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From the Department of Orthopaedic Surgery, Lund University Hospital in Lund, Sweden.

Knee arthroplasty in rheumatoid arthritis

An analysis of 240 cases of hemi-, hinge and resurfacing arthroplasties

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KNEE ARTHROPLASTY IN RHEUMATOID ARTHRITIS

An analysis of 240 cases of hemi-, hinge and resurfacing arthroplasties

I. INTRODUCTION

While arthroplasty of the knee was attempted already 100 years ago, the techniques used today are based on the pioneer work in the 1950s (McIntosh 1967, Shiers 1954, Walldius 1957 and McKeever 1959). During the 1970s the development and use of new designs for knee arthroplasty have developed exponentially; at present more than 400 different designs are available on the market, and in Sweden 1 000 arthroplasties are performed yearly. It is not easy for the surgeon to choose between widely different concepts and methods for arthroplasty of the knee; published results are confusing, contradictory and difficult to interpret. An important reason for this confusion is that most published series fail to make a distinction between osteoarthrosis and rheumatoid arthritis. However, most patients subjected to arthroplasty of the knee because of arthrosis do not suffer from generalized arthropathy and the knee condition is focal (Ahlbäck 1968), whereas rheumatoids have a generalized disease, characterized by poly-arthropathy with panarthritis. The aim of this work was to compare the clinical results and identify complications and reasons for failures of three different arthroplasty methods using the hemi-, hinge and resurfacing principles. All patients had rheumatoid arthritis (RA) (Golding 1966) and population differences in the three materials were identified.

SURGERY FOR RHEUMATOID ARTHRITIS OF THE KNEE IN LUND

From 1967 through 1976, more than 1 000 operations were performed for rheumatoid arthritis of the knee at the Department of Orthopaedic Surgery at the University Hospital of Lund, Sweden. Synovectomy was by far the most common operation (542 cases). For correction of deformities high tibial osteotomies were performed in 75 knees and capsulotomies in 60. Baker cysts were excised in 53 knees. Up to 1973, 27 arthrodeses were carried out (Brattström 1971).

This work analyses the result of 240 consecutive knee arthroplasties in rheumatoid arthritis performed in Lund 1967-1976. The material includes 67 McIntosh arthroplasties with observation time on an average 3.3 years (1.0-6.0) operated 1967-1972, 64

Guépar arthroplasties with observation time on an average 2.7 years (1.1-4.3) operated 1972-1976 and 109 Marmor arthroplasties with observation time on an average 2.2 years (1.0-3.6) operated 1974-1976.
These three arthroplasties represent three different replacement principles.

The McIntosh prosthesis is a hemiprosthesis which resurfaces the tibial condyle and by a spacer effect can correct deformity and instability. From 1967 through 1970, the McIntosh prosthesis was the only arthroplasty used in Lund and the indications were therefore quite liberal. Attrition of the femoral condyles to a slight degree was not a contraindication. Lateral instability and malposition in varus-valgus up to 30° were also accepted.

The Guépar prosthesis is a simple mechanical hinge cemented in the medullary cavity. The prosthesis has a fixed transverse axis of rotation, and stability is totally independent of the soft tissue of the knee: constrained principle. From 1972 through 1973, the Guépar hinge prosthesis was that most used at the clinic. This was partly due to the existence of a pool of patients where an arthrodesis had been the only realistic alternative because the McIntosh prosthesis was insufficient. Since 1974, the use of the Guépar prosthesis was substantially reduced following the introduction of the Marmor prosthesis.

The Marmor prosthesis resurfaces the femur and the tibia and is thus a total prosthesis for the femoro-tibial (FT)-joints, having the same propensity as the McIntosh prosthesis to correct deformity and instability. From 1974, this prosthesis totally replaced the McIntosh prosthesis and during 1975 and 1976, partly even the indication for using a Guépar prosthesis. It was also used in younger patients.

The McIntosh and Marmor prostheses do not decrease free movements between the femur and tibia and stability in the arthroplasty depends entirely on the ligaments and extra-articular soft tissue: unconstrained principle.

By the end of the period dealt with in this work, the Guépar prosthesis had been largely replaced by the Attenborough prosthesis, which represents the group of hemiconstrained prostheses that permit rotation between the tibia and the femur and a certain limited lateral instability.

II. MATERIAL AND METHODS

All patients were admitted to the Department of Orthopaedic Surgery or Rheumatology at the University Hospital of Lund, and operated at the Department of Orthopaedics. The diagnosis of rheumatoid arthritis was established according to the American Rheumatoid Association's (ARA) criteria for classical, definite and probable RA (Golding 1966), and will henceforth be termed RA.

Preoperative status

Case records and patient interviews provided information about previous disease, the preoperative ARA functional classification (Berglund et al. 1973) and social status. Preoperative degree of pain and dependence on walking or other aids were part of the status at admission recorded by the surgeon and the physiotherapist.

This status included observations of exudate and capsular thickening, femoro-patellar crepitation and decreased lateral mobility of the patella. Sagittal instability was noted by the anterior drawer sign with the knee flexed 90°. Lateral instability was measured with the knee flexed 5° (Hallén 1965). Range of movement of the knee was measured with a goniometer. Unless otherwise indicated extension was always passive. Varus and valgus was measured in the standing position using a goniometer; an FT-angle of 174° was defined as neutral (Fig 2). The quadriceps power was measured as a breaking force on isometric contraction with 90° knee flexion and resistance applied immediately proximal to the talo-crural joint.

Complications

Early complications during the operation and postoperatively within two months as well as late complications were identified from the case records and interviews.

Status at follow-up

The author examined all patients. Parameters were identical to what was described under preoperative objective status. ESR was registered at follow-up for estimating disease activity.

EVALUATION SYSTEM

The Weinfeld's (1969) knee joint evaluation system was used throughout. A good result is

equal to a low score (minimum 0, maximum 33 demerit points). Points are given for each of the parameters: pain, use of walking aids, flexion, extension defect, varus or valgus deformity at weight-bearing, lateral instability and quadriceps weakness (Table I). The total is thus an expression of the deviation from normal. The same value of points can however represent different combinations of pathologic findings. The points allocated for a given parameter are chosen with regard to the functional consequences. A total score between 0 and 2 is described as excellent, between 3 and 6 as good, between 7 and 10 as fair and 11 or more as poor. On statistical analysis of the material the group with 0 to 6 points is called "satisfactory" and 7 or higher "not satisfactory".

In using Weinfeld's point system it is important to bear in mind that the score for the specific knee reflects the deviation from a normal knee (0 point) and a knee that at follow-up has a score of 7 or more, thus being placed in the group "not satisfactory", can be judged by both the surgeon and the patient as being improved. The patient can, for instance, preoperatively score 14 points and at follow-up 7 points; in spite of this improvement the case would still fall into the "not satisfactory" group.

Weinfeld's evaluation system was chosen because it is largely based on objective criteria and is numerical in nature. Thus the risk of biased judgement arising from the patient's and the examiner's loyalty to the surgeons is reduced. It facilitates comparison between pre- and postoperative status and comparison of results according to different replacement methods. The system is well suited for data computing and statistical analysis. A number of other evaluation systems exist and this makes comparison between different works extremely difficult (Andersson 1972). The Weinfeld's system has been used by Potter (1972) and Jani and Morscher (1973) for evaluation of arthroplasty with the McIntosh prosthesis.

Table I.

Weinfeld's evaluation system

Pain	Points
None or unimportant	0
After more than 200 m walking	1
After less than 200 m walking	3
Immediately at weight-bearing	6
Considerable pain at rest	7
Use of support at walking	
Can walk without support	0
Cane out-doors	1
Cane in-doors	2
Crutches all the time	4
Extension defect	
Extension defect $\leqq 5^\circ$	0
Extension defect $> 5^\circ - \leqq 15^\circ$	1
Extension defect $> 15^\circ - \leqq 30^\circ$	2
Extension defect $> 30^\circ$	4
Flexion	
Flexion $> 80^\circ$	0
Flexion $> 60^\circ - \leqq 80^\circ$	1
Flexion $> 30^\circ - \leqq 60^\circ$	3
Flexion $\leqq 30^\circ$	6
Medial or lateral instability	
Instability $< 10^\circ$	0
Instability $\geqq 10^\circ - < 20^\circ$	2
Instability $\geqq 20^\circ$	4
Varus-valgus at weight-bearing	
Malposition $< 10^\circ$	0
Malposition $\geqq 10^\circ - < 20^\circ$	2
Malposition $\geqq 20^\circ - < 30^\circ$	3
Malposition $\geqq 30^\circ$	4
Quadriceps power	
Quadriceps power N $\geqq 200$	0
Quadriceps power N $\geqq 150 - < 200$	1
Quadriceps power N $\geqq 100 - < 150$	2
Quadriceps power N < 100	4

Sum of demerit points = result

Rating: Excellent 0-2 points
Good 3-6 points
} 0-6 points: "Satisfactory"

Fair 7-10 points
Poor 11-33 points
} 7-33 points: "Not satisfactory"

Subjective status at follow-up

Pain at rest or at weight-bearing was recorded; the latter in relation to walking distance. Use of support at walking was recorded. Details regarding medication during the observation period were noted. Based on information concerning activities of daily living (ADL-status) and need for public assistance, the ARA functional classification was determined and the socio-economic status assessed. Pain at weight-bearing, arthroplasties and arthrodeses performed in other major joints in the lower extremities were also registered. The patients were asked for their opinion of the result of the operation.

ROENTGEN MATERIAL

The analysis was based on the following roentgen examinations.
Preoperatively. Standard frontal and lateral projections of the knee and an axial projection of the femoro-patellar joints (FP-joints) in 30° of knee flexion were usually taken in the supine position, and frontal projections on weight-bearing in varus and valgus provocation according to Norman (Hagstedt 1974). Because of pain, synovitis, flexion contracture and varus and valgus malposition, extreme provocation was not always possible.
At follow-up. Similar examinations as preoperatively; axial projection of FP-joint only when clinically indicated. For comparison of position of prosthetic components the immediate postoperative and the follow-up roentgen examinations were compared.

Analysis of roentgen material

The author evaluated the roentgen material of the McIntosh and Guépar material. The Marmor material was evaluated in co-operation with the Roentgenological Department II at the University Hospital of Lund (Niels Egund and Hildur Laurusdottir). Clinical and roentgenological observations were not correlated until all observations were registered and data analysed.

Cartilage reduction and attrition in FT-joint preoperatively. Analysis of the medial and lateral compartments were made on frontal projections of the knee in weight-bearing and varus provocation and valgus provocation, respectively.

A simplified model of Ahlbäck's (1968) classification for gonarthrosis was used. The simplification was adopted for the following reasons.
1) RA as opposed to osteoarthrosis usually involves both FT-compartments. In this work the destruction in the most pathological compartment was selected for classification.
2) Destruction in RA does not develop uniformly: through cyst formation and subchondral

Figure 1.

Classification of FT-compartment destruction in rheumatoid arthritis of the knee.

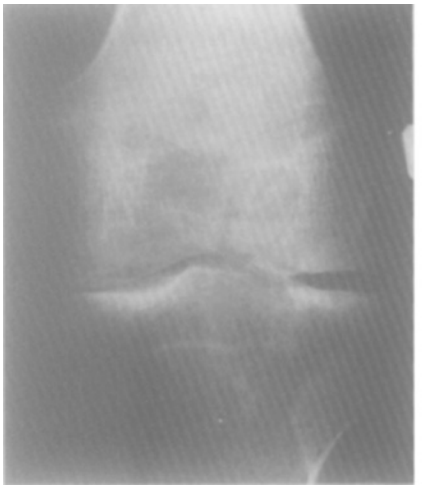


Fig. 1a. Narrowing of the articular space in the medial compartment.

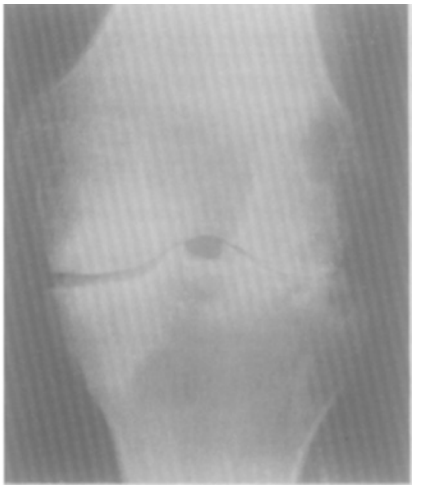


Fig. 1b. Obliteration of the articular space in the lateral compartment.

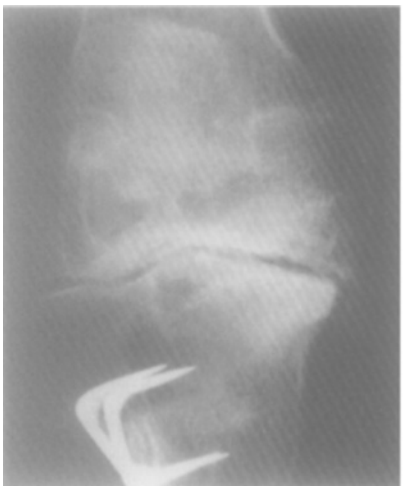


Fig. 1c. Attrition of moderate degree in the medial compartment.

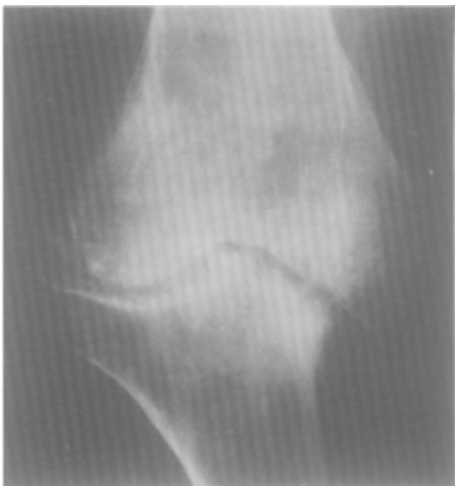


Fig. 1d. Attrition of severe degree in the medial compartment.

Classification of cartilage reduction and attrition in FT-joints preoperatively (Hagstedt 1974)

Narrowing of the articular space was defined as total cartilage thickness of 1-3 mm in the most destroyed compartment (equal to Ahlbäck class I). (Fig. 1a).

Obliteration of the articular space was defined as cartilage thickness of less than 1 mm in the most destroyed compartment, but no certain destruction of subchondral bone (equal to Ahlbäck class II). (Fig. 1b).

Attrition of bone was defined as changed configuration of the condyle of the tibia and/or femur. This class also included knees with subluxation of the tibia (equal to Ahlbäck classes III-V). (Fig. 1c-1d).

Classification of cartilage reduction and attrition in FP-joints

Normal cartilage was defined as at least 3 mm cartilage thickness and well-marked FP-joint spaces.

Cartilage reduction was defined as cartilage thickness of 0-3 mm and well-marked FP-joint spaces.

Attrition was defined as not detectable or a pathological configuration of the joint line. This group included cases with lateralization or medialization of the patella.

Measurements of varus and valgus deviations

The longitudinal axes of the femur and tibia were marked on the frontal projections with varus-valgus provocation. The lateral open angle between the longitudinal axes of the femur and tibia at weight-bearing was designated the FTP-angle (Femoro-tibial angle Provoked) (Fig. 2). The FTP-angle was measured on varus and valgus provocation and the largest divergence from 174° was recorded.
Hagstedt in a study of gonarthrosis indicated the normal variation for the FT-angle at 168-180°. The difference between FTP-angle in varus and valgus provocation was calculated as a measurement of instability in the knee at weight-bearing.
In the Marmor and Guépar material lateral subluxation of tibia was also registered when found to exceed 5 mm.

The errors in angle registration were considerable because short films were used in part of the examinations and presence of flexion contractures.

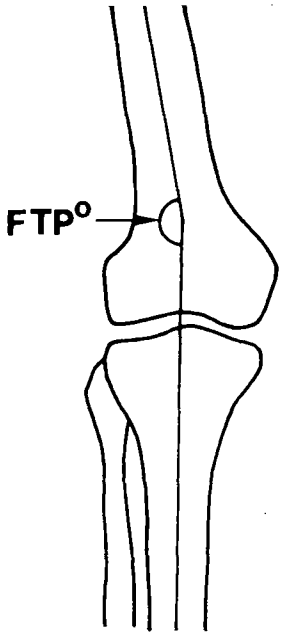


Fig. 2. The FTP-angle was defined as the lateral open angle between the longitudinal axes of femur and tibia in the frontal exposure on weight-bearing and provocation in varus and valgus (Hagstedt 1974).

Analysis of roentgen material at follow-up

McIntosh

Destruction of the femoral condyles was judged on the basis of provoked frontal exposures at weight-bearing and a standard lateral exposure. The FTP angle was assessed using the same methods as in the preoperative examination. The position of the prosthesis was assessed on the basis of standard projections on frontal and lateral views. Comparison was made with the immediate postoperative examination.

Guépar

Position of prosthesis, cement surrounding the stems and presence of operative fractures were registered on the standard projections in lateral and frontal views. The maximum width of the radiolucent zones around the bone cement in the presence of infection and/or fracture were registered in all roentgen exposures during the observation time. In the rest of the material, the width of the zone was registered one year after operation. Scalloping and periosteal reactions were looked for in all examinations.

Marmor

FTP angle measurement was made on the same basis as at the preoperative examination. Based on standard frontal and lateral projections, the angle of the tibial components in relation to the longitudinal axes of tibia was measured. Fracture or buckling of the indicator wire was noted as a sign of loosening of the prosthesis. The radiolucent zone under the tibial component was measured at the last examination. By comparing the first postoperative examination and the examination at follow-up, changes in the position of prosthetic components were noted. The position of the femoral component in relation to the tibial plates was assessed.

Statistical methods x)

Common parametric tests generally make certain assumptions about the population being tested and further assume at least interval level of measurement. From a statistical point of view the important variables in this clinical investigation must be considered at not ordinal level of measurements and for that reason tests concerning association between variables, proportions and differences in location were accomplished by means of the following nonparametric procedures: X^2-test, McNemar test, Wilcoxon Signed-Rank test and Kruskal-Wallis one-way test. In applicable cases distribution-free multiple comparison techniques were used in judging treatments with a controlled level of significance (experimentwise error rate).

All processing of the data material was carried out by standard statistical software at the computer center of the University of Lund, in certain situations by means of specially developed programs for a minicomputer.

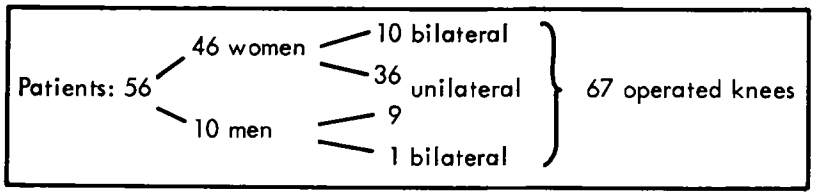
x) Aid in the statistical analysis is gratefully acknowledged to Mr. Lars Ek.

III. McINTOSH ARTHROPLASTY

MATERIAL AND METHODS

From 1967 through 1973 the McIntosh prosthesis was used in 59 patients for a total of 70 knees. A follow-up was carried out during 1973-1974; two patients were examined in 1976. Three patients (3 knees) were excluded from the material: one patient could not be traced, two patients died from unrelated causes more than a year following surgery but prior to the follow-up. According to case records, the result were acceptable to the three patients. The follow-up thus included 56 patients with 67 operated knees (Fig. 3). The average age at operation was 54 years (26-74).

Fig. 3.



The observation time was on an average 3.3 years (1.0-6.0 years). Six patients had at follow-up been re-operated with another type of prosthesis (one bilateral). In these knees, the observation time was calculated up to the time for re-operation.

In more than half of the operated knees, RA had been present for more than 10 years pre-operatively. No patients with less than 2 years of RA were operated upon.

Table 2.
ESR preoperatively.

ESR mm/h	0-25	25-65	66-150	Insufficient data
Knees	21	32	13	1

Previous treatment of the operated knee

Intra-articular cortisone. In 28 knees, between 1 and 10 cortisone injections were given and in 27 knees, more than 10 injections. Only 12 knees were never treated with intra-articular cortisone.

Synovectomy. Chemical synovectomy, using osmium acid, had been carried out in seven knees and a combination of chemical and surgical synovectomy in 22. Surgical synovectomy alone had been made in eight knees making a total of 37 chemical and/or surgical synovectomies, 25 of them between one and three years before arthroplasty.

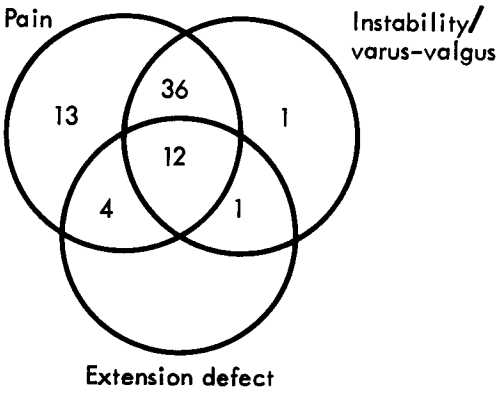
Capsulotomy was performed in six knees for correction of a flexion contracture.

High tibial osteotomy was carried out in four knees to correct a valgus deformity.

Indications for arthroplasty

The indications for the McIntosh arthroplasty were not uniform. During the latter part of the period, the indications were more restricted as a consequence of increasing experience and introduction of new prosthetic alternatives. The Venn-diagram (Fig. 4) shows the clinical symptoms that motivated the operation.

Fig. 4.
Clinical indication for McIntosh arthroplasty in 67 knees.



Pain at weight-bearing or on walking less than 200 m.
Instability $\geq 10^{\circ}$ and/or
Varus $\geq 10^{\circ}$
Valgus
Extension defect $> 15^{\circ}$

Pain was found in all except two knees, operated because of instability and extreme valgus. In 48 knees a combination of pain and considerable deformity and/or instability was found and 16 had pain and an extension defect. Decreased flexion was not of such degree as to constitute an indication for arthroplasty.

Contraindications. With an extension defect of more than 30°, varus or valgus of more than 30° and subluxation of the tibia of more than 1 cm, it was not considered technically possible to construct a mobile yet stable and painfree joint by means of a McIntosh arthroplasty. In these knees, arthrodesis was considered or the development of a better prosthesis was awaited.

Operative technique

Two surgeons have operated on 64 knees and assisted at a further three.(Fig. 5a-b). The operation was performed under general or epidural anaesthesia through a medial parapatellar incision in a bloodless field. In 20 cases during the first years, the tibial tuberosity was detached to allow an easier approach to the knee joint. In the remaining 47 knees the patella was dislocated laterally. A synovectomy was performed. In the presence of a flexion contracture a wedge was chiselled away from the tibia so that full extension became possible. An adequately sized prosthesis was chosen to allow for circumferential cortical bearing and lateral stability.

Bone cement as recommended by Kates (Brattström 1973) was used during 1971-1972 in 25 knees for attaching the prosthesis.

Unicompartment arthroplasty was performed in 14 knees (Fig. 6a-b); 11 of those in the lateral compartment. If the tibial tuberosity was detached, it was reattached with a screw or staple and a long leg plaster cast with an opening for the patella was applied following which the bloodless field was released. Vacuum drainage was maintained for 24-48 hours postoperatively. Prophylactic antibiotics and anticoagulation therapy were not used routinely.

Postoperative treatment

During the first postoperative days quadriceps exercise was started and the patella was passively mobilized. From the third day passive flexion and extension was started. From the tenth day, the patient was allowed to flex and extend actively and to walk with crutches. After two weeks full weight-bearing was permitted and if flexion did not reach 90° four weeks after operation, manipulation under anaesthesia was carried out. If the tibial tuberosity was detached and reattached the patient was treated in the long leg plaster cast for two weeks, and during the next four weeks increasing passive flexion and weight-bearing with the use of a dorsal plaster slab was permitted. If passive flexion did not reach 60° after three weeks, open mobilization was performed. This was carried out in 15 of 20 operations where the tibial tuberosity was detached and reattached.

COMPLICATIONS

Operative complications and technical difficulties

In 25 of 67 operations, technical difficulties or complications were encountered and modifications were adopted.

Fracture of the tibia. In one knee, the cortical bone in the tibial condyle was fractured

when chiselling. A fracture of the intercondylar eminence with a dislocation of the insertion of the anterior cruciate ligament was noted in seven knees. Five of the fractures were left untreated. In one the eminence was reattached with a wire and in one with a screw. The screw perforated the posterior cortex of the tibia and because of the risk of erosion of the popliteal artery the screw was removed three weeks later.

Cysts in the tibia. In seven knees one of the tibial condyles was eroded by a subchondral cyst and extensive resection was necessary to achieve satisfactory bone support under the prosthesis; in three cases the cyst was filled with bone cement.

Wrong size of prosthesis. In three operations the thickest prosthesis was not adequate to compensate for the amount of destruction in the lateral condyle. In one, the biggest plate was not large enough to obtain cortical bearing along the entire circumference and in another a prosthesis that was too thin was used as the correct size was not available.

Patella dislocation. In one knee with 10° of valgus preoperatively, the patella was found to be dislocated at operation and despite a medial transfer of the tibial tuberosity and a medial plication of the joint capsule, it remained dislocated.

Extension defect. In two knees full correction of an extension defect was not achieved and a 10° lag had to be accepted. In one of these knees this was still present at the follow-up.

Incongruity. In one knee the arthroplasty was complicated by a lateral subluxation of the tibia and in another congruity between the femoral condyles and the prostheses was not obtained.

Postoperative complications

Complications occurred in eight knees. No thrombosis or embolism occurred in this series. No patient died as a direct result of the operation.

