11. MORRELL, M. T., and DUNNILL, M. S.: The Post-Mortem Incidence of Pulmonary Embolism in a Hospital Population. British J. Surg., **55:** 347-352, 1968.
12. NICHOLS, A. B.; BELLER, G. A.; COCHAVI, SAADIA; MCKUSICK, K. A.; and STRAUSS, H. W.: Detection of Pulmonary Emboli by Positron Imaging of Inhaled ^{15}O-Labeled Carbon Dioxide. Sem. Nucl. Med., **10:** 252-258, 1980.
13. NICHOLS, A. B.; COCHAVI, SAADIA; HALES, C. A.; BELLER, G. A.; and STRAUSS, H. W.: Resolution Rates of Pulmonary Embolism Assessed by Serial Positron Imaging with Inhaled 0-15-Labeled Carbon Dioxide. J. Nucl. Med., **20:** 281-286, 1979.
14. NICHOLS, A. B.; COCHAVI, SAADIA; HALES, C. A.; STRAUSS, H. W.; MCKUSICK, K. A.; WALTMAN, A. C.; and BELLER, G. A.: Scintigraphic Detection of Pulmonary Emboli by Serial Positron Imaging of Inhaled ^{15}O-Labeled Carbon Dioxide. New England J. Med., **229:** 279-284, 1978.
15. ROTHERMEL, J. E.; WESSINGER, J. B.; and STINCHFIELD, F. E.: Dextran 40 and Thromboembolism in Total Hip Replacement Surgery. Arch. Surg., **106:** 135-137, 1973.
16. SEVITT, S., and GALLAGHER, N. G.: Prevention of Venous Thrombosis and Pulmonary Embolism in Injured Patients. Lancet, **2:** 981-989, 1959.
17. WALKER, IRWIN; AUKLAND, PAUL; HIRSH, JACK; COATES, GEOFFREY; COCKSHOTT, PETER; TAYLOR, ROBERT; and HULL, RUSSELL: The Low Specificity of Postoperative Perfusion Lung Scan Defects. Canadian Med. Assn. J., **124:** 153-157, 1981.
18. WILLIAMS, J. W.; ELKMAN, E. A.; and GREENBERG, STEPHEN: Asymptomatic Pulmonary Embolism. A Common Event in High Risk Patients. Ann. Surg., **195:** 323-327, 1982.
19. WILLIAMS, J. W.; ELKMAN, E. A.; GREENBERG, S. H.; HEWITT, J. C.; LOPEZ-CUENCA, ENRIQUE; JONES, G. P.; and MADDEN, J. A.: Failure of Low Dose Heparin to Prevent Pulmonary Embolism after Hip Surgery or above the Knee Amputation. Ann. Surg., **188:** 468-474, 1978.

The Infected Hip after Total Hip Arthroplasty

BY GARY C. CANNER, M.D.*, MARVIN E. STEINBERG, M.D.†, R. BRUCE HEPPENSTALL, M.D.†, AND RICHARD BALDERSTON, M.D.‡, PHILADELPHIA, PENNSYLVANIA

From the Hospital of the University of Pennsylvania and the Philadelphia Veterans Administration Hospital, Philadelphia

ABSTRACT: **We studied the cases of fifty-two patients with an infection at the site of a prosthetic total hip replacement, and are reporting the significant clinical features, infecting organisms, methods of treatment, and results at long-term follow-up. Forty-eight per cent of the hips had had an operation prior to the index arthroplasty, and 42 per cent had a wound complication. All patients had pain in the infected hip, but only 54 per cent had an erythrocyte sedimentation rate of more than thirty millimeters per hour, 44 per cent had fever, and 15 per cent had leukocytosis. In 88 per cent of the patients a single organism was grown on culture, and *Staphylococcus epidermidis*, *Staphylococcus aureus*, and *Escherichia coli* were present in about 75 per cent. When antibiotic therapy alone was the initial treatment, the infection was eradicated in only one patient. Excisional arthroplasty was the definitive surgical procedure in thirty-three patients and the infection was eradicated in twenty-seven of them, but the clinical result was satisfactory in only twenty. Of ten patients who had a true Girdlestone arthroplasty, none had recurrence of the infection and all had a clinically satisfactory outcome.**

