



Single-stage revision of peri-prosthetic infection following total elbow replacement

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This study reviews the predisposing features, the clinical, and laboratory findings at the time of diagnosis and the results of single-stage revision of prosthetic replacement of the elbow for infection.

Deep infection occurred in six of 305 (1.9%) primary total elbow replacements. The mean follow-up after revision was 6.8 years (6 months to 16 years) and the mean age at the time of revision was 62.7 years (56 to 74). All six cases with infection had rheumatoid arthritis and had received steroid therapy. The infective organism was *Staphylococcus aureus*. Four of the six elbows had a developed radiolucency around one component or the other. Successful single-stage exchange arthroplasty was carried out with antibiotic-loaded cement in five of the six cases. In one, the revision prosthesis had to be removed following recurrence of the infection. The functional result was good in three elbows, fair in one, poor in one and fair in the resection arthroplasty.

Refinements in prosthetic arthroplasty have made it a reliable procedure for restoration of functional motion to severely arthritic elbows.¹ While the initial fixed-bearing implants tended to progress to early loosening, the development of so-called 'sloppy joints' has been a major advance.² The surgical approach and technique have also been modified to improve any flexion contracture, while at the same time preserving the integrity of the extensor mechanism.³⁻⁵ Infection is one of the most worrisome complications after prosthetic joint replacement. Infection following total elbow replacement occurs in 5.3% (0% to 11.5%).³ Options for the treatment of infection have ranged from long-term antibiotic suppression, to exchange arthroplasty or resection arthroplasty. To date, resection arthroplasty, a procedure which results in poor patient satisfaction and poor elbow function, has generally been considered necessary to eradicate the infection. Single-stage revision arthroplasty using specific antibiotic-loaded cement has been established as a successful treatment option of peri-prosthetic infection after knee, hip and shoulder replacement.^{6,7}

infections which occurred after prosthetic replacement of the elbow.

Patients and Methods

Between 1978 and 1999, 305 primary total elbow replacements were carried out at the Endo-Clinic, Hamburg. The underlying pathology was rheumatoid arthritis in 77% (235), post-traumatic arthritis in 21% (64) and degenerative arthritis in 2% (6). We used the GSB 3-type prosthesis (Zimmer, Warsaw, Indiana). A survival rate of 90% at ten years for this type of implant has been reported with those introduced for rheumatoid arthritis faring better than those for post-traumatic arthritis.² This study was terminated in 1999 to allow sufficient time to detect late infection.

There were six infections following total elbow replacement in five patients. The mean follow-up period after completion of treatment of the infection was 6.8 years (6 months to 16 years). The patients were all women. One suffered from peri-prosthetic infection of both elbow joints over a period of seven years. The mean age was 62.7 years (56 to 74) at the time of operation.

Patients were assessed either at the clinic, by correspondence (by telephone and post) or by assessment from a local physician. A review of the records provided information about underlying disease, operations prior to the elbow replacement, the use of steroid therapy, the

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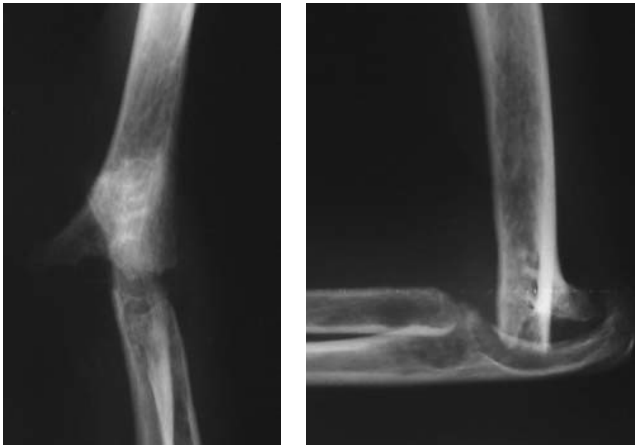


Fig. 1

Case 1. Anteroposterior and lateral radiographs prior to elbow arthroplasty. A resection arthroplasty had been done 18 months earlier. The patient had a painful, grossly unstable elbow.

findings of routine pre-operative laboratory tests, the nature of the surgical procedure and peri-operative complications. At the final assessment the clinical function and evidence of residual infection was recorded using the criteria of Morrey and Bryan.⁸ We excluded peri-prosthetic infections where the primary procedure had been carried out at another hospital because of the lack of clinical data.