Complicated wound healing - superficial infection. In four knees the wound failed to heal within four weeks. In two a culture was negative and no antibiotics were given. In the other two, the culture was positive (plasma coagulating staphylococcus, enterococcus and staph. aureus) and antibiotics were used. In these knees, the wounds healed later without signs of deep infection.

Dislocation of the patella. In one knee there was crepitation at the FP-joint and pain at extension. Clinically the patella was found subluxated laterally in the last 30° of extension.

Dislocation of the prosthesis. During manipulation under anaesthesia both plates were pressed down into the tibial condyles and a horizontal rotation of one of the plates occurred which resulted in a passive extension defect of 20°.

Miscellaneous. In one knee there was pain at weight-bearing. Exploration of the knee revealed a fragment of cement posterior to the lateral prosthesis. This was removed with relief of pain. Another knee with pain on weight-bearing was explored and a number of subchondral cysts in the lateral femoral condyle were cleared of synovial membrane. The cavity was filled with bone cement with relief of pain.

Hospital stay. The average duration was 48 days (18–126). In those patients where the tibial tuberosity had been detached, the length of stay was increased by about half as much again.

Late complications

Late complications occurred in eight knees.

Patella dislocation. In one knee the patella dislocated as a result of extreme valgus caused by compression of the lateral femoral condyle and a 2 cm lateralization of the tibia (Fig. 9). A hinge prosthesis was subsequently inserted in this knee.

Dislocation of the prosthesis. In one knee, a progressive sinking in of the lateral prosthesis and a lateralization of the tibia developed. In one knee the lateral plate dislocated and at revision the plate was fixed with cement. At a later date the medial plate dislocated to the lateral compartment (Fig. 11) and a hinge prosthesis was eventually inserted.

Collapse of the condyles. Two knees developed an increasing collapse of the lateral femoral condyle. This resulted in increasing valgus and instability. In both knees, a high tibial osteotomy was carried out. In one knee following a prosthesis in the lateral compartment, an increasing collapse of the medial tibial condyle developed which led to a prosthesis being inserted in the medial compartment as well.

Fractures. One patient who was operated bilaterally in 1971 sustained a supracondylar fracture of the left femur without adequate trauma followed 12 months later by an identical fracture in the right femur (stress fractures). Both fractures healed uneventfully.

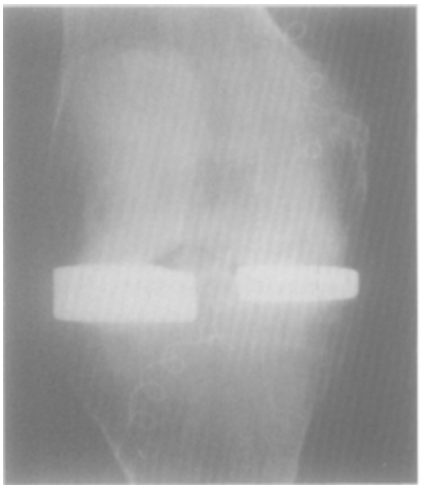


Fig. 5a. Normal position of prosthesis in frontal exposure.

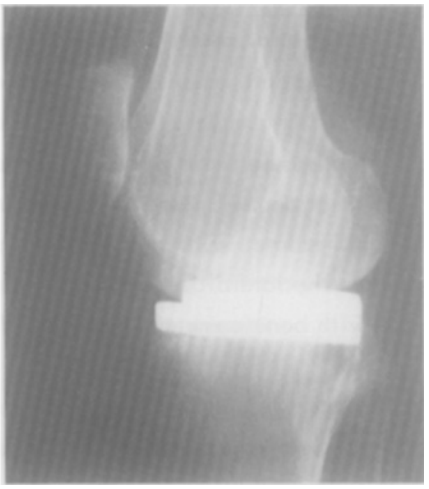


Fig. 5b. Normal position of prosthesis in lateral exposure.

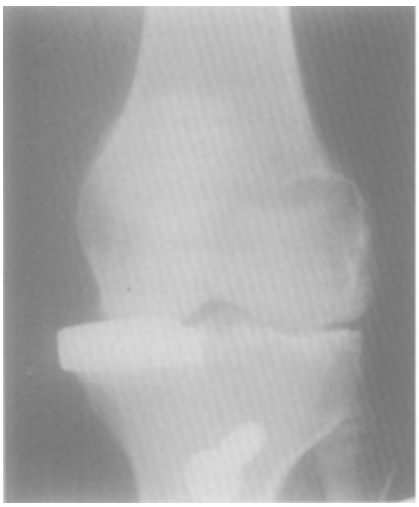


Fig. 6a. Hemiarthroplasty. Postoperative examination.

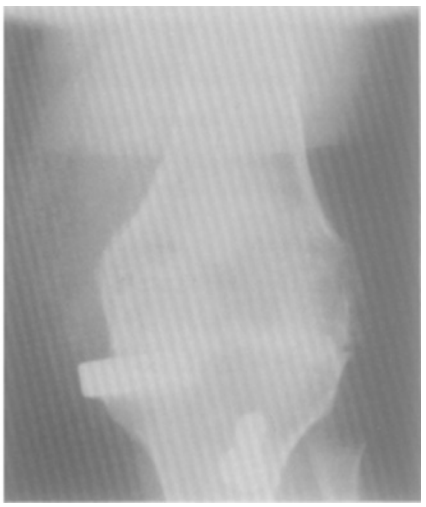


Fig. 6b. Destruction of contralateral compartment and medial femoral condyle 4 years postoperative.

FOLLOW-UP EVALUATION

The seven parameters in Weinfeld's evaluation system (see page 9) formed the basis for evaluation of status preoperatively and at follow-up. In the diagrams, the status at follow-up is marked by the position on the X-axes and the status preoperatively by the position on the Y-axes. Positions along the oblique line indicate unchanged status, over the oblique line improved and below the oblique line worse.

Table 3.
Pain.

	Follow-up 14	13	12	22	6	Sum	
7	6	8	6	12	4	36	
6	4	4	3	9	2	22	
3	3	1	2	1		7	Preop.
1			1			1	
0	1					1	
Points	0	1	3	6	7		

For the patient, pain was the primary indication for operation. In 47 knees pain was less severe at follow-up than preoperatively, unchanged in 16 and more severe in four.

In 40 of the operated knees pain on walking less than 200 m was present at follow-up, a synovial swelling was found in seven of those. Quadriceps power less than 100N was found in 32 and no less than 28 of them had pain when walking less than 200 m; the correlation was significant (Chi^2: $p = 0.0003$).

Table 4.
Use of support at walking.

	Follow-up 12	21	9	25	Sum	
4	2	4	4	12	22	
2	1	6	2	6	15	Preop.
1	2	4	1	1	8	
0	7	7	2	6	22	
Points	0	1	2	4		

The need for support at walking was reduced in 19 knees, unchanged in 25 and increased in 23. The failure to reduce the use of walking aids after knee arthroplasty was partly caused by pain at weight-bearing in other joints.

Table 5.
Extension defect.

	Follow-up 47	15	4	0	Sum	
4	1				1	
2	12	3	1		16	Preop.
1	16	9	3		28	
0	18	3			21	
Points	0	1	2	4		

Correction of preoperative extension defect was achieved in 29 of 45 knees, in three an improvement was noted. In 28 knees the extension defect was unchanged and in six increased.

Table 6.
Flexion.

	Follow-up 51	11	4	Sum	
3	0	0	0	0	
1	2	1	1	4	Preop.
0	49	10	3	62	
Points	0	1	3		

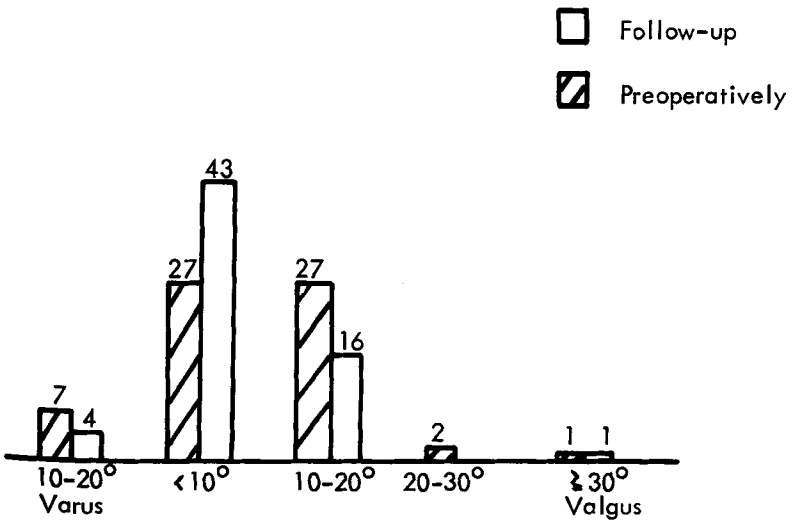
In Weinfeld's evaluation system the limit for acceptable flexion is set at 80°. A limit of 100° would probably be better as this is the minimum requirement for negotiating stairs and for rising from chairs. Flexion less than 80° was only present in four knees preoperatively and in none it was considered as an indication for arthroplasty. Postoperatively flexion less than 80° was present in 15 knees. The deterioration in flexion was significant.

Table 7.
Medial or lateral instability.

	Follow-up 37	20	4	Sum	
4	2	2	1	5	
2	22	13	3	38	Preop.
0	13	5		18	
Points	0	2	4		

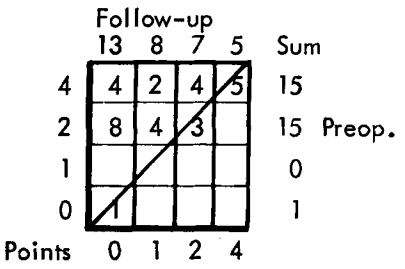
In 43 knees with preoperative lateral instability an improvement was achieved in 26 knees. The instability was unchanged in 27 and increased in eight.

Fig. 7.
Varus-valgus deformity at weight-bearing (clinical)



Preoperatively seven knees were in more than 10° of varus and 30 were in more than 10° of valgus. At follow-up four knees were in varus; in only one of them was the deformity present preoperatively. In 16 knees 10-20° of valgus was found at follow-up and in one more than 30°. The deformity developed postoperatively in only four knees.
21 knees had no deformity preoperatively or at follow-up. The deformity was corrected or diminished in 23 knees, unchanged in 13 and increased in seven.

Table 8.
Quadriceps power.



Conclusion of results according to Weinfeld

For each of the seven parameters, the average point score preoperatively and at follow-up was calculated on the basis of the number of corresponding observations.

Table 9.
Score according to Weinfeld for the McIntosh material preoperatively and at follow-up.

	Preoperatively	Follow-up	Number of corresponding observations	Wilcoxon's SRT:p
Pain (0-7 points)	6.1	3.3	67	< 0.01
Use of support at walking (0-4 points)	1.9	2.1	67	0.788
Extension defect (0-4 points)	1.0	0.3	66	<0.001
Flexion (0-6 points)	0.0	0.3	66	<0.05 (worse)
Medial or lateral instability (0-4 points)	1.4	0.8	61	<0.001
Varus-valgus on weight-bearing (0-4 points)	1.2	0.7	64	<0.05
Quadriceps power (0-4 points)	2.9	1.3	31	<0.001
Sum demerit points	14.5	8.8		

The average demerit points was 14.5 preoperatively and 8.8 at follow-up. The score was thus reduced by 39 %.

At follow-up reduction in pain and improvement of extension and lateral stability were noted. Quadriceps power increased and varus or valgus on weight-bearing was reduced. Against this, a moderate reduction of flexion and an increased need for support in walking was noted. The reduction of flexion was less than the improvement of extension achieved. Movement was therefore improved within the important range 0-80°.

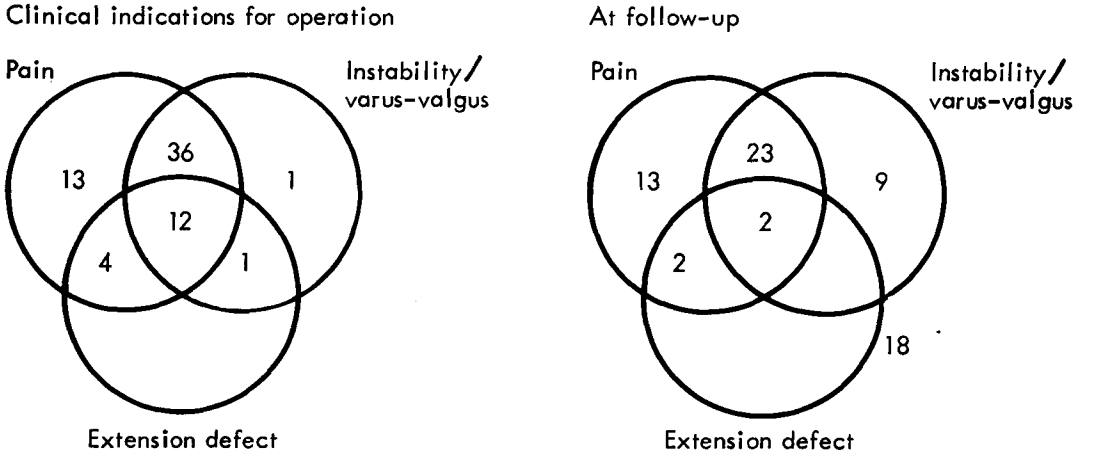
In classifying the knees at follow-up 12 were excellent, 11 good, 14 fair and 30 poor. By simplifying the system into only two groups to facilitate statistical analysis of the material, 23 knees were "satisfactory" (0-6 points) and 44 "not satisfactory" (7-33 points).

When comparing the status preoperatively with that at follow-up for the individual knee, excluding factors that could not be correlated because of insufficient data (quadriceps power preoperatively in 35 knees), it was noted that, of the 44 knees with a "not satisfactory" result, 27 were improved, 4 unchanged and 13 worse.

Clinical indications for operation and results at follow-up

The clinical indications for operation and findings at follow-up were compared with similar parameters in Venn diagrams to illustrate the effect of arthroplasty.

Fig. 8.



See Fig. 4 for definitions.

Preoperatively, all knees were within the diagram; at follow-up, 18 knees lie outside the diagram; those knees were without considerable clinical symptoms. At follow-up, there were 25 knees less with pain. The combination extension defect and pain was reduced from 16 to 4 and the combination pain and instability and/or varus-valgus malposition was reduced from 48 to 25.

EFFECT OF COMPLICATIONS ON FINAL RESULTS

("Satisfactory" implies a Weinfeld score 0-6)

	No. of knees	"Satisfactory"	"Not satisfactory"
Operative complications	25	5	20
Loosening of insertion of ant. cruciate lig.	7	1	6
Cysts in tibial condyle	7	1	6
Wrong size of prosthesis	5	-	5
Incongruence	2	-	2
Others	4	3	1
Postoperative complications (within two months)	8	2	6
Complicated wound healing	4	-	4
Dislocation of the patella	1	-	1
Dislocation of the prosthesis	1	-	1
Others	2	2	-
Late complications (after two months)	8	2	6
Supracondylar femur fracture	2	2	-
Dislocation of the patella	1	-	1
Dislocation of the prosthesis	2	-	2
Collapse of the condyles	3	-	3
Without complications	32	16	16

PREOPERATIVE ROENTGEN FINDINGS RELATED TO RESULTS

The numbers in parentheses after the number of knees in the tables show the number of "not satisfactory" results at follow-up to indicate the prognostic value.

Table 10.
Reduction of cartilage and attrition in FT-joints preoperatively.

Narrowing of the articular space	5 (3)
Obliteration of the articular space	36 (21)
Attrition	22 (19)

(Insufficient data: 4)

Result at follow-up were significantly poorer when attrition was present in one or both compartments (Chi^2: $p = 0.024$).
On the basis of the description of cartilage and bone attrition at operation, the material was divided into three grades according to the degree of destruction. The gradings were chosen to enable direct comparison with the roentgen evaluation. In 34 knees the clinical and roentgen assessment of the destruction was equal; in 22 the destruction according to the operative findings was more pronounced compared to the roentgen examination and in seven the operative findings were less than was expected. A significant correlation was found between the preoperative roentgen examination and the destruction as found at surgery (Chi^2: $p = 0.029$).

Table 11.
Reduction of cartilage and attrition in FP-joints preoperatively.

Normal height of cartilage >3 mm	25 (15)
Reduction of cartilage 0-3 mm	26 (18)
Attrition	11 (9)

(Insufficient data: 5)

With attrition in the FP-joint the final results were "not satisfactory" in 9 of 11 knees. Significant correlation could not be proved.

Table 12.
FTP-angle on varus and valgus provocation preoperatively.

>180°	10 (8)
180-168°	9 (1)
167-163°	20 (11)
<163°	17 (14)

(Insufficient data: 11)

The best results at follow-up were in knees that preoperatively had an FTP-angle within the normal range; in 8 of 9 knees a "satisfactory" result was obtained.

Even for knees in slight valgus, the result was quite acceptable. At an FTP-angle between 163 and 180°, the result was significantly better at follow-up than in knees with an FTP-angle outside this range (Chi^2: $p = 0.002$).

Table 13.
FTP-angle difference on varus and valgus provocation preoperatively.

FTP-angle difference $< 5^\circ$	25 (13)
FTP-angle difference $\geqq 5^\circ$	32 (24)

(Inadequate data: 10)

The FTP-angle difference was used as an indication of stability, even if there were considerable errors in method. Poorer results were seen when the FTP-angle difference exceeded 5° (Chi^2: $p = 0.07$). Correlation between an FTP-angle difference and degree of cartilage reduction and attrition, as judged at operation or by analysis of the roentgen material preoperatively were found (Chi^2: $p = 0.029$ and Chi^2: $p = 0.014$). Those correlations that reflect what should be expected indicate that the method error on measuring the FTP-angle difference was not too important.

ROENTGEN EXAMINATIONS AND RESULTS AT FOLLOW-UP

(Numbers in parentheses show the "not satisfactory" results at follow-up).

Table 14.
Attrition of femur condyles at follow-up.

Only those with an obviously changed configuration of the femoral condyles or attrition were considered pathological.

Normal configuration of femur condyles	43 (26)
Attrition or changed configuration	19 (15)

(Inadequate data: 5)

The result was significantly poorer with attrition or changed configuration of the femoral condyles (Chi^2: $p = 0.025$).

Table 15.
FTP-angle on varus and valgus provocation at follow-up.

$>180^{\circ}$	7 (5)
$180\text{-}168^{\circ}$	26 (10)
$167\text{-}163^{\circ}$	14 (12)
$<163^{\circ}$	9 (8)

(Inadequate data: 11)

The result was significantly better at follow-up when the FTP-angle in provocation was within the normal range ($168\text{-}180^{\circ}$) (Chi^2: $p = 0.0005$).

Table 16.
FTP-angle difference on varus and valgus provocation at follow-up.

FTP-angle difference $<5^{\circ}$	38 (18)
FTP-angle difference $\geqq 5^{\circ}$	17 (16)

(Inadequate data: 12)

At an FTP-angle difference exceeding 5° significantly poorer results were noticed (Chi^2: $p = 0.001$).

Table 17.
Position of prosthesis at follow-up.

Most pronounced displacement of the most dislocated prosthesis	
Lateral shift >5 mm $\leqq 10$ mm	2 (2)
Lateral inclination $>5^{\circ} \leqq 10^{\circ}$	7 (5)
Lateral inclination $>10^{\circ} \leqq 20^{\circ}$	4 (3)
Anterior inclination $>5^{\circ} \leqq 10^{\circ}$	6 (6)
Horizontal rotation more than 20°	1 (0)
Severe dislocation: Inclination $>20^{\circ}$ or lateral shift >10 mm	10 (10)
Displacement	30 (26)
No displacement	34 (17)

(Inadequate data: 3)

Only 4 of 30 knees with displacement of one or both prostheses had a "satisfactory"

result at follow-up. When no dislocation was noted, 17 of 34 knees had a "satisfactory" result. The 10 knees with severe dislocation had a "not satisfactory" result at follow-up. The result was significantly poorer when displacement was present (Chi^2: $p = 0.002$).

When comparing the position of the prosthesis at follow-up and immediately postoperatively, it was found that in 10 knees the displacement was present immediately postoperatively. In 11 knees a slight displacement was present postoperatively but this increased during the observation time. In nine knees, the position of the prosthesis was normal immediately postoperatively, but the increased displacement developed during the observation time. The most usual displacement immediately postoperatively was an anterior inclination of one or both prostheses due to compensating for a preoperative extension defect.

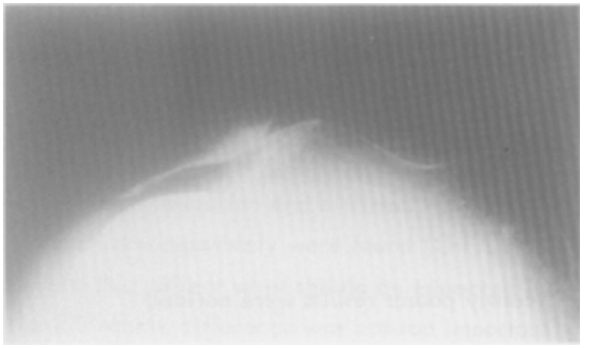


Fig. 9. Postoperative subluxation of patella secondary to subluxation laterally and outward rotation of tibia.

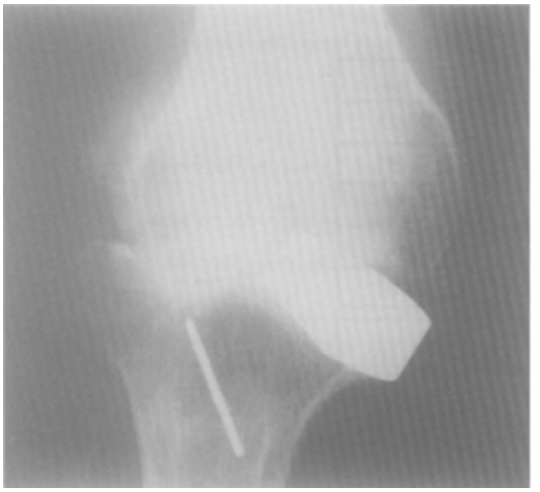


Fig. 10. Pronounced displacement of the prosthesis and lateral subluxation of the tibia.

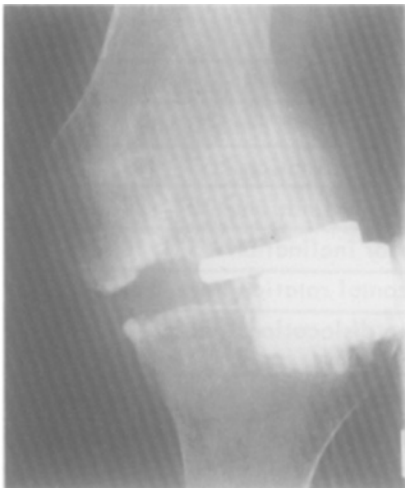


Fig. 11. Dislocation of the medial prosthesis to the lateral compartment.

Patients' opinion at follow-up

15 patients regretted having had the operation and 52 thought that they had benefited by the operation. All knees that in the opinion of the patients were unacceptable had according to Weinfeld's point system a "not satisfactory" result. The average score for this group was 15 points against 8.4 points for the others. The reason for the patients' disappointment in 13 knees was pain at rest or immediately at weight-bearing.

To obtain a more precise idea of the patients' impression of the result, the following four possibilities were suggested:

Table 18.

Almost normal	7
Improved	44
Unaltered	11
Deteriorated	5

Statistical correlation could be shown between the patients' opinion and the evaluation result according to Weinfeld (Chi^2: $p = 0.0003$).
There was also a statistical correlation between patients' opinion and pain at follow-up (Chi^2: $p = 0.007$).

ARA function class

All patients were graded both preoperatively and at follow-up according to the American Rheumatoid Arthritis Function Class System (Class I: Manage without help, to Class IV: Totally dependent). This system was modified by dividing class III into subgroups a and b. Patients in subgroup IIIa were considered stable enough to remain in this class with continued rheumatological treatment; patients in subgroup IIIb (patients at risk) were likely to deteriorate to group IV unless surgery was undertaken. Functional classification depends on the status of the entire locomotor system and can alter with disease activity as well as therapy during the observation time.

Table 19.

ARA	Preoperatively	Follow-up
II	3	7
IIIa	18	22
IIIb (risk)	30	22
IV	13	13

(Insufficient data: 3)

Improved	21
Unchanged	33
Worse	10

The improvement was significant (Wilcoxon's SRT: $p = 0.029$).

No significant change in the socio-economic situation as a result of arthroplasty in the knee was found, but it must be seen as most satisfactory that 55 of these very disabled patients still manage to live at home.

DISCUSSION

McIntosh arthroplasty in the Lund material resulted in 23 knees (34 %) with "satisfactory" and 44 (66 %) with "not satisfactory" results, using the Weinfeld point system at follow-up after an observation period of, on average, 3.3 years. On the basis of 10 published materials (Andersson et al. 1973, Blum et al. 1974, Conaty 1974, Hastings and Hewitson 1973, McIntosh and Hunter 1972, Jani and Morscher 1973, Jessop and Moor 1972, Neville and Martins 1972, Potter 1969, and Schorn et al. 1977) the frequency of good or excellent results in a total of 553 knees in patients with rheumatoid arthritis can be calculated at 57 % (38-82 %) with average observation periods of 1.6-4.0 years. To compare different populations with different evaluation systems is of doubtful value, however (Andersson 1972). Jani and Morscher (1973) (11 knees with observation period 3.8 years) and Potter (95 knees with observation period 3 years) evaluated their materials using the Weinfeld point system and found "satisfactory" results in 82 % and 56 % respectively. By using the evaluation criteria as reported by Blum et al. (1974) (51 knees followed for 1.6 years), only 16 % of the knees in the Lund material fulfilled the requirements for a good result; Blum et al. (1974), however, reported 43 % good result in their series. The results of the Lund material thus seem to be inferior to other published works. This might be due to population differences, but can also be caused by differences in indications and contra-indications to surgery, the operative technique and postoperative treatment. However,

the indications for operation with a hemiprosthesis in the 10 materials referred to were in accordance with the indications used in the Lund material.

