ACTA ORTHOPAEDICA SCANDINAVICA
SUPPLEMENTUM NO. 193

From the Department of Orthopaedic Surgery, University of Lund, Sweden

Compartmental Arthroplasty for Gonarthrosis

BY

GUNNAR THÓR JÓNSSON

MUNKSGAARD . COPENHAGEN

ISBN 87-16-09021-7
ISSN 0300-8827
Printed in Sweden
Rahms i Lund, 1981

CONTENTS

TABLES

FIGURES

I. INTRODUCTION

The unicompartmental resurfacing prostheses for knee arthroplasty have now been in use for a decade since they were introduced by Gunston (1971). More than half of 1700 arthroplasties performed for gonarthrosis in Sweden during 1976-1979 were unicompartmental (Bauer et al. 1980). Reports regarding the results are controversial. Marmor (1973, 1977 and 1979), Engelbrecht (1976) and Larsson & Ahlgren (1979) have reported good results in large series with follow-up for 3-5 years as have others in smaller series (Skolnick et al. 1975, Dolibois & Mallory 1976 and 1978, Andrews & Regan 1979). On the other hand, Insall & Walker (1976), Insall & Aglietti (1980) and Laskin (1978) reported poor results and concluded that there is no place for the use of unicompartmental arthroplasty in the treatment of gonarthrosis.

At the Department of Orthopaedic Surgery, University Hospital in Lund, Sweden, the resurfacing prosthesis of the unicompartmental type was introduced in October 1974. A prospective investigation of the knees operated for gonarthrosis with this technique was then started. This is a report on the first 102 consecutive cases, followed for at least 2 years and on average 3 1/2 years. A subgroup of moderately severe medial arthrosis (Stage III) was followed for 4 1/2 years on average. Patients with rheumatoid arthritis were excluded from this investigation but have been reviewed by Andersen (1979).

The purpose of this investigation was:

(1) to analyse the effect of arthroplasty with the compartmental endoprosthesis in gonarthrosis;

(2) to develop pre- and postoperative routines and to standardize operative techniques for this method;

(3) to define the range of indications for the use of the compartmental endoprosthesis in the treatment of gonarthrosis.

Coded data. All observations presented and discussed here are shown in code form in Chapter X.

DEFINITIONS USED IN THIS WORK

Planes

The frontal plane is vertical and goes through or parallel to the tangent of the dorsal aspects of the two femoral condyles.
The sagittal plane is vertical and perpendicular to the frontal plane.
The transverse plane forms a right angle with both the frontal and the sagittal planes.

Axes

The femoral mechanical axis lies in the frontal plane and connects the centers of the femoral head and the femoral intercondylar groove.
The tibial mechanical axis lies in the frontal plane and connects the centers of the tibial eminence and the ankle joint.
The mechanical axis of the lower limb lies in the frontal plane and connects the centers of the femoral head and the ankle joint; normally this axis transects the center of the tibial eminence (Maquet 1976).

Angles

The PT-angle is the angle between the longitudinal axis of the diaphysis of the tibia in the frontal plane and the tangent of the articular surface of the tibial prosthesis in the frontal plane, the medial angle for medial prosthesis and the lateral angle for lateral prosthesis.
The PTS-angle is the posterior angle between the longitudinal axis of the diaphysis of the tibia in the sagittal plane and the tangent of the articular surface of the tibial prosthesis in the sagittal plane.
The angular deviation of the mechanical axis is the angle between the femoral and tibial mechanical axes in varus or valgus when the mechanical axis of the lower limb falls medial or lateral to the center of the tibial eminence.

II. PATIENT MATERIAL

During the period October 1974 through June 1977, 108 primary arthroplasties for gonarthrosis were performed with unicompartmental prostheses in 99 patients at the Department of Orthopaedic Surgery, University Hospital in Lund. 102 knees in 93 patients were included in the study (Table 1); 6 knees in 6 patients were unavailable for follow-up because of death or other reasons. All prostheses used were of the unconstrained unicompartmental type; the Richard's Modular (Marmor) Knee was used in 99 knees and the French Lotus Knee in 3 knees.

Table 1. Patient material

	Patients	Arthroplasties
Base material	99	108
Dead within 2 years	4	4
Unsuitable for follow-up because of hemiparesis	1	1
Not available for follow-up	1	1
	93	102
Follow-up material		
Women	71	76
Men	22	26
Type of arthroplasty		
Medial		78
Lateral		14
Medial + Lateral		10

The oldest patient was 88 years and the youngest 52 years with an average age of 71 years. There were 71 women and 22 men.

Follow-up time was defined as the period of time from the knee arthroplasty to the last examination (1979) or to the time of reoperation in 13 failed knees. The shortest follow-up time for knees not reoperated was 27 months, the longest 59 months with an average follow-up time for all knees of nearly 3 1/2 years. A subgroup of 31 medial arthroplasties was followed for 4 1/2 years (44-68 months).

GENERAL CONDITION (Figure 1)

At the time of operation most of the patients were in fairly good mental and physical condition for their age, even though the majority were on medication for cardiovascular disease. Three patients had neurologic disease, two diabetes, two renal disease, two severe spondyloarthritis of tuberculous origin, and one lung disease. One patient had poor vision because of glaucoma and one was blind. Two had both diabetes and heart disease and three diverse diseases (pernicious anaemia, insulinoma).

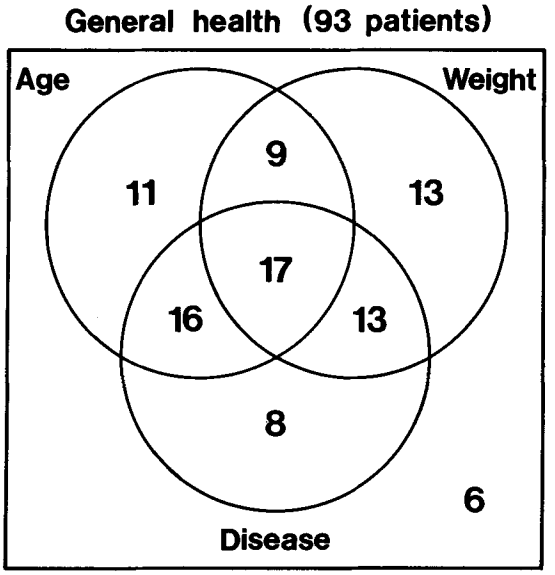


Figure 1. General health at time of operation
Correlation of age over 70 years, weight over 70 kg (women) or 80 kg (men), and significant general disease.

Obesity was common, especially among the women. The body weight/length ratio was 76/160 in women and 81/172 in men, with 44 women weighing more than 70 kg and 13 men weighing more than 80 kg. The Broca's index (weight in kg divided by cm exceeding 1 meter of length, Drenick 1979) was 1.27 for women and 1.12 for men. Only 12 patients had a Broca's index <1.00.

TYPE OF ARTHROSIS

All the 102 knees had femoro-tibial arthrosis, primary in 94 and secondary in 8 (Table 2). In addition, two thirds or 68 had roentgenographic signs of patellar arthrosis (Figure 2). The radiographic type and stage of arthrosis was determined as described on p. 14.

Table 2. Type of gonarthrosis

Primary arthrosis	94	
with chondrocalcinosis		21
without chondrocalcinosis		73
Secondary arthrosis	8	
osteonecrosis		6
fracture of tibial condyle		2
Total	102	

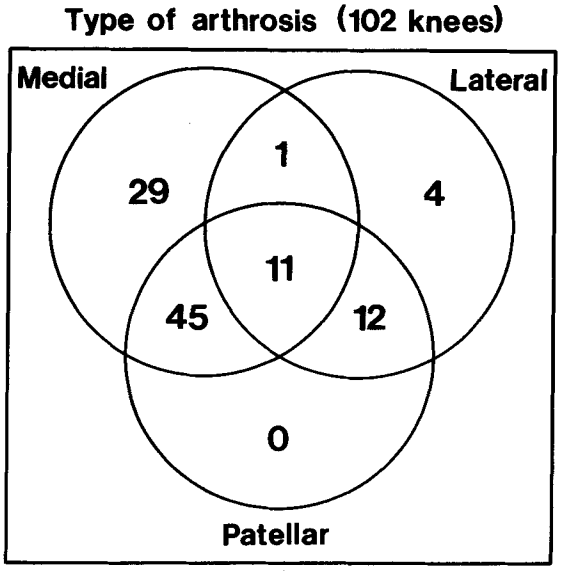


Figure 2. Type of arthrosis

Type of arthrosis was determined roentgenographically according to Ahlbäck (1968), see p. 14.

PREVIOUS KNEE OPERATIONS

Twenty-four patients had undergone prior surgery of the affected knee. Eighteen had had tibial osteotomy for arthrosis, and four minor surgery as meniscectomy or removal of loose bodies with four having had both tibial osteotomy and minor operations. Two knees had been operated for a fractured tibial condyle.

Total hip arthroplasty for arthrosis had been performed previously in 10 cases; five on the ipsilateral side, three on the contralateral side and two bilaterally.

III. METHODS

CLINICAL EXAMINATION

All patients were interviewed and examined according to predetermined criteria preoperatively and postoperatively at 6 months, one year and then annually. The patients were instructed to contact the investigator if signs of complications should occur between the predetermined follow-up dates.

Pain. The major symptom in most knees was pain, and this was the main indication for surgery in all cases. The pain was usually of long duration in primary cases; 77 had had pain for more than 5 years and only 10 for less than 2 years; most cases with pain of short duration were secondary to osteonecrosis.

Three categories of pain were identified. Pain on walking was recorded as the patient's opinion on walking distance to significant pain (Table 10). Pain at rest was recorded as occurring only after physical activities, or mainly spontaneous (Table 11). In addition, an attempt was made to assess postoperative patellar pain, defined as retropatellar pain clearly distinguished by the patient from the preoperative pain on walking at the affected femoro-tibial compartment. This pain was considered patellar in origin when caused by patellar loading activities like stair climbing, rising from a deep chair, kneeling, etc; it was assessed according to how often it was felt (Figure 15).

The requirement of analgesics was recorded (Table 17, p. 53).

Range of motion and stability. The patients were examined in the supine position. The range of motion and stability were measured with an international standard goniometer (Zimmer catalogue No. 337). Medio-lateral stability examined in maximal extension was recorded as stable (0-4^{o}) or unstable (5^{o} or more)(Figure 16). Medial or lateral thrust on walking was noted as was sagittal stability.

Deformity of varus or valgus type was measured with goniometer, the patient standing on both legs (Figure 21).

Walking ability. The maximal walking distance regardless of pain was recorded (Figure 19). Use of walking aid(s) and ability to rise from a chair were recorded separately (Appendix 3). Limitation of walking ability by pain in the other knee, a hip or by other factors was also recorded.

Stair climbing ability was recorded (Table 18, p. 55).

Activities of daily living. Functional assessment of every day activities was recorded in five categories from (1) unable to perform basic activities of daily living (walks only assisted, needs help for self-care), (2) able to perform only basic activities of daily living, (3) able to do light domestic work, (4) able to do all domestic work, including housecleaning through (5) fully independent, including shopping (Table 16).

Subjective assessment. The patients were asked about their own opinion on pain at rest, pain on walking and walking ability after the operation (Table 15, p. 51).

ROENTGENOGRAPHIC EXAMINATION

The diagnosis of gonarthrosis was based on the roentgenographic appearance using the criteria of Ahlbäck (1968). Three types of femoro-tibial arthrosis were identified: medial, lateral and medial + lateral (Figure 2). The knees with medial or lateral arthrosis were further classified in Ahlbäck's 5 stages from joint space narrowing to gross bone attrition, and femoro-tibial subluxation was recorded (Table 19). Radiographic signs of patellar arthrosis were identified for each facet. Calcification of soft parts were recorded.

The preoperative examination was performed standing while bearing weight on both legs. Antero-posterior exposures were taken with varus and valgus stress for evaluation of the femoro-tibial articulations (Norman 1974). The patellar joint was examined with axial projection in standing (Ahlbäck 1968).

At the postoperative examination, performed in the same way as the preoperative one, the position of the tibial component and radiolucent zones were recorded as were signs of loosening, i.e. buckling of the tibial component, breakage of the indication wire, and settling (Tables 24 and 25)(Boegård et al. 1981).

At the follow-up the mechanical axis of the lower limb was determined roentgenographically. A whole leg examination including the hip, knee and ankle joints was done with the patient standing only on the examined leg, using a focus distance of 2 meters. This frontal exposure was taken at a 90^{0} angle from a side exposure defined by a tangential appearance of the posterior aspects of both femoral condyles observed by fluoroscopy (Egund & Norman 1979). From the whole leg examination the mechanical (weight bearing) axis (Maquet 1976) was determined as was the angular deviation of the mechanical axis (see Definitions) or the actual deformity of the leg (Table 23).

OPERATION

The operation was done through a single medial parapatellar incision, even in lateral unicompartmental and in medial + lateral arthroplasties.

Most knees in this series were operated with the technique described by Marmor (1973) for his Modular Knee. Thus no positioning instruments were used and the resection of the proximal tibia was done with a power instrument leaving the cortical rim of the bone intact and the tibial component resting on cancellous bone. Usually neither the joint capsule nor the collateral ligament were released.

This method was found to be inadequate in many ways. The narrow exposure of the bony surfaces made positioning of the tibial component difficult, the correction of deformity was often insufficient as the contracted structures were not released, and the positioning of the prosthetic components was often unsatis-

factory.

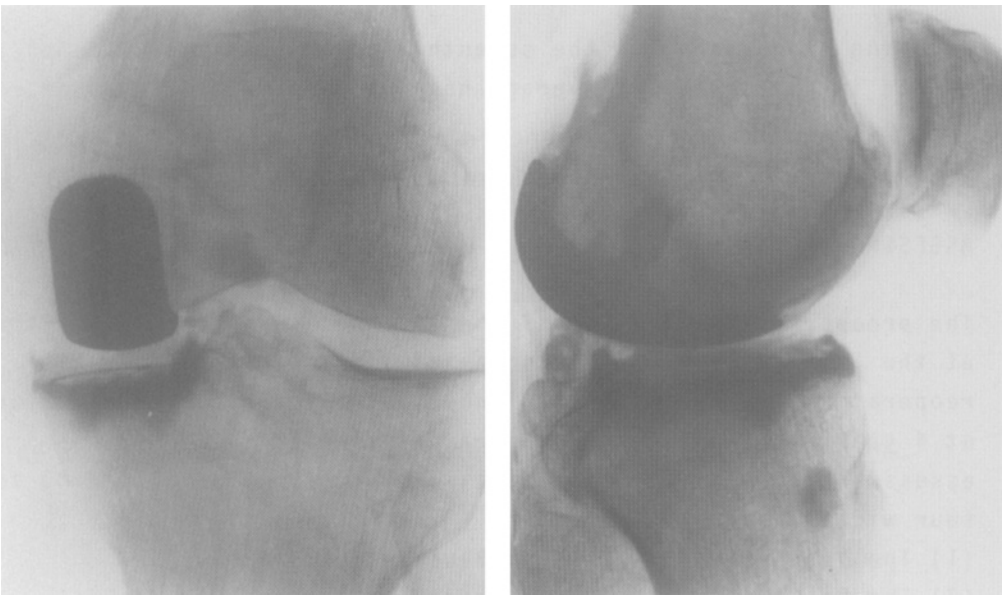
This led to a change in operative technique during the last year of this investigation. The last 10 cases in this series were operated with a positioning jig (from the French Lotus prosthesis) by doing an L-shaped (horizontal) resection of the proximal tibia and using a tibial component of larger diameter resting on the cortical bone of the tibia as much as possible. Release on the medial side of the contracted capsule and the deep portion of the collateral ligament from the tibia made correction of deformity easier (Jönsson & Lindstrand 1980).

The operation was done under epidural (58 cases) or neuroleptic (44 cases) anaesthesia. A tourniquet was always used; it was released and hemostasis completed before the capsule was sutured. Suction drainage was maintained for 24-36 hours.

Thorough inspection of the joint was routinely done and the state of the articular cartilage in each compartment was recorded. Calcification of soft parts of the joint was recorded and, usually, a specimen was examined for pyrophosphate crystals with polarized light microscopy. The degree of synovitis was recorded as none, mild, moderate or severe.

Prophylactic antibiotic therapy with Cloxacillin 1 gram four times daily was used in all but three cases; the initial dose was given one hour before the operation and the therapy continued for 2 weeks. Prophylactic anti-thrombotic therapy was administered using 6 per cent Dextran 70 (Macrodex); 500 ml were infused during the operation and 500 ml on the following day. 98 arthroplasties were done in a conventional operating room and 4 with vertical laminar air flow.

The average operation time was 90 minutes (60-135 minutes) including the time for laying the postoperative bandage, elastic or plaster. Bleeding in the suction drainage was 360 ml on average (100-900 ml). Six different surgeons performed the operations in this series.



A B

Figure 3. A medial unicompartmental arthroplasty for Stage III arthrosis with Marmor's (1973) technique. Good alignment of both components.

POSTOPERATIVE MANAGEMENT

At the end of the operation the leg was wrapped in a compressive dressing from the toes to the groin. In the last 22 cases a longitudinally split plaster cylinder was used, with the knee in maximal extension to prevent flexion contracture. This plaster was bivalved on the following day and the dorsal shell used, at night only, for one week.

The patients were allowed to sit in bed or in a chair on the first postoperative day and quadriceps exercises were begun. Full weight bearing with a walking aid was encouraged on the second day as were cautious flexion exercises. The patients were trained twice a day by the physiotherapist and began stair

climbing exercises from the seventh day. Manipulation was not needed in any case. The average hospital stay was 12 days, after the operation.

ASSESSMENT SYSTEMS

The preoperative condition of the 102 knees was compared to that at the last examination. This was at 1 year for 7 knees, all reoperated, at 2 years for 30 knees, at 3 years for 41 knees and at 4 years for 24 knees. The parameters recorded permitted assessment of pre- and postoperative knee function according to four widely used systems:

(1) The Venn Diagram System of Bauer et al. (1969);

(2) The Hospital for Special Surgery (HSS) Knee Rating Scale (Ranawat et al. 1976)(Appendix 1);

(3) The London Hospital (LH) Points Scoring System for an Overall Assessment of Knee Function (Freeman et al. 1977) (Appendix 2);

(4) The Assessment Chart of the British Orthopaedic Association (Aichroth et al. 1978)(Appendix 3).

The Venn Diagram System (Figure 14) was used in the classification of results with failure defined as those knees that had not become painfree, acceptable those that were painfree but not mobile and/or stable, and satisfactory those that had reached the conjoined set of mobility, stability and freedom from pain. Failed knees and acceptable knees were thus subsets of non-satisfactory knees.

A comparison of the three different assessment systems formed part of this project and is reported in the Results below. The results according to the Assessment Chart of the British Orthopaedic Association are listed in Appendix 3.

The social function of the patients was assessed by evaluation of three parameters, viz. independence, requirement of analgesics, and maximal walking distance (Figure 18).

STATISTICS

The Student's t-test and the Chi-square test with Yate's correction were used. The following levels of significance were used:

*** = $p < 0.001$ (highly significant)
** = $0.001 < p < 0.01$ (significant)
* = $0.01 < p < 0.05$ (almost significant)
NS = $p > 0.05$ (not significant)

The statistical analysis was done by Karl-Göran Thorngren.

IV. RESULTS

EARLY COMPLICATIONS

In the 108 arthroplasties there were no deaths associated with the operation. Two patients had cerebral vascular episodes, probably due to hypertensive crises during the anaesthesia; one resulted in hemiparesis and one in blindness, and these patients were excluded from the follow-up. Four patients had transient cardiac arrythmia with heart incompensation, and one had pulmonary atelectasis.

Thromboembolism was diagnosed in 4 patients and adequately treated in all.

Four knees had signs of superficial wound infection with skin necrosis in two of these. Culture from the wounds revealed Staphylococcus Albus and Alcaligenes bacteria in one knee while three cultures were sterile. The drainage from these knees ceased spontaneously under antibiotic treatment and did not recur.

Peroneal nerve palsy occurred in three cases: two palsies were transient. The third knee with bicompartmental femoro-tibial arthrosis and valgus deformity had medial + lateral arthroplasty; the peroneal palsy has partially recovered but has decreased the walking capacity to some extent.

The hospital stay for cases with early complications was 17 days compared to 11 days for those without early complications.

Two patients were readmitted to the hospital within one month of the operation because they had high ESR and the operated knee was painful, warm and swollen, and on aspiration the joint fluid was turbid. Both patients had a history of pyrophosphate arthritis with intraarticular soft tissue calcifications observed at operation. In both cases pyrophosphate crystals were found in the synovial fluid and treatment with Indomethacin was successful.

LATE COMPLICATIONS AND FAILURES

There were 15 failures in this series (15 per cent). The cause of failure was established in 14 cases, 13 of which were reoperated (Table 3). Fourteen knees, while still symptomfree, had roentgenographic evidence of late complications that may lead to failure.

The late complications fell into 6 main categories (Table 6): (1) loosening of the tibial component, (2) abnormal contact between the femoral component and bone, (3) degeneration of the opposite compartment of the knee, (4) deep infection, (5) patellar arthrosis, and (6) other complications.

Loosening. Obvious loosening of the tibial component with pain on walking occurred in four knees, all operated with unicompartmental arthroplasty for medial arthrosis. The symptoms started 3-6 months after the operation in two cases, at 1-2 years in one case and at 2-3 years in one. In three knees (Cases 002, 003 and 012, Table 3) there was significant, almost constant pain on walking and these knees were reoperated with extraction of the loose component and exchange to a thicker one.

Case 002 (Figure 4, Table 3), operated with a 6 mm tibial component for a Stage I medial arthrosis secondary to osteonecrosis, was symptomfree during the first year. During the second year increasing pain developed caused by loosening and settling of the tibial component with breakage of the indication wire and the cement. The knee was reoperated after 3 years with revision and exchange of the loose tibial component to a 12 mm component. The result after reoperation was satisfactory (HSS 89).

