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Revision of infected knee arthroplasty

Sixteen infected knee arthroplasties were revised and followed for 5 (1-10) years. There were nine recurrences of infections, but in one of these a second revision was successfully carried out. The remaining seven revisions resulted in only four functioning prostheses. The results were poor for hinged and stabilized prostheses for which arthrodesis, after eradication of the infection, is recommended. Infected compartmental prostheses with good bone stock could be treated with a two-stage procedure using tricompartmental revision prostheses.

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Revision of infected total hip replacement using exchange arthroplasty is now an accepted treatment giving successful results in three quarters of the cases, unless there is a fistulating gram- negative infection with severe bone destruction (Carlsson et al. 1978, Buchholz et al. 1981).

A review of the literature on revision of infected knee arthroplasty up to 1986 yielded reports on 81 knees, 58 of which were still noninfected at follow-up (Petty et al. 1975, Deburge & Guepar 1976, Hovelius & Josefsson 1979, Vanhegan et al. 1979, Cameron & Hunter 1982, Nelson 1982, Insall et al. 1983, Woods et al. 1983, Bliss & McBride 1985, Freeman et al. 1985, Johnson & Bannister 1986). The largest series reported is that of Rand & Bryan (1983), who found 8 functioning knees out of 14 revised infected knees having used a two-stage procedure with a follow-up of 4–11 years.

We report a follow-up of 16 revised infected knee arthroplasties.

Patients and methods

Sixteen infected knee arthroplasties in 15 patients were treated with an exchange arthroplasty between 1975 and 1985 at our hospital (Table 1).

Twelve of the initial prostheses had been implanted in Lund, and four had been referred from other hospitals. All had received prophylactic antibiotics at the time of implantation. There were 12 women and 4 men with an average age of 62 (46-77) years at the primary arthroplasty. The underlying diagnosis was rheumatoid arthritis in 10 patients (11 knees) and arthrosis in 5. The type of prosthesis used for the primary arthroplasty was hinged in nine knees, tricompartmental in one, bicompartmental in one, and unicompartmental in five. Eight patients had had other operations on the knee prior to the primary arthroplasty; these included 4 tibial osteotomies, 2 meniscectomies, 2 synovectomies, 2 removals of loose bodies, 2 patellectomies, 1 operation for pseudarthrosis after tibial osteotomy, and 1 extirpation of a Baker's cyst. Four patients had bilateral knee arthroplasties; one of these patients had bilateral infection. Three patients had fusion of the other knee. Two patients had bilateral hip arthroplasties that remain uninfected.

The clinical onset of infection was classified as early if it occurred within 3 months of the primary arthroplasty; otherwise, it was classified as late (Insall et al. 1983). Eight knees were infected early; they had not been asymptomatic at any time postoperatively and presented with pain, swelling, fever, and, in five knees, with a draining sinus. Eight knees had late infections; after a satisfactory arthroplasty, four knees presented with acute pain and swelling. In one of these (Case 10) the infection appeared 4 years after implantation, but 2 weeks after an operative procedure when the loose axis of the hinged prosthesis was reinserted; at that time the patient was receiving antibiotics for osteitis of his contralateral calcaneus, which was still draining . In three knees the symptoms developed insidiously, and in one knee (Case 7) the infection was discovered by growth in tissue biopsy cultures taken intraoperatively, the revision being performed for mechanical loosening.

In this study, infection was considered proven when one or more of the following 4 criteria were met (Knutson et al. 1985):

1. A sinus from the joint or adjacent bone.
2. Three or more positive cultures from five tissue biopsies taken at the time of operation.
3 Septicemia with isolation of the same bacteria in the blood and in the knee aspirate.
4. Growth of the same bacteria in two or more knee aspirations.