Contraindications to McIntosh arthroplasty

Contraindications varied in different published materials. McIntosh (1971) found it technically possible at surgery to compensate for an extension defect up to 40° by loosening the insertion of the posterior capsule to the tibia and by resection of a ridge on the femoral condyles; moreover, if the cruciate ligaments obstructed extension they could be resected. In most reports, lower values of an extension defect were regarded as a contraindication. Kenwright and Duthie (1971) and Jani and Morscher (1973) accepted only 20°; Andersson et al. (1973), Hastings and Hewitson (1973), Potter (1972) and Mowat et al. (1973) accepted up to 30°. In the Lund material up to 30° were accepted and no correlation was observed between the degree of extension defect preoperatively and the result at follow-up.

McIntosh (1971), Potter (1972), Nelson and Evarts (1971) considered 30° of varus or valgus as a contraindication. Andersson et al. (1973), Neville and Martins (1972) and Mowat et al. (1973) only accepted 20°. Subluxation of the tibia was considered a contraindication by Jani and Morscher (1973), McIntosh (1971) and Potter (1969). In the Lund material, up to 30° of valgus or varus on weight-bearing was accepted. Significant correlation between valgus or varus and result at follow-up was not found. On measuring angles on frontal roentgen exposures at weight-bearing and provocation so that the greatest divergence from 174° was registered in varus or valgus provocation, a "satisfactory" result was found at follow-up in 8 of 9 knees with an FTP-angle between 168 and 180°. At an FTP-angle exceeding 180° or less than 163°, the result was significantly worse.

Kenwright and Duthie (1971), McIntosh (1974), and Nelson and Evarts (1971) considered predominant destruction of the femoral condyles as a contraindication for hemiarthroplasty. Neville and Martins (1972) only accepted 5 mm reduction of the femoral condyles. In the Lund material, obvious deformation of the femoral condyles was a contraindication. By reviewing the roentgen material at follow-up, pathological configuration of one or both femoral condyles in 19 knees was found and the result at follow-up was "satisfactory" in only four knees. These changes in the femoral condyles mainly developed after the arthroplasty and were believed to be caused by the articulation between an unelastic metal surface and abnormal cartilage at the femoral condyles.

Potter (1969) found large subchondral cysts to be a contraindication. In the Lund material, an unsatisfactory result was found in 6 of 7 knees with large subchondral cysts in the tibia at operation. Andersson et al. (1973), Jani and Morscher (1973) and Nelson and Evarts

(1971) considered extreme osteoporosis a contraindication. In the Lund material the degree of osteoporosis was not quantitatively measured, but where systemic cortisone therapy had been administered for some years preoperatively, results were no worse than in the rest of the material.

Other involved joints

Hastings and Hewitson (1973) considered poor function in the hip and foot joints a contraindication. In the Lund material at follow-up, pain was experienced by eight patients at weight-bearing in the ipsilateral hip and by 11 in the contralateral hip. In all cases where pain in the hips at weight-bearing was present, the result of the knee arthroplasty was "not satisfactory" at follow-up. In this material, pain at weight-bearing in the foot joints did not affect the result of the arthroplasty. In eight patients where arthrodesis in the contralateral knee was performed before the knee arthroplasty, the result of the arthroplasty in all cases was "not satisfactory".

Surgical approach

Most authors have recommended a medial parapatellar approach. Hastings and Hewitson (1973) recommended a lateral approach because of diminished damage to lymph drainage. Burrough et al. (1973) and Jessop and Moor (1972) recommended the use of two parapatellar incisions when prostheses were inserted in both compartments. In the Lund material a medial parapatellar incision was consistently used; the wound failed to heal within four weeks in only four knees. Detachment of the tibial tuberosity was recommended by McIntosh (1971) and Jessop and Moor (1972) in the presence of severe destruction of the knee. Hastings and Hewitson (1973) divided the patella tendon instead, because osteoporosis made detachment of the tibial tuberosity a hazardous procedure. Other authors found detachment of the tuberosity to be unnecessary. In the Lund material, the tibial tuberosity was detached in 20 knees; the operation was made technically easier by this approach, but convalescence was delayed because of the necessary postoperative immobilization and the high incidence of open mobilization. In spite of normal wound healing, absence of infection and a final result that did not differ from the rest of the material, there was a 50 % increase in the time spent in hospital.

Operative procedure

Neville and Martins (1972) found that synovectomy was contraindicated because of decreased postoperative mobility after synovectomy. McIntosh (1971) found that a synovitis often became inactive after arthroplasty and that synovectomy was indicated only in very active cases. Most other authors have consistently performed a synovectomy at arthroplasty. In the Lund material, synovectomy was consistently carried out. The operation

time was hardly increased and the partial denervation of the joint (Kellgren and Samuel 1950) may have been an advantage during mobilization.

Opinions seem to differ considerably concerning management when pronounced destruction was found in the FP-joints. Most authors mentioned that patellectomy should be avoided if possible. The highest frequency of patellectomy was found in Murray's material (1967), 10 patellectomies in 20 arthroplasties. Keever (1959) recommended patella prosthesis, Potter (1969) recommended fascia lata plasty. In the Lund material, only osteophytes were removed and erosions scraped. Although reduction of cartilage or attrition was found in 37 of 62 knees, considerable FP-joint problems were noted in only two knees postoperatively and then associated with patella subluxation. In 9 of 11 knees with preoperative attrition in FP-joints, results at follow-up were "not satisfactory", however.

McIntosh (1971) recommended reshaping of the femoral condyles. Potter (1969) and several others claimed the importance of chiselling away the bony ridge on the anterior part of the femoral condyles which develops when flexion contracture is present and the anterior edge of the tibia impinges on the femoral condyles. Turner et al. (1972) considered the use of a femoral mould prosthesis to be indicated if the main part of the destruction was localized to the femoral condyles. In the Lund material, hemiarthroplasty was not performed if the femoral condyles were severely deformed. Because of the usually thin eburnated cortical covering of the femoral condyles, the possibilities of remodelling the condyles were not considered realistic.

Bone cement was not routinely used in any of the reports referred to in this discussion, but the use of cement for filling defects in the tibia is recommended. Kates, who developed a modification of the McIntosh prosthesis for fixation with bone cement, recommended the consistent use of cement. In the Lund material, fixation with bone cement was only used in 25 knees with increasing frequency during the latter years. Burrough et al. (1973), McIntosh (1969) and Murray (1967) recommended insertion of a prosthesis into both compartments in rheumatoid arthritis regardless of the state of the least destroyed compartment. Blum et al. (1974), Conaty (1973) and Mowat et al. (1973) recommended that a prosthesis be inserted only in one compartment if this achieves lateral stability and alignment. In the Lund material, unicompartment operation was performed in 14 knees which were less destroyed preoperatively than those in which a bicompartment arthroplasty was carried out. At follow-up equal results in uni- and bicompartment operations were found.

Postoperative management

Although the intentions were to achieve primary wound healing and as good mobility as

possible, not two authors have recommended the same postoperative regime. McIntosh (1971) used Jones's compression bandage and kept the knee extended for five days before flexion was permitted. Potter (1969) recommended flexion on the third day, but used a plaster cast to immobilize the knee at night for 8-12 weeks. Weight-bearing was permitted by McIntosh (1971) after 5-7 days. Potter (1969) considered that full weight-bearing was possible after three months. In the Lund material wound healing was not a major problem. From this point of view, passive flexion after three days had no harmful effects. When cement is not used to fix the prosthesis, it seems reasonable to delay flexion and weight-bearing until fibrous retention of the prosthesis has developed. At surgery, it was often observed that the prosthesis dislocated and that the anterior end of the prosthesis did elevate on flexing the knee. With osteoporosis impaction of the prosthesis into spongious bone is also likely. In this material a change in position of the prosthesis from the first postoperative examination to follow-up was found in 20 knees. The result at follow-up when there was displacement of the prosthesis was "satisfactory" in only 4 of 30 knees; it was not known when displacement occurred, but some of the displacements might have been caused by the early mobilization.

Manipulation under anaesthesia

McIntosh (1971) recommended manipulation under anaesthesia if flexion had not exceeded 90° after two weeks; cortisone was simultaneously injected into the knee. In Potter's material (1969), manipulation under anaesthesia was carried out in one third of the operated knees. When the tibial tuberosity was detached, open manipulation after 2-3 weeks was considered an almost obligatory second stage and in this material it was done in 15 of 20 knees.

Of 47 knees operated without detachment of the tibial tuberosity, manipulation under anaesthesia was done in only five knees. In one of them, both prostheses were impacted into the tibia and a horizontal rotation of one of the prostheses developed with a marked impairment of mobility. Early and active mobilization was instituted partly to avoid the risks involved with manipulation.

Deep infection

In the 10 clinical materials previously referred to involving 553 RA knees, deep infection was reported in 24 (4 %). Only McIntosh and Hunter (1972) stated that they used irrigation with neomycine during surgery. Systemic antibiotics did not seem to have been used by any of the authors. In the Lund material, prophylactic antibiotics were not used, and despite this, no instance of deep infection was noted. The highest incidence of delayed wound healing or superficial infection was found in 10 of 51 knees in Blum's et al.

material (1974). In the Lund material, complicated wound healing was found in four knees (6 %).

SUMMARY

67 knees in 59 patients with RA were operated with the McIntosh prosthesis from 1967 to 1973.

At follow-up 3.3 years postoperatively, an arbitrarily chosen degree of normalization of the knee, 0-6 points according to Weinfeld's evaluation system equal to a "satisfactory" result, was achieved in 23 of 67 knees. Of 44 knees with seven or more points ("not satisfactory"), an improvement was noted in 27 knees, unchanged in four and worse in 13. The arthroplasty led to a reduction in pain, diminished extension defect and correction of lateral instability. Quadriceps power was increased and deformity at weight-bearing reduced. A moderate reduction of flexion was noted. In 55 knees, an improvement was achieved in the patients' opinion; in 16, the knee was unchanged or worse than preoperatively. A moderate but significant improvement of ARA functional classification occurred.

No fatal or life-threatening complications or deep infections were noted. A "not satisfactory" result was found in connection with accidential loosening of the anterior cruciate ligament, presence of large cysts in the tibia, incongruency after insertion of the prosthesis, and a prosthesis not large enough. Postoperative complications in the form of dislocation of the patella, dislocation of the prosthesis and collapse of the nonoperated compartment resulted in a high frequency of "not satisfactory" results. "Not satisfactory" results at follow-up were also found when malposition of the prosthesis was present, when valgus or varus deformity was present, if the FTP-angle difference was $\geqq 5^{\circ}$ and when destruction of the femoral condyles develop postoperatively.

An improvement of results could obviously be achieved by stricter indications for the method. Hemiarthroplasty gave poor results in patients who have been artrodesed in the opposite knee, had pain in the hips at weight-bearing, previous osteotomy or capsulotomy of the involved knee or who used a support to walk indoors preoperatively. There only remained a small group of patients with moderate pathological changes in the knee where late synovectomy could be a realistic alternative. Although the frequency of complications was acceptable at the time, McIntosh arthroplasty has nothing to recommend its use as a rational prosthetic alternative.

IV. GUEPAR ARTHROPLASTY

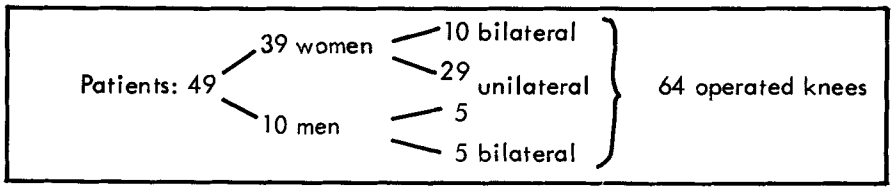
MATERIAL AND METHODS

The methods described in the introductory section p. 7 were only modified with regard to the prosthetic design. Postoperative roentgen examination at weight-bearing and provocation was not found to be of value because the mobility that developed on loosening of the prosthesis between cement and bone was so limited that the errors in FTP-angle measurements made the results unreliable. The postoperative roentgen examination aimed at identification of prosthetic loosening and/or infection.

To evaluate as early as possible the results of a Guépar arthroplasty, a preliminary postoperative examination was made after 12 months. During 1976-1977, an additional follow-up was carried out if at least six months had elapsed since the preliminary examination. In this way, 48 knees were examined on two occasions with on average 16 months (6-33) between examinations. In knees with complicated wound healing or suspected deep infection, case records were checked, and where indicated, the patient was re-examined in June 1978.

From 1972 through 1976, 49 patients, 39 women and 10 men, with RA were operated on with the Guépar prosthesis. Five men and 10 women were operated bilaterally making a total of 64 prostheses.

Fig. 12.



All operated knees were examined by the author and are included in the material.
Observation time averaged 2.7 years (1.1-4.3).
Average age at operation 63 years (29-77); women 65.4, men 54.3.

More than half of the patients had RA for more than 10 years before arthroplasty. 53 knees were symptomatic for more than five years.

Table 20.
ESR preoperatively.

ESR mm/h	0-25	26-65	66-150
Knees	15	34	15

Previous treatment of the operated knee

Intra-articular cortisone. In 22 knees 1 to 10 cortisone injections were given and in 24 more than 10 injections; 18 were never treated with intra-articular cortisone.

Synovectomy. Chemical synovectomy using osmium acid was carried out in seven knees and a combination of chemical and surgical synovectomy in 12 knees. Surgical synovectomy alone was done in seven knees making a total of 26 chemical and/or surgical synovectomies.

Capsulotomy was performed in four knees for correction of a flexion contracture.

High tibial osteotomy was carried out in five knees; two for correction of valgus, two for varus, and one for correction of an extreme flexion contracture.

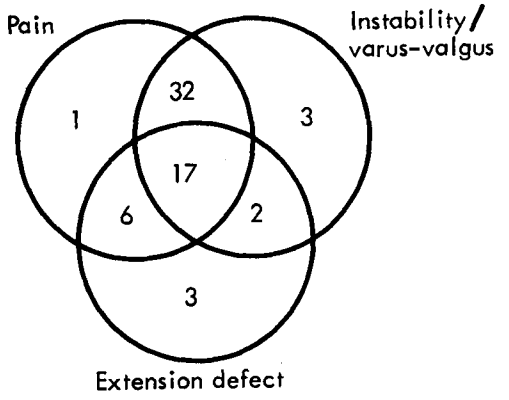
McIntosh arthroplasty. Eight previous McIntosh arthroplasties were converted to Guépar arthroplasties.

Marmor arthroplasty. Two previous Marmor arthroplasties were converted to Guépar arthroplasties because of collapse of the medial tibial condyle and loosening with displacement of the prosthesis.

Indications for operation

The indications for Guépar arthroplasty were changed during 1972-1976. When the prosthesis was introduced in 1972, there was a group of patients with extremely destroyed knees in which a McIntosh prosthesis would not have been sufficient for reconstruction. Because of the initially promising results following surgery, the indications for Guépar arthroplasty were considerably widened and from 1973 through 1974, it was also used in knees which previously would have been operated with a McIntosh prosthesis. Later, through our own experiences and reported complications following hinge joint arthroplasty, the indications were limited to the most severely destroyed knees.
No maximum limit for degree of deformity, subluxation between tibia and femur or extension defect was established; it was possible by means of sufficient bone resection to align the tibia and femur and obtain full extension.

Fig. 13.
Clinical indication for Guépar arthroplasty in 64 knees.
See Fig. 4 for definition of subsets.



Pain was found in 56 knees (Fig. 13). In eight knees without pain, the main indication was instability and/or deformity in five and in three, an extension defect exceeding 30°. 54 knees were unstable and/or in varus or valgus exceeding 10°. In 28 knees there was an extension defect exceeding 15°. Decreased flexion was not of such degree as to constitute an indication.

Contraindications

Arthroplasty was not performed if there was a known focus of infection.

Operative technique

One surgeon performed 51 operations and eight others performed 13 operations. The operation was performed in a bloodless field under general or epidural anaesthesia. A medial parapatellar incision was used and a synovectomy was carried out. The collateral and cruciate ligaments were divided and the distal 15 mm of the femoral condyles resected so that the resected surface made a lateral open angle to the longitudinal axis of the femur of approximately 83°. The posterior aspect of the femoral condyles and the inferior part of the patella groove were removed. The proximal tibia was resected at a right angle to the longitudinal axis, making the total resection of femur and tibia approximately 18 mm or more for correction of flexion contractures. The position of the patella in relation to the depression on the femoral component was checked and if the patella dislocated laterally, a lateral release was performed and if necessary the tibial tuberosity was transferred medially. When inserting the cement the marrow cavities were

drained by a tube to prevent increasing pressure developing in the marrow cavity. Solucortef 100 mg was administered intravenously and the patient was ventilated with pure oxygen. These precautions were taken to prevent cardiopulmonary complications due to fat microembolism in the pulmonary capillaries (Olerud 1974). The femoral and tibial components were connected by the axle and the knee extended while the cement polymerized. Because of lateral dislocation of the patella during surgery and preoperative lateral rotation deformity in many knees the tibia had a tendency to rotate outwards. If the patella at this stage had a tendency to dislocate, a medial plication was done. A long-leg plaster cast was applied, and the bloodless field released. Vacuum drainage was applied and maintained for 24-48 hours.

Antibiotics. Prophylactic treatment with cloxacillin 1 g x 4 and probenecid 1 g x 2 was started before surgery and continued postoperatively for 10 days in 52 of 64 operations. In 12 operations no antibiotics were given before surgery or was discontinued earlier than 10 days because of secondary effects.

Anticoagulation therapy was not used routinely.

Postoperative treatment

The quadriceps was exercised from the first postoperative day and weight-bearing was permitted after 3-4 days. The plaster cast was removed at two weeks and active flexion began. If 90° flexion was not reached two weeks later manipulation under anaesthesia was performed; in this material in 34 knees.

COMPLICATIONS

Operative complications and technical difficulties

In 34 of 64 operations no technical difficulties or complications were encountered. The technique was modified or complications noted in 30 operations. In two operations two complications were noted.

Patella dislocation. In 17 knees lateralization of the patella occurred when the capsule was closed; in six the tibial tuberosity was transferred medially; in nine the lateral patella retinaculum was divided longitudinally (lateral release) and/or medial plication was performed. In one knee a left-side prosthesis was used in the right knee thus maintaining slight varus and diminishing the tendency of the patella to dislocate.

Extension lag (relaxed patellar ligament). In four knees with preoperative flexion contracture and limited quadriceps amplitude, the patellar ligament was extremely slack after insertion of the prosthesis. In two of the knees the tibial tuberosity was transferred 3 cm distally to prevent an extension lag.

Fractures or perforations. Perforation of the femur (2) or tibia (3) caused by reaming or at insertion of the prosthetic components occurred in five knees but did not cause any major weakening of the bone. Prolonged immobilization was not necessary and mobilization followed the normal routine. In one knee after a previous high tibial osteotomy, the medial tibial condyle was fractured and the tibia rotated 25° laterally when the prosthesis was cemented.

Loss of substance in tibial condyles. Severe destruction of the tibial condyles because of subchondral cysts was found in three knees. Most of the resection therefore was of the tibia. In one knee the loss of bone in the tibia was caused by a total collapse of the medial tibial condyle following a failed Marmor arthroplasty.

Wrong prosthesis. In one knee with extreme varus preoperatively, a right knee prosthesis was inserted in the left knee due to an error in labelling following sterilization. Most of the varus was however corrected and the prosthesis was therefore accepted.

Postoperative complications

General complications occurred in four patients and local complications in 21 knees.

General complications. Respiratory complications developed in three patients within the first week after the operation: lung embolus in one, pneumonia in two. The patients made an uneventful recovery following conventional therapy. In one case, a toxicodermi with fever developed caused by a previously unknown allergy against the prophylactic antibiotic.

Complicated wound healing - superficial infection. In 13 knees, the wound failed to heal within four weeks. In one a necrosis measuring 7 x 2 cm healed without surgery after six months. Several cultures were negative, but the surrounding tissue was red and warm. In four a defect of 0.5-2 cm with a serous secretion and negative culture was present. In one, blisters developed around the incision and culture showed β-streptococcus. In four, secretion continued from the wound for 4-8 weeks and positive culture was found (anaerobic streptococci, staph. epidermidis (two knees), aerobacter). All organisms cultured are usually found in normal skin and no signs of clinical infection were present. Antibiotic therapy was continued until the wound healed.

In three, infection with purulent secretion, local redness, swelling and tenderness were present. Culture in two cases showed staph. aureus and in one E. coli. The infections healed with antibiotic therapy after 8, 26 and 28 weeks but antibiotics were continued for three months, one year and two years, respectively.

Table 21.
Predisposing factors for complicated wound healing.

	Complicated wound healing (13)	Normal wound healing (51)
Patella dislocation at surgery or post-operatively	8	13
Transfer of the tibial tuberosity	4	4
Previous knee operations	6	25
Cortisone preoperatively more than one year	5	25
No prophylactic antibiotics at surgery	2	10
Manipulation under anaesthesia	8	26

Analysis of possible reasons for complicated wound healing (Table 21) showed that transfer of the tibial tuberosity (Chi^2: $p = 0.026$), patella dislocation at surgery or postoperatively (Chi^2: $p = 0.013$) were significantly increased.

Deep infection. In one knee with uncomplicated wound healing, the knee became painful swollen and warm one month after operation. No culture was taken, but because of the clinical picture, treatment with antibiotics was continued for six months. The patient died of unrelated disease one year after operation without signs of infection in the knee.

Patella dislocation. In two knees with a tendency to patella dislocation at surgery, dislocation occurred postoperatively, although correction with lateral release and medial plication was performed at operation. Both knees were reoperated with a new medial plication.

Peroneal palsy occurred after three operations. In one, the nerve was explored at six weeks and was found intact. All three completely recovered.

Pressure necrosis over the achilles tendon. In one knee a pressure sore developed in the skin over the achilles tendon. The defect healed spontaneously.

Femoral fractures. During physiotherapy, two weeks after manipulation under anaesthesia,

one patient experienced intense pain at the middle of the femur. Roentgen examination showed a fracture of the femoral diaphysis level with the tip of the prosthetic stem. This might have been due to an infraction during manipulation or a stress fracture. The fracture healed in balanced traction in eight weeks.

Duration of hospitalization. The average time spent in the Department of Orthopaedics or Rheumatology was 45 days (8-180). When complicated wound healing was present, the duration was increased on an average by 44 %.

Late complications

Complications registered later than two months after operation but within the observation time occurred in 21 knees.

Patella dislocation. In five knees, the patella dislocated on flexion, lateral to the trochlea on the femoral component (Fig. 16a and b). In one knee, this dislocation caused pain on flexion and extension and a transfer of the tibial tuberosity was carried out. This reoperation was complicated by a superficial infection.

Fractures. A femoral shaft fracture occurred after a fall at home in a patient with a known late infection and a more than six mm broad radiolucent zone around the cement and loosening of the prosthesis (Fig. 17a and b); following immobilization the fracture healed without complications.

Late infection. Because of the importance of deep infection as a complication after hinge arthroplasty all knees with complicated wound healing or suspected deep infection, even when evident after the follow-up examination, were reviewed in June 1978. Evidence of late infection were found in 15 knees. The observation time was on average 4.6 years (2.1-6.0).
Diagnosis of late infection was based on a combined assessment of local clinical symptoms such as pain, swelling, redness and warmth, fistula and skin necrosis, and general signs of infection such as fever, leucocytosis, ESR and CRP elevation and bacteriological findings. Roentgen observations such as abnormal width and enlargement of radiolucent zones, scalloping and periosteal reaction were also considered. Scintimetry with Sr^{85} was done in most cases of suspected infection.

Appearance of late infection

Half of the late infections appeared within the first year after operation. After the first year, the cumulative curve became quite straight and was still rising. After five years, an additional infection was found and it seems reasonable to expect more in the future.

Table 22.
Initial manifestation of late infection.

Dolor, rubor, calor (2-3 months)	2
Fistula (12-41 months)	5
Septic arthritis (4-52 months)	3
Increasing radiolucent zone + pain at weight-bearing (11-62 months)	5

Two of the three patients that developed septic arthritis died of sepsis within one week despite intensive antibiotic therapy.

Table 23.
Result of culture.

No culture	2	
Culture from wound or fistula	6	Anaerobic streptococci, β-streptococci, staph. aureus, staph. albus + coliform rods, staph. aureus + gramnegative rods, clostridia
Aspiration of the knee	1	Negative
Fenestration of femur	1	Staph. aureus
Operative tissue culture at reoperation (6 samples in each case)	5	3 none isolated in 5-6 of 6 samples 1 Propione bact. acne in 4 of 6 samples 1 Streptococci in 5 of 6 samples

According to Lindberg (1978), infection should be proved by taking six tissue samples from the suspected area when no antibiotics have been administered for six weeks. These requirements were fulfilled in only two knees; in one propiione bact. acne was found in 4 of 6 samples, and in the other β-streptococci was found in 5 of 6 samples. In one knee a fenestration was done; pus was present and culture showed staph. aureus which was considered the causative organism.
In six knees where no culture was made or no organism was identified but where the patient was under treatment with antibiotics when the culture material was obtained, infection could have been present. In six knees culture from the wound or fistula showed the abovementioned organisms which might have been the causative organism, but contamination could not be excluded.

The bacteriological diagnosis was thus definitely established in only three knees. In 12 knees infection might have been present, but the causative organism was not positively identified.