Although infection after total hip-replacement arthroplasty is uncommon, it is an extremely serious complication. Its incidence has variously been calculated to be between 0.8 and 3.0 per cent[3,6,19]. However, there have been few published reports of large series of patients. In 1972, Charnley reported on eighty-five infections (1.6 per cent) after 5,800 total hip replacements that he had performed without the use of prophylactic antibiotics. Hunter and Dandy[14] studied the cases of all such patients in Canada prior to 1977, and found a total of 137 patients with 139 infected hips. Lindberg et al. reviewed the cases of patients from eight different departments of orthopaedic surgery in Sweden and Norway, and found a total of 113 who had primary revision (implantation of a total hip prosthesis after removal of the infected prosthesis, in the same surgical procedure). Most recently (1981), Buchholz et al. reviewed the cases of 583 German patients in whom primary revision was done in a center to which appropriate patients were referred.

We had four goals in the present study: first, to characterize the clinical findings in our patients; second, to identify the infecting organism or organisms; third, to review the various modes of treatment; and fourth, to determine the short-term and long-term results.

Materials and Methods

Fifty-two infected hips in fifty patients were diagnosed and treated at the Philadelphia Veterans Administration Hospital (sixteen hips) and at the Hospital of the University of Pennsylvania (thirty-six hips) between 1970 and 1980. We reviewed all charts and radiographs and performed a recent follow-up evaluation on all patients.

We evaluated the results to determine if the infection had been eliminated and rated the over-all clinical status with respect to pain, function, and mobility on the Harris scale. If a patient had recurrent drainage, an elevated eryth-

* McCrae Medical Associates, 1235 Penn Avenue, Wyomissing, Pennsylvania 19610. Please address reprint requests to Dr. Canner.
† Silverstein Pavilion, Second Floor, 3400 Spruce Street, Philadelphia, Pennsylvania 19104.
‡ 811 Spruce Street, Philadelphia, Pennsylvania 19107.

TABLE I

Type of Infection	No of Hips*	No. with Elevated Erythrocyte Sedimentation Rate*	No. with Elevated White Blood-Cell Count*	No. with Fever*	No. with Hematoma*	No. with Drainage*	No. with Wound Erythema or Other Complications*
Early	19 (16/3)	7 (6/1)	3 (3/0)	8 (8/0)	3 (2/1)	6 (6/0)	4 (3/1)
Delayed	15 (9/6)	10 (7/3)	1 (0/1)	6 (4/2)	3 (1/2)	1 (1/0)	2 (0/2†)
Late	18 (11/7)	10 (4/6)	4 (2/2)	8 (5/3)	0	2 (2/0)	1 (1/0)

* Numbers in parentheses indicate the numbers of hips treated at the Hospital of the University of Pennsylvania/numbers of hips treated at the Veterans Administration Hospital.

† Postoperative dislocation with open reduction in one of two hips.

rocyte sedimentation rate, leukocytosis, fever, or radiographic or histological changes that were typical for infection, the case was recorded as a reinfection[12]. A patient was judged to have a satisfactory result if he or she had none of the described indications of an infection and the Harris hip rating was more than 65 points, indicating minimum pain and reasonable function.

Results

Twelve of the sixteen infected hips that had been treated at the Veterans Administration Hospital and twenty-two of the thirty-six that had been treated at the University Hospital had undergone the initial total replacement at the same institution; the incidences of infection were approximately 5 and 1.8 per cent, respectively, of the total hip replacements performed at the hospitals during the ten-year period. The average age of the patients was sixty years (range, twenty-seven to eighty years). Thirty-one patients were men and nineteen were women; both of the patients with bilateral involvement were women. The primary preoperative disorders were: osteoarthritis in nineteen hips; avascular necrosis in eleven; traumatic arthritis in seven; rheumatoid arthritis in six; congenital dysplasia in six; and slipped epiphysis, radiation osteonecrosis, and chronic osteomyelitis with osteoarthritis in one hip each. No important difference could be found in the relative frequency of diagnoses in these infected hips compared with the entire population with total hip arthroplasty. In twenty-five (48 per cent) of the fifty-two hips another surgical procedure preceded the index total hip arthroplasty; these included osteotomy, internal fixation of a fracture, and implantation of an endoprosthesis. An average of two prior operations had been performed per patient in this subgroup. The types of total hip prostheses used in the index operations were: Charnley-Müller in eighteen hips, Tronzo in sixteen, Bechtol in eleven, Sbarbara in three, Ring in two, and McKee-Farrar and Aufranc-Turner in one each.