Table 1. Infected knee arthroplasties

Case	Age^A/ Sex	Diagnosis^B	Initial prosthesis^C	Debut^D	Infecting organism^E	Revision prosthesis^C	Antibiotic Local^F	Antibiotic Systemic^G
1	61 F	O	Ma	4 wk	Pa	Gp	Yes	Cl Pc
2	61 F	O	Gm	2 wk	ag + Pa	Ma	No	Cl
3	52 M	O	FS	6 wk	Sa	At[1]	Yes	Dc
4	54 M	O	Ma	39 mo	Sa	Ki[1]	Yes	Fc
5	77 F	O	Gp	14 mo	Se	Gp	Yes	Cf Cl
6	71 F	R	Ma	S/3 wk	?	At	Yes	Cl
7	62 F	R	Ma	40 mo	Se	TC	Yes	Cf
8	63 F	R	Ma	S/84 mo	Sa	PCA[1]	Yes	Fc
9	62 F	R	Wa	S/3 wk	Ec + Se	Gp	Yes	Cl
10	57 F	R	Sh	S/42 mo	Pa	Sh	Yes	Cl
11	46 M	R	Gp	S/3 wk	Sa + aS	Sh	Yes	Cl
12	57 F	R	Sh	29 mo	Sa	Sh	Yes	Fc
13	70 M	R	Gp	S/36 mo	Pa	Gp	No	Cl
14	58 F	R	Gp	S/4 mo	Se	Sh	No	Cm
15	73 F	R	Gp	S/3 wk	ag	Gp	Yes	Cm
16	62 F	R	Gp	S/3 wk	Se	At[1]	Yes	Tc

A Age at the primary arthroplasty.
B O-osteoarthrosis, R-rheumatoid arthritis.
C At-Attenborough, FS-Freeman-Swanson, Gm-Geomedic, Gp-Guepar, Ki-Kinematic, Ma-Marmor, Sh-Shiers, TC-Total Condylar, Wa-Walldius.
D wk-weeks, mo-months, S-sinus formation.
E ag-anaerobic grampositive cocci, aS-anaerobic Streptococci, Ec- *Enterococcus*, gS-gamma streptococci, Pa-*P. acnes*, Sa-*S. aureus*, Se-*S. epidermidis*, ?-no pathogen cultured.
F Gentamicin cement (Palacos®).
G *Cf-Cefalexine, Cl-Cloxacillin, Cm-Clindamycin*, Dc-Dicloxacillin, Fa-Fucidic acid, Fc-Flucloxacillin, Pc-Penicillin.
H Dose in gram/day.

The presence of infection was established preoperatively by positive culture obtained by repeated aspirations in five knees, from a draining sinus in nine, and by growth in tissue biopsy cultures taken intraoperatively in 2 knees.

In 11 cases clinical onset and proven infection coincided. In the other cases, the time interval between the clinical symptoms and proven infection average 13 (7-20) months.

The time interval between primary arthroplasty and revision averaged 34 (8-89) months and between proven, early as well as late, infection and revision, 12 months.

The infecting organism were all gram-positive (Table 1).

The prosthesis used at revision was hinged in 9 knees, stabilized in 3, tricompartmental in 3, and unicompartmental in 1. Gentamicin cement was used at the revision in 13 knees.

The five revisions performed after 1979 were two-stage procedures; the first stage comprised extraction of the infected prosthesis and bone cement with temporary insertion of gentamicin-loaded beads. Four to eight weeks later, when the wound was well healed, a new prosthesis (from 1981 always of tricompartmental design) was implanted using gentamicin cement. Antibiotics were given parenterally immediately after tissue biopsies had been taken and then orally for a least 6 months.

The patients were followed-up 5 (1-10) years after the first revision.

Results

Five knees (4 patients) had noninfected prostheses with painless, stable joints with good mobility. However, one of the functioning prostheses was the result of a second revision performed for recurrent infection.

