Osteolysis in Failed Total Knee Arthroplasty: A Comparison of Mobile-Bearing and Fixed-Bearing Knees

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Background: Osteolysis is an important complication associated with total knee arthroplasty. The purpose of this study was to compare the prevalence of osteolysis after failed total knee arthroplasty with a mobile-bearing prosthesis and after failed arthroplasty with a fixed-bearing prosthesis.

Methods: Eighty revision total knee arthroplasties performed between 1995 and 1998 were included in this study. All had radiographic evidence of advanced polyethylene wear. The mobile-bearing group consisted of thirty-four knees with a Low Contact Stress implant, and the fixed-bearing group included forty-six knees. The average time (and standard deviation) from the primary operation to the revision was 102.8 ± 26.5 months in the mobile-bearing group and 96.0 ± 30.1 months in the fixed-bearing group. The prerevision radiographs and operative findings were reviewed.

Results: The prevalence of osteolysis was significantly higher in the mobile-bearing group (47%; sixteen of thirty-four knees) than in the fixed-bearing group (13%; six of forty-six knees) ($p = 0.003$). The distal part of the femur was involved in thirteen knees in the mobile-bearing group and in four knees in the fixed-bearing group. Seventeen knees had osteolysis in the posterior aspect of the femoral condyle, which was the most common site of osteolysis; however, twelve of them had no evidence of osteolysis on prerevision radiographs.

Conclusions: The prevalence of osteolysis was higher in the knees with a mobile-bearing prosthesis than in those with a fixed-bearing prosthesis. The osteolysis was predominantly on the femoral side, adjacent to the posterior aspect of the condyle. Radiographic evaluation of osteolysis in the distal part of the femur may not be reliable and usually leads to an underestimation of the degree of osteolysis.

Osteolysis as a complication after total knee arthroplasty has been well documented[1-5] and results from a granulomatous response to polyethylene, polymethylmethacrylate, or metal particulate debris[2,4,6,7].

The metal-backed bearing surface of a total knee prosthesis can be either fixed or mobile. Goodfellow and O'Connor[8] (Oxford knee; Biomet, Bridgend, South Wales, United Kingdom) and Buechel and Pappas[9] (Low Contact Stress [LCS] knee replacement system; DePuy, Warsaw, Indiana) developed the movable polyethylene bearing in the 1970s in order to decrease contact stress and constraint. The design allows both congruity and mobility to improve wear resistance and minimize loosening. The long-term results have been satisfactory[10]; however, there have been sporadic case reports of osteolysis associated with a mobile-bearing knee[11].

Osteolysis can be assessed either radiographically or by intraoperative observation. The majority of previously reported series of patients with osteolysis after total knee arthroplasty that we are aware of have involved prostheses with a fixed polyethylene bearing design[1-5]. The diagnosis of osteolysis in most of these reports was made with radiography only. However, radiographic review usually leads to an underestimation of the degree of osteolysis[5]. The purpose of this study was to determine and compare the prevalence of osteolysis associated with knees with a failed mobile-bearing prosthesis and those with a failed fixed-bearing prosthesis. In addition, intraoperative findings were compared with prerevision radiographic findings.

Materials and Methods

Between 1995 and 1998, 108 revision total knee arthroplasties were done at Mackay Memorial Hospital in Taipei, Taiwan. All patients signed an informed consent form, and the study was approved by the hospital's Institutional Review

Fig. 1-A

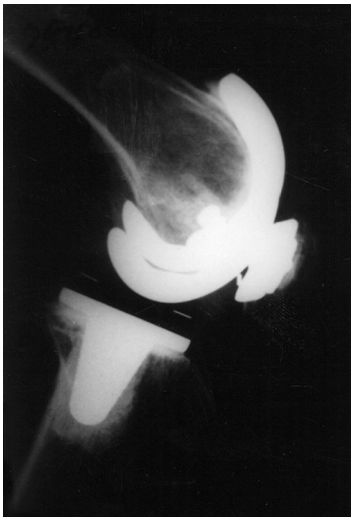

Fig. 1-B

Fig. 1-A An osteolytic lesion was present in the posterior aspect of the femoral condyle at surgery. **Fig. 1-B** The lesion was not recognized on the prerevision radiograph.

