Acute knee injuries : diagnostic & treatment management proposals

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ACUTE KNEE INJURIES

Diagnostic & Treatment Management Proposals

Proefschrift

ter verkrijging van de graad van Doctor aan de Universiteit
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het College van Dekanen in het openbaar te verdedigen op
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I. INTRODUCTION

1. General considerations

Humans belong to the only known species that is both plantigrade and functionally bipedal. The human knee is the result of nearly 400 million years of tetrapod evolution (Dye '87).

As stated by Feagin (Feagin '88) the knee is a "joint of necessity".

Therefore the knee is injured more frequently than any other joint in the human body, because it is part of a weight-bearing limb, and secondly, does not have the stability procured by the joint congruity of the hip and the ankle.

The aim of this work is to study some particular aspects of the pathology generated by knee injuries of the diagnosis of the latter, and to evaluate , if available, long term results of treatment of these lesions. This will be done through personal observations and literature reviews.

2. Rationale

A. Epidemiology

As orthopaedic surgeons we seem to be challenged by an epidemic of knee injuries. This could be related to social behavior, where recreational and sports activities, as well as work and traffic conditions put the knee at risk.

Numerous epidemiologic studies confirm these clinical impressions.

The incidence of knee (ligament) injuries in an Health Management Organisation of the San Diego (U.S.A.) area (population : 280.000 members) was studied by Miyasaka and Daniel. They reported 0.98 knee injuries/per 1.000 members/year (Miyasaka '91).

A Danish study performed by Niehlsen and Yde in Aarhus (population 250.000 inhabitants) reported 6 % of all injuries to involve the knee (Niehlsen and Yde '91), with 0.30 anterior cruciate ligament (ACL) and 0.70 meniscal injuries / 1.000 inhabitants.

In a study with special emphasis on patellar dislocation, Casteleyn and Handelberg reviewed acute knee injuries during a 15 month interval in one Emergency Department in the Brussels Belgium area. This revealed a similar incidence of 5.8 % knee injuries (Casteleyn '89).

Maffulli et al. have reported on (sports) injuries in Asia, with an incidence of knee injuries as high as 10.4 % in Japan, and 35 % in Hong Kong (Maffulli '96).

A prospective 8-year study of students' athletic activities in Hawaii revealed 36.3 injuries / 1000 participants / year.

41.2 % of the latter were knee injuries.

When related to sports participation, the risk of knee injuries and especially of ACL injuries seems indeed even much higher. Caraffa followed prospectively 600 soccer players in 40 semiprofessional and amateur teams during three soccer seasons. An incidence of 1.15 ACL injuries /team / year was recorded . A proprioceptive training could however reduce this incidence to 0.15 / team / year (Caraffa '96). Hewson reported 42 ACL injuries/ 1.000 players at risk/year in college football (Hewson '86), Levy 0.36 ACL injuries / 1000 exposures in women collegiate rugby players (Levy '97). FEAGIN and associates reported an

average of 1 ACL injury/day at a large ski area, which represented 1.2 ACL injury/1.000 skier/day (Feagin '87).

A prospective study of ski injuries between 1972 and 1984 showed a 60 % decrease in lower extremity injuries, but a 2.7 -fold increase in knee sprains (Johnson '91). Knee sprains related to ski increased from 3 % in 1972 to 20 % in 1994, with a proportion of severe knee sprains increasing from 17 % to 70 % (Ettlinger '95). Another study comparing ski injuries occurring during the 1981- 1982 and the 1993 - 1994 seasons reported an 89 % decrease of tibial fractures, but a 280 % increase of ACL injuries (Deibert '98). Although diagnostic procedures improved during this period, this factor can not explain such a huge increase.

This let some authors (Zarins '88, Bobic '92, Frank '97) to project figures of more than 100.000 ski-related ACL injuries / year in het U.S.A., or maybe 250.000 world-wide !

Anyhow, it is already estimated that between 60.000 and 75.000 surgical ACL reconstructions are done per year in the U.S.A. (Johnson '94, Frank '97).

B. Treatment controversies

Perhaps no other joint has received more attention than the knee. It has been a major focus of both basic sciences and clinical research. Numerous books have been written; numerous symposia have been held; innumerable scientific papers and reviews have been written and presented on this single joint.

So much information has been dispersed that knowledge has almost become a barrier to the furtherance of knowledge.

The first serious attempt to understand the problem of knee injuries was made by Palmer in his extensive monograph. He rationalized treatment and advised operative treatment (Palmer '38).

This trend towards operative treatment was further enhanced by reports of progressive joint degeneration due to chronic ligamentous pathology (Feagin '79, Noyes '83, Charnat'85, Kannus '87, Barrack '90, Daniel '94).

Recent review articles and editorials challenged however these views, and reemphasized the value of conservative treatment (Johnson '93, Gillquist '93, Lindstrand '95, Dandy '98).

Johnson concluded even that "there are relatively few hard facts concerning treatment outcome, so our statements can be considered only as opinions, with the probability that others will come with different conclusions than we provide here" (Johnson '95).

This uncertainty concerning treatment is to a large extent related to the absence of- in depth- knowledge of the "natural history" of knee injuries (Garrick '88). Many factors contribute to our lack of natural history outcome studies.

First of all , some injuries are unreported, or lost, at many points in the chain of events between the occurrence and the treatment of the injury. Each time a case is lost, the remaining group of "found" cases becomes less representative.

Secondly the severity range of the injury can bias the recruiting of cases, with more severe injuries presenting for treatment immediately. On the other hand the duration of symptoms and the recurrence of injuries can also push patients towards seeking medical assistance.

But the passage of time after the injury does not always result in continued disability or recurrent injuries. With time, the functional manifestations of injury could disappear.

Finally, in the absence of symptoms associated with activities of daily living (A.D.L.), the patients higher activity level will be the major determinant of perception of disability.

C. Patient populations

It becomes therefore clear that knee injuries have to be related to the concerned patient population (Heier '97, Noyes '97).

The epidemiologic data have already shown the role of sports and recreational activities, in the etiology of these injuries. Further high demand knee activities after the injury, will also have a different impact on the injured knee structures (Roos '95). The outcome of treatment has therefore to be weighted in function of patient activity levels.

But activity level is not the only factor on which patient populations have to be described. Age is also primordial, but this factor is also mostly related to physical activity, as the results of ACL treatment in middle-aged patients do not seem fairly different from those in younger ones (Briges '98, Plancher '98, Vianello '98) .

In children and adolescents the problem of ligamentous injuries, and in particular of the A.C.L., seems also quite peculiar. Once considered extremely rare, complete traumatic tears of the ACL in skeletally immature patients with open physes are now being diagnosed with increasing frequency (Micheli '97). Subsequent meniscal injuries develop in a significant number of these patients.

Non-operative treatment, primary surgical suture- with exception of bony avulsion lesions- and extra-articular stabilisation procedures have not been reported to restore dynamic knee stability or prevent further meniscal damage.

Concerning children and adolescents, surgical reconstructions of the ACL with drill holes and graft fixation through the physis still raise some

concern, although preliminary reports of limited patient series do not show growth disturbances (Stanitski '95, Shelbourne '96, Lo '97).

Gender also seems important, with reports of proportionally higher injury rates in women (Powers '79, Ferretti '92).

Female basket-ball players experienced four times as many ACL injuries as their male counterparts (Arendt '95) and female soccer players had twice the injury rate of their male counterparts (Bjorndal '97).

Although alterations in the ACL cellular metabolism caused by estrogen fluctuations have been demonstrated (Liu '97, Finerman '98), complications and results of ACL reconstructions are fairly similar in both sexes (Barber-Westin '97).

Many theories have been advanced to explain the increased rate of ACL injuries among women, including shoe-surface interface, joint laxity, muscle strength and function, joint anatomy and cyclical hormone effects (Arendt '97, Blecher '98, Rozz '98, Thomas '98).

The presence of androgen receptors in the ACL, suggests that male sex hormones may have an effect on the structure and composition of the ligament (Hamlet '97)

ARENDT EA, DICK R

Knee injury patters among men and women in collegiate basketball and soccer. NCAA Data and review of literature.

Am. J. Sports Med. 23 : 694 - 701, 1995

ARENDT EA

Anterior cruciate ligament injuries in women.

Sports Med. Arthroscopy Rev. 5 : 149 - 155, 1997

BARBER - WESTIN SD, NOYES FR, ANDREWS M

A rigorous comparison between the sexes results and complications after anterior cruciate ligament reconstruction.

Am. J. Sports Med. 25 : 514 - 526, 1997

BARRACK RL , BRUCKNER JD, KNEISL J

INMAN WS, ALEXANDER AH

The outcome of nonoperatively treated complete tears of the anterior cruciate ligament in young adults.

Clin. Orthop. 259 : 192-199, 1990

BEACHY G, AKAU CK, MARTINSON M, OLDERR TF

High school sports injuries. A longitudinal study at Punahou school : 1988 to 1996.

Am. J. Sports Med. 25 : 675 - 681, 1997

BJORDAL JM, ARNØY, HANNESTAD B, STRAND T

Epidemiology of anterior cruciate ligament injuries in soccer.

Am. J. Sports Med. 25 : 341 - 345, 1997

BLECHER AW, RICHMOND JC

Transient laxity of an anterior cruciate ligament-reconstructed knee related to pregnancy. A case report.

Arthroscopy 14 : 77 - 79, 1998

BOBIC V

Current concepts in anterior cruciate ligament reconstruction.

Surgery 10 : 241-247, 1992

BRIGGS KK, PLANCHER KD, STEADMAN JR

ACL reconstruction in patients 40 years and older : long-term follow-up study.

Arthroscopy 14 : Suppl. 1 : 17, 1998

CARAFFA A, CERULI G, PROJETTI M., AISA G, RIZZO A

Prevention of anterior cruciate ligament injuries in soccer. A prospective control study of proprioceptive training.

Knee Surg. Sports Traumatol. Arthroscopy 4 : 19 - 21, 1996

CASTELEYN PP, HANDELBERG F

Arthroscopy in the diagnosis of occult dislocation of the patella.

Acta Orthop. Belg. 55 : 381-383, 1989

CHAMBAT P

Le ligament croisé antérieur,

In : Cahiers d'enseignement S.O.F.C.O.T.

Duparc J ed.

Expansion Scientifique Française, Paris p. 79-101, 1985.

DANDY DJ, HOBBY JL

Anterior cruciate ligament reconstruction.

J. Bone Joint Surg, 80B : 189 - 190, 1998

DANIEL DM, FITHIAN DL

Indications for ACL surgery.

Arthroscopy 10 : 432-441, 1994

DEIBERTMC, ARONSSON DD, JOHNSON RJ, ETLINGER CF, SHEALY JE

Skiing injuries in children, adolescents and adults.

J. Bone Joint Surg. 80A : 25 - 32, 1998

DYE SF

An evolutionary perspective of the knee.

J. Bone Joint Surg. 69A : 976-983, 1987

ETTLINGER CF, JOHNSON RJ, SHEALY JE

A method to help reduce the risk of serious knee sprains incurred in alpine skiing.

Am. J. Sports Med. 32 : 531-537, 1995

FEAGIN JA

The syndrome of the torn anterior cruciate ligament.

Orthop. Clin. North Am. 10 : 81-96, 1979

FEAGIN JA, LAMBERT KL, CUNNINGHAM RR;

Consideration of the ACL injury in skiing.

Clin. Orthop. 216 : 13-18, 1987

FEAGIN JA

The Knee : Joint of necessity,

In : The crucial ligaments.

Feagin JA ed .

Churchill Livingstone, New York , p. 398-400 ,1988.

FERRETTI A, PAPANDREA P, CONTEDECA F, MARIANI PP

Knee ligament injuries in volleyball players.

Am. J. Sports Med. 20 : 203-207, 1992

FINERMAN GA, HATCH JD, LIU SH, PANOSSIAN V, WARREN D

Estrogen affects the cellular metabolism of the human ACL : a potential explanation for female athletic injuries.

Arthroscopy 14 Suppl. 1: 35 - 36, 1998

FRANK CB, JACKSON DW

The science of reconstruction of the anterior cruciate ligament.

J. Bone Joint Surg. 79 A : 1556 - 1576, 1997

GARRICK JG

Epidemiology of the ACL

In : The crucial ligaments.

Feagin JA Ed.

Churchill Livingstone, New York p. 173-176, 1988

GILLQUIST J

Repair and reconstruction of the ACL : is it good enough ?

Arthroscopy 9 : 68-71, 1993

HAMLET WP, LIU SH, PANOSSIAN V, FINERMAN GA

Primary immunolocalization of androgen target cells in the human anterior cruciate ligament.

J. Orthop. Res. 15 : 657 - 663, 1997

HEIER KA, MACK DR, MOSELEY JB, PAINE R, BOCELL JR

An analysis of anterior cruciate ligament reconstruction in middle-aged patients.

Am. J. Sports Med. 25 : 527 - 532, 1997

HEWSON GF, MENDINI RA, WANG JR

Prophylactic knee bracing in college football.

Am. J. Sports Med. 14 : 262 - 266, 1986

JOHNSON RJ, POPE MH

Epidemiology and prevention of skiing injuries.

Ann. Chir. Gyn. 80 : 110-115, 1991

JOHNSON RJ, BEYNNON BD, NICHOLS CS, RENSTRÖM PA

The treatment of the injuries of the ACL

J. Bone Joint Surg. 74A : 140-151, 1992

JOHNSON RJ

Revision ACL surgery

In : Knee surgery.

Fu F, Harner CD, Vince KG ed.

Williams and Wilkins, Baltimore, p. 877-895, 1994

KANNUS P, JÄRVINEN M

Conservatively treated tears of the anterior cruciate ligament : long term results.

J. Bone Joint Surg. 69A : 1007-1012, 1987

LEVY AS, WETZLER MJ, LEWARS M, LAUGHLIN W

Knee injuries in women collegiate rugby players.

Am. J. Sports Med. 25 : 360 - 362, 1997

LINDSTRAND A

The ACL problem.

Acta Orthop Scand 66 : 105-106, 1995.

LO IK, KIRKLEY A, FOWLER PJ, MINIACI A

The outcome of operatively treated anterior cruciate ligament disruptions in the skeletally immature child.

Arthroscopy 13 : 627 - 634, 1997

LIU SH, AL-SHAikh RA, PANOSSIAN V, FINERMAN GA, LANE JM

Estrogen affects the cellular metabolism of the anterior cruciate ligament. A potential explanation for female athletic injury.

Am. J. Sports Med. 25 : 704 - 709, 1997

MAFFULI N, CHAN KM, MIAO M, FU FH, KUROSAKA M

Athletic knee injuries. Similarities and differences between Asian and Western experience.

Clin. Orthop. 323 : 98 - 105, 1996.

MICHELI LJ, COADY C

Anterior cruciate ligament reconstruction in the pediatric age group.

Sports Med. Arthroscopy Rev. 5 : 106 - 111, 1997

MIYASAKA KC, DANIEL DM, STONE ML, HIRSHAM P

The incidence of knee ligament injuries in the general population.

Am. J. Knee Surg. 4 : 3-8, 1991.

NIEHLSSEN AB, YDE J

Epidemiology of acute knee injuries : a prospective hospital investigation.

J. Trauma 31 : 1644-1648, 1991

NOYES FR, MOOAR PA, MATTHEWS, PS, BUTLER DL

The symptomatic ACL deficient knee.

J. Bone Joint Surg. 65A : 154-162, 1983

NOYES FR, BARBER-WESTIN SD

A comparison of results of arthroscopic-assisted anterior cruciate ligament reconstruction between workers compensation and noncompensation patients.

Arthroscopy 13 : 474 - 484, 1997

PALMER I

Injuries of the ligaments of the knee joints. A clinical study.

Acta Orthop. Scand. 53, Suppl. 81 : 1 - 282, 1938

PLANCHER KD, STEADMAN JR, BRIGGS KK, HUTTON KS

Reconstruction of the anterior cruciate ligament in patients who are at least forty years old.

J. Bone and Joint, Surg. 80A : 184 - 197, 1998

POWERS JA

Characteristic features of injuries of the knee in women.

Clin. Orthop. 143 : 120-124, 1979.

ROOS H, ORNELL M, GÄRDSSEN P, LOGMARDER LS, LINDSTRAND A

Soccer after ACL injury : an incompatible combination ?

A national survey of incidence and risk factors and a 7 years follow up of 310 players.

Acta Orthop. Scand. 66 : 107-112, 1995

ROZZI SL, LEPHART SM, GEAR WS, FU FH

Knee joint laxity and neuromuscular characteristics of male and female soccer and basketball players.

Proceedings AOSSM Specialty Day, New Orleans, p. 33, 1998

SHELBOURNE KD, PATEL DV, MC CARROLL JR

Management of ACL injuries in the skeletally immature adolescents.
Knee Surg. Sports Traumatol. Arthroscopy 4 : 68-74, 1996

STANITSKI CL

ACL injuries in the skeletally immature patient : diagnosis and treatment.
J. Am . Acad. Orthop. Surg. 3 : 146-158, 1995

THOMAS R, CASCIO B, FEAGIN JA

The influence of the menstrual cycle on ACL laxity.
Poceedings AOSSM Speciality Day, New Orleans, p. 32, 1998

VIANELLO R, RENATO V, RIGON A, MARZANO N

Intra-articular ACL reconstruction in the over 40-year-old patient.
Arthroscopy 14, Suppl. I, p. 47, 1998.

II. Own Studies

1. Epidemiology of knee injuries

A. Traumatic haemarthrosis of the knee

B. Arthroscopy in the diagnosis of occult dislocation of the patella

TRAUMATIC HAEMARTHROSIS OF THE KNEE

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We have investigated a prospective series of 100 acute traumatic haemarthroses of the knee in a general non-athletic population. All the patients had normal radiographs and an aspiration which confirmed the haemarthrosis, before undergoing ligament testing and an arthroscopic examination under anaesthesia. Only one patient had no serious pathology; in the other 99 a total of 193 lesions were recorded. Thirty knees had only one isolated lesion, 69 had combined lesions. This study confirms the serious nature of an acute traumatic haemarthrosis of the knee, even in non-athletic patients.

Haemarthrosis of the knee, without gross joint injury, has, in the past, often been considered benign (Jones 1946); this opinion was based on clinical and radiological examination. Recent arthroscopic studies, however, have reported a very high number of articular lesions in such cases (Gillquist, Hagberg 1977; DeHaven 1980; Noyes, Bassett et al. 1983). These findings might, of course, be atypical since patients were almost exclusively young athletes injured in sports accidents and clinical studies of less than 100 patients seemed to confirm the benign nature of haemarthroses (Jain, Swanson and Murdoch 1983). In order to clarify this controversy that we decided to perform a consecutive, prospective arthroscopic study in a general patient population.

PATIENTS AND METHODS

The material of this study consisted of a consecutive series of 100 patients with haemarthrosis of the knee who were treated at the emergency department of our hospital. They met the following criteria: early onset of knee pain, following a recent acute injury; confirmation of haemarthrosis by aspiration; exclusion of gross joint injury or patellar dislocation by routine clinical examination; and exclusion of fractures or osteochondral lesions by radiographs, including skyline views or arthrograms if necessary. The series had a broad age range (12 to 61 years) although it mostly concerned young individuals, with a

mean age of 24 years (Fig. 1). The sex ratio was predominantly male (80 to 20).

The causal injuries were diverse, but falls and other accidents at home (26 patients), as well as hobbies and recreational activities (54 patients) dominated; only 14 were traffic accidents and six were accidents at work. Most were low energy injuries. There were no high level athletes in the sports trauma group, since these were mostly referred direct to our orthopaedic department and are therefore not included in this study.

All the patients in our series were further evaluated by clinical examination under general or epidural anaesthesia, followed by arthroscopy; the delay between trauma and this examination was kept as short as possible, in order to avoid secondary lesions (Fig. 2). The arthroscopies, which represented about 10% of all the arthroscopic examinations carried out in our orthopaedic department during the same period, were performed by only two surgeons (PPC and FH). A standard set-up was used, with large-bore high flow irrigation, but no pump. A tourniquet and leg holder were used in most cases. Probing was always done, and the posterior cruciate ligament was visualised with a 70° arthroscope. The arthroscopic criteria for the diagnosis of a collateral ligament injury were a blood infusion in the medial or lateral gutter, and abnormally easy opening of the medial or lateral compartment.

Statistical evaluation of the data was performed by Student's *t*-test and the chi-square test.

RESULTS

No complications could be attributed to the examinations under general or epidural anaesthesia, or to the arthroscopies; and there were no statistically significant differences in the mean age, or sex ratio between the different trauma groups.

Clinical examination under anaesthesia revealed anterior cruciate ligament injuries in 67 cases, posterior cruciate ligament injuries in nine, and collateral ligament

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TRAUMATIC HAEMARTHROSIS OF THE KNEE

Fig. 1

Age distribution of 100 patients with an acute haemarthrosis of the knee.

Table I. Lesions found at arthroscopy in the different trauma groups

	Recreational	Home	Work	Traffic	Total
Anterior cruciate	45	17	4	9	75
Posterior cruciate	-	1	-	10	11
Collateral	15	6	-	4	25
Menisci	31	8	3	9	51
Capsular	5	3	4	6	18
Chondral	4	6	-	3	13
Total	100	41	11	41	193

Fig. 2

Delay between trauma and arthroscopy.

Fig. 3

Isolated lesions found in 30 cases.

Fig. 4

Combined, multiple lesions found in 69 cases. MEN, meniscal; ACL, anterior cruciate ligament; PCL, posterior cruciate ligament.

Fig. 5

Venn diagram of the most frequently encountered combined lesions of ACL, menisci and collateral ligaments.

injuries in 23. The most consistently positive test for anterior cruciate lesions was the Lachman sign (63 cases). The anterior drawer sign at 90° of flexion (38 cases) and the pivot shift sign (16 cases) showed lower sensitivity.

The arthroscopic technique used permitted complete visualisation of all compartments of the knee. In only one case was no important intra-articular lesion found. In the other 99 a total of 193 lesions were recorded; 30 knees presented only one isolated lesion, 69 presented multiple or combined lesions (Figs 3, 4, and 5).

Only a few statistically significant correlations were found (Table I). Almost all the posterior cruciate lesions (10 out of 11) were caused by traffic accidents, and none were sports-related. Anterior cruciate injuries, isolated or combined, were statistically more frequent in sports injuries ($p < 0.005$), and chondral lesions were predominantly non-sports related ($p < 0.005$).

The diverse nature of the injuries made precise information about the mechanism unreliable. A popping noise was mentioned by only 21 patients: 20 with anterior cruciate ligament injuries (of which there were 75 in all) and one with a meniscal injury (of which there were 51).

DISCUSSION

Although 54 of the 100 haemarthroses in this study followed recreational activities, it is important to stress that no high level athletes were included. The population studied was a broad mix of patients of different ages, with diverse types of accident, typical of those seen in a general trauma centre; this cannot be compared with the young athletic population seen in specialised sports centres. Nevertheless, our results show almost exactly the same number and distribution of intra-articular lesions as those reported from such centres.

In our study anterior cruciate lesions were somewhat more frequent in sports injuries, while posterior cruciate lesions seemed to require higher energy trauma as in traffic accidents. The low incidence of chondral injuries, compared with previous series, can be explained by our exclusion of all patients with radiologically visible lesions.

We also found that clinical examination, even when

performed under anaesthesia, still underestimated the extent and the number of lesions found at arthroscopy. The combination of all our clinical tests successfully diagnosed only 89% of the anterior and 82% of the posterior cruciate lesions found arthroscopically. We have the impression that the pivot shift sign can be masked in acute injuries by soft-tissue effusion and joint distension; this could explain its low frequency in our hands.

The importance of a correct diagnosis in patients with a haemarthrosis of the knee has been emphasised in various studies (Noyes, Paulos et al. 1980; Mariani, Puddu and Ferretti 1981). These have demonstrated that undiagnosed and untreated knee injuries have a poor outcome, and Smillie (1978) has stated that: "... there are few worse errors than to enclose a recently injured knee in a plaster cast without a diagnosis ...".

Our results do not imply that each lesion found arthroscopically needs to be treated surgically. We believe that in a general patient population there is a definite place for conservative management of knee injuries and that treatment needs to be tailored to the requirements of each individual patient.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES

- DeHaven KE. Diagnosis of acute knee injuries with hemarthrosis. *Am J Sports Med* 1980;8:9-14.
- Gillquist J, Hagberg G, Oretop N. Arthroscopy in acute injuries of the knee joint. *Acta Orthop Scand* 1977;48:190-6.
- Jain AS, Swanson AJG, Murdoch G. Hemarthrosis of the knee joint. *Injury* 1983;15:178-81.
- Mariani PP, Puddu P, Ferretti A. Hemarthrosis treated by aspiration and casting: how to condemn the knee. *Am J Sports Med* 1982;10:343-5.
- Noyes FR, Bassett RW, Grood ES, Butler DL. Arthroscopy in acute traumatic hemarthrosis of the knee: incidence of anterior cruciate tears and other injuries. *J Bone Joint Surg [Am]* 1980;62-A:687-95.
- Noyes FR, Paulos L, Mooss LA, Signer B. Knee sprains and acute knee hemarthrosis: misdiagnosis of anterior cruciate ligament tears. *Phys Ther* 1980;60(12):1596-1601.
- Smillie IS. *Injuries of the knee joint*. 5th ed. Edinburgh etc: Churchill Livingstone, 1978:69.
- Watson-Jones R. *Fractures and joint injuries*. 3rd ed. Edinburgh: E & S Livingstone Ltd, 1946:702.