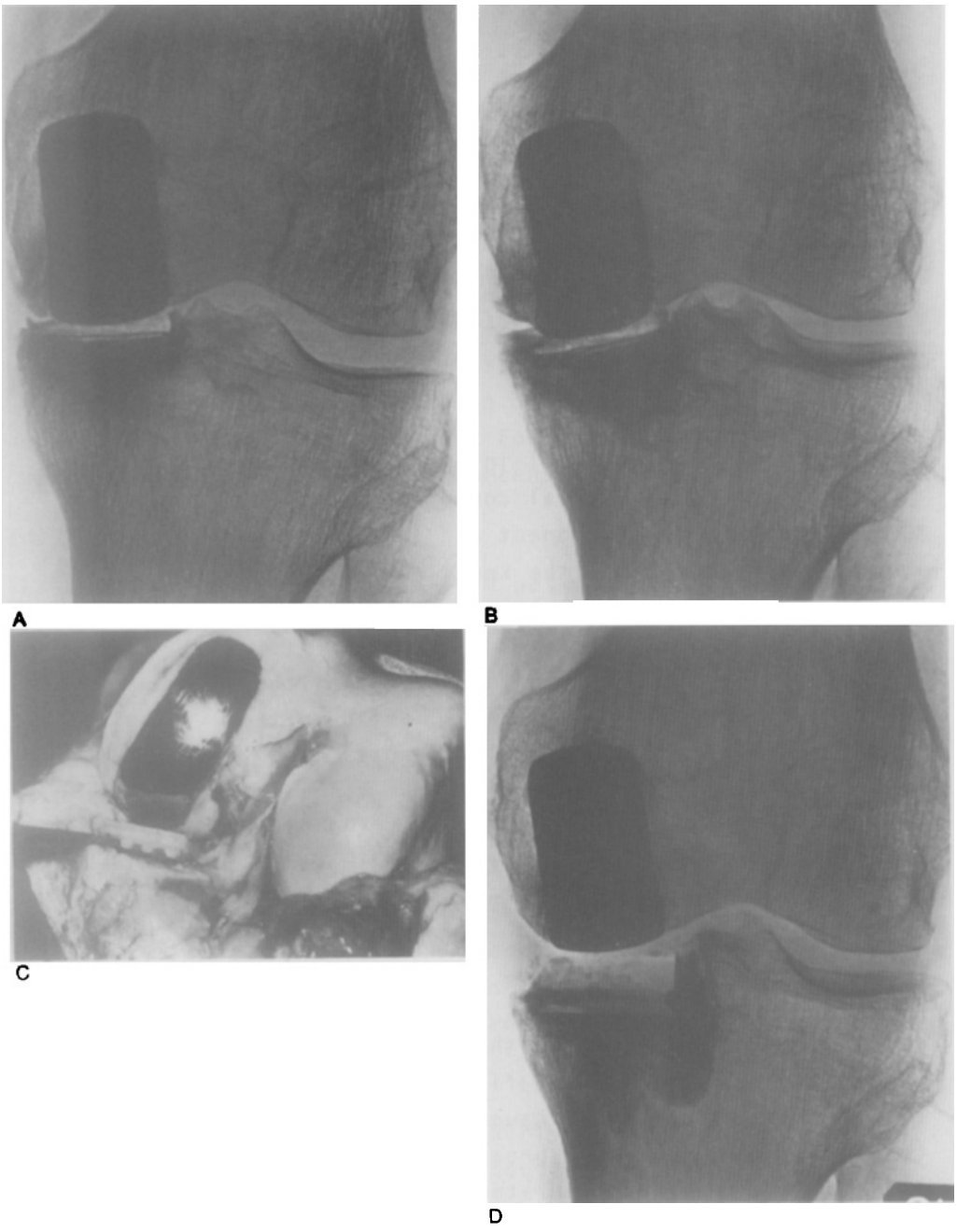


Figure 4. Case 002. 80-year old male with Stage I arthrosis secondary to osteonecrosis

A. One year after a medial arthroplasty with a 6 mm tibial component. Buckling of the indication wire. Symptoms started during the second year.

B. 3 years after arthroplasty. Increased buckling and settling of the tibial component.

C. At revision 3 years after arthroplasty the tibial component was easily lifted out and exchanged to a 12 mm component. The femoral component was intact. Normal cartilage in the lateral compartment.

D. 1 year after revision.

Table 3. Failed knees

	Case	Type of complication	Confirmed or supposed cause of complication	Time between op. - compl.	Stage of arthrosis	HSS-score	Venn Diag. ass.	Treatment	End-result HSS-score	Venn Diag. ass.
Medial arthroplasty	002	Loosening	Thin tibial prosthesis (6 mm)	1-2 y	I (Osteonecrosis)	69	F	Revision	89	S
	003	Loosening	Malposition (9 mm prosthesis)	3-6 m	I (Osteonecrosis)	69	F	Revision	99	S
	012	Loosening	Thin tibial prosthesis (6 mm)	3-6 m	II (Osteonecrosis)	54	F	Revision	72	A
	050	Abnormal contact	Malposition of prosthesis	6-12 m	V with > 5 mm subluxation	54	F	Revision	80	S
	032	Lat. arthrosis	Lat. arthrosis at op.	1-3 m	IV with > 10 mm subluxation	52	F	Converted to hinge arthroplasty	77	S
	098	Lat. arthrosis Rec. synovitis	Loose cement Instability	1-2 y	III with < 5 mm subluxation	69	F	Converted to Total Condylar Arthroplasty	87	S
	112	Lat. arthrosis	Loose cement Instability + Subluxation	1-3 m	IV with 5-10 mm subluxation	62	F	Converted to Total Condylar Arthroplasty	90	S
	081	Lat. arthrosis Rec. synovitis	Instability + Subluxation	2-3 y	IV with 5-10 mm subluxation	52	F	Converted to Total Condylar Arthroplasty	86	S
	036	Patellar arthrosis	---	3-6 m	II	65	F	Patellar arthroplasty	72	S
	055	Rec. synovitis Instability	Pyrophosphate arthritis Instability + Subluxation	1-3 m	V with > 10 mm subluxation	60	F	None (patient died)	60	F
	040	Not known	Pyrophosphate arthritis? Instability + Subluxation	2-3 y	IV with 5-10 mm subluxation	46	F	None (patient died)	46	F
Lateral arthroplasty	027	Med. arthrosis Dislocation Loosening	Instability + Subluxation	2-3 y	IV with > 10 mm subluxation	35	F	Converted to Total Condylar Arthroplasty	66	A
Medial and lateral arthroplasty	073	Abnormal contact Patellar pain	Malposition of prostheses and subluxation	3-6 m	I medially and laterally	63	F	Revision	67	F
	076	Abnormal contact	Malposition of prostheses and subluxation	1-3 m	I medially	48	F	Converted to Total Condylar Arthroplasty	82	S
	017	Infection	Propionibact. acnes 5/8	1-3 m	IV medially I laterally with > 10 mm subluxation	48	F	Converted to hinge arthroplasty	48	F*

S = Satisfactory, A = Acceptable (Non-satisfactory but painfree), F = Failure

* Knee eventually went to arthrodesis

Case 006 operated for a Stage III medial arthrosis with a 6 mm tibial component developed clear radiographic signs of loosening with pain 2 years after the operation. The symptoms persisted for a period of 3-4 months but thereafter subsided completely. A planned reoperation was postponed, and the case was rated satisfactory (HSS 87) at the last examination 54 months after the operation (Figure 5).

A B

Figure 5. Case 006. 75-year old female with a Stage III medial primary arthrosis operated with a 6 mm tibial component. Roentgenograms four years after the arthroplasty.

A. Breakage of the indication wire and forward displacement of the tibial component.

B. Buckling of the tibial component and breakage of the cement.

Three of the 4 clearly loose tibial components were 6 mm and one 9 mm thick. The three reoperated knees all had the preoperative diagnosis of osteonecrosis while the fourth knee had primary arthrosis. The end-result after reoperation was satisfactory in two knees and acceptable in one.

In Cases 027 and 032 (Table 3) loosening of a tibial component was observed in combination with other complications. In these knees loosening was considered to be secondary to instability of the knee but not the primary cause of complication.

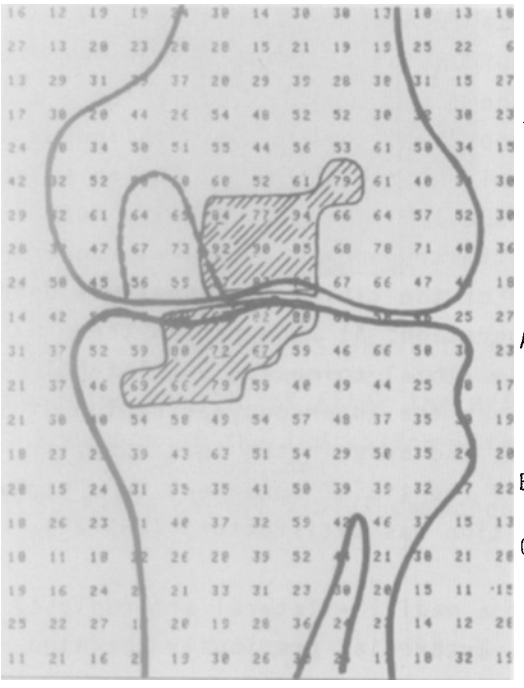
Abnormal contact between prosthesis and bone. Three knees developed subluxation which in combination with malposition of the endoprostheses resulted in abnormal contact of a femoral component against the tibial intercondylar spine. In all cases pain developed within 1 year of the operation. This complication was difficult to diagnose with certainty by radiography in two cases but radionuclide scintimetry was of diagnostic value in both.

The first knee (Case 050), previously operated with tibial osteotomy, had a medial arthroplasty for Stage IV arthrosis. Postoperatively the knee rated unstable, had a varus deformity of 5-10^{0}, and 10^{0} medial sloping of tibial prosthesis. However, the result was acceptable during the first 6 months but after a minor accident increasing pain developed. At the one year follow-up an abnormal contact between a prominent tibial intercondylar spine and the femoral condyle was suspected radiographically, definitely diagnosed by Sr-85 scintimetry and confirmed at reoperation (Figure 6) when exchange of the tibial component was done 16 months after the primary operation. At reoperation there was an abnormal contact between the tibial spine and the lateral part of the femoral component and even the intercondylar region of the femur. Resection of osteophytes and bone in the intercondylar region was done and exchange of the tibial component to a higher one. The result of the reoperation was satisfactory (HSS 80).

The second knee (Case 073) had a medial + lateral arthroplasty for Stage I medial and lateral arthrosis, previously operated with tibial osteotomy. Pain developed after 3 months, there was

A

B



C

Figure 6. Case 050. 66-year old female with a Stage V medial arthrosis previously operated with tibial osteotomy.

The result was good during the first months but the patient then had increasing pain after a minor accident.

A. One year after the arthroplasty. There seems to be no space between the tibial intercondylar spine and the intercondylar region of the femur.

B. There is a very prominent tibial intercondylar spine.

C. Sr-85 bone imaging with rectilinear scanning revealed the highest uptake in the intercondylar region of the femur and in the intercondylar spine of the tibia where there is normally the lowest uptake.

roentgenographic evidence of abnormal contact between the lateral femoral component and the tibial intercondylar spine, and the knee was revised with exchange of the lateral femoral component. This knee rated as failure even after the reoperation because of sagittal instability caused by insufficient anterior cruciate ligament and patellar pain from a medial patellar facet arthrosis (Table 3).

The third knee (Case 076) had a medial + lateral arthroplasty for Stage I medial arthrosis with cartilage changes laterally, observed at the operation; instability resulted in dislocation and severe impingement between the lateral femoral component and the tibial intercondylar spine within 3 months (Figure 7). The knee

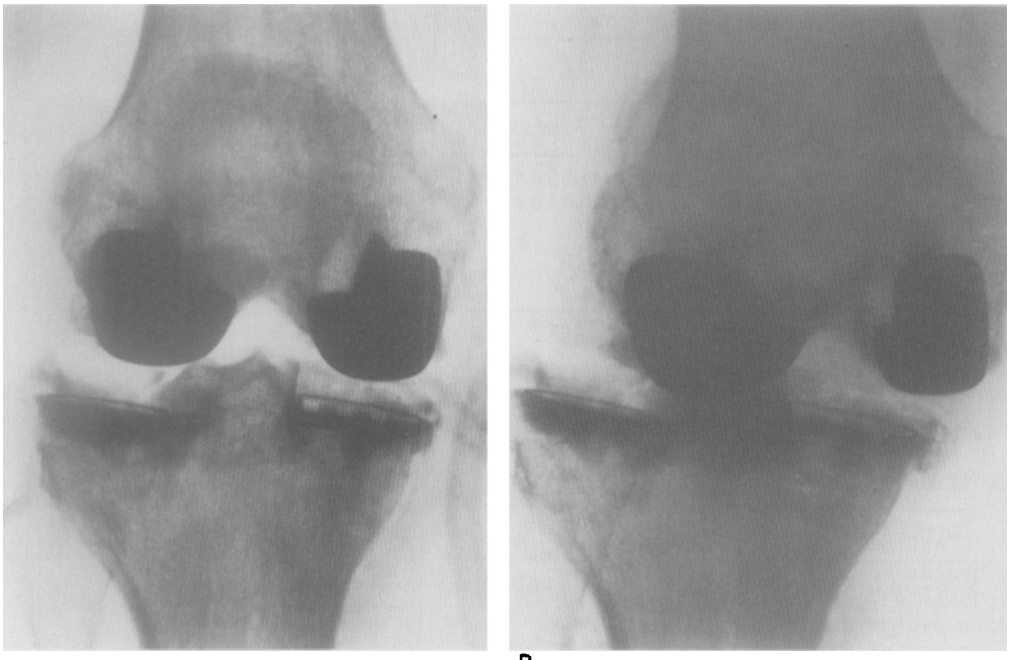


Figure 7. Case 076. 73-year old female operated with medial + lateral arthroplasty

A. Non-weight bearing examination the day after the operation. There is 11° medial sloping of the medial tibial component and 16° medial sloping of the lateral tibial component. Stability was not obtained.

B. Weight bearing examination with valgus stress 14 months postoperatively. There is gross subluxation of the tibia and evidence of abnormal contact between the lateral femoral component and the tibial spine confirmed at Total Condylar arthroplasty 19 months after the primary operation.

rated as failure and was converted to Total Condylar arthroplasty after 19 months with satisfactory result (HSS 82).

Degeneration of the opposite compartment. Seventeen of 78 knees operated with medial unicompartmental arthroplasty had roentgenographic evidence of cartilage degeneration in the lateral compartment at the follow-up (Table 4). Five of these had early arthrotic changes in the lateral compartment already preoperatively but 12 of the 78 knees had developed secondary degeneration in the lateral compartment. These secondary changes were, however, minimal or Stage I in 8 knees, Stage II in one knee, and Stage III in 3 knees.

Table 4. Degeneration of the lateral compartment after medial arthroplasty

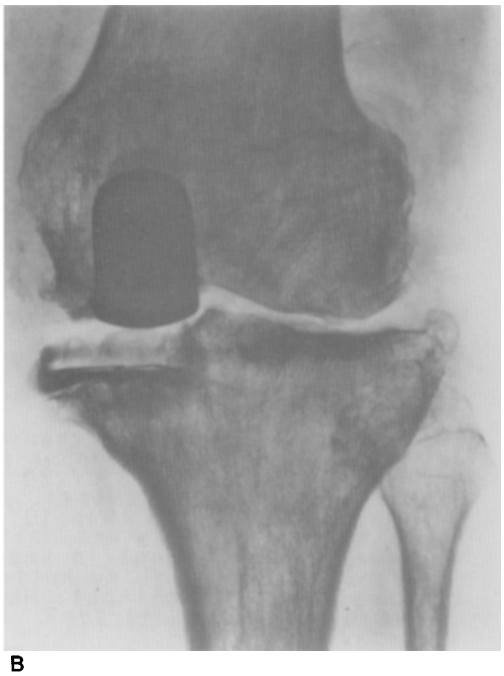
Preop.stage of arthrosis in medial compartment	No. of knees with degen. changes in lateral compartment at last examination	Assessment		Knees with early lateral arthrosis before op.	Ratio of knees develop. secondary lateral arthrosis	Reoperated knees
		HSS	Venn			
III	1	69	1 F	0	1/32	1
IV	10	82	4 S 3 A 3 F	2	8/21	3
V	6	81	3 S 3 A	3	3/15	0
Total	17			5		4

S = Satisfactory, A = Acceptable, F = Failure

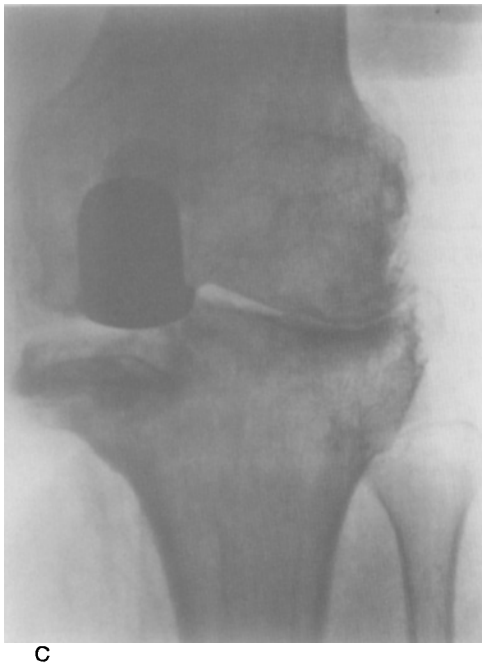
Development of secondary lateral arthrosis occurred almost exclusively in the advanced stages of arthrosis, or in 11 of 36 Stage IV and V knees, compared to one of 32 Stage III knees ($p < 0.01$) and none of the 10 knees in the mildest stages.

The cause of secondary lateral arthrosis was found to be secondary to loose polymethacrylate cement in two knees (Case 098 Stage III and Case 112 Stage IV). Among other factors analysed secondary lateral arthrosis was found to be significantly re-

A



B



C

Figure 8. Case 033 illustrates a knee with secondary lateral arthrosis already preoperatively.

A. Stage IV medial arthrosis with a typical lateral subluxation of the tibia at weight bearing examination. There is roentgenographic evidence of secondary lateral arthrosis with attrition of the tibial spine and subchondral sclerosis of the tibia. Even though there were pathological changes of the cartilage in the lateral compartment arthroplasty was only performed medially.

B. Non-weight bearing examination 3 months after the operation showed a narrowed joint space in the lateral compartment (standing exposure with valgus stress, technically not suitable for publication, showed Stage II lateral arthrosis).

C. Weight bearing examination with valgus stress 43 months after the operation showed progress of the lateral arthrosis to Stage III. In spite of this the knee permitted a walking distance of more than 500 m, rated acceptable (HSS 80), and the subjective assessment was favourable.

lated to the postoperative alignment of the knee, i.e. under- and overcorrection, and to femoro-tibial subluxation. Thus lateral arthrosis developed in 7 of 18 knees having either $>5^{0}$ of varus or valgus postoperatively, compared to 5 of 60 knees corrected to at most 5^{0} of varus or valgus ($p < 0.01$)(Figure 21). Furthermore, all 11 Stage IV and V knees developing secondary lateral arthrosis had more than 0.5 cm femoro-tibial subluxation preoperatively, compared to 7 of 20 knees that did not develop secondary arthrosis ($p < 0.01$). Likewise postoperative femoro-tibial subluxation more than 0.5 cm was recorded in 7 of the 11 knees compared to 3 of 20 knees ($p < 0.05$)(Table 5). Finally, instability and more than 10^{0} medial sloping of the tibial component was more frequent in knees with secondary lateral arthrosis, compared to knees without. However, this difference was not significant.

Table 5. Possible causes of secondary lateral arthrosis in 11 knees with Stage IV and V arthrosis

	Tibial subluxation >0.5 cm		Unstable	Medial sloping of tibial component
	Preop.	Postop.	Postop.	$>10^{0}$
Loose cement	1[X]	0	0	1
Overcorrection $>5^{0}$ valgus	2	1	0	0
Undercorrection $>5^{0}$ varus	4	3	3	3
Uncertain	4	3	2	3
Stage IV and V knees with secondary lateral arthrosis n = 11	11/11	7/11	5/11	7/11
Stage IV and V knees without secondary lateral arthrosis n = 20	7/20	3/20	6/20	6/20

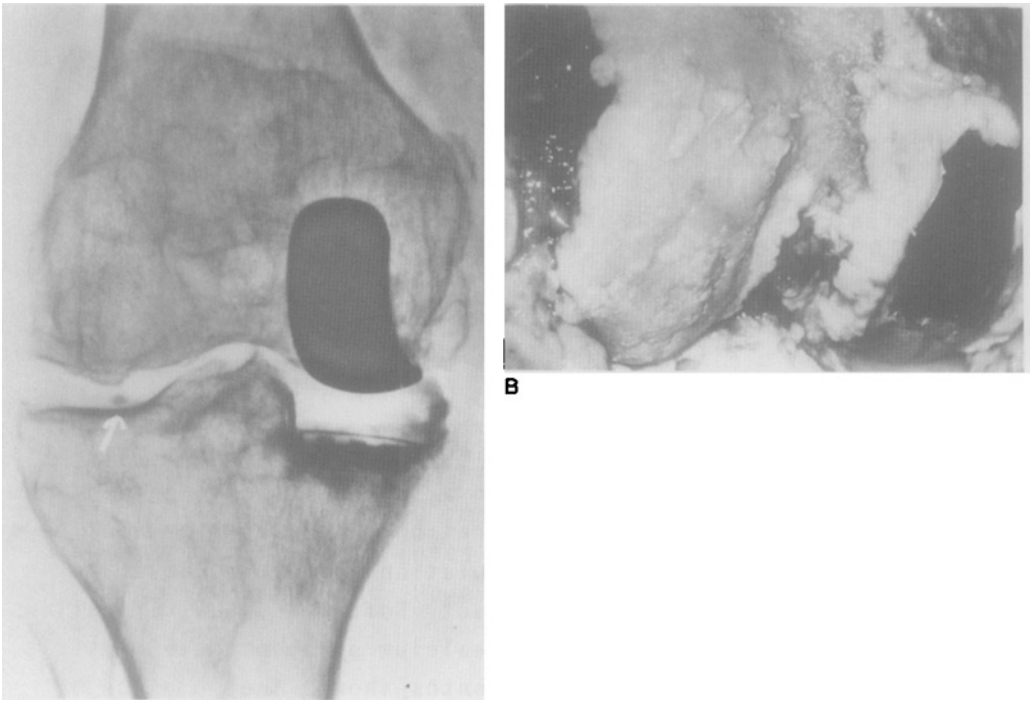
[X] This knee was also overcorrected to $>5^{0}$ valgus.

Among the 17 medially operated knees having arthrosis in the lateral compartment at the last interview only 4 had had clinical

symptoms which had started early (1-3 months) in two cases and late (1-2 years and 2-3 years) in two. These knees were all reoperated (Table 3). The other 13 knees having roentgenographic changes in the lateral compartment did well clinically, 7 rated satisfactory and 6 acceptable according to the Venn Diagram System and the average rating on the HSS scale was 89 (75-98). The mean observation time for these 13 knees was 44 months (27-55).

Case histories of knees developing secondary lateral arthrosis

Case 098 (Figure 9) operated for a Stage III medial gonarthrosis without subluxation. At the operation there was degeneration of cartilage in the patellar articulation while the cartilage in the lateral compartment was intact. Soft tissue calcifications noticed at operation contained calcium pyrophosphate crystals. Radiographic examination at 3 months showed that a piece of cement had broken loose, and at 6 months it had migrated to the lateral compartment. At 18 months it was still present in the lateral compartment, which now was beginning to degenerate. The patient was almost symptomfree during the first postoperative year, but then started to have increasingly severe periodic attacks of pain and effusion. Conversion to a Total Condylar arthroplasty was done 31 months after the primary operation. Besides considerable synovitis there was obvious degeneration of the cartilage in the lateral compartment and small inclusions embedded in the cartilage consisted of inorganic material, probably methylmethacrylate. Thus progression of arthrosis in the lateral compartment seemed to be caused by cement in this knee, perhaps enhanced by pyrophosphate arthritis. The result after the reoperation was satisfactory (HSS 87).



A

B

Figure 9. Case 098. 76-year old female operated with medial arthroplasty for a Stage III medial gonarthrosis.

A. Non-weight bearing examination 18 months after the operation. A piece of cement has broken loose and migrated to the lateral compartment where it was initially observed 6 months after the operation. The patient had mild symptoms.

B. At reoperation there was degeneration of cartilage in the lateral compartment and brown pigmented synovitis in the joint. Conversion to Total Condylar arthroplasty was done.