Board. The knees that had loosening (twelve), an infection (eight), a failed patella (four), instability (three), or tibial subsidence (one) were excluded, leaving eighty knees with radiographic evidence of advanced polyethylene wear that were treated with a revision operation. All knees had osteoarthritis. All femoral prostheses were made of cobalt-chromium, except for the Miller-Galante knee implants (Zimmer, Warsaw, Indiana), which were made of titanium. The knees were divided into those with a mobile-bearing design (thirty-four knees) and those with a fixed-bearing design (forty-six knees).

The mobile-bearing group consisted of twenty-one knees with the Low Contact Stress posterior cruciate ligament-retaining (meniscal-bearing) prosthesis and thirteen with the Low Contact Stress posterior cruciate ligament-sacrificing (rotating-platform) prosthesis. Twenty-five knees had fixation with cement, five had fixation without cement, and four had hybrid fixation (Table I). There were twenty-eight female and six male patients, and the average age (and standard deviation) at the time of the revision was 66.5 ± 6.5 years. The average time-interval (and standard deviation) from the primary operation to the revision was 102.8 ± 26.5 months.

The fixed-bearing group consisted of twenty-four knees with a Porous-Coated Anatomic prosthesis (PCA; Howmed-

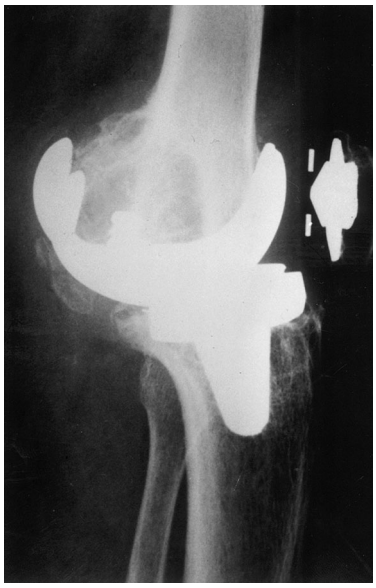

Fig. 2-A

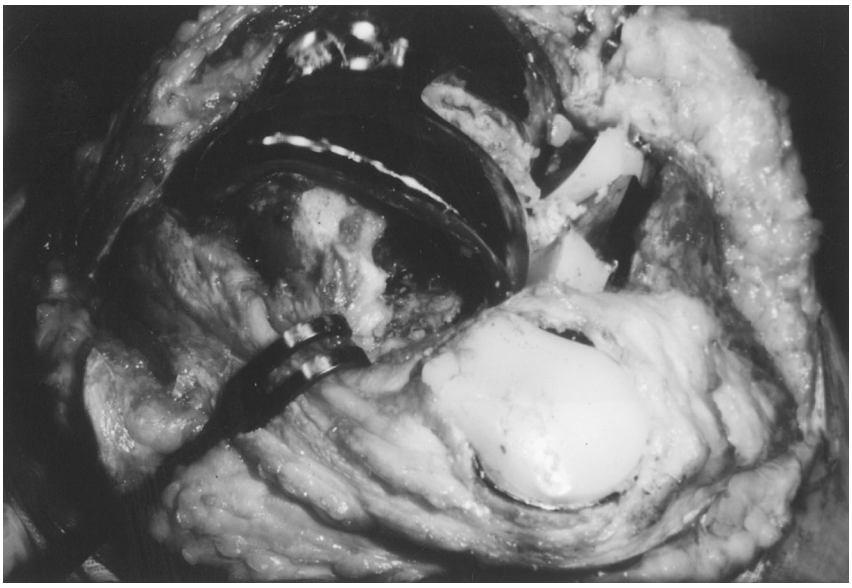

Fig. 2-B

An osteolytic defect in the femoral condyle was identified on a radiograph made before the revision (Fig. 2-A) and at the time of the revision surgery (Fig. 2-B).