ARTHROSCOPY IN THE DIAGNOSIS OF OCCULT DISLOCATION OF THE PATELLA

by P.P. CASTELEYN and F. HANDELBERG*

The authors investigated the incidence of acute patellar dislocation by clinical and radiologic examination and by arthroscopy. Acute patellar dislocation represented 2.44% of all knee injuries in their series, and only 25% of the former were evident at the initial examination.

Keywords: arthroscopy; dislocation; patella.
Mots-clés: arthroscopie; luxation; rotule.

RESUME

P.P. CASTELEYN et F. HANDELBERG - Intérêt de l'arthroscopie dans le diagnostic des luxations occultes de la rotule.

Les auteurs ont recherché l'incidence de la luxation aiguë de la rotule par l'étude clinique, radiologique et arthroscopique.

La luxation aiguë de la rotule représente 2,44% de l'ensemble des lésions traumatiques du genou. Seulement 25% des luxations sont évidentes lors du premier examen.

SAMENVATTING

*P.P. CASTELEYN en F. HANDELBERG
Arthroscopie bij de diagnose van occulte patellaluxatie.*

De auteurs onderzochten de incidentie van acute patellaluxatie door middel van klinisch onderzoek, radiologie en arthroscopie.

De acute patellaluxatie zou 2,44% van alle knietraumata vertegenwoordigen. Slechts 25% van deze luxaties kan bij het eerste onderzoek waargenomen worden.

INTRODUCTION

The diagnosis of patellar subluxation is probably as much overused as the diagnosis of chondromalacia patellae.

The statistics of the Hughston Orthopaedic clinic reveal that of 1200 patients in which the former

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diagnosis was evoked only 708 cases could be substantiated as symptomatic patellar subluxation or dislocation, either acute or chronic (3).

Furthermore, the relationship between subluxation and dislocation is at best not clear. Patellar subluxation is usually associated with certain morphological or biomechanical predisposing factors.

On the other hand, does patellar dislocation occur in normal or in pathological knees? Does acute patellar dislocation predispose to recurrent patellar subluxation and dislocation? (2).

These questions cannot be solved because the real incidence of acute patellar dislocation is obscure, owing to the different patterns of presentation of this traumatic entity. Some patients are seen with the patella still dislocated laterally. Others show an acutely swollen and painful knee, with a clear history of patellar luxation and immediate reduction. A vast number of patients complain later on and can only remember an acute knee injury, for which no clear diagnosis was established (1).

MATERIALS AND METHODS

We postulated that an occult dislocation of the patella could only occur with a rupture of the medial retinaculum patellae and/or of the vastus medialis obliquus muscle. This would lead to some form of hemarthrosis.

Since it is a policy of our department to perform arthroscopy on all knees presenting with an acute hemarthrosis, all occult patellar dislocations would therefore be found in this group.

The charts of all arthroscopies performed during a 15-month time interval (January 1986 to March 1987) were reviewed.

The cases with a fresh rupture or hematoma of the medial patellar retinaculum were examined in detail, and their clinical records, radiographs, and video-tapes were studied.

RESULTS

During the time interval studied (15 months), 984 acute knee injuries were seen in our Department of Orthopedics and Traumatology.

Only 5 presented a persistently dislocated patella or had an undisputable history of acute patellar dislocation.

The 269 arthroscopic procedures revealed a total of 19 occult dislocations. The diagnosis of patellar dislocation had not been evoked before arthroscopy on the basis of history, clinical or radiological examination in the latter cases.

Most of the cases of occult dislocation had a similar clinical pattern, consisting of indirect knee trauma, mild acute hemarthrosis and painful functional impairment (especially in flexion and valgus stress), without any ligamentous laxity.

It is noteworthy that associated traumatic chondral lesions of the lateral condyle and of the medial patellar facet were also seen in cases with only a hematoma of the medial retinaculum.

The retrospective review of the radiographs detected only some minor osteochondral lesions of the patella and/or the femoral condyles on skyline views. AP and lateral views were always normal (4).

The follow-up of all 24 dislocations, during a 1- to 2-year period, did not show any evidence of further subluxation or dislocation of the patella.

DISCUSSION - CONCLUSION

This study shows that 2.44 acute dislocations of the patella can be expected for each 100 knee injuries.

Only about 25% of these dislocations are apparent on the first examination, or show clear clinical or radiological signs of a reduced acute dislocation.

Relying on our epidemiologic data, one can expect to see 7 occult dislocations for each 100 arthroscopies performed for acute knee injuries.

Our limited series and follow-up does not allow any conclusions to be drawn concerning the relationship between acute dislocation and recurrent subluxation and dislocation. This study confirms the necessity to perform arthroscopy on every patient with acute knee trauma presenting with hemarthrosis, and in whom no clear diagnosis can be made by clinical and/or radiological examination.

Only the combination of clinical and radiologic examination and arthroscopy can provide a precise evaluation of the incidence of acute patellar luxation.

REFERENCES

1. BORING T.H., O'DONOGHUE D.H. Acute patellar dislocation. *Clin. Orthop.*, 1978, 136, 182-185.
2. FICAT R.P., HUNGERFORD D.S. *Disorders of the patello-femoral joint*. Ed. Masson, Paris, 1977.
3. HUGHSTON J.C., WALSH W.M., PUDDU G.C. *Patellar subluxation and dislocation*. Ed. WB Saunders, Philadelphia, 1984.
4. TEN THIJE J.H., FRIMA A.J. Patellar dislocation and osteochondral fractures. *Neth. J. Surg.*, 1986, 38, 150-153.

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2. Diagnostic procedures

- A. CT arthrography and MRI of the patella
- B. Chondral lesions of the patella evaluated with computed tomography, magnetic resonance imaging and arthroscopy
- C. IRM du cartilage . Comparaison IRM -arthroscopie -
à propos de 320 cas

CT ARTHROGRAPHY AND MRI OF THE PATELLA

by F. HANDELBERG*, M. SHAHABPOUR**, F. VAN BETTEN*,
C. PIERRE JEROME**, P.P. CASTELEYN* and P. OPDECAM*

The importance of CT scanning in the diagnosis of patello-femoral disorders is reviewed and illustrated. CT double-contrast technique is compared to Magnetic Resonance Imaging (MRI) using both clinical examples and a cadaver study. The authors demonstrate the superiority of MRI to CT in detecting retropatellar cartilage lesions.

Keywords : knee ; CT double-contrast technique ; magnetic resonance imaging ; retropatellar cartilage ; chondromalacia.

Mots-clés : genou ; arthro-scanner ; imagerie par résonance magnétique ; cartilage rotulien ; chondromalacie.

RESUME

F. HANDELBERG, M. SHAHABPOUR, F. VAN BETTEN, C. PIERRE JEROME, P.P. CASTELEYN et P. OPDECAM - *Arthro-scanner et NMR de la rotule.*

L'importance de la tomographie computerisée dans le diagnostic des dérangements fémoro-patellaires est résumée et illustrée. La technique de l'arthro-scanner est comparée à la Résonance Magnétique (IRM) à l'aide d'exemples cliniques et

d'une étude sur cadavres.

Les auteurs démontrent la nette supériorité de sur l'arthro-scanner dans l'évaluation du cartil实现.

SAMENVATTING

F. HANDELBERG, M. SHAHABPOUR, VAN BETTEN, C. PIERRE JEROME, CASTELEYN en P. OPDECAM - *Arthrographie en MRI van de patella.*

Het belang van de CT scan in de diagnose femoropatellair lijden wordt samengevat geïllustreerd.

De CT dubbelcontrast techniek wordt vergeleken met de Magnetische Resonantie (MR) door middel van zowel klinische voorbeelden, als aan de hand van een kadaverstudie.

De auteurs tonen het duidelijk overwicht van MRI ter evaluatie van het retropatellair kraakbeen aan.

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INTRODUCTION

In the early nineteen-eighties, the first publications appeared concerning CT scanning of the knee joint. At that time radiologists and orthopedic surgeons of our hospital were already deeply involved in the study of patellar disorders (1, 2).

Our colleagues concluded that measurements of the sulcus angle according to Ficat were inaccurate on CT, as different angles were found on different slices. They also found that using Wiberg's classification of the patellar shape on CT, 50% of the patellae did not correspond to the type described in the axial roentgenogram. Wiberg's classification was thus not reliable on CT.

A more useful contribution of CT to the study of the knee was visualization of the retropatellar cartilage using double-contrast technique. Various authors (3, 4, 5, 6, 7, 12, 14) have studied the congruity indicating that the cartilage exactly follows the contour of the patella, the regularity of the contour of the cartilage, the uptake of contrast material in the case of fissures and ulcerations, and the measurement of the thickness of the cartilage. All this is done without the superpositions obtained with axial arthrograms.

Figure 1 shows the right knee of a 25-year-old female investigated with double-contrast technique. It demonstrates slight erosive lesions of the lateral facet of the patellar cartilage. Figure 2 shows her left knee, where a lateral subluxation appears clearly. Besides moderate sclerosis of the subchondral bone, no evident pathology of the cartilage is seen. As this patient complained of bilateral anterior knee pain, a release of the lateral retinaculum was performed on both sides with excellent results.

In the last few years, magnetic resonance imaging (MRI) has provided a revolutionary technique for the investigation of human joints. The advantages of this method include absence of ionizing radiation

FIG. 1.- Right knee : slight erosive lesions of the lateral facet of the patella

FIG. 2.- Left knee : lateral subluxation of the patella. Moderate subchondral sclerosis

and multiplanar imaging capability without any manipulation of the knee. The excellent soft tissue contrast allows the delineation of the different structures (fig. 3) : the medullary bone appears white, owing to its high content of fat (high signal intensity) ; the cortical bone has a low signal

intensity and appears dark ; the articular cartilage has an intermediate signal intensity and is very well delineated ; and the cruciate ligaments, quadriceps

and patellar tendons are clearly seen, as well as fat and muscles surrounding the bony structures.

FIG. 3. - T1-weighted MR image in the sagittal plane. - • Medullary bone (1), cortical bone (2), retro-patellar cartilage (arrows). - • PCL (3), quadriceps tendon (4), patellar tendon (5).

There are no studies on the use of MRI in the diagnosis of recurrent dislocation, but its value in the evaluation of the retropatellar cartilage is indisputable (15, 16, 17).

In figure 4, an early stage of chondromalacia is detected as a round area of low signal intensity within the cartilage (sagittal T2-weighted image). Without the use of contrast material, MRI is also

capable of demonstrating ulcerations in the cartilage. The surrounding synovial fluid appears bright on the T2-weighted image, clearly delineates the cartilage and penetrates within the ulceration (fig. 5).

On the double-contrast CT scan of the right knee of a 36-year-old man complaining of anterior knee pain, no clear cartilaginous lesion was seen (fig. 6).

← FIG. 4.- Sagittal MR image (T2-weighted).
Early stage of chondromalacia (arrow).

FIG. 5.- MR image in the axial plane (T2-weighted). - Ulceration in the retropatellar cartilage

FIG. 6.- Double-contrast CT-scan of the right knee.
No clear cartilaginous lesions

FIG. 7.- MR image in the axial plane, both knees. Right fissure of the lateral facet. Left : ulceration.

An MRI axial view of the same knee, 3-mm thick, shows a fissure of high signal intensity on the lateral facet. A more severe ulceration is also seen on the opposite side (fig. 7). The diagnosis of chondromalacia was confirmed arthroscopically in this case.

A few authors have already published their findings concerning cartilage defects (9, 10, 15, 16). They studied and compared artificially induced lesions on cadaver knees, as well as arthroscopically confirmed lesions in patients. It appeared that MRI was capable of detecting most of the lesions equal to or larger than 4 mm in width and 3 mm in depth. To detect defects as small as 2 mm, Gylys-Morin used intra-articular Gadolinium DTPA as contrast material in a cadaveric study (10). Until now, there is no published study comparing MRI and CT double-contrast technique. Our purpose is to compare the findings of the two methods.

MATERIALS AND METHODS

On fresh cadaver knees, drill holes of different size and depth were surgically placed. The width of the drill holes ranged from 0.8 mm to 5 mm with different depths, 1 and 2 mm.

After closure of the knee, first MRI then arthroscopic examinations with contrast injection were performed.

RESULTS

Lesions of 1.5 and 2 mm could be detected on MRI by using a high-resolution program and 2-mm thick slices only after a second attempt (fig. 8); 0.8 mm holes were not recognized.

FIG. 9.- MRI : Axial view showing the two large defects on the medial facet (5 and 3 mm) (a, c).
The upper contiguous slice shows the three smaller defects (from medial to lateral
respectively 2, 1.5 and 0.8 mm) (b, d).

FIG. 8.- CT double-contrast study of a cadaver knee. 1.5- and 2-mm drill holes.

Without injection of contrast material, T1-weighted MR-images showed three small dark lesions surrounded by high-signal areas (respectively 0.8, 1.5 and 2 mm) (fig. 9 a-b). On corresponding T2-weighted images the lesions appeared as small superficial defects (fig. 9 c-d). On the same slices two large defects were visualized. These lesions were precisely delineated by intraarticular fluid, appearing bright on T2-weighting. Therefore MRI allowed easy detection of all the lesions that were surgically created.

CONCLUSION

Until now, the comparative advantages of CT and MRI regarding the alignment of the patella have not been demonstrated.

Computed tomography following arthrography appears to be a relatively invasive but valuable tool in the assessment of retropatellar cartilage, but this

diagnostic modality appears less advantageous than MRI.

Early chondral lesions, as well as associated abnormalities of the menisci, ligaments, tendons, are easily detected on MRI without exposing the patient to ionizing radiation. Moreover, the development of new techniques such as spin-echo sequences, is improving the evaluation of articular cartilage.

We consider the 3-dimensional analysis, using an image processing system and rapid imaging techniques, to be the best method. It allows reconstruction in every plane from a volume of 1 mm thick slices.

Despite the current limitations, such as cost and availability of the apparatus, we believe that CT will become the method of choice in the investigation of knee-joint pathology.

REFERENCES

1. BOVEN F., BELLEMANS M.A., GEURTSBACH P., POTVLIEGE R. A comparative study of the patello-femoral joint on axial roentgenogram, arthrograph, and computed tomography following arthrography. *Skel. Radiol.*, 1982, 8, 183-185.
2. BOVEN F., DE BOECK M., LEEMANS W., POTVLIEGE R. Computed tomography of the patello-femoral joint in double contrast. *J. belge Radiol.*, 1983, 70, 429-435.
3. CROSBY EB., INSALL I. Recurrent dislocation of the patella. *J. Bone Joint Surg.*, 1976, 58-A, 9-13.
4. DELGADO-MARTINS N. A study of the position of the patella using computerized tomography. *J. Bone Joint Surg.*, 1979, 61-B, 443-444.
5. DOWD G., BENTLEY G. Radiographic assessment of patellar instability and chondromalacia patellae. *J. Bone Joint Surg.*, 1986, 68-B, 297-300.
6. IHARA H. Double-contrast CT arthrography of the patellofemoral joint. *Clin. Orthop.*, 1985, 198, 50-55.

- INSALL J., FALVO K., WISE D. Chondromalacia patellae. *J. Bone Joint Surg.*, 1976, 58-A, 1-8.
- JACKSON D., JENNINGS L., MAYWOOD R., BERGER P. Magnetic resonance imaging of the knee. *Am. J. Sports Med.*, 1988, 16, 29-37.
- HAJEK P., BAKER L., SARTORIS D., NEUMANN C., RESNICK D. MR Arthrography : Anatomic-pathologic investigation. *Radiology*, 1987, 163, 141-147.
- GYLYS-MORIN V., HAJEK P., SARTORIS D., RESNICK D. Articular cartilage defects. Detectability in cadaver knees with MR. *Am. J. Radiol.*, 1987, 148, 1153-1157.
- MANSAT C., BONNEL F., JAEGER I. *L'appareil extenseur du genou*. Ed. Masson, Paris 1985.
- MERCHANT A., MERCER R., JACOBSEN R., COOL C. Roentgenographic analysis of patellofemoral congruence. *J. Bone Joint Surg.*, 1974, 56-A, 1391-1396.
- MINK J., REICHER M., CRUES J., FOX J. *MRI of the knee*. Ed. Raven Press, New York, 1987.
- LAURIN C., LEVESQUE H., DUSSAULT R., LABELLE H., PEIDES J. The abnormal lateral patellofemoral angle. *J. Bone Joint Surg.*, 1978, 60-A, 55-60.
15. SHAHABPOUR M., OSTEAX M. In : Sintzoff S., Osteaux M. *Imagerie du genou*. Ed. Masson, Paris, 1989.
16. WOJTYK E., WILSON M., BUCKWALTER K., BRAUNSTEIN E., MARTEL W. Magnetic resonance imaging of knee hyaline cartilage and intraarticular pathology. *Am. J. Sports Med.*, 1987, 15, 455-463.
17. YULISH B., MONTANEZ J., GOODFELLOW D., BRYAN P., MULOPULOS G., MODIC M. Chondromalacia patellae : Assessment with MR Imaging. *Radiology*, 1987, 164, 763-766.

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Chondral Lesions of the Patella Evaluated with Computed Tomography, Magnetic Resonance Imaging, and Arthroscopy

Frank Handelberg, M.D., Maryam Shahabpour, M.D., and Pierre-Paul Casteleyn, M.D.

Summary: In a small series of cadaver knees, experimentally created lesions of the patellar cartilage were compared using contrast computed tomography (CT) and magnetic resonance (MR) imaging. Contrast CT was able to recognize only 50% of the lesions smaller than 3-mm diameter at the first attempt, and none of the lesions of 0.8 mm. MR imaging detected all the lesions, even those as small as 0.8 mm, without use of contrast material. Simultaneously, a prospective clinical study comparing MR diagnoses of chondral lesions with arthroscopic findings was initiated in a series of 54 knees. This clinical study revealed that, concerning patellar chondral lesions, the accuracy of MR imaging compared with arthroscopy (the gold standard) was 81.5%. The sensitivity was 100%, but the specificity only 50% due to the false positives. Reexamination of the MR records enabled us to refine the MR diagnosis and to propose a staging of the chondral lesions. The high rate of false-positive results in our series can be explained by the hypothesis that MR imaging can possibly detect very early lesions, which appear as abnormalities in the deep cartilage layers. **Key Words:** Contrast computed tomography—Magnetic resonance imaging—Patellar cartilage.

In the early 1980s, papers were published on computed tomography (CT) scanning of the knee joint. Using the double-contrast technique, the patellar cartilage could be clearly visualized. Various authors have studied the congruity and alignment, the regularity of the contour, the penetration of contrast material in fissures and ulcerations, and the thickness of the cartilage (1-6). All this could be assessed without having superpositions as in arthrograms, and without knee flexion.

For a few years, magnetic resonance (MR) imaging has appeared as a revolutionary technique in the investigation of human joints. The advantages of

this method include absence of ionizing radiation and use of contrast material, and multiplanar imaging capabilities without any manipulation of the knee. The excellent soft-tissue contrast allows the delineation of meniscal and ligamentous structures.

On the other hand, only a few authors reported findings concerning cartilage defects (7-12). Wojtys et al. studied lesions created on the patella and condyles of cadaver knees, as well as arthroscopically confirmed lesions in patients (13). Their study revealed that MR imaging was able to detect most of the lesions ≥ 4 mm in width and 3 mm in depth.

To detect small 2-mm defects, Gylys-Morin et al. used intraarticular gadolinium-diethylenetriamine pentaacetic acid as contrast material in a cadaveric study (14). They concluded that intraarticular fluid is necessary for the delineation of focal defects.

To date, we have found no published study comparing MR imaging and the CT double-contrast

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technique. We decided to correlate both methods in a small series of cadaver knees.

Simultaneously, a prospective clinical study was initiated in which MR diagnoses of chondral lesions were compared with arthroscopic findings.

MATERIAL AND METHODS

Experimental Study

On fresh cadaver knees, drill holes of different sizes and depths were surgically performed. The diameter of the drill holes ranged from 0.8 to 5 mm and the depth from 1 to 2 mm. The knees were completely removed, with hermetically closed joint capsules, leaving a few milliliters of saline in the joint, simulating normal synovial fluid.

MR imaging without contrast injection, followed by CT examination with contrast injection, were performed. MR signals were generated by a 1.5-T magnet (Magnetom, Siemens, Erlangen, Germany), using T2 spin-echo pulse sequences with 3-mm-thick contiguous slices (TR = 2,500 ms, TE = 22 and/or 80 ms). CT was performed using the double-contrast technique and a high-resolution program with a Somatom DRG (Siemens). The scans were taken using x-rays of 125 kV and 45 mA amperes; the slice width was 2 mm with an increment of 2 mm; exposure time was 5 s.

CT and MR images were then analyzed and compared, each by a single observer who knew the presence of the lesions, but not their number and exact location on the patella.

Clinical Study

A series of 53 young patients (representing 54 knees) presenting with knee pain without clear clinical diagnosis was examined with MR before undergoing arthroscopy. Most of the patients complained of diffuse knee pain, but neither history nor clinical examination was clearly indicative of meniscal or chondral lesion. Although the examiners had a strong clinical impression of organic knee pathology, this pathology did not, in their opinion, require an immediate arthroscopy. The age range was 12–66 years with a mean age of 33 years. There were 30 men and 23 women (sex ratio—3:2). In all patients T2 spin-echo pulse sequences were used in the sagittal plane (3-mm-thick contiguous slices, TR = 2,100 ms, TE = 22 and/or 80 ms). We completed the examination by an axial view with T2 pulse sequence (FISP) was performed in the sagittal plane (1-mm-thick slices, TR = 30 ms, TE = 10 ms, flip

angle = 40°) in the 16 other cases; this pulse sequence allowed axial and coronal reconstructions.

The validity of the correlation was based on a complete arthroscopic examination, with probing of all the intraarticular elements.

The classification of Ficat and Hungerford was used to describe the chondral lesions (15). The results of the MR examinations were known by the surgeons before arthroscopies, which were performed by the authors in 44 cases, and by skilled arthroscopists of the Brussels area in the 10 other cases.

RESULTS

The cadaver study showed that large lesions of 3- and 5-mm diameter were easily seen on contrast CT, but 50% of the 1.5 and 2 mm lesions were missed on a first examination. All the 1.5- and 2-mm lesions could be detected only after a second attempt. The 0.8-mm holes were not recognized at all.

In contrast, MR imaging without contrast allowed easy detection of all experimentally created lesions, even the smallest. Figure 1 shows a T2-weighted image showing three small superficial defects that measured 0.8, 1.5, and 2 mm, respectively. On the contiguous slice, two larger defects of 3 and 5 mm are visualized on the medial facet (Fig. 2). These lesions are precisely delineated by intraarticular fluid appearing bright on T2.

Looking at the results of the clinical study, on a total of 54 knees, lesions of the patellar cartilage were reported on 44 MR examinations. Only 34 of

FIG. 1. T2-weighted axial image of a cadaver knee (TR = 2,500 ms, TE = 80 ms). Three small lesions (arrowheads) are seen on the lateral facet of the patella. They measure, respectively, from medial to lateral, 2, 1.5, and 0.8 mm in diameter.

FIG. 2. T2-weighted image of a slice contiguous to that shown in Fig. 1. Two larger defects (5 and 3 mm, respectively) are seen on the medial facet of the patella.

these 44 knees presented corresponding lesions at arthroscopy. In the remaining 10 knees, no chondral lesion or softening of the cartilage was found.

Compared with this arthroscopic standard, the accuracy of MR was 81.5%, the sensitivity 100%, and the specificity only 50% due to the false positives. The positive predictive value was 77.3%, the negative predictive value was 100% (Table 1). Staging of these lesions with MR imaging was more difficult. Among the 34 cases with exact correlation, the staging was exact in 26 of them (76.5%); 2 were overrated by MR (5.8%) whereas 6 were underrated (17.6%).

When we examined other than patellar lesions, 13 condylar and 5 tibial lesions were seen on MR images, whereas 11 and 4 were respectively found at arthroscopy. Three condylar and one tibial lesions were missed by MR imaging. Thus, for other than patellar cartilage lesions, the accuracy of MR imag-

ing was 87%, the sensitivity 78.9%, and the specificity 91.4%. The positive predictive value was slightly better: 83.3%, and the negative predictive value was still good: 88.8%. False negatives, on the other hand, represented 21.1% (Table 1).

DISCUSSION

Comparison of our data with those of other series in the literature was not easy, because the only recent article correlating MRI with arthroscopic chondral findings took into account the diagnoses of rheumatoid and degenerative arthritis, and diffuse changes of the knee joint, including joint effusion and synovial alterations (16).

In our study we reexamined the MR records of cases showing a discrepancy between MR and arthroscopic diagnosis. Although the reported accuracy rates only concern the results of the first MR interpretation, this second look allowed our radiologist to refine the MR diagnosis and to propose the following MR staging of the chondral lesions.

1. Stage I lesions, described as softening while probing during arthroscopy or as small fibrillations, are usually seen on "proton density" and T2 MR images as round areas of low signal intensity within the cartilage (Fig. 3).

2. Stage II lesions, corresponding to fissures in

FIG. 3. Stage I lesion: T1-weighted image of a T2 sequence (sagittal plane, TR = 2,100 ms, TE = 22 ms). A round area of low signal intensity is seen within the substance of the patellar cartilage corresponding to a softening lesion ("chondromalacia") at arthroscopy.

