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MARMOR KNEE ARTHROPLASTY

Clinical Results and Complications during an Observation Period of at least 3 Years

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During the period October 1975–June 1977, Marmor arthroplasties were performed on 70 knees, 52 of which had rheumatoid arthritis (RA) and 18 osteoarthritis (OA). These patients were followed up in a prospective study. Following arthroplasty, all knees in this material showed primary improvement with respect to pain, walking ability, stability, and extension deficit. The pain in the contralateral knees was studied postoperatively and within 1 year 9 out of 25 RA knees and 6 out of 10 OA knees showed a spontaneous improvement amounting to at least two steps on the pain scale. Four patients died in the course of the observation period and none of them suffered from knee pain. The late complications of the arthroplasties have been analysed separately. During the observation period, which now averages 45 months (36–55), five knees in the RA group and one in the OA group deteriorated to such an extent as to call for reoperation. Of the remaining 60 knee joints 57 have only initial pain or no pain at all, and the other three knees have pain only after physical efforts.

Key words: Marmor knee, clinical results and complications; polycentric knee arthroplasty

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Artificial knee joint surgery during the last 10 years has been characterized by a very rapid development which calls for continual reports of the results to facilitate the evaluation of the effects of the operative methods and the functioning of the prostheses (Symposium *Clin. Orthop.* 1973, 1976, 1979, Thema *Z. Orthop.* 1975, Symposium *J. Bone Joint Surg.* 1978, Bauer et al. 1979).

In addition to the operative technique and the design of the prostheses (Walldius 1957, Engelbrecht 1971, Marmor 1973, Sonstegard et al. 1977, Ring 1980), the pre- and postoperative regimen and the way in which problems are dealt with are, without doubt, factors of great importance for the patients, yet these factors are seldom mentioned in the literature. It would thus seem appropriate to include a full report on the pre, per- and postoperative routines in connection with a description of the method of investigation.

PATIENTS AND METHODS

From October 1975 to June 1977, Marmor arthroplasties were performed on 70 knees. These 70 arthroplasties have been followed up in a prospective study. Seventy-five per cent of these knees (i.e. 52 knees) had rheumatoid arthritis (RA) and the remaining 25 per cent (18 knee joints) osteoarthritis (OA) (Figure 1). One of the knees, having sequelae after a tibial condylar fracture, has been included in the OA group. Figure 1 also shows the distribution of age and sex. No demiarthroplasties or unicompartmental femoro-tibial replacements (Knutsson & Lindstrand 1980) have been performed on rheumatics, whereas five demiarthroplasties have been performed on OA patients, two of these operations being done to complete previous unicompartmental St. Georg "Sledge" prostheses (Engel-

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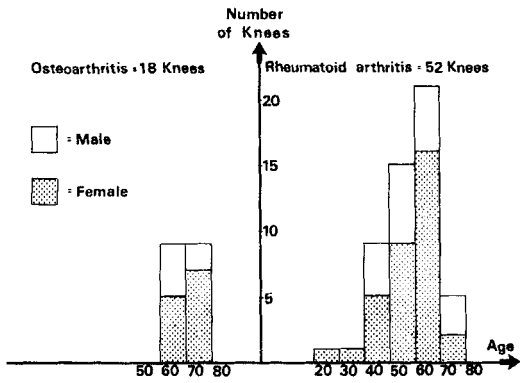


Figure 1. Distribution of patients according to age, sex and diagnosis (number of knees).

brecht 1971). Fourteen RA patients and one OA patient had both knees operated on.

Four patients died in the course of the observation period. Their mean period of observation amounted to 12 months (range 3–27 months).

During the observation period six knee joints in five patients developed complications necessitating reoperation. The remaining 60 knee joints have been kept under observation for 36–55 months, the mean period of observation being 45 months up to June 1980.

The main indications for surgery were severe pain on walking, and often continuous pain at rest, with a very limited walking range. In the evaluation of pain and walking ability we followed a system devised by Merle d'Aubigné (Merle d'Aubigné et al. 1949, Merle d'Aubigné & Postel 1954). According to this system, pain and walking range are graded 1–6, with 1 corresponding to the most severe handicap and 6 indicating normal conditions (Table 1) (cf. Charnley 1972).