TABLE I Methods of Prosthetic Fixation and Prevalence of Osteolysis

Mode of Fixation*	Total No. of Knees	Mobile-Bearing Group		Fixed-Bearing Group	
		No. of Knees	Knees with Osteolysis	No. of Knees	Knees with Osteolysis
Cemented	52	25	9	27	2
Cementless	24	5	4	19	4
Hybrid	4	4	3	0	0
Total	80	34	16	46	6

*Hybrid fixation indicates that the femoral component was inserted without cement and the patellar and tibial components were inserted with cement.

ica, Rutherford, New Jersey), eighteen with a Miller-Galante prosthesis (Zimmer), three with a Tricon prosthesis (Smith and Nephew Richards, Memphis, Tennessee), and one with an Anatomic Modular Knee (AMK; DePuy). All knees in this group had retained the posterior-cruciate ligament. Twenty-seven knees had fixation with cement, and nineteen had fixation without cement (Table I). There were forty-four female and two male patients, and the average age (and standard deviation) at the time of the revision was 69.3 ± 5.0 years. The average time-interval (and standard deviation) between the primary operation and the revision was 96.0 ± 30.1 months.

At the time of the revision, all interfaces between bone and prosthesis or cement were checked for evidence of osteolysis and it was recorded if present. Lesions in the distal part of the femur were classified according to their location (the anterior or posterior aspect or the medial or lateral condyle). Tibial and patellar lesions were classified as medial or lateral. The hypertrophic synovial membrane was excised, and histological specimens were obtained from the area or areas of osteolysis. All failed tibial and patellar polyethylene components were replaced. Stable intact prosthetic components were left in situ. All of the components were revised if wear of the metallic component was noted. The osteolytic defects were curetted and filled with allograft cancellous bone.

Two authors (C.-H.H. and H.-M.M.) independently assessed the prerevision radiographs (anteroposterior, lateral, and Merchant views) for evidence of periprosthetic osteolysis. The radiographic criteria for osteolysis were a loss of trabecular bone away from the fixation interface[12] or lesions with either a sclerotic border of demarcation or a patchy absence of cancellous bone trabeculae[12]. A chi-square test was used for statistical analysis.

Results

At the time of the revision, all retrieved tibial polyethylene components were found to have severe damage with delamination, deformation, or even wear through to the metal base-plate. Polyethylene wear was most commonly observed posteromedially. There was no notable wear on the backside of

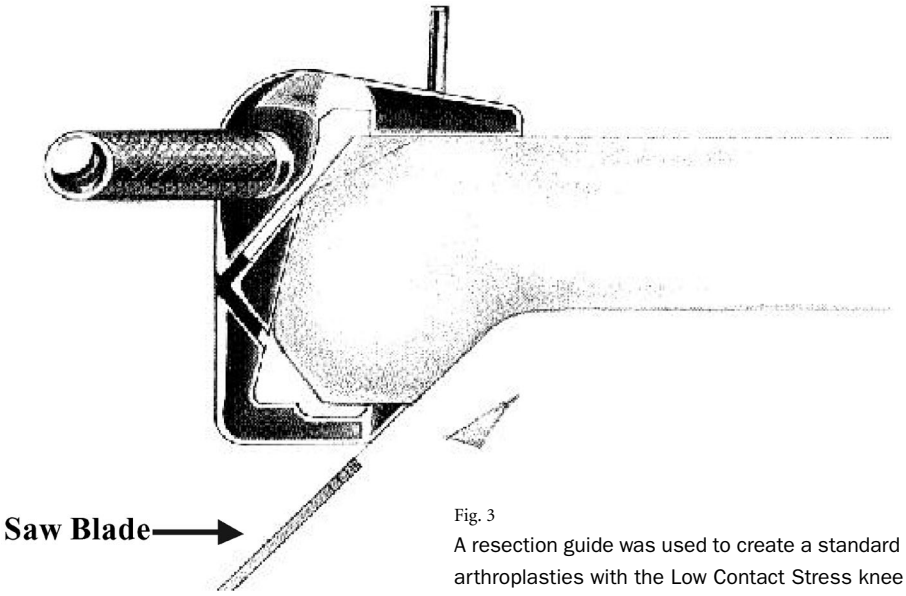

Fig. 3

A resection guide was used to create a standard posterior resection cut on the femoral condyles in arthroplasties with the Low Contact Stress knee (LCS; DePuy, Warsaw, Indiana).