The left elbow was involved in three cases and the right in three. Of the six cases of infection, all occurred in arthroplasties for rheumatoid arthritis and all had received steroid therapy. In one case a resection arthroplasty had been undertaken before the joint replacement (case 1, Fig. 1). In the other five, a surgical procedure had not been performed previously. All the patients had pain, loss of function, erythema, or warmth in the elbow. They were considered to have an infection when they had a positive culture, there was a strong clinical suspicion of infection, or both (Table I).

Deep infection was considered to be present when a culture of material from an aspiration of an elbow joint showed bacterial growth.

It has been our practice to aspirate the cavity of the joint, and culture the fluid obtained.⁹ In a proportion of cases where the result has been negative, a subsequent culture at operation has been positive.⁹ In the present study, aspiration of the joint was positive in five of the six cases. The one with a negative culture (case 3) was in a patient who had previously been treated by oral antibiotic therapy; microbiological confirmation of infection was achieved at operation. *Staphylococcus aureus* in pure culture accounted for all of the infections. We did not observe any mixed cultures in which multiple organisms were considered pathogenic. An infection was defined as acute if it was diagnosed within three months of the operation, as subacute if it was detected between three months and one year, and as late if it was recognised after one year.¹⁰ The time of clinical manifestation varied significantly. The infection was acute in two elbows, subacute in one and late in three, in whom the infection was recognised more than six years after implantation.

In three elbows the infection developed spontaneously at 2 months, 6 years and 7 years after operation, and no predisposing factor or remote focus of infection was discovered. In two elbows the infection spread directly from an ulcer which had developed spontaneously over the olecranon (Fig. 2). Seven years after a successful single-stage revision of an arthroplasty of the left elbow a peri-prosthetic infection of an arthroplasty of the opposite elbow was diagnosed and treated by direct exchange surgery. One patient had revision surgery because of aseptic loosening five years before the peri-prosthetic infection occurred. Two of the patients showed systemic symptoms of fever and malaise at the time of diagnosis. The leucocyte count was elevated in only one of the six patients. Measurements of the C-reactive protein levels and the erythrocyte sedimentation rate (ESR) exceeded normal values in all patients. The uncorrected sedimentation rate (Westergren) exceeded 30 ml in one hour in five of the six patients. The mean value for these patients was 38.6 ml (30 to 54). In one case the ESR rate was only slightly elevated (15 ml). These tests are of limited help, since in most patients who have rheumatoid arthritis, the values can be elevated.

Radiological assessment is difficult, because radiolucent lines are common after total elbow replacement.¹¹ Progress-

Table I. Clinical data of the six patients with peri-prosthetic infection that occurred after prosthetic replacement of the elbow. All had been diagnosed with rheumatoid arthritis

Case	Age (yrs)	Side*	Steroids	Prior surgery	Time to manifestation	Temperature (°C)	White blood cells (/nl)	C-reactive protein (mg/dl)	ESR† (mm/h)	Organism‡
1	56	L	Yes	Yes	2 mths	38.7	28.1	326	15/27	<i>Staph. aureus</i>
2	59	L	Yes	No	1 mth	36.8	8.6	16.4	42/80	<i>Staph. aureus</i>
3	56	R	Yes	No	7 yrs	36.5	3.6	25	32/72	<i>Staph. aureus</i>
4	67	L	Yes	No	1 yr	37.0	4.2	90	30/63	<i>Staph. aureus</i>
5	74	R	Yes	No	6 yrs	38.2	3.1	84	35/68	<i>Staph. aureus</i>
6	64	R	Yes	No	6 yrs	37.0	2.6	71	54/76	<i>Staph. aureus</i>

* L, left; R, right

† ESR, erythrocyte sedimentation rate

‡ *Staph. aureus*, staphylococcus aureus



Fig. 2

Case 2. The infection spread directly from an ulcer that had developed spontaneously over the olecranon.

sive radiolucency combined with severe bone destruction should alert the surgeon to the possibility of septic loosening as shown in case 3 (Fig. 3). Radiologically, four of the six elbows had a radiolucency around either component when first seen for infection.