Case 112 (Figure 10), who previously had had a tibial osteotomy, had a medial arthroplasty for Stage IV arthrosis with 0.5-1.0 cm femoro-tibial subluxation. Postoperative pain was recorded within 3 months and there was roentgenographic evidence of lateral compartment degeneration after one year. There was 11^{o} medial sloping of the tibial component and the knee was overcorrected to almost 10^{o} of valgus. The knee was unstable. At reoperation there were deep furrows in the cartilage of the lateral femoral condyle caused by a loose piece of methylmethacrylate cement. The knee had a Total Condylar arthroplasty with satisfactory result (HSS 90).

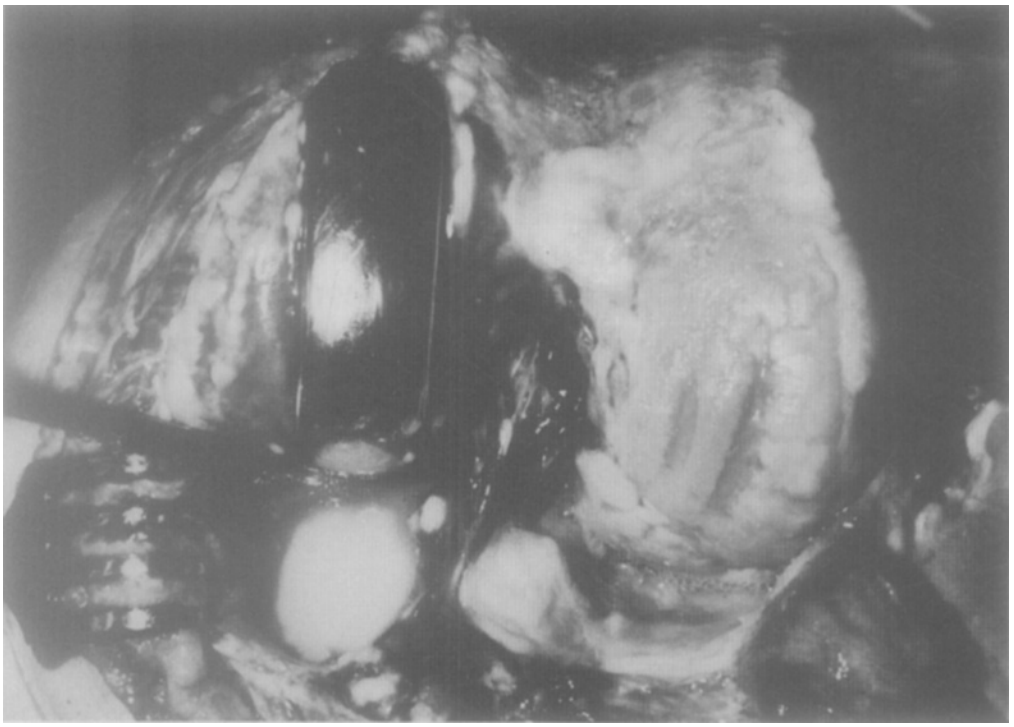


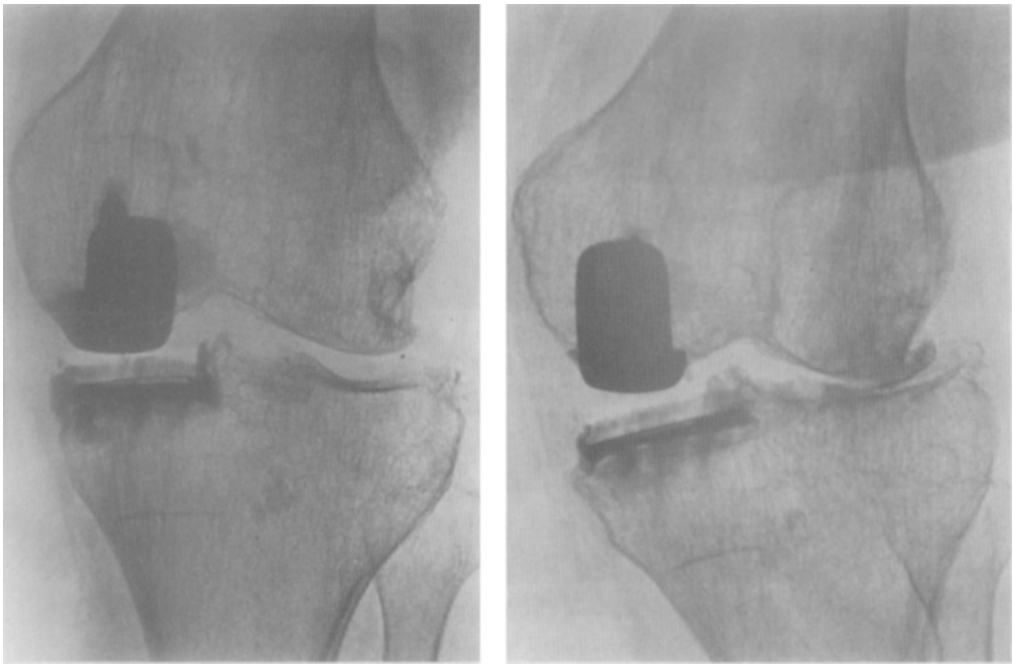
Figure 10. Case 112 at reoperation 18 months after a medial arthroplasty. Deep furrows in the lateral femoral cartilage were caused by a piece of cement. Severe brown pigmented synovitis of the nodulary type was observed.

Case 081 had Stage IV medial arthrosis with 0.5-1.0 cm femoro-tibial subluxation. There was 14^{o} medial sloping of the tibial component and the knee was slightly undercorrected. After the arthroplasty the knee was still unstable, but it was painfree during the initial two years. Pain then started at the lateral aspect of the knee and roentgenographic examination showed degeneration of the lateral compartment. The knee had a Total Condylar arthroplasty with satisfactory result (HSS 86).

Case 008 had Stage V medial arthrosis with severe femoro-tibial subluxation. The tibial component was placed at a medial slope of 14^{o} and the knee, initially having $20\text{-}25^{o}$ of varus, was undercorrected to $5\text{-}10^{o}$ of varus. The subluxation increased and secondary lateral arthrosis was evident within one year. However, this patient was almost asymptomatic at the 4-year follow-up (HSS 81).

Case 090 (Figure 11), a 73-year old female with general joint laxity and habitual patellar dislocations, was operated with a medial arthroplasty for Stage IV arthrosis and a 0.5-1.0 cm femoro-tibial subluxation, overcorrected to almost 10^{o} of valgus.

The tibial component had a medial slope of 5^{o}. Roentgenographic examinations at 2 years showed increased subluxation, severe wear of the lateral intercondylar spine of the tibia, and secondary arthrosis of the lateral compartment (Figure 11). However, the patient was asymptomatic at the last interview and rated satisfactory (HSS 94).



A B

Figure 11. Case 090. Development of secondary lateral arthrosis in an overcorrected Stage IV knee

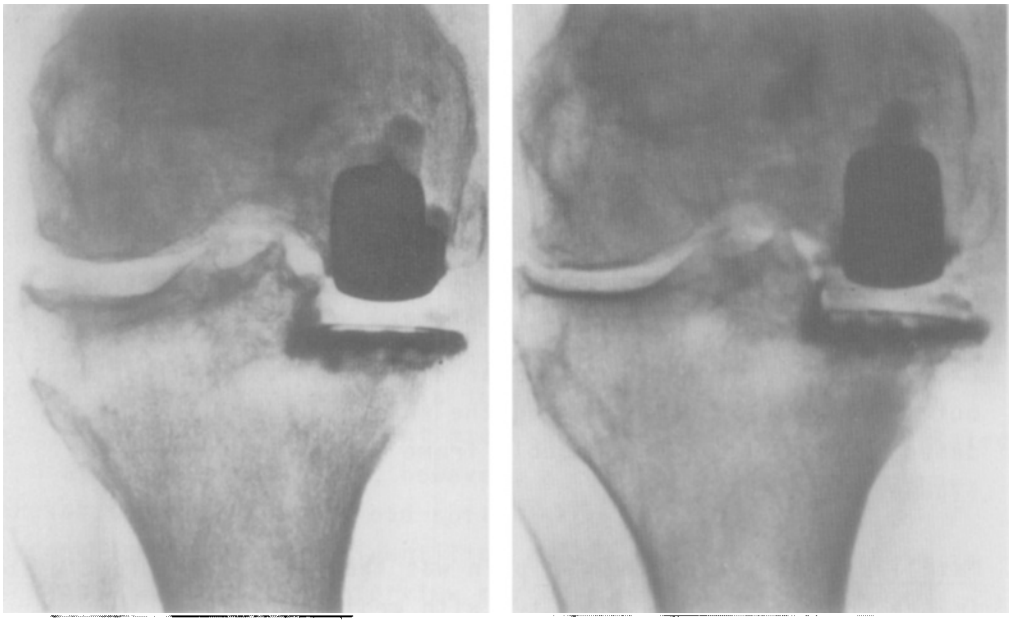
A. Several weeks postoperatively. Weight bearing examination with valgus stress. Normal lateral cartilage but attrition of the tibial spine. The knee has been overcorrected to almost 10^{o} of valgus.

B. Weight bearing examination with valgus stress 2 years after the operation shows development of secondary lateral arthrosis with increased valgus deformity.

Extended follow-up of Stage III knees with medial arthrosis

When the results of the roentgenographic examinations had revealed the clear tendency of secondary lateral degeneration in the more advanced stages (IV and V) it was decided to extend the follow-up of Stage III knees. The average follow-up time of these

31 knees (one was reoperated) initially being 41 months (29-53) was extended on average 15 months making the follow-up time 56 (44-68) months or 4 1/2 years. Roentgenographically a beginning (Stage I) lateral compartment degeneration may have developed in one knee (Case 057) 5 years postoperatively (Figure 12). The knee



A B

Figure 12. Case 057. 57-year old female operated for medial arthrosis Stage III.

A. Weight bearing examination with valgus stress one year after the operation. Normal lateral joint space.

B. Weight bearing examination with valgus stress at extended follow-up 5 years after the arthroplasty. A beginning narrowing of the lateral joint space is suspected.

was stable and had alignment of 0-5° valgus. The patient had no clinical symptoms, and rated satisfactory (HSS 93).
Thus lateral arthrosis has developed in only 1 of 32 Stage III knees during 4 1/2-year follow-up and was caused by a loose methacrylate cement.

In the 14 lateral arthroplasties degeneration of the medial compartment occurred in one Stage IV knee (Case 027) with a preoperative valgus deformity of 25°. The tibial component was placed at

90^{o}. The valgus deformity of nearly 30^{o} was corrected to $5\text{-}10^{o}$ of valgus. The knee was unstable but the result was acceptable during the first 2 years. After an accident, instability increased with severe degeneration of the medial compartment, and finally the tibial component loosened. The knee had a Total Condylar arthroplasty with acceptable result (HSS 66).

Infection. Deep infection occurred in one knee (Case 017) operated with medial + lateral arthroplasty after a failed tibial varus osteotomy done for incipient lateral arthrosis. No infection had been observed after the osteotomy. Prophylactic antibiotic was used and the operation was done in a conventional theatre. There was no early complication and the wound healed uneventfully. Within 6 months there was roentgenographic and scintimetric evidence of infection which was confirmed by culture of Propionibacterium Acne in 5 of 8 samples at reoperation. Extraction and exchange to Guêpar hinge arthroplasty was done but the infection recurred and the knee eventually was arthrodesed by the Adrey-Vidal double frame technique (Connes 1973) (Table 3).

Patellar arthrosis. Patellar pain was the main reason for failure in one knee (Case 036) operated with medial arthroplasty for Stage II arthrosis. Severe pain developed in the knee after 3-6 months, apparently patellar in origin; there was no evidence of other complications. A patellar arthroplasty (Bechtol II) was performed 30 months after the primary operation. There was severe cartilage wear on both facets of the patella at the reoperation. The pain was considerably but not completely relieved; spinal stenosis that was confirmed later might have aggravated the pain that developed in the knee region.

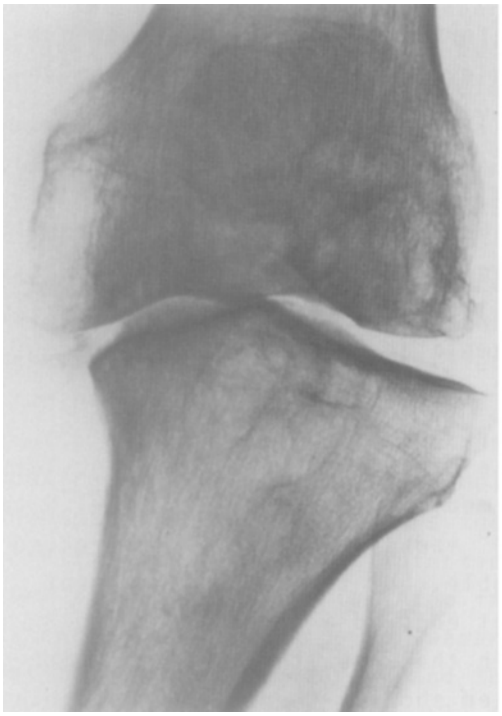
Patellar pain was accessory to failure in two other knees.

Other complications. In one knee instability and increased subluxation, associated with recurrent attacks of synovitis, caused pain leading to failure.

This knee (Case 055) had medial arthroplasty for Stage V arthro-

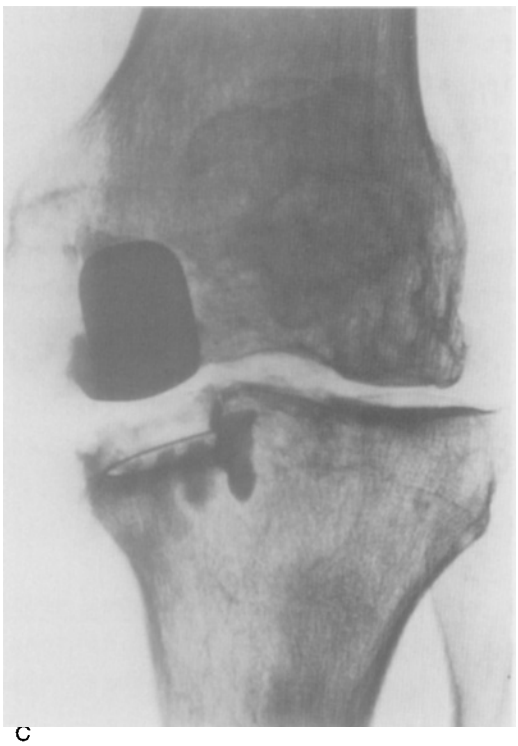
sis with more than 20^{o} varus deformity and more than 1 cm subluxation. Stability was not achieved and correction of the deformity was poor with 5-10^{o} of varus. The tibial component sloped 19^{o} medially (Figure 13). There was a clinical history of pyrophosphate arthritis, and intraarticular soft tissue calcifications were observed. The knee never became painfree and the symptoms periodically increased, associated with attacks of pyrophosphate arthritis. The knee rated as failure (HSS 60). Reoperation was contemplated but the patient died of heart disease before the 3-year follow-up.

In one knee (Case 040) the cause of failure was uncertain. This knee was operated for Stage IV medial arthrosis with 0.5-1.0 cm femoro-tibial subluxation. A 10^{o} varus deformity was corrected to 0-5^{o} varus, the knee was stable, but the tibial component sloped 20^{o} medially. The patient enjoyed a good result for 3 years but then developed pain in the knee, the cause of which was not found as the patient died shortly thereafter of unrelated causes. This patient had, however, a clinical history of pyrophosphate arthritis and had soft tissue calcifications with pyrophosphate crystals identified at the operation. The pain in the knee at the last interview may thus have been related to this but synovial fluid was unfortunately not examined at that time.



A

B



C

Figure 13. Case 055. 83-year old male with longstanding symptoms from both knees. Previously operated in the right knee with a hinge prosthesis with poor result.

A. Preoperative non-weight bearing examination showing Stage V arthrosis of the left knee with lateral subluxation of the tibia.

B. On weight bearing with varus stress, the subluxation increased substantially.

C. Non-weight bearing examination one year after the arthroplasty. There is 19° medial sloping of the tibial component and a moderate subluxation of the tibia. The knee was unstable and was rated as failure.

Summary of the types of causes in late complications and failures

There were altogether 29 late complications in the whole series. Fifteen knees were rated as failures and 13 of these were reoperated while 14 had insignificant clinical symptoms (Table 6). Analysis of the late complications revealed that not less than 24 of the 29 cases were caused by mechanical failure, technical error or were unsuitable for the type of arthroplasty performed.

Table 6. Late complications

Type	Total	Failures	Reop.	Not failures	Confirmed or probable causes of preventible origin	
Loosening	4	3	3	1	Mech. failure Malposition	3 1
Abnormal contact	3	3	3	0	Malposition of prosthesis and instability	3
Degeneration of lateral compartment	17	4	4	13	Degen. preop. Overcorrection Undercorrection Loose cement Instab. + med. sloping	5 2 4 2 2
Degeneration of medial compartment	1	1	1	0	Instability	1
Uncertain	1	1	0	0		
Infection	1	1	1	0		
Patellar arthrosis	1	1	1	0		
Instability + recurrent synovitis	1	1	0	0	Instability	1
	29	15	13	14		24

Thus, in the categories of loosening and abnormal contact three were caused by mechanical failure of a thin tibial component and four by malposition in combination with instability. In the 17 cases of degeneration of the lateral compartment after medial

arthroplasty five knees had degeneration laterally already preoperatively, two were associated with overcorrection and four with undercorrection, two caused by loose cement in the joint and two by combined instability and medial sloping of the tibial component. In another 2 knees instability was supposed to be the cause of failure (Table 6).

Reoperations

Thirteen knees were reoperated (Table 3). At reoperation prophylactic antibiotic therapy was not started until at least 5 specimens had been taken for bacterial culture according to the recommendations of Kamme & Lindberg (1981).

The extracted tibial components did not show excessive wear except in two cases, namely the infected knee, where gross dislocation had occurred several months before, and in one tibial component with loosening not reoperated until nearly 2 years after symptoms had begun. All femoral components extracted were intact.

In five knees a revision with exchange of components was done. In three of these the end-result was satisfactory (HSS 89, 99 and 80), in one acceptable (HSS 72), and one knee remained in the group of failures because of sagittal instability and patellar pain (HSS 67).

Five knees had Total Condylar arthroplasty with satisfactory end-result in four (HSS 86, 87, 90 and 82) and acceptable in one (HSS 66).

Two knees were converted to Guépar hinge arthroplasty with satisfactory end-result in one (HSS 77) while the other knee, reoperated for an infection, became re-infected, rated as failure and eventually went to arthrodesis.

In one knee a Bechtol II patellar arthroplasty was done 30 months after the first operation with satisfactory end-result (HSS 72).

The average HSS score in these 13 knees before reoperation was 57, and after reoperation 78 (Table 3). The average observation time after reoperation was 22 months with a range of 6-40 months.

Late complications in chronologic sequence. The arthroplasties performed in the first, second and third year of the study were analysed separately in terms of late complications and failures (Table 7).

There was a clear trend to improved results with increased experience. Complications occurred in 15 of 34 knees operated during the first year compared to 14 in 68 operated during the second and third years ($p < 0.05$). Other differences in Table 7 were, however, not statistically significant.

Table 7. Late complications and failures after arthroplasties performed in the 1st, 2nd and 3rd year

	All late complications		All failures		Failures appearing within 2 years of operation	
	Ratio	Fraction	Ratio	Fraction	Ratio	Fraction
1st year	15/34	.44	7/34	.20	6/34	.18
2nd year	8/39	.21	6/39	.15	4/39	.10
3rd year	6/29	.21	2/29	.07	2/29	.07

Preoperative subluxation and postoperative instability of knees with medial arthrosis were analysed and are listed in Table 8. The number of knees in Stage IV-V with femoro-tibial subluxation more than 1.0 cm decreased from 6 during the first year to none during the third year ($p < 0.05$). Likewise the number of knees with postoperative instability decreased from 9 of 23 in the first year to 3 of 27 in the third ($p < 0.05$). The results expressed as postoperative varus deformity improved. Thus, 8 of 23 knees operated during the first year had a varus deformity more than 5^{0} postoperatively but only 3 of 27 operated during the third year.

Table 8. Preoperative subluxation and postoperative instability of knees operated with medial arthroplasty

	Preoperative subluxation >1.0 cm		Postoperative instability	
1st year				
23 arthroplasties	6	(.26)	9	(.39)
2nd year				
28 arthroplasties	2	(.07)	5	(.18)
3rd year				
27 arthroplasties	0		3	(.11)

ASSESSMENT BY VENN DIAGRAM SYSTEM (Figure 14)

When the three factors mobility, stability and freedom from pain were evaluated in combination, 65 knees or two thirds were satisfactory, i.e. normal or near normal after the arthrplasty versus none before ($p < 0.001$). Similarly the worst category of unstable, painful knees with impaired range of motion contained 32 knees before and only 2 after the operation ($p < 0.001$).

Results in different types of arthroplasty. The 65 knees that rated satisfactory included 53 of 78 medial arthroplasties, 9 of 14 lateral arthroplasties, and 3 of 10 medial + lateral arthroplasties (Table 9).

The 15 knees rated as failures consisted of 11 of 78 medial arthroplasties, one of 14 lateral arthroplasties, and 3 of 10 medial + lateral arthroplasties. No statistical differences were found between the different groups.

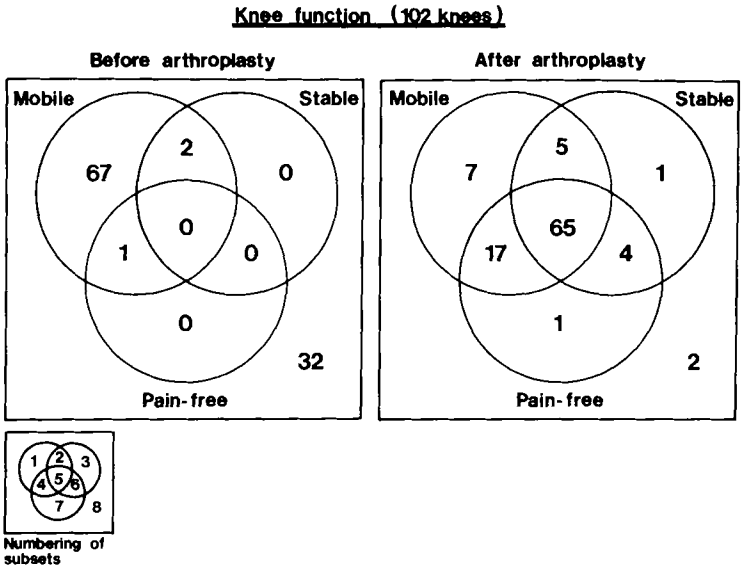


Figure 14. Knee function before and after the arthroplasty

All knees were evaluated in terms of the three basic characteristics of a weight bearing joint: mobility, stability and freedom from pain. Mobile meant at least 90^0 flexion and extension defect of no more than 5^0. Stability was recorded when the varus and/or valgus instability was less than 5^0. Freedom from pain was recorded when the patient had no walking pain or could walk at least 500 meters without pain.

Table 9. Results assessed by the Venn Diagram System

	S	A	F	Total	Fraction failures
Medial arthroplasty	53	14	11	78	.14
Lateral arthroplasty	9	4	1	14	.07
Medial + lateral arthroplasty	3	4	3	10	.30
Total	65	22	15	102	.15

S = Satisfactory (subset 5, Figure 14)
A = Acceptable (subsets 4, 6 and 7)
F = Failure (subsets 1, 2, 3 and 8)

Pain on walking. Only one knee was relatively painfree before the operation while 87 had no pain on walking after the operation (Table 10). This difference was highly significant. Fifteen knees had significant pain on walking after the arthroplasty and were rated as failures; 13 of these were reoperated.