Factors predisposing to deep infection

Complicated wound healing. In four knees with late infection, wound healing was not established four weeks after operation. Only one of them had a clinically superficial infection initially with a fistula in the tibial tuberosity area. Fistulography and exploration failed to show any communication with the joint. These four knees were treated with antibiotics for 2, 15, 17 and 48 months before the deep infection became manifest.

Antibiotic prophylaxis was used in 52 knees. Late infection developed in nine. In 12 knees, no prophylactic antibiotics were administered before surgery or was ended because of secondary reactions. Late infection developed in six. Prophylactic antibiotics significantly reduced the frequency of late infection.

Transfer of the tibial tuberosity. In 5 of 15 knees with a late infection, the tuberosity had been transferred. In 49 knees without late infection, the tuberosity was only transferred in three. Transfer of the tuberosity significantly increased the frequency of late infection.

Dislocation of the patella at surgery or postoperatively, previous knee operations and cortisone medication did not substantially predispose to late infection in this material.

Treatment of late infection

Treatment with antibiotics. Nine patients with 11 infected knees were treated with antibiotics from 6 to 60 months (average 27 months). Two patients with three infected knees were still under treatment with antibiotics. These knees were almost painfree but the prostheses were clinically loose with instability; the patients' condition precluded reoperation. In three knees, antibiotic treatment was discontinued, and more than 12 months had passed without signs of reinfection. Because of progress of infection in spite of antibiotic treatment, five knees were reoperated.

Change of prosthesis. In four knees the prosthesis was removed; in two, it was replaced with a new Guépar prosthesis, and in two with a Shier prosthesis. The reoperations were done 16, 17, 37 and 42 months after infection became manifest. The Shier prosthesis was chosen in two knees because the stems were longer than in the Guépar prosthesis. When removing the infected prosthesis, a 1 cm wide groove was opened longitudinally in the femur and tibia until the tip of the cement was identified and through this channel all

cement was chiselled away. After synovectomy and removal of all non-viable tissue, a new prosthesis was inserted with cement containing gentamycin.

Arthrodesis was carried out in one knee 61 months after the initial signs of infection. Observation time was too short to decide whether osseous healing would be achieved (Fig. 18a and b).

Amputation. In one knee a fulminant septic arthritis developed within a few days 18 months after the arthroplasty. The prosthesis was removed, perfusion drainage instituted and intensive systemic antibiotic therapy started but septicaemia with toxic manifestations developed. On vital indication, an above-knee amputation was performed. The patient survived, has a lower limp prosthesis and a total hip arthroplasty in the contralateral hip performed without complications.

Status June 1978

Late infections were diagnosed in 15 knees in 13 patients. Two patients had died of septicaemia. One above-knee amputation had been carried out (vide supra). Four had been reoperated with a change of prosthesis and were without signs of present infection. One of these four was still on antibiotics because of an infection in the other knee. One knee had been arthrodesed. One with a slowly progressive low virulent infection was due for a change of prosthesis. Three had no signs of infection more than one year after discontinuing antibiotics. One had a continuous infection in both knees and was on antibiotics.

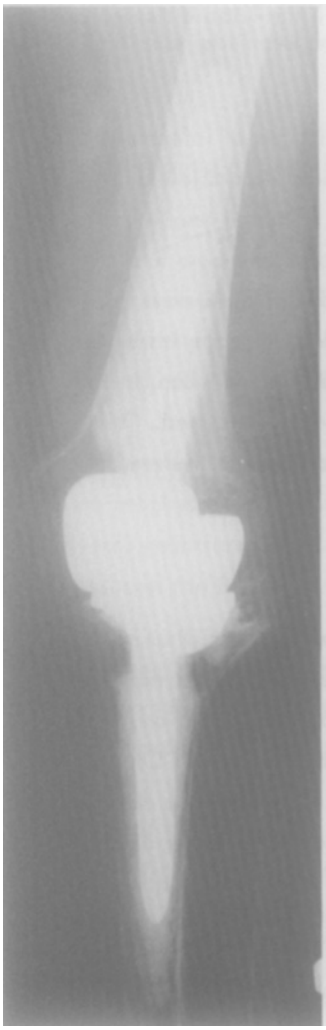


Fig. 14a. Normal position of prosthesis in frontal exposure.

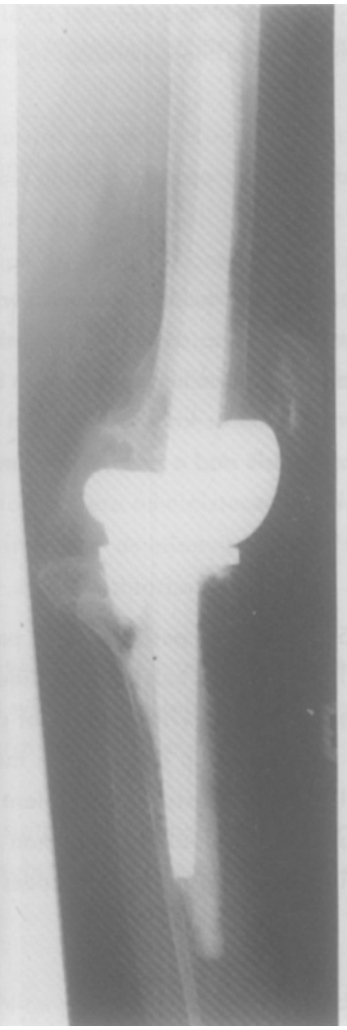


Fig. 14b. Normal position of prosthesis in lateral exposure.

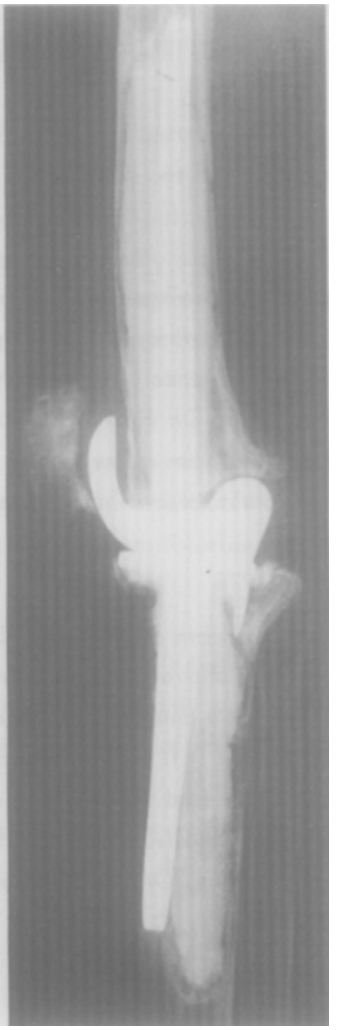


Fig. 15. Perforation by tibial stem, pathological radiolucent zone caused by late infection.

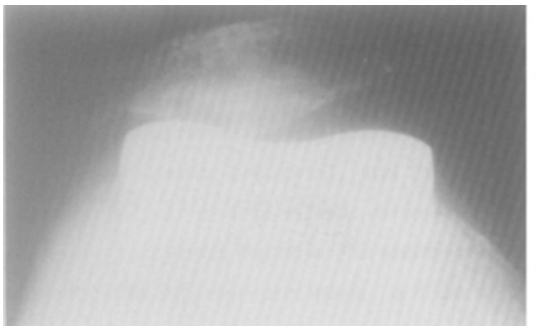


Fig. 16a. Lateralisation of patella at the postoperative examination.

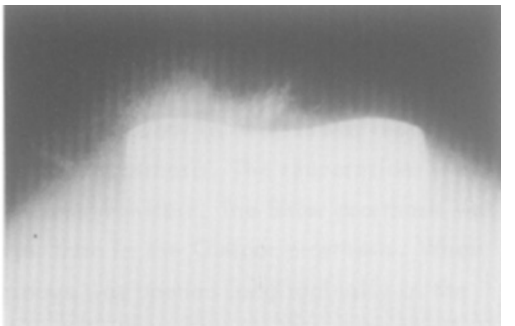


Fig. 16b. Increased lateralisation of patella and deformation three years after operation.

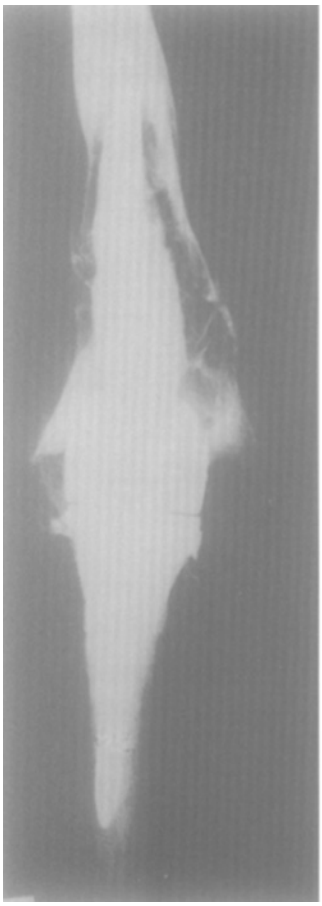


Fig. 17a. Femoral shaft fracture in a case with late infection and extreme radiolucent zones.

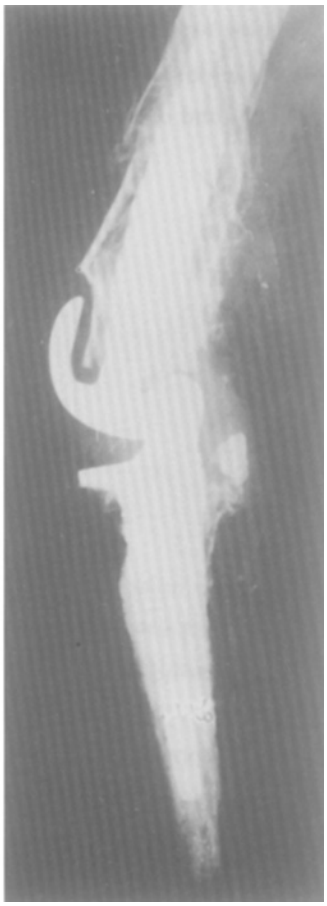
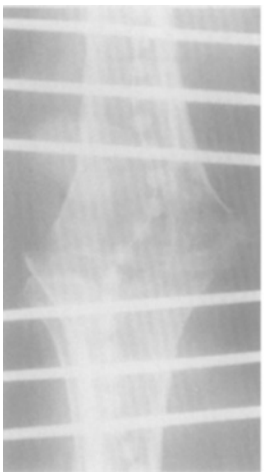
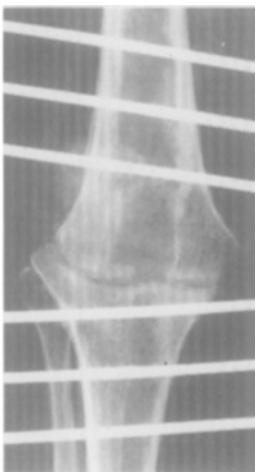


Fig. 17b. Lateral exposure.



a.



b.

Fig. 18a. Arthrodesis using Audrey-Vidal instrument in infected case. Cement beads with Gentamycin were retained in the marrow cavities for 2 weeks (Wahlig et al. 1978).
Fig. 18b. Same case 5 months later, the arthrodesis was not completely united.

FOLLOW-UP EVALUATION

The seven parameters in Weinfeld's evaluation system (see page 9) formed the basis for the evaluation of status preoperatively and at follow-up.

Table 24.
Pain.

Preop. \ Follow-up	43	4	5	6	5	Sum
7	26	2	3	4	5	40
6	9	2	2	2		15
3						
1						
0	8					8
Points	0	1	3	6	7	

Pain at rest or immediately at weight-bearing was an important indication for operation in 55 knees. 35 of them were painfree after operation and in 13 knees, pain was diminished. In 16 knees pain on walking was present at follow-up. From the preliminary examination to follow-up approximately 12 months after operation (48 knees examined) pain increased in eight knees and diminished in 10.
An analysis of the reasons for pain at follow-up in 16 knees on less than 200 m walking showed a high incidence of tibial tuberosity transfer, dislocation of the patella at surgery and postoperatively and complicated wound healing. No increase in pain was found in relation to late infection. However, no significance can be attached to these factors even though occurring more than twice as much in the group with pain.

Table 25.
Use of support at walking.

Preop. \ Follow-up	15	9	10	30	Sum
4	8	3	5	27	43
2		6	5	3	14
1					0
0	7				7
Points	0	1	2	4	

In 22 knees the need for support at walking was diminished, in 39 unchanged and in

three increased. From the preliminary examination to follow-up, the need diminished in nine and increased in five. When quadriceps power was less than 100N at follow-up, the need for support at walking significantly increased.

Table 26.
Extension defect.

	Follow-up 51	10	2		Sum	
4	4	3	1		8	
2	19	1			20	Preop.
1	14	2	1		17	
0	14	4			18	
Points	0	1	2	4		

Arthroplasty reduced or eliminated the extension defect in 42 knees, left it unchanged in two, and increased it in five. From preliminary examination to follow-up, it increased in nine and was reduced in three. No correlation could be shown between extension defect at follow-up and decreased quadriceps power.

Table 27.
Flexion.

	Follow-up 50	8	4	1	Sum	
6		1			1	
3	1	1			2	Preop.
1	6	2	1		9	
0	43	4	3	1	51	
Points	0	1	3	6		

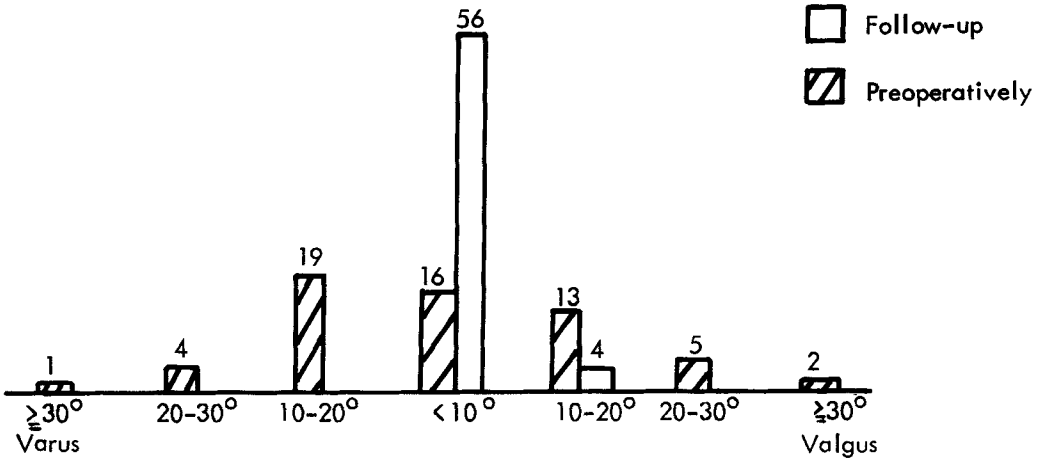
Flexion less than 80° was found preoperatively in 12 knees. Of these, an improvement of flexion was found in nine. Flexion less than 80° was found in 13 postoperatively. Of these, the flexion had been reduced in nine. From the preliminary examination to follow-up, flexion increased in six and was reduced in one.

Table 28.
Medial or lateral instability.

	Follow-up 58	2	1	Sum	
4	12			12	
2	36		1	37	Preop.
0	10	2		12	
Points	0	2	4		

Arthroplasty eliminated preoperative instability in 48 of 49 knees. At follow-up, instability exceeding 10° was found in three knees. Of the 58 knees with less than 10° lateral or medial instability, a very limited (less than 5°) mobility was registered when the observation time exceeded two years. This mobility, obviously present but not of a magnitude that permitted reliable measurement, could be caused by wear of the prostheses, or what is probably more relavant, mobility between cement and bone because of granulation tissue around the cement, which roentgenologically is visualized as a radiolucent zone. From preliminary examination to follow-up, medial or lateral instability ≧10° developed in three knees. Late infection with loosening of the prosthesis was the cause of instability in these knees.

Fig. 19.
Varus-valgus deformity at weight-bearing (clinical).



In 40 knees with considerable varus (24 knees) or valgus (16 knees) preoperatively, the FT-angle on weight-bearing was corrected to 164-184°. Only four knees had valgus of 10 to 20° at follow-up. This was caused in three by the stems of the prostheses abutting against the lateral cortex and in one, by late infection with loosening and marked resorption around the bone cement.

Table 29.
Quadriceps power.

	Follow-up 8	4	17	17	Sum	
4	6	2	15	14	37	
2	2	2	2	3	9	Preop.
1						
0						
Points	0	1	2	4		

The quadriceps power was improved in 27 of 46 knees but power exceeding 200N was reached in only eight. The quadriceps power was registered at the preliminary examination approximately one year after the operation and at follow-up on average 16 months later. A comparison of the quadriceps power on these two occasions showed an improvement in two knees, no change in 25, and a reduction in 24. This reduction was significant (Wilcoxon's SRT: $p < 0.0001$); many patients on testing experienced considerable, deep and intensive pain, which often continued for several hours afterwards.

Conclusion of results according to Weinfeld

For each of the seven parameters, the average point score preoperatively and at follow-up was calculated on the basis of the number of observations.

Table 30.

Score according to Weinfeld for the Guépar material preoperatively, at the preliminary examination and at follow-up.

	Pre-operatively	Preliminary examination (48)	Follow-up	Number of observations	Significant improvement (p) x)
Pain (0-7 points)	5.9	1.5	1.3	63	<0.001
Use of support at walking (0-4 points)	3.1	2.6	2.3	64	<0.001
Extension defect (0-4 points)	1.4	0.1	0.2	63	<0.0001
Flexion (0-6 points)	0.3	0.6	0.4	63	0.523
Medial or lateral instability (0-4 points)	2.0	0.0	0.1	61	<0.0001
Varus-valgus at weight-bearing (0-4 points)	1.7	0.1	0.1	60	<0.0001
Quadriceps power (0-4 points)	3.5	1.4	2.3	46	<0.001
Sum demerit points	17.9	6.3	6.7		

x) From preoperative to follow-up status.

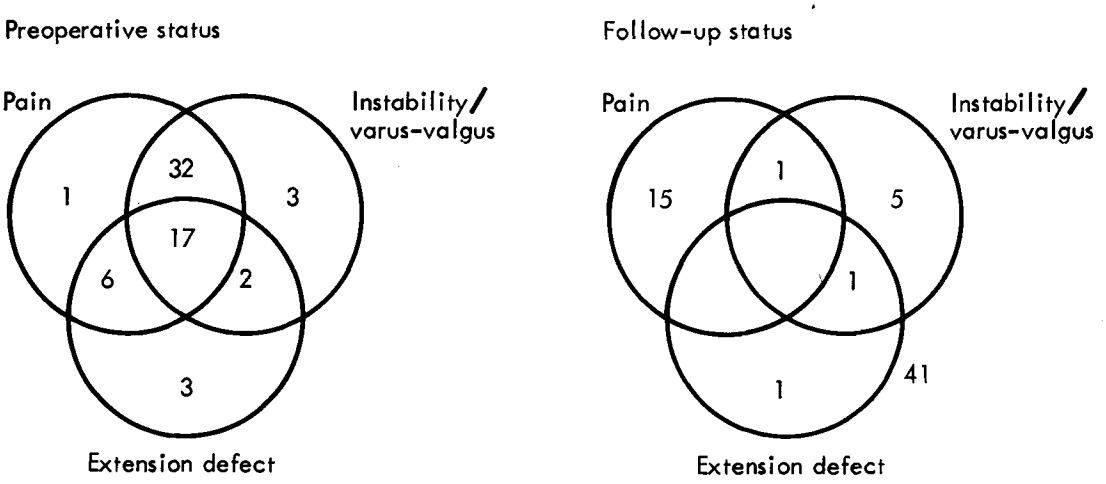
The average demerit points was 17.9 preoperatively against 6.7 at follow-up. The score was thus reduced by 63 %. Results at the preliminary examination of 48 knees approximately 12 months after operation was on average 6.3 points, which was 0.4 points better than average at the follow-up about 16 months later. The deterioration was caused by decreased quadriceps power at follow-up. On the basis of a comparison between average demerit points preoperatively and those at the three-year follow-up it can be concluded that the Guépar prosthesis has significantly reduced pain, need for support at walking, extension defect, lateral instability, varus-valgus deformity and quadriceps weakness. Flexion has not been significantly reduced.

On the basis of Weinfeld's evaluation system, the score at follow-up in 10 knees was excellent, 20 good, 20 fair and 14 poor. By simplifying the system into only two groups, 30 knees had a "satisfactory" result (0-6 points) and 34 a "not satisfactory" result (7-33 points). When comparing the status preoperatively and at follow-up for the individual knee with the exclusion of parameters that cannot be correlated because of inadequate data (quadriceps power preoperatively in 18 knees), it was found that 31 of the 34 knees with a "not satisfactory" result were improved, two unchanged, and one worse. The considerable improvement reached even in this group could be confirmed by the patients' own judgement, 29 knees improved, two unchanged and three worse.

Clinical indication for operation and result at follow-up

Clinical indications for operation and findings at follow-up were compared with similar parameters at follow-up in a Venn diagram.

Fig. 20.
See Fig. 4 for definition of subsets.



Preoperatively 57 of 64 knees had a combination of two or three parameters. At follow-up, 41 knees were outside the diagram and only two knees still had a combination of two of the preoperative parameters. Guépar arthroplasty was less effective in eliminating pain. In three of the seven knees at follow-up with lateral instability and/or malposition in varus or valgus, prosthetic loosening caused by infection was responsible.

EFFECT OF COMPLICATIONS ON FINAL RESULTS

("Satisfactory" implies a Weinfeld score 0-6)

	No. of knees	"Satisfactory"	"Not satisfactory"
Operative complications	30	9	21
Dislocation of the patella	17	4	13
Active insufficiency of extensors	4	2	2
Fracture or perforation (tibia or femur)	7	-	7
Bony defects in tibial condyle	3	2	1
Wrong side prosthesis	1	1	-
No. of complications (2 complications were noted in 2 operations)	32		

	No. of knees	"Satisfactory"	"Not satisfactory"
Postoperative complications (within two months)	21	9	12
Delayed wound healing	13	5	8
Dislocation of the patella	2	-	2
Peroneal palsy	3	1	2
Others	3	3	-
Late complications (after two months)	21	5	16
Late infection	15	3	12
Dislocation of the patella	5	2	3
Fracture of the femur	1	-	1
Without complications	16	10	6

PREOPERATIVE ROENTGEN FINDINGS RELATED TO RESULTS

The numbers in parentheses indicate "not satisfactory" results at follow-up.
Obliteration of the articular space was found in 16 knees and attrition of FT-joints in 48. In 19 of the knees, attrition was combined with lateral subluxation of tibia in relation to femur. Results at follow-up were not related to the degree of observed destruction in FT-joints.

Table 31.
Reduction of cartilage and attrition in FP-joints.

Height of cartilage > 3 mm	12 (6)
Reduction of cartilage 0-3 mm	23 (8)
Attrition	29 (20)

With attrition in the FP-joint, the result was found significantly worse at follow-up (Chi^2: $p = 0.021$).

Table 32.
FTP-angle on varus/valgus provocation.

FTP > 180°	18 (7)
FTP 180-168°	15 (8)
FTP 167-163°	6 (4)
FTP < 163°	8 (6)

(Inadequate data: 19)

Results at follow-up were better when the FTP-angle exceeded 180° and became gradually worse with decreasing FTP-angle (Chi^2: $p = 0.031$). Operative or postoperative dislocation of the patella was more common when the FTP-angle was < 168° but there was no significant correlation.

The FTP-angle difference on varus/valgus provocation were found to be without prognostic value.

ROENTGEN EXAMINATION AND RESULTS AT FOLLOW-UP

The aim of the analysis of the postoperative roentgen material was to demonstrate signs of prosthetic loosening and infection. The analysis was based on all existing roentgen material for each knee.

Operative fractures and perforations

Fractures or perforations of the diaphysis at operation were demonstrated by the presence of extraosseous bone cement or the existence of loose fragments; callus formation or periosteal reaction were late signs of operative fractures. In six knees a perforation of the diaphysis was found: two in the femur and four in the tibia. All perforations were localized near the point of the stem and probably occurred on reaming or inserting the prosthesis. There was no displacement in any of the fractures and healing was uneventful. The result at follow-up was "not satisfactory" in all six knees with perforation, although the prosthesis in only one knee was positioned with the point of the stem extraosseously (Fig. 15).

Position of prosthesis

Direct contact of the prosthetic stem with cortical bone occurred in four knees in the femur. 18 knees in the tibia and nine knees both proximally and distally. The result at

follow-up seemed not to be related to the position of the prosthesis in the medullary cavity.

Cement covering of the prosthetic stems

In 30 knees both stems were completely surrounded by cement and the results here were "satisfactory" in 16. In 34 knees one or both prosthetic stems were not completely surrounded by cement and results here were "satisfactory" in 14. The difference was not significant. An indication of the importance of surrounding the prosthetic stems for maximum fixation was the fact that the radiolucent zone, measured 12 months after operation, significantly more often exceeded 1 mm when the stems were not completely surrounded. This indicates that loosening of the prosthesis, although often of no major clinical importance, develops more rapidly in this group.

Demarcation zone

The demarcation zone was defined as the radiolucent zone which often developed postoperatively around the cement and parts of the prostheses in contact with bone and which was limited by a condensation of osseous tissue (internal cortex). To regard a wide radiolucent zone as being pathological, knowledge of the normal demarcation zone in relation to time was essential. It was therefore necessary to establish a normal material which excluded knees with deep infection, fracture or inadequate cementation of the prosthesis. This subset was extracted by the exclusion of knees having the following criteria:

1) Pain on walking less than 200 m
2) Inadequate cementation of one or both prosthetic stems
3) Operative or postoperative fractures of the femur or tibia
4) Knees with known ur suspected late infection

By this method 16 knees were extracted as a "normal material". All postoperative roentgen examinations for these knees were perused and the width of the zone was registered in relation to time following surgery.