The interval between the date of the index operation and the date of diagnosis of infection was less than three months for nineteen hips (37 per cent), three to twelve months for fifteen (29 per cent), and more than twelve months for the remaining eighteen hips (34 per cent). These figures for early, delayed, and late infections are similar to those reported by others[8,9,14,23]. The signs and symptoms at the time of diagnosis included pain in all fifty-two hips, an increased erythrocyte sedimentation rate in twenty-seven (54 per cent), a febrile episode with a temperature higher than 38 degrees Celsius in twenty-two (44 per cent), and leukocytosis in eight (15 per cent). Table I shows the incidence of these signs and symptoms at the time of diagnosis for the hips with early, delayed, and late infection. None of the signs and symptoms were consistently found in any one group. There were relatively few early infections in the patients treated at the Veterans Administration Hospital.

In 42 per cent of the hips, wound complications were noted in the immediate postoperative period (at two to three weeks). A majority of them were eventually classified as having an early infection. In the one hip that had dislocated early and required open reduction, a delayed infection developed. Although the patients at the Veterans Administration Hospital had a higher incidence of infection, they did not have a higher incidence of wound complications or early infection. Of the hips in which infection appeared more than twelve months after operation, six had distant septic foci, which probably gave rise to hematogenous spread of the infection. The foci included severe infections of the skin, the oral cavity, the urinary tract, and an abdominal wound. In each patient inappropriate or no antibiotic coverage had been prescribed and the same organisms were grown on culture of a specimen from the focus as were grown from a specimen from the infected hip. The remaining twelve late infections may have been due either to hematogenous spread from an unknown septic focus or to the exacerbation of a low-grade infectious process. All but one of these twelve patients had concurrent rheumatoid arthritis, chronic hepatitis, diabetes, sickle-cell anemia, chronic tuberculous infection, or a history of alcohol or drug abuse.

In reviewing the bacteriological findings of these infections, we found that in most (forty-seven of the fifty-two hips) a single organism was responsible. *Staphylococcus aureus* (ten hips), *Staphylococcus epidermidis* (sixteen hips), and *Escherichia coli* (ten hips) were by far the most common organisms, as has been found in previous series[15]. The responsible organisms were obtained by preoperative aspiration of the hip or tissue culture, or both, in twenty-nine hips and by intraoperative wound culture in the others.

The initial treatment consisted of antibiotics alone in nine hips (group 1), antibiotics and drainage in twenty-three (group 2), primary revision in five (group 3), and excisional arthroplasty in fifteen (group 4) (Table II). The method of treatment was chosen mostly according to the surgeon's preference, although early in the series (before 1976) there

TABLE II

NO. OF INFECTIONS IN EACH TREATMENT GROUP*

Type of Infection	Group 1	Group 2	Group 3	Group 4
Early	5 (3/2)	10 (10/0)	2 (1/1)	2 (2/0)
Delayed	1 (1/0)	6 (3/3)	2 (1/1)	7 (5/2)
Late	3 (2/1)	7 (5/2)	1 (1/0)	6 (2/4)
Total	9	23	5	15

* Numbers in parentheses indicate the numbers of hips treated at the Hospital of the University of Pennsylvania/numbers of hips treated at the Veterans Administration Hospital.

was a greater tendency to treat patients with antibiotics alone or with antibiotics and drainage (groups 1 and 2) than there was later in the series.

In about half of the patients in whom ingress and egress tubes were used for the treatment of the infection, there was a change in the type of organism identified in the hip secondary to colonization of the wound. Typically, there was a change from a gram-positive organism such as Staphylococcus to a gram-negative rod such as Pseudomonas, Klebsiella, or Enterobacter species. The secondary flora were almost uniformly resistant to all available oral antibiotics.