Table 10. Pain on walking before and after knee arthroplasty
n = 102

	None	Only starting pain	>1000 m	500-1000 m	100-500 m	<100 m	At first step
Before	0	0	0	1	4	10	87
After	68	3	6	10	3	2	10

Pain at rest. Preoperatively nearly one third or 33 had spontaneous pain at rest, usually disturbing sleep, 50 had pain at rest after physical activities, and only 19 had no pain at rest (Table 11). Postoperatively two thirds or 72 had no pain at rest, 26 only after physical activities, and 4 knees had spontaneous pain, all of them categorized as failures. All these changes in pain at rest, before and after the operation, were highly significant.

Table 11. Pain at rest in gonarthrosis

	Preop.	Postop.
None	19	72
Only after physical activities	50	26
Spontaneous even at night	33	4
Total	102	102

Patellar pain. Postoperatively 36 knees had symptoms judged to come from the patellar articulation (Figure 15); the majority had only occasional discomfort, but 11 knees had frequent though mild pain and 5 had always pain at special patellar loading activities.

There was a poor correlation of cartilage changes observed at the patellar articulation at operation and the clinical symptoms at follow-up (Figure 15); only 8 of 36 knees with major cartilage changes at the patellar articulation had major symptoms at patellar loading activities, whereas 28 of these 36 knees had minor or no symptoms. Eight of the 52 knees having minor cartilage changes had major symptoms while 44 had not. None of the knees with normal patellar cartilage had clinical symptoms from the patellar joint.

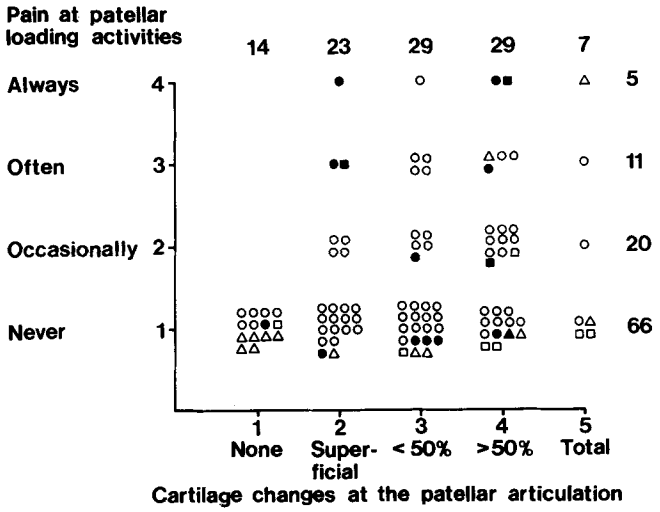


Figure 15. Patellar pain in gonarthrosis

Pain judged to come from the patellar articulation after resurfacing knee arthroplasty in relation to changes found at operation.
Symbols: o = medial arthroplasty
Δ = lateral arthroplasty
□ = medial + lateral arthroplasty
Filled symbols: failed knees

Stability. Two knees were rated as stable before and 75 after the operation (Figure 16).

Of the 15 knees rated as failures, 9 were unstable after the

operation and thus two thirds of the failed knees had both instability and pain. Remaining instability was most common in knees with large preoperative deformities, 12 having had more than 15^{o} of varus or valgus.

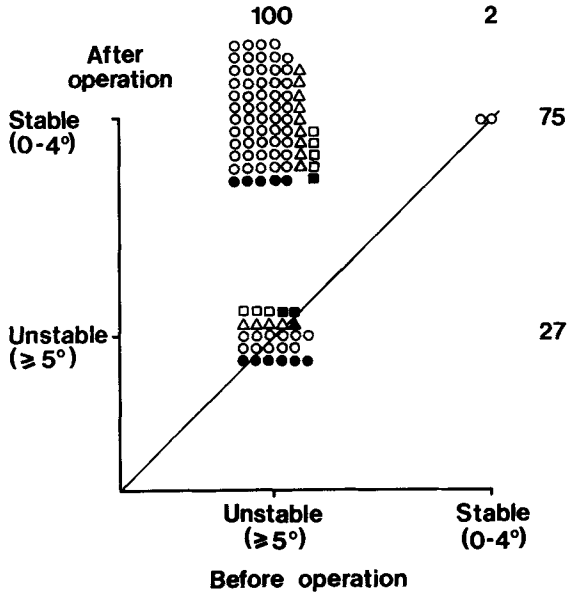


Figure 16. Stability before and after knee arthroplasty
The stability was measured with goniometer at full extension.
Symbols: o = medial arthroplasty
Δ = lateral arthroplasty
□ = medial + lateral arthroplasty
Filled symbols: failed knees

Both the stable and unstable knees improved significantly by the operation ($p < 0.001$). However, overall results in the 75 knees that acquired full stability by the operation were significantly better ($p < 0.001$) than in the unstable knees (Table 12). Thus, the 75 stable knees had an average postoperative HSS score of 87, while the 27 unstable knees scored 73. Six of the 75 stable knees were rated as failures compared to 9 of the 27 unstable knees. The risk of failure thus increased four times with instability ($p < 0.01$).

Table 12. Relation of postoperative stability to overall results

Postoperative stability	No. knees	HSS-score Preop.	HSS-score Postop.	No. failures	Fraction failures
Stable ($0-4^0$)	75	42	87	6	.08
Unstable ($\geq 5^0$)	27	40	73	9	.33
Total	102			15	

Mobility. Two thirds or 70 knees were mobile before the operation and more than nine of ten or 94 after the arthroplasty ($p < 0.001$)(Figure 14). Of the eight knees not rated as mobile after the operation five had greatly impaired range of motion preoperatively and were improved, while three failed knees rated as mobile before had decreased mobility after the operation. The average postoperative range of motion was 110^0, a gain of 13^0.

The postoperative flexion was on average 112^0, a gain of 8^0. Flexion increased in three fourths of the knees, but 23 knees had decreased flexion postoperatively, in most cases only by $5-10^0$ but more than 10^0 in four knees.

The average preoperative flexion deformity (extension defect) was 7^0 and was diminished to 2^0 after the operation. Forty-four knees had had a flexion deformity of more than 5^0 preoperatively. After the operation only 5 had a flexion deformity of more than 5^0 (Figure 17). This difference was highly significant.

The 22 knees where plaster cylinder was used postoperatively had a 9^0 flexion deformity before and 3^0 after the operation on average, or the same correction as in the whole series. However, according to the physiotherapist, maximal extension was obtained easier and earlier in these knees.

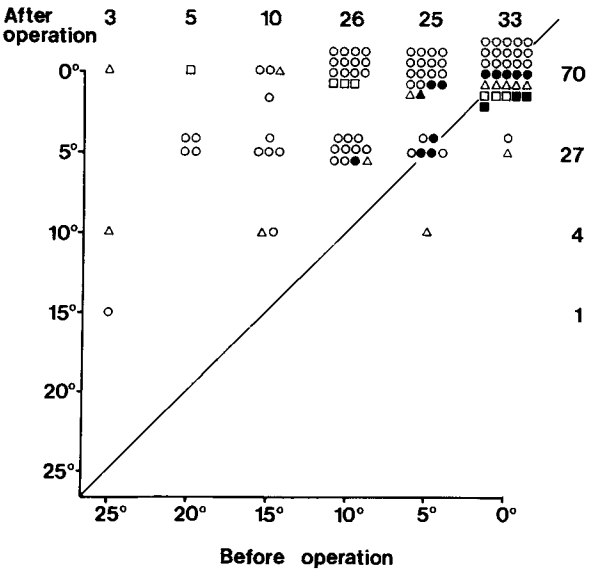


Figure 17. Flexion deformity

Symbols: o = medial arthroplasty
Δ = lateral arthroplasty
□ = medial + lateral arthroplasty
Filled symbols: failed knees

ASSESSMENT BY THE HSS KNEE RATING SCALE

The average HSS score for the entire series was 42 preoperatively and 83 postoperatively (Table 13). There was no significant difference in pre- and postoperative scores in the different types of arthroplasties.

ASSESSMENT BY THE LH POINTS SCORING SYSTEM

The average LH score for the entire series was 40 preoperatively and 97 postoperatively. The postoperative rating according to this system was similar for the medial and the lateral arthro-

plasties, and somewhat lower for the medial + lateral arthroplasties (Table 13).

Table 13. Results at 2-5 year follow-up expressed in terms of two different scoring systems

	Medial	Lateral	Medial + lateral	Total material
Number of knees	78	14	10	102
HSS score				
Preoperatively	42	42	43	42
Postoperatively	85	83	75	83
Excellent (85-100)	50	7	4	61
Good (70-84)	14	6	3	23
Fair (60-69)	9	0	1	10
Poor (< 60)	5	1	2	8
LH score				
Preoperatively	40	42	40	40
Postoperatively	98	100	86	97
"Acceptable" (≥95)	65	13	7	85
Not "acceptable"	13	1	3	17

Comparison of Assessment by the Three Different Systems

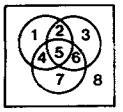
As regards the 65 knees rated as satisfactory by the Venn Diagram System there was good agreement between the different assessment systems. Thus all these knees (subset 5, Table 14) rated 70 or more (good and excellent) by the HSS score and 95 or more (acceptable in all parameters) by the LH score. As regards the category of failure by the Venn Diagram (subsets 1, 2, 3 and 8) there was good agreement with the LH score with an average score of 45, no knee rating higher than 65. However, by the HSS score the 15 failed knees rated 56 on average with no less than 7 "fair" (60-69 points). Thus nearly half of the knees rated as failures by the Venn Diagram System rated as "fair" by the HSS score.

Only two of the 22 acceptable knees in the Venn Diagram System (subsets 4, 6 and 7) rated below 95 on the LH score (60 and 75);

the HSS score for this category was below 70 for only 3 knees ("fair") while 12 rated 70-84 ("good") and 7 rated 85 or more ("excellent").

The mean HSS score of the three groups, satisfactory, acceptable and failures, was 91, 81 and 56, respectively, highly significant differences. The LH score in the same groups was 107 for satisfactory knee, 101 for acceptable knees ($p < 0.01$) while the failed knees only scored 46, separated from the other groups by high significance.

Table 14. Three systems of assessment of results of the 102 arthroplasties

Assessment by Venn Diagram	Type of arthroplasty				Numbering of Venn Diagram subsets 			
Subset	Medial	Lateral	Medial + lateral	Σ	HSS		LH	
					m	(range)	m	(range)
1	6	1	0	7	55	(35-69)	46	(35-60)
2	4	0	1	5	62	(46-69)	55	(45-65)
3	0	0	1	1	48		25	
4	11	4	2	17	82	(68-95)	101	(60-110)
5	53	9	3	65	91	(76-99)	107	(95-110)
6	3	0	1	4	76	(69-86)	99	(75-110)
7	0	0	1	1	73		105	
8	1	0	1	2	51	(48-54)	35	(20-50)
Σ	78	14	10	102				

HSS = Hospital for Special Surgery Knee Rating Scale
LH = The London Hospital Points Scoring System
The Venn Diagram: subset 5 was satisfactory, 4, 6 and 7 acceptable, and 1, 2, 3 and 8 failed; for definition of parameters, see Figure 14.

Subjective Assessment

The patient's own opinion largely agreed with the rating systems (Table 15); knees considered to be improved had high ratings in all systems and knees that were considered unchanged or worse

had low ratings. However, in the 15 failed knees pain at rest was much improved in 2 knees and better in one; three of the failed knees were improved as regards pain on walking, and no less than 5 of the 15 failed knees were considered by the patients to permit better walking ability than before the operation.

Table 15. Patients' opinions on final result of compartmental arthroplasty for gonarthrosis

		Venn Diagram			HSS	LH
		S	A	F		
Pain at rest						
Much better	80	61	17	2	88	105
Better	9	3	5	1	78	90
Unchanged	12	1	0	11	55	46
Worse	1	0	0	1	52	60
Pain on walking						
Much better	79	62	17	0	89	106
Better	11	3	5	3	78	89
Unchanged	10	0	0	10	54	45
Worse	2	0	0	2	48	30
Walking ability						
Much better	80	62	18	0	89	105
Better	11	3	3	5	70	78
Unchanged	8	0	1	7	55	52
Worse	3	0	0	3	55	35

S = Satisfactory
A = Acceptable
F = Failure
HSS = Hospital for Special Surgery Knee Rating Scale
LH = London Hospital Points Scoring System

SOCIAL FUNCTION

More than half or 52 knees permitted satisfactory social function after the operation while only 3 were in this category preoperatively (Figure 18). Likewise 69 knees were in the worst category before and only 14 after the operation ($p < 0.001$); 10 of these were rated as failures. All the functions independence, walking ability and analgetic consumption improved significantly

by the arthroplasty ($p < 0.001$).

Independence. Eleven knees permitted independence preoperatively while 63 or nearly two thirds of the knees were rated in this group after the arthroplasty ($p < 0.001$)(Figure 18). Of the 39 knees not belonging to this group, 12 were rated as failures and the other 27 were associated with disease, senility and/or pain from other joints. Eleven patients were disabled by pain in the other knee joint, 6 in combination with a major disease.

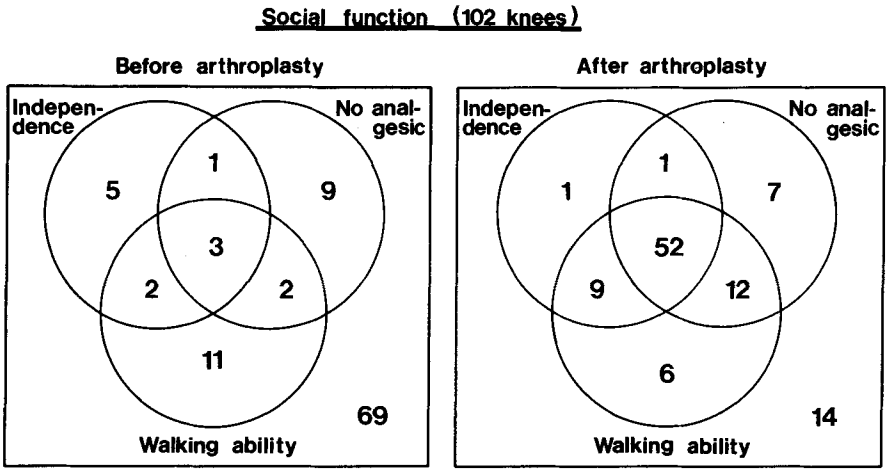


Figure 18. Social function before and after arthroplasty

All knees were evaluated according to the patients' independence of other people, use of analgesics and to their ability to walk. Independence was recorded when the patient was able to take care of his/her household, including housecleaning, and could shop alone. No analgesics was recorded when the patient did not require any analgesics for the affected or operated knee. Walking ability was recorded when the patient was able to walk at least 500 meters regardless of pain.

The ability to perform every-day activities improved after 76 of the 102 operations (Table 16). Thirty-eight knees did not permit more than basic activities of daily living before the operation

while only 7 did not after the operation, and 6 of these were failures. Twenty-six knees were unchanged; 11 permitted independence already preoperatively, 10 were rated as failures and 5 knees did not improve independence because of other diseases.

Table 16. Ability to perform every-day activities before and after knee arthroplasty

n = 102

	Independent	All domestic work	Light domestic work	Can only perform ADL	Cannot even perform ADL
Before	11	16	36	38	1
Significance	***	NS	**	***	NS
After	63	16	16	7	0

Analgesics. The requirement of analgesics was substantially diminished after the operation (Table 17). Of the 30 knees still requiring analgesics postoperatively, 11 were failures, and of the remaining 19, 9 took analgesics occasionally for patellar pain, while 10 required analgesics after longer walking distances. All but one of these 19 patients were taking analgesics only occasionally (Figure 18 and Table 17).

Table 17. Requirement of analgesics

	Every day	Occasionally	None
Preoperatively	56	31	15
Significance	***	NS	***
Postoperatively	8	22	72

Walking ability. Before the arthroplasty only 18 knees permitted a walking distance of 500 m or more, compared to 79 or 77 per cent at the last interview (Figure 19). Of the 23 knees with walking restricted to less than 500 m after the operation, 13 were failures and the other 10, associated with senility, disease or pain from other joints, still had an improved walking ability.

Three knees had shorter walking distance after the operation and were all failures.

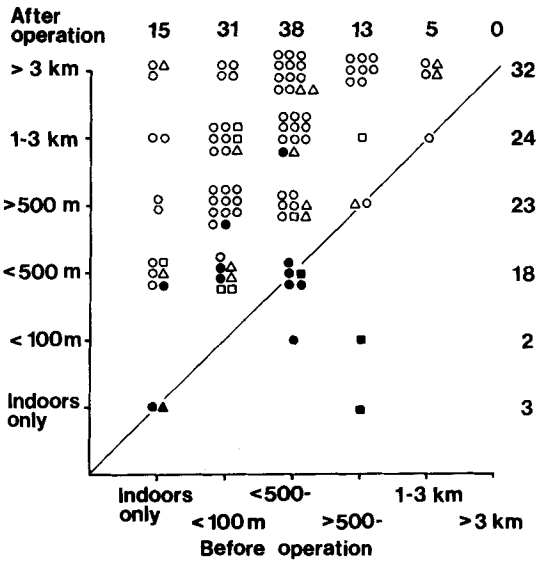


Figure 19. Walking ability regardless of pain before and after resurfacing knee arthroplasty

Symbols: o = medial arthroplasty
Δ = lateral arthroplasty
□ = medial + lateral arthroplasty
Filled symbols: failed knees

Stair climbing ability. There was significant improvement in stair climbing ability. Preoperatively 10 were unable, 49 had great difficulty and only 4 could climb stairs normally (Table 18). After the arthroplasty 68 could climb stairs normally with or without support; only one was unable and 9 had great difficulties. The improvement was similar after medial ($p < 0.001$) and lateral ($p < 0.01$) arthroplasties while only 2 of 10 ($p > 0.05$) could climb stairs normally after medial + lateral arthroplasty. There was a good agreement between the HSS score and stair climbing ability both pre- and postoperatively. Seven of 10 knees with great difficulty or inability to negotiate stairs postoperatively and 6 of 24 who climbed stairs with one foot at a time were rated as failures in contrast to only 2 of 68 who climbed normally.

Ability to rise from a chair. The ability to rise from a chair was improved in most patients and only those rated as failures had great difficulty in doing so after the arthroplasty (Appendix 3).

Table 18. Stair climbing ability. Pre- and postoperatively.

	Medial		Lateral		Medial + lateral		Total material		HSS-score		No. failures
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	
1. Normal with or without support	3	57	1	9	0	2	4	68	66	90	2
2. One foot at a time	31	13	4	4	4	7	39	24	45	77	6
3. With great difficulty	37	7	8	1	4	1	49	9	39	58	6
4. Unable	7	1	1	0	2	0	10	1	29	46	1
	78	78	14	14	10	10	102	102			

Walking aids. The dependence on walking aids diminished clearly by the operation even if many patients continued to use walking stick(s) postoperatively either on the doctor's recommendation or by long-term habit (Appendix 3).

OPERATIVE FINDINGS

Synovitis. The condition of the synovia at the operation was recorded in 97 knees. There were no signs of synovitis in 13 knees, mild synovitis in 64 knees, moderate in 17, and severe in 3 knees. Synovectomy was done in 3 knees. Assessment by the HSS score in the different groups showed no relation between synovial condition at operation and the final results. One knee with severe synovitis at operation rated as failure (Case 027, p. 35), but this was supposed to be caused by postoperative instability and later degeneration of the unoperated medial compartment.

Pyrophosphate arthritis. Twenty-one knees had had a clinical history of suspected or confirmed pyrophosphate arthritis. All these knees had soft tissue calcifications at operation and in 13 a specimen was sent for crystal analysis showing calcium pyrophosphate crystals in all. Only 7 of these knees had definite soft tissue calcification roentgenographically. Thirteen of the 21 knees with calcific deposits rated as satisfactory and 5 rated as failures.

The mean postoperative HSS score for this group of 21 knees was, however, the same as the average for all knees or 83. The failed knees in this group had all been operated with medial arthroplasty; 3 had had signs of recurrent synovitis (Cases 055, 081 and 098); in one the cause of failure was unknown (Case 040) and one (Case 032) had early degeneration of the lateral compartment already preoperatively. Recurrent attacks of pyrophosphate arthritis may thus have been an important cause of failure in these knees.

ROENTGENOGRAPHIC OBSERVATIONS

By definition all knees in this series had roentgenographic evidence of arthrosis with structural changes involving the subchondral bone, not associated with rheumatoid arthritis. Further details of the roentgenographic technique and observations will be published by Boegård et al. (1981).

Types of Arthrosis

The types of arthrosis and the combination of different types in each knee is shown in Figure 2. Medial arthrosis only was found in 29 knees, lateral arthrosis only in 4 knees, and medial + lateral arthrosis only in one knee.

Patellar arthrosis was combined with medial femoro-tibial arthrosis in 45 knees, with lateral arthrosis in 12 knees and with

both medial and lateral arthrosis in 11 knees, for a total of combined patellar and femoro-tibial arthrosis in 68 knees or two thirds of the entire material.

The pre- and postoperative HSS score in the different subsets and the number of failures according to the Venn Diagram System were recorded in each group. In medial gonarthrosis, the 29 knees without arthrosis in the other compartments rated 43 preoperatively and the 45 knees with medial and patellar arthrosis rated 40. The postoperative score in these groups were 84 and 85, and the number of failures 5 and 6, respectively.

The 4 knees with lateral arthrosis only rated 49 preoperatively and 90 postoperatively, while the 12 knees with combined lateral and patellar arthrosis rated 40 before the operation and 80 after the operation. There was no failure in the first group and one failure in the second.

The 11 knees with arthrosis in all compartments rated lowest of all knees both pre- and postoperatively or 37 and 72 points, respectively, and there were 3 failures in this group. It is noteworthy that 5 knees in this group were operated with medial arthroplasty only.

Stage of Gonarthrosis

In the 78 knees operated with medial arthroplasty all stages of arthrosis were represented (Table 19), Stage III being the most common with 32 knees, while 21 knees were in Stage IV, 15 knees in Stage V and Stage I and II were the most infrequent with 4 and 6 knees, respectively, most of these secondary to osteonecrosis. In general the amount of femoro-tibial subluxation increased with increasing stage of arthrosis; minor subluxation was found at all stages but femoro-tibial subluxation of more than 1 cm was only found in Stages IV-V.

In the 14 knees operated with lateral arthroplasty 3 had Stage I, 2 Stage II, 6 Stage III, 2 Stage IV, and one Stage V femoro-

tibial arthrosis (Table 19). Femoro-tibial subluxation was rare in these knees; 9 had no signs of subluxation, 4 had 0.1-1.0 cm subluxation and only one more than 1 cm.