treatment				
Dose[H]	Duration (mo)	Recurrence of infection[DE]	Follow-up (mo)	End results
4.0	6	S/7 wk/Ec	88	Nonfused arthrodesis[2].
4.8	6			
4.0	18	No	82	Mechanical loosening. Fused arthrodesis[3].
2.0	6	S/3 wk/Sa	24	Fused arthrodesis[3].
4.5	8	No	57	Functioning prosthesis.
4.0	9	S/5 mo/gS	42	Nonfused arthrodesis[2].
4.0	9			
4.0	Ongoing	S/3 wk/Sa	87	Secondary revision failed due to mechanical loosening.
4.0	1	S/47 mo/Sa	13	Secondary revision. Functioning prosthesis.
2.0	Ongoing	No	14	Functioning prosthesis.
4.0	15	S/3 wk/Ec	87	Above-knee amputation after failed secondary revision using hinged prosthesis.
4.0	88	S/3 wk/Se	116	Resection arthroplasty after three failed excisions of sinuses.
4.0	12	S/3 wk/?	88	Fused arthrodesis[3].
3.0	Ongoing	No	112	Functioning prosthesis.
4.0	8	No	28	Functioning prosthesis.
0.9	24	No	24	Failed prosthesis. Pain & stiffness. Death from unrelated causes.
0.6	69	S/3 mo/?	69	Failed prosthesis. pain & stiffness. Death from septicaemia.
0.2	8	No	28	Failed prosthesis. Pain & stiffness. Death from unrelated causes.

1 Two-stage procedure using gentamicin beads (Septopal®).
2 External fixation (Charnley, Hoffmann).
3 Intramedullary nailing using a long Küntscher nail.

One knee was arthrodesed because of mechanical loosening and was fused using intramedullary nailing (Knutson et al. 1985).

Two knees failed for unknown reasons. Both patients had pain and stiffness, but no definite signs of infection or mechanical loosening. They died from unrelated causes 2 to 3 years after revision.

Four knees were arthrodesed because of recurrence of infection with sinus formation. Two knees were fused using a two-stage procedure with gentamicin beads and intramedullary nailing. The other two knees were treated with a one-stage procedure with gentamicin beads and external fixation, and neither of these were fused.

One knee underwent resection arthroplasty and another above-knee amputation after repeated revisions using hinged prostheses due to recurrence of the infection with sinus formation.

The final two knees failed due to recurrence of infection with sinus formation. In one patient a secondary revision was performed using a hinged prosthesis and this failed due to mechanical loosening; the patient refused further surgery. The other patient died from a pulmonary embolism associated with a sudden severe septic reaction in her infected knee five and a half years after revision.

Nine patients underwent more than one revision. Of these, only one patient had a functioning prosthesis.

Nine knees with hinged or stabilized primary prostheses were revised using prostheses with similar designs and this resulted in five recurrences of infection with sinus formation, two failed prostheses, and only two functioning prostheses.

Three knees with primary surface replacement prostheses were revised to hinged or stabilized prostheses. All failed because of recurrence of infection with sinus formation.

Four knees with primary surface replacements were revised using surface replacements. Two of these had functioning and non-

infected prostheses. One was noninfected, but was arthrodesed because of mechanical loosening. The fourth knee was reinfected, but had a functioning prosthesis after a second revision using a tricompartmental prosthesis.

None of the eight patients with early infections had functioning revision prostheses.

There were five infections with *Staphylococcus aureus*; three occurred late and all led to functioning prostheses. One knee infected with *Enterococcus* and *Staphylococcus epidermidis* failed. Of the nine knees infected with the low virulent organisms *Staphylococcus epidermidis, Propionibacterium acnes* and unspecified anerobic gram-positive cocci, two ended up with functioning prostheses.

Case report (No. 7-8, Table 1) A 72-year-old woman with rheumatoid arthritis had a bicompartmental Marmor arthroplasty performed on her left knee in 1976 and on her right knee in 1977. Because of mechanical loosening, her left Marmor was replaced in 1980 with a total condylar prosthesis using gentamicin cement. Cultures of tissue biopsies taken intraoperatively showed growth of *Staphylococcus epidermidis*. At 3 years the knee was painless, stable, had good mobility, and no signs of infection. In October 1984, she developed an infected wound on her left forefoot with growth of *Staphylococcus aureus*. The wound healed, but after a few weeks she developed septic arthritis of both knees with a draining sinus of her right knee. Cultures showed growth of *Staphylococcus aureus*.

