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DEFORMATION AND LOOSENING OF THE TIBIAL COMPONENT IN KNEE ARTHROPLASTY WITH UNICOMPARTMENTAL ENDOPROSTHESES

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Roentgenological signs of deformation and loosening of the tibial component in knee arthroplasties with unicompartmental endoprostheses occurred in one-third of 87 rheumatoid (RA) knees within 2 years and in one-fifth of 107 osteoarthritic (OA) knees within 3 years after the operation. Compared with thicker components significantly more 6 mm components in RA, and 6 and 9 mm components in OA became deformed and loose. There was no difference in the clinical assessment of the knees with and without deformed tibial components. Reoperations were recorded during an extended follow-up. In the group with initially asymptomatic loosening twelve RA knees within four and a half years and three OA knees within four years developed pain on weight-bearing and had to be reoperated. One patient (OA) had loose components without any roentgenological signs; the loosening was first discovered when the unoperated compartment was revised because of secondary osteoarthrosis. Knees fitted with 6 mm components more often required reoperation because of loosening than did those with thicker components.

Key words: joint prosthesis; knee arthroplasty; osteoarthrosis; rheumatoid arthritis; tibial prosthetic loosening

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Loosening of the tibial component is the most commonly reported reason for failure in knee arthroplasties with unconstrained unicompartmental endoprostheses (Ilstrup et al. 1976a, Marmor 1976, Insall & Walker 1976). The failure-rate in some studies is no less than 10 per cent with a follow-up of 2 years or more (Gunston & McKenzie 1976, Marmor 1979), and the same rate has been reported for bicompartmental semiconstrained endoprostheses (Ilstrup et al. 1976b, Freeman et al. 1978, Lacey 1978).

Many factors may cause loosening; for instance, deep infection, instability, uncorrected deformity, malposition of the prosthetic component, inadequate fixation technique and poor bone quality (Walker et al. 1976, Lotke & Ecker 1977).

Marmor (1976, 1979) and Ducheyne et al. (1978) warn against the use of thin, 5–6 mm polyethylene tibial components because of the high risk of deformation and loosening. However, not only are thin components still available but also new endoprosthesis designs with thin components have been introduced. Knee arthroplasties employing unicompartmental endoprostheses are widely used and half of the 3302 knee arthroplasties done in Sweden during a 4-year period, October 1975–October 1979, were of

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this kind (according to data from the Swedish Knee Arthroplasty Project: Bauer et al. 1980).

The aim of this study was to analyze the frequency of roentgenological signs of tibial component deformation and loosening in relation to the thickness of the component and the failure-rate based on reoperations because of loosening.

PATIENTS AND METHODS

Rheumatoid arthritis (RA)

During a 3-year period (1974–1976), 87 patients with classical RA according to ARA (Golding 1966) were treated with unicompartmental knee endoprostheses of Richard's Modular type at the Department of Orthopaedic Surgery in Lund, Sweden. Six arthroplasties were done in only one compartment and 81 in both compartments of the knee. The operation was performed with an L-resection of the tibial condyle with the prosthetic component resting on cortical and cancellous bone rather than on cancellous bone only (Marmor 1973).

Fifty-nine patients were female and 28 male. The mean age at the time of the operation was 59 years (range 24 to 79 years). These patients have been reported in detail elsewhere by Langer Andersen (1979).

The clinical and roentgenological assessment was made after an average follow-up time of 26 months (range 12 to 43 months). Reoperations were recorded during an extended follow-up, the total average follow-up being 56 months.

Osteoarthrosis (OA)

During a 4-year period (1974–1977), 107 patients with primary or secondary OA were treated with unicompartmental knee endoprostheses in Lund. Richard's Modular prosthesis was used in all but three cases that were treated with a Lotus prosthesis. Eighty-one arthroplasties were done in the medial compartment, 14 in the lateral and 12 in both compartments of the knee. Only during the last year was the operation carried out with an L-resection of the tibial condyle; in all the other cases it was done according to the original method (Marmor 1973).

Seventy-six patients were female and 31 male. The mean age at the time of operation was 71 years (range 52 to 88 years). These patients have been reported in detail by Jónsson (1981).