In addition to the normal preoperative assessment of each patient we also examined the skin of the entire body and had bacterial cultures made from the patient's urine, nose, throat, and possible skin affections. If any of these cultures were positive the infection was always treated before operative measures were taken.

The operations were performed in a conventional operating room. No antithrombotic drugs were given. Lumbar epidural analgesia was used and cloxacillin 2 g × 3 was given during the first 24 hours, starting just before surgery, followed by 1 g × 3 for about a week postoperatively. In the case of a subcutaneous haematoma or a slight rubor of the suture channels the cloxacillin prophylaxis was combined with gauze dressings soaked in 70 per cent ethanol and applied on the operating wound. The operations were carried out with a tourniquet and the average period of tourniquet ischaemia for all patients was 117 min (range, 70–155 min). No untoward effects of this procedure were encountered even when applying a tourniquet for 2.5 hours in a few cases (Modig et al. 1978). The cement was applied as early as possible to achieve optimum anchorage to the bone (cf. Miller et al. 1979). To increase the cement-bone interface each prosthetic bed was prepared with 8–15 small holes. Only a medial parapatellar incision was made, whereas on the whole the technique devised by Marmor (1973) was applied. Generally, however, the components of the prosthesis were cemented at two sittings. First, the tibial modules, not thinner than 9 mm, were cemented with the knee flexed, to provide visual control of the position of the prostheses and to facilitate removal of excessive cement while it was polymerizing. Subsequently, the femoral parts were cemented, great care being exercised to ensure that the front edges of the femoral prostheses fitted flush with the remaining articular cartilage of the femur,

Table 1. Merle d'Aubigné classification (modified) for grading pain and walking ability, 1 to 6 (cf. text)

	1	2	3	4	5	6
PAIN	Pain even at rest.	Severe when trying to walk. Prevents physical activity.	Moderate. Permits some physical activity.	Pain after physical efforts, disappears at rest.	Initial pain.	No pain.
	1	2	3	4	5	6
WALKING ABILITY	Confined to bed or some mobility when supported.	Time and range very limited with or without support.	Less than 1 km, using a stick. Can stand upright for considerable periods.	Considerable range, using a stick, limited without.	No stick required, remaining lameness.	Normal gait.

in order to prevent symptoms of patellar impingement at a later stage (Mochizuki & Schurman 1979).

The peroperative bleeding in rheumatics was estimated to average 600 ml (range, 100–2,400 ml) and the figure for the OA knees was about the same (range, 100–1,500 ml). Following insertion of two Redon® drains the postoperative bleeding was 635 ml on average (range, 275–1,305 ml) in the rheumatics group and 800 ml (range, 275–1,500 ml) in the OA group. The surgeon himself changed the knee dressing under sterile conditions some 30 hours after the operation. Subsequent changes of the dressings were performed by the surgeon when required. Only soft dressings were used, never plaster. Exercise of the quadriceps muscle was started within 24 hours of the operation and active flexion including hold-relax exercises was carried out on an increasing scale from the second day postoperatively. The patients were instructed to load the operated leg as far as pain and muscle strength permitted from the fourth postoperative day, the training being individualized to avoid swelling of the knee. The average postoperative hospitalization time was 19.0 days (range, 12–41 days) in the case of RA patients and 16.8 days (range, 8–29 days) for OA patients.

The patients were checked in the clinic whenever necessary. In addition, they were subjected to routine examinations after 6 weeks, 3 months, 6 months, 1 year, 1.5 years, 2 years, 2.5 years, 3 years, etc., postoperatively for checking factors such as pain, walking ability, lateral stability, passive movement, and extension deficit. X-ray check-ups were carried out immediately after the operation and then after 6 weeks, 3 months, 1 year and every subsequent year and, in addition, at irregular intervals if problems arose.

In the present report a graphic presentation similar to the one previously adopted by Freeman et al. (1977) was used. The preoperative status was compared with the situation at the last check. Early (i.e. during the stay in hospital postoperatively) and late complications occurring during the period of observation were analysed and reported separately. The effect of the arthroplasty on pain in the contralateral knee was studied.

RESULTS

At the last examination of the four patients who subsequently died, none showed signs of pain whereas the walking ranges varied, depending on weaknesses that had developed from other diseases (Table 2). None of the patients died in connection with, or from, the operation.

