed antero-medial instability.
SPI – straight posterior instability (posterior drawer sign with the tibia in neutral position). No patient in this group showed more than + instability.

In 9 patients with tear of the ACL from the tibia with a bone fragment the result was generally good (Table 4). One third of the patients with a total substance tear of the ACL either needed a re-operation because of instability or had symptoms and signs of ACL insufficiency at follow-up (Table 4).

The results of primary reconstructions and re-operations are shown in Table 4. The mean score after re-operations was 63.0±23.3.

Among 30 patients with the primary diagnosis of partial tear of the ACL one patient required surgery later on because of persistent instability. In 3 patients there was a pivot shift sign at the follow-up examination and another 3 had symptoms of giving way without a pivot shift sign (Table 4). Of 7 patients with secondary symptoms and signs of ACL tear, the clinical examination suggested recurrent subluxation of the patella in one case. In another a subtotal-total tear of the ACL was treated conservatively. In the remaining 5 patients an incorrect primary assessment of the ACL was suggested by the findings at follow-up (5/30, 17 per cent). In 4 of these patients the primary diagnosis of partial ACL tear was made on arthroscopy.

Posterior cruciate ligament (PCL; n=21). The mean score for all patients with PCL tear was 89.3±17.4 (Figure 4). Three patients (14 per cent) had symptoms of giving way (Table 3), and another 3 complained of pain. Ten patients (47 per cent) had a 1+ posterior drawer sign on clinical examination (Table 3). The functional result was as a rule good in all kinds of PCL tear, and even in patients with PCL and ACL tears in combination if one cruciate was only partially torn (mean score 94.1±8.8). However there was one re-operation in this group; this patient had sustained further trauma. Four patients (score 43, 45, 89 and 100) had total tears of both cruciates. Two of them had symptoms of instability.

Table 4. Mean score and incidence of re-operation or symptoms and signs of instability at follow-up in patients with anterior cruciate tear (n=85)

	Type of rupture			
	Total			Partial
	Suture	Substance Reconstruction	Bone fragment	
n	40	6	9	30
reop (pivot shift at follow-up)	4 (3)	1	0	1
pivot shift	8	2	0	3
symptoms of instability (questionnaire)	2	0	1	3
score	88.8±14.0	82.2±19.4	89.8±11.0	93.3±11.0

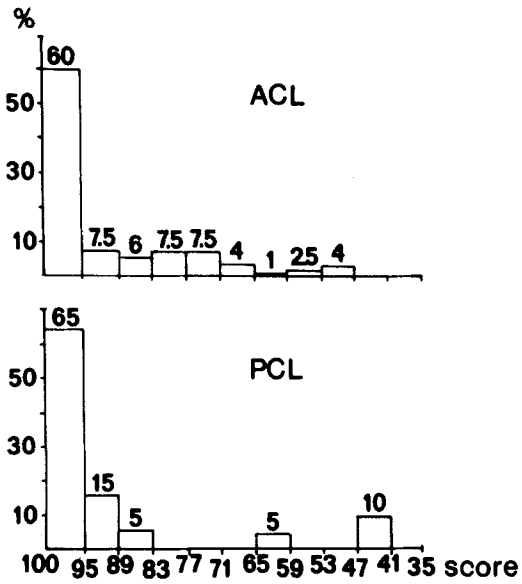

Figure 4. Distribution of scores in patients with tear of the anterior (ACL; n=80) or posterior cruciate ligament (PCL; n=20). Patients evaluated with a questionnaire are not included. Values are given as a percentage of the total number of patients.

Medial ligament complex (MED; n=53). The mean score in this group was 92.1±12.7. Ten patients (19 per cent) reported symptoms of giving way, 8 only during vigorous activity and 3 (6 per cent) showed a pivot shift sign on clinical examination (Figure 5). Symptoms and signs of instability were commoner in patients in whom the diagnosis of medial ligament tear was established without arthroscopy than in patients in whom arthroscopy was used (9/27 compared to 2/26; $P < 0.05$; Figure 5).