The incision is in the line of the previous incision, and the approach described by Gschwend¹² was used in all cases. The ulnar nerve is exposed and protected followed by extensive debridement of necrotic material and the sinus tracts. The aim is to excise radically all infected or devascularised scar tissue and necrotic bone. The amount of bleeding is variable, the components and cement are removed meticulously. Every fragment of cement must be removed.⁹ Irrigation is used throughout the operation, mostly for its mechanical effect. The amount of bone to be removed is variable, the extent judged by experience. In one case, the procedure was complicated by an intra-operative fracture of the humerus. The implant is fixed with antibiotic-loaded cement. The list of antibiotics which were added is shown in Table II. A minimum of suture material is used for wound closure. A through-and-through stitch for the skin and fat helps obliterate dead space, as does effective suction drainage into all the recesses of the wound. Appropriate antibiotics were administered intravenously for a mean of 37.1 days (7 to 180). The choice of drug was based on the result of the cultures of material which had been taken either from previous aspiration of the elbow joint or at operation. Full blood counts and serum levels of the antibiotics were



Fig. 3

Case 3. Anteroposterior radiograph showing endosteal scalloping and lucenies.

monitored at regular intervals to reduce the risk of toxicity.

One wound did not heal primarily post-operatively. There were two late deep infections, one treated by excision arthroplasty and one by a further one-stage revision which has been successful at eight months. None of the patients suffered from ulnar neuropathy or triceps insufficiency after revision arthroplasty.

Results

The results were classified using the Mayo Performance Score.⁸ In the elbow from which the prosthesis had to be removed because of persistent infection there was marked radiological deformity (Fig. 4), but the final result was fair with a score of 60. In the other five elbows the functional result was good in three, fair in one and poor in one. In one elbow, removal of the prosthetic components was difficult and a fracture of the humerus occurred (Fig. 5). Fortunately, this healed and the functional result was fair.

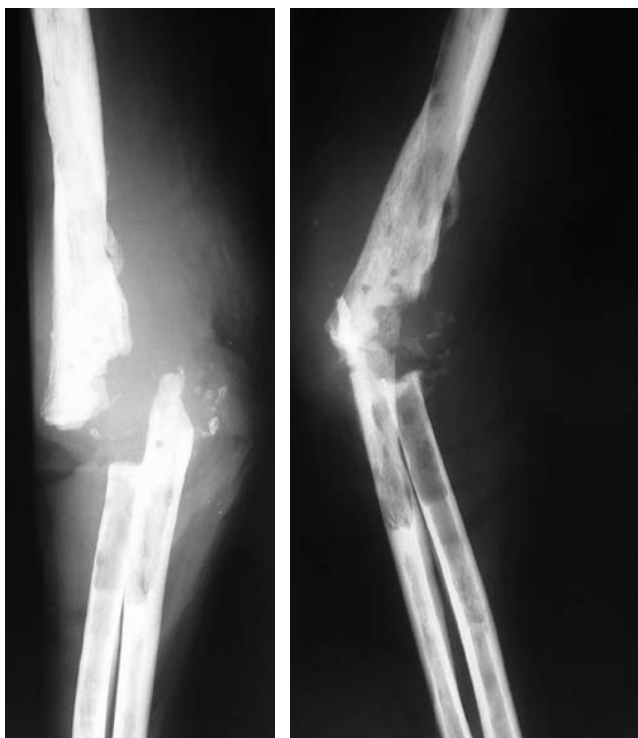


Fig. 4

Anteroposterior and lateral radiographs. The infected elbow arthroplasty was removed and a resection arthroplasty was performed. The functional result was fair, but there was gross instability. The anteroposterior radiograph demonstrates unsatisfactory bony containment of the olecranon between the humeral condyles after resection arthroplasty. The lateral radiograph demonstrates bony deficiency causing instability.

Discussion

There is a high rate of complications after arthroplasty of the elbow.² Peri-prosthetic infection is a severe and potentially devastating complication. We found a relatively low rate (1.9%) of deep sepsis but previous studies have indicated that the incidence of infection is approximately 3% to 4%.¹³ Little information is available regarding the treatment of infection after total elbow replacement. Early reports focused primarily on the diagnosis, epidemiology, risk factors and recommendations for antibiotic prophylaxis.¹ Conservative treatment by systemic antibiotic therapy can arrest the peripheral cellulitic phase of deep infection and reduce pain but does not arrest the underlying disease process.⁹ Salvage of prostheses associated with infection in other major joints by suppressive antibiotic therapy, has had limited success except in the immediate post-operative period.¹⁰ Most treatment has been limited to debridement, resection arthroplasty and re-implantation in two stages.

Wolfe et al¹⁰ described how all except two of 12 patients underwent exploration of the wound, irrigation and debridement of the necrotic material and sinus tracts, and closure of the wound over a suction drain. Antibiotics were

administered for between four and six weeks. Irrigation and debridement had to be repeated in eight cases (75%). Ten prostheses were removed, two immediately and eight after salvage had failed. Most were converted to an excision arthroplasty by excising all the infective material, taking care to retain the humeral condyles for stability. Only one patient with a low-grade infection had re-implantation of the prosthesis six weeks later; two were treated by arthrodesis. The authors conclude that attempted salvage needs to be restricted to the immediate post-operative treatment.