Pain

Figures 2 and 3 show graphically the results achieved with the RA and OA groups with regard

Table 2. Four RA patients died in the course of observation before "the 3-year check-up". The table shows their data with respect to pain and walking ability at the final check-up

Case no.	Obs. time (months)	Pain	Walking ability
13	12	6	2
44	27	6	6
62	3	6	4
70	7	5	3

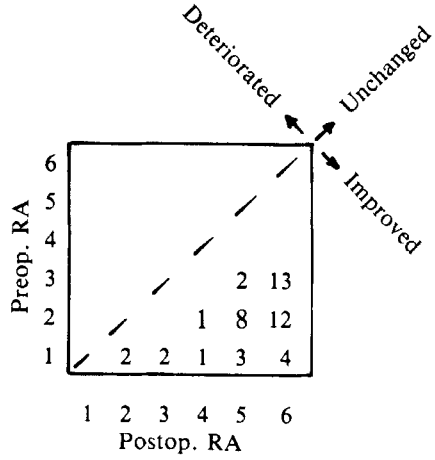


Figure 2. The situation of the rheumatic knees with regard to PAIN preoperatively and at the most recent check-up. (The complications are included.) Preoperatively: Vertical axis. Postoperatively: Horizontal axis. For key to graph see Table 1. Figures in graph refer to number of knees. (Hence four RA knees showed pain at rest preoperatively but had no pain postoperatively.)

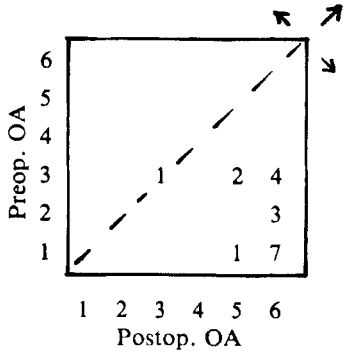
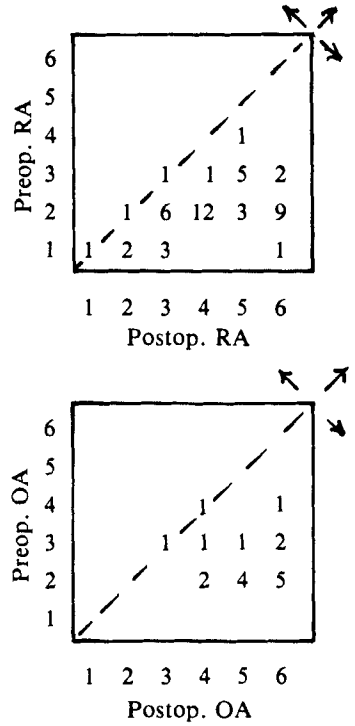


Figure 3. The corresponding figures for OA knees: cf. legend to Figure 2. (Seven OA knees showed pain at rest preoperatively but had no pain postoperatively.)

to pain. The condition of the reoperated knees was also investigated immediately before the reoperation. From the figures it can be seen that all the patients had been on the unfavourable half of the pain scale prior to the operation and that most of them had been suffering from severe or very severe pain. Postoperatively all the patients, with the exception of four RA and one OA patient, are on the favourable half of the scale. The five exceptions were also primarily on the favourable half, but in these cases complications supervened, resulting in moderate or severe pain. These knees have been reoperated on and are reported separately. The rheumatics suffered less pain at reoperation than before the first operation despite their complications. The patient with osteoarthritis had deteriorated as compared with his preoperative pain situation.

Walking ability

Figures 4 and 5 demonstrate the preoperative walking ability as compared with conditions at the most recent follow-up examination. There is a notable improvement as compared with the preoperative state. Fifteen per cent of the rheumatic patients were confined to bed or had a very limited walking ability preoperatively (Figure 4). The bedridden rheumatic who had to remain in bed even postoperatively is a young woman with severe, multiple joint disease and an almost ankylotic knee joint (30° flexion), yet quite free of pain after the operation. Two further rheumatics and two OA patients had not changed their walking ability at the most recent check-up. Three of these four patients had shown a primary improvement postoperatively. Two of them had complications and were reoperated on.



Figures 4 and 5. Walking ability of RA and OA patients as determined preoperatively and postoperatively: cf. legend to Figure 2.