TABLE 1. Magnetic resonance imaging versus arthroscopy in chondral lesions

	Patella	Other cartilage lesions
Accuracy	81.5%	87%
Sensitivity	100%	78.9%
Specificity	50%	91.4%
Pos. predictive value	77.3%	83.3%
Neg. predictive value	100%	88.8%

4A,B

FIG. 4. These T2-weighted axial slices show the patellar cartilage outlined by joint fluid of high signal intensity. (TR = 2,500 ms, TE = 80 ms). A: A superficial fissuration is seen on the first section (arrow). This is a stage II lesion. B: On the adjacent slice, a deep ulceration is indicated by the large white arrow (stage III lesion). In the cartilage of the medial facet, there is a thin defect with a small flap lesion (black arrow). Note the low-signal area of subchondral sclerosis (small white arrows) on the lateral facet.

5A,B

FIG. 5. A: Stage IV lesion (sagittal section, TR = 2,200 ms, TE = 22 ms). Thinning of the patellar cartilage and inhomogeneity of signal intensity (arrows) in a degenerative knee. B: This normal and intact patellar cartilage (arrows) exemplifies the lesion seen in (A). T1-weighted image (sagittal plane, TR = 800 ms, TE = 15 ms).

FIG. 6. Stage 0 lesion: compared with the gray signal intensity of the normal superficial layers of the cartilage, the deep zones show a linear decreased signal intensity on this sagittal proton density image (arrows) (TR = 2,100 ms, TE = 22 ms).

which synovial fluid can penetrate, and sometimes with associated flap lesions, often appear as zones of low signal surrounded by high signal within the cartilage on T2 images (Fig. 4A).

3. Stage III lesions are easily recognized. Superficial or deep defects of the cartilage surface filled by synovial fluid appear bright (high signal intensity) on T2-weighted images (Fig. 4B).

4. Thinning and irregularity of the contour of the cartilage are easily diagnosed in degenerative arthritis (stage IV) (Fig. 5A).

Regarding the false positives, we now believe that MR imaging can possibly detect very early lesions as abnormalities in the deep cartilage layers. They appear as linear, dark areas in the gray signal of the cartilage. They could represent "stage 0" lesions (Fig. 6).

These abnormalities were described in our series on 10 MR examinations and were not found at arthroscopy, in which not even a mild softening was detected. It is clear that if these findings reflect true early lesions, and not artifacts, the accuracy and especially the specificity of MR imaging of patellar lesions should be considered higher than in our statistics. Nevertheless, these images could also be regarded as representing a variation of normal. Further studies that correlate histologic with MR findings need to be performed.

Concerning femoral and tibial cartilage lesions, correlation of MR imaging and arthroscopy was

clearly better in our series (Table 1). Actually, interpretation of tibiofemoral cartilage with spin-echo sequences is disturbed by the "chemical shift" artifact. Fast three-dimensional sequences are less sensitive to this artifact. Nevertheless, the lower sensitivity percentage of other than patellar chondral lesions in this study can be explained by the fact that a three-dimensional acquisition was performed in less than one-third of the cases.

CONCLUSIONS

CT with contrast is a valuable but relatively invasive tool in the assessment of patellar cartilage, but appears less reliable than MR imaging in lesions smaller than 3 mm.

Compared with arthroscopy, MR imaging has a sensitivity of 100% and a relatively high accuracy of 81.5% in evaluating patellar cartilage. It allows staging of chondral lesions and might detect very early intracartilaginous lesions not diagnosed at arthroscopy.

The development of new MR techniques such as fast sequences with three-dimensional analysis is greatly improving the evaluation of cartilage, especially tibial and femoral, because the "chemical shift" artifact is decreased.

REFERENCES

1. Boven F, Bellemans MA, Geurts I, Potvliege R. A comparative study of the patello-femoral joint on axial roentgenogram, axial arthrogram, and computed tomography following arthrography. *Skeletal Radiol* 1982;8:183-5.
2. Boven F, De Boeck M, Leemans J, Potvliege R. Computed tomography of the knee joint in double contrast. *J Belg Radiol* 1983;66:429-35.
3. Crosby EB, Insall J. Recurrent dislocation of the patella. *J Bone Joint Surg [Am]* 1976;58:9-13.
4. Delgado-Martins N. A study of the position of the patella using computerized tomography. *J Bone Joint Surg [Br]* 1979; 61:443-4.
5. Dowd G, Bentley G. Radiographic assessment in patellar instability and chondromalacia patellae. *J Bone Joint Surg [Br]* 1986;68:297-300.
6. Ihara H. Double-contrast CT arthrography of the cartilage of the patellofemoral joint. *Clin Orthop* 1985;198:50-5.
7. Jackson D, Jennings L, Maywood R, Berger P. Magnetic resonance imaging of the knee. *Am J Sports Med* 1988;16: 29-37.
8. Hajek P, Baker L, Sartoris D, Neumann C, Resnick D. MR arthrography: Anatomic-pathologic investigation. *Radiology* 1987;163:141-7.
9. Mansat CH, Bonnel F, Jaeger L. *L'appareil extenseur du genou*. Paris: Masson, 1985.

PATELLAR LESIONS STUDIED BY CT, MR, ARTHROSCOPY

10. Mink JH, Reicher MA, Crues JV III, Fox JM. *Magnetic resonance imaging of the knee*. New York: Raven Press, 1987.
11. Shahabpour M, Osteaux M. In: Sintzoff S, Osteaux M, eds. *Imagerie du genou. Imagerie par resonance magnetique*. Paris: Masson, 1989:94-123.
12. Yulish B, Montanez J, Goodfellow D, Bryan P, Mulopulos G, Modic M. Chondromalacia patellae: assessment with MR imaging. *Radiology* 1987;164:763-6.
13. Wojtys E, Wilson M, Buckwalter K, Brunstein E, Martel W. Magnetic resonance imaging of knee hyaline cartilage and intraarticular pathology. *Am J Sports Med* 1987;15:455-63.
14. Gyllys-Morin V, Hajek P, Sartoris D, Resnick D. Articular cartilage defects. Detectability in cadaver knees with MR. *AJR* 1987;148:1153-7.
15. Ficat RP, Hungerford DS. *Disorders of the patello-femoral joint, Chondrosis and Arthrosis*, chp. 12, pp. 194-232. Baltimore: Williams & Wilkins, 1977.
16. Konig H, Aicher KP. MRI evaluations of cartilage and meniscal disorders of the knee: a comparison with ultrasound scintigraphy and CT. *Hospimedica* 1988;6:49-59.

IRM DU CARTILAGE COMPARAISON IRM ARTHROSCOPIE, à propos de 320 cas

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Si l'IRM permet de visualiser directement le cartilage de manière non invasive, ses performances diagnostiques sont encore très controversées en ce qui concerne la détection précoce de lésions cartilagineuses patello-trochléennes et surtout fémoro-tibiales.

Le problème principal provient de l'absence de consensus sur la ou les séquences d'acquisition optimale(s) à utiliser.

De nombreuses études cliniques (2-5, 6-7, 9-11, 13-14, 16, 18-20, 23-24) et expérimentales sur cadavres (1, 12, 15, 17, 21, 22) ont été effectuées durant ces 10 dernières années. Ces études portent sur un nombre limité de cas et utilisent des techniques différentes (séquences écho de spin T1, T2, T2 rapide, T1 avec injection intraveineuse ou intraarticulaire de contraste, écho de gradient avec acquisition 3D (GRASS, spoiled-GRASS avec suppression de la graisse...), séquences avec transfert de magnétisation,...)

Depuis avril 1987, nous avons effectué plus de 10000 examens IRM de genoux, en utilisant de façon systématique, des séquences écho de spin T2 classiques puis ultérieurement rapides (avec coupes de densité protonique) dans les 3 plans de l'espace, complétées dans certains cas par des séquences écho de gradient avec acquisition 3D FISP ou DESS (GRASS) pondérées T2* et FLASH (spoiled-GRASS SPGR) avec suppression du signal de la graisse, pondérées T1.

L'étude suivante a pour objectifs de déterminer prospectivement la précision diagnostique des séquences écho de spin T2 dans la détection des lésions cartilagineuses patello-trochléennes et fémoro-tibiales et de rechercher (rétrospectivement) des signes IRM permettant de mieux caractériser les différents stades arthroscopiques (I à IV selon la classification de FICAT).

MATERIELS ET METHODES

320 examens IRM ont été prospectivement corrélés aux résultats de l'arthroscopie.

Les patients (205 hommes, 115 femmes) d'âge moyen de 34 ans avec des extrêmes allant de 16 à 72 ans présentaient tous un syndrome de dérangement interne du genou.

L'examen IRM est réalisé de façon systématique en coupes sagittales écho de spin T2 et en coupes coronales et axiales écho de spin T2 (classique puis ultérieurement rapide, à deux échos), sur un appareil Siemens avec un champ magnétique de 1.5 ou de 1 Tesla.

Pour l'écho de spin T2 classique, le temps de répétition est de 2400 msec, les temps d'écho de respectivement 20 et 80 msec ; pour l'écho de spin T2 rapide, le temps de répétition est de 4700 msec et les temps d'écho de respectivement 20 et 95 msec, l'épaisseur des coupes étant de 3 mm dans tous les cas. Les images sont réalisées avec un champ de vue moyen de 180 mm pour les coupes sagittales et de 200 pour les coupes axiales et une matrice moyenne de 256 sur 160 points avec une seule acquisition.

L'examen est toujours interprété par le même radiologue sur écran et sur film, avec comparaison systématique des coupes de densité protonique (premier écho) et des coupes pondérées T2. L'intervalle maximum entre l'IRM et l'arthroscopie est de deux mois.

L'arthroscopie a été effectuée par deux orthopédistes spécialistes du genou et systématiquement illustrée par un schéma indiquant le stade et la localisation exacte des lésions. (Schéma 1)

Schéma I

TR : trochlée

FA : condyle fémoral antérieur

FM : condyle fémoral moyen

FP : condyle fémoral postérieur

TI : plateau tibial

R : rotule

(D : distal ; M : moyen ; P : proximal)

CR : crête rotulienne

EXT : externe

INT : interne

Les chirurgiens étaient au courant du diagnostic IRM et de la localisation des lésions décrites; ceci était inévitable puisque l'IRM était réalisée dans le but de préciser un diagnostic clinique incertain.

Nous avons utilisé la classification IRM de Yulish (24), un peu modifiée :

■ **Stade I** : épaissement focal du cartilage avec hyposignal en T2 (1er et 2e)

a

b

Figure 1

Chondromalacie rotulienne de stade I (à l'arthroscopie).

Sur les coupes sagittales écho de spin T2 (a : 2400/20; b : 2400/70), le cartilage rotulien apparaît épaissi et de signal hétérogène (légèrement augmenté) au niveau des 2 facettes et de la crête rotulienne (flèches épaisses). Le cartilage trochléen paraît aussi pathologique (signal hétérogène, contours irréguliers) sur les coupes de résonance magnétique (flèches fines); cela n'a pas été décrit à l'arthroscopie, mais celle-ci a été effectuée 2 mois après l'IRM.

échos) ou zones focales de signal anormal. (Figures 1, 2, 3)

■ **Stade II** : irrégularité discrète du contour cartilagineux avec parfois visualisation d'une fissure, gonflement cartilagineux (ou parfois amincissement) et signal hétérogène en T2 (1er et 2e échos). (Figures 4, 5, 6)

■ **Stade III** : défaut cartilagineux superficiel (avec pénétration de liquide synovial); fragmentation profonde, apparence "en chair de crabe", amincissement substantiel. (Figures 5, 7, 8)

■ **Stade IV** : défaut cartilagineux profond avec visualisation de l'os sous-chondral; anomalies du signal de l'os sous-chondral. (Figures 9, 10)

La classification arthroscopique est basée sur celle de FICAT (8) : stade I : chondropathie fermée (surface cartilagineuse

Figure 2

Chondropathie tibiale externe de stade I (à l'arthroscopie)

La coupe sagittale T2, premier écho (2400/20) montre un cartilage tibial épaissi et de signal hétérogène avec des zones hypointenses (têtes de flèches); aspect irrégulier du contour cortical postérieur du plateau tibial externe (flèches).

a

b

c

Figure 3

Chondropathie de stade I du condyle fémoral interne et du plateau tibial interne (à l'arthroscopie).

L'atteinte fémorale est suspectée sur les coupes sagittale (a) et coronale (b) sous forme d'un épaississement focal du cartilage et de l'os sous-chondral (têtes de flèche), de signal faible en densité protonique (a : 2 400/20; b : 4 700/19). Par contre, la lésion tibiale n'a pas été décrite prospectivement sur les coupes IRM; de discrètes hétérogénéités de signal sont décelées à posteriori (c, petites flèches). Présence d'un flap horizontal au niveau des cornes postérieure et moyenne du ménisque interne (b, flèche).

Figure 4

Chondropathie rotulienne de stade II (à l'arthroscopie).

La coupe sagittale pondérée T2 (2 400/70) montre des petites irrégularités de surface au niveau de la facette rotulienne interne près de la crête (têtes de flèches)

Figure 5

Fissure cartilagineuse profonde au niveau de la facette rotulienne externe chez une secrétaire de 32 ans présentant une douleur antérieure depuis 2 ans et cliniquement suspecte de chondropathie rotulienne.

Hypersignal linéaire sur les deux échos de la séquence T2 rapide (a : 4 700/16, b : 4 700/98) obtenue dans le plan axial (flèche).

Amincissement cartilagineux au niveau de la crête rotulienne (têtes de flèche).

Dysplasie rotulienne associée de type Wiberg II.

intacte) avec œdème et ramollissement cartilagineux au palpeur; stade II : chondropathie fissuraire; stade III : chondropathie ulcéraire superficielle, stade IV : chondropathie ulcéraire profonde avec mise à nu de l'os sous-chondral.

RESULTATS

Sur les rapports arthroscopiques, 692 sites sont décrits comme normaux; 588 lésions de stade I à IV sont mises en évidence au niveau des différents sites (Tableau II).

Des lésions chondrales de stade I sont détectées au niveau de 33 rotules, 9 trochlées, 76 condyles fémoraux et 71 plateaux tibiaux. Des lésions de stade II sont décrites au niveau de 112 rotules, 4 trochlées, 144 condyles fémoraux, 101 plateaux tibiaux. Lorsque des lésions de

stade II et III coexistent au niveau du même site, nous ne prenons en considération que le stade le plus avancé pour la classification.

L'arthroscopie a révélé 38 défauts cartilagineux (III-IV) ou zones d'amincissement significatif. Des lésions de stade III sont détectées au niveau de 8 rotules, 5 trochlées, 8 condyles fémoraux et 7 plateaux tibiaux. Des lésions de stade IV sont présentes au niveau de 2 rotules, 1 trochlée, 3 condyles fémoraux et 4 plateaux tibiaux.

La sensibilité, la spécificité et la précision des coupes sagittales couplées aux coupes axiales, pour la détection et la stadification des lésions décrites à l'arthroscopie, est déterminée (Tableaux III à VI).

La sensibilité de l'IRM est la fréquence des lésions détectées par l'IRM chez les patients effectivement porteurs de lésions. Elle est calculée pour chaque

a

b

c

Figure 6
Fissure cartilagineuse rotulienne post-traumatique (chondropathie fissuraire ouverte) avec hypersignal linéaire parallèle à l'os sous-chondral (flèches) et prolongement transversal (tête de flèche noire), de signal intense en T2 (b : 2400/80). Sur la coupe de densité protonique (a : 2400/20), présence de zones arrondies de signal faible autour de la zone fissuraire (têtes de flèche blanches). Sur la coupe axiale fine (2 mm d'épaisseur) réalisée en séquence écho de gradient pondérée T1 avec acquisition 3D et suppression de la graisse (c : 60/10/60°), la fissure n'est pas visible ; on ne décèle qu'une discrète hétérogénéité du signal intracartilagineux et de petites irrégularités de contour.

stade de chondropathie en utilisant le nombre de sites avec le stade décrit et confirmé par l'arthroscopie. Elle est de 100 % pour les lésions patello-trochléennes de stade III et IV (avec 3 vrais positifs pour le stade IV, 13 vrais positifs pour le stade III). Elle est de 89.6 % pour les lésions patello-trochléennes de stade II (avec 104 vrais positifs). Elle n'est que de 52.3 % pour les lésions patello-trochléennes de stade I (avec 22 vrais positifs).

Le nombre de sites de chondropathies qui n'est pas correctement classifié par l'IRM, est considéré comme le nombre

de faux négatifs (nombre de sites avec IRM négative alors qu'il y a une lésion). Nous n'avons pas trouvé de faux négatifs pour les lésions patello-trochléennes de stades III et IV ; nous avons 12 faux négatifs pour le stade II et 20 faux négatifs pour le stade I.

La spécificité est le pourcentage des sites normaux à l'IRM dans la population des sites effectivement normaux. Elle est déterminée en utilisant le nombre de sites pour lequel le stade IRM n'est pas confirmé par l'arthroscopie. Le nombre de faux positifs est le nombre de sites ayant une IRM positive alors qu'il n'y a pas de

a

b

Figure 7

Chondropathie rotulienne de stade arthroscopique II à III

Les coupes sagittales écho de spin T2 (a : 2 400/20 ; b : 2 400/70) montrent une petite zone superficielle de signal anormal, augmenté en densité protonique (a), intense en T2 (b), au niveau de la facette interne (têtes de flèche).

lésion. La spécificité est de 100 % pour les chondropathies patello-trochléennes de stades III et IV (pas de faux positifs). Elle est de 96.3 % pour celles de stade II (19 faux positifs) et de 87.2 % pour celles de stade I (76 faux positifs). Le nombre élevé de faux positifs s'explique en partie par le fait que tout hétérogénéité du signal cartilagineux, même quand elle n'était visible que sur les coupes de densité protonique, était considérée comme suspecte de chondropathie (de stade I), ceci dans le but de pousser le chirurgien à décrire l'état du cartilage rotulien sur son compte rendu.

Le nombre de sites considérés comme normaux à l'arthroscopie et le nombre de sites avec un stade arthroscopique différent du stade IRM est le nombre de vrais négatifs : il est de 637 pour les lésions patello-trochléennes de stade IV, 627 pour celles de stade III, 505 pour celles de stade II et 522 pour celles de stade I.

Enfin, la précision de l'IRM (qui est le pourcentage de patients bien classés) pour la détection des chondropathies patello-trochléennes est de respectivement 100, 100, 95 et 85 % pour les stades IV à I.

La valeur prédictive positive (VPP) est le nombre de sites présentant effectivement une lésion par rapport au nombre total de sites avec IRM positive. Elle est de 100 % pour les stades III et IV, de 84.5 % pour le stade II et très faible (22.4) pour le stade I.

La valeur prédictive négative (VPN) est le nombre de sites n'ayant effectivement pas de lésion par rapport au nombre total de sites avec IRM négative. Elle est très élevée pour tous les stades (100 % pour les stades III et IV, 97.6 pour le stade II et 96.3 pour le stade I).

Pour les localisations fémoro-tibiales, le taux de sensibilité est de 100 % pour les stades III et IV, les taux de spécificité et

a

b

c

d

Figure 8

Lésions cartilagineuses de stade II à III au niveau des deux compartiments fémoro-tibiaux.

Sur les coupes sagittales écho de spin T2 (a : 2 400/20, b : 2 400/70), le cartilage fémoral présente un signal hétérogène et des contours irréguliers avec des zones d'amincissement focal (flèches).

Les coupes coronales écho de spin T2 rapide (c : 4 700/19, d : 4 700/93) montrent l'amincissement chondral et sous-chondral très important

de la portion externe du condyle fémoral et du plateau tibial externe (petites flèches).

Le condyle fémoral interne présente une zone de signal intense (flèche) et un aspect focalement irrégulier de l'os sous-chondral (têtes de flèche).

a

b

Figure 9

Chondropathie rotulienne de stade IV

chez un électricien victime de plusieurs accidents de travail et se plaignant

de craquements articulaires et de douleurs sous-rotuliennes, surtout à la descente des escaliers.

Sur le premier écho de la séquence T2 rapide (a : 4 700/16), le cartilage rotulien externe apparaît aminci (petites flèches) puis interrompu de façon nette (grande flèche).

Sur la coupe axiale pondérée T2 (b : 4 700/98), on ne peut se rendre compte de l'épaisseur cartilagineuse. On met par contre en évidence un petit flap cartilagineux entouré de liquide au niveau de la crête rotulienne (flèche) et des remaniements géodiques sous-chondraux de signal intense en T2 (têtes de flèche).

de précision de respectivement 100 et 99.8 % pour les lésions de stade IV et III. Le taux de sensibilité est de 88.5 % pour les lésions fémoro-tibiales de stade II, le taux de spécificité de 84.5 % et le taux de précision de 86 %. Les résultats obtenus pour les lésions fémoro-tibiales de stade I sont tout à fait insuffisants (26.5 % pour la sensibilité, 67.5 % pour la spécificité, 58.1 % pour la précision).

Les faux positifs (160 au total) ont essentiellement été décrits au niveau du cartilage tibial externe, les faux négatifs (108 au total) au niveau des surfaces fémorales.

DISCUSSION

Parmi les études cliniques, les premières ont porté sur les séquences écho de spin T2 classique (Tableau I).

- Celle de *Yulish et al* (24) portait sur les rotules de 19 patients dont les lésions cartilagineuses de stade II ou III étaient correctement identifiées par les séquences écho de spin T2 (par comparaison aux constatations arthroscopiques).

- Nous avons étudié prospectivement 54 patients (10), à l'aide de coupes sagittales, complétées par des coupes axiales dans 38 cas, en séquence écho de spin T2 et avons trouvé un bon taux de sensibilité mais un taux de spécificité insuffisant pour les lésions de stade I et II. Considérant les lésions rotuliennes, les

a

b

Figure 10
Petite ulcération cartilagineuse profonde
du condyle fémoral interne
chez un sportif qui a subi une ménisectomie
interne quelques mois auparavant
et présente un gonflement douloureux
du genou depuis la reprise des sports.

Interruption focale du cartilage
avec pénétration de liquide synovial de signal
intense (flèche) sur les deux échos
de la séquence T2 rapide (a : 4 700/19,
b : 4 700/93) obtenue dans le plan coronal.

Une coupe coronale fine de 1,5 mm
d'épaisseur obtenue en séquence écho
de gradient T2* avec acquisition 3D,
sur l'aimant de 1 Tesla (c : 28/9/40°) montre
de façon nette que le défaut est profond
avec mise à nu de l'os sous-chondral
(tête de flèche). Cette séquence permet
de mettre en évidence une réaction
d'hyperostose sous-chondrale focale grâce
aux effets de susceptibilité magnétique
(petites flèches).

c

résultats étaient globalement de 100 %
pour la sensibilité, 50 % pour la spécifi-
cité et 81.5 % pour la précision.

■ **Mac Cauley et al** (14) ont évalué les
rotules de 52 patients en coupes axiales
de 5 mm d'épaisseur, en séquence écho
de spin T2 et ont déterminé rétrospecti-
vement une sensibilité de 86 %, une spé-

cificité de 74 % et une précision de 81 %

■ **Brown et al** (3) ont étudié les rotules de
75 patients en coupes axiales, en séquen-
ce écho de spin T2 et ont obtenu une sen-
sibilité de 91 %, une spécificité de 88 %
et une précision de 89 % pour les stade
III à IV et des taux insuffisants pour le
stades débutants.

Figure 11

*Chondropathie probable de la partie antérieure du condyle fémoral interne
(non décrite à l'arthroscopie).*

Les coupes sagittales écho de spin T2 (a : 2 400/20; b : 2 400/70) mettent en évidence une zone d'interruption du contour chondral et sous-chondral (flèche), de signal augmenté, associée à une réaction sous-chondrale focale (têtes de flèches).

Ce cas illustre le fait que les rapports arthroscopiques ne sont pas toujours fiables à 100 %, même quand ils sont détaillés.

%	Sensibilité	Spécificité	Précision	Corrélation
Yulish 87 19 rotules X-Z; 4 mm				11/12 (II-III)
Shahab pour 90 54 rotules X + Z; 3 mm	100	50	81.5	
Mc Cauley 92 52 rotules Z; 3 mm	86	74	81	
Brown 93 75 rotules Z; 3 mm	91	88	89	(III-IV)
Vallotton 95 33 rotules Z; 3 mm	84.7	97.2	91.6	

Tableau I

Taux de corrélation obtenus dans les études cliniques utilisant les séquences écho de spin T2

	Stades				
Sites	I	II	III	IV	Total
Rotule	33	112	8	2	155
Trochlée	9	4	5	1	19
Condyles fémoraux	76	144	8	3	231
Plateaux tibiaux	71	101	7	4	183
Total	189	361	28	10	588

Tableau II
Répartition et sévérité des lésions cartilagineuses en arthroscopie

Stades	Sensibilité	Spécificité	Précision	VPP	VPN
I	32.2	78.3	71.5	20.5	87
II	88.8	91.3	93.5	80	95.4
III	100	99.9	99.8	96.4	100

Tableau III
Taux de corrélation IRM-arthroscopie (en %)
Résultats globaux sans distinction de localisation des lésions.