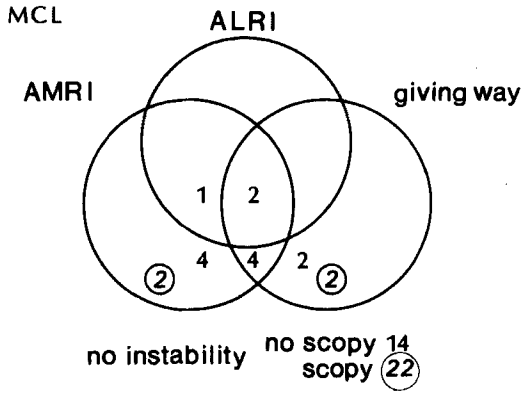

Figure 5. Frequency of various types of instability at follow-up in 27 cases of injury to the medial ligament complex (MCL) diagnosed without arthroscopy and in 26 cases diagnosed with arthroscopy (italic numbers). ALRI – antero-lateral rotatory instability; AMRI – antero-medial rotatory instability.

Lateral ligament and various other injuries (LAT; n=16). Five patients had lateral ligament tears without cruciate injury (mean score 95.8±4.0) and 11 had various other diagnoses (mean score 93.5±8.6), mostly tears of the plica lata (Gillquist et al. 1977). There was one re-operation, owing to an undiagnosed cruciate tear in a patient with the primary diagnosis of lateral collateral ligament injury, but this patient could not be traced at the time of follow-up.

Arthroscopy was done in 26 patients. As the strict indication was symptoms and signs of knee disorder, the mean score in these patients (79.9±16.8) was significantly lower than for the others in the study ($P < 0.01$). Nine patients were examined after repair of the ACL. At re-arthroscopy 2 ACL were classified as normal (one was a tear with a bone fragment), 5 were partially torn with laxity and disorganization of the fibres, and 2 were totally torn with atrophy.

Six out of 12 patients examined by arthroscopy after an isolated tear of the medial ligament complex showed signs of an old injury of the ACL, but in 4 of them the injury to the band was insignificant and was disregarded in the secondary diagnosis. In the remaining 5 patients with various other types of injuries arthroscopy did not reveal anything that had to be considered in the secondary diagnosis.

Patients with instability in extension of the knee at follow-up had a poor result (antero-lateral rotatory instability, $n=19$, 74.6±17.5, or abduction/adduction instability $n=2$, score 53 and 45) compared to patients with instability in flexion only (anterior drawer sign with the tibia in neutral position, $n=14$, 92.4±11.7, antero-medial rotatory instability, $n=23$, 91.6±13.1 and straight posterior instability, $n=10$, 96.0±3.7; $P < 0.001$; Figure 6).

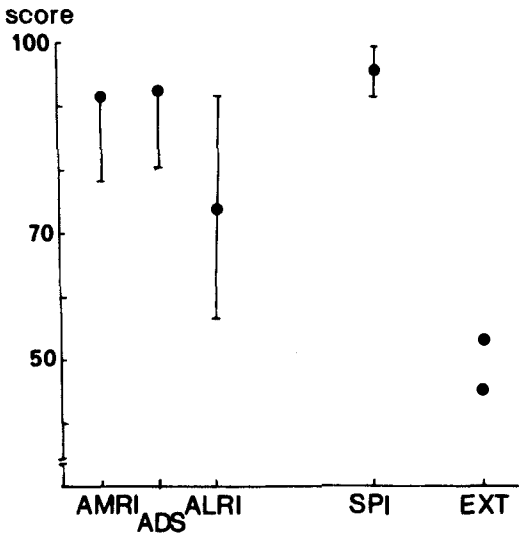

Figure 6. Score in different types of instability (mean and standard deviation). AMRI – antero-medial instability (anterior drawer sign in external rotation of the tibia; n=23). ADS – anterior drawer sign in neutral position of the tibia (n=14). ALRI – antero-lateral instability (pivot shift sign; n=19). SPI – straight posterior instability (posterior drawer sign in neutral position of the tibia; no patient showed instability exceeding +; n=10). EXT – abduction or adduction instability in extension (n=2).

The majority of patients with antero-lateral rotatory instability (15/19, 79 per cent) had symptoms of giving way. In patients with antero-medial rotatory or straight posterior instability and in patients with anterior drawer sign with the tibia in neutral position there were only a few who noted giving way (7/47, 15 per cent; $P < 0.001$).

DISCUSSION

"Complete diagnosis" and "early repair" have been given as conditions for a good result of knee ligament surgery (Palmer 1938, 1957, Abbot et al. 1955, O'Donoghue 1955, Solonen & Rokkanen 1967, Liljedahl & Nordstrand 1969, Jacobsen & Töndevold 1975). Both O'Donoghue (1955) and Liljedahl & Nordstrand (1969) have reported good results of early repair of acute ligament injuries to the knee. In our study most patients had a functional score of 90 per cent of normal or better, in the operated as well as the conservatively treated group. The ability to take part in sport after treatment was closely related to the stability of the injured joint. Symptoms of "giving way" and a positive pivot shift sign were generally incompatible with athletics. A slight or moderate instability of the flexed joint was common among our patients, but did not affect the functional result. Instability in extension (pivot shift or abduction/adduction instability) was less common, and was associated with a poor result.