the polyethylene. The majority of patellar components had minor wear. Six knees with the Low Contact Stress prosthesis and five knees with the Miller-Galante prosthesis had fractures of the patellar polyethylene. A large osteolytic defect associated with fracture of the femoral component was noted in a knee with a Low Contact Stress prosthesis (the mobile-bearing group). In the fixed-bearing group, one knee had loosening of the tibial component in association with osteolysis and two knees had loosening of the femoral component but no osteolysis was found at the time of surgery.

Osteolysis was identified intraoperatively in sixteen (47%) of the thirty-four knees in the mobile-bearing group. The osteolysis occurred in the distal part of the femur (thirteen knees), in the proximal part of the tibia (five), and in the patella (four) (Table II). In the fixed-bearing group, osteolysis was identified intraoperatively in six (13%) of the forty-six knees. The osteolysis occurred in the distal part of the femur (four knees), in the proximal part of the tibia (four), and in the patella (one) (Table II). The overall prevalence of osteolysis identified intraoperatively for both groups was 28% (twenty-

TABLE II Demographic Data on the Patients with Osteolysis

Case	Gender	Age *(yr)*	Weight *(kg)*	Type of Prosthesis*	Method of Fixation	Location of Osteolysis	Time in Situ *(mo)*
1	F	67	67	LCSm	Cementless	Med. aspect of femur, med. part of patella	100
2	F	70	75	LCSm	Cementless	Med. aspect of femur	96
3	F	73	62	LCSm	Cementless	Med. aspect of femur	126
4	F	67	56	LCSm	Cementless	Med. aspect of tibia	135
5	F	62	66	LCSm	Cemented	Lat. aspect of femur	98
6	M	62	75	LCSm	Cemented	Lat. aspect of femur, lat. part of patella	92
7	F	67	74	LCSm	Hybrid	Lat. part of patella	123
8	M	67	54	LCSm	Hybrid	Med. aspect of femur	98
9	F	60	61	LCSr	Cemented	Lat. aspect of femur	132
10	F	71	54	LCSr	Cemented	Lat. aspect of femur, med. part of tibia, med. part of patella	140
11	F	60	65	LCSr	Cemented	Lat. aspect of tibia	117
12	F	73	75	LCSr	Cemented	Lat. aspect of femur, med. part of tibia	95
13	F	62	60	LCSr	Cemented	Lat. aspect of femur	104
14	F	68	72	LCSr	Cemented	Med. aspect of femur, med. part of tibia	110
15	F	67	87	LCSr	Cemented	Med. aspect of femur	88
16	M	68	82	LCSr	Hybrid	Med. aspect of femur	55
17	F	73	62	PCA	Cementless	Med. aspect of femur, med. part of tibia	135
18	F	73	60	PCA	Cementless	Lat. aspect of femur	120
19	M	63	54	PCA	Cementless	Med. aspect of femur	105
20	F	69	52	PCA	Cemented	Lat. aspect of femur, med. part of tibia, med. part of patella	133
21	F	71	45	MG	Cementless	Med. aspect of tibia	96
22	F	66	66	MG	Cemented	Med. aspect of tibia	85

*LCSm = Low Contact Stress meniscal bearing knee, LCSr = Low Contact Stress rotating bearing knee, PCA = porous-coated anatomic knee, and MG = Miller-Galante knee.