Stades	Sites	Sensibilité	Spécificité	Précision	VPP	VPN
I	Rotule et trochlée	52.3	87.2	85	22.4	96.3
	Surfaces Fémoro-tibiales	26.5	67.5	58.1	19.5	75.5
II	Rotule et trochlée	89.6	96.3	95.1	84.5	97.6
	Surfaces fémoro-tibiales	88.5	84.5	86	77.9	92.2
III	Rotule et trochlée	100	100	100	100	100
	Surfaces fémoro-tibiales	100	99.8	99.8	93.7	100
IV	Rotule et trochlée	100	100	100	100	100
	Surfaces fémoro-tibiales	100	100	100	100	100

Tableau IV
Taux de corrélation IRM-arthroscopie (en %)

	Sensibilité	Spécificité	Précision	Stades
Shahab pour 97	52.3	87.2	85	I
320 rotules	89.5	96.3	95.1	II
X-Y : 3 mm	100	100	100	III-IV

Tableau V
Taux de corrélation IRM-Arthroscopie (en %) pour les lésions patello-trochléennes

	Sensibilité	Spécificité	Précision	Stades
Colin 94 37 patients X, Y; 3 mm	47	95.5	72.5	
Shahab pour 97 320 patients X, Y; 3 mm	26.5 88.5 100	67.5 84.5 99.9	58.1 86 99.9	I II III-IV

Tableau VI

Taux de corrélation IRM-Arthroscopie (en %) pour les lésions fémoro-tibiales

■ *Colin et al* (4) ont examiné 37 patients en coupes sagittales et coronales, en séquence écho de spin T2 et ont conclu que seules les chondropathies fémoro-tibiales évoluées (avec mise à nu de l'os sous-chondral) sont bien visualisées. (Tableau VI)

■ *Valotton et al* (23) ont réalisé une étude de corrélation IRM-arthroscopie chez 33 patients, en utilisant des coupes axiales de 3 mm d'épaisseur, en séquence écho de spin T2 et ont obtenu des scores de sensibilité et de spécificité beaucoup plus élevés que les auteurs précédents (sensibilité globale de 84,7 %, spécificité de 97,2 % et précision de 91,6 %).

Les études suivantes ont étudié les taux de corrélation IRM-arthroscopie pour les séquences avec suppression de la graisse.

■ *Rose et al* (19) ont étudié les rotules de 71 patients en coupes axiales épaisses de 4 à 5 mm, en séquence écho de spin T2 ou T2 rapide à deux échos avec suppression de la graisse. Ils ont obtenu une sensibilité de 72 %, une spécificité de 88 %, une précision de 79 % (cette dernière ne différant pas substantiellement des études n'utilisant pas les séquences avec suppression de la graisse).

■ *Broderick et al* (2) ont réalisé des coupes sagittales de 4 mm d'épaisseur en

séquence écho de spin T2 rapide à deux échos avec suppression de la graisse, chez 13 patients arthrosiques qui ont subi ultérieurement une arthroscopie ; ils ont déterminé de bons taux de corrélation.

■ *Gagliardi et al* (9) ont étudié les rotules de 27 patients en coupes axiales fines de 3 mm, en séquence écho de spin T2 et en séquence SPGR 2D avec suppression de la graisse ; ils ont obtenu des taux de sensibilité plus élevés pour les séquences écho de spin que SPGR 2D avec suppression de la graisse mais de nombreux faux positifs avec les séquences écho de spin T2.

■ *Recht et al* (18) ont examiné le cartilage fémoro-patellaire de 41 patients avec des coupes axiales de 2 à 2,5 mm d'épaisseur, en séquence SPGR 3D avec suppression de la graisse et ont détecté des lésions cartilagineuses avec une sensibilité de 81 %, une spécificité de 97 % et une précision de 97 %. Ils n'ont cependant pu détecter que 6 des 13 lésions débutantes (2A) avec cette technique.

■ *Disler et al* (7) ont comparé IRM et arthroscopie chez 48 patients examinés à l'aide de coupes sagittales de 3 mm d'épaisseur en écho de spin T2 et de coupes sagittales et de reconstructions axiales fines de 1,5 mm d'épaisseur en séquence SPGR 3D avec suppression de

la graisse. Des coupes axiales ont également été réalisées en séquence écho de spin T2 rapide à deux échos dans 26 cas. Ils ont obtenu des taux de sensibilité sensiblement plus élevés pour la séquence SPGR 3D avec suppression de la graisse que pour la séquence écho de spin T2.

D'après les résultats de notre étude, la séquence écho de spin T2 (avec coupes de densité protonique) permet une évaluation satisfaisante de nombreuses lésions cartilagineuses.

Sur la séquence écho de spin T2, le *cartilage* normal apparaît homogène et de contour régulier. Il présente un signal intermédiaire (gris) sur les coupes de densité protonique et uniformément faible (noir) sur les coupes pondérées T2. L'*os sous-chondral* est noir et d'épaisseur variable sur les coupes de densité protonique. Sur les coupes pondérées T2, il est indistinguable du cartilage. L'*os médullaire* a un signal intense en densité protonique, faible en T2 (deuxième écho).

Le *liquide* a un signal intermédiaire en densité protonique, intense sur le premier écho de la séquence T2 rapide et intense sur le deuxième écho de la séquence T2 (classique ou rapide). Il existe donc un contraste élevé entre le contour cartilagineux et le liquide sur les coupes pondérées T2 et entre le cartilage et l'*os sous-chondral* sur les coupes de densité protonique.

Les coupes de densité protonique (premier écho) ont un rapport signal/bruit élevé. Elles donnent une idée de l'épaisseur du cartilage; elles montrent certaines anomalies de contour, certaines anomalies de signal et des remaniements de l'*os sous-chondral*. Elles permettent une bonne évaluation des lésions cartilagi-

neuses, à condition de tenir compte des hétérogénéités de signal dues aux différentes couches du cartilage articulaire normal et à des artéfacts propres à la séquence écho de spin T2 (15, 17, 21). Les coupes pondérées T2 (deuxième écho) mettent en évidence les défauts cartilagineux remplis de liquide synovial, certains remaniements du signal cartilagineux, sous-chondral et intramédullaire. Lorsque le cartilage n'est pas directement visualisé, dans toute son épaisseur (comme c'est le cas au niveau des condyles fémoraux), on peut rechercher des signes indirects d'atteinte cartilagineuse, tels que des irrégularités d'épaisseur de l'*os sous-chondral*.

Les images écho de spin pondérées T2 ont un score de faux positifs relativement élevé (9). Les résultats sont, à notre avis, améliorés lorsqu'on combine les coupes pondérées T2 et les coupes de densité protonique, ces dernières donnant une évaluation un peu moins faussée de l'épaisseur cartilagineuse, surtout en séquence écho de spin T2 rapide.

D'autre part, dans cette étude, les images de densité protonique et pondérées T2, sont examinées sur écran et comparées systématiquement pour chaque position de coupe, ce qui, à notre avis, améliore la détection des lésions.

Les taux de corrélation particulièrement élevés de cette étude sont vraisemblablement dues aussi à la grande expérience des images écho de spin T2 puisque nous les utilisons systématiquement depuis plus de 10 ans (sur plus de 10000 genoux). Ces images présentent, en effet, par rapport aux séquences plus adaptées au cartilage (SPGR 3D avec suppression de la graisse...), l'avantage d'offrir des informations anatomiques additionnelles, par exemple l'étude des ménisques dans

le plan axial, la confirmation de souris articulaires, l'évaluation du tendon rotulien dans le plan axial...

Une limitation importante de la séquence écho de spin T2 est l'absence de contraste entre le cartilage et la graisse préférentielle en ce qui concerne l'articulation fémoro-patellaire ou entre les deux surfaces cartilagineuses d'une articulation, en l'absence de réaction liquidienne focale. Un bon contraste cartilage-graisse peut être obtenu grâce aux séquences SPGR 3D avec suppression de la graisse, ce que nous pratiquons actuellement en l'absence de réaction liquidienne dans l'espace fémoro-patellaire (6).

Bien que l'arthroscopie ait été utilisée comme standard de référence dans cette étude, cette procédure a des limites potentielles pour la détection de défauts cartilagineux (6,19) (Figures 1, 11). Celles-ci comprennent la difficulté de déterminer la profondeur d'un défaut lorsque l'os sous-chondral n'est pas mis à nu et la difficulté de détecter des lésions intracartilagineuses lorsque la surface cartilagineuse apparaît intacte; leur évaluation est limitée à la palpation. Or, si

dans les atteintes dégénératives du cartilage, les remaniements débutent habituellement à la surface cartilagineuse, les lésions post-traumatiques peuvent léser les couches profondes sans nécessairement atteindre la surface du cartilage. Les lésions peuvent apparaître sous forme d'un hypersignal linéaire parallèle à l'os sous-chondral sur les coupes pondérées T2 (16). Ce type de lésion peut, au stade débutant, être méconnu par l'arthroscopie à l'inspection de la surface articulaire.

En conclusion, d'après cette étude de corrélation arthroscopique, les séquences écho de spin T2 classiques et rapides à deux échos permettent de classer de manière fiable les anomalies cartilagineuses de stade II à IV.

Les taux de corrélation sont insuffisants pour les lésions cartilagineuses de stade I, en particulier pour les localisations fémoro-tibiales.

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BIBLIOGRAPHIE

1 - ADAM G., NOLTE-ERNSTING C., PRESCHER A.
Experimental Hyaline Cartilage Lesions : Two-dimensional Gradient-Echo MR Imaging
JMRI, 1991, 1, 665-672.

2 - BRODERICK L.S., TURNER D.A., RENFREW D.L. ET AL.
Severity of articular cartilage abnormality in patients with osteoarthritis : evaluation with fast spin-echo MR vs arthroscopy
AJR 1994, 162 : 99-103

3 - BROWN T.R., QUINN S.F.
Evaluation of Chondromalacia of the patellofemoral compartment with axial magnetic resonance imaging
Skeletal Radiology, 1993, 22, 325-328.

4 - COLIN T., PROVOST N., BEGUIN J., LOYAU G.
Contribution of magnetic resonance imaging to the evaluation of femorotibial cartilage lesions
Rev. Rhum. [Engl. Ed.], 1994, 61 (5), 297-302

5 - DE SMET A.A., MONU J.U.V., FISHER D.R.
Signs of Patellar Chondromalacia on Sagittal T2-weighted Magnetic Resonance Imaging
Skeletal Radiology, 1992, 21, 103-105.

6 - DISLER D.G., MCCAULEY T.R., WIRTH C.R. ET AL.
Detection of knee hyaline cartilage defects using fat-suppressed three-dimensional spoiled gradient-echo MR imaging : comparison with standard MR imaging and correlation with arthroscopy
AJR 1995, 165, 377-382

7 - DISLER D.G., MC CAULEY T.R.,
KELMAN C.G. ET AL.

Fat-suppressed three-dimensional spoiled gradient-echo MR imaging of hyaline cartilage defects in the knee : comparison with standard MR imaging and arthroscopy
AJR 1996, 167, 127-132

8 - FICAT R.P., HUNGERFORD D.S.

Disorders of the patello-femoral joint
Baltimore, Williams and Wilkins eds, 1977, 194-232

9 - GAGLIARDI J.A., CHUNG E.M.,
CHANDNANI V.P. ET AL.

Detection and Staging of Chondromalacia Patellae : Relative Efficacies of Conventional MR Imaging, MR Arthrography and CT Arthrography
AJR 1994, 163, 629-636

10 - HANDELSBERG F., SHAHABPOUR M.,
CASTELEYN P.P.

Chondral Lesions of the Patella Evaluated with Computed Tomography, Magnetic Resonance Imaging and Arthroscopy
The Journal of Arthroscopic and Related Surgery, 1990, 6, 24-29.

11 - HARDY P.A., RECHT M.P., PIRAINO D. ET AL.

Optimization of a dual echo in the steady state (DESS) free-precession sequence for imaging cartilage
JMRI 1996, 6, 329-335

12 - HODLER J., BERTHIAUME M.J.,
SCHWEITZER M.E.

Knee Joint Hyaline Cartilage Defects : A comparative Study of MR and Anatomic Sections
J CAT 1992, 16, 597-603.

13 - KRAMER J., RECHT M.P., IMHOF H. ET AL.

Postcontrast MR arthrography in assessment of cartilage lesions
JCAT 1994, 18, 218-224

14 - MCCAULEY T.R., KIER R., LYNCH K.J.

Chondromalacia Patellae : Diagnosis with MR Imaging
AJR 1992, 158, 101-107.

15 - MODL J.M., SETHI L.A., HAUGHTON V.M.

Articular Cartilage : Correlation of Histologic Zones with Signal Intensity at MR Imaging
Radiology 1991, 181, 853-855

16 - PETERFY C.G., GENANT H.K.

Emerging application of magnetic resonance imaging in the evaluation of articular cartilage
Radiol Clin North Am 1996, 34, 195-213

17 - RECHT M.P., KRAMER J., MARCELIS S.

Abnormalities of Articular Cartilage in the Knee : Analysis of Available MR Techniques
Radiology 1993, 187, 473-478.

18 - RECHT M.P., PIRAINO D.W., PALETTA G.A.

Accuracy of Fat-suppressed Three-dimensional Spoiled Gradient-Echo FLASH MR Imaging in the Detection of Patellofemoral Articular Cartilage Abnormalities
Radiology 1996, 198, 209-212.

19 - ROSE P.M., DEMLOW T.A., SZUMOWSKI J.,
QUINN S.F.

Chondromalacia Patellae : Fat-suppressed MR Imaging
Radiology 1994, 193, 437-440

20 - REISER M.F., BONGARTZ G., ERLEMANN R.

Magnetic Resonance in Cartilaginous lesions of the knee joint with three-dimensional gradient-echo imaging
Skeletal Radiology 1988, 17, 465-471

21 - RUBENSTEIN J.D., KIM J.K.,

HENKELMAN R.M.

Effects of compression and recovery on bovine articular cartilage : appearance of MR images
Radiology 1996, 201, 843-850

22 - SEO G.S., AOKI J., MORIYA H., KARAKIDA O.,
SONE S., HIDAKA H., KATSUYAMA T.

Hyaline cartilage : in vivo and in vitro assessment with magnetization transfer imaging
Radiology 1996, 201, 525-530

23 - VALLOTTON J.A., MEULI R.A., LEYVRAZ P.F.,
LANDRY M.

Comparison between magnetic resonance imaging and arthroscopy in the diagnosis of patellar cartilage lesions
Knee Surg. Sports Traumatol. Arthroscopy, 1995, 3, 157-162

24 - YULISH B.S., MONTANES J.,
GOODFELLOW D.B.

Chondromalacia Patellae : Assessment with MR Imaging
Radiology 1987, 164, 763-766.

3. Management of ACL injuries

- A. Non-operative management of anterior cruciate ligament injuries in the general population
- B. ACL management : an analysis of medium and long term results

NON-OPERATIVE MANAGEMENT OF ANTERIOR CRUCIATE LIGAMENT INJURIES IN THE GENERAL POPULATION

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The operative treatment of lesions of the anterior cruciate ligament (ACL) in athletes has been widely advocated and performed. We have investigated the outcome of non-operative management in a lower-demand, general population. We reviewed a consecutive group of 228 patients, which excluded professional and high-level athletes, for two to 12 years after an ACL lesion had been diagnosed by arthroscopy.

There was a low incidence of secondary ACL and meniscal surgery, 5.4% and 3.5% respectively, and all these procedures were performed during the first three years after the ACL injury.

We studied a subgroup of 109 patients with follow-up of at least five years (mean 8.5 years) and evaluated them using the IKDC score. The general outcome was reasonably satisfactory, with 23% in grade A, 50% in grade B, 21% in grade C and only 6.4% in grade D. We found no statistically significant prognostic effect within this group as regards age, activity levels, or the incidence of associated lesions.

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Lesions of the anterior cruciate ligament (ACL) in athletes have been studied extensively in orthopaedic sports medicine, and operative treatment using grafts is widely advocated for this particular group of patients (Fetto and Marshall 1980; Noyes et al 1983a; Kannus and Järvinen 1987; Andersson et al 1989; Barrack et al 1990; Daniel and Fithian 1994). Many ACL lesions, however, are seen in non-athletes as a result of accidents or low-grade recrea-

tional activities (Jain, Swanson and Murdoch 1983; Casteleyn, Handberg and Opdecam 1988).

We aimed to investigate the outcome of the conservative treatment of ACL lesions in a lower-demand population.

PATIENTS AND METHODS

Over a period of 12 years, we managed a total of 228 patients with acute traumatic knee haemarthrosis. All had examination under anaesthesia and arthroscopy.

Of these, we treated 46 by ACL reconstruction. The included patients with gross or multidirectional joint laxity (grade-3 or grade-4 pivot shift, combined lesions of the ACL and lateral collateral ligament (LCL) or posterior cruciate ligament (PCL)) and in addition all high-level or professional athletes. These 46 cases (16.8%) were excluded from the study group.

This left a consecutive group of 228 patients (83%) who were managed conservatively. There was an almost four fold male to female ratio and the mean age at the time of injury was 33.2 years (16 to 66). The main causes of injury were daily living activities (28.1%), traffic accidents (11.8%), and recreational activities (60.1%) (Table I).

Initial management. In 83% of the cases, arthroscopic evaluation was within three weeks of the index injury. The proportions of isolated ACL ruptures and those associated with meniscal and ligamentous lesions were comparable with those reported in previous studies (Casteleyn et al 1988) (Tables I and II); only 21 of the ACL tears (9%) were partial. Intrasynovial ACL lesions (14; 6.1%) were left as much as possible within the synovial sheath. There was spontaneous partial reattachment of the distal ACL stump to the PCL in 18 knees (7.9%); these were left undisturbed. Some ACL remnants which seemed likely to impinge between the femur and tibia and limit extension were trimmed. No reconstructive ACL surgery was performed during the initial arthroscopy.

Meniscal surgery was performed if indicated and feasible. Three of 27 torn lateral menisci and 17 of 105 medial menisci were sutured. Minor lesions, of one lateral and seven medial menisci, were left untreated. All other meniscal lesions (77.1% of the medial and 85.2% of the lateral meniscal lesions) were treated by partial arthroscopic meniscectomy. No surgery was performed for medial collateral ligament (MCL) lesions.

All patients were treated by a comprehensive rehabilitation

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Table I. Details of the whole series and of the subgroups with secondary ACL and meniscal surgery

	Whole series (n = 228)	ACL surgery (n = 11)	p value	Meniscal surgery (n = 7)	p value
Age in years	33.2	26.5	<0.5	31.5	NS
Male:female ratio	4:1	2:1	<0.05	4:1	NS
Activity level (number; percentage)					
1	25 (11.0)	1 (9.1)	NS	1 (14.3)	NS
2	119 (52.2)	6 (54.5)	NS	3 (42.8)	NS
3	67 (29.4)	3 (27.3)	NS	2 (28.6)	NS
4	17 (7.5)	1 (9.1)	NS	1 (14.3)	NS
Aetiology (number; percentage)					
Activities of daily living	64 (28.1)	3 (27.3)	NS	2 (28.6)	NS
Traffic accidents	27 (11.8)	1 (9.1)	NS	1 (14.3)	NS
Recreation	137 (60.1)	7 (63.6)	NS	4 (57.1)	NS
Lesions (number; percentage)					
Isolated ACL	48 (21.0)	2 (18.2)	NS	2 (28.6)	NS
ACL + 1 other	108 (47.4)	5 (45.5)	NS	3 (42.9)	NS
ACL + >1 other	72 (31.6)	4 (36.4)	NS	2 (28.6)	NS

Table II. Lesions diagnosed during initial arthroscopy

Lesions	Number	Percentage
Isolated ACL	48	21.05
ACL + 1 other	108	47.37
ACL + >1 other	72	31.58
ACL + medial meniscus	105	46.05
+ lateral meniscus	27	11.84
+ medial collateral ligament	64	28.07
+ lateral collateral ligament	15	6.58
+ posterior cruciate ligament	0	0.0

tion programme for six to eight weeks. Early weight-bearing was allowed with the eventual protection of a cast or a brace in cases of partial ACL and intrasynovial ACL, MCL and LCL lesions.

Follow-up. The initial 228 patients have been followed up for 2 to 12 years. Data were collected during annual examinations or by written questionnaire or telephone interviews. Of these patients, 25 (11%) have been lost to follow-up leaving 203 with known results at over two years. Records were maintained of pre- and postinjury levels of activity and of the reasons for any long-term modification of the level of activity.

We classified activity levels into four groups:

- 1) strenuous activity which included jumping, pivoting and cutting (soccer);
- 2) moderate activity, involving heavy manual work (skiing, tennis);
- 3) light activity such as jogging or running; and
- 4) sedentary activity such as housework and the normal activities of daily living.

We recorded all subsequent surgery for the ACL lesion (intra-articular or extra-articular) and all subsequent meniscal surgery. These data were then used to construct survival tables with ACL or meniscal surgery or both considered as

end-points. The age, gender, activity level, aetiology of the injury and any associated lesions in the patients who required secondary ACL and/or meniscal surgery were then compared with similar data from the patients who had no subsequent operations (Table I).

We tried to review all 132 patients with at least five years' follow-up for their subjective opinion, clinical examination, and radiological assessment. Of these, 23 (17%) refused further clinical and radiological examination. The 109 patients who were studied in detail did not differ significantly from the initial cohort as regards mean age, gender, or distribution of activity level, cause of injury or associated lesions. The mean period from the initial injury was 8.5 years (5 to 12). The final assessment was recorded on the International Knee Documentation form (Hefti et al 1993). This assesses results in seven separate subgroups (see Table IV). These are subjective assessment, symptoms, range of motion, ligament examination (which in our study included use of the KT 2000 tester (Medmetric Corporation, San Diego, California) with 134 N displacement force), compartmental crepitus, radiography and a one-leg hop test. The result in each subgroup is scored on a four-point scale. The lowest grade determines the global grade of the subgroup, and the worst evaluation group determines the final score.

We tried to find correlations between the final grade and age at injury, associated lesions, activity level or modification and length of follow-up, using the analysis of variance, the paired *t*-test, and the Mann-Whitney U test.

RESULTS

Survival. Only 11 of the 203 patients followed for two to 12 years had needed secondary ACL surgery (5.4%) and seven had secondary meniscal surgery (3.5%) (Table I). All these procedures had been performed during the first three years after the index injury with none later than this. These

Fig. 1

Survival curves after non-operative management of ACL injuries, using as end-points secondary ACL surgery, secondary meniscal surgery, and both together.

figures give a high survival rate which persists for three to 12 years (Fig. 1).

We found no correlation between survival and cause of injury, associated lesions or activity levels, but the patients who had needed subsequent ACL surgery were younger and had a lower male-to-female ratio (Table I).

Activity levels. The initial activity levels were those of a general population with a fair proportion of manual workers, some of them involved in moderate sport and recreational activities (Table I). None of the patients who needed secondary ACL and meniscal surgery had modified their activity level since the injury and its treatment. Less than half of all the patients had modified their activity levels after the ACL injury (Table III) and of those who reported a decrease, only 57 (65.5%) considered that this decrease in activity level was related to their ACL injury.

Table III. Activity level modification after ACL injury in 203 patients

	Number	Percentage
Increase of 1 level	4	2.0
No modification	112	55.2
Decrease		
1 level	39	19.2
2 level	20	9.9
3 level	28	13.8

As expected, the relationship between decrease in activity level and the original injury became less important with length of follow-up. Any decrease in activity was reported to be injury-related by 78% when it occurred less than five years after injury, by 57% between five and eight years, and by only 17% when it occurred after more than eight years.

IKDC examination. The results in 109 patients are summarised in Table IV. The subjective results were satisfac-

tory: 82.4% of the patients stated that their knee was normal or nearly normal. This was confirmed by the rather benign nature of the symptoms; 61% achieved a normal grade and 21% a nearly normal grade. The range of motion was marginally limited in only 19%, with no important extension or flexion deficits. The lowest grades were found as expected in the KT 2000 ligament examination subgroup, but even for this test 32.1% of the knees had a nearly normal grade. As regards compartmental crepitus 84% were normal and there was no radiological narrowing of the joint space in 76%.

For the one-leg hop test, 57% had normal rates; this confirmed the low intensity of any symptoms and the reasonably good function of most of the knees. The overall evaluations gave 23% in grade A, 50% in grade B, 21% in grade C and 6.4% in grade D.

We could find no prognostic correlation between age at the time of injury, associated lesions, activity level at time of injury and at time of evaluation, and the final evaluation grade. There was no marked decrease in evaluation grades with increasing length of follow-up (Fig. 2).

DISCUSSION

The results of our study must be analysed with caution, since 11% of the patients were lost to follow-up, and 17% of the patients whom we traced at over five years refused further clinical examination. The main strength of our work is that the population of patients was selected at the time of the initial injury; many previous studies of the non-operative management of ACL injuries were based on patients who were seeking further treatment because of significant complaints (Fetto and Marshall 1980; McDaniel and Dameron 1980; Giove et al 1983; Noyes et al 1983a; Finsterbush et al 1990).