Lateral instability, extension deficit and passive movement

A preoperative varus-valgus instability from 5° up to 15° at maximum extension of the knee existed in 58 per cent of the rheumatics and in 67 per cent of the osteoarthrosis group (Table 3). All these knees had been stabilized on the operating table but some instability supervened as time passed. At the most recent check-up this instability amounted to 5° in all five unstable knees; in the RA group two of the four knees reported and the one knee in the OA group were reoperated on for complications.

Among the rheumatics 63 per cent had an extension deficit exceeding 10° preoperatively whereas the same type of defect occurred in 28 per cent of the OA group (Table 4). Full extension could not be achieved peroperatively in one RA knee whereas at the most recent examination

Table 3. Incidence of lateral instability amounting to 5° or more during the period of observation

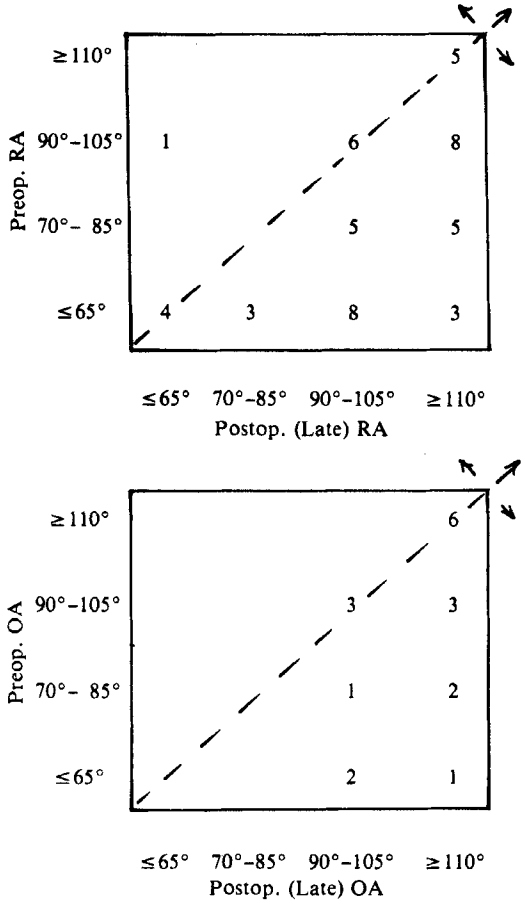
	Instability	RA (n=52) n	OA (n=18) n
Preoperative	5°–15°	30	12
Peroperative		0	0
1 year postop.	5°	2	1
Late	5°	4	1

Table 4. Incidence of extension deficit amounting to more than 10° during the period of observation. One RA knee excluded because of incomplete data

	RA (n=51)			OA (n=18)		
	n	Range	Mean	n	Range	Mean
Preoper.	32	15°–55°	27°±10° s.d.	5	15°–40°	22°
Peroper.	1	20°		0		
Late	5	15°–30°	21°	1	15°	

a total of six knees displayed an extension defect of more than 10°.

Figure 6 shows that 40 out of 48 RA knees



Figures 6 and 7. Passive mobility in RA knees (Figure 6) and OA knees (Figure 7) preoperatively and at the most recent check-up. Marked deterioration of mobility in one RA knee. This patient is reported as a complication in Table 7 (Case no. 5).

(i.e., 83 per cent) had a flexion range of 90° or more postoperatively. The corresponding figure for the OA knees was 18 out of 18 (Figure 7). In four of the five RA knees with a late passive movement of maximum 65° the range had been just as poor preoperatively (cf. Ritter & Stringer 1979). The fifth RA knee is reported as Case no. 5 in the "Late complications" section (Table 7), and had displayed good postoperative motility until shortly before reoperation.

X-ray

An inward inclination of 20° of the medial tibial prosthesis was noted in three knees. The lateral tibial prosthesis in each of these knees was in a neutral position or showed an outward inclination, and the patients displayed a good painless function throughout the period of observation. In each of the three knees complicated by a translation, however, both tibial prosthesis components showed an inward inclination from 5° to 15°. Inclinations of 10° forwards in one knee, or 15° and 20° backward in two knees, have not resulted in any complications or disturbances during the period of observation. In a few patients it was noted that a so-called radiolucent zone not exceeding 2 mm was present between the cement and the bone but it has not been possible during the observation period to draw any conclusions with regard to prosthesis loosening or prognosis.