In the "normal material" the demarcation zone was less than 1 mm during the first four postoperative years, except in one knee where the demarcation zone was 1.5 mm after two years.

Demarcation zone after one year. In 58 knees the width of the demarcation zone registered at one year following surgery was between 1 and 2 mm in seven knees, 2-4 mm in five knees and 4-6 mm in three knees. 15 knees therefore had a demarcation zone after one year which exceeded "normal" expectations.

Of the 15 knees with a demarcation zone exceeding 1 mm after one year, the cement surrounding one or both prosthetic stems was inadequate in 12. Late infection was present in five of them and in three, pain was present on walking less than 200 m. In three with adequate cementation of the prosthesis, no presence of late infection and no pain on weight-bearing the cause of a wide demarcation zone was obscure. Significant correlation was found between a wide demarcation zone and inadequate cementation of prosthesis (Chi^2: $p = 0.017$).

Demarcation zone in late infection

In 15 knees with late infection, the demarcation zone was measured in all roentgen examinations. In eight, the demarcation zone did not exceed 1 mm. This means that a "normal" demarcation zone did not exclude infection. In seven knees with a late infection, the demarcation zone increased to more than 1 mm and in five of them progressive widening of the demarcation zone proved of practical value in establishing the diagnosis of infection.

Scalloping - periosteal reaction

Scalloping means local widening of the radiolucent zone around the prosthesis (Sjöstrand 1974). In this material, scalloping was seen in three knees, 1.0-3.5 years postoperatively and late infection was present in all. Periosteal reaction on a level with one of the points of prosthetic stems was seen in eight knees.
Late infection was present in 6 of 11 knees with scalloping and/or periosteal reaction. In these the demarcation zone exceeded 1 mm at examination one year postoperatively in three knees. The role of infection in the development of periosteal reaction or scalloping was difficult to evaluate because 9 of the 11 knees with scalloping and/or periosteal reaction did not have sufficient cement surrounding on one or both prosthetic stems and therefore an inadequate cementation of the prosthesis may have accounted for the periosteal reaction. A fracture was seen in only one knee with scalloping and a persistent periosteal reaction and a demarcation zone of more than 6 mm wide with deep infection (Fig. 17a and b). In three knees, a normal demarcation zone was found with no late infection or fractures present, but a periosteal reaction, level with the tip of the prosthetic stem. In one of these knees the prosthesis was not sufficiently surrounded by cement and in the other two, the tip of the stem was in contact with cortical bone; the periosteal reaction was considered a stress phenomenon.

Patients' opinion at follow-up

Three patients stated that they would have refused operation had they known the outcome. 61 patients were satisfied with the operation at the time of follow-up. Of the

three patients who regretted the operations one had an above-knee amputation, one was arthrodesed, and one had pain at rest and only 30° of flexion following surgery. At follow-up, the patients' opinion was:

Table 33.

Almost normal	20
Improved	39
Unchanged	2
Deteriorated	3

A statistical correlation existed between the patients' opinion and the evaluation of results according to Weinfeld (Chi^2: $p = 0.0005$).

ARA functional classification

The ARA functional classification depends on the status of the entire locomotor system and can alter with the disease activity; therapy as well during the observation time can influence the functional grading, but it was still of interest to note whether knee arthroplasty had any influence.

Table 34.

ARA	Preoperatively	Follow-up
II	3	10
IIIa	13	18
IIIb (risk)	24	18
IV	24	18

Improved	25
Unchanged	32
Worse	7

The improvement was significant (Wilcoxon's SRT: p 0.001) which was impressing when it was taken into account that these patients on average had 1.2 other joints in the lower extremities which were painful at weight-bearing. The stability through hinge joint arthroplasty appears to be most beneficial to the patient in activities of daily living. There was a significant correlation between ARA functional classification and results according to Weinfeld (Chi^2: $p = 0.0005$). However, the considerable functional gains reflected in an improvement in ARA functional classification following surgery did not result in any significant change in socio-economical conditions.

DISCUSSION

Following Guépar arthroplasty in the Lund material results were "satisfactory" in 30 knees and "not satisfactory" in 34 at follow-up 2.7 years (1.0-4.3) after operation. Clinical reports of Guépar arthroplasty in mixed materials of OA and RA were published by Deburge et al. (1976) including 103 RA knees with an observation time exceeding 24 months, Insall et al. (1976) 24 RA knees with an observation time exceeding 24 months, Sneppen et al. (1978) 35 RA knees with an observation time 3-26 months. Witvoët et al. (1974) have also published clinical results, but the patient material seems to be partly identical with the series reported by Deburge et al. (1976).

Insall et al. (1976) and Witvoët et al. (1974) reported two thirds excellent to good results. Engelbrecht et al. (1976) reported 77 % good results in 240 operations (OA + RA) with on average 33 months observation time. Lettin et al. (1978) using the Stanmore prosthesis in 100 knees (OA + RA) reported freedom from pain in 94 % and increased mobility in 67 % after more than two years.

Arden (1973) reported 80 % good results in Shier arthroplasty after more than one year. Following arthroplasty with the Walldius prosthesis, results between 67 % and 80 % were reported by Bain (1973), Freeman (1973), Walldius (1967) and Wilson and Venters (1976). Because of obvious differences in the evaluation system and population differences, a direct comparison of these results was not possible. A discrepancy obviously exists between the results in the Lund material and reported frequencies of excellent and good results. On the basis of the above clinical reports with a total of 1163 arthroplasties and the results in this material of 64, the intention was to discuss principle views of indication and complications.

Indications

The main merit of the total constrained principle is the potential for reconstructing knees with extreme deformity and instability. None of the works referred to indicated any maximum limits of destruction or instability. Arden (1973) and Engelbrecht et al. (1976) found that even ankylosed and previously arthrodesed knees could be operated with a hinge joint prosthesis if the extensor apparatus was intact. In the Lund material, the prognosis was poor when the FTP-angle preoperatively was less than 168° or attrition in FP-joints was found mainly caused by operative and postoperative FP-joint problems. The minimum indication according to Witvoët et al. (1974) and Bain (1975) was a destruction so pronounced that arthrodesis was the only alternative. Walldius (1967) found maximum invalidity equal to life in a wheel-chair the main indication. Of special interest is the minimum indication in materials where other prosthetic principles were used in the same period.

Insall et al. (1976) reported on a material where three different unconstrained prostheses were used during the same period as the Guépar prosthesis. Here, the result following Guépar arthroplasty was better than in arthroplasties where unconstrained prostheses were used, although the destruction in the Guépar operated cases was more pronounced. They warned against using the Guépar prosthesis in younger patients because of wear on the axis of the prosthesis and on the basis of one case of fracture of the prosthesis, but did not draw any other conclusions regarding the choice between constrained and unconstrained principles. Engelbrecht et al. (1976) reported results using the St. George hinge and Schlitten surface prosthesis during the same period and on the basis of almost 900 arthroplasties recommended that hinge prosthesis should be used when extension defects or lateral malposition exceeded 20°, when considerable ligamentary destruction was present, or when mobility was less than 70°.

In the Lund material, indications were not uniform during the years when the prosthesis was used, but was always weighed against arthrodesis and against unconstrained arthroplasty. The introduction of the hemiconstrained prostheses which will probably replace the constrained hinge prosthesis has made it difficult at present to categorically state the indications for the hinge joints. On the basis of present experience, constrained or hemiconstrained prostheses should be used when the extension defect is greater than 20°, or malposition more than 20°. Probably the most important indications are subluxation of the tibia, outward rotation of the tibia and insufficiency of the cruciate ligament which prevents congruency between prosthetic components in an unconstrained arthroplasty. It is often an advantage to make the final decision during surgery when different prosthetic alternatives are possible.

Complications

An analysis of the complications and those reported in the literature illustrate the risks and drawbacks of the constrained arthroplasty.

General complications

Serious cardiopulmonary, systemic or cerebrovascular complications following hinge joint arthroplasty were reported in several series. Deburge et al. (1976) in 292 Guépar arthroplasties had 14 serious hypotensions, five with cardiac arrest; three died, lung embolism was noted in another five, postoperative respiratory insufficiency in five and serious cerebrovascular problems developed in 12. Kenesi (1978) in 758 operations reported 18 deaths in connection with the operation and in another 20 cases life-threatening cardiopulmonary complications occurred within the first 24 hours following surgery. Kenesi claimed that possible reasons for these complications were toxic reaction to

the lung parenchyma of nonpolymerized monomer, haemodynamic disturbances when releasing the bloodless field, bleeding from the operation area and fat embolism. In the Lund material, lung embolism occurred in one case and pneumonia in two but fat embolism could not be excluded. Serious complications were perhaps avoided by draining the marrow cavities with a catheter when the cement was introduced and the prosthesis inserted and by good anaesthesia. Before inserting the prosthesis, Solucortef 100 mg was given i.v., and the patient ventilated with pure oxygen.

Dislocation of the patella

A Guépar, Stanmore, St. Georg and Walldius arthroplasty through the "trochlea" for articulation with the patella provide a hemiarthroplasty in the FP-joint. In most published materials, FP problems have been considerable. Deburge et al. (1976) reported FP-joint pain in 43 of 103 Guépar arthroplasties; in 38 knees the patella was not central in relation to the "trochlea" of the prosthesis. Insall et al. (1976) found that pain was present when pressure was applied over the patella in 50 % of the cases and that alignment of the patella over the "trochlea" was often not achieved although lateral release was done at the arthroplasty. Sneppen et al. (1978) had subluxation or total dislocation of the patella in 32 of 50 cases, but found that pain did not necessarily occur with subluxation. Engelbrecht et al. (1976) stated that FP-joint pain was the most usual explanation for residual pain which was found in 18 % of the cases at follow-up, but that pain tolerance often developed after 1-2 years.

FP-joint problems were considerable in the Lund material. In 17 knees, the patella at surgery showed a tendency to dislocate laterally. The tibial tuberosity was transferred in six knees and a lateral release and/or medial capular plication was carried out in nine. Despite this the patella dislocated later in seven knees and reoperation was necessary in three. In the Lund material, the frequency of dislocation increased slightly, but not significantly by increasing valgus malposition preoperatively. Lettin et al. (1978) using the Stanmore prosthesis in 80 cases had no dislocations. This can be due to the fact that the "trochlea" in this prosthesis is more anatomical in design and the patella is also reshaped using a template so that congruency in the femoro-patellar joint is achieved. In the Walldius arthroplasty (Bain 1973, Blundell-Jones 1973, Freeman 1973, Walldius 1967, Wilson and Venters 1976) the presence of FP-joint pain or dislocation was not mentioned. It might imply that the FP-joint problem was less important when using this prosthesis. If cement was not used, maximum outward rotation of the tibia was probably not often present. In the Shier arthroplasty, patellectomy is necessary. Arden (1973) reported rupture of the patella ligament due to attrition against the prosthesis in 5 of 192 knees and other disadvantages of patellectomy such as delayed wound healing, infection and biomechanical disadvantages must be considered. The Guépar group (Alnot et al.

1971) claimed that outward rotation of the tibia was the main reason for dislocation of the patella. Sneppen et al. (1978) claimed that damage to the vastus medialis, incorrect design of the "trochlea", preoperative valgus and outward rotation of the tibia were all contributory causes. In the author's opinion the tendency to dislocation was mainly due to faulty operative technique. By introducing the axis while the bone cement in the tibia was still unpolymerized, the patella dislocated laterally and the knee flexed, a powerful outward rotation force was created on the tibia through the patellar ligament and the tibial part of the prosthesis was therefore in inward rotation in relation to the tibia itself. Lettin et al. (1978) used a lateral parapatellar incision and dislocated the patella medially; this prevented the outward rotation of the tibia.

Wound healing

The highest incidence of wound healing complications was noted by Lettin et al. (1978) in 100 Stanmore arthroplasties with delayed wound healing in 29 knees, skin necrosis in nine and a fistula in two. Arden (1973) in Shier arthroplasties found wound healing complications in 17 % of 192 cases. The required patellectomy was probably contributory. Other reports previously referred to gave lower incidences of wound healing problems. In the Lund material the wound failed to heal within four weeks in 13/64 knees despite immobilization in plaster. Transfer of the tibial tuberosity and dislocation of the patella had an adverse effect on wound healing in the distal part of the incision, corresponding to the area of the tuberosity. Deep infection later occurred in four cases.

Wound healing complications are probably partly caused by the large volume of the implant and a relatively thin soft tissue covering. They are less of a problem in unconstrained knee arthroplasty where although the approach to the joint, operation time and duration of bloodless field are the same, the implant is much smaller in size.

Deep infection

Deep infection has been reported in hinge arthroplasty in all larger series and has been extremely difficult to treat. The highest incidence of deep infection was found in Walldius' material (1967), 14 % of deep infection in 67 knees, and in Blundell-Jones' material (1973), 11 % deep infections in 120 operations. The Walldius prosthesis is larger than others and was inserted without the use of bone cement which did not seem to be necessary for the high infection rates to occur. Bain (1973), Freeman (1973) and Wilson and Venters (1976), who cemented the Walldius prosthesis, reported infection rates of 5-10 %. Deburge et al. (1976) and Insall et al. (1976) both reported 7 % deep infection using the Guépar prosthesis. The lowest infection rate 2 % was reported by Engelbrecht et al. (1976) using the St. George prosthesis and Lettin et al. (1978), 3 %

using Stanmore prosthesis. In the Lund material, deep infection was diagnosed in 16 knees (25 %). In one knee, the infection was noted within the first two months and in 15 knees two months to five years following surgery. A direct comparison of the reported rates might be misleading. In the Lund material, for example, the diagnosis was attained without demands for bacteriological verification.

Treatment of deep infection is extremely difficult when a cemented hinge prosthesis is used. The implant is introduced deeply into two marrow cavities and the soft tissue covering is quite thin in the knee. Resection of bone at arthroplasty and often destruction by the infection increases the problems of reconstruction. An analysis of reported deep infections, 7.5 % in approximately 1100 arthroplasties in the series previously referred to, revealed that three patients died of septicaemia, eight had above-knee amputations, in seven the prosthesis was removed and in 45 knees an arthrodesis was attempted but union occurred in only 15. The prosthesis was changed in 11 knees with a relapse in four and healing in seven. In 16 knees, the infection was treated by systemic antibiotics; in 13 the infection healed.

Loosening

Fixation of the prosthesis in bone tissue is problematic and loosening of the prosthesis with instability, deformity and pain at weight-bearing, without signs of infection was shown in most published materials with an observation period exceeding two years. Watson et al. (1976), in 38 RA knees operated with a Shier prosthesis with an observation period of two to seven years, found that pain and instability recurred within 18 months following surgery. In the same period, cystic radiolucencies and periosteal reactions were noted level with the tip of the stems as well as subsidence of the femoral component into the femur to an extent that limited flexion. These X-ray changes indicated loosening of the femoral component. Loosening with clinical symptoms were noted in 35 of 38 knees. According to Watson et al. (1976), prosthetic loosening with pain, instability and gradual decreasing mobility was unavoidable after more than 18 months following surgery. Arden (1973) reported only 7 % with loosening with an observation period exceeding 12 months in a Shier arthroplasty material of 192 knees. Following Guépar arthroplasty, Deburge et al. (1976) reported loosening in 2 % (6 cases) in 292 arthroplasties, Insall et al. (1976) in 7 % (3 cases) in 45 arthroplasties. In arthroplasty with Walldius prosthesis without the use of bone cement as recommended by Walldius (1967), Blundell-Jones (1973) reported that all prostheses were loose after two years.

The Lund material had lateral instability exceeding 10° in three knees; these had deep infection. Most of the other knees had slight (less than 5°) lateral instability, but none of them had an anterior drawer sign. None of these patients experienced instability on

walking. The slight lateral instability was taken to indicate that rigid fixation of the prosthesis and cement to the bone tissue in one or both diaphyses was not maintained in most cases after two years. In the same period when this slight instability developed, a significant decrease of the quadriceps power was noted. On forceful contraction of the quadriceps, most patients experienced an intensive, deep pain. The weakening of the quadriceps power was considered to be caused by pain inhibition; perhaps pain was caused by compression of granulation tissue in the space between cement and bone. In the Lund material aseptic loosening was of quite limited consequence and the instability was without practical importance. The effect of quadriceps weakening was difficult to judge; patients with hinge joint prostheses do not usually flex much in the stand-phase during walking and the demands on quadriceps power therefore are less than normal (van Hussen 1973). Adequate fixation of the prosthesis at operation appeared important. The Lund material had a significantly increased frequency of a radiolucent zone larger than 1 mm after one year when one or both prosthetic stems were not properly surrounded by cement. Also Insall et al. (1976) noted a slight instability following Guépar arthroplasty, and explained it as being caused by wear of the axle in the prosthesis. Mazas et al. (1973) reported on wear of the prosthesis in vitro and by simple trigonometric calculations on the basis of these values, it does not seem probable that wear of the axle contributes to the lateral instability to any great extent. Removal of the prosthesis after several years of function in active patients revealed only negligible wear of the axle.

SUMMARY

64 knees in 49 patients with RA were operated with the Guépar prosthesis from 1972 through 1976. At follow-up 2.7 years after operation, an arbitrarily chosen degree of normalization of the knee, 0-6 points according to Weinfeld's evaluation system equal to a "satisfactory" result, was attained in 30 of 64 operated knees. Of 34 knees with a "not satisfactory" result, an improvement was noted in 31, unchanged in two and worse in one. Arthroplasty resulted in reduction of pain, of need for support in walking, of extension defect, of lateral instability and of the deformity at weight-bearing. Quadriceps power was improved. Flexion was not significantly diminished. 59 knees were judged by the patients to be improved and five knees were unchanged or worse. A significant improvement in ARA functional classification occurred.

No serious general complication in relation to the operation was noted. Considerable operative and postoperative FP joint problems were found, especially following preoperative valgus. The result was significantly worse when dislocation of the patella existed. Following perforation of the femoral or the tibial diaphyses at surgery, the result was

"not satisfactory". Although immobilized in plaster for two weeks postoperatively, there was delayed wound healing in 13 knees and four of them developed late infection.

Late infection developed in 15 knees. Infected cases were reviewed, on average, 4.6 years after operation; they were followed after the end of the general observation period. As a consequence of infection, two patients died of septicaemia and one had an above-knee amputation. Five knees were reoperated; four with a change of prosthesis and one arthrodesis. At follow-up, the result was "satisfactory" in only three with late infection.

Mechanical loosening of the prosthesis with slight lateral instability and reduction of quadriceps power was noted at follow-up when the observation period exceeded two years in most of the cases, but did not affect the result of the arthroplasty.

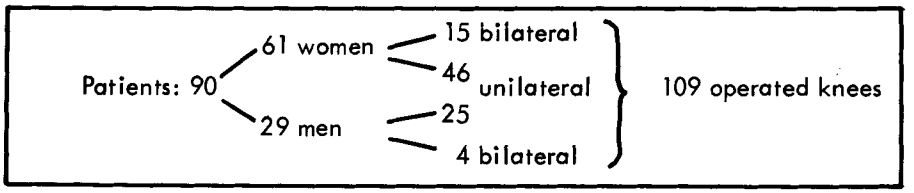
The main merit of the constrained principle is the almost unlimited capacity for correcting deformities and instability. But a high frequency of patella dislocation, complicated wound healing, and late infection strongly argues against use of the method unless improvements in technique and infection prophylaxis are developed. Dislocation of the patella can probably generally be prevented if outward rotation of the tibia is prevented by cementing in the tibial component before fixating the femoral component. A reduced frequency of dislocation of the patella could also result in a lower frequency of delayed wound healing. A reduction of the frequency of late infections could probably be achieved by improved hygiene and prophylactic antibiotics. Since the introduction of a number of hemiconstrained prostheses, the use of hinge joint prostheses can probably be restricted but observation periods thus far have been too short to establish rational indications.

V. MARMOR ARTHROPLASTY

MATERIAL AND METHODS

With the intention of evaluationg as early as possible the results following Marmor arthroplasty, a preliminary examination was made approximately 12 months after operation. During 1977-1978, a second follow-up was made of all arthroplasties at least six months after the preliminary examination. In this way, 96 knees were examined on two occasions with, on average, 15 months (6-32) between them from 1974 through 1977. Marmor arthroplasty was performed in 90 patients with RA in 61 women and 29 men; 4 men and 15 women were operated bilaterally making a total of 109 knees.
Demiarthroplasty was performed in nine knees (5 lateral, 4 medial).

Fig. 21.



All operated knees were examined by the author and are included in the material.

The observation time averaged 2.2 years (1.0-3.6). One knee included in this series was reoperated with a Guépar arthroplasty one month following surgery because of collapse of the medial compartment.

Average age at operation was 59 years (24-79) with identical sex distribution.

Most patients had had rheumatoid arthritis for more than 10 years before the arthroplasty. Three-fourths of the knees were symptomatic for more than five years.

Table 35.
ESR preoperatively.

ESR mm/h	0-25	26-65	66-150
Knees	13	58	38

Previous treatment of the operated knee

Intra-articular cortisone. In 56 knees 1-10 cortisone injections were given and in 37 knees more than 10 injections. 16 knees were never treated with intra-articular cortisone.

Synovectomy. Chemical synovectomy using osmium acid was carried out in 12 knees and a combination of chemical and surgical synovectomy in 29 knees. Surgical synovectomy alone was performed in 18 knees making a total of 59 chemical and/or surgical synovectomies.

Capsulotomy was performed in three knees for correction of a flexion contracture.

High tibial osteotomy was carried out in three knees; two for correction of an extension defect and one for correction of an extension defect combined with valgus malposition.

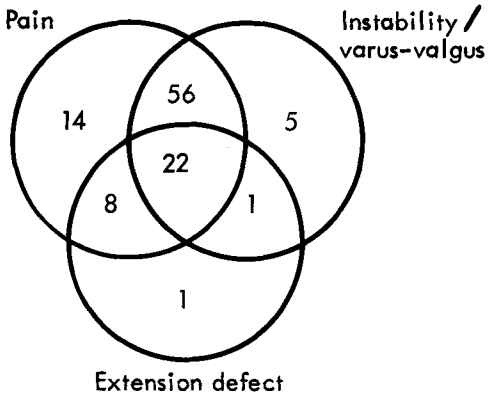
McIntosh arthroplasty. Seven previous McIntosh arthroplasties were converted to Marmor arthroplasties.

Indications for operations

Indications in this material were not uniform. In 1974, the Marmor prosthesis was used as an alternative to Guépar arthroplasty when the pathological changes were not too advanced. In 1975 and 1976, the indications were widened to include also those knees with severe destruction because of an unacceptably high incidence of deep infections following Guépar arthroplasty. In retrospect it is obvious that the indications for the Marmor arthroplasty at that period were in some cases unrealistic.

After introduction of the Attenborough prosthesis in 1977, the Marmor prosthesis could again be reserved for knees requiring resurfacing and where deformities were correctible within the potentials of the prosthetic design.

Fig. 22.
Clinical indications for Marmor arthroplasty in 107 knees.
See Fig. 4 for definition of subsets.



Pain was present in 100 knees. Of them, extension defects exceeding 15° were found in 30 and instability and/or malposition ≥10° in 78. In seven without pain preoperatively, the indication for operation was an extension defect and/or malposition. Decreased flexion was in no instance of major importance as an indication for surgery.

Contraindications

Synovectomy was preferred if joint surfaces were congruent, the deformity was moderate and the patient younger than 60 years. In 1974 and 1975, the Guépar prosthesis was preferred if varus or valgus malposition or extension defect exceeded 20°. Lateral subluxation of the tibia and pronounced outward rotation of the tibia which could not be corrected were relative contraindications.

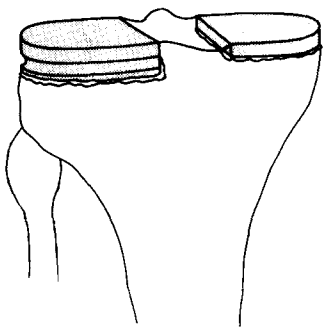


Fig. 23. The medial prosthesis is countersunk in a trough according to the original technique. The lateral prosthesis is placed with circumferential cortical support.

Operative technique

Two surgeons operated two thirds of the knees and seven surgeons operated 1-15 knees each. The operation was performed in a bloodless field under general or epidural anaesthesia. A medial parapatellar incision was used and the patella was dislocated laterally. A synovectomy was performed. Resection of the posterior fifth of the femoral condyles allowed for the tibia plateaux to be chiselled at right angles to the longitudinal axis of the tibia. In Marmor's (1973) description of the technique, the tibial plates are placed within corticalis, but we have considered it an advantage to have circumferential cortical support for the prosthesis (Fig. 23). The position of the femoral prosthesis was determined by the need for congruency in relation to the tibial components and the need for sufficient support (Fig. 24a and b). Prominence of the anterior part of the femoral component was when possible avoided because this might cause impingement on the patella during flexion (Fig. 25a and b). The size of the femoral component was decided by the configuration of the condyle. Before closure of the joint capsule it was ensured that the patella did not impinge on the anterior edge of the femoral components. In this series patellectomy was performed in 12 knees for this reason. After patellectomy, mobilization was more difficult and in most cases persistant weakness of the quadriceps resulted. A long-leg compression bandage was applied and vacuum drainage was maintained for 24-48 hours.

Antibiotics. Cloxacillin 1 g x 4 and probenecid 1 g x 2 was started before surgery and continued postoperatively for 10 days in 86 knees. In 23 knees no antibiotics were given before surgery or were discontinued earlier than 10 days because of secondary effects.