In group 1, the treatment regimen included commonly therapeutic doses of appropriate antibiotics, as determined by drug-sensitivity testing, administered intravenously for a total of four to six weeks. In only two hips was the infection eradicated, and both of these results were clinically satisfactory. Of the remaining seven patients, two were subsequently treated with concurrent antibiotics and surgical drainage but they had a clinically poor result. In group 2, the treatment (by antibiotics and drainage) failed in twenty-two of the twenty-three patients, not including the two patients from group 1 who were subsequently treated with antibiotics and drainage. Excisional arthroplasty was performed after failure of the antibiotics and drainage treatment in eighteen of the remaining twenty-two patients, and the results of these subsequent procedures will be discussed later. The average interval between treatment with antibiotics and drainage and treatment with excisional arthroplasty was ten months (range, one to sixty months). In the five hips in group 3 (primary revision without use of antibiotic-loaded cement), there were two satisfactory results. Two other hips had apparent eradication of the infection but with a clinically unsatisfactory result, and in one patient the infection clearly recurred. Of the fifteen hips in group 4 (excisional arthroplasty as the initial treatment), the infection was apparently eradicated in thirteen. One patient, however, was receiving daily oral antibiotics on a chronic basis at the time of the study, and the infection may simply have been temporarily suppressed. Four of the fifteen hips had a clinically unsatisfactory result because of moderate to severe pain, poor function, or recurrent infection.

When excisional arthroplasty was utilized as the final definitive surgical procedure, as either the initial (fifteen hips) or subsequent treatment (eighteen hips), there was apparent eradication of the infection in twenty-seven and a clinically satisfactory result in twenty of the thirty-three hips. Excisional arthroplasty involves temporary or permanent removal of the femoral and acetabular components. Some of the hips had a true Girdlestone procedure at the time of the excisional arthroplasty. A Girdlestone procedure involves the formation of two congruous, articulating surfaces at the hip, produced by removing the lateral acetabular rim and osteotomizing the proximal part of the femur at the intertrochanteric line[12,26,27]. Figure 1 shows a hip with a good result after a Girdlestone procedure. In our series, when a Girdlestone arthroplasty was performed care was taken to remove all of the cement, the wound was closed primarily, and skeletal traction was applied to maintain distraction at the pseudarthrosis for six weeks (Figs. 2-A and 2-B). Parenteral antibiotics were given for this six-week period and then discontinued. Oral antibiotics were rarely used during this time. An additional four to six-month period of protected weight-bearing with crutches, a walker, or an ischial weight-bearing brace was then recommended. (Despite postoperative traction, moderate proximal migration of the femur took place.) Meticulous attention was paid to these details according to the protocol worked out at the Nuffield Orthopaedic Centre[26]. Of the twenty hips with a clinically successful result, ten had had a Girdlestone arthroplasty and ten, some other excisional arthroplasty.