Complications

Early complications: The early complications as noted in 70 operated knee arthroplasties can be seen in Table 5. These patients had no late com-

Table 5. EARLY COMPLICATIONS recorded in the first series of 70 Marmor arthroplasties

EARLY COMPLICATIONS	
	n
Transient peroneal palsy	1
Haemarthrosis	1
Broncho-pneumonia	1
Delayed healing of incision	1

Table 6. LATE COMPLICATIONS recorded during the period of observation with special notes on complications leading to reoperation

LATE COMPLICATIONS		
RA (53 knees)		
	n	
Mechanical loosening	3	(3 reop.)
Haematogenous infection	1	(1 reop.)
Translation (subluxation)	2	(0 reop.)
Patellar friction	1	(1 reop.)
OA (18 knees)		
Translocation (subluxation)	1	(1 reop.)

plications. No primary wound infection demanding active surgical intervention has been encountered. A few rubors of the incision margins disappeared following application of dressings soaked in alcohol.

Late complications: Eight cases of late complications were observed. Of these complications six demanded reoperation (Table 6). One further patient was reoperated because of a traumatic cement fracture (loose body); this patient, however, was not registered as having a complication of the arthroplasty.

Table 7 provides a survey of the clinical development of the eight knees with late complica-

Table 7. A survey of the clinical course with regard to pain and walking ability of the knee arthroplasties with supervening complications. (Grading key see Table 1.) The Table presents preoperative diagnoses, types of complication, and dates of operation and reoperation. The two case numbers reported at the bottom of the Table have not been reoperated as they still remain clinically satisfactory

Case no.	Diagnosis/ complications	Date of op.	Date of reop.	Clinical status	Preop.	0.5 y	1 y	1.5 y	2 y	2.5 y	3 y	4 y	4.5 y	Post-reop.
5	RA/loosening (+ translation)	17 Nov. 1975	20 May 1980	Pain	1	6	6	6	6	4	6	5	2	5
				Walking ability	2	6	4	6	6	6	6	4	2	3
10	RA/Patellar scraping	22 Dec. 1975	14 June 1976	Pain	2	5								5
				Walking ability	2	5								5
31	RA/loosening	13 Sep. 1976	26 Apr. 1979	Pain	1	5	5	5	3	2				5
				Walking ability	1	3	3	2	2	2				3
34	RA/loosening	18 Oct. 1976	5 June 1979	Pain	1	6	6	6	6	3				3
				Walking ability	1	3	3	2	2	2				2
42	OA/translation	17 Dec. 1976	31 Jan. 1980	Pain	3	6	6	6	6	6	3			6
				Walking ability	3	6	6	6	6	6	3			6
54	RA/infection	28 Feb. 1977	19 Apr. 1979	Pain	1	6	6	–	3					4
				Walking ability	2	6	6	–	3					3
11	RA/translation	12 Jan. 1976	Not reop.	Pain	2	3	3	5	5	5	4	5		
				Walking ability	1	2	2	3	3	3	3	3		
67	RA/translation	27 May 1977	Not reop.	Pain	3	6	6	6	5	3	6			
				Walking ability	3	4	6	3	3	3	5			

Figure 8. RA patient (Case no. 5) displaying settling of the prosthesis of the medial tibial plateau. The X-rays show a gradual change of position, without pains until very late in the course. (X-rays taken: 17 Nov. 1975, 2 Nov. 1976, and 16 May 1980). At the reoperation (called for by suspected loosening and a translation) 4.5 years after the initial operation it was not possible macroscopically to verify the presence of any loose component.

tions. Two mechanical loosenings (Cases nos. 31 and 34 in Table 7) occurred in the knees of one rheumatic patient who had been operated on both sides. Both knees had to be reoperated some 2.5 years after the first operation. At the reoperation a Spherocentric® prosthesis (Matthews et al. 1973) was inserted in one knee and in the second knee a recementation of the loosened femoral prosthesis was done. In the third knee classified as a mechanical loosening (Case no. 5 in Table 7), with ensuring obliqueness of the medial tibial plateau, a gradual translation occurred which amounted to 1.5 cm at the reoperation (insertion of a Spherocentric® prosthesis). Despite a marked gradual translocation of the medial tibial prosthesis on the X-ray (Figure 8) it was not possible to verify a loosening at the reoperation and a so-called prosthesis settling was considered (Laskin 1978, Bryan & Peterson 1979).