Table 19. Stage of medial gonarthrosis

		Subluxation (cm)				Patellar arthrosis				
		None	0-0.5	0.6-1.0	>1.0	None	Med.	Lat.	Both facets	Insuff. exam.
Stage I	4	2	1	1	0	3	0	1	0	
Stage II	6	2	1	3	0	2	0	2	2	
Stage III	32	5	16	11	0	10	8	3	9	2
Stage IV	21	0	7	8	6	5	2	5	7	2
Stage V	15	0	8	5	2	4	2	0	8	1
Total	78	9	33	28	8	24	12	11	26	5

Stage of lateral gonarthrosis

		Subluxation (cm)				Patellar arthrosis			
		None	0-0.5	0.6-1.0	>1.0	None	Med.	Lat.	Both facets
Stage I	3	2	0	1	0	1	0	1	1
Stage II	2	1	1	0	0	1	0	1	0
Stage III	6	4	2	0	0	2	0	4	0
Stage IV	2	1	0	0	1	0	0	0	2
Stage V	1	1	0	0	0		1	0	0
Total	14	9	3	1	1	4	1	6	3

For radiographic classification standing X-ray projections were taken with varus vs. valgus stress (Norman 1974). Ahlbäck's classification (1968) was used.

Stage I	Joint space narrowing	
Stage II	Joint space obliteration	
Stage III	Minor bone attrition	0-0.5 cm
Stage IV	Moderate bone attrition	0.6-1.0 cm
Stage V	Severe bone attrition	>1.0 cm

The Relation between Stage of Arthrosis and Varus Deformity

The average varus deformity in medial gonarthrosis increases with the degree of arthrosis (Figure 20). Thus in Stage I and II

the varus deformity was approximately 9^0, in Stage III 11^0, in Stage IV 12^0, and in Stage V 16^0. However, the individual amount of varus deformity varied greatly within each stage.

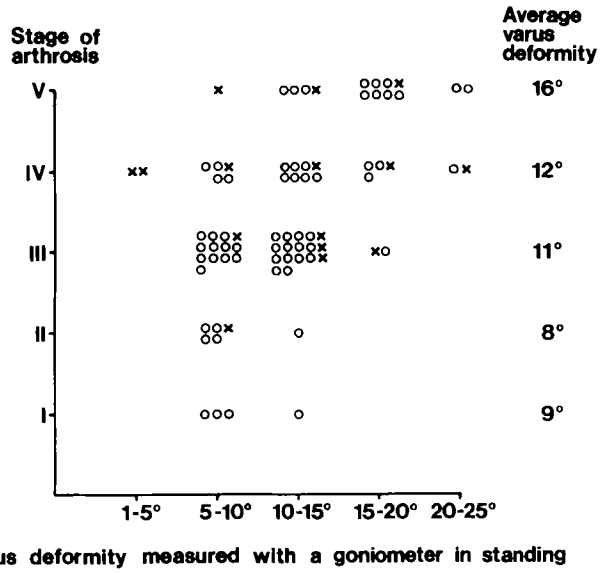


Figure 20. The relation between stage of arthrosis and varus deformity in knees with medial gonarthrosis

Symbols: x = previously osteotomized knees
o = not osteotomized knees

RESULTS OF MEDIAL ARTHROPLASTY IN RELATION TO SEVERITY OF GONARTHROSIS

Preoperatively the knees scored between an average of 37 in Stage V to 48 in Stage I on the HSS Rating Scale. The postoperative score was significantly higher in Stage III or 90 points compared to Stages IV+V 32 points (Table 20); the postoperative scores in Stages I-II could not be evaluated on comparative grounds because the cases were few and had disproportionately high incidence of postoperative complications due to material failure (loosening of thin tibial components). The pattern of the LH

score was the same for the different groups. The number of failures by the Venn Diagram definitions and knees with post-operative instability were again lower though not statistically significant in Stage III arthrosis compared to Stage IV-V. Thus there was only one failure in 32 Stage III knees while there were 6 failures in 36 Stage IV-V knees. Postoperative instability was more frequent in Stage IV-V than in Stage III or in 13 of 36 and 2 of 32, respectively (Table 20).

There were 8 knees with medial arthrosis that had preoperative femoro-tibial subluxation of more than 1 cm (Table 19), all in Stage IV-V. The average preoperative HSS score in these knees was 39 and the average postoperative score was 79. Not less than 7 of these 8 knees had postoperative complications and 3 of these were rated as failure.

Table 20. Results of medial knee arthroplasty in relation to preoperative stage of radiographic classification

	Stage III		Stage IV + V
Number of knees	32		36
Postoperative instability	2	**	13
Failure	1	NS	6
Preoperative HSS score	44	NS	39
Postoperative HSS score	90	**	82
Preoperative LH score	43	NS	39
Postoperative LH score	105	*	96

See Table 19 for radiographic classification.

In medial arthroplasties the correction of varus deformity was rather poor (Figure 21). In 28 of 78 knees the alignment of the knee to 0-5° valgus was achieved; 32 had 0-5° varus, 15 had 5-10° varus, and 3 knees were slightly overcorrected to 5-10° of valgus. The mean pre- and postoperative deformities were correlated; the 28 knees in the best category had an average preoperative varus deformity of 13° and the least corrected category (remaining more than 5° varus) had a preoperative varus deformity of 19°. However, the correlation between severe preoperative deformities and postoperative failure was low.

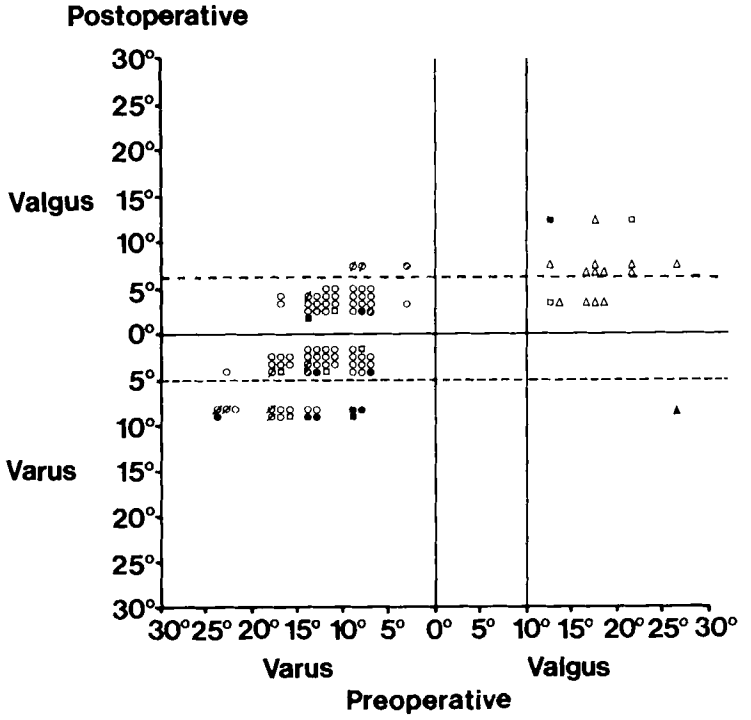


Figure 21. Goniometer recorded deformities before and after compartmental knee arthroplasty (n = 102).

Symbols: o = medial arthroplasty
Δ = lateral arthroplasty
□ = medial + lateral arthroplasty
Filled symbols: failed knees
ø = medial arthroplasty with degeneration of the lateral compartment at the last examination
● = failed medial arthroplasty with degeneration of the lateral compartment at the last examination

On the other hand there was a correlation between the postoperative deformities and the overall results. Thus, if the 15 undercorrected knees (>5° varus) and the 3 overcorrected knees (>5° valgus) operated with medial arthroplasty are considered as an entity and compared to the 60 better corrected knees (<5° varus or valgus) the failure rate was significantly different or 6 of 18 compared to 5 of 60 ($p < 0.05$, Table 21). The postoperative HSS score in these groups was 77 and 87, respectively ($p < 0.01$). The best result was achieved in knees corrected to 0-5° valgus with an average HSS score of 90 and a failure rate of .07, and the poorest in knees with more than 5° of varus postoperatively, an average HSS score of 76 ($p < 0.001$) and a failure rate of .33 (Table 21).

Table 21. The correlation between postoperative alignment and results after medial arthroplasty

Postoperative alignment	Knees	Venn Diagram			HSS	
		S	A	F	Pre	Post
6-10° valgus	3	2		1	49	85
0-5° valgus	28	23	3	2	42	90
0-5° varus	32	24	5	3	41	84
6-10° varus	15	4	6	5	40	76

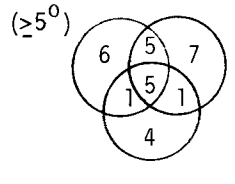
S = Satisfactory
A = Acceptable (non-satisfactory but painfree)
F = Failure
HSS = Hospital for Special Surgery

In knees operated with lateral arthroplasty all except one of 14 knees were corrected to 0-10° of valgus; one knee (Case 027) with initially the same postoperative alignment failed because of instability, degeneration of the medial compartment, and developed a varus deformity. In medial + lateral arthroplasty only three knees were corrected to 0-10° valgus (Figure 21).

The risk of failure after medial arthroplasty was higher in unstable compared to stable (6/17 versus 5/61) and poorly corrected compared to corrected (6/18 versus 5/60) knees ($p < 0.05$). When these unfavourable factors existed in combination the risk of failure increased significantly as 5 of 10 unstable and poorly

corrected knees rated as failures compared to 4 of 53 stable and corrected knees ($p < 0.01$, Table 22).

Table 22. The correlation of postoperative instability, poor correction of deformity and failure in medial arthroplasty (n = 78)



		Ratio of failures
Stable	5/61	.08
Unstable	6/17	.35
Corrected	5/60	.08
Poorly corrected	6/18	.33
Corrected + stable	4/53	.08
Uncorrected + unstable	5/10	.50

The Mechanical Axis of the Lower Limb after Knee Arthroplasty

In the normal knee joint the mechanical axis transects the center of the tibial spine (Maquet 1976). During the period of investigation a whole leg roentgenographic examination including the hip and the ankle joint was introduced as a routine examination before and after operations for gonarthrosis (Egund & Norman 1979). Thus the mechanical axis was determined in only a few knees preoperatively but in nearly all knees at the last examination.

In the knees operated with medial arthroplasty the average postoperative angular deviation of the mechanical axis was 7^{o} varus (Table 23); the angular deviation changed from 10^{o} varus in the knees operated during the first year to 5^{o} of varus in those operated during the third year ($p < 0.05$). In the knees operated with lateral arthroplasty the postoperative angular deviation of the mechanical axis was 6^{o} of valgus on average and in the medial + lateral knees it was 6^{o} of varus on average.

The correlation of goniometer recorded deformities and the more exact roentgenographic determination of deformity expressed as angular deviation of the mechanical axis was generally good (Figure 22).

Table 23. The angular deviation of the mechanical axis after arthroplasty of the knee

	No. op.	No. roentg. analyses	Ang. dev. of the mech. axis	Range	S.D.
Medial					
Year 1	23	18	10^0 varus	2^0 valgus - 17^0 varus	5.4
Year 2	28	25	7^0 varus	4^0 valgus - 13^0 varus	4.6
Year 3	27	24	5^0 varus	10^0 valgus - 20^0 varus	7.2
Lateral	14	12	4^0 valgus	10^0 valgus - 14^0 varus	4.1
Medial + lateral	10	6	6^0 varus	3^0 valgus - 17^0 varus	7.7

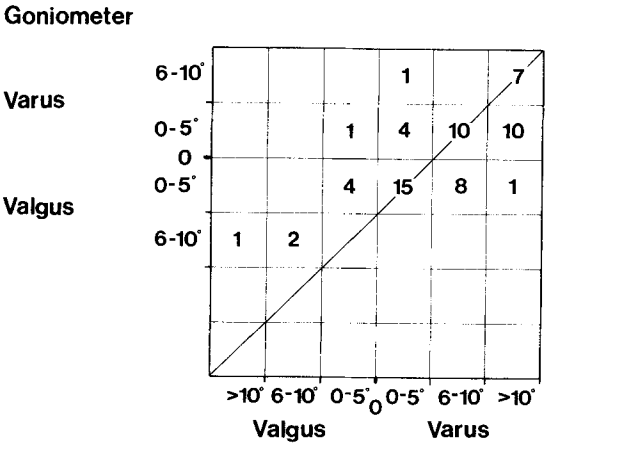


Figure 22. Correlation of roentgenographically determined angular deviation of the mechanical axis and goniometer recorded deformities after medial arthroplasty (n = 67).

THE TIBIAL COMPONENT

Position. There were great variations in the orientation of the tibial component. Thus in medial arthroplasty the tibial component sloped on average 9^{o} medially (range 22^{o} medially to 3^{o} laterally) and 4^{o} posteriorly (range 26^{o} posteriorly to 13^{o} anteriorly). In the lateral compartment there was a medial (central) slope of 2^{o} (range 4^{o} medially to 9^{o} laterally) and a posterior slope of 8^{o} (range 21^{o} posteriorly to 4^{o} anteriorly) (Table 24).

The zone of the bone-cement interface was recorded at the last roentgenographic examination. No zone was observed around 26 components, a small zone of 0-1 mm around 69 components, between 1-2 mm around 11 components, and 2-5 mm in one case (Table 25). The zone could not be determined in 5 knees.

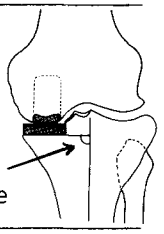
Evidence of loosening with fracture of the indication wire and buckling was observed at 26 tibial components (Table 25), more often at the thinner components (6 and 9 mm) or in 21 of 62 compared to 5 of 50 at the thicker components ($p < 0.01$).

Settling of the tibial component was observed in 16 cases (14 medial, 2 lateral). The magnitude of settling could not be measured with the roentgenographic technique used (Boegård et al. 1981).

Table 24. The inclincation of the tibial components in the frontal and sagittal planes in medial and lateral arthroplasties

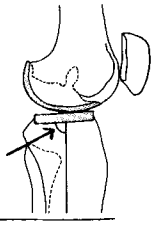
A. Antero-posterior projection

	Number operations	Number roentg. analyses	Mean PT angle	Range	SD	
Medial						
Year 1	23	21	81	70-91	5.3	
Year 2	28	28	80 81	68-90	5.7	5.2
Year 3	27	25	82	73-93	4.6	
Lateral						
	14	14	92	86-99	4.2	



B. Lateral projection

	Number operations	Number roentg. analyses	Mean PTS angle	Range	SD	
Medial						
Year 1	23	21	82	66-97	9.0	
Year 2	28	28	86 86	64-103	7.5	7.2
Year 3	27	24	89	74-99	5.3	
Lateral						
	14	14	82	69-94	7.2	



See Definitions for PT and PTS angles.

Table 25. Thickness of tibial components used, roentgenographic evidence of loosening and radiolucent zones

Thickness of tibial component	No. of components	No. with roentg.evidence of loosening (fraction)	Clin.symp. because of loosening	Reop.	Zone (mm)				Insuff. data
					None	0-1	1-2	2-3	
6 mm	11	5 (.5)	3	2	1	7	2	0	1
9 mm	51	16 (.3)	1	1	17	29	4	0	1
12 mm	30	4 (.1)	-	-	7	19	3	0	1
15 mm	13	1 (.1)	-	-	1	10	1	0	1
18 mm	4	-	-	-	0	2	1	0	1
21 mm	3	-	-	-	0	2	0	1	
	112	26	4	3	26	69	11	1	5
Medial	88	24 (.3)	4	3	24	52	8	0	4
Lateral	24	2 (.1)	0	0	2	17	3	1	1
Total	112	26 (.2)	4	3	26	69	11	1	5

RESULTS IN VARIOUS PATIENT GROUPS

Knees previously operated with tibial osteotomy. Eighteen knees underwent arthroplasty (15 medial, 3 medial + lateral) after a failed tibial osteotomy done 1-7 years earlier. The results in this group were somewhat inferior to virgin operations; only 10 knees rated satisfactory and four were failures. The failures did not seem to be directly related to the prior osteotomy as such (2 impingements between the femoral component and the tibial spine, 1 infection, and 1 degeneration of the contralateral compartment caused by loose pieces of cement), but not less than 8 were rated as unstable postoperatively. The average HSS score was 39 before and 76 after the operation. The infected knee had not had any sign of infection prior to the arthroplasty.

Knees with arthrosis secondary to osteonecrosis. There were 6 knees operated with medial arthroplasty for arthrosis secondary to osteonecrosis of the medial femoral condyle. Three of these

knees rated as failure, all because of technical complications (Table 3). The mean HSS score for this group was 78. However, 2 of the reoperated knees rated satisfactory after the operation and one acceptable. The average HSS score after reoperation was 90 points.

Overweight patients. In a group of 27 patients that weighed 85 kg or more the failure rate was somewhat higher than in the group as a whole or 6/27. However, the failures did not seem to be due to overweight as such.

Eight patients weighed 100 kg or more. In this group there was no failure and all knees rated satisfactory after a follow-up period of more than 4 years in 3 cases, 3 years in 2 cases and 2 years in 3 cases.

The oldest patients. There were 33 knees in patients 75 years or older. The rate of failure was slightly higher than in the whole group or 7/33 (fraction .2). The increased failure rate was due to the higher proportion of Stage IV-V arthrosis.

Remarkable Cases

A 79-year old woman (Case 054) had a medial arthroplasty for Stage V arthrosis of her left knee. Preoperatively she had a varus deformity of 10-15^{o}, pain at walking from the first step and a maximal walking distance of 100-200 m. The result of the arthroplasty was satisfactory and the walking distance at the one year follow-up was more than 3 km. Two and a half years after the arthroplasty the patient was treated at the Department of Internal Medicine for thyrotoxicosis with heart incompensation. Soon after discharge the patient fell and got a pertrochanteric fracture of the left femur. This was operated with open reduction and internal fixation with a McLaughlin plate and nail but after the operation she became icteric because of bile stasis and hemolysis of unknown origin. Her general condition was poor for several weeks and she had to be fed parenterally. During this poor condition she developed a gangrene of her left foot which necessitated a left-sided below knee amputation. The

hemolysis and the patient's jaundice were successfully treated and the amputation stump healed uneventfully. The patient could thereafter be rehabilitated with a below knee leg prosthesis and was at the 4-year follow-up and at the age of 83 years in full activity, taking care of her own household and able to walk 500-1000 m. Her knee still rated satisfactory and the HSS score was 82.

A 70-year old woman (Case 106) with Parkinson's disease got an osteonecrosis of the medial condyle of her right femur, developing to a Stage III medial gonarthrosis within a year and a half. She was then totally wheel-chair bound and completely dependent of others. She was operated with a medial arthroplasty (Case 6 in Bauer 1978). After a transient state of confusion postoperatively the patient was rehabilitated rather rapidly. At the 2-year follow-up she was living alone, taking care of her own household and had a walking distance of over 3 km. The knee rated satisfactory with range of motion 0-130^{o}, full stability and no pain. The HSS score was 95 compared to 24 preoperatively.

V. DISCUSSION

Ahlbäck (1968) observed that cartilage destruction in primary gonarthrosis is confined to one or two but almost never involves all the three articulations of the joint. The same pattern was found in this series (Figure 2); however, bi- and tricompartmental engagement was more common because this series consisted of knees with severe arthrosis chosen for arthroplastic surgery while Ahlbäck's series consisted of knees in an unselected outpatient material.

The focal nature of the disease was confirmed by Hernborg and Nilsson (1977) who found main involvement of the femoro-tibial compartment, medial or lateral, where it was initially observed 10-18 years earlier; the opposite compartment became involved as a late, secondary phenomenon in medial arthrosis, but this did not occur in lateral arthrosis.

The origin and mechanism of pain in gonarthrosis are still a matter of dispute. However, there is mounting evidence that correction of a varus deformity by tibial osteotomy in medial arthrosis can relieve pain and arrest progress of the disease (Bauer et al. 1969, Coventry 1973, Insall et al. 1974, Hagstedt 1974, Tjörnstrand 1981). Residual pain from simultaneous patellar arthrosis or late degeneration of the lateral femoro-tibial articulation has not been a matter of serious concern according to most authors.

Precisely because of the focal nature of arthrosis, as distinct from rheumatoid arthritis, unicompartmental replacement is an attractive alternative for patients with gonarthrosis not suitable for osteotomy because of age, medical condition, type, and/or stage of gonarthrosis.

During the period of introduction the technical pitfalls of a new technology are often slowly revealed in a process of trial-and-error, in retrospect interpreted as more or less obvious errors in the selection of patients and surgical technique. In

the treatment of gonarthrosis both indications for surgery and surgical technique have changed continuously during the 1960's and 1970's. The effect of this process has been dramatic. By today's standards one half of the patients reported by Bauer et al. (1969) should have had a prosthetic arthroplasty rather than an osteotomy because they had severe bone loss, gross instability or lateral arthrosis. The arthroplasty methods have been thoroughly modified in the search for stability without overburdening the bone stock; fixed hinge stem endoprostheses have lost ground to new devices. This trend is clearly evident in this report as in others on unicompartmental arthroplasties. Some authors have changed their indications and improved the operative technique (Marmor 1973, 1977, 1979, Dolibois & Mallory 1976, 1978, Larsson & Ahlgren 1979) while others have abandoned the technique and condemned the use of it (Insall & Walker 1976, Insall & Aglietti 1980, Laskin 1978).

ASSESSMENT SYSTEM

It is not easy to evaluate the effects of arthroplasty of the knee, and criteria for comparing different series of patients have not been universally accepted. The different nature of rheumatoid arthritis and gonarthrosis and in general very different aims of the treatment by knee arthroplasty in these groups of conditions make it difficult to assess them in the same terms.

For practical use the optimal assessment system should allow the examiner to assess the result by using only a few parameters included in the routine clinical examination. The Venn Diagram System of Bauer et al. (1969) answers this demand by combination of the three basic characteristics of knee function: mobility, stability and freedom from pain.

Mobility and stability are relatively easy to define (Hallén & Lindahl 1965) and examine relative to pain, which cannot be measured directly. The subjective nature of pain invites imprecise and vaguely described terms of characterization, e.g. none, mild,

moderate-severe, etc. This may be one reason for the large discrepancy in the results reported in different series of unicompartmental arthroplasty. However, pain can be defined in more precise terms. We have found an endurance test,the walking distance, to be a reasonably precise and relevant expression of knee function in patients with gonarthrosis. A painfree walking distance of 500 meters would allow most patients in urban areas to reach public transportation (Hernborg & Nilsson 1977). It seems reasonable therefore to assess a knee as painfree if it allows a walking distance of 500 meters without disturbing pain in spite of transient pain after longer walking distances or occasional patellar pain at special activities. This definition of a painfree knee is more taxing than one based on requirement or non-requirement of analgesics (Bauer et al. 1969); it reflects the higher ambition of surgeon and patients permitted by improved techniques for treatment of gonarthrosis.

Comparison with other assessment systems

By definition the central subset in the Venn Diagram contains "satisfactory" knees. The "non-satisfactory" knees were in turn "acceptable" if painfree, the most important objective of an arthroplasty for gonarthrosis; when this was not achieved the knee was a "failure".

Comparison of this assessment system with the HSS and LH systems revealed important similarities and dissimilarities, mainly based on different numbers of categories in each system. The 65 satisfactory knees were all included in the best categories of the other systems (Figure 23 A). However, these categories also included almost all those knees in this series which were painfree but had impaired mobility and/or stability, i.e. were non-satisfactory although acceptable. At the other end of the scale there was almost perfect agreement between the Venn Diagram system and the LH system whereas the HSS system rated no less than 7 of our failures as "fair" rather than "poor" (p. 49), indicating a too generous definition of "fair". However, if the categories of "failure" in the Venn Diagram System, "not acceptable" in the LH system and "fair + poor" in the HSS system, were evaluated in combination there was a very good agreement (Figure 23 B).