The findings of Feagin & Curl (1976) in 64 cases of isolated ACL tear contrast with the results of O'Donoghue (1955) and Liljedahl & Nordstrand (1969) and the present study. Feagin & Curl found the results disappointing, with progressive disability in many patients. As most injured knees have compound injuries (Lysholm et al. 1981), an unsatisfactory result may be due to inaccuracy of diagnosis. It may be noted that we only found 1.5 per cent true isolated tears of the ACL. Nicholas (1976) suggested in a comment to the report by Feagin & Curl (1976) that the assessment of a full diagnosis might improve the result.

Missing and consequently not repairing a number of associated tears to other structures of the joint must adversely affect the late result of treatment. Even though it improves the diagnosis of tears to other structures of the joint (Lysholm et al. 1981), this is not the main value of arthroscopy in acute injuries to the knee. Most previous studies in this field have dealt with the results of *operative* treatment of ligament injuries. The indication for surgery has as a rule been settled at clinical examination under anasthesia. The addition of arthroscopy makes the selection of patients for operative or conservative treatment safer, as shown in this study by a lower incidence of errors in the primary diagnosis in the arthroscopy group. A number of missed ligament tears treated conservatively will not affect the result of operative treatment; this is not reflected in the studies by O'Donoghue (1955) or Liljedahl & Nordstrand (1969) or in any other study as far as we know.

When a full diagnosis is made before treatment it follows that there can be no indication for immobilization in plaster in the non-operative

treatment of knee injuries. The results of non-operative treatment in this study were the same with or without immobilization. Smillie (1978) asserts that enclosing of a recently injured knee in a cast without a confirmed diagnosis is contraindicated.

We have repaired all substance tears of the ACL by Palmer's (1938) technique regardless of the site of injury and the condition of the band ends. However, in repairs more than 2 weeks after the injury, reconstruction was used in almost half the patients, as late suture of the ACL is commonly followed by re-rupture (Liljedahl & Nordstrand 1969). With this principle of treatment, suture of the ligament was found to have been successful in two-thirds of the patients at follow-up; one-third had symptoms and signs indicating a non-functioning ACL. A number of factors influence the healing of the ACL repair.

(i) The vascularity. Except for tears at the tibial insertion of the ligament, the vascular supply will be disrupted at injury (Alm et al. 1974, Clancy et al. 1979).

(ii) The tear of the ligament is not confined to the site of macroscopic injury (Noyes et al. 1974, Kennedy et al. 1976). In partial tears the band can show microscopic wide-spread derangement of fibres. In almost one-fifth of the patients with the primary diagnosis of partial tear of the ACL symptoms and signs of giving way were noted at follow-up. Arthroscopy is helpful in diagnosing partial tears of the ACL (Lysholm et al. 1981). To obtain maximum accuracy in the evaluation of the partial ACL tear at arthroscopy, we now use a probe to test the band. This was not done routinely in the beginning of the study, which may have contributed to the presence of secondary instabilities in this group.

(iii) A correct siting of the femoral insertion is important for the result (Gillquist et al. 1971, Alm et al. 1974).

(iv) The choice of suture material may also be important (O'Donoghue et al. 1971).

Primary repair of the PCL gave a good functional result, although a slight posterior drawer sign was frequently noted at follow-up. The same good results after early surgical repair of the PCL have recently been reported by Hughston et al. (1980) and Moore & Larson (1980). The problem with the acute tear of the PCL is, on the other hand, a diagnostic one. We have asserted that arthroscopy is helpful in the diagnosis of PCL injuries, and have found a high proportion of PCL injury in our patients (Lysholm & Gillquist 1981, Lysholm et al. 1981).

Patients treated by medial meniscectomy had a lower score than patients treated operatively without medial meniscectomy. The same observation was made by Oretorp et al. (1979). The importance of the medial meniscus for knee stability is well known (Wang & Walker 1974, Hsieh & Walker 1976). A common injury in medial compartment tears is avulsion of the meniscus from the capsule. Re-suture of the meniscus has been suggested in these cases (Hughston et al. 1976, Price & Allen 1978). Any injury to the posterior oblique ligament, either to its tibial or femoral parts, should be repaired to increase medial stability and to preserve the function of the posterior horn of the medial meniscus (Hughston & Eilers 1973).