The clinical and roentgenological assessment was done after an average follow-up time of 40 months (range 13 to 59 months). Reoperations were recorded during an extended follow-up, the total average follow-up being 52 months.

Follow-up interval. The patients' progress has been studied with the aid of an early postoperative roentgenological investigation and a clinical and roentgenological follow-up at 3, 6 and every 12 months.

Roentgenological assessment. We have used tibial components which have a metal indicator wire lying around the periphery of the bottom of the component. When the prosthesis is inserted the indicator wire comes into close contact with the underlying bone cement. Deformation of the tibial component results in deformation of the indicator wire and this together with unchanged, dislocated, fragmented or fractured bone cement causes partial or total loosening between the cement and the bone or the component. As long as the component is not dislocated, the degree of loosening cannot be seen roentgenologically and hence we only report the occurrence of broken, twisted or buckled indicator wires.

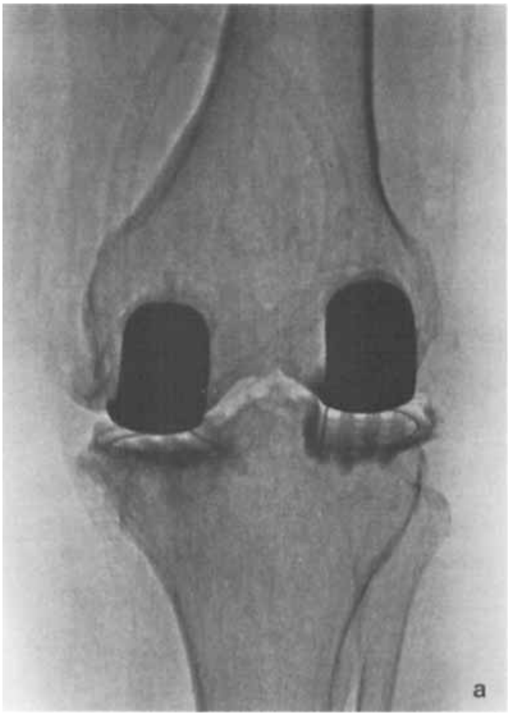
Clinical assessment. This took the form of a comparison between two subsets in both RA and OA, one with roentgenological signs of deformation and loosening and one without. The assessments were made after an average follow-up time of 26 months in RA and 40 months in OA. RA patients were evaluated according to Weinfeld's Knee Evaluation System (Potter et al. 1972) and OA patients according to the Hospital for Special Surgery Knee Rating Scale (Ranawat & Shine 1973), the London Hospital Point Scoring System for an Overall Assessment of Knee Function (Freeman et al. 1977) and the Venn Diagram System (Bauer et al. 1969).

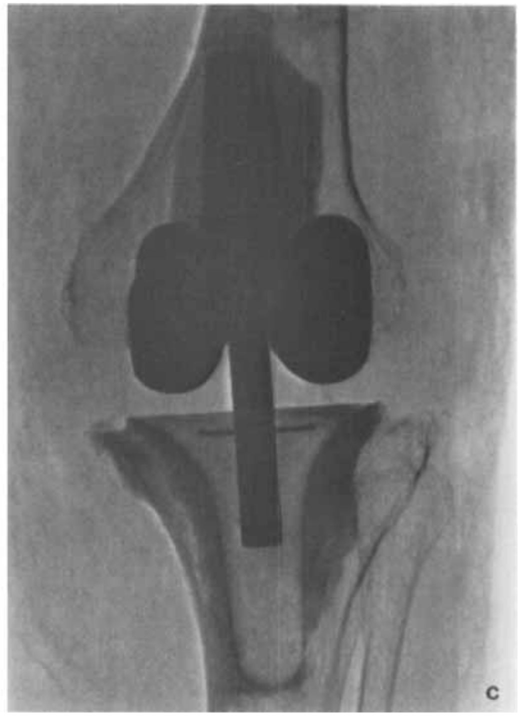
Statistical analysis. Calculations were done with standard computer programs by Lars Ek, Department of Statistics, University of Lund, Sweden. Chi^2 tests were used. If a statistical significance of difference was found this was further analyzed by the multiple comparison technique.