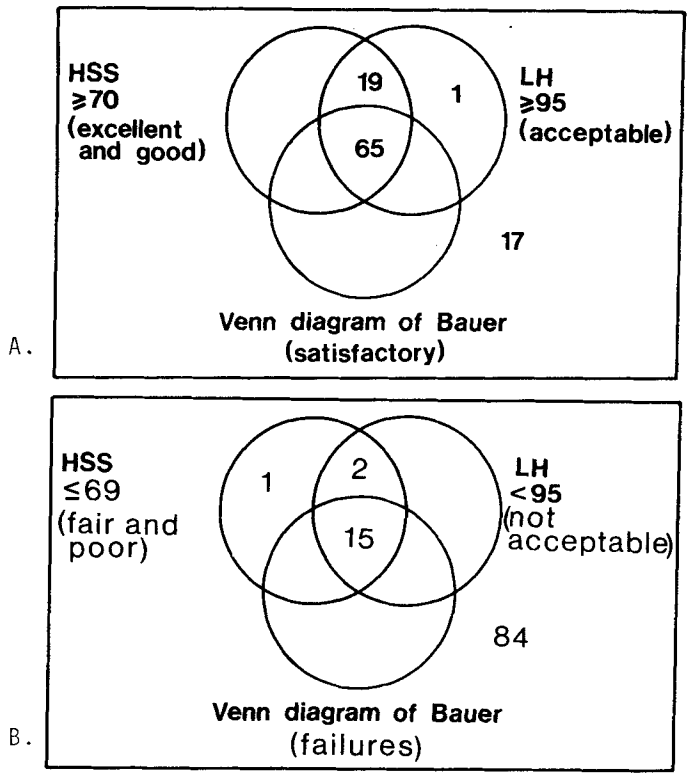


Figure 23 A-B. Comparison of knee assessment (102 knees)

With reduction of the 4 HSS and the 3 Venn Diagram System categories into 2 categories each not less than 99 knees had the same rating with 84 good and 15 poor results. The three systems therefore seem to be equivalent in separating the poor from the good knees.

However, in interpreting the results within each of these categories the HSS and LH systems give only marginal differences in numerical values without further information, while the Venn Diagram System illustrates which of the basic characteristics of the knee are normal and which are not. This feature and its simple construction of only 3 parameters easily observed at routine clinical examination makes it superior for use in assessment of arthrotic knees.

Simplified assessment system

In the majority of cases arthrosis does not cause disabling limitation of knee motion, and gross instability is usually associated with severe pain on walking. Comparison of Figure 14 with Table 18 shows a good fit between the pre- and postoperative Venn Diagrams and the different degrees of stair climbing ability; 13 of the 15 failed knees permitted at best climbing stair with one foot at a time, and only 2 of the failed knees were included in the 68 knees which permitted normal stair climbing; 64 of these 68 knees had improved their climbing ability at follow-up.

Very probably stair climbing ability would be an easy test to apply in multicenter investigations of arthroplasty for gonarthrosis; it is virtually free from subjective evaluation and it is not timeconsuming, a common complaint of participants in such investigations. With reference to the multicenter investigations of arthroplasty of the knee organized by the British (Aichroth et al. 1978) and the Swedish (Bauer et al. 1980) orthopaedic societies the examination of arthrosis patients could probably be simplified considerably without loss of information. Such simplified function assessment is clearly not suited for rheumatoid arthritis.

WHY FAILURE?

Pain

The definition of failure in this series was pain on walking within a distance of 500 m. Fifteen knees were rated as failures while the other 87 all had relief of walking pain.

In this series patellar arthrosis was found roentgenographically and/or visually in almost two thirds of the cases (Figure 2), and in Ahlbäck's (1968) series the patellar articulation was roentgenographically abnormal in one third of his 257 cases of medial femoro-tibial arthrosis. Some symptoms from the patellar joint are thus to be expected. The same situation arises in knees operated with osteotomy (Tjörnstrand 1981).

The opinion on the frequency and severity of patellar pain after knee arthroplasty differs widely. Flynn (1978) stated that 30 per cent had significant patellar complaints after 200 U.C.I. arthroplasties. Insall et al. (1976) found residual pain after arthroplasty to be most frequently attributed to the patellar articulation in their comparison of 4 models of arthroplasties without patellar replacement. Marmor (1977) reported 5 cases of 69 having patellar symptoms following unicompartmental arthroplasty which he, however, ascribed in all cases to impingement of the femoral component upon the patella rather than to a process of the patellar articulation. Engelbrecht et al. (1976) reported a 10 per cent frequency of patellar pain after resurfacing arthroplasty; in most cases the pain was well tolerated; patellectomy was done in 1 per cent of their cases. Neither Larsson & Ahlgren (1979) nor Andrews & Regan (1979) reported any disabling symptoms from the patellar articulation after 75 and 23 unicompartmental arthroplasties, respectively.

Insall & Walker (1976) did not find patellectomy to be a good solution in a series of 24 unicompartmental arthroplasties where four of the eight knees that rated "fair" or "poor" had patellar pain. However, in their series not less than 19 were patellectomized indicating that the state of the patellar articulation was poorer than usual compared to other series, and that patellar pain might have been the major source of pain even preoperatively.

Contrary to Miller et al. (1973) who found a clear relation between roentgenographic changes and clinical patellar symptoms in a group of non-operated patients, patellar symptoms in this series were unpredictable and not correlated with preoperative roentgenographic changes, and the same was observed by Insall et al. (1974). Neither could patellar symptoms in this series be predicted with any certainty by the macroscopic pathologic changes found at the operation (Figure 15).

Although patellar replacement may improve the results of arthroplasty in femoro-tibial arthrosis associated with patellar arthrosis (Finerman et al. 1979), this additional procedure carries a risk which is probably not indicated in the majority of cases.

It is an important question whether symptoms from the patellar joint are severe enough to spoil the result of a femoro-tibial knee arthroplasty.

In this series one third or 36 knees had patellar symptoms to some extent postoperatively. In 20 of these 36 knees patellar symptoms were negligible, occurring only occasionally and only at special patellar loading activities like stair climbing, rising from a chair, etc. In 11 cases patellar pain occurred rather frequently but mostly at special patellar loading activities. This pain was in some cases annoying but in no case severe enough to alter the patient's opinion of an otherwise good result since in most cases she/he was able to walk long distances and was socially independent. Only 5 knees had more constant patellar pain at this type of activities (Figure 15); two of these had femoro-tibial pain on walking as well and were rated as failures. One knee was rated as failure because of pain coming solely from the patellar articulation while two knees did well on occasional treatment with analgesics for the patellar pain making surgical treatment unnecessary.

Although patellar symptoms are quite common after femoro-tibial arthroplasty our conclusion is that in most cases it is mild and occasional and in general well tolerated by the patient, especially after explanation of its source and nature. Patellar pain is seldom disabling or of such severity that it spoils the overall result.

Instability

Although attainment of full stability is considered essential for good results with the newer types of endoprostheses (Freeman et al. 1978, Moreland et al. 1979) surprisingly few authors have commented on the postoperative stability after unicompartmental arthroplasty, and instability has not been stated to be a major cause of failed arthroplasties.

Engelbrecht et al. (1976) reported that about 10 per cent of 226 knees operated with sledge arthroplasty had "slight" instability (less than 20^{0}) and 4 per cent had severe instability postopera-

tively; seventy-five of their cases had rheumatoid arthritis and they did not relate the incidence of postoperative instability to diagnostic categories. They ascribed instability to improper selection of cases but stated at the same time that most deformities of up to 20^{o} may be overcome by implantation of a sledge prosthesis.

Larsson & Ahlgren (1979) reported instability in 8 of 75 knees operated with the St. Georg sledge prosthesis for gonarthrosis but they did not define stability in terms of degrees.

Postoperative stability as a parameter and its definition varies widely in different assessment systems used for arthroplasty. Bauer et al. (1969) used the existence or non-existence of thrust on walking; the Weinefeldt evaluation system (Andersen 1979) accepts instability up to 10^{o}; the HSS scoring system gives 10 points for a stable knee, 8 for mild instability ($0-5^{o}$) and 5 for moderate instability ($6-15^{o}$) of 100 possible points; the LH score does not assess stability at all (Appendix 1-2).

In this series instability, examined in extension according to Hallén & Lindahl (1965) was evaluated by rather strict criteria and was observed postoperatively in as many as 27 knees; instability was the single most important denominator associated with failure (Table 12) as 9 of 15 failures were rated unstable. Further instability was frequent in knees developing secondary arthrosis after unicompartmental arthroplasty. Instability was found significantly more often in knees with the most severe stages of arthrosis or in 13 of 36 Stage IV and V knees compared to 2 of 32 Stage III knees (Table 20).

The failure to obtain stability in this series was mainly ascribed to the operative technique used, especially in medial arthroplasties (p. 16). Sagittal stability recorded both pre- and postoperatively (Coded data) was uncommon and was not associated with late complication except in one case (073) where the primary cause was abnormal contact.

Restricted motion

Knees eligible for resurfacing arthroplasty usually have a fairly good range of motion. In this series the range of motion was 97^{o} preoperatively and it increased on average 13^{o} after the operation. Only three knees deteriorated, all because of postoperative complications.

Severe flexion deformity is also uncommon in this group of knees; in this series only 8 knees had a preoperative flexion deformity of 20^{o} or more (Figure 17). However, mild and moderate flexion deformities are rather common; 44 knees had a preoperative flexion deformity of 10^{o} or more and 69 knees of 5^{o} or more.

Insall & Walker's (1976) opinion that flexion deformity cannot be corrected by unicompartmental arthroplasty does not seem to apply to arthrosis. In this series flexion deformity decreased on average from 7^{o} to 2^{o} and only five knees had a postoperative flexion deformity of $>5^{o}$. A slight postoperative flexion deformity was, however, common in this series; 27 knees had a flexion deformity of $1\text{-}5^{o}$ but this did not seem to influence the functional result and was usually not noticed by the patient.

The effect of the operation on the flexion capacity is more uncertain. Even if flexion increased in three fourths of the knees in this series and the average gain was 8^{o}, 19 knees had $5\text{-}10^{o}$ decreased flexion postoperatively, and 4 knees 10^{o}

It can be concluded that the mild or moderate flexion deformity common in gonarthrosis suitable for compartmental arthroplasty is not a contraindication to this operation. Although moderate flexion deformities are not eliminated with certainty, the remaining deformity is usually negligible. In this series of 102 knees only 4 knees were unsatisfactory because of restricted motion only (Figure 14).

Loosening of the tibial component

Loosening of the tibial component has been a major cause of complication in most series of unicompartmental or condylar replace-

ments with reported incidence between 3 and 20 per cent. Thus Marmor (1979) had 11 loosenings of 6 mm tibial components in a series of 56 unicompartmental arthroplasties followed for more than 4 years, 6 of which needed reoperations. Mallory & Dolibois (1978) reported one in 21 cases, Engelbrecht et al. (1976) a loosening incidence of 3 per cent, Larsson & Ahlgren (1979) four in 75 cases, Insall & Walker (1976) 3 in 24 cases and Laskin (1978) one loosening in 37 cases. In bicompartmental arthroplasty Lacey (1978) using the UCI-prosthesis reported loosening of tibial components requiring reoperation in 7 per cent, and Freeman et al. (1978) reported loosening or tilting of the tibial component in 13 per cent with the ICLH-prosthesis.

The most obvious cause of loosening of the tibial component in unicompartmental arthroplasty is material failure, i.e. use of thin (6 mm) polyethylene components that on weight bearing show plastic deformation and cold flow of the component which breaks loose from the underlying cement fixation. Other causes that may lead to loosening of a tibial component are giving way of the underlying cancellous bone, caused by overloading that may be due to insufficient correction of deformity or deficient cementation technique.

Frank loosening of tibial components in this series occurred only in arthroplasties done during the first year, and all involved thin tibial components. Since 1977 components thinner than 9 mm have not been used and no new cases of frank loosening with clinical symptoms have occurred. As long as polyethylene is the material of choice for low friction arthroplasty it might be reasonable to put plastic components thinner than 10-12 mm on a metal tray for minimizing the deflections of compressive and destructive type between the component and the bone as suggested by Marmor (1979). Metal trays are used for bi- and tricompartmental arthroplasties. Further, the problem of loosening and settling of the tibial component can to some extent be solved by placement of the component on cortical bone as shown experimentally by Bargren et al. (1978), and clinically by Freeman et al. (1978). Shearing is one of the most important forces applied to the non-constrained surface replacements. Walker et al. (1976)

pointed out the risk for the anterior part of the tibial component to tilt when shearing forces are applied posteriorly. This force can be countered effectively by anchoring holes of sufficient size in the underlying bone improving the cementation bonds of the prosthesis.

Roentgenographic signs of loosening such as breakage of the marking wire, fracture of cement and buckling of a polyethylene component, were observed more often than clinical symptoms of loosening (Table 25). These signs were seen in as many as 5 of 11 6 mm components and in 16 of 51 9 mm components but occurred only in 5 of 50 cases in which thicker components were used (Table 25). These roentgenographic signs of loosening were seen far more frequently at the medial compartment as opposed to the lateral compartment.

The clinical importance of these findings is still uncertain as the majority of the knees were symptomfree. Similar findings with even higher frequency of roentgenographic signs of loosening were found in a series of compartmental arthroplasties for rheumatoid arthritis (Knutsson et al. 1981).

Radiolucent zones at the tibial component is a common finding after knee arthroplasty; Laskin (1978) reported findings of a zone in 86 per cent in unicompartmental arthroplasty, Ahlberg & Lindén (1977) in all of 40 St. Georg sledge prostheses and Lacey (1978) in 90 per cent after arthroplasty with the UCI prosthesis. In this series zones were found in 75 per cent of 112 tibial components examined (Table 25). A zone exceeding 2 mm was, however, found in only one case. The development of a radiographic zone around the polyethylene component of most knee prostheses thus seems to be rather a rule than an exception and is accepted as the normal course as long as the zone does not exceed 2 mm and the patient is symptomfree. A film of granulation tissue has been shown to develop between the cement and bone which probably is the explanation of this radiographic zone (Willert et al. 1974, Vernon-Roberts & Freeman 1977).

There is considerable evidence that micro-movements and migration

of polyethylene prostheses occur after total arthroplasty. By using stereophotogrammetry, with small tantalum markers placed in the polyethylene component and bone, Jönsson et al. (1981) showed that small but significant movements occurred in all 7 unicompartmental prostheses during the two first years after the operation. Baldursson et al. (1980) found significant migration of the acetabular cup in total hip replacements for rheumatoid arthritis.

Degeneration of the Opposite Compartment

Laskin (1978) reported degeneration of the lateral compartment in 4 of 34 unicompartmental medial arthroplasties. He suspected polyethylene particles to be the cause of cartilage degeneration as such particles were found ground into the surface of the cartilage at microscopic examination. He also considered overcorrection of a preoperative varus deformity as a possible cause. Engelbrecht et al. (1976) reported degeneration of the non-operated compartments in 16 of 243 unicompartmental arthroplasties. They did, however, not report how many of these occurred in the 20 unicompartmental arthroplasties done for rheumatoid arthritis in the same series. They warned against unicompartmental arthroplasty when even minor involvement of the opposite cartilage is observed.

Marmor (1979) reported degeneration of the opposite compartment in 2 of 56 unicompartmental arthroplasties followed for more than 4 years. Mallory & Dolibois (1978) and Larsson & Ahlgren (1979) reported no complication of this type in their series of 21 and 75 unicompartmental arthroplasties followed for 2-4 years.

Insall & Aglietti (1980) reported progress of arthrosis in the contralateral compartment in 11 of 22 knees 6 years after unicompartmental arthroplasty.

In this series of 92 unicompartmental arthroplasties 13 knees developed definite changes in the opposite compartment. Five of these were rated as failures while 8 were still symptomfree (Table 6). The majority of these knees or 11 had Stage IV and V medial arthrosis and all had subluxation of the tibia of more

than 0.5 cm before the operation which thus seems to be an especially unfavourable factor. The cause of secondary lateral arthrosis occurring in the present series could be explained in most cases. Thus it was, in addition to femoro-tibial subluxation, apparently related to overcorrection (more than 5^{o} valgus) in 3 cases, the danger of which has been pointed out previously by many authors (Laskin 1978, Sledge & Ewald 1979, Cartier 1979, Insall & Aglietti 1980, Goutallier 1981).

Loose cement in the joint was the obvious cause in 2 cases, a condition earlier described by Robins (1977). In 4 cases undercorrection (more than 5^{o} varus) was considered to be the cause of a secondary lateral arthrosis which occurred in significantly higher proportion in this category of knees compared to those corrected to a more desirable alignment ($<5^{o}$ valgus or varus). In other knees development of secondary lateral arthrosis was associated with combined instability and sloping of the tibial component more than 10^{o} medially.

Thus secondary arthrosis occurred almost only in knees with severe stage of arthrosis with femoro-tibial subluxation that had had a technically unsatisfactory operation,while it occurred in only one Stage III knee after follow-up for 4 1/2 years.

In knees operated with osteotomy for medial arthrosis there were only occasional and non-symptomatic cases with degeneration of the uninvolved compartment even after 5-10 years (Tjörnstrand 1981). From the theoretical point of view, unicompartmental arthroplasty should give the same result.

Polyethylene has neither caused severe foreign body reactions in the form of synovitis during more than a decade's extensive clinical use in arthroplasties in different joints nor have there been reports on its detrimental effect on cartilage in the patellar articulation in bicompartmental knee replacements. In normal rate of wear (Charnley & Halley 1975) the synovia is considered to be able to cope with the small particles released from the joint surfaces (Willert & Semlitsch 1975, Vernon-Roberts & Freeman 1977, Revell et al. 1978, Wroblewski 1979). The theory

of Laskin (1978) and Insall & Aglietti (1980) that particles of polyethylene from prosthetic wear cause the degeneration of the opposite compartment in unicompartmental arthroplasty is not proven. Detrimental effects of the polyethylene on the bone have been associated with abnormal rates of wear where large particles of polyethylene have been released(Mendes et al.1972, Wroblewski 1979).

The risk of degeneration of the opposite compartment in unicompartmental arthroplasty can probably be eliminated by the following measures: (1) careful selection of cases by thorough preoperative compartmental evaluation of the arthrosis by weight bearing radiography with varus and valgus stress, which in doubtful cases can be complemented by radionuclide bone imaging (Bauer & Smith 1969, Thomas et al. 1975); (2) avoidance of knees with significant femoro-tibial subluxation; (3) attainment of full stability and correct positioning of the prosthesis; (4) avoidance of overcorrection and gross undercorrection of the knee; (5) avoidance of excessive bone cement around the prosthetic component.

Abnormal contact between prosthesis and bone

Abnormal contact between prosthetic components and bone is essentially caused by malposition and incongruence of the prosthetic components, usually associated with instability and subluxation. The most frequently reported complication of this type is impingement of the patella on the anterior edge of the femoral component which was reported in 7 of 56 knees by Marmor (1979) and in 10 of 86 rheumatoid knees by Andersen (1979).

In this series impingement on the patella occurred in only one knee but it was not associated with pain. However, abnormal contact between a femoral component and the tibial spine occurred in 3 knees with reoperations in all (Table 3). This type of abnormal contact, often described under other headings of complications such as instability or dislocation, have been described by Sledge & Ewald (1979) and Shoji et al. (1976). The unconstrained design of most unicompartmental prostheses implies that good congruence between the prosthetic components and full stability are imperative; otherwise there is a risk of the components gliding off

each other resulting in abnormal contact.

Infection

Deep infection is a rather infrequent complication after unicompartmental arthroplasties; in this series only one knee had deep infection. The incidence of deep infection in the Swedish multicenter study of 1700 arthroplasties for gonarthrosis since 1976 is lowest for the unicompartmental arthroplasties or 1 per cent, compared to 4 per cent for bi- and tricompartmental arthroplasties, and 8 per cent for the hinged knees (Bauer et al. 1980).

In summary this series illustrates the teething problems of a new technique. The analysis of failures has revealed that the majority were caused by material and technical failure and/or improper selection of knees for this type of arthroplasty. Not less than 12 of 15 failures could have been prevented with knowledge gained from this study (Table 6). Thus only 3 failures, viz. one of unknown origin, one infection and one patellar arthrosis were not directly preventable. Likewise 12 of the 14 late complications without clinical symptoms could have been prevented. Most of the failures occurred in knees operated during the first year, decreased substantially during the second year with the lowest complication rate in arthroplasties done during the third year. The improved operative technique and stricter indications for this type of arthroplasty from the third year of this series has lowered the incidence of complications.

IMPROVEMENT OF UNICOMPARTMENTAL ARTHROPLASTY

The importance of correct prosthetic placement, good alignment of the extremity and acquirement of stability, has become evident by increased biomechanical research and analyses of failures (Lotke & Ecker 1977, Rand & Coventry 1980, Kagan II 1977, Ducheyne et al. 1978, Freeman et al. 1978). The statement of Swanson (1978) that standards of precision are becoming a condition for success in joint replacement is indeed true.

Stability and alignment

Instability in knees with gonarthrosis eligible for unicompartmental arthroplasty is usually moderate with only a slight lengthening of the collateral ligament on the convex side of the deformity and contracture principally of the capsular structures on the concave side, most often resulting in a mild fixed deformity. The cruciates are more or less intact with fairly good sagittal stability.

Theoretically correction of deformity with good lateral stability by spacer effect of the prosthesis should be relatively easy. This series has shown, however, that the operative technique of Marmor (1973) should be modified as follows:
(1) Release of the contracted capsule and its connection to bone through the menisco-tibial ligament (deep portion of the collateral ligament) simplifies the correction of varus deformity;
(2) Position of the tibial component on cortical bone gives better access to the operative field and simplifies putting in a component of sufficient height to ensure good alignment of the components and stability of the collateral ligaments during cementation. The optimal alignment of the extremity appears to be in the vicinity of a normal mechanical axis. In medial unicompartmental arthroplasty both overcorrection and gross undercorrection were unfavourable in this series, while slight undercorrection, or $0\text{-}5^{0}$ valgus (corresponding to an angular deviation of the mechanical axis by a few degrees of varus), seemed to be the most favourable. The desired alignment can be obtained by using a straight bar as described by Freeman et al. (1978) or by preoperative roentgenographic analysis (Villers & Cartier 1978).

Component positioning

The danger of improper component orientation resulting in excessive loads, component loosening and stress fractures have been demonstrated by Lotke & Ecker (1977), Lacey (1978) and Rand & Coventry (1980). It is becoming universally realised that positioning by eye is unreliable, and several newer designs are marketed with a set of positioning instruments.

In unicompartmental arthroplasty 2 types of orientation have to

be controlled: (1) orientation in relation to the long axis of the bones, and (2) orientation in the transversal plane and congruence between the femoral and tibial components.

In unconstrained arthroplasty inclination of the prosthesis is probably better tolerated than in constrained arthroplasty. In the present series inclination of the prosthesis in the frontal plane has not proven to be the direct cause of failure but was suspected to be an associated factor in several cases, especially development of secondary lateral arthrosis, where insufficient stability was associated with sloping of the tibial component medially maintaining the preoperative subluxation. The roentgenographic analyses of tibial component alignments showed great variations of position (Table 24), indicating that positioning by eye is difficult even for the experienced surgeon.

A definite source of failure in this series was malposition of the tibial component in the transversal plane with improper congruence between the femoral and tibial components which in combination with instability caused abnormal contact in 3 cases and loosening in one (Table 3).