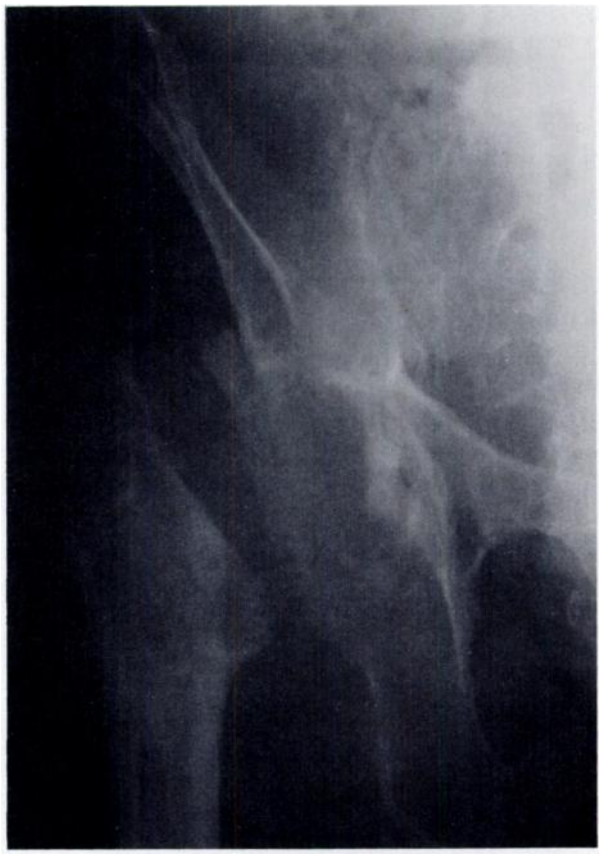

FIG. 1

Radiograph showing a hip that had a properly performed Girdlestone arthroplasty.

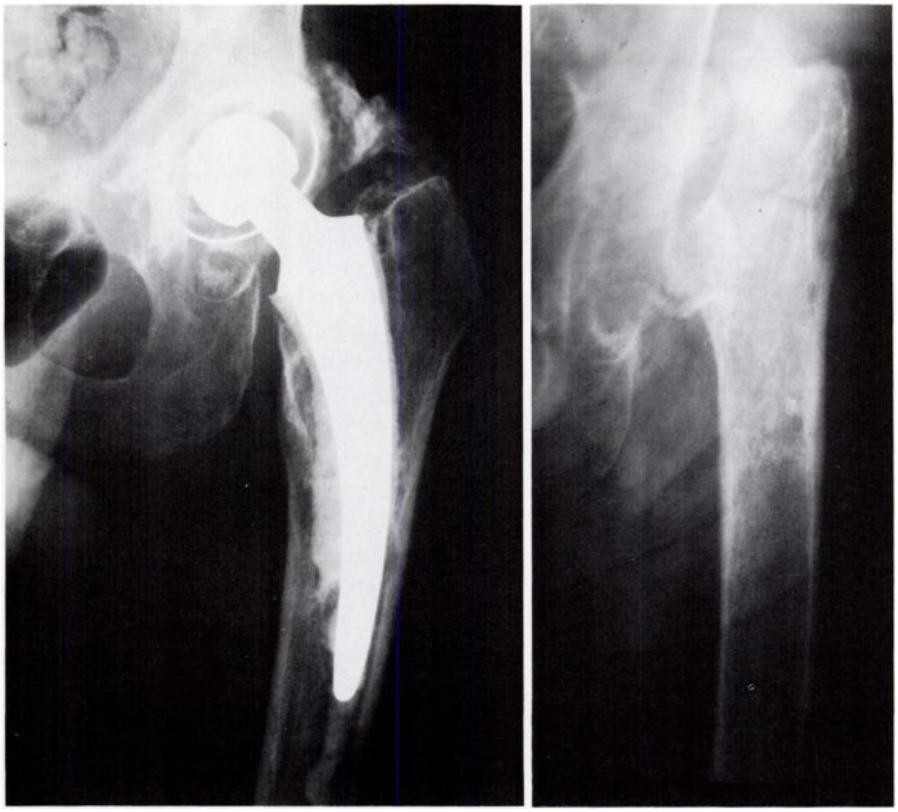

FIG. 2-A FIG. 2-B

Fig. 2-A: Preoperative radiograph of an infected hip with a loosened total hip prosthesis and extension of cement far down the medullary canal.
Fig. 2-B: Postoperative radiograph showing that all of the cement has been removed.

Three hips had delayed revision of an excisional arthroplasty (removal of the components and reinsertion at a second procedure): one at six months, one at eighteen months, and one at twenty-four months after excisional arthroplasty. All of these patients had apparent eradication of the infection. One result, however, was judged to be clinically unsatisfactory due to pain and poor function. One patient with a satisfactory result after secondary total hip arthroplasty was receiving chronic suppressive antibiotic therapy at the time of the conclusion of the study, thirty-six months after the second operation.