Late infection following elbow arthroplasty frequently occurs after local contamination by trauma, subsequent operation or inflammatory bursitis. The elbow joint is subcutaneous with relatively little soft-tissue cover and disruption of the skin may lead to joint sepsis. Two cases in this series had an ulcer over the olecranon which had developed spontaneously. Caution should be employed before salvage of the prosthesis is attempted.¹ Repeated debridement of thin, relatively avascular tissues may lead to either breakdown of the wound or avulsion of the triceps, and the close proximity of important neurovascular structures poses a risk of irreversible nerve injury.¹

When salvage of a prosthesis associated with infection is unsuccessful, resection arthroplasty is recommended.³ In this procedure the need for bony containment must be balanced against that for aggressive debridement of cement and necrotic bone. When adequate containment of the olecranon is impossible because of bony defects or an intra-operative fracture, the result is an unstable elbow.³ Morrey and Bryan⁸ found the results of resection arthroplasty after infection were good in six patients and fair in five, with failure in one due to a painful ankylosis. Wolfe et al¹⁰ noted that three of eight patients who had a resection arthroplasty sustained a fracture during the procedure. In our series of single-stage revision arthroplasty only one intra-operative fracture of the humerus occurred.

Direct exchange arthroplasty of an infected prosthesis is attractive because there is only one major operation, there is less morbidity because the patient can have a well-functioning joint sooner, and there is less expense if the infection is eradicated by the direct exchange. We are not aware of any data available about direct exchange for an infected elbow arthroplasty. Similar rates of control of infection have been reported following single- and two-stage procedures (88% and 85%, respectively) for treatment of peri-prosthetic infection after total hip replacement.¹⁴

All of our patients had rheumatoid arthritis, with an increased risk of infection following total joint replacement¹⁵ because of an altered immune response and general debilitation. There may also be numerous sites of skin breakdown with attendant bacterial colonisation. The incidence of spontaneous joint infection and respiratory infection is increased in rheumatoid arthritis.¹⁶ Infection is a leading cause of mortality in this disease, and the use of steroids may have some significance in the development of sepsis after total elbow replacement.

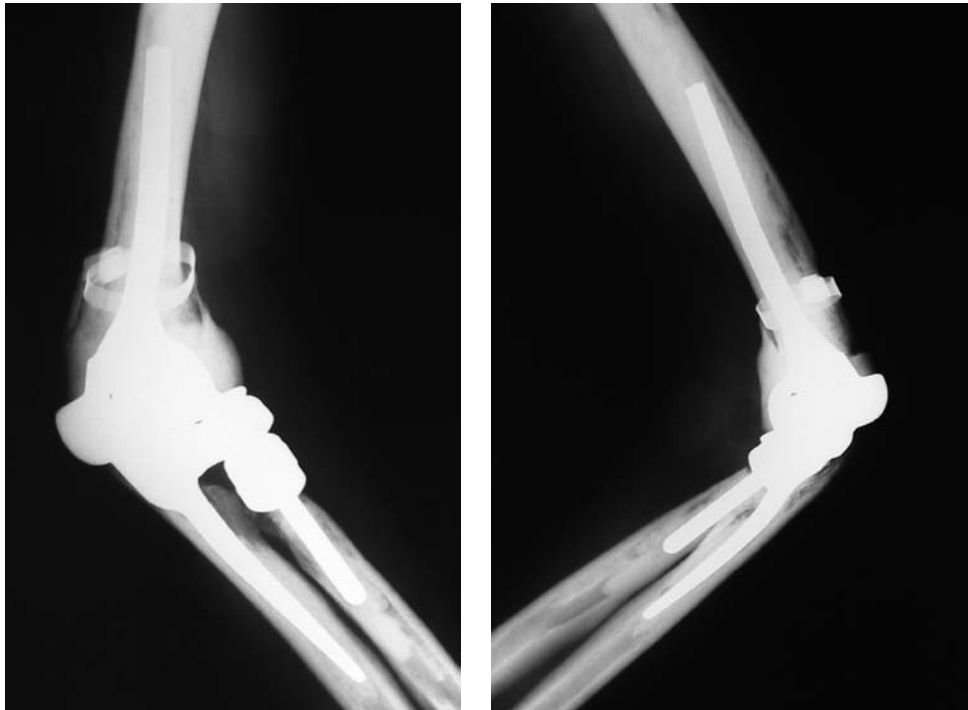


Fig. 5

Case 4. Anteroposterior and lateral radiographs after one-stage revision arthroplasty. The patient sustained a fracture of the humerus during the procedure; fortunately the fracture healed uneventfully.