RESULTS

Case reports

Case 1. A 67-year-old woman with a 20-year history of classical RA, mainly affecting her hands and knees, was operated on because of left-sided knee pain and decreasing walking ability. Radiographs showed obliterated joint spaces and some bone attrition. A bicompartmental knee arthroplasty was performed with Richard's Modular prosthesis with a 6 mm tibial component medially and a 9 mm laterally (Figure 1a). One year later the patient had good knee function and was free from pain but the medial tibial indicator wire was deformed. Three years later, walking ability decreased rapidly because of pain over the medial condyle on weight-bearing. A roentgenological examination showed that the anteromedial aspect of the medial tibial





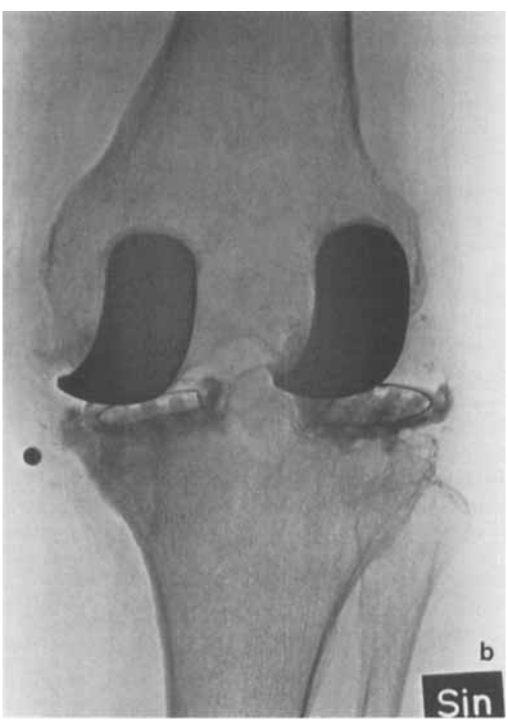


Figure 1. The left knee of a 67-year-old woman with rheumatoid arthritis treated with a bicompartmental arthroplasty with Richard's Modular prosthesis. a) Immediately after the operation. b) Four years later. The medial tibial component is depressed anteromedially and the indicator wire twisted and broken. c) The revised knee with an Attenborough stabilized prosthesis.

component was depressed into the spongious bone and there was a small fracture of the condyle medial to the prosthesis (Figure 1b). The knee pain persisted and at the reoperation both tibial components were found to be loose; the medial component had dislocated half a centimetre out of its cement bed. Five bacterial cultures were negative. The prosthesis was replaced by an Attenborough stabilized endoprosthesis (Figure 1c). One year later the patient was fully weight-bearing and free from pain.

Case 2. An 80-year-old man without known knee disease complained of a sudden persistent pain in the left knee. Two months later medial femoral osteonecrosis was diagnosed. A medial unicompartmental knee arthroplasty with Richard's Modular prosthesis was performed 5 months later using a 6 mm thick tibial component (Figure 2a). The postoperative period was uneventful and at the 1-year follow-up the patient was satisfied and could walk continuously for 3 hours, al-

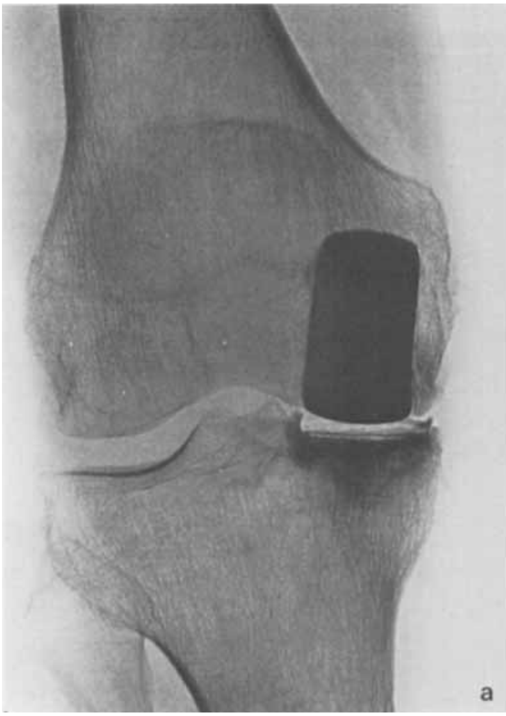


Figure 2. The left knee of an 80-year-old man with osteoarthrosis secondary to medial femoral osteonecrosis. Arthroplasty with Richard's Modular prosthesis. a) Immediately after the operation. b) Three years later. The tibial component is depressed and the indicator wire broken and bent. c) The revised knee.