two of eighty knees), and the overall prevalence of femoral osteolysis was 21% (seventeen of eighty knees). The prevalence of osteolysis was significantly higher in the mobile-bearing group than in the fixed-bearing group ($p = 0.003$). The most common site of osteolysis was the posterior part of the femoral condyle (Fig. 1). All osteolytic lesions in the distal part of the femur were adjacent to the femoral prosthesis. In ten knees, the femoral condyle consisted of a thin shell of cortical bone with perforations. The other seven knees had eroded through the cortex, forming a large uncontained defect. The presence and extent of the defects found intraoperatively were not associated closely with prerevision radiographic findings. Of the twenty-two knees with osteolysis, eleven had fixation with cement and eight had fixation without cement. The remaining three knees had hybrid fixation (Table I). The prevalence of osteolysis was 21% (eleven of fifty-two knees) in the group that had the components inserted with cement and 33% (eight of twenty-four knees) in the group that had the procedure without cement ($p = 0.25$).

Histological evaluation of the specimens from the region of osteolysis in all knees revealed birefringent intracellular polyethylene particles within the cytoplasm of the histiocytes and giant cells.

Radiographic evidence of osteolysis in the proximal part of the tibia and the patella was associated with intraoperative observation of osteolysis. However, of the seventeen knees (thirteen in the mobile-bearing group and four in the fixed-bearing group) with defects in the femoral condyle that were identified intraoperatively, only five had had osteolysis on prerevision radiographs (Fig. 2).

Discussion

Previous reports on osteolysis after total knee arthroplasty have focused on prostheses of a fixed-bearing design[1-5]. Only a few cases of severe osteolysis associated with polyethylene wear of a mobile-bearing prosthesis have been reported[11,13].

In this series, the prevalence of osteolysis in the mobile-bearing knee group (47%; sixteen of thirty-four knees) was significantly higher than that in the fixed-bearing knee group (13%; six of forty-six knees) ($p = 0.003$). Osteolysis was found in the distal part of the femur, most commonly in the posterior part of the femoral condyle, in 21% (seventeen) of the eighty knees. Femoral lesions were involved in 78% (seventeen) of the twenty-two knees in which osteolysis was identified intraoperatively. On the basis of these observations, we postulated that two possibilities might be involved. First, although excision of posterior femoral osteophytes is a common practice in knee arthroplasty, the Low Contact Stress knee arthroplasty uses an extra cut of the posterior part of the femoral condyles to increase the range of motion (Fig. 3). This cut leaves an exposed cancellous bone surface that is not covered by the prosthesis and might provide a pathway by which wear particles gain access to the interface between the bone and implant. Second, smaller phagocytosable polyethylene particles may be generated in the Low Contact Stress mobile-bearing knee replacement, owing to the more conformed articular surface and additional undersurface wear. Further detailed examination of the size and morphology of the particles is needed. Additionally, various designs of prostheses were used in the fixed-bearing group in this study. This may also have been a factor affecting the rates of osteolysis.

Many reports on osteolysis associated with total knee arthroplasty have focused primarily on knees with cementless prostheses[4,12,14]. In the present study, osteolysis was found both in knees with cemented prostheses and those with cementless prostheses of different designs.

In many of the reports on osteolysis after total knee arthroplasty, the diagnosis was made by radiographic assessment[1,4]. However, the true prevalence is difficult to evaluate because of the limitations of imaging. Peters et al.[4] demonstrated that 16% of 174 consecutive total knee arthroplasties without cement had radiographic evidence of osteolysis at an average of thirty-five months after primary surgery.

Osteolysis that is identified radiographically occurs predominantly on the tibial side and may be caused by gravity in the weight-bearing position[15]. However, the flanges of the femoral prostheses, which tend to obscure distal femoral osteolytic lesions[3,4,15], may also be an important factor. In our series, twelve of the seventeen knees with femoral condylar osteolytic defects that were found intraoperatively had had no evidence of osteolytic resorption on prerevision radiographs. We believe that osteolysis on the femoral side is not easily recognized on plain radiographs unless the defects are quite large. They are often hidden by the femoral component of the prosthesis on the anteroposterior radiograph[12] and also by the other side of the femoral condyle on the lateral radiograph. Thus, routine radiographs usually underestimate the presence and extent of osteolysis found at revision surgery. ■

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