- Diagnosis made by clinical examination and arthroscopy provides safer grounds for the selection of patients for operative or conservative treatment than does diagnosis based on clinical examination alone, even if undertaken under anaesthesia.
- Missing some component of the injury, and consequently not treating it properly is a major cause of poor results of therapy.
- In two-thirds of the patients with total substance tears of the ACL the functional result of early repair was good, with no signs of anterolateral rotatory instability and no symptoms of giving way.
- A careful evaluation of partial tears of the ACL before treatment is important to reduce the risk of secondary instability.
- Early repair of PCL gave a good functional result in most cases.
- There is no need for immobilization in plaster in the non-operative treatment of acute ligament injuries to the knee.
- Medial meniscectomy had an unfavourable effect on the result of ligament repair. The procedure should be avoided if possible.
- Mild or moderate instability in flexion was a

common finding at follow-up, but did not affect the functional result. The pivot shift sign and abduction/adduction instability in extension were highly correlated with a poor result.

ACKNOWLEDGEMENTS

The study was supported by grants from the research council of the Swedish Sports Association. Statistical advice given by E. K. Leander, Ph.D. is gratefully acknowledged.

REFERENCES

Abbot, L. C., Saunders, J. B., Bost, F. C. & Andersson, C. E. (1944) Injuries to the ligaments of the knee joint. *J. Bone Joint Surg.* **26**, 503–521.

Alm, A., Gillquist, J. & Strömberg, B. (1974) The medial third of the patellar ligament in reconstruction of the anterior cruciate ligament. *Acta Chir. Scand.,* Suppl. 445.

Alm, A. & Strömberg, B. (1974) Vascular anatomy of the patella tendon and cruciate ligaments. *Acta Chir. Scand.,* Suppl. 445.

Broström, L., Gillquist, J., Liljedahl, S.-O. & Lindwall, N. (1968) Behandling av invetererad ruptur av främre korsbandet. *Läkartidnigen* **65**, 4479–4487 (in Swedish).

Clancy, W. G., Rosenberg, T. D., Narechania, R. G. & Wisnefske, D. (1979) Anterior cruciate ligament reconstruction in primates and man – a biomechanical and micro-angiographic evaluation of patellar tendon substitution (Abstract). The International Sociery of the Knee, Lyon, France.

Ellison, A. E. (1979) Distal ilio-tibial band transfer for anterolateral rotatory instability of the knee. *J. Bone Joint Surg.* **61**-A, 330–337.

Feagin, J. A., Abbot, H. G. & Rokus, J. A. (1972) The isolated tear of the anterior cruciate ligament. *J. Bone Joint Surg.* **54**-A, 1340.

Feagin, J. A. & Curl, W. E. (1976) Isolated tear of the anterior cruciate ligament: 5-year follow-up study. *Am. J. Sports Med.* **4**, 95–100.

Gillquist, J., Liljedahl, S.-O. & Lindwall, H. (1971) Reconstruction for old rupture of the anterior cruciate ligament. *Injury* **2**, 271–278.

Gillquist, J. & Hagberg, G. (1976) A new modification of the technique of arthroscopy of the knee joint. *Acta Chir. Scand.* **142**, 123–130.

Gillquist, J., Hagberg, G. & Oretorp, N. (1977) Arthroscopy in acute injuries of the knee joint. *Acta Chir. Scand.* **48**, 190–196.

Gillquist, J., Hagberg, G. & Oretorp, N. (1979) Arthroscopic examination of the posteromedial compartment of the knee joint. *Int. Orthop.* **3**, 13–18.

Hsieh, H.-H. & Walker, P. (1976) Stabilizing mechanisms of the loaded and unloaded knee joint. *J. Bone Joint Surg.* **58**-A, 87–93.

Hughston, J. C. & Eilers, A. F. (1973) The role of the posterior oblique ligament in repairs of acute medial ligament tears of the knee. *J. Bone Joint Surg.* **55**-A, 923–940.

Hughston, J. C., Andrews, J. R., Cross, M. J. & Moschi, A. (1976) Classification of knee ligament instabilities, part 1. *J. Bone Joint Surg.* **58**-A, 159–172.

Hughston, J. C., Bowden, J. A., Andrews, J. R. & Norwood, L. A. (1980) Acute tears of the posterior cruciate ligament. *J. Bone Joint Surg.* **62**-A, 438–450.