The conservative management which we used during the 14 years of the study must be considered in relation to the

Table IV. IKDC evaluation of 109 patients. The numbers in bold type are the global results for each group (see text)

Group	Grade							
	A		B		C		D	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Subjective assessment	33	30.3	57	52.3	18	16.5	1	0.9
Function	33	30.3	55	50.5	21	19.3	0	
Impact on activity	38	34.9	56	51.4	14	12.8	1	0.9
Symptoms	67	61.5	23	21.1	14	12.8	5	4.5
Pain	88	80.7	14	12.8	6	5.5	1	0.9
Swelling	98	89.9	6	5.5	4	3.6	1	0.9
Partial giving-way	70	64.2	22	20.2	13	11.9	4	3.7
Full giving-way	93	85.3	10	9.1	6	5.5	0	
Range of motion	88	80.7	21	19.2	0	0	0	0
Extension lack	97	88.9	12	11.0	0	0	0	
Flexion lack	104	95.4	5	4.5	0	0	0	
Ligament examination	35	32.1	52	47.7	21	19.2	1	0.9
Lachmann	60	55.0	48	44.0	1	0.9	0	
End-point	91	83.4			18	16.5		
70° drawer	65	59.6	39	35.8	5	4.6	0	
Medial joint opening	40	36.7	64	58.7	4	3.7	1	0.9
Lateral joint opening	97	89.0	12	11.0			0	
Pivot shift	39	35.8	53	48.6	16	14.7	1	0.9
Crepitus	93	85.3			15	13.8	1	0.9
Patellofemoral	104	95.4			4	3.7	1	0.9
Medial compartment	98	89.9			11	10.1	0	
Lateral compartment	107	98.1			2	1.8	0	
Joint narrowing (radiological)	83	76.2			21	19.3	5	4.6
Medial	84	71.1			20	18.4	5	4.6
Lateral	95	87.2			13	11.9	1	0.9
Patellofemoral	87	79.8			18	16.5	4	3.7
Hop test	63	57.8	40	36.7	4	3.7	2	1.8
Final evaluation	25	22.9	54	49.5	23	21.1	7	6.4

evolving knowledge on ligament healing; some of our earliest patients were treated during the early 1980s. We would not now use casting for ligament sprains or partial ruptures of the ACL (Daniel et al 1994).

Our review of a general patient population, less interested in sporting activities, also means that precise data about physical activity are more difficult to obtain. The IKDC assessment form does not offer the same refinement of

analysis as the Tegner score, but seems to be more applicable to this type of population. It should also be noted that the mean time between injury and latest radiological examination in our 103 patients (8.5 years; 5 to 12) may be too short to show significant degenerative changes in this low-demand population.

The most surprising result of our study was the fairly limited laxity shown by ligament examination; only 44.9%

Fig. 2

Changes in the proportions of A and B global evaluation grades with length of follow-up showing no significant deterioration.

of Lachmann tests showed side-to-side differences of more than 3 mm, and only 15.5% showed gross pivot shifts. Among possible explanations are the exclusion from the study of knees with gross instability and the appreciable percentages of isolated ACL lesions, intrasynovial lesions, and spontaneous reattachments to the PCL. Other factors may be a rehabilitation programme designed to protect and enhance the healing of the secondary knee restraints, and the population which included many heavy manual workers who do not undertake jumping, cutting and pivoting activities.

The low rate of meniscal injuries and the absence of meniscal surgery later than three years after the index injury are also rather surprising. The same factors and the progressive reduction of activity levels with time may provide an explanation. Only actual surgery on the menisci was recorded, and it is possible that some meniscal lesions in this low-demand population produced only slight symptoms which did not result in recorded meniscal surgery. For obvious ethical and economical reasons, it was impossible to conduct second-look arthroscopic or MRI examinations to provide more rigorous data on secondary meniscal lesions.

Most of the recent papers on ACL lesions deal mainly with athletic or high-demand patient populations, and many focus on the poor results of conservative treatments in this population, with their high incidence of secondary injuries (Noyes et al 1983a; Finsterbush et al 1990), degenerative changes (Fetto and Marshall 1980; Kannus and Järvinen 1987; Pattee et al 1989), cessation of sport activities (Andersson et al 1989; Sommerlath, Lysholm and Gillquist 1991) and on the need for secondary joint stabilisation (Noyes et al 1983b; Barrack et al 1990). These reports led to the concept that only surgical reconstruction could allow unrestricted return to sport and prevent secondary problems (Daniel and Fithian 1994).

This view remains controversial: a recent study failed to show a higher proportion of contact sports participation at seven years after surgical reconstruction as compared with conservative treatment (Roos et al 1995). It has also been shown that subsequent degenerative changes cannot be avoided, even after the latest surgical techniques which take full account of ACL anatomy and biomechanics (Sommerlath and Gillquist 1992). Such degenerative changes may be less important in conservatively treated patients (Daniel et al 1994); our limited data support these observations. Various hypotheses have been put forward to explain subsequent degeneration in apparently stable knees.

The extent of concomitant meniscal injury is of course important, but its influence has not been proven (Daniel et al 1994; Küllmer, Letsch and Turowski 1994). Bone 'bruises', sustained at the time of injury, may perhaps damage the subchondral bone (Graf et al 1993; Fowler 1994). Even the geometry of the femoral condyle has been evoked (Friden et al 1993). The mechanical properties of articular cartilage (Setton et al 1994) and changes in synovial fluid cytokines (Cameron et al 1994) have been reported to be

influenced by the initial ACL lesion; these changes may help to induce degenerative changes in a reconstructed knee which is subjected to further high-demand activities.

Our long-term study indicates that patients who are willing to avoid these activities can have acceptable functional results after non-operative treatment of an ACL injury. The outcome does not appear to deteriorate with time, and includes only very limited osteoarthritic changes. Our findings support previous short-term and medium-term reports on the conservative treatment of ACL injuries (Glove et al 1983; Satku, Kumar and Ngoi 1986; Buss et al 1995). Despite the very numerous publications on the subject, the management of ACL lesions is almost as controversial today as it has been for 50 years (Lindstrand 1995).

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REFERENCES

- Andersson C, Odensten M, Good L, Gillquist J. Surgical or non-surgical treatment of acute rupture of the anterior cruciate ligament. *J Bone Joint Surg [Am]* 1989;71-A:965-74.
- Barrack RL, Bruckner JD, Kneisl J, Inman WS, Alexander AH. The outcome of nonoperatively treated complete tears of the anterior cruciate ligament in active young adults. *Clin Orthop* 1990;259:192-9.
- Buss DD, Min R, Skyhar M, et al. Nonoperative treatment of acute anterior cruciate ligament injuries in a selected group of patients. *Am J Sports Med* 1995;23:160-5.
- Cameron ML, Fu FH, Paessler HH, Schneider M, Evans CH. Synovial fluid cytokine concentrations as possible prognostic indicators in the ACL-deficient knee. *Knee Surg Sports Traumatol Arthroscopy* 1994;2:38-44.
- Casteley P, Handberg F, Opdecam P. Traumatic haemarthrosis of the knee. *J Bone Joint Surg [Br]* 1988;70-B:404-6.
- Daniel DM, Fithian DC. Indications for ACL surgery. *Arthroscopy* 1994;10:434-41.
- Daniel DM, Stone ML, Dobson BE, et al. Fate of the ACL-injured patient: a prospective outcome study. *Am J Sports Med* 1994;22:632-44.
- Fetto JF, Marshall JL. The natural history and diagnosis of anterior cruciate ligament insufficiency. *Clin Orthop* 1980;147:29-38.
- Finsterbush A, Frankl U, Matan Y, Mann G. Secondary damage to the knee after isolated injury of the anterior cruciate ligament. *Am J Sports Med* 1990;18:475-9.
- Fowler PJ. Bone injuries associated with anterior cruciate ligament disruption. *Arthroscopy* 1994;10:453-60.
- Friden T, Jonsson A, Erlandsson T, Jonsson K, Lindstrand A. Effect of femoral condyle configuration on disability after an anterior cruciate ligament rupture: 100 patients followed for 5 years. *Acta Orthop Scand* 1993;64:571-4.
- Glove TP, Miller SJ III, Kent BE, Sanford TL, Garrick JG. Non-operative treatment of the torn anterior cruciate ligament. *J Bone Joint Surg [Am]* 1983;65-A:184-92.
- Graf BK, Cook DA, De Smet AA, Keene JS. 'Bone bruises' on magnetic resonance imaging evaluation of anterior cruciate ligament injuries. *Am J Sports Med* 1993;21:220-3.
- Hefti F, Müller W, Jakob RP, Stäubli H-U. Evaluation of knee ligament injuries with the IKDC form. *Knee Surg Sports Traumatol Arthroscopy* 1993;1:226-34.
- Jain AS, Swanson AJG, Murdoch G. Hemarthrosis of the knee joint. *Injury* 1983;15:178-81.
- Kannus P, Järvinen M. Conservatively treated tears of the anterior cruciate ligament: long-term results. *J Bone Joint Surg [Am]* 1987;69-A:1007-12.
- Küllmer K, Letsch R, Turowski B. Which factors influence the progression of degenerative osteoarthritis after ACL surgery? *Knee Surg Sports Traumatol Arthroscopy* 1994;2:80-4.

- Lindstrand A. The anterior cruciate ligament problem. *Acta Orthop Scand* 1995;66:105-6.
- McDaniel WJ Jr, Dameron TB Jr. Untreated ruptures of the anterior cruciate ligament: a follow-up study. *J Bone Joint Surg [Am]* 1980;62-A:696-705.
- Noyes FR, Mooar PA, Matthews DS, Butler DL. The symptomatic anterior cruciate-deficient knee. Part I. The long-term functional disability in athletically active individuals. *J Bone Joint Surg [Am]* 1983a;65-A:154-62.
- Noyes FR, Matthews DS, Mooar PA, Grood ES. The symptomatic anterior cruciate-deficient knee. Part II. The results of rehabilitation, activity modification and counselling in functional disability. *J Bone Joint Surg [Am]* 1983b;65-A:163-74.
- Paltee GA, Fox JM, Del Pizzo W, Friedman MJ. Four to ten year follow-up of unreconstructed anterior cruciate ligament tears. *Am J Sports Med* 1989;17:430-5.
- Roos H, Ornell M, Gärdsell P, Lohmander LS, Lindstrand A. Soccer after anterior cruciate ligament injury: an incompatible combination? A national survey of incidence and risk factors and a 7-year follow-up of 310 players. *Acta Orthop Scand* 1995;66:107-12.
- Satku K, Kumar JP, Ngol SS. Anterior cruciate ligament injuries: to counsel or operate? *J Bone Joint Surg [Br]* 1986;68-B:458-61.
- Setton LA, Mow VC, Müller FJ, Pita JC, Howell DS. Mechanical properties of canine articular cartilage are significantly altered following transection of the anterior cruciate ligament. *J Orthop Res* 1994;12:451-63.
- Sommerlath K, Lysholm J, Gillquist J. The long-term course after treatment of acute anterior cruciate ligament ruptures: a 9 to 16 year follow-up. *Am J Sports Med* 1991;19:156-62.
- Sommerlath K, Gillquist J. The long term course of various meniscal treatments in anterior cruciate ligament deficient knees. *Clin Orthop* 1992;283:207-14.

MANAGEMENT OF ANTERIOR CRUCIATE LIGAMENT LESIONS : SURGICAL FASHION, PERSONAL WHIM OR SCIENTIFIC EVIDENCE ? STUDY OF MEDIUM- AND LONG-TERM RESULTS

P. P. CASTELEYN

The medium- and long-term results of conservative and surgical treatment of ACL lesions were evaluated by analysis of the current literature. Only reports with a minimum follow-up of 4 years were taken into account. Concerning conservative treatment, the literature search revealed only 7 papers with a total of 636 cases. Reports on the results of surgical treatment were separated into four categories : primary repairs, with 13 papers (1205 cases), extraarticular tenodesis, with 4 papers (232 cases), ACL reconstruction, with 26 papers (2693 cases) and ACL prosthetic replacement (reconstruction using synthetics) with 5 papers (370 cases).

The mean functional scores show about 70% good and excellent results for all treatment regimens. Clinical laxity persists in almost all conservatively treated cases, in almost half of the cases with primary repair, extraarticular tenodesis, and synthetic substitution, and in almost one-third of the cases with ACL reconstruction.

The incidence of secondary ACL surgery (4.6%) was lowest in the conservative group, whereas secondary meniscus surgery was lowest in the ACL reconstruction group (3.5%). Compared with the conservative group (12%), surgical treatment evolved to a higher osteoarthritic morbidity. Sports participation was higher in the ACL reconstruction group. This analysis may provide a more realistic view on the outcome of treatment of ACL lesions, and on the relationship between treatment, activity level and osteoarthritis.

Keywords : knee ; anterior cruciate ligament ; medium & long term results.

Mots-clés : genou ; ligament croisé antérieur ; résultats à moyen et long terme.

INTRODUCTION

Social behavior, recreational and sports activities, as well as occupational and traffic accidents seem to be generating an epidemic of knee and especially ACL injuries.

This led some authors (11, 30) to project figures of more than 250, 000 ACL injuries, year worldwide. It is estimated that between 60, 000 and 75, 000 surgical ACL reconstructions, year are presently performed per year in the U.S.A. (30, 39). This trend towards operative treatment was further enhanced by reports of progressive joint degeneration due to chronic ligamentous pathology (14, 29). Recent review articles and editorials challenged this view however and reemphasized the value of conservative treatment (32, 38, 39, 46).

Although the orthopedic literature is replete with the management of ACL problems, most reports on treatment concern details of surgical technique, and/or short-term results. The fundamental questions concerning the treatment of the ACL lesions thus remain unsolved.

The aim of this study was therefore to search the literature to provide an analysis of the available

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medium- and long-term reports of conservative and surgical treatments of ACL lesions.

MATERIAL AND METHODS

The main orthopedic journals and monographs were researched from 1975 until mid-1998 for reports on medium- and long-term results of ACL treatments.

It was the initial intention of the author to use a strict methodology for paper selection, focusing on objectively measurable variables, separate evaluation of different pathologies (chronic versus acute, partial versus total ACL tears, isolated versus combined lesions), population groups (low versus high demand, young versus middle-aged), and randomized treatment modalities.

These scientific standards had to be abandoned however, as almost none of the available papers fulfilled the above-mentioned criteria. The only selection criterion that could possibly be maintained was a minimum follow-up of 4 years.

Reports with a mean follow-up of 4 years or more, but including cases with less than a 4-year follow-up were not taken into account owing to possible biases related to favorable short-term results.

The following data were analyzed if available: number of cases reported, percentage of cases followed, length of follow-up (mean and range), type of ACL lesion (partial versus total, acute versus chronic), treatment regimen, residual laxity (Lachmann test, instrumented Lachmann test, pivot shift test), type and value of functional score, sports participation, secondary meniscal and ACL surgery, loss of motion and osteoarthritis.

The reports on conservative treatment, on primary surgical repair, on extraarticular tenodesis, on ACL reconstruction and on ACL prosthetic replacement, were evaluated separately.

Treatment results of acute and chronic ACL lesions, as well as of different surgical reconstructive techniques could not be analyzed separately, owing to the limited number of reports available. A statistical evaluation and comparison between the different treatment groups could not be performed because of the lack of precise data in most reports.

RESULTS

A. Conservative treatment

Only seven reports (6, 13, 15, 20, 62, 69, 72) concerning 636 cases reach the benchmark of 4

years of follow-up. Five of the 7 reports include patients with more than 10 years of follow-up. The main follow-up rate is 78.5% (range 57-96%) (table I).

Although the functional results are satisfactory with a mean of 70% good and excellent results (range 57-82%), the clinical evaluation demonstrated the persistence of knee laxity, with 89% positive Lachmann's (range 9 to 100%), 58.5% positive instrumented Lachmann's (range 9 to 84%) and 59% positive pivot shifts (range 5 to 84%).

Sports participation is rather low (mean 45%, range 30 to 55%). The amount of high-level sports participation never exceeds 30%, even in series reporting specifically on "athletes". A constant trend is the decline in sports participation over time after the index injury. However in most series which mention this phenomenon, this decline is not related to the knee injury in one-third to one-half of the cases. This non-knee related decline in sports participation also increases with length of follow-up.

Secondary ACL reconstructions are rare (mean 4.6%, range 0 to 18%) and are in most series related to gross or recurrent instability during activities of daily living.

Secondary meniscal surgery is also limited (mean 12%, range 3.5 - 23.7%).

The mean occurrence of osteoarthritis is moderate (18%), but with a wide range of values (7 to 61%).

B. Primary repair

The reports on primary repair include sutures as well as reinsertions of the torn ACL remnants, or repairs augmented with autogenous tissue, be it fascia lata, patellar or hamstring tendons (6, 7, 10, 16, 26, 28, 35, 36, 41, 47, 68, 71, 75) (table II).

It is striking that only 13 papers report on a follow-up of more than 4 years, with only 4 papers including patients with more than 10 years of follow-up. All reports together amount to only 1205 cases of ACL ruptures of which 1 out of 5 was lost to follow-up.

Although many scores are in the good and excellent range, residual laxity is not rare, with

21 to 94% (mean 41.9%) positive manual Lachmann tests. The instrumented Lachmann's show even less good values of about 31 to 73% (mean 52.5%) positive tests. The results of the pivot shift tests are less reliable, since the values differ widely between series, with a range from 6 to 55% (mean 23.7%).

About 45.2% of this primary repair patient population returned to sports participation after the ACL injury and repair. The information on secondary meniscal and ACL surgery remains fragmentary, with widely scattered values. The incidence of secondary meniscal surgery ranges from 2 to 38% (mean 16.4%); that of secondary ACL surgery from 0 to 25% (mean 12.0%).

C. Extraarticular tenodesis

The reports available concern isolated extraarticular tenodeses, without intraarticular ACL reconstruction, for chronic ACL deficiencies (5, 17, 34, 65) (table III). Although extraarticular tenodeses have apparently been used widely, the number of long-term reports is limited, with only four papers, dealing with 232 patients of whom only 60% have been followed.

The scores do not seem too bad and range from 52 to 82% good and excellent results. The validity of the scores is however directly challenged by the high number of positive Lachmann (mean 54.3%, range 37%-91%), instrumented Lachmann (mean 63.0%, range 63%-64%) and pivot shift tests (mean 47.4%, range 33%-75%). Sports participation after the procedure is reduced to a mean of 54.2%.

Secondary meniscal and ACL surgery (respectively 5 to 28%, mean 23.4% and 6 to 26%, mean 13.6%) as well as arthritic degeneration (13 to 51%) is frequent.

D. ACL reconstruction

Again, the number of reports and cases with a follow-up of more than 4 years is fairly low: only 26 papers or 2693 patients, of whom 23% were lost to follow-up (1, 3, 4, 8, 9, 20, 22, 36, 37, 40, 44, 45, 50, 52, 53, 54, 57, 61, 63, 64, 66,

67, 73, 74, 78, 79), 7 papers include cases with 10 year or more of follow-up (table IV).

Only three of these papers (3, 36, 57) deal exclusively with acute ACL lesions; two others report separately on acute and chronic ACL lesions (20, 50), and seven reports combine the results of acute and chronic cases (8, 9, 37, 40, 45, 61, 63). All other studies are limited to chronic ACL lesions.

Many studies also combine the results of different types of grafts, of operative techniques, of various types of isolated intraarticular reconstructions or of intraarticular reconstructions combined with extraarticular tenodeses. The evaluation of each technique is therefore almost impossible. In addition the majority of these studies are retrospective, and when combining techniques, without randomization.

Again, as with the primary repairs, we can witness a discrepancy between rather good functional scores (Lysholm 66% to 100% good and excellent, Cincinnati 66% to 85% good and excellent, IKDC 47% to 77% A and B) and rather fair and poor results concerning laxity (positive Lachmann: 4 to 91%, mean 34.8%, positive instrumented Lachmann: 6 to 70%, mean 31.1%, positive pivot shift: 3 to 52%, mean 20.8%).

The data concerning secondary meniscal and ACL surgery are fragmentary and fall within a wide range of values from 0 to 15% (mean 3.5%) for meniscal surgery and from 0 to 14% (mean 3.0%) for ACL surgery.

Only 14 papers, reporting on 865 cases (or 31% of all analyzed cases), studied the appearance or aggravation of osteoarthritis with radiographs and/or bone scans. These papers show 37.4% of cases (range 12-100%) to have developed osteoarthritis, mostly of a mild-to-moderate grade.

E. Ligament prostheses

The synthetics were studied separately, as including them in the global evaluation of the ACL reconstructions could be considered to create a negative bias in the evaluation of the latter.

Only five long-term reports on ACL prostheses are available with two including patients with

Table I. Long term results of conservative treatment

Author	Year	N cases	% F/U		Years F/U		Diagnosis	% L. achrom.	Instrumented Lachman		% Privet +	Funct. Score		% Sports	% Second Surg		% Arthroscopy
			Min.	Max.	Min.	Max.			Type	Force		Type	Value		% meniscus	% ACL	
Anderson	89	39	96		3.75	6	4.8		93	Straker	90 n	Lysolam	mean 86	30	23.7	2.5	—
Paine	89	68	72	4	10.2	5.5			100	K.T. 1000	89 n	Lysolam	67% G.E.	43	5	18	15
Sommerlath	92	19	—	9	15	12.2			36	Straker	90 n	Lysolam	82% G.E.	32	5.2	0	61
Cicotti	94	52	57	5	13	7			97	K.T. 1000	max.	Lysolam	57% G.E.	—	13.3	0	7
Daniel	94	56	75	3.8	9.4	5.3			—	max.	9% +	—	—	48	7	3.5	—
Shirakura	95	59	89	3.7	11.1	6.9			—	max.	84% +	—	—	44	20	2.1	18
Candeyo	96	109	83	5	12	8.5			—	max.	72% +	—	—	55	7.5	5	—
									—	max.	45% +	IKDC	72% A + B	—	3.3	5.4	21.2

Table II. Meta-analysis of reports concerning primary repair of ACL

Author	Year	N Cases	% F/U		Years		Treatment	% L. achrom.	Arthrometer		% Privet +	Functional Score		% Sports	Second Surg		% Arthroscopy
			Min.	Max.	Min.	Max.			Type	Force		Type	Value		% Men	% ACL	
Fragin	76	64	50	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Anderson	89	111	96	4	6	—	—	—	—	—	—	—	—	—	—	—	—
Engelbrecht	89	84	88	4	9	—	—	—	—	—	—	—	—	—	—	—	—
Kaplan	90	70	74	5	13	6	—	—	—	—	—	—	—	—	—	—	—
Anderson	91	167	93	4	6.6	70	—	—	—	—	—	—	—	—	—	—	—
Sherman	91	106	67	4	7	5	—	—	—	—	—	—	—	—	—	—	—
Sommerlath	91	60	88	9	18	12	—	—	—	—	—	—	—	—	—	—	—
Cross	93	47	64	5	7	—	—	—	—	—	—	—	—	—	—	—	—
Grundtich	95	74	70	5	7	6	—	—	—	—	—	—	—	—	—	—	—
Trager	95	130	77	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Isak	96	105	69	7	16	10	—	—	—	—	—	—	—	—	—	—	—
Geunrich	96	100	82	5	7	6	—	—	—	—	—	—	—	—	—	—	—
Isenberg	97	48	69	—	10	—	—	—	—	—	—	—	—	—	—	—	—
Isenberg	98	68	69	6	10	8	—	—	—	—	—	—	—	—	—	—	—

Table III. Meta-analysis of reports of extraarticular tenodesis

Author	Year	N cases	% F/U		Years F/U		Treatment	% L. achrom.	Arthrometer		% Privet +	Functional Score		% Sports	Second Surg		% Arthroscopy
			Min.	Max.	Min.	Max.			Type	Force		Type	Value		% Men	% ACL	
Amisaki	88	40	67	8	14	11	—	—	—	—	—	—	—	—	—	—	—
Uchikoshi	88	39	71	5	8	6	—	—	—	—	—	—	—	—	—	—	—
Reid	92	46	67	7	13	11	—	—	—	—	—	—	—	—	—	—	—
Geunrich	95	107	48	5	14	9	—	—	—	—	—	—	—	—	—	—	—