From March to June 1985, she was revised bilaterally with a two- stage procedure using gentamicin beads and reinsertion of cemented PCA prostheses.

At follow-up in July 1986, her knees were painless and stable; each knee had a mobility of 0-80 degrees, and there were no signs of reinfection. The patient is now on life-long oral treatment with flucloxacillin 1 g twice daily.

Discussion

Infection of a knee arthroplasty is a serious complication with an incidence range from 1 per cent in nonconstrained prostheses (Insall et al. 1979) to 12 per cent in hinged prostheses (Hui & Fitzgerald 1980). Rheumatoid patients have been reported to have an increased incidence of infection (3%) compared with patients with arthrosis (2%) (Knutson et al. 1986).

There are four ways to combat infection of an arthroplasty:

1. Antibiotics and/or debridement, the latter being proposed for early infections where the prosthesis is not loose (Petty et al. 1975, Freeman et al. 1985).

2. Resection arthroplasty, which is rarely used but in single cases, has been reported to be successful (Kaufer & Matthews 1981).

3. Arthrodesis, which is the most widely used alternative to revision arthroplasty. A two-stage procedure using gentamicin beads and intramedullary nailing or external fixation with a ventral frame has given a high fusion rate (Kaufer et al. 1983, Knutson et al. 1985).

4. Revision arthroplasty, which has been reported to give promising results by some authors. Freeman et al. (1985) presented eight noninfected prostheses out of eight revised knees with infected compartmental prostheses treated with a one-stage procedure using gentamicin cement and antibiotics and followed-up for 1-3 years. In our study there were eight one-stage procedures using hinged or stabilized prostheses and gentamicin-cement resulting in only two functioning prostheses. With a follow-up of 1-6 years, Insall et al. (1983) reported 11 noninfected tricompartmental prostheses out of 11 revised infected knee arthroplasties using a two-stage procedure similar to ours except that antibiotics were given parenterally during the 6-week delay; no antibiotics were added to the cement. Five knees in our study, including one with a successful second revision, were treated with the two-stage procedure; three knees received tricompartmental prostheses and all of them resulted in functioning prostheses; two received stabilized prostheses ending in one fused arthrodesis and in one stiff and painful knee.

Early infections in our study had a worse prognosis than late infections. This corroborates the findings of Bliss & McBride (1985), who pointed out, however, that it is difficult to determine the relative importance of the dur-

ation of infection before treatment and the virulence of specific organisms.

The time interval between proven early infection and revision averaged 1 year, and this might reflect an earlier uncertainty of how to act in these cases. Other reports on the results of revision arthroplasty do not state the delay between diagnosis of infection and revision. In 3 of our cases, early debridement and antibiotics were tried, initially with good results, but with return of infection after a few months.

Rand & Bryan (1983) found that low virulence infections have a better prognosis than high-virulence infections. Our study did not confirm this. Of the nine low virulence infections, two resulted in functioning prostheses compared with three out of six with high-virulence infections. However, if the infecting organism is *Staphylococcus aureus*, Freeman et al. (1985) have suggested that a one-stage procedure should be the method of choice in cases without sinus formation. The three *Staphylococcus aureus* infections in our study without sinus formation all resulted in functioning prostheses, albeit only one after a one-stage procedure.

Treatment of infected knee arthroplasties is difficult. In a recent study reporting on the outcome of 25 knee arthroplasties with deep infection (Johnson & Bannister 1986), excision of a sinus track, wound debridement, and exchange arthroplasty were universally unsuccessful. The choice is usually between arthrodesis and revision arthroplasty. Many factors influence the choice: the general health of the patient, the condition of adjacent joints, the state of the tissues around the knee, the amount and quality of bone stock, previous surgery, the type of primary and revision arthroplasty, the sensitivity and type of the infective organism, and the patient's requirements for activities of daily living.

We conclude that infected hinged or stabilized prostheses should be arthrodesed, that infected compartmental prostheses could be treated with an early revision arthroplasty using gentamicin beads in a two-stage procedure, and that antibiotic-loaded cement should then be used when inserting the tricompartmental revision protheses.

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