though a small buckling of the tibial indicator wire was found. One and a half years later the patient reported increased pain on weight-bearing and decreased walking ability. A roentgenological examination showed that the tibial component was depressed into the spongious bone. The indicator wire was buckled and broken (Figure 2b). Sr^{85} scintimetry indicated a four-fold increased uptake over the medial tibial condyle. At the re-arthroplasty, loosening of the tibial component and the cement was confirmed, and centrally under the component a resorption cavity in the spongious bone was filled with granulation tissue. Five bacterial cultures were negative. The 6 mm component was replaced by a 15 mm component after further resection of the condyle (Figure 2c). Two years later the patient was fully weight-bearing and free from pain.

At the end of the follow-up time a significantly greater number of the 6 mm tibial components in RA (Table 1) and of the 6 and 9 mm components in OA (Table 2) were roentgenologically deformed and loosened compared with the other components. In RA a total of one-third of the tibial components were deformed and in OA one-fifth. There was no statistical difference in roentgenological deformation and loosening-rate between the RA and OA groups ($Chi^2 = 3.7, P > 0.05$) (Tables 1 and 2).

Patients with or without roentgenological signs

Table 1. Roentgenological deformation (average follow-up 26 months) and loosening (average follow-up 56 months) related to the thickness of the tibial component in unicompartmental knee endoprostheses. 168 components in 87 knees with rheumatoid arthritis

Thickness of the tibial component	Number of tibial components		
	Inserted	Deformed	Reoperated
6 mm	59	33***	7
9 mm	68	13	4
12 mm	29	4	2
15 mm	12	4	2
Totally	168	54	15 (9%)

The incidence of deformation and loosening of 6 mm components was higher than that of other components. $P<0.001$***.

Table 2. Roentgenological deformation (average follow-up 40 months) and loosening (average follow-up 52 months) related to the thickness of the tibial component in unicompartmental knee endoprostheses. 119 components in 107 knees with osteoarthrosis

Thickness of the tibial component	Number of tibial components		
	Inserted	Deformed	Reoperated
6 mm	13	5 } *	2
9 mm	54	16 } *	1
12 mm	32	4	–
15 mm	13	1	–
18 mm	4	–	–
21 mm	3	–	–
Totally	119	26	3 (3%)

The incidence of deformation and loosening in 6 and 9 mm components was higher than that in other components. $P < 0.05$*.

Table 3. Analysis of failure in 87 knee arthroplasties in rheumatoid arthritis. Indications for 22 reoperations. Average follow-up 56 months

2 arthrodeses
- 1 – loosening of the tibial components and later fracture of the femur
- 1 – severe extension defect

20 re-arthroplasties
- 11 – loosening of the tibial component
- 3 – loosening of the femoral component
- 3 – degeneration of the unoperated compartment of the knee
- 2 – instability and subluxation
- 1 – deep infection

Table 4. Analysis of failure in 107 knee arthroplasties in osteoarthrosis. Indications for 13 reoperations. Average follow-up 52 months

13 re-arthroplasties
- 3 – loosening of the tibial component
- 1 – degeneration of the unoperated compartment and loosening of tibial and femoral component
- 2 – degeneration of the unoperated compartment of the knee
- 3 – collision between the femoral component and the tibial spine
- 2 – instability
- 1 – patello-femoral pain
- 1 – deep infection

of prosthetic deformation and loosening were compared and no difference in clinical assessment was found at the follow-up. Twenty-two out of 87 RA patients had been reoperated at the end of the extended follow-up with a total average of 56 months. Two reoperations were arthrodeses and twenty re-arthroplasties (Table 3). Fifteen prostheses were replaced because of mechanical loosening, three on the femoral and twelve on the tibial side. Of 12 patients with tibial prosthetic loosening, 10 were reoperated after the initial clinical and roentgenological follow-up. Nine had roentgenological signs of prosthetic deformation at the initial follow-up. The last patient developed roentgenological signs of deformation during the extended follow-up before the reoperation.