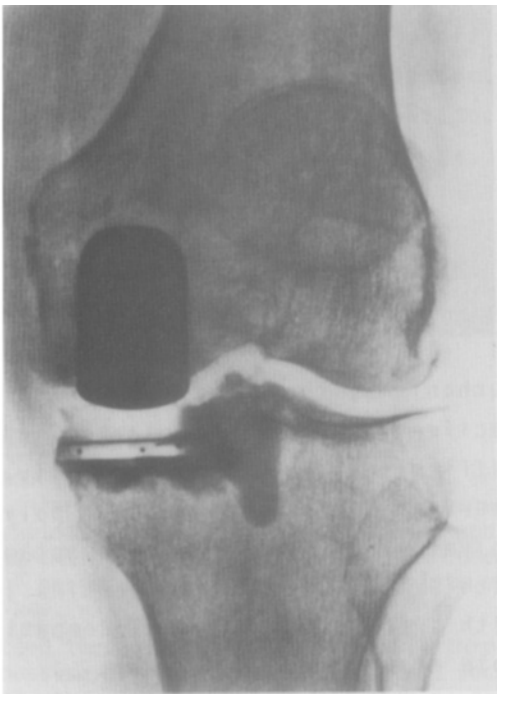
There appears thus to be a need for a positioning instrument not only to control the position of the components in relation to the long axes of the femur and tibia but especially for controlling the articulation between the components (Figure 24).

During the last months of this series a positioning jig from the French Lotus prosthesis was used for the resection of the tibial condyle and this has later been developed for positioning of the femoral component and ensurance of full congruence between both components (Jönsson & Lindstrand 1980).

Component wear

Wear of the polyethylene components in knee prostheses appears to be somewhat more extensive than has been reported in hip prostheses (Shoji et al. 1976, Charnley & Halley 1975, Cullen et al. 1977). Extensive wear rates in the knee are probably closely

A



B

C

Figure 24. Modified operative technique

A. Preoperative projection shows arthrosis secondary to osteonecrosis of the medial femoral condyle.

B. 1 year after unicompartmental arthroplasty with the aid of a guiding instrument. The PT-angle is 90^{o} and the tibial component lies on cortical bone. There is good congruence between the femoral and tibial components. The varus deformity has been corrected and good alignment has been obtained.

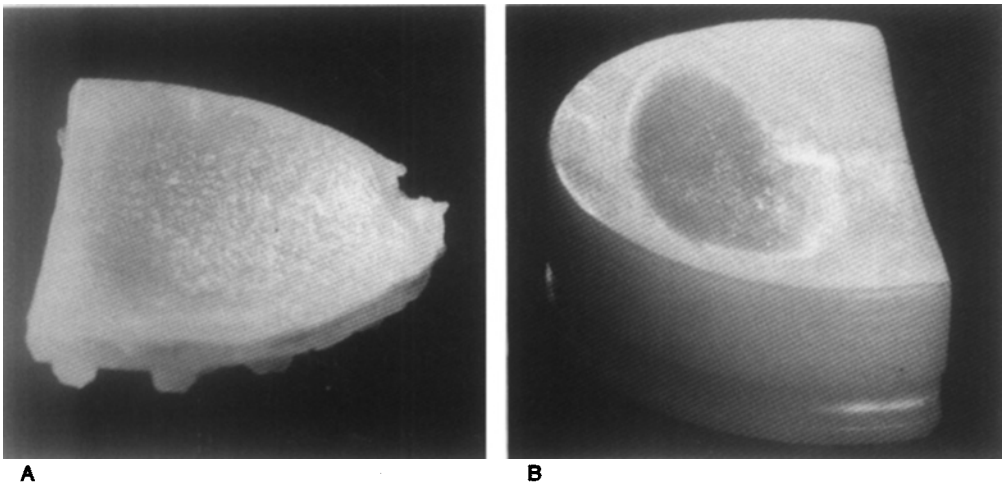
C. The PTS-angle is 87^{o}. There is good congruence and no flexion deformity.

related to the design of the prosthesis and enhanced by deformations or cracks in the polyethylene as well as malposition of components that can lead to erratic loading. There is evidence that the most severe cases of wear are due to entrapped particles of acrylic bone cement abrading the softer polyethylene (Revell et al. 1978). This type of wear can be avoided by thorough removal of excessive cement at the operation.

Recent research on polyethylene wear by Rose (1977) and Rose et al. (1979) has on the other hand shown a great variety of wear mechanisms, the most important of which are associated with defective fusion of the plastic in the moulding procedure which is difficult to avoid. Consequently, relatively wide variations in wear rate can be expected in polyethylene components. Although polyethylene has many disadvantages and an alternative material with better physical properties is highly desirable, such material with sufficiently high biocompatibility is apparently not available at present.

In the present series extensive wear of polyethylene components was only seen in one 6 mm prosthesis extracted because of loosening and in two because of infection. All were highly deformed and had acrylic particles embedded in the surface (Figure 25).

Stability of femoral components of the Marmor or St. Georg type, having large contact areas on cortical or subcortical bone, seem to be very good as only sporadic cases of femoral component loosening or settling have been reported. In this series one femoral component was found to be loose at reoperation done for secondary lateral arthrosis but there was preoperatively no suspicion of this by clinical and roentgenographic examinations. Failures connected with loosening or sinking in of the femoral component described by Williams et al. (1979) must be ascribed to the design of the femoral component used (the Manchester prosthesis).



A B

Figure 25. Wear of tibial components

A. A 6 mm tibial component extracted from a knee operated for medial arthrosis secondary to osteonecrosis three years earlier (Case 002, Figure 4). The patient had had clinical symptoms and evidence of roentgenographic loosening for two years. The indication wire was broken and the component is highly deformed with signs of heavy wear caused by methacrylate embedded in the polyethylene surface.

B. A 12 mm tibial component extracted three years after a medial arthroplasty for Stage IV arthrosis because of recurrent synovitis and secondary degeneration of the lateral compartment (Case 081). There is no excessive wear and no deformation of the component. This was typical for most tibial components extracted after reoperation in this series.

INDICATIONS FOR COMPARTMENTAL ARTHROPLASTY

The course of untreated gonarthrosis is usually progressive (Hernborg & Nilsson 1977); treatment by definite surgical intervention is indicated at an early stage (Tjörnstrand 1981). The possibilities of surgical treatment and hence indications for surgery have changed dramatically during the last two decades. Thus joint debridement and arthrodesis being the only alternatives during the fifties lost ground to the osteotomies during the sixties which in turn were superseded by the arthroplasties during the seventies. The pattern for choice of treatment of gonarthrosis has, however, taken different courses at different centres. The preference at some institutions border on a monotherapy by one type of prosthesis (Insall et al. 1979) while differentiated treatment for the different types and stages of arthrosis is advocated by others. In Sweden half of the arthroplasties performed for gonarthrosis during 1976-1979 were of

the compartmental type (Bauer et al. 1980). The development at the Department of Orthopaedic Surgery in Lund during the seventies is illustrated in Figure 26.

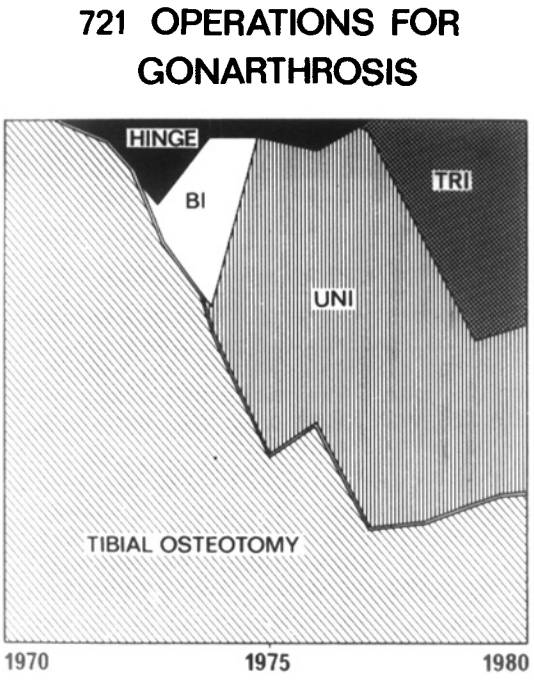


Figure 26. Operations for gonarthrosis in Lund during the period 1970-1980. Osteotomy decreased when the knee prostheses were introduced; since 1977 the osteotomy fraction has constantly been one quarter of the operations. The unicompartmental prosthesis was almost the only one used during the operation period of this series but has lost ground to the tricompartmental prosthesis. Uni-, bi- and tri- stand for unicompartmental etc endoprostheses (Knutsson & Lindstrand 1980). Hinge means hinge endoprostheses.

Thus, by today's standards the choice of surgery depends on the type and stage of arthrosis, and by the general condition of the patient. Osteotomy gives long-lasting pain relief and prevents further progress of the disease provided adequate correction is obtained (Tjörnstrand 1981). However, rehabilitation following osteotomy is strenuous for older patients, full correction is difficult to achieve in medial arthrosis Stage IV and over, and lateral arthrosis is not suited for osteotomy (Shoji & Insall 1973). Osteotomy must therefore be considered the operation of choice in younger patients with Stage I-III medial gonarthrosis.

The results after medial arthroplasty in the early stages of medial arthrosis have been good in this series, even after 5 years. Similar results have been reported by many authors (Mallory & Dolibois 1978, Marmor 1979, Larsson & Ahlgren 1979). The rapid recovery after a unicompartmental arthroplasty therefore makes this method attractive for the elderly and weak patients. Contrary to Rozing et al. (1980) we have had good results of unicompartmental arthroplasty for arthrosis secondary to osteonecrosis.

Even pronounced critics of unicompartmental arthroplasty (Insall & Aglietti 1980, Laskin 1979) have accepted this method for lateral gonarthrosis and this was confirmed in this series.

Sound strategy for attacking problems should include the possibility for honourable retreat. Salvage operations for non-union after high tibial osteotomy can be performed with good result (Tjörnstrand et al. 1978) and late complications in this series could be adequately treated. On the other hand the rate of fusion, after arthrodesis done for failed arthroplasties in 80 knees, in the Swedish multicenter study was significantly lower for both bi-tricompartmental and hinged than for unicompartmental cases (Lidgren et al. 1981).

Based on the experience gained from this series and recent reports of others, the following range of general indications for unicompartmental arthroplasty in gonarthrosis can thus be recommended.

Medial arthroplasty for patients older than 65 years with medial unicompartmental arthrosis Stage I-III and minor tibial subluxation.

Lateral arthroplasty for patients with lateral unicompartmental arthrosis Stage I-IV, even in middle aged persons; tibial subluxation does not seem to be a problem in these cases.

Contraindications. In this series the results for Stage IV-V medial gonarthrosis operated with unicompartmental arthroplasty

were significantly poorer than for the earlier stages when material failures of the thin tibial components were excluded. The incidence of secondary progressive arthrosis in the opposite compartment was significantly higher in Stage IV-V knees. Even if the majority of these knees were inadequately operated, it must be concluded that medial arthroplasty is contraindicated in Stage IV-V arthrosis with coexisting femoro-tibial subluxation while non-subluxed knees seem to be eligible for this technique. In these knees we feel, like Ahlberg & Lindén (1977), that arthroplasty of the tricompartmental type is the method of choice rather than medial + lateral unicompartmental arthroplasty. The former operation is simpler and the patellar joint is included in the arthroplasty; we have had good experience with the Total Condylar endoprosthesis in this type of severe arthrosis including the 4 reoperations reported here (Jönsson et al. 1980).

In addition to the stages of arthrosis where unicompartmental arthroplasty is clearly contraindicated, the following conditions may constitute a relative contraindication or need for special consideration before a decision is made as to which treatment is to be chosen.

(1) Pyrophosphate arthritis. Knees with known recurrent pyrophosphate arthritis may continue to have such attacks after the arthroplasty.

(2) Patellar arthrosis. Femoro-tibial arthrosis associated with severe patellar symptoms probably should be operated with tricompartmental arthroplasty.

VI. SUMMARY

102 knees in 93 patients, age 71 (52-88) years, operated during a 3-year-period with compartmental endoprostheses for arthrosis were followed prospectively for 3 1/2 (2-5) years. A subgroup of 31 knees was followed for 4 1/2 years.

All stages and types of arthrosis were represented and most knees had severe symptoms with longstanding pain as the main indication for the operation. There were 78 medial, 14 lateral and 10 medial + lateral arthroplasties.

The operative technique described by Marmor (1973) was used in the majority of cases. Prophylactic antibiotic and antithrombotic treatment was administered routinely. Suction drainage for 24-36 hours was used. Early mobilisation with full weight bearing was practised. The average hospital stay was 12 days. Postoperative follow-ups were done at 6 weeks, 6 months, one year and then annually.

Three wellknown systems were used in assessment of the results: (1) the Venn Diagram System of Bauer et al. (1969), (2) the Hospital for Special Surgery (HSS) Knee Rating Scale, and (3) the London Hospital (LH) Points Scoring System, and these were compared. The Venn Diagram System rated 65 knees satisfactory, 22 acceptable (lack of mobility or stability, but painfree) and 15 failures (not painfree). Pain on walking was relieved in 87 knees.

The majority of failures were caused by material and technical factors and improper selection of knees for this type of arthroplasty. Poor results were related to postoperative instability, inadequate correction of deformity, and malposition of the prosthetic components.

The range of motion was improved on average by 13^{o} and the flexion deformity decreased from 7^{o} to 2^{o}. Stability was improved in most knees but 27 knees did not get full stability; deficient stability was the most common denominator in knees with late complications and failure.

Social function expressed in terms of independence, requirement of analgesics and walking ability was dramatically improved.

Comparison of different types of arthroplasties showed similar results in medial and lateral unicompartmental arthroplasty with the highest rate of satisfactory knees in the former and the lowest rate of failures in the latter. The results in medial + lateral arthroplasties were somewhat inferior.

In medial arthroplasty the results were related to the stage of arthrosis, being clearly superior in Stage III arthrosis compared to Stage IV and V. Results in Stage I and II arthrosis were spoiled by a high incidence of loosening of the thin tibial components used in these knees.

Progressive arthrosis in the contralateral compartment after unicompartmental arthroplasty occurred in 12 of 78 medial arthroplasties and in one of 14 lateral arthroplasties. This complication occurred, however, almost exclusively in Stage IV and V arthrosis knees with femoro-tibial subluxation.

Co-existing patellar arthrosis did not seem to influence the results of the operation to any significant degree.

Reoperations were performed in 13 knees with revision in 5, conversion to another prosthesis in 7, and patellar arthroplasty in one. The end-result was satisfactory in 9 knees, acceptable in 2 and failure in 2. The final results in the 102 knees after reoperation of failures were 74 satisfactory knees, 24 acceptable, and 4 failures.

It was concluded that:

(1) Unicompartmental arthroplasty is a good operation for unicompartmental femoro-tibial arthrosis, i.e. in the medial type through Stage III and in the lateral type through Stage IV.

(2) There is a considerable risk of progressive lateral arthro-

sis after medial arthroplasty in Stages IV and V with femoro-tibial subluxation.

(3) It is important to achieve stability and correction of deformity in compartmental knee arthroplasty.

(4) The operative technique (Marmor 1973) used in this series can be improved by the use of guide instruments for positioning of the tibial component on cortical rather than on cancellous bone only, and correction of deformity by release of soft structures.

(5) Thin tibial components should not be used.

(6) Late complications after compartmental arthroplasty can be adequately treated by salvage operations.

VII. APPENDIX

1. THE HOSPITAL FOR SPECIAL SURGERY (HSS) KNEE RATING SCALE
(Ranawat & Shine 1976)

1. PAIN - 30 points	
1. No pain at any time	30
2. No pain on walking	15
3. Mild pain on walking	10
4. Moderate pain on walking	5
5. Severe pain on walking	0
6. No pain at rest	15
7. Mild pain at rest	10
8. Moderate pain at rest	5
9. Severe pain at rest	0
2. FUNCTION - 22 points	
A1. Walking and standing unlimited	12
2. Walking distance of 5 to 10 blocks and standing ability intermittent (more than 1/2 hour)	10
3. Walking 1 to 5 blocks and standing ability up to 1/2 hour	8
4. Walk less than 1 block	4
5. Can't walk	0
B1. Climb stairs	5
2. Climb stairs with support	2
3. Transfer activity	5
4. Transfer activity with support	2
3. ROM - 18 points	
1. 1 point for each 8^{o} of arc of motion-maximum of 18 points	
4. MUSCLE STRENGTH - 10 points	
1. Good-Can't break quadriceps power	10
2. Good-Can break quadriceps power	8
3. Fair-Moves through arc of motion	4
4. Poor-Can't move through arc of motion	0
5. FL DEFORMITY - 10 points	
1. No deformity	10
2. Few degrees	8
3. $5\text{-}10^{o}$	5
4. 11^{o} or more	0
6. INSTABILITY - 10 points	
1. N	10
2. Mild - $0\text{-}5^{o}$	8
3. Moderate - $6\text{-}15^{o}$	5
4. Severe - 16^{o} or more	0

Remarks: Substract 1 point for using a cane, 2 points for 1 crutch and 3 points for 2 crutches. Two points for 5^{o} of extension lag, 3 points for 10^{o} and 5 points for 15^{o} or more. One point for 5^{o} valgus and varus deformities.

Excellent 85-100, Good 70-84, Fair 60-69, Poor < 60.

2. THE LONDON HOSPITAL (LH) POINTS SCORING SYSTEM FOR AN OVERALL ASSESSMENT OF FUNCTION (Freeman et al. 1977)

		Points
Pain	None	50
	Mild	40
	Moderate	15
	Severe	0
Ability to walk	Outdoors, 30+ minutes	20
	Outdoors, 0-30 minutes	15
	Indoors	5
	Unable	0
Range of movement	80^{o} +	30
	$60\text{-}79^{o}$	20
	$30\text{-}59^{o}$	5
	$0\text{-}29^{o}$	0
Acceptable function	Pain	40-50
	Function	15-20
	Movement	30
	If "acceptable" in all above categories	10
	Overall assessment	95-110

3. THE BRITISH ORTHOPAEDIC ASSOCIATION KNEE FUNCTION ASSESSMENT CHART (Aichroth et al. 1978)

The knees in this series were assessed according to the British Orthopaedic Association Knee Function Assessment Chart. The preoperative status and that at the last interview are tabulated beneath, except for subjective assessment, gait and extension lag.

PAIN

(4) None
(3) Mild pain, not interfering with activities or sleep
(2) Moderate pain, either reducing activities or disturbing sleep
(1) Severe pain

ABILITY TO WALK

Distance	*or*	*Time*
(5) >1 kilometre (unlimited)		>60 minutes
(4) Up to 1 kilometre		30-60 minutes
(3) Up to 500 metres		10-30 minutes
(2) 50-100 metres (outdoors)		5-10 minutes
(1) Indoors only		Indoors only
(0) Unable		Unable

WALKING AID

(4) None
(3) Stick outside
(2) Stick always
(1) Two sticks/crutches/frame
(0) Unable to walk

FLEXION DEFORMITY

(5) 0 degrees
(4) <10 degrees
(3) 11-20 degrees
(2) 21-30 degrees
(1) >30 degrees

MAXIMUM FLEXION

(4) >100 degrees
(3) 81-100 degrees
(2) 61-80 degrees
(1) <60 degrees

VALGUS ANGLE

When the tibia is stressed laterally

(4) 0-10 degrees
(3) <20 degrees
(2) <30 degrees
(1) >30 degrees

VARUS ANGLE

When the tibia is stressed medially

(5) 0 degrees
(4) <10 degrees
(3) <20 degrees
(2) <30 degrees
(1) >30 degrees

ABILITY TO GET OUT OF CHAIR

(4) with ease
(3) With difficulty
(2) Only by using arms
(1) Unable

ABILITY TO CLIMB STAIRS

(4) Normal
(3) One step at a time
(2) Only with a bannister, stick or both
(1) Unable or only by bizarre method

Clinical assessment pre- and postoperatively in 102 knees

	Grade of assessment									
	0		1		2		3		4	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Pain	-	-	89	11	13	5	0	22	0	64
Ability to walk	2	0	14	3	30	2	38	19	18	78
Walking aid	1	0	32	10	34	14	23	33	12	45
Gait										
Flexion deformity	-	-	0	0	3	0	42	1	57	101
Maximal flexion	-	-	2	1	12	5	29	17	59	79
Extension lag										
Valgus angle	-	-	2	0	3	0	10	3	0	44
Varus angle	-	-	0	0	4	0	51	0	32	55
Get out of chair	-	-	1	0	61	8	36	48	4	46
Climb stairs	-	-	9	1	89	31	4	43	0	27

In the assessment of, ability to walk, flexion deformity and varus angle, grades 4 and 5 of the chart are here united to one grade 4.

VIII. ACKNOWLEDGEMENTS

I wish to express my gratitude to:
The patients of this investigation and the personnel of the Departments of Orthopaedic Surgery and Diagnostic Radiology in Lund.

Claes Westrup for introducing me to the minicomputer,
Karl-Göran Thorngren for statistical advice,
Karin Nilsson and Jan Strömblad for help with the illustrations,
Göran Eliasson, Kaj Knutsson, Ingemar Nilsson and the Photographic Department in Lund for help with photographs,
Brian Casey for constructive criticism,
Margaretha Håkanson for typing the manuscript.

Financial support was obtained from the Swedish Medical Research Council (Project No. B81-17X-02030l-15C), Stiftelsen Konsul Thure Carlsson's Minne, Stiftelsen för bistånd åt vanföra i Skåne and Alfred Österlund's Stiftelse.

IX. REFERENCES

Ahlberg, A. & Lindén, B. (1977) Arthroplasty of the knee in osteoarthritis and rheumatoid arthritis. Acta Orthop Scand 48:99-104.

Ahlberg, A. & Lindén, B. (1977) The radiolucent zone in arthroplasty of the knee. Acta Orthop 48:687-690.

Ahlbäck, S. (1968) Osteoarthrosis of the knee. A radiographic investigation. Acta Radiol Suppl. 277.

Aichroth, P., Freeman, M.A.R., Smillie, J.S. & Souter, W.A. (1978) A knee function assessment chart. J Bone Joint Surg 60-B:308-309.

Andersen, J.L. (1979) Knee arthroplasty in rheumatoid arthritis. Acta Orthop Scand Suppl. 180.

Andrews, J.R. & Regan, T.P. (1979) Unicompartmental replacement for medial compartment gonarthrosis. Preliminary report. South Med J 72:675-680.

Baldursson, H., Hansson, L-I., Olsson, T.H. & Selvik, G. (1980) Migration of the acetabular socket after total hip replacement determined by roentgen stereophotogrammetry. Acta Orthop Scand 51:535-540.

Bargren, J.H., Day, W.H., Freeman, M.A.R. & Swanson, S.A.V. (1978) Mechanical tests on the tibial components of non-hinged knee prosthesis. J Bone Joint Surg 60-B:256-261.

Bauer, G.C.H. (1978) Osteonecrosis of the knee. Clin Orthop. 130:210-217.

Bauer, G.C.H. et al. (1980a) Knee joint surgery in arthrosis and rheumatoid arthritis. Läkartidn 77:2085-2118.

Bauer, G.C.H., Insall, J. & Koshino, T. (1969) Tibial osteotomy in gonarthrosis. J Bone Joint Surg 51-A:1545-1563.