Table IV. Meta analysis of reports of AET-1 resistance

Author	Year	n Cases	% (1 U)	Years F.U.			Acute Chron.	Treatment	% 1st relapse	Antiretroviral			% Priorit	Functional		% Spont	Second Surg		% Late	% Adverse
				Min	Max	Mean				Type	Force	% *		Type	Value		% Mon	% A.C.T.		
Johnson	84	134	85	5	10	8	A + C	PT, AZV, B, F	66	Chn	7	31.3	9.7	1-pyridin	90% G.E	92	1.1	6.7	0 - 0* Ext.	14
Korshak	88	60	83	4	9	5	C	PT, AZV, B, F Q.T. AZV, U.I.T	55				9.7	11.5 S	Mean 40.6	100	-	-	0 - 22* Pbx	-
Landberg	88	30	100	4	8	5	C	PT, AZV, B, F P.L. AZV, U.I.T	87				19.8 T	1-pyridin	Mean 92	-	-	-	50% Ext.	-
Milano	90	212	89	4	9	5	C	PT, AZV, U.I.T E.T	46				31	1-pyridin	71% G.E	-	0.4	-	50% Pbx	-
Wolter	90	71	87	5	10	8	C	P.L. U.I.T PT + E.T	39				18	11.5 S	Mean 89	48	1.6	-	0	36
Holman	91	90	83	5	-	-	C	ST + E.T ST + E.T	Mean 2 mm	K.I	98 N	Mean 1.4	Mean 1.2	Combinat	75% G.E 50% G.E	-	-	-	-	-
Reckman	91	103	73	6	-	-	A	PT, U.I.T + E.T	58.1				mean 1.4	1-pyridin	Mean 95	78	13	-	22% Ext.	36
Agazzi	92	44	96	4	10	7	C	PT, AZV, B, F + E.T	7	K.I	Mean 1.6	41	mean 1.4	mean	60% G.E	83	2.3	-	10% Pbx	26
Tempery	93	69	88	4	-	9	C	P.L. U.I.T. + E.T	5				9	1-pyridin	60% G.E	-	8.5	-	30% Pbx	61
Andriani	94	217	32	5	9	7	C	ST, AZV, B, F + E.T	19	K.I	89 N	41	mean 1.4	Zidov	90% G.E	-	-	Mean 8 + Pbx	31	
Landi	94	91	97	5	-	-	A A 40% S.T. AZV, 32% P.T. AZV, 25% I.L. 25%	S.T. AZV, 32% P.T. AZV, 25% I.L. 25%		K.I	Mean 1.6	67	36	-	-	44	4	-	-	-
Leoni	94	214	84	4	8	5	A 17% A 17% C 83%	P.L. AZV, 25% A 17% C 83%		K.I				1-pyridin	70% G.E	90	1.9	7	7.5% Ext.	41
Saengpho	94	171	82	4	8	5	C	P.L. B, 1 + A.I.T	32				17	1-pyridin	70% G.E	90	1.9	7	7.5% Ext.	41
Maraschi	95	82	100	4	8	5	A 20% C 75%	PT, AZV, B, 1 + A.I.T	32	K.I	Mean 1.6	37.1	32	1-pyridin	70% G.E	90	1.9	7	7.5% Ext.	41
Prichard	95	79	51	9	14	11	A 30% C 70%	P.L. AZV, U.I.T, 7 B, 1 + E.T	5	K.I	Mean 1.6	22.5	29	1-pyridin	70% G.E	90	1.9	7	7.5% Ext.	41
Spachth	95	75	100	5	12	8	C 60%	60% S.T. AZV (1 indomethacin)	24				29	1-pyridin	70% G.E	90	1.9	7	7.5% Ext.	41
Zavira	95	14	100	8.5	11	8.5	C	PT, AZV, U.I.T + E.T 40% P.T. AZV	4	K.I	Mean 1.6	22.5	29	1-pyridin	70% G.E	90	1.9	7	7.5% Ext.	41
Agazzi (transverse)	96	77	90	4	8	5	A	ST, AZV, U.I.T, AZV	10	K.I	Mean 1.6	22.5	29	1-pyridin	70% G.E	90	1.9	7	7.5% Ext.	41
Milano	96	304	87	5	9	7	C	PT, AZV, B, F P.L. AZV, B, F	42	K.I	Mean 1.6	22.5	29	1-pyridin	70% G.E	90	1.9	7	7.5% Ext.	41
Milano	96	96	71	5	9	7	A	P.L. AZV, B, F P.L. AZV, B, F	22.2	K.I	Mean 1.6	22.5	29	1-pyridin	70% G.E	90	1.9	7	7.5% Ext.	41
Laplan	96	21	101	8.5	10	9	C	PT, AZV, B, F P.L. AZV, B, F	11	K.I	Mean 1.6	22.5	29	1-pyridin	70% G.E	90	1.9	7	7.5% Ext.	41
Agazzi	97	101	88	5.4	7	8.6	C	PT, AZV, B, F	11	K.I	Mean 1.6	22.5	29	1-pyridin	70% G.E	90	1.9	7	7.5% Ext.	41
Landi	98	97	88	5	-	9	A 32% C 32%	PT, AZV, B, F	11	K.I	Mean 1.6	22.5	29	1-pyridin	70% G.E	90	1.9	7	7.5% Ext.	41
Chou	98	80	81	5	-	-	A 32% C 32%	PT, AZV, B, F	11	K.I	Mean 1.6	22.5	29	1-pyridin	70% G.E	90	1.9	7	7.5% Ext.	41
Milano	98	30	90	9	11	11	C	S.T. + E.T	33.4				18.5	11.5 S	Mean 40.6	77	1	4.4	20% Ext.	28

$P(H)$, $P(F)$ = Further studies, $Q(F)$ = Quadriceps motion, $F(F)$ = Force exerted, $\sigma(F)$ = standard deviation of force

more than 10 year follow-up (19, 23, 48, 49, 51) (table V).

The total number of cases (370) is very low, but with a follow-up of 77%. Two of the reported series were treated with the Leeds-Keio synthetic ligament scaffold, but the arthroscopic, operative and histological follow-up data show that it does not induce a valid neoligament and therefore acts as a prosthesis. The synthetic reconstructions were overwhelmingly performed in chronic cases. Fifty-eight percent of the patients (range 17 to 85%) demonstrated a positive Lachmann, 38.6% (range 31%-50%), a positive instrumented Lachmann and 41.7% (range 25 to 62%) a positive pivot shift.

In contrast with the other treatment regimens we seem to find a better correlation between the laxity values and the functional score, with a low 71.3% of Lysholm good and excellent scores (43 to 78%). The mean sports participation was 54.6% (range 52 to 83%).

The protective effect of the synthetic ACL reconstruction against further meniscal lesions is questionable, given the 23.2% incidence (range 14 to 40%) of postreconstruction meniscal surgery.

Synthetic ACL grafts seem doomed to failure through fatigue and abrasion, and this is reflected by a 17.6% incidence (range 7 to 51%) of further ACL surgery. The fragmentary data in the reports concerning postoperative loss of motion seem to indicate a lower rate of iatrogenic loss of motion, but the degree of secondary osteoarthritic degeneration towers above the results of all other procedures (50% to 83%).

F. Comparison of the different procedures

The analysis of the long-term results of primary repair, extraarticular tenodesis, reconstruction and prosthetic replacement of the ACL confirm that the best results have been obtained with ACL reconstructions (table VI).

ACL reconstructions were also compared with conservative treatments (table VII). The mean follow-up of the conservatively treated series is somewhat longer, with also substantially more reports (71% versus 27%) including patients with

at least 10 years of follow-up. The most striking difference between both treatment regimens concerns the residual knee laxity.

After conservative treatment almost all patients (89%) still demonstrate a positive Lachmann and 2 out of 3 (59%), a positive pivot shift.

The surgical treatment can abolish the Lachmann and instrumented Lachmann in about 2 out of 3 cases (respectively 34.8 and 31.1%) and the pivot shift in about 4 out of 5 cases (20.8%).

The mean functional scores seem to yield nearly identical results with surgical (73% good and excellent results) and conservative (70% good and excellent results) treatments.

There is a marked difference in the incidence of secondary ACL surgery after conservative (4.6%) and surgical (8.0%) treatment, the latter surprisingly being twice as frequent. The lower rates of secondary meniscal surgery after ACL reconstruction (3.5% versus 12% after conservative treatment) show the protective role of the surgical reconstruction.

The broad range of secondary meniscal surgery after conservative treatment (3.5-23.7%) indicates however that persistent ACL deficiency is not the only factor in the genesis of further meniscal injury. The reported percentages of secondary osteoarthritis are somewhat higher after surgical treatment (37.4% versus 27.6% after conservative treatment).

DISCUSSION

Reviewing the above-mentioned medium-term reports and results, one is astonished by the paucity of the available data concerning a rather frequent pathology, for which surgical techniques have often been advocated.

The scientific value of this analysis can be questioned, owing to the poor scientific standard of almost all published reports.

Arbitrary selection of patients, short follow-ups with low follow-up rates, and nonrandomised treatment regimens are the main culprits inducing unacceptable biases and limiting the usefulness of most reports.

Table V Meta-analysis of reports of ACL reconstructions with prostheses

Author	Year	N Cases	% F.U.	Years F.U.			Acute/Chronic	Treatment	% Lachm *	Arthrometer			% Pivot *	Functional Score		% Sports	Second Surg		% Loss Motion	% Arthritis
				Min.	Max.	Mean				Type	Force	% *		Type	Value		% Men	% ACL		
Dandy	94	100	73	4	6	9	C	I.K. + L.F.	85	-	-	-	40	Lysolm	74% G.E.	66	14	7.1	-	-
Jernst Makhslo	93	50	74	3	7	6	C	I.K.	24	81	131 N	38.0	34.0	IKDC	67% A + B	70	-	10	10% Flex.	-
	96	50	74	413	8	-	25% A 75% C	Carbon	17	Stryker	-	mean 2.5	-	Lysolm	43% G.E.	-	-	-	23% Ext.	76
Mancoske Malesha	98	40	100	3	6	6	A	I.K.	30	81	131 N	30	25	IKDC	55% A + B	87	-	7.5	-	50
	97	70	79	7	11	9	C	Dacron	-	Stryker	90 N	11	62	Lysolm	67% G + E	50	40	31	-	61

N.B.:

I.K.: Lachm + Knu

Table VI. Comparison of the meta-analysis of different surgical treatments for ACL

Treatment	N° reports		Total N° cases	% F.U.	% Lachm. *	% instr. Lachm. *	% Pivot *	Second. Surg.		% Sports
	> 4 y F.U.	some cases > 10 y F.U.						% Men	% ACL	
Primary repair	13	4	1,205	80	41.9 (21 - 94)	52.5 (31 - 71)	21.7 (6 - 55)	16.4 (6 - 38)	12.0 (0 - 25)	45.2 (27 - 92)
Extraarticular tenodesis	4	3	232	60	54.3 (37 - 91)	63.0 (61 - 64)	47.4 (33 - 75)	23.4 (5 - 28)	13.6 (6 - 26)	55.2 (44 - 74)
Reconstruction	26	7	2,693	77	34.8 (4 - 91)	31.1 (16 - 70)	20.8 (3 - 52)	3.5 (0 - 15)	8.0 (0 - 14)	74.4 (8 - 100)
Synthetics	5	2	370	77	58.0 (17 - 85)	38.6 (31 - 50)	41.7 (25 - 62)	23.2 (14 - 40)	17.6 (7 - 51)	54.6 (52 - 83)

Table VII. Surgical versus conservative results

	Conservative treatment	Surgical treatment
% Lachmann *	89 (9 - 100)	34.8 (4 - 91)
% instrumented Lachmann *	58.5 (9 - 84)	31.1 (16 - 70)
% Pivot *	59 (5 - 84)	20.8 (3 - 52)
% good / exc. funct. score	70 (37 - 82)	73 (47 - 100)
% sports participation	45 (30 - 55)	74.4 (8 - 100)
% secondary ACL surgery	4.6 (0 - 18)	8.0 (0 - 14)
% secondary meniscal surgery	12.0 (3.5 - 21.7)	3.5 (0 - 15)
% osteoarthritis	18 (7 - 61)	37.4 (12 - 100)

This is therefore not an ideal meta-analysis which can provide indisputable results and conclusions.

It is however the only available pooled evaluation of medium- and long-term results of ACL treatments, and it could have informative value concerning ACL management.

Many of the reports on primary repair concern a fair number of isolated and partial ACL lesions, which can generate a favorable bias.

Isolated extraarticular tenodeses show an unacceptable recurrence rate of knee laxity over time and most authors agree that these techniques should no longer be used. Short-term reports on the association of extraarticular tenodeses with intraarticular ACL reconstructions yield conflicting results (56, 59, 77).

The results of surgical reconstructions can be biased by the pooling of results of chronic and acute cases, as the results of treatment of chronic ACL deficiency are less optimal (58).

It is difficult to group and compare studies concerning intraarticular reconstructions of the ACL, owing to the wide spectrum of different techniques used.

The reconstruction can be performed open or arthroscopically, through tibial and femoral bone tunnels, or with the graft routed "over the top" of the lateral femoral condyle.

The graft materials, for which the relative strength and stiffness were extensively studied, are mostly fascia lata, patellar tendon and/or quadriceps tendon, and hamstring tendons.

Autografts as well as allografts, also of the Achilles tendon, have been used (57, 58).

The latter have been processed deep-frozen, freeze-dried, sterilized with ethylene oxide, or with gamma radiation. These processings also influence the mechanical characteristics of the grafts (80).

Xenografts on the other hand have been relatively rapidly discarded, because of deleterious short-term results.

The fixation of the graft is performed with sutures, bone screws, interference screws, staples or special anchors. Surgical techniques also evolve

over time, sometimes on unproven grounds (32), but also based upon better knowledge of graft materials and intraarticular anatomy.

It has been suggested, but not demonstrated, that the iatrogenic complications, as well as some poor outcome results after ACL reconstruction, are related to imperfect surgical techniques and inadequate or suboptimal anatomic reconstructions (4, 27).

One can question this view, considering the tremendous emphasis on surgical techniques for ACL reconstruction to be found in the literature and the huge number of ACL reconstructions performed (30).

Moreover, the laxity after surgical treatment remains worrisome, as it is seen to progress over time (18, 36, 64, 66, 79), and since a notable proportion of patients will ultimately not be stabilized by the procedure.

A few reports (36, 37, 61, 64, 66, 79) studied the laxity and the functional scores at different time intervals. Johnson found no difference in laxity scores after 5 to 7.5 years of follow-up, compared with 7.5 to 10 years of follow-up (37).

A recent paper did not report an increasing laxity between 1 and 5 years of follow-up (61).

Most other sequential reports show a deterioration to occur, mostly between 2 and 5 years of follow-up. This probably explains Johnson's absence of difference, as the laxity had already recurred before the 5- to 7.5-year time interval. The deterioration is mainly visible in the laxity data, less in the functional scores. The latter can paradoxically improve, but this is mostly the effect of regaining some motion which had been reduced due to the reconstructive procedure.

Due to many pessimistic short- and medium-term reports, the use of synthetics has nowadays been virtually discontinued (33, 43, 55, 60). De Smedt (24) has clearly demonstrated that the broad dissemination of these unproven techniques and devices fooled numerous surgeons, and led thousands of patients to be submitted to operative treatments of which the results could have been predicted by a few scientifically sound reports.

The high number of prosthetic ligament failures, combined with foreign body reactions to abrasion

particles even generated the development of specific revision techniques (32).

The association of mechanical degradation through laxity and meniscal loss, with biological degradation through particle-induced foreign body synovitis, probably explains the high rate of secondary osteoarthritis after procedures using synthetics.

The present analysis also shows a discrepancy between functional scores and clinical laxity tests. Laxity values obtained by static laxity tests are of course useful evaluation data, but their value and relevance have to be considered with caution.

Indeed, the forces applied to the articular structures of the knee during these tests are probably very small compared to the forces generated during activities of daily living and sports. The acceleration and the resultant tissue strain could also be extremely different.

This hypothesis explains the higher percentages of positive instrumented Lachmann's found when testing the same knees with increasing displacement forces, e.g. as with the KT 1000 at 89 and 134 Newton and at maximal manual displacement force (3, 20).

On the other hand, Vergis and Gillquist have shown that ACL deficient knees, when tested with an electrogoniometric system during single step ascents and descents, were able to keep the active dynamic laxity within normal limits, despite revealing abnormal laxity during static tests (76). This emphasizes the role of proprioception and knee muscle activity.

As all functional scores are based partially on the patient's subjective assessment and symptoms, it is clear that the latter, and therefore also the scores, are closely activity-related.

A cascade of events has been described going from ACL disruption (associated or not with meniscal injuries) over to secondary reinjuries with meniscal tears and to joint arthritis (21).

The effect of ACL reconstructive surgery on this cascade of events remains unclear, and the further evolution of osteoarthritis is clearly not exclusively meniscus-related.

Whereas the surgical reconstructions suffer fewer secondary meniscal lesions, they end up with a higher percentage of osteoarthritis. Sommerlath had already demonstrated that there was a significant variation in osteoarthritis in ACL-deficient knees, not only related to the degree of meniscal loss, but also to the activity level (70). These clinical impressions were confirmed by Daniel *et al.*, who reported an increased incidence of osteoarthritis, diagnosed by radiology and bone scanning, in patients with "successfully" reconstructed knees. This could not be explained by a significantly higher incidence of meniscal surgery in patients who had undergone ACL reconstructions (20).

Similar findings were also reported by Fritschy *et al.* (31) and Aglietti *et al.* (2). The common link between these reports is a higher activity level in the ACL reconstructed knees, perhaps allowed by the ACL reconstruction?

The ratio of Noyes and Barber (56), 1/3 worse, 1/3 unchanged, 1/3 improved, is often quoted as what to expect from nonoperative treatment protocols. However the present analysis of nonoperative treatments of acute ACL injuries demonstrates clearly better results.

Series reporting the results of conservative treatment in lower activity level populations, and others in which treatment included patient counseling to avoid cutting, pivoting and jumping sports also report markedly lower rates of secondary meniscal surgery (13, 62) compared with series of conservative treatment in higher activity level populations with unrestricted sports participation (6, 15, 20). The rather low activity level, resulting in a reduced incidence of secondary meniscal lesions, can also explain the low rate of osteoarthritis. The only conclusion that can be drawn from the comparison of scores of surgical and conservative treatment, is that both treatment regimens offer almost equal results, but probably at different activity levels, as illustrated by the difference in sports participation which is almost twice as frequent after surgical treatment (74%) as after conservative treatment (45%).

Sports participation has to be questioned as an outcome criterion of ACL treatment. Whereas

sports participation at the same level, with the same frequency and intensity, was considered in former years "the" success criterion of ACL treatment, more thorough data on the imperfect nature of available ACL treatments have now shed a different light on ACL treatment outcome (27, 32).

The real benchmarks of success have to be the avoidance of treatment morbidity, secondary surgery and osteoarthritis. This supports the hypothesis of Dye of the "envelope of function" as a zone in which articular homeostasis can be maintained in relation to some intensity and frequency of articular loading (25). This "envelope of function" can probably not be totally restored by ACL reconstruction, and unrestricted loading disrupts the homeostasis, which leads to osteoarthritis. On the other hand a more limited activity level with an unreconstructed knee can still allow articular homeostasis.

Nonetheless the orthopedic community has until now failed to produce sufficient well documented, randomised, long-term reports in order to establish a scientific evidence basis for the management of ACL lesions.

Even taking into account the difficulties related to, and the energy required by, these studies, surgeons frequently confronted with ACL pathology should consider participation in these studies as an ethical duty, notwithstanding patient demands and economic pressures.

REFERENCES

1. Aglietti P., Buzzi R., D'Andrea S., Zaccherotti G. Long term study of anterior cruciate ligament reconstruction for chronic instability using the central one-third patellar tendon and a lateral extraarticular tenodesis. *Am. J. Sports Med.*, 1992, 20, 38-45.
2. Aglietti P., Buzzi R., Zaccherotti G., De Biase P. Patellar tendon versus doubled semitendinosus and gracilis tendons for anterior cruciate ligament reconstruction. *Am. J. Sports Med.*, 1994, 22, 211-218.
3. Aglietti P., Buzzi R., Menchetti P. P., Giron F. Arthroscopically assisted semitendinosus and gracilis tendon graft in reconstruction for acute anterior cruciate ligament injuries in athletes. *Am. J. Sports Med.*, 1996, 24, 726-731.
4. Aglietti P., Buzzi R., Giron F., Simeone A. J., Zaccherotti G. Arthroscopic-assisted anterior cruciate ligament reconstruction with the central third patellar tendon: A 5-8 year follow-up. *Knee Surg. Sports Traumatol. Arthroscopy*, 1997, 5, 138-144.
5. Amisault J. D., Cameron J. C., MacIntosh D. L., Marks P. Chronic anterior cruciate ligament deficiency: Long term results of MacIntosh's lateral substitution reconstruction. *J. Bone Joint Surg.*, 1988, 70-B, 622-624.
6. Andersson C., Odensten M., Good L., Gillquist J. Surgical or non-surgical treatment of acute rupture of the anterior cruciate ligament: A randomized study with long term follow-up. *J. Bone Joint Surg.*, 1989, 71-A, 965-974.
7. Andersson C., Odensten M., Gillquist J. Knee function after surgical or non-surgical treatment of acute rupture of the anterior cruciate ligament: a randomized study with a long term follow-up period. *Clin. Orthop.*, 1991, 264, 255-263.
8. Anderson A. F., Snyder R. B., Lipscomb A. B. Anterior cruciate ligament reconstruction using the semitendinosus and gracilis tendons augmented by the Loefer iliotibial band tenodesis: A long term study. *Am. J. Sports Med.*, 1994, 22, 620-626.
9. Bach B. R., Tradonsky S., Bojchuk J. et al. Arthroscopically assisted anterior cruciate ligament reconstruction using patellar tendon autograft. Five-to-nine-year follow-up evaluation. *Am. J. Sports Med.*, 1998, 26, 20-29.
10. Besnard P., Goutallier D. Suture du ligament croisé antérieur renforcée par des fibres de carbone. Résultats anatomiques et dégradation articulaire à 8 ans de recul. *Rev. Chir. Orthop.*, 1998, 34, 162-171.
11. Bobic V. Current concepts in anterior cruciate ligament reconstruction. *Surgery*, 1992, 10, 241-247.
12. Buckley S. L., Barrack R. L., Herbert-Alexander A. The natural history of conservatively treated partial anterior cruciate ligament tears. *Am. J. Sports Med.*, 1989, 17, 221-225.
13. Casteleyn P. P., Handelberg F. Nonoperative management of anterior cruciate ligament injuries in the general population. *J. Bone Joint Surg.*, 1996, 78-B, 446-451.
14. Chambat P. Le ligament croisé antérieur. In: Duparc J. ed. *Cahiers d'enseignement S.O.F.C.O.T. Expansion scientifique française*, Paris, 1885, pp. 79-101.
15. Cicotti M. G., Lombardo S. J., Nonweiler B., Pink M. Non-operative treatment of ruptures of the anterior cruciate ligament in the middle-aged patients: Results after long term follow-up. *J. Bone Joint Surg.*, 1984, 76-A, 1315-1321.
16. Cross M. J., Wootton J. R., Bokor D. J., Sorrenti S. J. Acute repair of injury to the anterior cruciate ligament: A long-term follow-up. *Am. J. Sports Med.*, 1998, 26, 128-131.
17. Dahlstedt L. J., Dalen N., Jonsson U. Extraarticular repair of the unstable knee: Disappointing 6 year results of the Slocum and Ellison operations. *Acta Orthop. Scand.*, 1988, 59, 687-691.