Thirteen re-arthroplasties had been performed on the 107 OA patients at the end of the extended follow-up with a total average of 52 months. Four of these were done because of tibial prosthetic loosening (Table 4). Three of these four patients had roentgenological signs of loosening before reoperation. The fourth patient was reoperated because of painful development of arthrotic changes in the unoperated compartment of the knee. The tibial and femoral components were found to be loose at the reoperation. The removed tibial component was a medial one, 9 mm thick.

All patients with OA and RA knees with tibial prosthetic loosening were relieved of pain on weight-bearing after re-arthroplasty.

The clinical relevance of the initial, roentgenologically detectable, asymptomatic tibial prosthetic deformation and loosening is demonstrated by the fact that such findings have preceded 15 out of 16 reoperated cases of tibial prosthetic loosening. The number of reoperated loosened tibial components was greater in RA than in OA ($Chi^2 = 4.9$, $P < 0.05$) (Tables 1 and 2). The clinical hazard of using the 6 mm component is demonstrated by the larger number of reoperations after insertion of this component; 9 out of 72 thin 6 mm components required reoperation in comparison with 9 out of a total of 215 thicker components ($Chi^2 = 6.3$, $P < 0.05$) (Tables 1 and 2).

DISCUSSION

Unconstrained endoprostheses are designed with an incongruity between the femoral and tibial components, this being a condition of the unconstrained principle, which has the beneficial effect of minimizing the shearing forces on the tibial component. However, the functional load on the tibial component will thus be distributed over a very small area and this will therefore increase the known risks of plastic and elastic deformation of the polyethylene (Swanson & Freeman 1977).

Elastic deformation may affect thin components. With a properly placed prosthesis the load will be greater centrally where the spongious bone is weaker and less at the periphery where the bone is reinforced by cortical bone. This could lead to deformation of the central part of the cement bed especially if it is thin, causing a central compression or bone resorption, bent indicator wire and eventually clinical symptoms of prosthetic loosening with pain on weight-bearing (Case 1).

Plastic deformation of the tibial component will not only deform the proximal surface of the component but also eventually induce a deeper deformation ("cold creep") with increasing width and buckling. When the distal surface of the component is deformed the indicator wire will be ruptured or bent. At the same time the fit between the prosthesis and the cement may be lost and the component will become partially or totally loose. This loosening within the prosthetic system may not be painful. Translatory movements in the knee may however suddenly or slowly dislocate the tibial component from its bed with increasing pain on weight-bearing (Case 2). Probably the functional load will deform a thin component sooner and at a deeper level.

An important reason for this report is that thin components are available and still being inserted. There have previously been a few warnings against using thin, 5–6 mm components in unicompartmental endoprostheses in the knee joint (Marmor 1976 and 1979). Our results are in accordance with these warnings since we found significantly more deformed and loosened thin components in both RA and OA based on a roentgenological evaluation. Such deformation and loosening was seen in one-fourth of all tibial components and seems initially to be asymptomatic but within 5 years 15 knees with such findings were reoperated because of increasing pain on weight-bearing. Six mm components more often required reoperation because of loosening than did other components. The overall high reoperation rate in RA is partly explained by the earlier broad indications for unconstrained arthroplasties. Today we treat RA knees with major deformity and translatory instability either with semiconstrained or in some cases stabilized prostheses. Arthroplasty of only one compartment is suitable for the moderate stages of OA but should not be used in RA which always involves all compartments of the knee.

Our conclusion is that only tibial unicompartmental components thicker than 9 mm should be used.

There is reason to believe that not all of the roentgenologically deformed components will develop into painful loosening. The compression fracture may heal, or the deformed component may take the load on a larger area slowing down the process of deformation, or the loose component may remain in its cement bed.

Loosening at the bone-cement interface with an intact tibial component with adjacent cement may occur as a slow *migratory dislocation.* It should be noted that in these cases the indicator wire will not be deformed. In order to detect small sliding or rotating movements an ordinary roentgenological examination is not sufficient because of the problems of finding reference points for measurement (Baldursson 1979). For this reason migratory loosening is not reported in this study.

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