Anticoagulation therapy was not used routinely.

Postoperative treatment

Quadriceps exercise started from the first postoperative day and as soon as the leg could be elevated against gravity, weight-bearing with crutches was allowed.

COMPLICATIONS

Operative complications and technical difficulties

In 66 of 109 operations, no technical difficulties or complications were encountered. In 43 operations, the technique was modified or complications were noted. Two complications were noted in 15 operations.

Fracture of the tibia - resection of the tibial spine. In five operations, the tibial spine was fractured; in three other operations, the spine was chiselled away because of collision against the anterior rim of the intercondyloid fossa. In these eight knees, the insertion and thereby the function of the anterior cruciate ligament was destroyed.

Fracture of the femur. In one knee with pronounced rotatory instability, the medial femoral component was entrapped during flexion postero-medially against the tibial condyle. During reduction the medial femoral condyle was fractured. The fracture was retained in position by wire and healed uneventfully, although mobilization was long and troublesome.

Cysts in the femur or tibia. In seven knees large cysts were found subchondrally in the femoral or tibial condyles, necessitating larger resections or the filling of defects with cement.

Impingement of the patella. In 15 knees, impingement of the patella against the anterior edge of one or both femoral components occurred at operation. This was caused by prominence of the femoral component in the patella sulcus and was often combined with a pathologically altered patella. In 12 knees, a patellectomy was performed but in three the impingement was accepted with the expectation that the patella would be worn so that congruency would develop. An extension defect was found at follow-up in 5 of 15 knees against 22 of 94 knees without FP-joint problems at operation. The difference was not significant. However, the quadriceps power was significantly reduced after patellectomy.

Extension defect. In seven knees with an extension defect between 15-35° preoperatively, the tibial plates were anteriorly inclined. In four of these there was an extension defect exceeding 10° at follow-up.

Congruence problems. In seven knees, the surgeon considered the relationship between the tibial and femoral components as not being satisfactory; in five the tibia later subluxated laterally or posteriorly in relation to the femur, resulting in collapse of the arthroplasty. Reoperation with an Attenborough prosthesis was performed in three knees and with a Guépar prosthesis in one. Reoperation was planned in another.

Insufficient correction of malposition. Deformity in valgus was accepted in three knees to achieve lateral stability and full extension.

Cementation problems. One or both tibial components were found insufficiently anchored

after cementing in seven knees. In six knees recementing was done; in one the insufficient anchorage was accepted. In three knees one of the tibial components was anchored in an unplanned inclination due to dislocation under the polymerization phase.

Others. In two knees extreme osteoporosis was found at operation. Partial rupture of the patellar ligament while everting and laterally dislocating the patella occurred in one knee. The rupture was repaired.

Postoperative complications

In six operations general complications were noted and local complications in 35.

General complications. At operation, cardiac arrhythmia occurred in one case and subendocardial infarction in two cases. Within the first postoperative week, one pneumonia, one Addison crisis in a cortisone treated patient and a deep vein thrombosis in the operated extremity were diagnosed. In all cases of general complications, the patients recovered without sequelae on conventional therapy. No cases of embolism were detected. No patient died as a result of the operation or during the hospital stay.

Complicated wound healing - superficial infection. In 11 knees the wound failed to heal within four weeks; culture was negative in 10. The reason for delayed wound healing in five knees was skin necrosis, which healed spontaneously in two and in three necessitated surgical intervention. In four knees, serous secretion was found which dried up spontaneously within three months. Antibiotics were given in all knees with delayed wound healing but in no case was this prolonged more than six months. Total wound rupture four days after operation occurred when one patient fell and hyperflexed the knee. The wound was resutured after irrigation with antibiotics and healed uneventfully. In one knee purulent secretion from the wound was found four weeks after operation and culture showed staph. albus. Revision was done at which a fragment of bone cement was found in the subcutaneous tissue. The wound healed after resuturing, but the knee was warm and tender and antibiotics were continued for six months.

A slightly increased incidence of patellectomy and high incidence of previous operations in the involved knee were found when wound healing was complicated. Systemic treatment with cortisone seemed not to be of importance. The hospital stay was only increased by 1.7 days on an average when complicated wound healing was present.

FP-joint pain. In five knees there was pain and crepitation at the FP-joint. Patellectomy was done in one and the knee became painfree, but because of an extension defect, quadriceps insufficiency and instability, an arthrodesis was later performed. In the other four knees, the pain spontaneously diminished.

Dislocation of prosthesis. In one knee with persistent pain at weight-bearing, the joint was explored one month after operation and one of the femoral components was found loosened. After recementing, the knee became painfree. In the first month after operation, an increasing varus malposition was recognized in one knee associated with increasing pain at weight-bearing. X-ray examination showed an increasing collapse of the medial compartment with loosening and dislocation of the tibial prosthesis. A Guépar arthroplasty was performed.

Peroneal palsy developed after seven operations. At follow-up, a partial anaesthesia on the dorsum of the foot was found in one patient; six were fully recovered.

Fracture. One patient fell at home one month after arthroplasty and fractured the medial femoral condyle. The fracture healed after eight weeks immobilization in a static orthosis.

Others. In four knees where patellectomy was performed in conjunction with the arthroplasty, an extension lag of 15-40° was found, in two of them the quadriceps power remained less than 50N at follow-up. One knee had painful crepitation, which did not arise from the FP-joint. A cineradiography showed that a collision between the lateral femoral prosthesis and the eminentia occurred during flexion. This phenomenon seemed to be caused by a moderate lateralization of the tibia and was probably accentuated by a weakness of the quadriceps, which was secondary to an earlier patellectomy. During physiotherapy, one knee suddenly locked in 90° of flexion. At aspiration 50 ml serous sanguinous fluid were removed. The locking has not recurred. One knee had continuous moderate bleeding from the wound for two weeks, although coagulation tests were normal. One 68-year-old cortisone-treated patient developed a postoperative haematoma in the thigh in the area where the bloodless field was applied. The haematoma resorbed spontaneously but the quadriceps power remained extremely reduced. During physiotherapy two weeks after operation, one patient fainted and fell, probably due to a subendocardial infarct and sustained a cervical hip fracture. Because of necrosis of the head of the femur after primary nailing, a Moore arthroplasty was later performed.

Hospital stay. The average stay in hospital in the Orthopaedic or Rheumatological Department was 34 days (7-119).

Late complications

16 late complications were noted in 15 knees.

Dislocation of prosthesis. One knee was explored six months after operation because of

pain at weight-bearing. A cineradiographic examination was made before reoperation. This showed a mobile femoral component, which was recemented, and the knee became painfree. Six knees had a dislocation of one or both tibial components within the first postoperative year. At arthroplasty, congruency between the tibial and femoral components was not achieved in this group. All these knees were reoperated; one had an arthrodesis, one a Guépar, and four an Attenborough.

Collapse of condyles. Because of pain at weight-bearing and increasing instability caused by destruction of the non-operated compartment following demi-arthroplasties, completion with a prosthesis in the lateral compartment was done in two knees and in the medial compartment in one. Pain at weight-bearing was found in a further two knees, which have not been reoperated.

Fractures. One patient fell at home one year after the arthroplasty sustaining a supracondylar femur fracture with minimum dislocation. Reoperation with recementation of a dislocated medial tibial plate was planned when the fracture occurred, but the patient preferred an arthrodesis.

One patient noted pain at weight-bearing localized at the medial compartment. Several roentgen examinations did not show anything abnormal. Scintimetry with Sr^{85} six months after operation showed increased activity in the medial tibial condyle. During the following months, callus could be seen in the medial condyle on roentgen, and the patient became painfree simultaneously with normalization of the scintimetry. This knee illustrates the difficulties of diagnosing stress fractures in patients with rheumatoid arthritis.

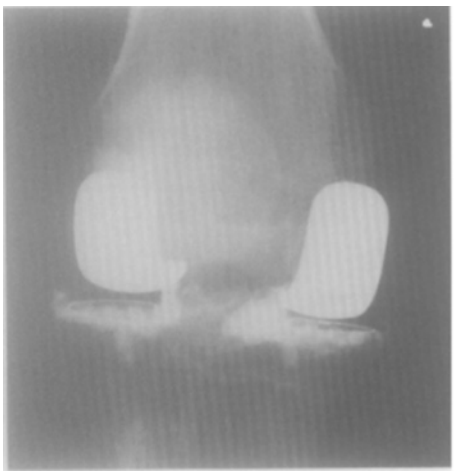


Fig. 24a. Normal position of prosthesis on lateral exposure.

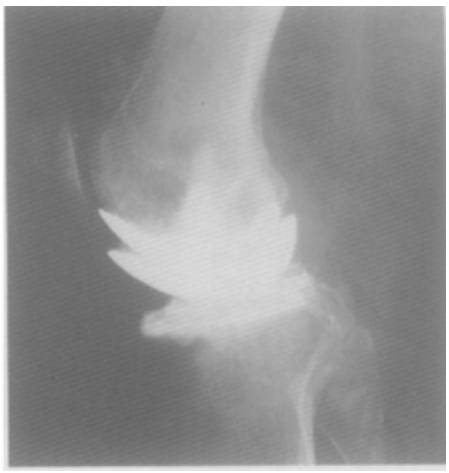


Fig. 24b. Normal position of prosthesis on lateral exposure.

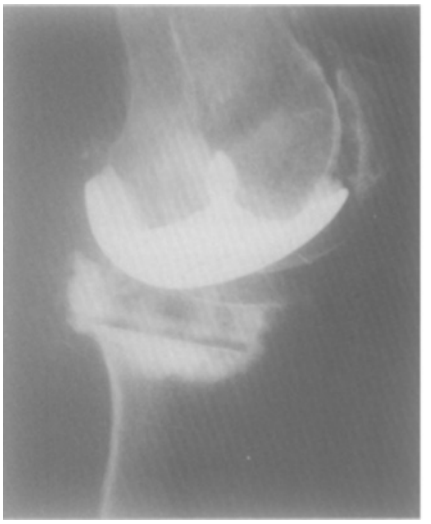


Fig. 25a. Impingement of patella on anterior edge of the femoral component: wear defect of patella.

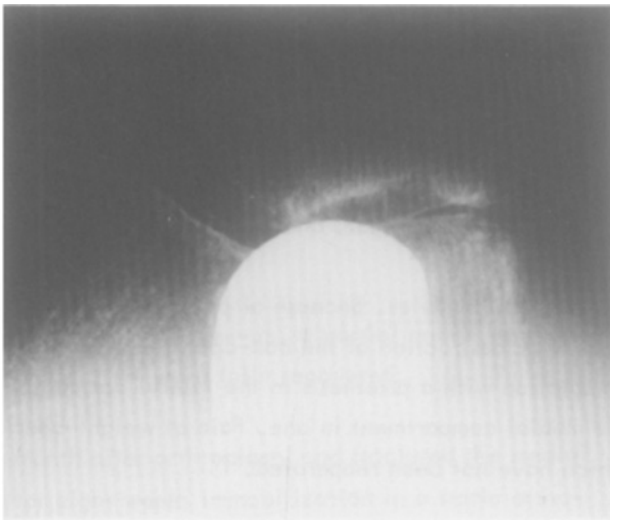


Fig. 25b. Same case axial exposure of the FP-joint: wear defect of patella.

Others. In two knees, loose fragments of cement were identified by roentgen examination, apparently without major clinical symptoms.

Late infection. Late infection occurred in two knees (2 %). In one of these the infection was multifocal, due to septicaemia.

FOLLOW-UP EVALUATION

The seven parameters in Weinfeld's evaluation system (see page 9) formed the basis for the evaluation of status preoperatively and at follow-up.

Table 36.
Pain.

	Follow-up 73	8	10	11	7	Sum	
7	41	2	6	5	5	59	
6	23	3	3	6	1	36	
3	3	1	1		1	6	Preop.
1	1					1	
0	5	2				7	
Points	0	1	3	6	7		

From the patients' point of view, pain was the main indication for operation. In this material, pain was an important indication in 101 of 109 operations. In 88 knees pain was eliminated or less severe at follow-up than preoperatively, unchanged in 17 and more severe in four. In five knees with pain at weight-bearing or at rest, reoperation with another prosthesis was done or was planned after the end of the observation time. From the preliminary examination to follow-up, pain diminished in 22 knees and increased in 12. In 28 knees with pain at walking less than 200 m at follow-up significant correlation was found to presence of exudate, anterior drawer sign, lateral instability, weakness of the quadriceps, and pain at weight-bearing in at least three other joints.

Pain at rest or immediately at weight-bearing was found in 18 knees at follow-up. An analysis of operative technical difficulties and the complications postoperatively, during the observation time and the clinical status at follow-up showed that the main cause of pain was most probably the following:

Dislocation of tibial component	6 knees
Incongruency between prosthetic components	4 knees
Instability (anterior drawer sign + lateral instability)	3 knees
FP-joint dysfunction	3 knees
Extension lag + quadriceps-insufficiency	2 knees

Table 37.
Use of support at walking.

	Follow-up 44	21	25	19	Sum	
4	23	7	12	13	55	
2	6	7	6	1	20	Preop.
1	5	4	1	1	11	
0	10	3	6	4	23	
Points	0	1	2	4		

In 60 knees the need for support at walking was reduced; unchanged in 33, and increased in 16. From the preliminary examination to follow-up (on average 15 months), the need for support at walking was reduced in 16 knees and increased in 22. At quadriceps power less than 150N, the need for support at walking was significantly increased. The need for support at walking was significantly increased when an extension defect was present.

Table 38.
Extension defect.

	Follow-up 82	22	5		Sum	
4	2	1	1		4	
2	16	9	4		29	Preop.
1	36	11	0		47	
0	28	1	0		29	
Points	0	1	2	4		

A preoperative extension defect was corrected by arthroplasty in 54 of 80 knees, reduced in a further 11 knees, unchanged in 43 and increased in one. From the preliminary examination to follow-up, it was eliminated in 10, reduced in two, developed in 10 and increased in three.

Table 39.
Flexion.

	Follow-up 104	4	1	Sum	
3		1		1	
1	4			4	Preop.
0	100	3	1	104	
Points	0	1	3		

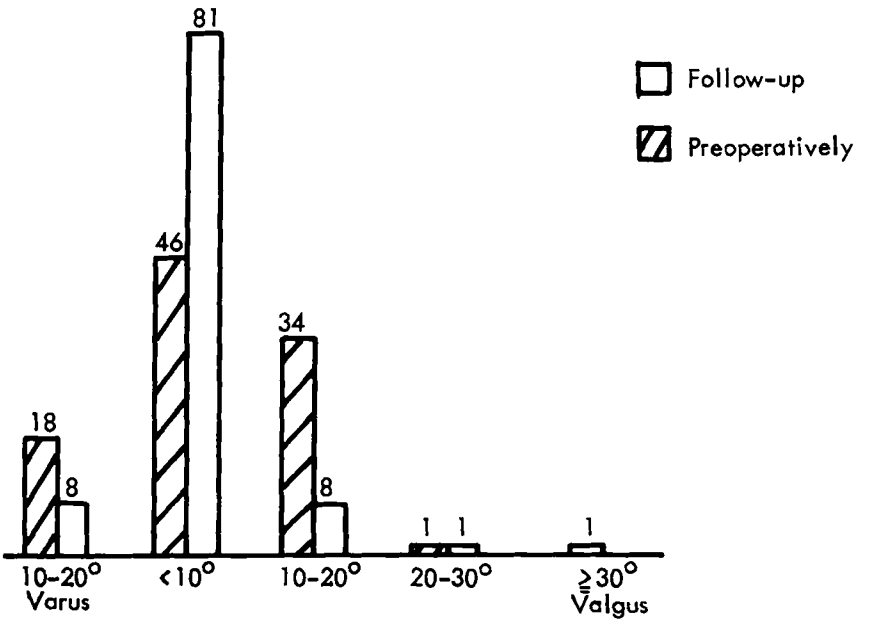
Flexion less than 80° was found preoperatively in five knees and at follow-up of these flexion exceeding 80° was found in four and an improvement in one. In five knees, flexion less than 80° was found at follow-up. From the preliminary examination to follow-up, flexion increased in seven knees and was reduced in two.

Table 40.
Medial or lateral instability.

	Follow-up 59	36	5	Sum	
4	1	4	1	6	
2	38	24	3	65	Preop.
0	20	8	1	29	
Points	0	2	4		

Preoperative instability was eliminated in 39 of 94 knees and reduced in four. In nine knees instability developed in preoperatively stable knees; in three it increased. At follow-up, instability $>10^{\circ}$ was found in 41 knees. From the preliminary examination to follow-up instability was significantly increased. A high incidence of loosening of the prosthesis and altered position could explain this development. The importance of medial or lateral instability might be increased by being found correlated to the presence of an anterior drawer sign (Chi^2: p 0.0001).

Fig. 26.
Varus-valgus at weight-bearing (clinical).



Preoperatively 18 knees had a varus malposition of more than 10°. 13 were corrected, but in three previously normal knees, a varus malposition developed. Of 35 knees with a valgus malposition $\geq 10^{\circ}$ preoperatively, correction was achieved in 25, reduction in one and increased valgus malposition developed in three knees. There was a significant correlation between the degree of varus and valgus malposition and the degree of cartilage reduction and bone attrition noted at operation. From the preliminary examination to follow-up, a reduction of malposition was found in five knees and an increase in 12.

Table 41.
Quadriceps power.

	Follow-up 25	17	18	13	Sum	
4	10	9	13	9	41	
2	11	6	4	3	24	Preop.
1						
0	4	2	1	1	8	
Points	0	1	2	4		

The quadriceps power was improved in 49 knees, unchanged in 17 and reduced in seven. From the preliminary examination to follow-up, an improvement was found in 18 knees and a deterioration in 27. No correlation was found between quadriceps power and passive mobility or crepitation of the patella.

Conclusion of results according to Weinfeld

For each of the seven parameters, the average point score preoperatively and at follow-up was calculated on the basis of the number of observations.

Table 42.
Score according to Weinfeld for the Marmor material preoperatively at the preliminary examination and at follow-up.

	Pre-operatively	Preliminary examination (12 months after operation)	Follow-up	Number of observations	Significant improvement (p)x)
Pain (0-7 points)	5.9	1.5	1.4	109	<0.001
Use of support at walking (0-4 points)	2.5	1.2	1.2	109	<0.0001
Extension defect (0-4 points)	1.1	0.3	0.3	109	<0.001
Flexion (0-6 points)	0.1	0.1	0.1	109	0.425
Medial or lateral instability (0-4 points)	1.5	0.5	0.9	100	<0.0001
Varus-valgus at weight-bearing (0-4 points)	1.1	0.2	0.4	99	0.015
Quadriceps power (0-4 points)	3.2	1.3	1.4	63	<0.001
Sum demerit points	15.3	5.1	5.7		

Improved: 9.6 points (63 %)

x) From preoperative to follow-up status.

The average demerit points preoperatively was 15.3 against 5.7 at follow-up. The score was thus reduced by 9.6 points (63 %). From the preliminary examination to follow-up 15 months later, the average score according to Weinfeld was increased by 0.6 points. The main reason for this deterioration was an increased incidence of lateral instability caused by loosening of the tibial components. On the basis of a comparison between the average points for the seven parameters included in the evaluation system preoperatively and at follow-up, it was found that with the Marmor arthroplasty there was a significant reduction of pain, of use of support at walking, of extension defect, of lateral instability, of varus and valgus deformity and of weakness of quadriceps. Flexion was not significantly changed.

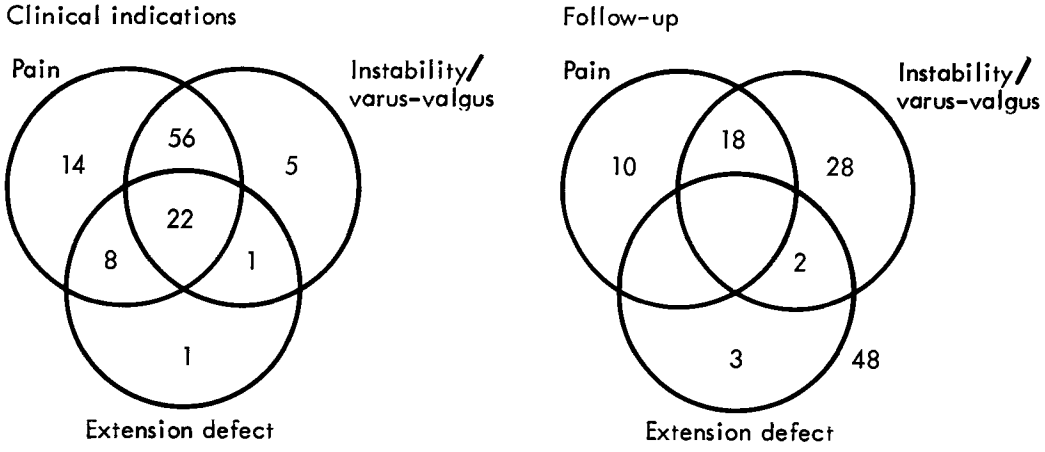
In classing the knees at follow-up according to score based on Weinfeld's evaluation system, 31 were excellent, 45 good, 13 fair, and 20 poor. By simplifying the system to include only two groups to facilitate the statistical analysis of the material, 76 knees were satisfactory (0-6 points) and 33 not satisfactory (7-33 points).

When comparing the status preoperatively and at follow-up for the individual knee, excluding parameters that cannot be correlated because of inadequate data (quadriceps power preoperatively in 36 knees), it was found that, of the 33 knees with a "not satisfactory" result, 21 were improved, 2 unchanged, and 10 worse. Dislocation of the prosthesis was responsible in 6 of the 10 knees that were worse. In the patients' opinion, an improvement was found in 17 knees, 7 were unchanged, and 9 had deteriorated.

Clinical indications for operation and results at follow-up

Clinical indications for operation were compared with similar parameters in Venn diagrams to illustrate the effect of arthroplasty.

Fig. 27.
See Fig. 4 for definition of subsets.



Preoperatively, all knees were in the diagram with 22 knees in the central subset. At follow-up, 48 knees were removed from the diagram and none remained in the central subset.

EFFECT OF COMPLICATIONS ON FINAL RESULTS

("Satisfactory" implies a Weinfeld score 0-6)

	No. of knees	"Satisfactory"	"Not satisfactory"
Operative complications (knees)	43	18	25
Accidental loosening of anterior cruciate lig.	8	3	5
Fracture medial femoral condyle	1	1	-
Tibial cysts	7	5	2
Impingement of patella on femur component	15	10	5
Anterior inclination of tibial component	7	3	4
Incongruency	7	2	5
Lateral malposition not corrected	3	2	1
Insufficient cement initially	7	3	4
Osteoporosis	2	1	1
Patella ligament rupture	1	1	-
No. of complications (2 complications were noted in 15 operations)	58		

	No. of knees	"Satisfactory"	"Not satisfactory"
Postoperative complications (within two months)	35	28	7
Complicated wound healing	11	6	5
Patella impingement	5	4	1
Dislocation femoral component	1	1	-
Dislocation tibial component	1	-	1
Peroneal palsy	7	7	-
Fracture femoral condyle	1	1	-
Others	9	9	-
Late complications (after two months) (knees)	15	4	11
Late infections	2	-	2
Dislocation of prosthesis	7	1	6
Collapse of non-operated compartment	3	-	3
Loose fragments of cement	2	2	-
Condylar fractures	2	1	1
No. of complications (2 complications were noted in one knee)	16		
Without complications	37	29	8

PREOPERATIVE ROENTGEN FINDINGS RELATED TO RESULTS

Narrowing of the articular space was found in six knees, obliteration in 19 and attrition of FT-joints in 67. The articular space exceeded 3 mm in the best compartment in only 10 knees. When attrition in one or both compartments was present, a significant increase in the FTP-angle difference in provocation in varus and valgus was found (Chi^2: $p = 0.015$). In 13 knees attrition was combined with subluxation of tibia in relation to femur. Results at follow-up were not related to the degree of observed destruction in the FT-joints.

Reduction of cartilage and attrition in FP-joints, FTP-angle at varus and valgus provocation and FTP-angle difference at varus and valgus provocation were evaluated after same methods as in the McIntosh material but were found without prognostic value.

ROENTGEN EXAMINATION AND RESULTS AT FOLLOW-UP

The findings at the roentgen examination will be published in a separate paper (Andersen et al., unpublished data) and only results of relevance to the discussion in this chapter will be presented here.

FTP-angle at varus and valgus provocation and FTP-angle difference at varus and valgus provocation were found without significant influence on the results at follow-up.

Position of tibial components at follow-up

The usual malposition on a frontal view were medial inclination of the tibial components. Malpositions were more usual in the medial compartment than in the lateral. On the lateral view, the usual malposition was posterior inclination.

Loosening of tibial components

The indicator wire is placed in direct contact with bone cement which anchors the component to the bone. A break and/or buckling of the indicator wire is therefore a sign of loosening of the prosthesis (Fig. 29).

Table 43.

Thickness of components	Lateral component		Medial component	
	Stable	Loose	Stable	Loose
6 mm	9	10	17	23
9 mm	31	8	24	5
12 mm	16	2	9	2
15 mm-21 mm	7	1	1	3

(Inadequate data: 22)

The indicator wire was broken in seven knees and buckled in 21. Breakage and buckling were combined in a further 26 knees. In 21 knees, the lateral prosthesis was loose and in 33, the medial prosthesis. The difference in frequency of loosening of medial and lateral components was significant (Chi^2: $p = 0.018$). In the medial compartment, a 6 mm thick prosthesis was used in 40 knees. Of these, 23 were loose. It was more usual to use a 6 mm thick prosthesis in the medial compartment than in the lateral and the higher incidence of loosening in the medial compartment could partly be explained by this.