Jacobsen, J. & Töndevold, E. (1975) Hemarthrosis of the knee. Emergency treatment, diagnosis and referral. *Ugeskr. Læger* **137**, 2759–2761 (in Danish).

Kennedy, J. C., Weinberg, W. & Wilson, A. S. (1974) The anatomy and function of the anterior cruciate ligament. *J. Bone Joint Surg.* **56**-A, 223–235.

Kennedy, J. C., Hawkins, R. J., Willis, R. B. & Danylchuk, K. D. (1976) Tension studies of human knee ligaments. *J. Bone Joint Surg.* **58**-A, 350–355.

Liljedahl, S.-O. & Nordstrand, A. (1969) Injuries to the ligaments of the knee. *Injury* **1**, 17–24.

Lysholm, J., Gillquist, J. & Liljedahl, S.-O. Arthroscopy in the early diagnosis of knee injuries. *Acta Orthop. Scand.* **52,** 111–118.

Lysholm, J. & Gillquist, J. Arthroscopic examination of the posterior cruciate ligament. *J. Bone Joint Surg.* (In press).

Lysholm, J. & Gillquist, J. The evaluation of knee ligament surgery with special emphasis on the use of a knee scoring scale. *Am. J. Sports Med.* (In press).

Moore, H. A. & Larsson, R. L. (1980) Posterior cruciate ligament injuries. Results of early surgical repair. *Am. J. Sports Med.* **8**, 68–78.

Müller, M. E., Allgöwer, M., Schneider, R. & Willenegger, H. (1979) *Manual of internal fixation of fractures.* Springer Verlag, Berlin, Heidelberg, New York.

Nicholas, J. A. (1976) Editorial comment. *Am. J. Sports Med.* **4**, 99–100.

Noyes, F. R., De Lucas, J. L. & Torvik, P. J. (1974) Biomechanics of anterior cruciate ligament failures. *J. Bone Joint Surg.* **56**-A, 236–253.

Noyes, F. R., Torvik, P. J., Hyde, W. B. & De Lucas, J. L. (1974) Biomechanics of ligament failures II. *J. Bone Joint Surg.* **56**-A, 1406–1418.

O'Donoghue, D. H. (1955) An analysis of end results of surgical treatment of major injuries to the ligaments of the knee. *J. Bone Joint Surg.* **37**-A, 1–13.

O'Donoghue, D. H., Frank, G. R., Jeter, G. L., Johnson, W., Zeiders, J. W. & Kenyon, R. (1971) Repair and reconstruction of the anterior cruciate ligament in dogs. *J. Bone Joint Surg.* **53**-A, 710–718.

Oretorp, N., Alm, A., Ekström, H. & Gillquist, J. (1978) Immediate effects of meniscectomy on the knee joint. The effect of tensile load on the joint ligaments in dogs. *Acta Orthop. Scand.* **49**, 407–414.

Oretorp, N., Gillquist, J. & Liljedahl, S.-O. (1979) Long term results of surgery for non-acute anteromedial rotatory instability of the knee. *Acta Orthop. Scand.* **50**, 329–336.

Palmer, I. (1938) On the injuries of the ligaments of the knee joint. *Acta Chir. Scand.*, Suppl. 53.

Palmer, I. (1957) Injuries to the cruciate ligaments as a surgical problem. *Wiederherstellungschir. Traumatol.* **4**, 181–196.

Price, C. T. & Allen, W. (1978) Ligament repair with preservation of the meniscus. *J. Bone Joint Surg.* **60**-A, 61–65.

Slocum, D. B. & Larson, R. L. (1968) Pes anserinus transplantation. *J. Bone Joint Surg.* **50**-A, 226–242.

Smillie, I. S. (1978) *Injuries of the knee joint.* 5th edition. Churchill Livingstone, Edinburgh, London and New York.

Snedecor, G. W. & Cochran, W. G. (1967) *Statistical methods.* Iowa State University Press, Iowa, USA.

Solonen, K. A. & Rokkanen, P. (1967) Operative treatment of torn ligaments in injuries to the knee joint. *Acta Orthop. Scand.* **38**, 67–80.

Wallis, W. A. & Roberts, H. V. (1956) *Statistics, a new approach.* The Free Press, New York, USA.

Wang, C. J. & Walker, P. S. (1974) Rotatory laxity of the human knee joint. *J. Bone Joint Surg.* **56**-A, 161–170.

Correspondence to: Jack Lysholm, M.D., Department of General Surgery, University Hospital, S.581 85 Linköping, Sweden.