Infection was diagnosed in one arthroplasty. Following a throat infection about 2 years after the initial operation, a haematogenous infection was suspected (Gristina et al. 1974, D'Ambrosia et al. 1976, Marmor & Berkus 1978, Blomgren & Lindgren 1979, Wigren et al. 1980). At the reoperation a one-step change was made to a Spherocentric® prosthesis which was cemented with Palacos® cum Gentamicin.

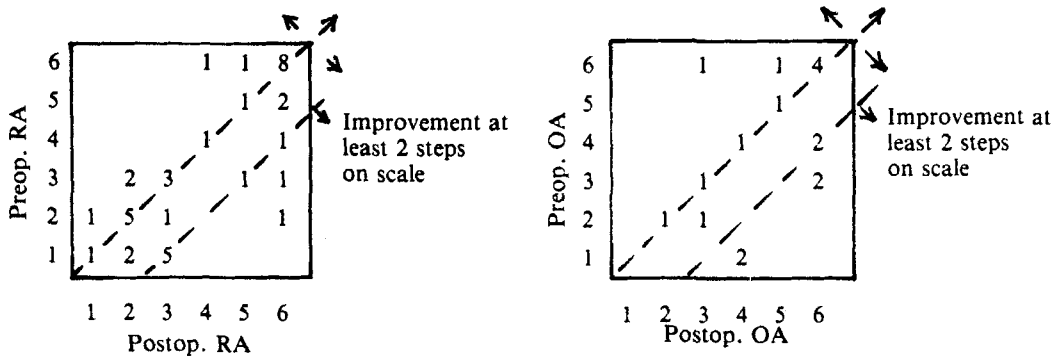
During the period of observation three knees with a so-called translation i.e., a lateral subluxation of the tibia, were noted. One of these knees displayed a 2.5 cm translation already preoperatively. This knee, primarily well aligned, underwent a gradual resubluxation, the translation again amounting to 2.5 cm at the time of reoperation including conversion to a Spherocentric® prosthesis. The other two knees showed no translation preoperatively.

One patient was reoperated half a year after the Marmor arthroplasty because of slight conflict between the lateral femoral component and the patella, and a partial lateral patellectomy was performed. The scraping then disappeared.

It has not been possible to demonstrate any ruptures or fractures in the tibial prostheses used (Ducheyne et al. 1978), and the macroscopic wear of the tibial components removed has been negligible (Bullough et al. 1976).

Reaction of the contralateral knee

Nine out of the 25 RA knees (i.e., 36 per cent) that were evaluated as 4 or worse on the pain



Figures 9 and 10. Reaction of the CONTRALATERAL KNEE with regard to pain in RA and OA patients, following knee arthroplasty. For key to graph see legend to Table 1. Within a year 9 out of 25 rheumatics showed spontaneous improvement, amounting to at least two steps on the scale. In the OA group a corresponding pain reduction occurred in 6 knees out of 10.

scale preoperatively showed a spontaneous improvement amounting to at least two steps within a year of the Marmor arthroplasty of the contralateral knee (Figure 9). Figure 10 demonstrates a corresponding spontaneous improvement in six out of ten (60 per cent) in the case of OA knees. One RA and one OA knee deteriorated two steps on the scale during the period of observation. Fourteen RA patients and one OA patient were operated bilaterally and both knees are included in the present report. Hence the reaction of the knee contralateral to the one operated on last in each pair cannot be included in Figures 9 and 10.

DISCUSSION

The knee arthroplasties reported in the present paper are the first series of Marmor arthroplasties performed in our clinic, and were thus carried out without any specific operative training or experience being available in the clinic. As the experience has increased and with the advent of new knee prostheses the indications for an operation with the Marmor prosthesis have been somewhat modified since operating on the cases included in the present report. Today severe instability and marked deformity may constitute indications for semiconstrained prostheses. Among the 70 operated knees with Marmor prostheses there are some cases where today we might well have considered an initial operation with a semiconstrained prosthesis.

An isolated lack of the anterior cruciate ligament, often noted in rheumatics with a serious articular degeneration, does not seem to influence the functioning of the knees of rheumatics after a successful Marmor arthroplasty.