Change in position of the prosthesis in relation to prosthesis loosening

In the lateral compartment, a change in the position of the tibial component exceeding 5° was found in 24 knees, and in the medial compartment, in 33 cases (Fig. 30). A significant correlation between loosening of prosthesis and change in position was found in the medial compartment (Chi^2: 0.012) and in the lateral compartment (Chi^2: $p = 0.0358$). Treatment with systemic cortisone for more than one year and the length and weight of the patient had no influence on the incidence of change in position of the prosthesis.

Radiolucent zone beneath the tibial prosthesis

In 11 knees where the zone exceeded 2 mm beneath one of the components, the result was "satisfactory" in five knees (Fig. 32). With increasing width of the zone there was a significant increased incidence of changed position of the prosthesis in the medial (Chi^2: $p = 0.009$) and lateral compartment (Chi^2: $p = 0.022$). This confirmed the supposition that the development of a radiological zone reflects mobility between bone and cement.

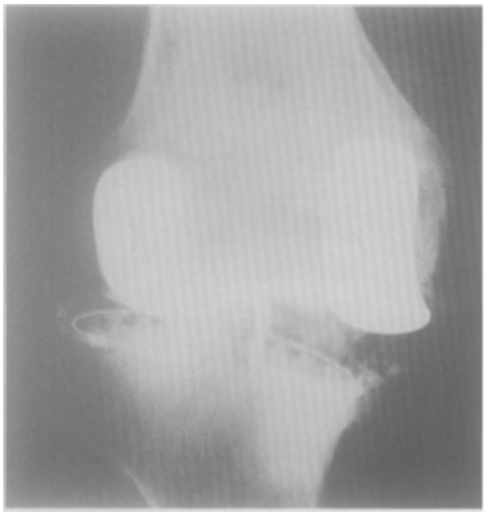


Fig. 28. Lateral subluxation of tibia, eminentia collision of lateral femoral component, dislocation of medial femoral component.

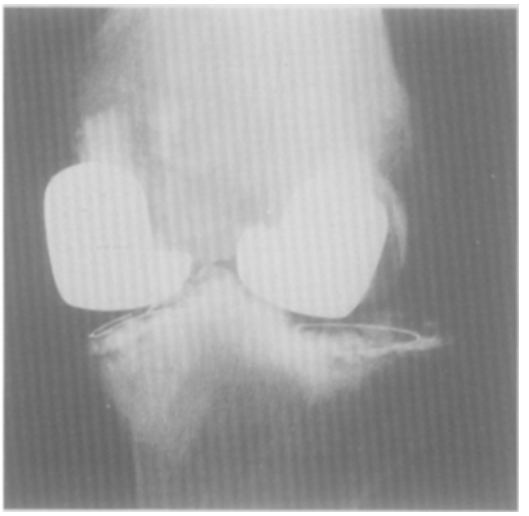


Fig. 29. Fracture of indicator wires. Buckling of the wire in medial compartment. Abnormal camber angle of lateral femoral component.

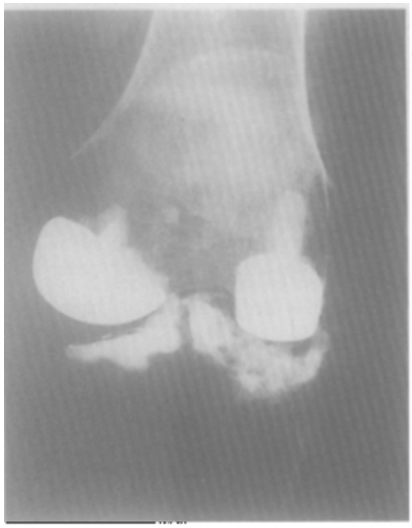


Fig. 30a. Collapse of lateral tibial condyle.

Fig. 30b. Dislocation of lateral tibial component.

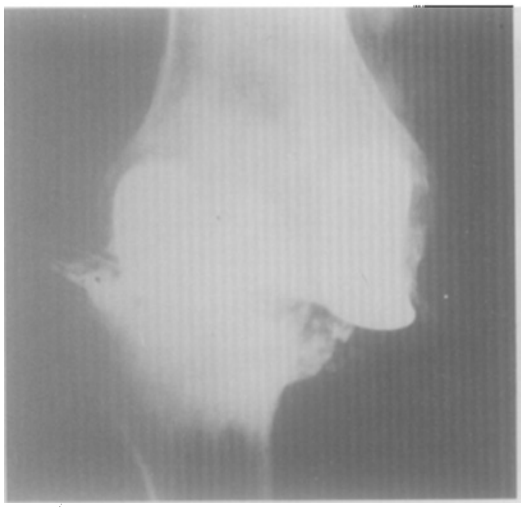


Fig. 31a. Lateral subluxation of tibia. Loosening of lateral tibial component, collapse of medial tibial condyle.

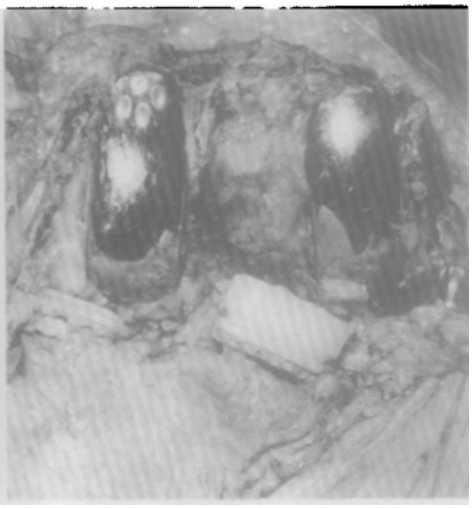


Fig. 31b. Findings at reoperation.

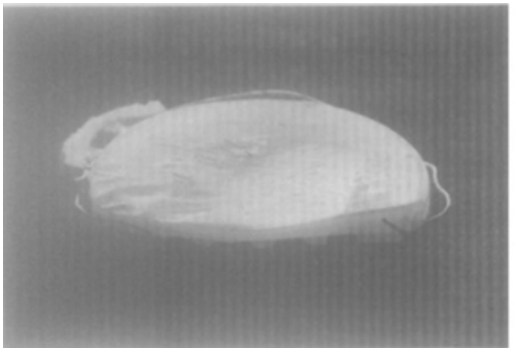


Fig. 31c. Wear of lateral tibial prosthesis. Indicator wire fractured and buckled.

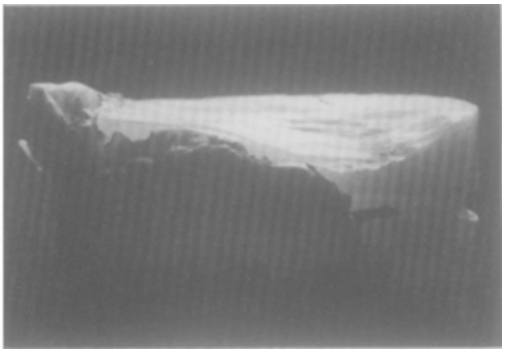


Fig. 31d. Wear of medial tibial component.

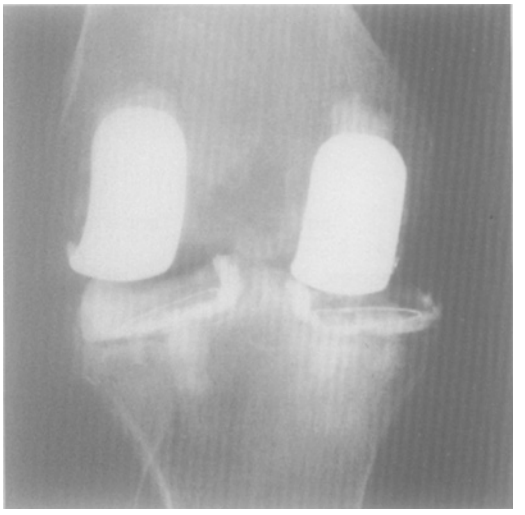


Fig. 32. Radiolucent zone 2 mm wide below lateral tibial component in a case with late infection. No signs of loosening between component and cement.

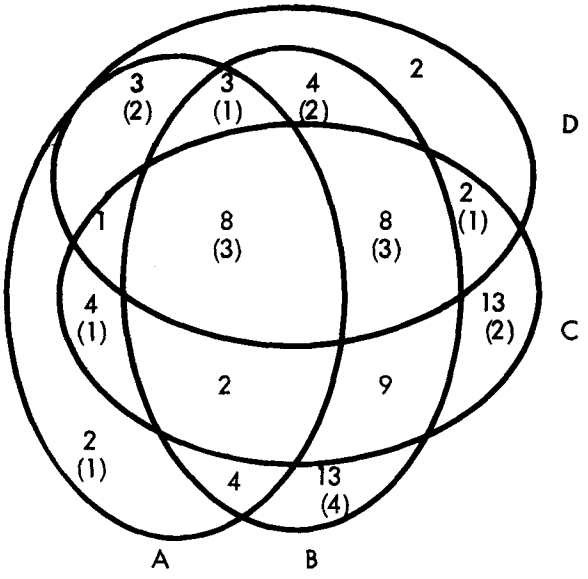
Summary of major pathological roentgen findings at follow-up

At operation, the technical aim was to achieve a normal FT-angle, positioning of the tibial components without major inclination, stable anchorage of all components and central articulation of the femoral and tibial components.

A Venn diagram indicates the correlation of major pathological findings at follow-up (Fig.33). Percentage of pathological findings are calculated in Table 44.

There were no abnormal findings at the X-ray examination at follow-up in 20 knees; at follow-up the result was "satisfactory" in 13. In 78 knees, one or more of the pathological findings mentioned under A, B, C and D were found. The incidence of "not satisfactory" results at follow-up varied from 22 to 42 % when at least one or two pathological findings were present. The highest incidence of "not satisfactory" results (42 %) occurred in conjunction with an eccentric articulation between the femoral and tibial component (D). The results were not significantly worse than the results in the rest of the material (Chi^2: $p = 0.069$).

Fig. 33. Major pathological roentgen findings at follow-up.
(Numbers in parentheses show the "not satisfactory results at follow-up)



A: FT-angle $<168^{\circ}$ or $>180^{\circ}$

B: Inclination of the tibial component $>10^{\circ}$

C: Loosening of the tibial components

1) Change of inclination exceeding 10° or

2) Breakage or buckling of indicator wire

D: Eccentric articulation between femoral and tibial components

(Inadequate data: 11).

Table 44.
Pathological findings.

	A	B	C	D	AB	AC	AD	BC	BD	CD	Normal	Whole material
Number of knees	27	51	47	31	17	15	15	27	23	19	20	98
Percentage of "not satisfactory" results at follow-up (%)	37	29	23	42	23	27	40	22	39	37	35	29

Patients' opinion at follow-up

11 patients stated that they would not have agreed to an operation had they known the final result. Two had a "satisfactory" and nine a "not satisfactory" result according to Weinfeld's point system. For a more precise idea of the patients' impression of the result, the following four possibilities were suggested:

Table 45.

Almost normal	39
Improved	51
Unchanged	10
Deteriorated	9

Statistical correlation was found between the patients' opinion and the evaluation result according to Weinfeld (Chi^2: p 0.001). The patients' opinion at follow-up was not correlated to disease activity as judged by the presence of pain in other joints. A correlation between the patients' opinion at the preliminary examination approximately 12 months after the operation and their opinion at follow-up, on average 15 months later, showed that 14 knees were considered improved, whereas 26 had deteriorated. The patients were significantly less enthusiastic at follow-up than at the preliminary examination.

ARA functional classification

All patients were classified preoperatively and at follow-up according to the American Rheumatoid Arthritis functional system. This system was modified by dividing Class III into subgroups a and b. Patients in subgroup IIIa were assessed as being able to remain in that class with continued treatment, but patients in subgroup IIIb (patients at risk) were in danger of deteriorating to group IV unless radically treated.

Table 46.

ARA	Preoperatively	Follow-up
II	3	19
IIIa	59	47
IIIb (risk)	31	28
IV	16	15

Improved	34
Unchanged	54
Worse	21

The improvement was significant (Wilcoxon's SRT: p = 0.015). It must be remembered that in 65 knees, pain at weight-bearing was present in at least one other major joint in the lower extremities. Correlation was also found between the result at follow-up accordick to Weinfeld and the ARA classification.

The functional improvement reflected in an improved ARA classification did not lead to any significant change in socio-economic conditions.

DISCUSSION

Following a Marmor arthroplasty in the Lund material there were 76 knees (70 %) with "satisfactory" results and 33 (30 %) with "not satisfactory" results after an observation period of 2.2 years (1.0-3.6).

The unconstrained total principle has only been in clinical use for about five years and therefore only a few series observed for more than two years have been published, none as far as is known restricted only to RA. Marmor (1976a), who developed the modular prosthesis reported 88 % excellent to good results in a series of 124 operated OA + RA knees with observation time > 2 years. Insall et al. (1976) reported 64 % excellent to good results in a mixed RA + OA series of 42 knees with observation time > 2 years using the duocondylar prosthesis. Cavendish et al. (1978), Engelbrecht et al. (1976) and Shaw et al. (1978) reported 85-90 % excellent to good results using the Liverpool Mark II, St. Georg Schlitten and Manchester prostheses in OA and RA. The observation time exceeded two years in these series.

Except for Insall et al. (1976), who reported results worse than those presented in this series, other series seem to have only one-third to one-half as many "not satisfactory" results than was found in the Lund material. Differences in evaluation and populations could explain the discrepancy but indications, details in prosthetic design and operative technique could account for real difference in results.

Loosening

Marmor (1976) reported loosening of the tibial components in 9 % of operated knees. Most of them were overweight OA patients where 6 mm components were used. In other reported series, the incidence of loosening was reported to be from 0-5 % (Engelbrecht et al. 1976, Insall et al. 1976, Laskin et al. 1976, Shaw et al. 1978).

In Lund, loosening of tibial components with considerable clinical symptoms was found in seven knees (6.5 %), but these were only a small fraction of the knees where roentgen at follow-up indicated loosening of tibial components. In the medial compartment 39 % and in the lateral compartment 25 % of the prostheses were loose. Loosening was significantly more common in the medial compartment than in the lateral probably because the 6 mm component was most often used medially.

Change of position

Baldursson et al. (1979) by roentgenstereophotogrammetry in one Marmor arthroplasty

without infection or clinical signs of prosthetic loosening, showed a migration of the tibial component with tilting. Similar examinations have shown migration of acetabular cups in hip arthroplasties. This migration of polyethylene components was considered a general phenomenon and they considered the radiolucent zone found around implants to indicate small movements or a continuous migration of the prosthesis. Insall et al. (1976) found a radiolucent zone under the tibial components in about 50 % of knees and explain this finding as a result of insufficient anchorage and caused by the elastic properties of polyethylene.

In the Lund material, the angle between the longitudinal axes of the tibia and a plane through the indicator wire changed $\geq 5^{\circ}$ in 132 of 187 tibial components examined. A radiolucent line ≥ 1 mm was seen under 95 of 162 components. A significant correlation was found between loosening and changed position and between the presence of a zone ≥ 1 mm and change of position.

In conclusion the present concept of unconstrained prostheses for practical use has considerable disadvantages. Wear of the tibial component results in a guiding through and the prosthesis therefore is no longer strictly unconstrained. The elastic properties of polyethylene favour loosening, which occurs early if thin components are used. Migration of polyethylene components seems to take place even if obvious loosening is not present. These observations are an indication for concern in the long-term use of this prosthetic principle. The wear could be reduced by using radiation improved polyethylene, as suggested by Grobbelaar et al. (1978) and the unfavourable effects of the elastic properties of polyethylene could perhaps be prevented by using metal interposed between polyethylene and bone cement (Goodfellow and Connor 1978) and thin tibial components should be avoided.

Contraindications

Contraindications vary in published clinical reports. An extension defect up to 20° was accepted by Engelbrecht et al. (1976), and Laskin et al. (1976). Cavendish et al. (1978) accepted up to 30°. Marmor (1976a) did not consider an extension defect of 60° in an ankylosed knee to be a contraindication. In the Lund series there was an extension defect exceeding 30° in four knees; full correction was obtained in only two of these. If an extension defect was not fully corrected, significantly worse results were found at follow-up and the need for support on walking was increased.

Engelbrecht et al. (1976) accepted varus or valgus up to 20°, Cavendish et al. (1978) and Marmor (1976a) used 30° as a limit. In the Lund series clinical malalignment up to

20° was accepted and the result at follow-up was not significantly influenced by the degree of malalignment found preoperatively.

Engelbrecht et al. (1976) and Shaw et al. (1978) draw attention to ligamentary insufficiency in general. Cavendish et al. (1978) found posterior dislocation and Insall et al. (1976) found rotation deformity or subluxation of special importance as contraindications. In the Lund material preoperative lateral subluxation of the tibia was a relative contraindication.

The anterior drawer sign has from a perusal of the literature not been mentioned as a contraindication. Cavendish et al. (1978) claimed that absence of the anterior cruciate ligament was not important. In this series, the preoperative drawer sign was not associated with a significantly worse result (Chi^2: $p = 0.079$), probably because an anterior drawer sign is an unreliable indication of the absence of the anterior cruciate ligament in a destroyed rheumatoid knee. At follow-up, a significantly worse result was found when the anterior drawer sign existed (Chi^2: $p = 0.041$). Correlation was also found between the anterior drawer sign and lateral instability at follow-up (Chi^2: $p < 0.0001$), which implied that two-dimensional instability was often present. In eight operations where the insertion of the anterior cruciate ligament was damaged, five had a "not satisfactory" result at follow-up. This finding also indicated the importance of internal stability.

Lateral stability was important. Only 2 of 39 knees with instability between 10 and 20° had an excellent result. Five knees with instability more than 20° had a poor result. Results were significantly worse when lateral instability was found at follow-up. Loosening and altered position of the tibial components, from the preliminary examination to follow-up gave rise to lateral instability. Stability acquired at operation was not always maintained. In eight knees where unsatisfactory congruency between the femoral and the tibial components was obtained at surgery, a total collapse of the tibial condyles occurred in spite of cementation in the desired position. These findings suggest the need for a review of the operative technique or the limits for indication.

On the basis of reported contraindications in published clinical series and in this material, an unconstrained arthroplasty can only be recommended when an extension defect preoperatively is less than 20° and full extension can be achieved without anterior inclination of the tibial prosthesis. Varus and valgus malposition should not exceed 20°, antero-posterior and lateral stability must be achieved at the operation and congruency between femoral and tibial components must be satisfactory. It is often impossible to predict whether these demands can be fulfilled at operation and it is therefore mandatory to be able to choose another form of arthroplasty if necessary.

The indications used in this series did not exceed recommendations of published works but on the other hand late synovectomy probably was preferred in many cases where others found arthroplasty suitable.

Surgical technique

Marmor (1976a) considered it a major concept in design that the tibial components should be placed in an exactly reamed excavation within the cortical rim. In this series an important modification was introduced (Fig. 30). The tibial condyles were resected with an osteotome and the components were anchored with circumferential cortical support. This modification, partly inspired by the operative technique in McIntosh arthroplasty, was technically simple and the cortical rim acting as a support was considered important for keeping the prosthesis permanently in position. On roentgenological finding of loosening of one-third of the tibial components and change of position from the first postoperative examination to follow-up, it was obvious that this technique did not fulfil the expectations of stable anchorage and the modification of the operative technique therefore was hardly motivated.

Complications

Deep infection was reported by Marmor (1976a) in 7/126 cases (5.6 %), and also had a high incidence of wound healing problems (34 %), prophylactic antibiotics were not used. None of the other series earlier referred to, including the Lund series, reported more than 0-2 % deep infections. Although bone cement is used and the operation time is 1-2 hours, deep infection has not been a quantitative problem.

FP-joint. Engelbrecht et al. (1976), Insall et al. (1976) and Sneppen et al. (1978) considered FP-joint problems the most usual reason for pain at follow-up. Sneppen et al. claimed that dislocation of the patella was an important reason. Marmor (1976b) reported that 21 % of 345 operated cases had retropatellar pain and in 6 % impingement was found. Patellectomy was considered a possibility by Engelbrecht et al. (1976) and Marmor (1976a) but it was regarded contraindicated by Insall et al. (1976) because it did not prevent pain and usually caused quadriceps insufficiency.

In the Lund material, an impingement of the patella on the anterior edge of one or both femoral components was noted at operation in 15 knees and patellectomy was performed in 12 which resulted in significantly decreased quadriceps power and in five knees extension defects were present at follow-up. Patellectomy was also found to predispose to complicated wound healing. In five knees with painful crepitations postoperatively, patellectomy was performed in one, and the pain diminished spontaneously in four.

It can be concluded that FP-joint problems are considerable in this type of arthroplasty and are not connected to any special model of modular design. Except for prevention of unnecessary prominence of the anterior edge of the femoral component, no acceptable treatment of this complication has been suggested.

SUMMARY

109 knees in 90 patients with RA were operated with the Marmor prosthesis from 1974 through 1977. At follow-up 2.2 years (1.0-3.6) postoperatively, an arbitrarily chosen degree of normalization, 0-6 points according to Weinfeld's evaluation system - "satisfactory" results - was achieved in 76 of 109 knees (70 %). Of 33 knees with ≥ 7 points - "not satisfactory" result - 21 were improved, 2 unchanged and 10 worse. The arthroplasty resulted in a reduction of pain, diminished extension defect and lateral instability and correction of malposition at weight-bearing. Quadriceps power increased and the need for support on walking was reduced. Flexion was not significantly changed. As judged by the patients 90 knees were improved and 19 unchanged or worse. There was a significant improvement in ARA functional classification.

Technical difficulties or operative complications occurred in 40 % of the operated knees. Predisposing factors for "not satisfactory" results were fracture of the tibial spine, cementation problems of the tibial components and when congruency between the femoral and tibial components were not achieved. Impingement of the patella on the femoral components treated by patellectomy resulted in weakening of the quadriceps and increased the risk of complicated wound healing which was the most usual postoperative complication (10 %).

Impingement problems were also found postoperatively, but pain and crepitation diminished spontaneously in 4 of 5 knees. Late infection developed in two knees.

Loosening of components with clinical symptoms of a severity that required reoperations occurred in nine; in two, the femoral component could be recemented, but in seven with loosening of the tibial component, arthrodesis or arthroplasty using another type of prosthesis was performed. A review of the roentgen material showed that approximately one-third of inserted tibial components were loose and a change in position of the component had occurred. These findings are probably precursors of future severe problems and are symptoms of failure of the unconstrained principle.

The use of 6 mm components and the insertion of the tibial components with circumferential underlying cortical bone support, probably an advantage for preventing compression but insufficient for withstanding the shearing forces, contributed to the high frequency of loosening in this material.

The restricted indications for unconstrained arthroplasty are due to the imperfections of the available design and the requirement of sufficient soft tissue stability. On the basis of present experience, unconstrained arthroplasty can be recommended if late synovectomy cannot be expected to result in an acceptable reduction of pain and permit walking. Extension defect and malposition should not exceed 20°. At surgery, antero-posterior stability and lateral stability as well as congruency between the femoral and the tibial components must be achieved. Because of the difficulties in predicting whether these requirements can be fulfilled, other prosthetic alternative should always be available.

VI. STATISTICAL ANALYSIS OF TOTAL MATERIAL AND SUBSETS

240 knees arthroplasties were performed at the Department of Orthopaedic Surgery, University Hospital of Lund from 1967 through 1976. This material was composed of three subsets:

1) 67 knees operated with unconstrained hemi-arthroplasty (McIntosh).

2) 64 knees operated with constrained arthroplasty (Guépar).

3) 109 knees operated with unconstrained total arthroplasty (Marmor).

POPULATION DIFFERENCES AND EQUALITIES IN SUBSETS

In this material, all knees were similarly evaluated using identical parameters. The three subsets were analysed for equalities and differences in population according to a variety of pre- and postoperative criteria, considered to have a potential influence on the results (Table 47). A Chi^2-test was performed for each criteria; if the p-value was less than 0.05, the subsets were judged significantly different. The three subsets were all identical according to 15 criteria. The McIntosh and Guépar subset were identical according to one criteria, the McIntosh and Marmor subset to nine criteria, and the Guépar and Marmor subset to five criteria. Observation time was significantly different for all three subsets.

Population differences in subsets of major importance for comparison

The observation period in the Marmor material was significantly shorter, i.e. 2.2 years as opposed to 2.7 years in the Guépar material and 3.4 years in the McIntosh material.

In the Guépar material, increased incidence was found of bony attrition at operation, possibly caused by a longer period of disease involvement in the involved knee. Increased deformity such as extension defects and varus- and valgus malpositions, and decreased quadriceps power was noted in the Guépar subset. Increased need for support on walking and the patient's lower functional classification according to the ARA system was primarily due to the condition of the involved knee, because duration of general disease, ESR, serology, pain at weight-bearing in other joints and previous arthroplasties in other joints were identical in the three subsets. As a consequence of the radicality in the Guépar arthroplasty, significantly worse results were not shown in the light of these population differences, but it does not exclude that worse results could have been expected if these patients had been totally unselected and operated with McIntosh or Marmor arthroplasty.