18. Dandy D. J., Gray A. J. Anterior cruciate ligament reconstruction with the Leeds-Keio prosthesis plus extra-articular tenodesis. *J. Bone Joint Surg.*, 1994, 76-B, 193-197.
19. Dandy D. J. Historical overview of operations for anterior cruciate ligament rupture. *Knee Surg. Sports Traumatol. Arthroscopy*, 1996, 3, 256-261.
20. Daniel D., Stone M. L., Dobson B. *et al.* Fate of the ACL-injured patient. A prospective outcome study. *Am. J. Sports Med.*, 1994, 22, 632-643.
21. Dehaven K. Meniscus repair in the athlete. *Clin. Orthop.*, 1995, 198, 31-35.
22. Dempsey S. M., Treggoning R. J. Nine-year follow-up results of two methods of MacIntosh anterior cruciate ligament reconstructions. *Clin. Orthop.*, 1993, 294, 216-222.
23. Denti M., Bigoni M., Dodaro G., Monteleone M., Arosio A. Long term results of the Leeds-Keio anterior cruciate ligament reconstruction. *Knee Surg. Sports Traumatol. Arthroscopy*, 1995, 3, 75-77.
24. De Smedt M. Les prothèses du ligament croisé antérieur : analyse d'une échec. *Acta Orthop. Belg.*, 1998, 64, 422-433.
25. Dye S. The knee as a biologic transmission with an envelope of function. A theory. *Clin. Orthop.*, 1996, 323, 10-186.
26. Engebretsen L., Benum P., Sundalsvoll S. Primary suture of the anterior cruciate ligament : A 6-year follow-up of 74 cases. *Acta Orthop. Scand.*, 1989, 60, 561-564.
27. Eriksson E. How good are the results of ACL reconstruction ? *Knee Surg. Sports Traumatol. Arthroscopy*, 1997, 5, 137.
28. Feagin J. A., Curl W. W. Isolated tear of the anterior cruciate ligament : 5-year follow-up study. *Am. J. Sports Med.*, 1976, 4, 95-100.
29. Feagin J. A. The syndrome of the torn anterior cruciate ligament. *Orthop. Clin. North Am.*, 1979, 10, 81-96.
30. Frank C. B., Jackson D. W. The science of reconstruction of the anterior cruciate ligament. *J. Bone Joint Surg.*, 1997, 79-A, 1356-1376.
31. Frisby D., Daniel D., Rossman D., Rangger C. Bone imaging after acute knee hemiarthrosis. *Knee Surg. Sports Traumatol. Arthroscopy*, 1993, 1, 20-27.
32. Gillquist J. Repair and reconstruction of the ACL : Is it good enough ? *Arthroscopy*, 1993, 9, 68-71.
33. Greis P. E., Steadman J. R. Revision of failed prosthetic anterior cruciate ligament reconstruction. *Clin. Orthop.*, 1996, 232, 78-90.
34. Grøntvedt T., Engebretsen L., Benum P., Anda S. Extraarticular transposition of the patellar tendon for anterolateral instability of the knee. *Acta Orthop. Scand.*, 1995, 66, 321-324.
35. Grøntvedt T., Engebretsen L., Rossvoll I., Smevik O., Nilsen G. Comparison between Magnetic Resonance Imaging findings and knee stability : Measurement after anterior cruciate ligament repair with and without augmentation : A five-to-seven-year follow-up of 52 patients. *Am. J. Sports Med.*, 1995, 23, 729-735.
36. Grøntvedt T., Engebretsen L., Benum P. *et al.* A prospective randomized study of three operations for acute rupture of the anterior cruciate ligament : a five-year follow-up of one hundred and thirty-one patients. *J. Bone Joint Surg.*, 1996, 78-A, 159-168.
37. Johnson R. J., Eriksson E., Haggmark T., Pope M. H. Five-to-10-year follow-up evaluation after reconstruction of the anterior cruciate ligament. *Clin. Orthop.*, 1984, 183, 122-140.
38. Johnson R. J., Beynon B. D., Nichols C. S., Renström P. A. The treatment of the injuries of the ACL. *J. Bone Joint Surg.*, 1992, 74-A, 140-151.
39. Johnson R. J. Revision ACL surgery. In : Fu F., Harner C. D., Vince K. G., eds. *Knee surgery*. Williams and Wilkins, Baltimore, 1994, pp. 877-895.
40. Holmes P. F., James S. L., Larson R. L., Singer K. M., Jones D. C. Retrospective direct comparison of three intraarticular anterior cruciate ligament reconstructions. *Am. J. Sports Med.*, 1991, 19, 596-600.
41. Kaplan N., Wickiewicz T., Warren R. F. Primary surgical treatment of anterior cruciate ligament ruptures : A long-term follow-up study. *Am. J. Sports Med.*, 1990, 18, 354-358.
42. Kdolsky R. H., Gibbons D. F., Kwasny O., Schabus R., Plenik H. Braided polypropylene augmentation device in reconstructive surgery of the ACL : Long term clinical performance of 594 patients and short term arthroscopic results, failure analysis by scanning electron microscopy and synovial histomorphology. *J. Orthop. Res.*, 1997, 15, 1-10.
43. Klein W., Jensen K. U. Synovitis and artificial ligaments. *Arthroscopy*, 1992, 8, 116-124.
44. Kornblatt I., Warren R. F., Wickiewicz T. L. Long term follow-up of anterior cruciate ligament reconstruction using the quadriceps tendon substitution for chronic anterior cruciate ligament insufficiency. *Am. J. Sports Med.*, 1988, 16, 444-448.
45. Levitt R. L., Malinin R., Posada A., Michlow A. Reconstruction of anterior cruciate ligament with bone-patellar tendon-bone and Achilles tendon allografts. *Clin. Orthop.*, 1994, 303, 67-78.
46. Lindstrand A. The ACL problem. *Acta Orthop. Scand.*, 1995, 66, 105-106.
47. Lundberg M., Messner K. Ten-year prognosis of isolated and combined medial collateral ligament ruptures : A matched comparison in 40 patients using clinical and radiographic evaluations. *Am. J. Sports Med.*, 1997, 25, 2-6.
48. Maletius W., Gillquist J. Long term results of anterior cruciate ligament reconstruction with a dacron prosthesis : The frequency of osteoarthritis after seven to eleven years. *Am. J. Sports Med.*, 1997, 25, 288-293.
49. Mäkilä S. E., Visuri T., Viljanen A., Jokio P. Reconstruction of the anterior cruciate ligament with carbon

- fibres: Unsatisfactory results after 8 years. *Knee Surg. Sports Traumatol. Arthroscopy*, 1996, 4, 132-136.
50. Marcacci M., Zaffagnini S., Iacono F., Neri M. P., Peritto A. Early versus late reconstruction for anterior cruciate ligament rupture: Results after five years of follow-up. *Am. J. Sports Med.*, 1995, 23, 690-693.
51. Marcacci M., Zaffagnini S., Visani A. *et al.* Arthroscopic reconstruction of the anterior cruciate ligament with Leeds-Keio ligament in non-professional athletes: Results after a minimum 5 years follow-up. *Knee Surg. Sports Traumatol. Arthroscopy*, 1996, 4, 9-13.
52. Meystre J. L., Vallotton J., Benvenuti J. F. Double semitendinous anterior cruciate ligament reconstruction: 10-year results. *Knee Surg. Sports Traumatol. Arthroscopy*, 1998, 6, 76-81.
53. Mitsou A., Vallianatos P., Piskopakis N., Maheras S. Anterior cruciate ligament reconstruction by over-the-top repair combined with popliteus tendon plasty. *J. Bone Joint Surg.*, 1990, 72-B, 398-404.
54. Mitsou A., Vallianatos P. Reconstruction of the anterior cruciate ligament using a patellar tendon autograft: A long term follow-up. *Int. Orthop.*, 1996, 20, 285-289.
55. Moyer D., Lerat J. L. A. Artificial ligaments for anterior cruciate replacement: A new generation of problems. *J. Bone Joint Surg.*, 1994, 76-B, 173-175.
56. Noyes F. R., Barber S. D. The effect of an extra-articular procedure on allograft reconstructions for chronic ruptures of the anterior cruciate ligament. *J. Bone Joint Surg.*, 1991, 73-A, 882-892.
57. Noyes F. R., Barber S. D. Reconstruction of the anterior cruciate ligament with human allograft: comparison of early and later results. *J. Bone Joint Surg.*, 1996, 78-A, 524-537.
58. Noyes F. R., Barber-Westin S. Anterior cruciate ligament reconstruction with autogenous patellar tendon graft in patients with articular cartilage damage. *Am. J. Sports Med.*, 1997, 25, 626-634.
59. O'Brien S. J., Warren R. F., Wickiewicz T. L. *et al.* The iliotibial band lateral sling procedure and its effect on the results of anterior cruciate ligament reconstruction. *Am. J. Sports Med.*, 1991, 19, 21-25.
60. Olson E. J., Kang J. D., Fu F. H. *et al.* The biomechanical and histological effect of artificial ligament wear particles: *in vitro* and *in vivo* studies. *Am. J. Sports Med.*, 1988, 16, 358-370.
61. Otto D., Pinczewski L. A., Clungefleiter, A. Odell R. Five-year results of single-incision arthroscopic anterior cruciate ligament reconstruction with patellar tendon autograft. *Am. J. Sports Med.*, 1998, 26, 181-188.
62. Pattee G. A., Fox J. M., Del Pizzo W., Friedman M. J. Four to ten year follow-up of unreconstructed anterior cruciate ligament tears. *Am. J. Sports Med.*, 1989, 17, 430-435.
63. Pritchard J. C., Drez D., Moss M., Heck S. Long term follow-up of anterior cruciate ligament reconstructions using freeze-dried fascia lata allografts. *Am. J. Sports Med.*, 1995, 23, 593-596.
64. Rackemann S., Robinson A., Dandy D. J. Reconstruction of the anterior cruciate ligament with an intra-articular patellar tendon graft and an extra-articular tenodesis: Results after six years. *J. Bone Joint Surg.*, 1991, 73-B, 368-373.
65. Reid J. S., Hanks G. A., Kalenak A., Kottmeier S., Aronoff V. The Ellison iliotibial-band transfer for a torn anterior cruciate ligament of the knee: Long term follow-up. *J. Bone Joint Surg.*, 1992, 74-A, 1392-1402.
66. Sandberg R., Balkfors B. The durability of anterior cruciate ligament reconstruction with the patellar tendon. *Am. J. Sports Med.*, 1996, 24, 341-343, 1988.
67. Saragaglia D., Leroy J. M., Tourné Y., Picard F., Abu Al Zahab M. Résultats à moyen terme de 173 plasties du ligament croisé antérieur selon la technique de MacIntosh renforcée par Kennedy-LAD. *Rev. Chir. Orthop.*, 1994, 80, 230-238.
68. Sherman M. F., Lieber L., Bonamo J. R., Podesta L., Reiter I. The long term follow-up of primary anterior cruciate ligament repair: Defining a rationale for augmentation. *Am. J. Sports Med.*, 1992, 20, 243-255.
69. Shirakura K., Terauchi M., Kizuki S., Moro S., Kimura M. The natural history of untreated anterior cruciate tears in recreational athletes. *Clin. Orthop.*, 1995, 317, 227-236.
70. Sommerlath K. The importance of the meniscus in unstable knees. A comparative study. *Am. J. Sports Med.*, 1989, 17, 773-777.
71. Sommerlath K., Lysholm J., Gillquist J. The long term course after treatment of acute anterior cruciate ligament ruptures: A 9-16 year follow-up. *Am. J. Sports Med.*, 1991, 19, 156-161.
72. Sommerlath K., Odensten M., Lysholm J. The late course of acute partial anterior cruciate ligament tears: A 9 to 15-year-follow-up evaluation. *Clin. Orthop.*, 1992, 281, 152-158.
73. Specchiulli F., Laforgia R., Mocci A. *et al.* Anterior cruciate ligament reconstruction: A comparison of 2 techniques. *Clin. Orthop.*, 1995, 311, 142-147.
74. Taylor G. R., Fernandez G. N., Robertson J. A. Long term results of anterior cruciate reconstruction using a fascia lata graft. *The Knee*, 1996, 3, 145-149.
75. Träger D., Pohle K., Tschirner W. Anterior cruciate ligament suture in comparison with plasty: a 5-year-follow-up study. *Arch. Orthop. Trauma Surg.*, 1995, 114, 278-280.
76. Vergis A., Hindriks M., Gillquist J. Comparison of dynamic knee laxity during active and passive motion versus static laxity. *Acta Orthop. Scand.*, 1996, 67 (suppl 272), 99.
77. Wilson W. J., Lewis F., Scranton P. E. Combined reconstruction of the anterior cruciate ligament in competitive athletes. *J. Bone Joint Surg.*, 1990, 72-A, 742-748.
78. Windsor R. E., Insall J. N. Bone block iliotibial band reconstruction for anterior cruciate insufficiency: Follow-up note and minimum five-year follow-up period. *Clin. Orthop.*, 1990, 250, 197-206.

79. Zavras T. D., MacKenney R. P., Amis A. A. The natural history of anterior cruciate ligament reconstruction using patellar tendon autograft. *The Knee*, 1995, 2, 211-217.
80. Zimmerman M. E., Contiliano J. H., Parsons J. R., Prewett A., Billotti J. The biomechanics and histopathology of chemically processed patellar tendon allografts for anterior cruciate ligament replacement. *Am. J. Sports Med.*, 1994, 22, 378-386.

SAMENVATTING

P. P. CASTELEYN. De behandeling van letsels van de voorste kruisband: heilkundig modeverschijnsel, persoonlijke voorkeur of wetenschappelijke gegrondheid? Een studie van middellange- en langetermijn resultaten.

De middellange en lange termijnresultaten van conservatieve en heilkundige behandelingen van voorste kruisbandletsels, werden door middel van literatuurstudie nagegaan. Enkel artikelen met een minimale follow-up van 4 jaar werden hiervoor in aanmerking genomen. Wat de conservatieve behandelingen betreft, kon de literatuurstudie enkel 7 artikelen terugvinden, met een totaal van 636 gevallen.

De artikelen betreffende de heilkundige behandelingen werden in 4 categorieën ingedeeld: primair heilkundig herstel, vertegenwoordigd door 13 artikelen (1205 gevallen), extra-articulaire tenodese, vertegenwoordigd door 4 artikelen (232 gevallen), voorste kruisbandreconstructies, vertegenwoordigd door 26 artikelen (2693) en prosthese synthetische vervanging, vertegenwoordigd door 5 artikelen (370 gevallen).

Wat ook het type behandeling is, geven de functionele scores ongeveer 70% goede en uitstekende resultaten weer.

De klinische laxiteit blijft echter beduidend in bijna alle conservatief behandelde gevallen, in de helft van de gevallen met primair herstel, extra-articulaire tenodese en prosthese synthetische vervanging en in bijna 1/3 van de gevallen met reconstructie van de voorste kruisband. De incidentie van secundaire heilkunde ter hoogte van de voorste kruisband was het laagst in de conservatief behandelde groep (4,6%), daar waar secundaire heilkunde ter hoogte van de menisci het laagst was in de groep met reconstructie van de voorste kruisband (3,5%). Nogthans evolueerde deze laatste groep, in vergelijking met de conservatief behandelde groep naar een hogere morbiditeit in verband met osteoartrrose. Sportdeelname was wel belangrijker in de groep met reconstructie van de voorste kruisband.

Deze analyse biedt dus een wellicht meer realistische kijk op de resultaten van de behandeling van de voorste kruisbandletsels, en illustreert het verband tussen behandeling, activiteitsniveau en osteoartrrose.

RÉSUMÉ

P. P. CASTELEYN. Le traitement des lésions du ligament croisé antérieur: mode chirurgical, préférence personnelle, ou évidence scientifique? Étude des résultats à moyen et long terme.

Les résultats à moyen et long terme des traitements conservateurs et chirurgicaux des lésions du ligament croisé antérieur ont été évalués sur base d'une analyse de la littérature. Seules, les séries comportant un follow-up minimum de 4 ans ont été prises en considération. En ce qui concerne les traitements conservateurs, l'étude de la littérature ne permet de retrouver que sept articles comprenant au total 636 cas.

Les articles concernant les traitements chirurgicaux ont été répartis en quatre catégories: les réparations primaires, avec 13 articles (1205 cas) les ténodèses extra-articulaires, avec 4 articles (232 cas), les reconstructions du pivot central avec 26 articles (2693 cas) et les remplacements prothétiques du ligament croisé antérieur, avec 5 articles (370 cas).

Les scores fonctionnels atteignent à peu près 70% de bons et excellents résultats, quel que soit le traitement. La laxité clinique persiste dans quasi tous les cas traités de façon conservatrice, dans près de la moitié des cas des réparations primaires, des ténodèses extra-articulaires, et des remplacements prothétiques, et dans quasi un tiers des reconstructions du ligament croisé antérieur. L'incidence d'interventions de reconstruction secondaire du pivot central, est la plus faible dans le groupe des traitements conservateurs (4,6%), alors que l'incidence de la chirurgie méniscale secondaire est la plus basse dans le groupe des reconstructions du pivot central (3,5%). Cependant, les traitements chirurgicaux évoluent plus souvent que les traitements conservateurs vers une morbidité liée à l'arthrose. La pratique sportive est cependant plus importante dans le groupe des reconstructions chirurgicales.

Cette analyse de la littérature permet une appréciation plus réaliste des résultats des traitements des lésions du ligament croisé antérieur, et met en exergue les relations entre traitement, niveau d'activité et arthrose.

III. GENERAL CONCLUSION AND PROPOSAL OF KNEE MANAGEMENT ALGORITME

A. *Summary and General Conclusions :*

Recreational and sports activities , work and traffic conditions have created an epidemic of knee injuries.

The current trend toward cost-restricted and outcome-oriented medical care imposes a cheap, accessible , and reproducible way to screen these knee injuries and differentiate between more benign and rather serious lesions.

The presence of an hemarthrosis, to be verified by arthrocentesis can be this screening determinant . (Gillquist '77, Dehaven '80, Casteleyn '88, Frank '88, Bomberg'90).

* If **no hemarthrosis** is present, there can still be a **meniscal injury**.

The clinical diagnostic accuracy for the latter is fairly good (O'Shea '96), and arthrography does not yield a higher accuracy rate. M.R.I. has an higher accuracy rate, but its use has to be restricted, for cost and accessibility related reasons to cases with a doubtful clinical diagnosis (Carmichael '97, Dandy '97, Dixon '96).

Arthroscopy seems to have a similar diagnostic accuracy as M.R.I. . Because of its morbidity, which even if rather low is not nihil, and again because of health care costs reasons, arthroscopy has to be used as a treatment procedure, and not as a purely diagnostic procedure (Boden '90, Rangger '96).

Concerning **chondral lesions**, the clinical diagnosis fares much poorer than for meniscal lesions, and here the diagnostic accuracy of M.R.I., even if lower than for meniscal injuries, is interesting (Gyllis-Morin '87, Handelberg '89, Shahabpour '97).

The cost-effectiveness of M.R.I. is highest in the differential diagnosis between meniscal and chondral lesions in doubtful cases, where arthroscopic treatment will not be mandatory for all patients.

If an **hemarthrosis** is present, the main suspected diagnoses are a **patellar dislocation**, or an ACL injury, associated or not with lesions to other articular structures. The diagnosis of the former is clinically often missed, as the presence of a massive hemarthrosis is the only constant clinical sign. Arthroscopy on the other hand will precisely diagnose the acute dislocation, and evaluate the associated chondral lesions (Dainer '88, Casteleyn '89, Schaffer '95, Sallay '95). The relevance of this arthroscopic diagnosis on further treatment outcome is however not established.

The clinical diagnosis of **ACL lesions** is more worrisome. Clinical laxity tests, and the use of instrumented laxity testing devices have increased the clinical diagnostic accuracy (Torg '76, Galway '72, Daniel '84, Daniel '85).

A positive Lachmann or instrumented Lachmann sign is pathognomonic of a torn ACL. A negative Lachmann is however still possible, in the presence of a torn ACL, due to a displaced meniscal fragment, the joint effusion, and the pain and muscle guarding in the acute setting (Casteleyn '88, Frank '95). The Lachmann test is also dependent on the experience of the examiner, on the extent of the ACL tear, and on the mechanical qualities of the secondary restraints (Noyes '91, Bjordal '97).

In the acute setting, the laxity tests will demonstrate a considerable number of false negative results (Noyes '80, O'Shea '96, Dehaven '80).

Reexaminations after some time, to allow subsidence of the joint and soft tissue effusion, and to try to provide a more painfree examination with less muscle guarding, could be a valuable alternative to enhance the clinical diagnostic accuracy.

This approach has however until now not been validated and the precise clinical diagnosis of partial ACL lesions as well of the associated lesions will even then remain low.

Radiology - notwithstanding Segonds'sign - and ultrasound are of limited diagnostic aid (Graf '89).

Stress radiology only slightly enhances the diagnostic accuracy compared with the use of arthrometers (Dejour '89, Lerat '88, Staubli '91) and M.R.I., in the acute setting is not vastly superior to the clinical diagnostic accuracy, concerning the ACL lesion (Casteleyn '93, Liu '95, Adalberth '94). It is however more valuable concerning the associated lesions.

The examination under anesthesia provides a clear diagnosis in the majority of cases, but still 10 % of all ACL injuries can be missed, and the complementary diagnostic information on associated lesions remains fragmentary (Noyes '80, Casteleyn '81, Pattee '89, Dahlstedt '89).

Only arthroscopy can guaranty a precise and complete diagnosis of all ACL injuries and of all associated lesions.

The first priority in the **treatment of all ACL lesions** is the treatment of the associated lesions, especially concerning the menisci. Limited partial meniscectomies, and surgical meniscal repairs will allow a maximal maintenance of the "meniscal stock" and reduce the progression to osteoarthritis (Dehaven '85, Fowler '87, Barber '97).

The choice between the conservative and the surgical treatment of the ACL lesion itself depends chiefly on the extend of the lesion (total versus partial), the resultant laxity, and the future activity level.

Age - as opposed to the usual age-related decline in strenuous physical activity levels - does not seem to influence the outcome and therefore the treatment indication (Barber '97).

The exact extend of a **partial ACL** lesion can be difficult to evaluate, but, in the absence of a gross pivot shift, conservative treatment is certainly a valuable treatment option, in the light of the fairly good outcome results (Noyes '89).

Further evaluation to assess eventual progression of ACL deficiency is however mandatory.

On the other hand, grossly unstable knees, with multidirectional laxity and marked pivot shift, are at major risk of giving-way, reinjury, repetitive meniscal injury, and osteoarthritis. These knees probably always need a surgical ACL reconstruction (Shelbourne '97, Bray '89).

However, the analysis of long-term treatment results demonstrates that even surgical ACL reconstruction cannot totally restore knee homeostasis, and cannot avoid secondary osteoarthritis in case of joint overloading (Dye '96, Küllmer '94).

A crucial element in the treatment of ACL lesions is therefore the honest information of the patient on the relationship between ACL-pathology induced osteoarthritis and activity levels, and concerning the to be expected results and morbidity of conservative and surgical treatment (Sommerlath '92, Gillquist '93, Ishibashi '97).

For professional athletes, socio-economical factors will also interfere with the decision-making.

For all other patients with **total ACL disruption**, the treatment indication depends on the informed patient's decision to comply or not with a - reduced - activity level compatible with knee homeostasis.

If a moderate activity level, without or with reduced cutting, pivoting and jumping activities can be accepted by the patient, then a conservative treatment can be considered (Sommerlath '92, Shelton '97, Dye '96). This implies a rehabilitation program aimed at muscle strength and coordination training, mainly with closed chain exercises.

Postural stabilisation and proprioceptive enhancement (Caraffa '96) are also useful.

Functional braces can be used for some recreational activities , but their efficiency remains controversial.

Further reevaluation, with clinical laxity testing is again mandatory to detect an increase of knee laxity through overstraining of the secondary restrains. Bone scanning can monitor the knee homeostasis (Dye '93).

If laxity progresses or if the bone scanning remains disturbed despite activity - compliance, the activity has to be further adapted, or a surgical reconstruction considered.

Primary surgical reconstruction can be an informed patients choice in order to maintain a desired level of activity.

One has however to be cautious that this reconstruction precisely does not open the way to joint overloading, disruption of knee homeostasis and osteoarthritis (Gillquist '93, Eriksson '97). Further monitoring of knee homeostasis with bone scanning after ACL reconstruction is therefore probably advisable.

A **treatment algoritme** which is essentially based on the concept of knee homeostasis could raise questions if arthroscopy still has a key role to play in the decision making.

The arthroscopic evaluation of acute traumatic knee hemarthrosis remains however mandatory :

- it is the only diagnostic procedure which , if associated with an examination under anesthesia, yields a complete and precise diagnosis of all lesions (Casteleyn '88). The "natural history" reports of - often undiagnosed - ACL lesions have demonstrated the deleterious effects of the absence of diagnosis, counseling and treatment, with progressive joint destruction and osteoarthritis (Bray '89, Noyes '83, Irvine '92).
- Patient counseling and information, the key to the treatment algoritme is only possible with a complete and precise diagnosis of the ACL and associated lesions.
- The latter, particularly of the menisci, are present in a majority of ACL ruptures. They can be treated during the same arthroscopic procedure, preserving a maximal "meniscal stock", especially in patients in whom no further surgical reconstruction of the ACL will be considered.
In patients in which a reconstruction will be performed - after some weeks to reduce the risk of arthrofibrosis (Mohtadi '91, Shelbourne '96) - it will reduce the further surgical procedure to this reconstruction.
- The arthroscopic evaluation of the acute knee hemarthrosis, and the subsequent lavage of the articulation of most blood, can maybe reduce or abolish another biologic cascade of events , leading to osteoarthritis, and induced by the hemarthrosis itself (Lohmander '93 94).

B. Knee injury management algorithm

ACUTE KNEE INJURY

→ ARTHROCENTESIS :

➡ No hemarthrosis : Clinical Evaluation

- **meniscal lesion** → Arthroscopic repair / meniscectomy
- **chondral lesions**
- **doubt ?** → MRI

➡ Hemarthrosis : Examination and Arthroscopy under anesthesia

- **patellar dislocation**

- **ACL lesion ± associated meniscal lesion**

↓
Primary arthroscopic repair/meniscectomy

↓
Information & counseling :

- **partial ACL** (neg. pivot shift) → **conserv. treatment**
(+ clinical F.U.)
(+ bone scan F.U.)

- **total ACL**
(or partial ACL with pos. pivot shift)

↪ **activity adaptation**

↪ **no activity adaptation**

↪ **gross laxity**

↓
→ **ACL reconstruction**
(+ bone scan F.U.)

↓
secondary activity
adaptation

ADALBERTH T, ROOS H, LAUREN M, AKESON P, SLOTH M, JOHNSON K,
LINDSTRAND A, LOHMANDER LS

Magnetic Resonance Imaging scintigraphy and arthroscopic evaluation
of traumatic hemarthrosis of the knee.

Am. J. Sports Med. 25 : 231 - 237, 1997

BARBER FA, ELROD BF, MCGUIRE DA, PAULOIS LE

Is an anterior cruciate ligament reconstruction outcome age dependent?

Arthroscopy 12 : 720 - 725, 1996

BJORDAL JM, ARNØY F, HANNESTAD B, STRANDT T

Epidemiology of anterior cruciate ligament injuries in soccer.

Am. J. Sports Med. 25 : 341 - 345, 1997

BODEN SD, LABROPOULOS PA, VAILAS JC (1990)

MR scanning of the acutely injured knee : sensitive, but is it cost
effective ?

Arthroscopy 6 : 306 - 310, 1990

BOMBERG CB, MAC GINTY JB

Acute hemarthrosis of the knee : indications for diagnostic arthroscopy.

Arthroscopy 6 : 221 - 225, 1990

BRAY R, DANDY D

Meniscal lesions and chronic anterior cruciate ligament deficiency.
Meniscal tears occurring before and after reconstruction.

J. Bone Joint Surg. 71 B : 128 - 130, 1989

CARAFFA A, CERULLI G, PROJETTI M, AISA G, RIZZO A

Prevention of anterior cruciate ligament injuries in soccer. A prospective control study of proprioceptive training.

Knee Surg. Sports Traumatol. Arthroscopy 4 : 19 - 21, 1996

CARMICHAEL IW, MacLEOD AM, TRAVLOS J

M.R.I. can prevent unnecessary arthroscopy.

J. Bone Joint Surg. 79-B : 624 - 625, 1997

CASTELEYN PP, HANDELBERG F, OPDECAM P

Traumatic hemarthrosis of the knee.