As far as the walking ability is concerned improvements are less obvious among the rheumatics than in the OA group (Figures 4 and 5). This may be explained by the fact that the RA knee joints in many cases are only one of a number of locomotor obstacles (Brattström et al. 1977).

Exercises of the extensors are started immediately after the operation as clinical experience has proved full extension to be the most difficult movement for the patients to achieve (cf. Collopy et al. 1977). This makes it important to include an estimation of the patient's mental state and motivation (Johnson 1975, Head & Paradies 1977, Arafiles & Gustilo 1979) in the preoperative judgement of the case, as intensive active training and co-operation on the part of the patient will be necessary immediately after the operation. If this cannot be accomplished there is a risk of poor articular motility, in contrast to the situation after hip joint arthroplasties where the mobility is generally improved, spontaneously, following successful surgery.

The lateral instability did not exceed 5° in any of the patients and was not even noticed by some of them. The supervening instability can be explained in part by the occurrence of complications – this was the case in three of the five unstable knees – but may also be caused by a mechanically unfavourable arrangement of the prosthesis components relative to each other. The instability observed has not had any notable effect on the knee function. It has been shown in earlier reports that the standard variation of lateral instability is very great. In an orthoradiographic study Edholm et al. (1976) demonstrated an instability variation in the range 0° to 12° with a mean value of 3.7° in subjects with completely healthy knees.

An extension defect of 10° in the knee joint results in only a slightly increased compression of the articular surfaces under load. At greater extension defects, however, the compression increases considerably (Perry 1967, Perry et al. 1975), which causes stronger attrition and may even result in mechanical loosening of the prosthesis. However, no such reason for loosening was seen in this study.

At a knee flexibility of 90° or more the patient is generally able to walk, to sit, to climb stairs, and even to cycle if the flexibility reaches at least 110° (Laubenthal et al. 1972, Kettelkamp & Nasca 1973). Most of the artificial knees in this study had a range of motion exceeding 90° (Figures 6 and 7).

The mechanical complications have occurred at a rather late stage in spite of a seemingly unfavourable position of the prosthesis components in relation to each other, with an ensuing unsatisfactory load situation. Yet, it has so far not been possible to determine the limit of tolerable obliqueness (Lotke & Ecker 1977, Goldie et al. 1979). In any case an inclination of the tibial prostheses in the same direction seems to increase the incidence of translation. A prolonged period of observation my be expected to reveal further mechanical complications in the future.

When a permanent deterioration with regard to pain and walking ability has been recorded this has been considered the major early sign of a complication. Lateral instability, extension deficit and range of movement, on the other hand, have not proved to be of clinical value in judging complications within the limits of the observation period. Nor have X-ray examinations been of any significance in the diagnosis of complications. They have, however, offered a valuable aid in verifying the clinical findings and in planning the appropriate action to be taken. Radiolucent zones as seen in a few of the symptom-free patients might be explained by interposition of blood and tissue debris between the cement and the bone. Charnley as early as in 1964 suggested that enlargement of the medullary canal is a result of osteoporosis and does not indicate loosening of the prostheses. According to Ahlberg & Lindén (1977) and Cameron & Freeman (1979) necrosis of the bone as a cause of radiolucent zones occurs as a consequence of the temperature increase during the polymerization of the cement (Biehl et al. 1974). This explanation is, however, considered improbable by Reckling & Dillon (1977) and Reckling et al. (1977). Gschwend (1978) states that a 2–3 mm zone is permissible between cortical bone and cement but that no zone can be tolerated between cancellous bone and cement.

The present paper reports postoperative hospitalization periods lasting up to 41 days in rheumatics and 29 days in OA patients. These few very prolonged postoperative nursing periods can be attributed to our long-term treatment scheme for patients with an operation on the contralateral knee during the same period of hospitalization. It has not been considered feasible to determine the precise length of the theoretical nursing period for the knee first operated on.

As for the spontaneous improvement of the pain experienced in the contralateral non-operated knee an improvement corresponding to two or more steps on the scale has been considered a definite relief of pain (i.e., not attributable to other factors). When the indication for operating the contralateral knee seems doubtful – and this is where pain should be decisive – it may be wise to postpone the operation in some cases. In this material no further spontaneous improvement of the contralateral knee was noticed later than 1 year postoperatively.

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