	McIntosh (67)			Guépar (64)			Marmor (109)			Total material (240)			Population difference
	Knees	Not satis-factory	p	Knees	Not satis-factory	p	Knees	Not satis-factory	p	Knees	Not satis-factory	p	Chi^2:p
Material													
Sex: Males	11	5	(-)	15	8	(-)	33	11	(-)	59	24	(-)	(-)
Females	56	40		49	26		76	22		181	88		
Age at operation:													
<60 years	52	32	(-)	18	8	(-)	44	10	(-)	114	50	0.05	McIntosh younger
≥60 years	15	12		44	26		65	23		126	61		
Observation time:													
<2 years	19	11	(-)	24	13	(-)	41	12	(-)	84	36	(-)	McIntosh longer than Guépar, longer than Marmor
≥2 years	48	33		40	21		68	21		156	75		
Duration RA in general:													
<5 years	24	15	(-)	11	5	(-)	24	7	(-)	59	27	(-)	Marmor longer duration
≥5 years	43	29		53	29		85	26		181	84		0.007
Duration RA in the knee:													
<10 years	31	15	0.006	20	10	(-)	28	11	0.014 (para-dox)	79	36	(-)	Guépar longer duration 0.05
≥10 years	36	29		44	24		81	22		161	75		
Disease activity													
ESR preoperatively:													
<35 mm/h	21	12	(-)	21	13	(-)	28	9	(-)	70	34	(-)	(-)
≥35 mm/h	35	31		43	21		81	24		159	76		
ESR postoperatively:													
<35 mm/h	18	9	(-)	23	14	(-)	32	11	(-)	73	34	(-)	(-)
≥35 mm/h	44	33		41	20		77	22		162	75		
Serology: negative	25	16	(-)	12	7	(-)	41	11	(-)	78	34	(-)	(-)
positive	35	22		31	15		62	19		128	58		
Activity of disease in patients' opinion:													
Less active	18	10		16	4		34	8		68	22		
Same	31	21	(-)	24	14	0.028	31	8		86	43	0.026	(-)
More active	17	17		24	16		44	17	(-)	85	45		

	McIntosh (67)			Guépar (64)			Marmor (109)			Total material (240)			Population difference
	Knees	Not satis-factory	p	Knees	Not satis-factory	p	Knees	Not satis-factory	p	Knees	Not satis-factory	p	Chi^2:p
Previous treatment													
Cortisone systemic:													
≤ 1 year	27	15	(-)	33	15	(-)	53	18	0.09	113	48	(-)	(-)
≥ 1 year	31	19		31	19		56	15		117	53		
Involved knee													
Cortisone intra-articular:													
≤ 5 injections	32	19	(-)	34	15	0.089	55	16	(-)	121	50	(-)	(-)
> 5 injections	35	25		29	19		54	17		118	61		
Osmium acid intra-articular:													
Yes	29	20	(-)	19	10	(-)	41	11	(-)	89	41	(-)	(-)
No	37	23		45	24		68	22		150	69		
Synovectomy: Yes	26	16	(-)	17	7	(-)	40	12	(-)	73	35	(-)	
No	41	28		47	27		69	21		157	76		
Capsulotomy: Yes	6	6	(-)	4	1	(-)	3	2	(-)	13	9	0.087	(-)
No	61	38		60	33		106	31		227	102		
Osteotomy: Yes	4	4	(-)	5	1	(-)	3	2	(-)	12	7	(-)	
No	63	40		59	33		106	31		228	104		
Other joints (until follow-up)													
Bilateral knee arthroplasty (same type): Yes	22	12	(-)	30	18	(-)	44	12	(-)	96	42	(-)	
No	45	32		34	16		65	21		144	69		
Arthroplasty other knee: (other type): Yes	2	2	(-)	6	2	(-)	11	6	(-)	19	10	(-)	(-)
No	65	42		58	32		98	27		221	101		
Arthrodesis other knee:													
Yes	8	8	0.027	2	1	(-)	3	0.	(-)	13	9	(-)	
No	59	36		2	33		106	33		27	102		

	McIntosh (67)			Guépar (64)			Marmor (109)			Total material (240)			Population difference
	Knees	Not satis-factory	p	Knees	Not satis-factory	p	Knees	Not satis-factory	p	Knees	Not satis-factory	p	Chi^2:p
Extension defect:													
≦15°	49	33	(-)	35	24	0.007 (para-dox)	76	23	(-)	160	80	(-)	Guépar more often extension defect 0.044
>15°	17	10		29	10		33	10		79	30		
Flexion: ≧80°	62	39	(-)	51	27	(-)	104	31	(-)	217	77	0.006	Guépar more often decreased flexion <0.001
<80°	4	4		13	7		5	2		22	13		
Medial or lateral instability:													
<10°	18	13	(-)	12	5	(-)	29	6	(-)	59	24	(-)	0.069
≧10°	43	25		50	29		71	24		164	78		
Quadriceps power:													
≧100N	17	7	(-)	9	4	(-)	32	8	0.05	58	19	0.028	Guépar worse quadriceps power 0.003
<100N	15	10		38	24		47	22		94	50		
Varus-valgus at weight-bearing:													
<10°	27	16	(-)	16	7	(-)	46	12	(-)	89	35	(-)	Guépar more often malposition <0.0001
≧10°	37	25		44	26		53	17		134	68		
Pain at rest: Yes	36	23	(-)	40	24	(-)	59	16	(-)	135	63	(-)	(-)
No	31	21		24	10		50	17		105	48		
Function preoperatively													
Need of support at walking indoors: Yes	37	29	0.012[x]	43	26	0.092	65	21	(-)	145	76	0.018	Guépar increased need of support <0.001
No	30	15		21	8		44	12		95	35		
ARA functional classification:													
II-IIIa	21	12	(-)	16	4	0.009	62	15	(-)	99	31	<0.001	Guépar worse functional classification <0.0001
IIIb-IV	43	29		48	30		47	18		138	77		

	McIntosh (67)			Guépar (64)			Marmor (109)			Total material (240)			Population difference
	Knees	Not satis-factory	p	Knees	Not satis-factory	p	Knees	Not satis-factory	p	Knees	Not satis-factory	p	Chi^2:p
Hip arthroplasty ipsilateral:													
Yes	8	7	(-)	7	4	(-)	11	5	(-)	26	16	0.04	(-)
No	59	37		57	30		99	28		214	95		
Hip arthroplasty contralateral:													
Yes	10	9	0.079	8	6	(-)	14	5	(-)	32	20	0.015	(-)
No	57	35		56	28		95	28		208	91		
Status in the knee preoperatively													
Exudate: Yes	39	27	(-)	28	12	(-)	71	21	(-)	138	60	(-)	McIntosh more often exudate < 0.0001
No	26	15		36	18		36	10		98	43		
Capsular swelling:													
Yes	60	38	(-)	36	21	(-)	77	23	(-)	173	82	(-)	McIntosh more often capsular swelling < 0.0001
No	6	5		28	13		32	10		66	28		
FP joint crepitations:													
Yes	45	29	(-)	47	29	(-)	80	23	(-)	172	81	(-)	McIntosh less often crepitation 0.007
No	14	7		4	0		11	3		29	10		
Fixation of patella:													
Yes	43	28	(-)	23	15	(-)	53	16	(-)	119	59	(-)	McIntosh more often fixation 0.042
No	14	7		27	13		38	11		79	31		
Anterior drawer sign:													
Yes	34	23	0.099	34	21	(-)	63	21	0.079	131	65	< 0.001	(-)
No	22	10		22	11		25	5		69	26		

	McIntosh (67)			Guépar (64)			Marmor (109)			Total material (240)			Population difference
	Knees	Not satis-factory	p	Knees	Not satis-factory	p	Knees	Not satis-factory	p	Knees	Not satis-factory	p	Chi^2:p
Pain at walking at follow-up													
Knee, contralateral:													
Yes	34	23	(-)	23	18	0.003	45	16	(-)	102	57	0.01	(-)
No	33	21		41	16		64	17		138	54		
Hip, ipsilateral:													
Yes	8	8	0.027	9	5	(-)	10	4	(-)	27	17	0.047	0.068
No	58	35		55	29		99	29		212	93		
Hip, contralateral:													
Yes	11	11	0.008	8	6	(-)	10	4	(-)	29	21	0.009	(-)
No	55	32		56	28		99	29		210	89		
Foot - foot joint ipsilateral:													
Yes	22	16	(-)	19	8	(-)	28	9	(-)	59	33	0.079	(-)
No	44	27		45	26		81	24		180	77		
Foot - foot joint contra-lateral: Yes	21	15	(-)	17	8	(-)	30	11	(-)	68	34	(-)	(-)
No	45	28		47	26		79	19		171	73		
Pathology at operation													
Destruction of ligaments:													
Yes	38	25	(-)	39	20	(-)	74	19	0.065	151	64	0.04	0.06
No	27	18		25	14		32	14		84	46		
Attrition of bone:													
Yes	31	18	(-)	9	5	(-)	40	13	(-)	80	36	(-)	Guépar more often attrition < 0.001
No	35	25		55	29		69	20		159	74		

DISCUSSION

In clinical work, it is usually necessary to accept differences in compared populations. Normally, the population characteristics are so complex that for practical use it seems more realistic to ignore the differences than to define them. This causes much uncertainty in assessment and might lead to serious errors. Tew and Waugh (1978), on the basis of five arthroplasty materials evaluated according to the criteria recommended by the British Orthopaedic Association Research Subcommittee showed that only average age at operation was equal in these series whereas the difference in all the other registered preoperative criteria was highly significant ($p < 0.001$) which implies that these materials were statistically different populations and therefore direct comparison between them is of doubtful relevance.

The three subsets in this work were characterized by a high degree of equality in population, the difference were well defined and comparisons therefore are permitted with an acceptable level of certainty.

VII. GENERAL DISCUSSION

RESULTS

By comparing the frequencies of pathological findings preoperatively and at follow-up in the three arthroplasty materials, the extent to which the methods were effective can be assessed. This is illustrated in the Venn diagrams on pages 25, 55 and 70 as well as by the other criteria included in Weinfeld's evaluation system.

Table 48.
Calculated % from Venn diagrams pages 25, 55 and 70.

%	McIntosh (67)		Guépar (64)		Marmor (109)	
	Preop.	Follow-up	Preop.	Follow-up	Preop.	Follow-up
I	97	60	88	25	93	17
II	75	51	84	10	79	53
III	25	6	44	3	30	5
I+II	72	37	73	2	73	17
I+III	24	6	36	0	28	0
II+III	19	3	30	2	22	2
I+II+III	18	3	27	0	21	0
Outside diagram	0	27	0	64	0	44

I. Pain

Pain was a major indication in 88 % - 97 % of the knees. The difference in the subsets was not significant. At follow-up, pain was found in 60 % in the McIntosh material, in 25 % in the Guépar material and in 17 % in the Marmor material.

II. Instability - varus/valgus malposition

Preoperative lateral instability and/or malposition exceeding 10° at weight-bearing was present in 75 % (McIntosh) to 84 % (Guépar) of knees; the Guépar material had a higher frequency of extreme malposition and varus was more usual than valgus. At follow-up, correction of malposition and/or lateral instability was significantly better when using the Guépar; only 10 % were not corrected as compared to 51 % and 53 % for the McIntosh and Marmor arthroplasties, respectively. Lateral instability and/or malposition after Guépar arthroplasty was caused of eccentric position of the prosthesis in the marrow

cavities or loosening secondary to deep infection. After hemiarthroplasty the following reasons for instability and/or malposition were found: 19 knees had severe attrition of one or both femoral condyles which developed after insertion of the prosthesis (Fig. 6a and b). A significantly worse result was found when attrition had developed in the femoral condyles. In 30 knees malposition of one or both prostheses was found; in 20 of them this increased or developed entirely during the observation period. In unconstrained total arthroplasty (Marmor), resurfacing was done on both the femur and the tibia and postoperative attrition therefore prevented. Loosening of one or both tibial components in 44 knees and altered position of one or both tibial components was found in 40 of 86 knees. The common use of a 6 mm tibial component was considered an important reason for the high rate of loosening and alteration of position. Ligamentary insufficiency was also important with regard to instability following Marmor arthroplasty. Where congruency was obviously not achieved at surgery, subluxation and collapse of medial compartment occurred.

III. Extension defect

The preoperative frequency of extension defect in the Guépar material (44 %) was significant greater, than in the McIntosh and Marmor materials. In constrained arthroplasty, an extension defect could be eliminated regardless of the amount. A risk with extreme resection of bone was the development of an extension lag, in two knees (3 %), an extension lag exceeding 20° was found at follow-up. Compared with the unconstrained principle, the result was very satisfactory. In unconstrained arthroplasty, an extension defect can be corrected by resection of the anterior edge of the tibial plateau. The tibial component must often of necessity be placed in an anterior inclination if full extension is to be achieved. Even though significantly worse results at follow-up after McIntosh and Marmor arthroplasty were not shown when extension defects were present at surgery, it must be considered a disadvantage that the normal dorsal translocation of the femur in relation to the tibia on flexion was probably diminished as a result of anterior inclination. After McIntosh arthroplasty, an extension defect exceeding 15° was found at follow-up in four knees (6 %); in Marmor arthroplasty in four knees (5 %). Independent of arthroplasty principle, a significant decrease of operative extension defect was achieved.

Flexion. Limited flexion was not of major importance as an indication in any of the knees. When extension defects were eliminated at operation, it was not always possible to increase the range of motion by the amount that the extension defect was diminished, probably because of a decreased amplitude in the extensor apparatus. Consequently because of a higher incidence of considerable extension defects preoperatively in the

Guépar material a higher frequency of knees with less than 80° flexion was found after constrained arthroplasty.

Quadriceps power. Preoperative weak quadriceps was significantly more often present in the Guépar material than in the other two subsets; also at follow-up, weak quadriceps was more often present following constrained than unconstrained arthroplasty. This might to some extent be caused by the extension lag after correction of large extension defects in the Guépar material. This can also possibly be accounted for by the inbuilt hyperextension in the Guépar prosthesis which permits walking without contraction of the quadriceps. From the preliminary examination to follow-up, there was a decrease in quadriceps power in the Guépar material probably secondary to loosening of the prosthesis. After unconstrained hemi- and total arthroplasty, there was equal frequencies of weak quadriceps. Increased frequency of pain at weight-bearing in the McIntosh material at follow-up led one to expect a higher frequency of weak quadriceps in this material, but it was probably compensated for by the lower average age in this subset.

Conclusion of result at follow-up

Following arthroplasty, the minimum expectation was that the knees postoperatively and at least for some years should be almost painfree, stable and free of deformity and this was so after Guépar arthroplasty in 64 % of the knees, after Marmor arthroplasty in 44 % and after McIntosh arthroplasty in 27 %. The constrained principle produced according to these criteria a better result than did unconstrained arthroplasty, although 25 % of the knees at follow-up were still considerable painful.

A comparison of hemi- with unconstrained total arthroplasty showed that they were equally able to correct lateral instability, malposition and extension defect. After hemiarthroplasty, there was an unacceptable frequency of pain at follow-up in 60 % compared to only 17 % after unconstrained total arthroplasty. The McIntosh hemiarthroplasty was not superior to the Marmor arthroplasty in any aspect discussed here and can no longer be regarded as a rational alternative in surgery of the knee in RA.

Table 49.
Result according to Weinfeld.

Points	McIntosh (67)		Guépar (64)		Marmor (109)	
	Preop.	Follow-up	Preop.	Follow-up	Preop.	Follow-up
Pain (0-7)	6.1	3.3	5.9	1.3	5.9	1.4
Use of support at walking (0-4)	1.9	2.1	3.1	2.3	2.5	1.2
Extension defect (0-4)	1.0	0.3	1.4	0.2	1.1	0.3
Flexion (0-6)	0.0	0.3	0.3	0.4	0.1	0.1
Medial or lateral instability (0-4)	1.4	0.8	2.0	0.1	1.5	0.9
Varus-valgus at weight-bearing (0-4)	1.2	0.7	1.7	0.1	1.1	0.4
Quadriceps power (0-4)	2.9	1.3	3.5	2.3	3.2	1.4
Sum demerit points	14.5	8.8	17.9	6.7	15.3	5.7

Preoperatively, there was a significantly higher score in the Guépar material and the average improvement in points was higher than in the other subsets; as a percentage of the preoperative score, the improvement was equal in the Guépar and the Marmor materials. Preoperatively, the McIntosh material had the lowest point score and at follow-up the highest point score, which implies the worst result. At follow-up, the lowest average point score was found in the Marmor material.

COMPLICATIONS

Technical difficulties and operative complications reflect the difficulties with a chosen technique and the pathological changes present in the knee in reconstructing a stable, mobile articulation. In the Guépar material, increased deformity was found preoperatively, but despite that, there was a lower frequency of complications than in the Marmor material.

Table 50.
Technical difficulties - operative complications.

	McIntosh (67)	Guépar (64)	Marmor (109)
Operative fractures	8	6	9
Subchondral cysts	7	4	7
Wrong prosthesis	5	1	-
FP-joint problems	1	17	15
Extension defect	2	4	4
Incongruency	2	-	7
Cementation problems	-	-	7
Miscallaneous	-	-	9
TOTAL	25 (37 %)	32 (50 %)	58 (53 %)

Operative fractures. The most usual type of fracture in McIntosh and Marmor arthroplasty was detachment of the eminentia resulting in loosening of the insertion of the anterior cruciate ligament which resulted in sagittal instability.
In Guépar arthroplasty, 5 of 6 fractures were perforations of the femoral and the tibial diaphyses which occurred during reaming or at insertion of the prosthesis although continuity of the bone was present; the results were uniformly "not satisfactory".

FP-joint problems. In McIntosh arthroplasty, the FP-joint was not influenced by the operation. In only one knee with lateral subluxation of the patella preoperatively was the patella found dislocated postoperatively.
In Guépar arthroplasty, a hemiarthroplasty is automatically performed in the FP-joint, but the trochlea of the prosthesis is not anatomical in design. During the operation, 17 knees had dislocation of the patella. Although precautions were taken dislocation was found in two knees postoperatively. The reason for the high frequency of dislocated patella in Guépar arthroplasty was probably multifactorial, but the forced outward rotation of the tibia by traction on the patella ligament during lateral dislocation of the patella during cementing was considered important. In operative patellar dislocations the risk of complicated wound healing increases. No increased risk of late infection was shown.
In 15 knees, where Marmor arthroplasty was done, the anterior edge of one or both prostheses was prominent in facies patellaris and at flexion impinged on the patella. Patellectomy was indicated in 12 knees because of impingement.

Incongruency. In unconstrained arthroplasty incongruency at surgery indicated a poor prognosis because the fundamental need for soft tissue stability was not achieved.

Cementation problems. In Marmor arthroplasty in seven knees, stable fixation of one or both tibial components was not achieved at the first cementing attempt. Lack of jigs and instruments for fixing the prosthesis in the desired position during cementing was considered the main reason for these failures.

Table 51.
Postoperative complications (complications noted less than two months after operation).

	McIntosh (67)	Guépar (64)	Marmor (109)
General			
Cardiopulmonary	-	3	4
Others	-	1	2
Local			
Complicated wound healing	4	13	11
Deep infection	-	1	-
FP-joint problems	1	2	5
Dislocation of prosthesis	1	-	2
Peroneal palsy		3	7
Fractures	-	1	1
Others	2	1	9
Total local complications	8 (12 %)	21 (33 %)	35 (32 %)

Complicated wound healing

After Guépar arthroplasty, complicated wound healing was found in 13 knees (20 %). The frequency was thus twice as high as in Marmor arthroplasty, although the extremity was immobilized in plaster for two weeks for optimum wound healing. Detachment of the tuberosity and dislocation of the patella at surgery and postoperatively predisposed to delayed wound healing. Prophylactic antibiotics had no influence on the frequency of complicated wound healing. In four knees with wound healing problems, a late infection developed afterwards (resulting in one death, one above-knee amputation, and one change of prosthesis). The time spent in hospital was increased on average 44 % when complicated wound healing was present. In the Marmor material an increased frequency of complicated wound healing after patellectomy and previous knee operations was found.

FP-joint problems. In two knees, the patella dislocated laterally after Guépar arthroplasty, although a capsular plication was carried out at surgery. After Marmor arthroplasty in five knees, crepitations and femoro-patellar pain on flexion were caused by

impingement of the patella on the anterior edge of the femoral component; in four, the pain later diminished without treatment.

Table 52.
Late postoperative complications.

	McIntosh (67)	Guépar (64)	Marmor (109)
Late infection	-	15	2
Dislocation of the patella	1	5	-
Dislocation of prosthesis	2	-	7
Collapse of condyles	3	-	3
Fractures	2	1	2
Miscellaneous	-		2
TOTAL	8 (12 %)	21 (33 %)	16 (14.6 %)

Late infection. After McIntosh arthroplasty, no incidence of late infection was noted, although no prophylactic antibiotics were used. In Guépar arthroplasty, late infection developed in 15 knees; in only four was there delayed wound healing. Increased frequency of deep infection was found after transfer of the tibial tuberosity and when no prophylactic antibiotics were used. The consequence of deep infection was considerable; two patients died of septicaemia, one above-knee amputation was carried out on vital indication and five were reoperated with change of prosthesis or arthrodesis. After Marmor arthroplasty, deep infection developed in two knees; one patient died of septicaemia caused by haematogenous spread from an infected varicose ulcer.

Dislocation of the patella. After McIntosh arthroplasty, lateral dislocation of the patella was found in one knee. This was probably secondary to subluxation of the tibia. After Guépar arthroplasty, the patella dislocated laterally in five knees. Reoperation with capsular plication or transfer of the tibial tuberosity was performed in three. In the Marmor material, no additional FP-joint problems developed after two months had elapsed since surgery.

Loosening of prosthesis - dislocation. After McIntosh arthroplasty, dislocation of the prosthesis was found in two knees with severe clinical symptoms. After Marmor arthroplasty, total collapse with a compression fracture and loosening of the prosthesis in the medial compartment developed in six knees where congruency between the tibial and the femoral components was not achieved at surgery. Because of the short observation period in the Marmor material and a known high frequency of loosening of components, an increase of this complication can be predicted.

Collapse of condyles. After McIntosh arthroplasty, a progressing collapse developed in the lateral femoral condyle in two knees and in one with a primary demiarthroplasty, an increasing destruction of the other compartment was noted. After Marmor demiarthroplasty there was a collapse in the non-operated compartment in 3 of 9 knees and reoperation with insertion of a prosthesis in this compartment was carried out. In another two considerable pain was experienced at weight-bearing. Unicompartment operation did not seem to be justified in RA even if one compartment at surgery was found well preserved.

VIII. SUMMARY

Functional results

On Weinfeld's evaluation there was a significantly higher preoperative score and at follow-up the highest improvement in points in constrained arthroplasty, (Guépar), but the percentage of improvement was equal in both the constrained and unconstrained (Marmor) total arthroplasty. The lowest point score at follow-up, which implies the best result according to Weinfeld's evaluation system, was found in the Marmor material. The lowest preoperative and the highest follow-up score was found in the McIntosh material which implies that the result in hemiarthroplasty is inferior to total arthroplasty. Following arthroplasty the minimum expectation was that the knees postoperatively and at least for some years thereafter should be relatively painless, stabile and free of deformity. These demands were fulfilled after constrained arthroplasty in 64 % of the knees, after unconstrained total arthroplasty in 44 %, and after hemiarthroplasty in 27 % of the knees. The constrained principle which secures correct alignment of femur and tibia and lateral stability and elimination of extension defect gave better results than the unconstrained arthroplasty although 25 % of the knees at follow-up still had considerable pain.

Technical difficulties and operative complications

The lowest incidence of technical difficulties or operative complications was seen in hemiarthroplasty (McIntosh) in 25 knees (37 %). The dominant problems were detachment of the anterior cruciate ligament, presence of subchondral cysts and attrition of condyles, which made the prosthetic principle insufficient for reconstruction.

The most severe pathological changes were found in the Guépar material. In 32 (50 %) of the constrained arthroplasties, technical difficulties or complications were noted. "Not satisfactory" results were found after perforation of the diaphysis, although continuity of the bone was present allowing full weight-bearing. After correction of extreme extension defects, remaining extension lag was found in two knees. Considerable FP-joint problems were noted; operative dislocation of the patella was common and regarded as generally caused by forced outward rotation of the tibia and the shape of the patella facet on the prosthesis.

The highest incidence of technical difficulties and operative complications were found in unconstrained total arthroplasty (Marmor) in 58 knees (53 %). Damage to the insertion of the anterior cruciate ligament, difficulties in cementation of the tibial components, incongruency between femoral and tibial components and passive extension defects were

caused by a too optimistic use of the method in knees where the pathological changes were too advanced and partly caused by the lack of jigs for resection and for retaining the tibial components during cementation. In the FP-joint, the prosthesis had a harmful effect. Prominence of the anterior edge of the femoral component caused patella impingement; patellectomy was therefore indicated in 12 knees.

Postoperative complications

The lowest incidence of complications was found after hemiarthroplasty (McIntosh). The wound in only four knees failed to heal within four weeks.

After constrained arthroplasty (Guépar), there were no general complications of a serious nature. In two knees, the patella dislocated postoperatively, although operative capsular plication was done. The biggest problem was complicated wound healing in 20 % of the knees. Patellar dislocation and transfer of the tibial tuberosity operatively predisposed to delayed wound healing. Complicated wound healing resulted in an increase of hospital stay and late infection developed in four of the knees.

After unconstrained total arthroplasty (Marmor), there was the same incidence of complications as after Guépar arthroplasty (32 %). Impingement of the patella on the femoral prosthesis caused by its design and position, was noted in five knees. In two knees, prosthetic components were loose in the postoperative period. In 10 % of the knees, the wound failed to heal within four weeks; patellectomy predisposed to complicated wound healing.

Late complications

Following hemiarthroplasty (McIntosh), the important complications were dislocation of the prosthesis and collapse of the non-resurfaced condyles.

After constrained arthroplasty (Guépar), the dominating problems were late infections in 15 knees (23 %) with serious consequences such as death, amputation and change of prosthesis. Dislocation of the patella occurred during the observation period in five knees.

After unconstrained total arthroplasty (Marmor), loosening of the prosthetic components was found in seven knees and in three knees, primary demiarthroplasties were reoperated with a prosthesis in the other compartment because of collapse of this non-operated compartment.

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