Table II. Type and result of treatment in six cases of deep sepsis after total elbow replacement. The elbow score was classified as published by Morrey and Bryan⁸

Case	Antibiotics (cement)	Antibiotics (IV)	Duration of antibiotics (days)	Complication	Follow-up	Range of motion/extension/flexion	Mayo elbow score	Satisfied
1	Lincomycin Gentamycin	Staphylex 3 x 2 g	7	No	6 mths	0/10/100	45	No
2	Clindamycin Gentamycin	Staphylex 4 x 2 g	180	Explantation of the prosthesis	4 yrs	0/20/50	60	No
3	Refosporin Gentamycin	Penicillin 2 x 10 mega-units	8	No	7 yrs	0/40/120	50	Yes
4	Lincomycin Gentamycin	Staphylex 3 x 2 g	10	Wound/revision	16 yrs	0/30/120	75	Yes
5	Lincomycin Gentamycin	Sobelin 2 x 600 mg	11	No	11 yrs	0/40/130	80	Yes
6	Lincomycin Gentamycin	Sobelin 2 x 600 mg	7	No	2 yrs	0/40/130	90	Yes

Increased awareness of the possibility of infection has led to a high index of suspicion and, to earlier recognition.³ Two elbows in the present series showed clinical evidence of deep infection less than three months after surgery, in one the infection was diagnosed between three and 12 months and in three the infection was not recognised until more than six years after implantation. Similar findings have been seen by others.¹⁰ In a series of 14 cases, Wolfe et al¹⁰ had two acute acute, six subacute and six late infections. In their series, one late infection occurred within three months of a second operation, whereas three others followed local pen-

etrating trauma and subsequent cellulitis. Patients may be seen while the infection is still acute and the components well fixed.¹ Radiological examination showed radiolucencies around one or other component in four of the six elbows in our series, but radiolucent lines are commonly seen after total elbow replacement.¹¹ Progressive radiolucency combined with severe destruction of bone should alert the surgeon to the possibility of septic loosening.

Laboratory data are not often helpful.³ The ESR and C-reactive protein levels may be elevated but these are not specific in these patients since the underlying inflammatory

disease may also cause this. Elevated leucocyte counts or significant left shifts are found in a minority of cases of infection. In this study, in all but one case there was microbiological confirmation of infection, when material from a pre-operative aspiration was investigated. At subsequent operation an organism was found in all cases.

In a study using the polymerase chain reaction (PCR) of over 250 specimens of synovial fluid from infected knee and hip joints, all of the patients who had an independent clinical verification of infection were PCR-positive, whereas pre-operative microbiological culture alone identified less than 20% as positive.¹⁷ The development and application of molecular biological methods for detection of disease provides a powerful diagnostic capability to permit clinicians to devise appropriate courses of treatment and make more informed surgical decisions.

Staph. aureus in pure culture accounted for all of the infections in our patients. Data from several other series show that the most common organism isolated from infected elbows is *Staph. aureus* (70%) followed by *Staph. epidermidis* (20%).^{3,18} Other organisms encountered include *Escherichia coli*, *Beta-hemolytic streptococcus*, *Pseudomonas aeruginosa*, *Propionibacterium acnes* and *Corynebacterium*.¹⁸ Another account of implant salvage has reported that infections associated with *Staph. aureus* fare better than those caused by *Staph. epidermidis*, perhaps because of the propensity of this organism to produce more effective biofilms.¹ Since the time of treatment of the patients in the current study, antibiotic-resistant organisms have emerged.¹⁹ In the future, treatment of such resistant organisms will frequently require the use of antibiotics that have substantially higher potential toxicity to the patient.²⁰

Encouraged by our results with infected knee and hip arthroplasties, we prefer to replace an infected elbow arthroplasty with a new prosthesis in a single-stage operation, using antibiotic-loaded bone cement for fixation.^{6,9} Antibiotics diffuse out of the impregnated cement²¹ and have been shown to have prophylactic²² and clinical value.⁹ We recommend the single-stage operation because its simplicity may be associated with a lower rate of mechanical complications and the functional results are promising. A single operation gives a significant advantage in debilitated or elderly patients.

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