J. Bone Joint Surg. 70 B: 404 - 406, 1988

CASTELEYN PP, HANDELBERG F

Arthroscopy in the diagnosis of occult dislocation of the patella.

Acta Orthop. Belg. 55 : 381 - 383, 1989

CASTELEYN PP, HANDELBERG F

Técnicas de diagnóstico por la imagen.

In : Principios de artroscopia y cirugía artroscópica.

Zarins B, Cugat R. Ed.

Springer-Verlag, Barcelona p. 56 - 65, 1993

DAHLSTEDT LJ, DALEN N

Knee laxity in cruciate ligament injury. Value of examination under anesthesia.

Acta Orthop. Scand. 60 : 181 - 184, 1989

DAINER RD, BARRACK RL, BUCKLEY SL, HERBERT ALEXANDER A

Arthroscopic treatment of acute patellar dislocations.

Arthroscopy 4 : 267 - 271, 1988

DANDY J

Arthroscopy and M.R.I. for the knee.

J. Bone Joint Surg. 79 B : 520, 1997

DANIEL DM, STONE ML, SACHS R, MALCOM L

Instrumented measurement of anterior knee laxity in patients with acute anterior cruciate ligament disruption.

Am. J. Sports Med. 13 : 401 - 407, 1985

DEHAVEN KE

Diagnosis of acute knee injuries with hemarthrosis.

Am. J. Sports Med. 8, 9 - 14, 1980

DEHAVEN KE

Meniscus repair in the athlete.

Clin. Orthop. 198 : 31 - 35, 1985

DEJOUR H, WALCH G, NEYRET PH, CHAMBAT P

Subluxation active en extension après rupture du ligament croisé antérieur : mesure radiologique et apport diagnostique.

J. Traumatol. Sport 6 : 22 - 27, 1989

DIXON AK

Magnetic resonance imaging of meniscal tears of the knee.

J. Bone Joint Surg. 78 B : 174 - 175, 1996

DYE S

The knee as a biologic transmission with an envelope of function. A theory.

Clin. Orthop. 323 : 10 - 18, 1996

DYE S, CHEW MH

The use of scintigraphy to detect increased osseous metabolic activity about the knee .

J. Bone Joint Surg. 75 A : 1388 - 1406, 1993

ERIKSSON E

How good are the results of ACL reconstruction ?

Knee Surg. Sports Traumatol. Arthroscopy 5 : 137, 1997

FRANK A, BEAYFILS Ph, RUA R, BENOIT J

L'arthroscopie dans les hémarthroses posttraumatiques du genou.

Rev. Chir. Orthop. 74, Suppl. II : 177 - 180, 1988

FRANK CB, GRAVEL JC

Hamstring spasm in anterior cruciate ligament injuries.

Arthroscopy 11 : 44 - 448, 1995

FOWLER P, REGAN W

The patient with symptomatic chronic anterior cruciate ligament insufficiency. Results of minimal arthroscopic surgery and rehabilitation.

Am. J. Sports Med. 15 : 321 - 326, 1987

GALWAY rd, BEAUPRE A, MC INTOSH DC

Pivot shift : a clinical sign of symptomatic ACL insufficiency

J. Bone Joint Surg. 54 B : 763 - 776, 1972

GRAF R

Sonographie am bewegungsapparat.

Orthopädie 18 : 2 - 11, 1989

GILLQUIST J, HAGBERG G, ORETOP N

Arthroscopy in acute injuries of the knee joint.

Acta Orthop. Scand. 48 : 190 - 196, 1977

GILLQUIST J

Repair and reconstruction of the ACL : is it good enough ? A commentary.

Arthroscopy 9 : 68 - 71, 1993

GYLYS-MORIN V, HAJEK P, SARTORIS D, RESNICK D

Articular cartilage defects. Detectability in cadaver knees with MR.

Am. J. Radiol. 148 : 1053 - 1157, 1987

HANDELBURG F, SHAHABPOUR M, CASTELLEY PP

Chondral lesions of the patella evaluated with computed tomography, magnetic resonance imaging and arthroscopy.

Arthroscopy 6 : 24 - 29, 1990

IRVINE G, GLASHOW M

The natural history of the meniscus in anterior cruciate insufficiency. Arthroscopic analysis.

J. Bone Joint Surg. 74 b : 403 - 405, 1992

ISHIBASHI Y, RUDY T, LIVESAY G, STONE J, FU F, WOO S.

The effect of anterior cruciate ligament graft fixation site at the tibia on knee stability : evaluation using a robotic testing system.

Arthroscopy 13 : 177 - 182, 1997

KÜLLMER K, LETSCH R, TUROWSKI B

Which factors influence the progression of degenerative osteoarthritis after ACL surgery ?

Knee Surg. Sports Traumatol. Arthroscopy 2 : 80 - 84, 1994

LERAT JL, MOYEN B, DUPRE-LATOURE L, MAINETTI E, LALAIN JJ, BRUNET E

Mesure des laxités antérieures du genou par radiographies dynamiques et par l'arthromètre KT 1000.

Rev.Chir. Orthop. 74, Suppl II : 194 - 197, 1988

LIU SH, OSTI L, HENRY M, BOCCHI L

The diagnosis of acute complete tears of the anterior cruciate ligament . Comparison of M.R.I. , arthrometry and clinical examination.

J. Bone Joint Surg. 77 B - 586 - 588, 1995

LOHMANDER L, HOERRNER L

Metalloproteinases, tissue inhibitor, and proteoglycan fragments in knee synovial fluid in human osteoarthritis.

Arthritis Rheum. 36 : 181 - 189, 1993

LOHMANDER L, ROOS H, DAHLBERG L, HOERRNER L, LARK M

Temporal patterns of Stromelysin - 1, tissue inhibitor, and proteoglycan fragments in human knee joint fluid after injury to the cruciate ligament of meniscus.

J. Orthop. Res. 12 : 21 - 28, 1994

MOHTADI NG, WEBSTER-BOGAERT S, FOWLER PJ

Limitation of motion following anterior cruciate ligament reconstruction : a case-control study.

Am. J. Sports Med. 19 : 620 - 625, 1991

NOYES FR, BASSET RW, GROOD ES, BUTLER DL

Arthroscopy in acute traumatic hemarthrosis of the knee. Incidence of anterior cruciate tears and other injuries.

J. Bone Joint Surg. 65 A : 154 - 162, 1983

NOYES FR, MOOAR LA, MOORMAN CT, MC GINNIS JH

Partial tears of the anterior cruciate ligament. Progression to complete ligament deficiency.

J. Bone Joint Surg. 71 B : 825 - 833, 1989

O'SHEA KJ, MURPHY KP, HEEKIN RD, HERZWURM PJ

The diagnostic accuracy of history, physical examination, and radiographs in the evaluation of traumatic knee disorders.

Am. J. Sports Med. 24 : 164 - 167, 1996

PATTEE GA, FOX JM, DEL PIZZO W, FRIEDMAN MJ

4 to 10 year follow-up of unreconstructed ACL tears .

Am. J. Sports Med. 17 : 430 - 435, 1989

RANGGER C, KLESTIL T, KATHREIN A, INDERSTER A, HAMID L

Influence of magnetic resonance imaging on indications for arthroscopy of the knee.

Clin. Orthop. 330 : 133 - 142, 1996

SALLAY PI, GARETT WE

Acute dislocation of the patella : A correlative pathoanatomical study.

Proc. am. Acad. Orthop. Surg. 337, 1995

SCHAFER N, LEHMANN M, MULLER W

Arthroscopic repair of the medial retinaculum and capsule in acute patellar dislocations.

Proc. Am. Acad. Orthop. Surg. 337, 1995

SHAHABPOUR M, TEBACHE C, CASTELEYN PP, HANDELBERG F, LEROUX GB,
MACHIELS F, DE MAESENEER M, OSTEAX M
IRM du cartilage : comparaison IRM arthroscopie , à propos de 320 cas.
In : Le genou traumatique et dégénératif.
Bard H, Drape JL, Goutallier D, Laredo JD Ed.
Sauramps Medical Montpellier, p. 161 - 176, 1997

SHELBOURNE K, PATEL D, MARTINI D
Classification and management of arthrofibrosis of the knee after anterior
cruciate ligament reconstruction.
Am. J. Sports Med. : 24 : 857 - 868, 1996

SHELBLOURNE K, STUBE K
Anterior cruciate ligament - deficient knee with degenerative arthrosis :
treatment with an isolated autogenous patellar tendon ACL
reconstruction.
Knee Surg. Sports Traumatol. Arthroscopy 5 : 150 - 156, 1997

SHELTON W, BARETT G, DUKES A
Early season anterior cruciate ligament tears.
A treatment dilemma.
Am. J. Sports Med. 25 : 656 - 658, 1997

SOMMERLATH K, GILLQUIST J
the long-term course of various meniscal treatments in anterior cruciate
ligament deficient knees.
Clin. Orthop. 283 : 207 - 214, 1992

TORG JS, CONRAD W, KALEN V
Clinical diagnosis of ACL instability in the athlete.
Am. J. Sports Med. 4 : 84 - 93, 1976

IV. SAMENVATTING

De toename van sport- en vrijetijdsactiviteiten, en de actuele werk- en verkeersomstandigheden hebben geleid tot een **epidemische toename van knietraumata**. In het raam van de huidige tendens tot klinische beoordeling van het medisch handelen, en van de beperking van de medische uitgaven, is het aangewezen dat een eenvoudige en goedkope **screeningstechniek** zou gevonden worden, om op reproduceerbare wijze een onderscheid te maken tussen eenvoudige benigne, en meer belangrijke letsels.

Dit onderscheid kan berusten op de aanwezigheid of niet van een **hemarthrose**. Deze laatste wordt vastgesteld door een gewrichtspunctie.

Indien er **geen hemarthrose** aanwezig is, kan het trauma een meniscaal of chondraal letsel veroorzaakt hebben.

Wat **meniscale letsels** betreft is de klinische diagnostische accuraatheid vrij goed, en wordt deze laatste niet verbeterd door arthrografie. Het onderzoek met magnetische resonantie geeft wel een verhoogde graad van accuraatheid. Het gebruik van magnetische resonantie moet echter beperkt worden tot gevallen met klinische diagnostische twijfel, en dit oa. om redenen van kostprijs.

De arthroscopie biedt een gelijkaardige diagnostische accuraatheid als magnetische resonantie. Arthroscopie moet echter eerder beschouwd worden als een behandelingsprocedure, niet als een zuivere diagnostische procedure, omwille van de hiermede gepaard gaande morbiditeit. Zelfs indien deze laag is, is ze niet onbestaande. Anderzijds is de kost van de diagnostische arthroscopie hoger dan deze van de magnetische resonantie.

Wat de **kraakbeenletsels** betreft, is de klinische diagnose ontoereikend. Ook hier is de diagnostische accuraatheid van magnetische resonantie hoger. Op het vlak van de kostenbaatanalyse, is het gebruik van magnetische resonantie aangewezen in de differentiaal diagnose tussen meniscale en chondrale letsels, gezien hierbij een arthroscopische behandeling niet noodzakelijk zal zijn voor alle patiënten.

Indien een **hemarthrose** door gewrichtspunctie wordt gevonden, kan men òf een dislocatie van de patella, òf een letsel van de voorste kruisband, al dan niet geassocieerd met letsels van de andere intraarticulaire structuren vermoeden.

Men stelt vast dat de klinische diagnose van **patelladislocatie** frequent gemist wordt. Het enige constant klinisch teken is hierbij de massieve hemarthrose. Arthroscopie laat een precieze diagnose toe van patelladislocatie, samen met een evaluatie van eventuele kraakbeenletsels.

Er zijn echter geen gegevens beschikbaar over de invloed van deze precieze arthroscopische diagnose op verdere behandeling en evolutie van deze pathologie .

Wat de klinische diagnose betreft van **letsels van de voorste kruisband**, is deze zonder twijfel verbeterd door het gebruik van specifieke laxiteitstesten, en het meten van de laxiteit, met aangepaste arthrometers.

Een positief teken van Lachmann of een teken van Lachmann bij arthrometrisch onderzoek is pathognomisch voor een voorste kruisbandruptuur. Het is echter mogelijk dat bij het klinische onderzoek er een negatief Lachmann-teken is, alhoewel er effectief een kruisbandruptuur bestaat.

Dit kan door een verplaatsing van een meniscaal fragment, door de vochtuitstorting in het gewricht, en door de pijn welke een spierspanning veroorzaakt, bij acute gevallen.

De accurateheid van de Lachmann-test blijkt af te hangen van de ervaring van de onderzoeker, van de uitbreiding van de kruisbandscheur en van de mechanische eigenschappen van de secundaire ligamentaire gewrichtsstabilisatoren.

In acute gevallen zouden klinische laxiteitstesten een vrij behoorlijk aantal vals-negatieve resultaten weergeven. Een heronderzoek van de patiënt, na enige tijd is een mogelijk alternatief om de klinische accurateheid te verhogen. Inderdaad door een vermindering van de vochtuitstorting in het gewricht en in de weke weefsels, kan een meer pijnvrij onderzoek mogelijk zijn, met minder spierspanning.

Deze aanpak werd tot nu toe echter niet op grondige wijze onderzocht. Anderzijds blijft een precieze klinische diagnose van partiële letsels van de voorste kruisband moeilijk.

Het radiologisch onderzoek - tenzij in de aanwezigheid van het teken van Segond - en het echografisch onderzoek brengen weinig bij tot de diagnose. Het stress radiologisch onderzoek is vergelijkbaar met het gebruik van klinische arthrometers. In acute omstandigheden is de diagnostische accurateheid van magnetische resonantie voor letsels van de voorste kruisband niet hoger dan de klinische accurateheid. Magnetische resonantie geeft echter nuttige informatie betreffende geassocieerde letsels.

Het onderzoek van de knie onder narcose biedt een duidelijke diagnose in de meerderheid van de gevallen, maar ongeveer 10 % van de voorste kruisbandletsels wordt zelfs in deze omstandigheden nog gemist.

Ook biedt het onderzoek onder narcose geen bijkomende informatie betreffende de geassocieerde letsels.

Enkel de arthroscopie kan een precieze en volledige diagnose van alle voorste kruisbandletsels, en alle geassocieerde letsels waarborgen.

De eerste prioriteit bij de **behandeling van voorste kruisbandtraumata** is de behandeling van de geassocieerde letsels, in het bijzonder van de menisci. Beperkte partiële meniscectomieën, en het heelkundig herstel van de menisci laten een maximaal behoud toe van de "meniscale stock" en verminderen derhalve de mogelijke progressie naar arthrose.

De keuze tussen een conservatieve of heelkundige behandeling van het voorste kruisbandletsel zelf, berust voornamelijk op de uitbreiding van het letsel (gedeeltelijk of totaal), de gewrichtslaxiteit, en het verder niveau van fysieke activiteit. De ouderdom op zichzelf lijkt geen invloed te hebben op de verdere evolutie en de keuze van de behandeling. Wel moet hierbij rekening gehouden worden met de normale vermindering, in verband met de leeftijd, van het fysieke activiteitsniveau.

Alhoewel de precieze omvang van **een gedeeltelijk letsel van de voorste kruisband** moeilijk te evalueren is, is een conservatieve behandeling hiervoor aangewezen, op basis van de relatief goede functionele resultaten.

Bij de conservatieve behandeling van deze gedeeltelijke letsels, is een verdere klinische opvolging noodzakelijk, om een eventuele progressie van de laxiteit op te volgen.

Een uitzondering hierop zijn knieën met een belangrijke laxiteit, wat tot uiting komt door een overduidelijk positief pivot shift-teken.

Hogervernoemde knieën met een zeer belangrijke laxiteit, vormen een risicogroep waar doorzakking, repetitief knietrauma en meniscale letsels leiden tot osteoarthrosis. Deze knieën vergen waarschijnlijk altijd een voorste kruisbandreconstructie.

De meta-analyse van de resultaten van **volledige voorste kruisbandletsels** op middellange termijn toont aan dat de heekkundige reconstructie van de kruisband geen volledig herstel biedt van de kniehomeostase en secundaire osteoarthrose niet kan voorkomen, in geval van gewrichtssurmenage.

Een centraal element in de behandeling van kruisbandletsels is derhalve de eerlijke informatie van de patiënt betreffende de mogelijke evolutie naar osteoarthrose, in verband met het activiteitsniveau, en de te verwachten resultaten en morbiditeit, zowel bij conservatieve als heekkundige behandeling.

Voor professionele atleten kunnen socio-economische factoren ook een rol spelen bij deze keuze. Voor alle andere patiënten met een volledige voorste kruisbandscheur, moet de behandelingsindicatie berusten op het aanvaarden door de patiënt van een activiteitsniveau dat compatibel is met het behoud van een kniehomeostase.

Indien de patiënt een **matig activiteitsniveau** kan aanvaarden, zonder activiteiten die draaibewegingen, brutale richtingsveranderingen, en springen, inhouden, dan kan een **conservatieve behandeling** overwogen worden. Dit veronderstelt het toepassen van een rehabilitatie programma gericht op spierversterking en coördinatie, in hoofdde met gesloten ketenoefeningen.

Posturale stabilisatie en verbetering van de proprioceptie zijn eveneens aangewezen. Het gebruik van functionele braces kan nuttig zijn bij

bepaalde recreatieve activiteiten maar er bestaat duidelijk geen eensgezindheid over het nut van deze braces.

Bij een conservatieve behandeling is periodische reëvaluatie van de klinische laxiteit aangewezen, hierdoor kan een eventuele toename van de laxiteit door overbelasting van de secundaire ligamentaire gewrichtsstabilisatoren nagegaan worden.

Botscentigrafie kan het behouden van de kniehomeostase nagaan.

Indien de klinische laxiteit toeneemt of indien de botscentigrafie positief blijft ondanks de aanpassing van het activiteitsniveau, dan hoeft een heelkundige reconstructie van de voorste kruisband overwogen te worden.

Een dergelijke **primaire heelkundige reconstructie** kan overwogen worden, indien de patiënt een bepaald **hoog activiteitsniveau** wenst te behouden.

Men moet echter behoedzaam zijn dat een heelkundige reconstructie niet de weg baant naar een verdere overbelasting van het gewricht, met verstoring van de kniehomeostase en hieruitvolgende osteoarthrose.

Een verdere evaluatie van de kniehomeostase met botscentigrafie na een voorste kruisbandreconstructie is derhalve waarschijnlijk aan te raden.

In een behandelingsalgoritme dat in hoofddorpe stoelt op het concept van de kniehomeostase kan men zich de vraag stellen of arthroscopie een belangrijke rol speelt in de besluitvorming.

De **arthroscopische evaluatie van de acute traumatische hemarthrose** van de knie blijft echter noodzakelijk :

- het is de enige diagnostische techniek, welke, in associatie met een onderzoek van het gewricht onder narcose, een volledige en precieze diagnose kan bieden van alle knieletsels.

De zogenoemde "natuurlijke geschiedenis" studies van voorste kruisbandletsels hebben aangetoond wat de negatieve effecten zijn van een gebrek aan diagnose, raadgeving en behandeling, leidend tot progressieve gewrichts- beschadiging en osteoarthrose.

- Een grondige patiënteninformatie en raadgeving, welke aan de basis ligt van het vooropgestelde behandelingsalgoritme is slechts mogelijk met een volledige en precieze diagnose van het voorste kruisbandletsel en de geassocieerde letsels.

- Deze laatsten , en meer bepaald de meniscale letsels betreft, zijn aanwezig in een meerderheid van voorste kruisbandrupturen. Ze kunnen dan ook behandeld worden tijdens dezelfde arthroscopische zitting, wat leidt tot een maximaal behoud van de "meniscale stock", in het bijzonder bij patiënten waar een verder heeldkundig herstel van de voorste kruisband niet zal overwogen worden.

Bij patiënten waar deze laatste reconstructie wel zal gebeuren, meestal na enkele weken later, om het risico van arthrofibrose te verminderen, wordt hierbij de reconstructieprocedure vereenvoudigd.

- De spoeling en het verwijderen van het bloed uit het gewricht bij de arthroscopische evaluatie van de acute traumatische kniehemarthrose kan wellicht ook een biologische cascade, ontketend door de hemarthrose zelf, en eveneens leidend tot osteoarthrose, deels ongedaan maken.

AKUUT KNIELETSEL

➔ GEWRICHTSPUNKTIE

➔ Geen hemarthros : Klinische Evaluatie

➔ Hemarthros : Onderzoek onder narcose en Arthroscopie

- **patella dislocatie**
- **VKB letsel ± meniscaal letsel**

↓
Primair arthroskopisch herstel/meniscectomie

↓
Informatie & raadgeving :

→ **gedeeltelijk VKB letsel** (neg. pivot shift) → **conserv. behandeling**
(+ klinische F.U.)
(+ bolscan F.U.)

→ **totale VKB**
(of gedeeltelijke VKB met pos. pivot shift)

→ **activiteitsaanpassing**
→ **geen activiteitsaanpassing**
→ **grote laxiteit**

↓
→ **VKB reconstructie**
(+ bolscan F.U.)

↓
secondeaire activiteits-
aanpassing

V. CURRICULUM VITAE

P.P. CASTELEYN werd geboren op 18 september 1946 in Antwerpen (België).

Na Grieks-Latijnse Humaniora studies aan het Onze-Lieve-Vrouw College te Antwerpen en het Koninklijk Atheneum te Berchem - Antwerpen vatte hij, in 1965 hogere studies aan in het zopas opgerichte Rijksuniversitair Centrum Antwerpen (R.U.C.A.).

In 1968 maakte hij deel uit van de eerste promotie die de titel van kandidaat in de Genees- en Natuurwetenschappen behaalde aan deze Universiteit.

Verdere studies in de Geneeskunde werden verricht aan de Vrije Universiteit Brussel (V.U.B.) waar de titel van dokter in Genees- Heel- en Verloskunde behaald werd met Grote Onderscheiding in 1972.

In 1978 behaalde hij, eveneens met Grote Onderscheiding, de Licentie in Verzekeringsgeneeskunde en Evaluatie van Lichamelijke Schade, aan de Université Libre de Bruxelles (U.L.B.).

Na het beëindigen van de geneeskunde studies werd P.P. CASTELEYN gedurende 1 jaar tewerkgesteld door het Belgisch Nationaal Fonds voor Wetenschappelijk Onderzoek.

Hierbij werden zelfvermenigvuldigingspatronen in de maag- darmtractus bestudeerd. Simultaan werd een postgraduaatsopleiding in de Algemene Heelkunde aangevat, met klinische stages als resident in het Universitair St. Pieter-Ziekenhuis (prof. BREMER en prof. DANIS) te Brussel.

Een erkenning als specialist in de Algemene Heelkunde werd behaald in 1978.

Gedurende deze opleiding in de Algemene Heelkunde groeide de interesse voor de Orthopedie en de Traumatologie, en na verdere stages als resident in de Centre Hospitalier Universitaire te Rijsel (prof. DE COULX) en in het Academisch Ziekenhuis van de Vrije Universiteit Brussel (prof. OPDECAM) werd in 1980 een erkenning als specialist in de Orthopedie en Traumatologie behaald.

Vanaf 1977 was P.P. CASTELEYN verbonden aan het Academisch Ziekenhuis van de Vrije Universiteit Brussel. Hij vervulde hierbij initieel zowel klinische als administratieve taken, bij de planning, oprichting, en opening van dit nieuw Academisch Ziekenhuis. Anecdootisch hierbij is het feit dat hij de eerste, door dit Ziekenhuis full-time tewerkgestelde aanwezige arts was.

P.P. CASTELEYN was hierbij ook opeenvolgend secretaris en Ondervoorzitter van de Medische Raad, en Ondervoorzitter van de Raad van Bestuur van het Academisch Ziekenhuis van de Vrije Universiteit Brussel.

De klinische en wetenschappelijke interesse en activiteit evolueerde progressief naar de studie enerzijds van de kniepathologie, anderzijds van de anatomie.

Dit leidde tot meer dan 140 mededelingen op wetenschappelijke congressen en symposia, 68 wetenschappelijke publicaties als eerste auteur, 85 wetenschappelijke publicaties als co-auteur, het auteurschap van 6 hoofdstukken en/of wetenschappelijke boeken, en het "editor-schap" van 1 wetenschappelijk boek.

P.P. CASTELEYN werd in 1984 benoemd tot Kliniekhoofd in de dienst Orthopedie en Traumatologie van het Academisch Ziekenhuis van de Vrije Universiteit Brussel en in 1991 tot Docent en Coördinator van de Leerstoel Menselijke Anatomie aan de Faculteit Geneeskunde en Farmacie van de Vrije Universiteit Brussel.

P.P. CASTELEYN is eveneens lid van talrijke wetenschappelijke verenigingen (Belgische Vereniging voor Orthopedie en Traumatologie, Société Internationale de Chirurgie Orthopédique et de Traumatologie, Société Internationale de Recherche en Orthopédie et Traumatologie, International Knee Society, International Arthroscopy Association, European Society for Knee Surgery Sports Traumatology and Arthroscopy, International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine, American Academy of Orthopaedic Surgeons.

Ook werd hij in 1997 ere-lid van de Société Française de Chirurgie Orthopédique et de Traumatologie.

Hij was voorzitter van de Belgische Vereniging voor Orthopedie en Traumatologie in 1992 - 1993, is lid van het Bestuur van de European Federation of National Associations of Orthopaedics and Traumatology sinds 1994, en Chairman van het 4de Congres van deze federatie, dat in 1999 in Brussel plaatsvond.