Bauer, G.C.H., Knutsson, K. & Lindstrand, A. (1980b) Svenska knäartroplastiker. Läkartidn 77:2088-2091 (in Bauer et al. 1980a).

Bauer, G.C.H. & Smith, E.M. (1969) ^{85}Sr scintimetry in osteoarthritis of the knee. J Nuclear Med 10:109-116.

Boegård, T., Egund, N., Jönsson, G. & Lindstrand, A. (1981) Radiographic evaluation of unicompartmental arthroplasties for medial gonarthrosis. Relation to clinical results. To be published.

Cartier, P. (1979) Positioning of the medular knee prosthesis, causes of failures, analysis - technical and radiological solutions. Read at the 1st Congress of the International Society of the Knee. Lyon, France.

Charnley, J. & Halley, D. (1975) Rate of wear in total hip replacement. Clin Orthop 112:170-179.

Connes, H. (1973) Hoffman's double frame external anchorage. Applications and results in 160 observations. Ed. Gaed, Paris.

Coventry, M.B. (1973) Osteotomy about the knee for degenerative and rheumatoid arthritis; indications, operative technique and results. J Bone Joint Surg 55-A:23-48.

Cullen, J.C., Tietjens, B.R., Poon, J. & Gavin, J.B. (1977) A scanning electron microscopic study of wear in the plastic components of prosthetic knee and hip joints. Aust NZ J Surg 47:189-192.

Dolibois, J.M. & Mallory, T.A. (1976) Unicompartmental total knee replacement. Clin Orthop 115:199-203.

Drenick, E.J. (1979) Definition and health consequences of morbid obesity. Surg Clin North Am 59:963-976.

Ducheyne, P., Kagan II, A. & Lacey, J.A. (1978) Failure of total knee arthroplasty due to loosening and deformation of the tibial component. J Bone Joint Surg 60-A:384-391.

Egund, N. & Norman, O. (1979) Pre- och postoperativ röntgenundersökning vid hög tibiaosteotomi. Nord Kongr Med Radiol Stockholm.

Engelbrecht, E., Siegel, A., Röttiger, J. & Buchholz, H.W. (1976) Statistics of total knee replacement; partial and total knee replacement design St. Georg. A review of a 4-year observation. Clin Orthop 120:54-64.

Finerman, G.A.M., Coventry, M.B., Riley, L.H., Turner, R. H. & Upshaw, J.E. (1979) Anametric total knee arthroplasty. Clin Orthop 145:85-90.

Flynn, L.M. (1978) Experiences with U.C.I. total knee. Clin Orthop 135:188-191.

Freeman, M.A.R., Todd, R.C. & Cundy, A.D. (1977) The presentation of the results of knee surgery. Clin Orthop 128:222-227.

Freeman, M.A.R., Todd, R.C., Bamert, P. & Day, W.H. (1978) ICLH arthroplasty of the knee: 1968-1977. J Bone Joint Surg 60-B: 339-344.

Goutallier, D. (1981) Early failures of uni-compartmental prostheses in the treatment of osteoarthritis of the knee. Read at the 2nd Congress of the International Society of the Knee. New Orleans, USA.

Gunston, F.H. (1971) Polycentric knee arthroplasty: Prosthetic simulation of normal knee movement. J Bone Joint Surg 53-B: 272-277.

Hagstedt, B. (1974) High tibial osteotomy for gonarthrosis. Thesis, Lund, Sweden.

Hallén, L.G. & Lindahl, O. (1965) The lateral stability of the knee joint. Acta Orthop Scand 36:179-191.

Hernborg, J.S. & Nilsson, B.E. (1977) The natural course of untreated osteoarthrosis of the knee. Clin Orthop 123:130-137.

Insall, J., Shoji, H. & Mayer, V. (1974) High tibial osteotomy. A five-year evaluation. J Bone Joint Surg 56-A:1397-1405.

Insall, J., Ranawat, C.S., Aglietti, P. & Shine, J. (1976) A comparison of four models of total knee-replacement prostheses. J Bone Joint Surg 58-A:754-763.

Insall, J. & Walker, P. (1976) Unicondylar knee replacement. Clin Orthop 120:83-85.

Insall, J., Scott, W.N. & Ranawat, C.S. (1979) The Total Condylar knee prosthesis. J Bone Joint Surg 61-A:173-180.

Insall, J. & Aglietti, P. (1980) A five to seven-year follow-up of unicondylar arthroplasty. J Bone Joint Surg 62-A:1329-1337.

Jónsson, G., Egund, N., Lindstrand, A., Ryd, L. & Selvik, G. (1981) The stability of the tibial component in unicompartment arthroplasty for gonarthrosis. Determined by stereophotogrammetry. To be published.

Jónsson, G. & Lindstrand, A. (1980) Unikompartmentplastik med riktinstrumentarium vid gonartros. Läkartidn 77:2102-2103 (in Bauer et al. 1980a)

Jónsson, G., Lindstrand, A. & Stenström, A. (1980) Total condylar endoprotes vid gonartros. Läkartidn 77:2106-2107 (in Bauer et al. 1980a).

Kagan II, A. (1977) Mechanical causes of loosening in knee joint replacement. J Biomech 10:387-391.

Kamme, C. & Lindberg, L. (1981) Aerobic and anaerobic bacteria in deep infections after total hip arthroplasty. Clin Orthop, in press.

Knutsson, K., Jönsson, G., Andersen, J.L., Lárusdóttir, H. & Lidgren, L. (1981) Deformation of the tibial component related to its' thickness in unicompartment knee endoprostheses. Acta Orthop Scand, accepted for publication.

Knutsson, K. & Lindstrand, A. (1980) Nomenklatur vid artroplastik med knäendoprotes. Läkartidn 77:2087-2088 (in Bauer et al. 1980a).

Lacey, J.A. (1978) A statstical review of 100 consecutive "U.C.I." low friction knee arthroplasties with analysis of results. Clin Orthop 132:163-166.

Larsson, S-E. & Ahlgren, O. (1979) Reconstruction with endoprosthesis in gonarthrosis. A report of 111 consecutive cases operated upon from 1973 through 1977. Clin Orthop 145:126-135.

Laskin, R.S. (1978) Unicompartmental tibio-femoral resurfacing arthroplasty. J Bone Joint Surg 60-A:182-185.

Laskin, R.S. (1979) Total knee replacement. Orthop Clin North Am 10:223-247.

Lidgren, L., Ekelund, L., Hovelius, L., Knutsson, K. & Lindstrand, A. (1981) Arthrodesis after failed knee arthroplasty. 80 patients. A multicenter investigation. 1st Meeting of the European Rheumatoid Surgical Society. Vienna April 23-25, 1981.

Lotke, A. & Ecker, M.L. (1977) Influence of positioning of prosthesis in total knee replacement. J Bone Jont Surg 59-A: 77-79.

Mallory, T.H. & Dolibois, J.M. (1978) Unicompartmental total knee replacement. A 2-4-year review. Clin Orthop 134:139-143.

Maquet, P. (1976) Biomechanics of the knee with application to the pathogenesis and the surgical treatment of osteoarthritis. Springer Verlag, Berlin.

Marmor, L.(1973) The modular knee. Clin Orthop 94:242-248.

Marmor, L. (1977) Results of single compartment arthroplasty with acrylic cement fixation. A minimum follow-up of 2 years. Clin Orthop 122:181-188.

Marmor, L. (1979) Marmor modular knee in unicompartmental disease (minimum 4-year follow-up). J Bone Joint Surg 61-A:347-353.

Mendes, D.G., Walker, P.S., Figarola, F. & Bullough, P.G. (1972) Total surface hip replacement in the dog: a clinical and pathological study. J Bone Joint Surg 54-A:1124-1125.

Miller, R., Kettelkamp, D.B., Laubenthal, K.N., Karagiorgos, A. & Smidt, G.L. (1973) Quantitative correlations in degenerative arthritis of the knee. J Bone Joint Surg 55-A:956-962.

Moreland, J.R., Thomas, R.J. & Freeman, M.A.R. (1979) ICLH replacement of the knee 1977 and 1978. Clin Orthop 145:47-59.

Norman, O. (1974), in Hagstedt, B. 1974.

Ranawat, C.S., Insall, J. & Shine, J. (1976) Duo-condylar knee arthroplasty. Clin Orthop 120:76-82.

Rand, J.A. & Coventry, M.B. (1980) Stress fractures after total knee arthroplasty. J Bone Joint Surg 62-A:226-233.

Revell, P.A., Weightman, B., Freeman, M.A.R. & Vernon-Roberts, B. (1978) The production and biology of polyethylene wear debris. Arch Orthop Traum Surg 91:167-181.

Robins, P.R. (1977) Internal derangement of the knee caused by a loose fragment of methylmethacrylate following unicompartmental total knee arthroplasty. Clin Orthop 128:208-209.

Rose, R.M. (1977) On the behaviour of polyethylene in total joint prostheses. Bull Hosp Joint Dis 38:45-46.

Rose, R.M., Crugnola, A., Ries, M., Cimino, W.R., Paul, I. & Radin, E.L. (1979) On the origins of high in vivo wear rates in polyethylene components of total joint prostheses. Clin Orthop 145:277-286.

Rozing, P.M., Insall, J. & Bohne, W.H. (1980) Spontaneous osteonecrosis of the knee. J Bone Joint Surg 62-A:2-7.

Shoji, H. & Insall, J. (1973) High tibial osteotomy for osteoarthritis with valgus deformity. J Bone Joint Surg 55-A:963.

Shoji, H., D'Ambrosia, R.D. & Lipscomb, P.R. (1976) Failed polycentric total knee prostheses. J Bone Joint Surg 58-A:773-777.

Skolnick, M.D., Bryan, R.S. & Peterson, L.F.A. (1975) Unicompartmental polycentric knee arthroplasty. Clin Orthop 112:208-214.

Sledge, C.B. & Ewald, F.C. (1979) Total knee arthroplasty. Experience at the Robert Breck Brigham Hospital. Clin Orthop 145:78-84.

Swanson, S.A. (1978) The state of the art in joint replacement. Part 3: Results, problems and trends. J Med Eng Technol 2: 16-20.

Thomas, R.H., Resnick, D., Alazraki, N.P., Daniel, D. & Greenfield, R. (1975) Compartmental evaluation of osteoarthritis of the knee: a comparative study of available diagnostic modalities. Radiology 116:585-594.

Tjörnstrand, B. (1981) Tibial osteotomy for medial gonarthrosis. Thesis, Lund, Sweden.

Tjörnstrand, B., Hagstedt, B. & Persson, B.M. (1978) Results of surgical treatment for non-union after high tibial osteotomy in osteoarthritis of the knee. J Bone Joint Surg 60-A: 973-977.

Walker, P.S., Ranawat, C. & Insall, J. (1976) Fixation of the tibial components of condylar replacement knee prostheses. J Biomech 9:269-275.

Vernon-Roberts, B. & Freeman, M.A.R. (1977) The tissue response to total joint replacement prostheses. In: The scientific basis of joint replacement. Eds: Swanson, S.A.W. & Freeman, M.A.R., Pitman Medical, pp. 86-129.

Villers, P. & Cartier, P. (1978) Procédé de mensuration radiologique pour la mise en place des prothèses partielles du genou. Ann Radiol 21:545-546.

Willert, H.G., Ludwig, J. & Semlitsch, M. (1974) Reaction of bone to methacrylate after hip arthroplasty. A long-term gross, light microscopic and scanning electron microscopy study. J Bone Joint Surg 56-A:1368-1382.

Willert, H.G. & Semlitsch, M. (1975) Reactions of the articular capsule to plastic and metallic wear products from joint endoprostheses. Sulzer Tech Rev 2:119-

Williams, E.A., Hargadon, E.J. & Davies, D.R.A. (1979) Late failure of the Manchester prosthesis. Its relationship to the disease process. J Bone Joint Surg 61-B:451-454.

Wroblewski, B.M. (1979) Wear of high-density polyethylene on bone and cartilage. J Bone Joint Surg 61-B:498-500.

X. CODED DATA

All data used in this series are given in code form in this chapter. The coded data and the key to these had to be diminished for space saving reasons. For using the coded data the next three pages thus have to be magnified to readable size.

KEY TO DATA

1	Number of patient	(001, 002 etc.)
2	Sex	1 = Male, 2 = Female
3	Site	1 = Right (dx), 2 = Left (sin)
4	Weight in kilograms	(076 e.g.)
5	Length in cm exceeding 1 m	
6	Age in years	
7	Diagnosis	4 = Primary arthrosis 5 = Primary arthrosis with pyrophosphate arthritis 6 = Posttraumatic arthrosis 7 = Arthrosis secondary to osteonecrosis
8	Disease	1 = Heart disease, 2 = Renal disease, 3 = Malignant disease, 4 = Diabetes, 5 = Collagenosis, 6 = Lung disease, 7 = Arterial hypertension, 8 = Neurologic disease, 9 = Other disease
9	Medicine	1 = Cortisone, 2 = Digitalis, 3 = Antihypertensive drug, 4 = 2 + 3, 5 = Antiepileptic drug, 6 = Psychotropic drug 7 = more than three medicines
10	Previous operations in the operated knee	1 = Arthrotomy, 2 = Synovectomy, 3 = Medial meniscectomy, 4 = Lateral meniscectomy, 5 = Medial + lateral meniscectomy, 6 = Removal of free body, 7 = Reconstruction of ligament, 8 = High tibial osteotomy, 9 = Previous arthroplasty, 10 = High tibial osteotomy + 1-7, 11 = 8 + 9 , 12 = 8 + 9 + 1-7, 13 = Previous fracture of tibia, 14 = Previous fracture of femur, 15 = Other operations
11	Previous operations in the other knee	(same as for 10)
12	Previous operation in the right hip	1 = Fracture of the femoral neck, 2 = Trochanteric fracture, 3 = Osteotomy, 4 = Hip replacement, 5 = Other operation
13	Previous operation in the left hip	(same as for 12)
14	Number of years with symptoms from the operated knee	1 = less than one year, 2 = 1-2 years, 3 = 2-5 years, 4 = 5-10 years, 5 = more than 10 years
15	Years of follow-up	1 = 1 year etc.
16	Type of arthroplasty	1 = Medial arthroplasty, 2 = Lateral arthroplasty, 3 = Medial + lateral arthroplasty
17	Size of femoral prosthesis	Column 1 denotes medial prosthesis, Column 2 denotes lateral prosthesis. 1 = Small, 2 = Medium-small, 3 = Medium, 4 = Large
18	Size of tibial prosthesis	Column 1 denotes medial prosthesis, Column denotes lateral prosthesis. 1 = 6 mm, 2 = 9 mm, 3 = 12 mm, 4 = 15 mm, 5 = 18 mm, 6 = 21 mm
19	Changes of patellar cartilage	1 = Normal, 2 = Superficial flaking, 3 = less than 50 % cartilage degeneration, 4 = more than 50 % cartilage degeneration, 5 = total degeneration of the cartilage, 6 = bone attrition
20	Osteophytes	1 = None, 2 = Moderate, 3 = Large
21	Synovitis	1 = None, 2 = Slight, 3 = Moderate, 4 = Severe, 5 = 3 + synovectomy, 6 = 4 + synovectomy
22	Calcifications of soft parts	1 = No, 2 = Yes, 3 = Yes sent for crystal analysis with negative result, 4 = Yes sent for crystal analysis with positive result
23	Operation theatre	1 = Laminar airflow, 2 = Usual theatre
24	Anaesthesia	1 = Epidural anaesthesia, 2 = Epidural anaesthesia with catheter, 3 = Neuroleptic anaesthesia, 4 = Other anaesthesia
25	Operation time	1 = 15 minutes, 2 = 30 minutes, 3 = 45 minutes etc.
26	Bleeding in the suction drainage	1 = 100 ml, 2 = 200 ml etc.
27	Antibiotics	1 = None, 2 = 1-7 days, 3 = 7-14 days, 4 = more than 14 days
28	Postoperative cast	1 = Yes, 2 = No
29	Hospital stay after the operation	The number denotes days
30	Early complications	0 = None, 1 = None evacuated haematoma, 2 = Evacuated haematoma 3 = Wound rupture, 4 = Wound necrosis, 5 = 1 + 4, 6 = Superficial wound infection, 7 = Deep wound infection, 8 = Paresis
31	Generai complications	1 = Vein thrombosis, 2 = Lung embolus, 3 = 1 + 2, 4 = Coronary infaction, 5 = Cerebral insult, 6 = Other complication
32	Late complications	1 = Loosening, 2 = Secondary arthrosis, 3 = Subluxation/instability 4 = Patellar arthrosis, 6 = Suture granuloma, 7 = Abnormal contact, 8 = Late infection
33	Treatment of complications	1 = None, 2 = Revision and exchange of component, 3 = Conversion to another prosthesis
34	Range of motion before arthroplasty	The first two columns denote extension deficit in degrees, and the three last columns denote maximal flexion capacity in degrees
35	Range of motion after the arthroplasty	(same as 34)
36	Stability before the operation	1 = No instability, 2 = Varus instability 0-4°, 3 = Varus instability > 4°, 4 = Valgus instability 0-4°, 5 = Valgus instability > 4°, 6 = Positive drawer sign + 2-3, 7 = Positive drawer sign + 4-5
37	Stability after the operation	(same as 36)
38	Pain on walking before the operation	1 = None, 2 = Only starting pain, 3 = More than 1 kilometer, 4 = 500-1000 m, 5 = 100-500 m, 6 = less than 100 m, 7 = from the first step
39	Pain on walking after operation	(same as 38)
40	Activities of daily living, before op	1 = Fully independent, 2 = Able to do all domestic work, 3 = Able to [illegible] 4 = Able to do light domestic work, 5 = Able to perform [illegible], but [illegible] 6 = Unable to perform work
41	Requirement of analgesics, before op	1 = Never, 2 = Occasionally, 3 = Every day
42	after op	
43	Walking activity, before op	1 = Unlimited, 2 = 1-3 km, 3 = 500-1000 m, 4 = 100-500 m, 5 = Indoors only
44	after op	
45	Pain at rest, before op	1 = None, 2 = Only after prolonged activity, 3 = Sometimes also at night
46	after	
47	Patellar pain at patellar loading activities, before op	1 = Never, 2 = Occasionally, 3 = Often, 4 = Always
48	Patellar pain etc, after op	(same as 48)
49	Varus-valgus deformity, bef op	The first column denotes varus deformity, the second column denotes

51	Varus-valgus deformity aft op	First column denotes varus deformity, second column denotes valgus deformity.(Same as 50)
52	Stair-climbing ability, bef op	1 = Normal, 2 = One foot at a time without support, 3 = Normal with support, 4 = One foot at a time with support, 5 = With great difficulty, 6 = Unable
53	" " " after op	(same as 52)
54	Rising from chair, before op	1 = Normal, 2 = Without support with difficulty, 3 = With support withour difficulty, 4 = With support and with difficulty, 5 = Unable
55	" " " after op	(same as 54)
56	Walking aid, before op	1 = None, 2 = One stick outdoors, 3 = One stick always, 4 = Two sticks, 5 = Crutches, 6 = Wheel-chair bound
57	" " after op	(same as 56)
58	Limitation by other joint, bef op	1 = The other knee, 2 = A hip, 3 = 1 + 2, 4 = Both hips, 5 = Poor balance 6 = Poor general condition
59	" " " " after op	(same as 58)
60	Other limiting factor, before op	0 = None, 1 = Heart-lung disease, 2 = Hips, 3 = Back, 4 = Foot, 5 = Vertigo, 6 = Other limiting factor
61	" " " after op	(same as 60)
62	Venn diagram assessment. Knee function, before op	1 = Subset 1, 2 = Subset 2 etc.
63	Venn diagram etc., after op	(same as 62)
64	Venn diagram assessment, social function, before op	1 = Subset 1, 2 = Subset 2, etc.
65	Venn diagram etc. after op	(same as 64)
66	London Hospital Score before arthroplasty	Preoperative score
67	London Hospital Assessment after the arthroplasty	Postoperative score
68	HSS score before the arthroplasty	Preoperative HSS score
69	HSS score after the arthroplasty	Postoperative score
70	Subjective assessment of pain at rest	1 = Much better, 2 = Better, 3 = Unchanged, 4 = Worse
71	Subjective assessment of pain on walking	(same as 70)
72	Subjective assessment of walking ability	(same as 70)
73	Roentgenographic classification before the operation	The first column denotes arthrosis in the medial compartment, the second column denotes the arthrosis in lateral compartment 1 = Stage I according to Ahlbäck, 2 = Stage II according to Ahlbäck etc. Column three denotes femoro-tibial subluxation, 0 = None, 1 = 0-0.5 cm, 2 = 0.5-1.0 cm, 3 = 1 cm or more.
74	Roentgenographic classification after the arthroplasty	First column denotes arthrosis in the medial compartment, second column denotes stage of arthrosis in the lateral compartment. P = Prosthesis, 1 = Stage I according to Ahlbäck, 2 = Stage II according to Ahlbäck etc Column three denotes femorotibial subluxation with the same definitions as in 73
75	Roentgenographic observations at the patellar articulation	Column one denotes arthrosis on the medial facet, 1 = Stage of arthrosis according to Ahlbäck etc, columns two denotes arthrotic changes at lateral facet with same definition as in first column, third column denotes lateral dislocation of patella. 0 = None, 1 = 1 cm, etc.
76	Roentgenographic signs at the patellar articulation after the arthroplasty	First column is not used. Second column denotes arthrotic changes at medial facet, third column denotes arthrotic changes at the lateral facet of the patella
77	Structural changes seen on roentgenographic examination	First column denotes subchondral sclerosis medially with 0 = None, 1 = in tibia, 2 = in femur, 3 = in both, 4 = triangulary formed sclerosis. Column two denotes subchondral sclerosis laterally (same definitions as first column). Third column denotes osteophytes medially, 0 = None, 1 = Small, 2 = Moderate, 3 = Large Column four denotes osteophytes laterally (same definitions as column 3). Column five denotes cysts in the bone 0 = None, 1 = Small, 2 = Moderate, 3 = Large Column six was not used
78	Roentgenographic changes in the central part of the joint	Column 1 denotes changes on the tibial intercondylar spine 1 = Sclerosis, 2 = Reduction of cartilage, 3 = Attrition, 4 = 1 + 2, 5 = 1 + 3. Column 2 denotes changes at the central part of the lateral or medial condyle (same definitions as column two). Column 3 is not used.
79	Roentgen calcifications	Different preoperative observations. 1 = Chondrocalcinosis, 2 = Osteonecrosis, 3 = Loose bodies
80	Mechanical axis of the lower limb	Gives the numerical value of the lateral hip-knee-ankle angle.
81	PP-angle in medial prosthesis	
82	PP-angle at lateral prosthesis	
83	PTS-angle at medial prosthesis	
84	PTS-angle at lateral prosthesis	
85	Different roentgenographic observations at medial tibial prosthes.	Column one denotes the position of the tibial prosthesis ad latus i.e. distance from the medial cortical bone in mm. Column two denotes the postition of the centre of the tibial prosthesis posterior to the longitudinal axis of the diaphysis of the tibia on side view. Column three denotes roentgenographic zone around the tibial prosthesis, 0 = None, 1 = 1 mm etc. Column four denotes fracture of the indication wire, 0 = no, 1 = Suspected, 2 = Broken wire. Column five denotes settling of the tibial prosthesis or fracture of the spongious bone. 0 = No, 1 = Fracture, 2 = Settling, 3 = 1 + 2. Column six denotes buckling of the tibial prosthesis, 0 = No, 1 = Yes.