Of the nineteen hips that had an excisional arthroplasty in which all of the cement was removed, seventeen had no recurrence of infection and thirteen had a clinically successful result. Of the fourteen hips from which all of the cement was not removed, ten had no recurrence of infection and seven had a clinically successful result. Of the ten hips in which a true Girdlestone arthroplasty was performed, there were no recurrences of infection and all had a clinically successful result, as defined earlier. In comparison, of the twenty-three hips that were treated by excisional arthroplasty without a true Girdlestone arthroplasty, infection was eradicated in seventeen and a clinically satisfactory hip was achieved in only ten.

The average length of follow-up of these patients was 4.1 years (range, six months to nine years). Only ten patients had less than two years of follow-up, and each had had obvious recurrence of the infection with a clinically unsatisfactory result. There were three deaths, each after more than two years of follow-up. None of the deaths were directly due to the infection, although one patient had had a recurrence and two had had a clinically unsatisfactory result.

Discussion

This study does not represent a national or multicenter review, but rather the cumulative experience of two hospitals supervised by one academic department of orthopaedic surgery. The advantages of our study included the facts that there was one surgical staff in charge, that the operative techniques and the approaches to treatment were the same, and that there was a uniform follow-up.

We reviewed the various modes of treatment that were used for infected hips after total replacement, including antibiotics alone, antibiotics with surgical drainage, excisional arthroplasty, and primary revision. Our findings suggested that only excisional arthroplasty consistently eliminated infection and resulted in a clinically satisfactory result. A secondary total hip replacement can later be attempted should infection be eradicated, but this was performed in only three of our thirty-three patients who had excisional arthroplasty. Primary revision was rarely attempted in our series, but in various reports, including those of Buchholz et al. and Carlsson et al., this procedure was successful in 70 to 90 per cent of patients. However, other studies[13] have suggested that the success rate may be much lower (25 per cent) when the hips that were described as

"healed" are more closely evaluated. Buchholz et al. defined a good result as eradication of infection and a stable arthroplasty.

As noted in this and other reports, a high percentage (48 per cent) of the patients have had previous operations on the affected hip prior to the initial (index) total hip arthroplasty[2]. In our total population with hip replacement, only 12 per cent of the patients who did not have infection had undergone a previous operation. We also noted that a very high percentage of our patients exhibited problems with wound-healing immediately after the primary total hip replacement.

While the patients at the Veterans Administration Hospital had a much higher infection rate than those at the University of Pennsylvania Hospital, they had relatively few wound complications and few early infections. However, they tended to have a higher incidence of other serious systemic diseases, including alcoholism and diabetes, with low resistance to infection. Thus, the high incidence of delayed and late infection in the Veterans Hospital patients may have been due to hematogenous spread from concurrent infection or exacerbation of a very low-grade process that would have been subclinical in a patient from the general population (University Hospital).

The most significant observations that can be drawn from this study relate to the follow-up evaluations of the patients. The average length of follow-up was slightly more than four years, with three deaths having occurred during this period. As has been noted in previous studies[21], the infection rate for patients with total hip replacement increases significantly with time. Thus, it is imperative that studies include long-term follow-up. Reviewing the cases of our patients with late infection, we found an average interval of 3.7 years from the time of the hip replacement to diagnosis of infection, and in six of the eighteen patients with a late infection the interval was longer than four years. To our knowledge all six of these infections were non-hematogenous. The hips that had successful treatment of a late infection were followed for an average of 4.5 years. In 1974, Müller noted that the statistics presented by Buchholz and Gartmann in 1972 for primary revision showed a 95 per cent success rate. One year later, however, this figure changed to 75 per cent. In 1981, Buchholz et al. reported a four-year average follow-up of good results after primary revision. Jupiter et al. reported that fourteen of eighteen primary revision arthroplasties were successful, yet only five of the fourteen had a follow-up of at least four years. In our study we attempted to minimize the number of patients who were lost to follow-up. The patients who had not been seen for as long as five years were located and contacted (sometimes with great difficulty), and in many instances the reason that they had not been seen and had been initially listed as lost to follow-up was that they had been doing quite well with the excisional arthroplasty. This may in part explain the significantly higher percentage of satisfactory results after excisional arthroplasty in this study compared with previous studies[7,22,24]. Petty and Goldsmith reported only a 20 per cent success rate for excisional arthroplasty

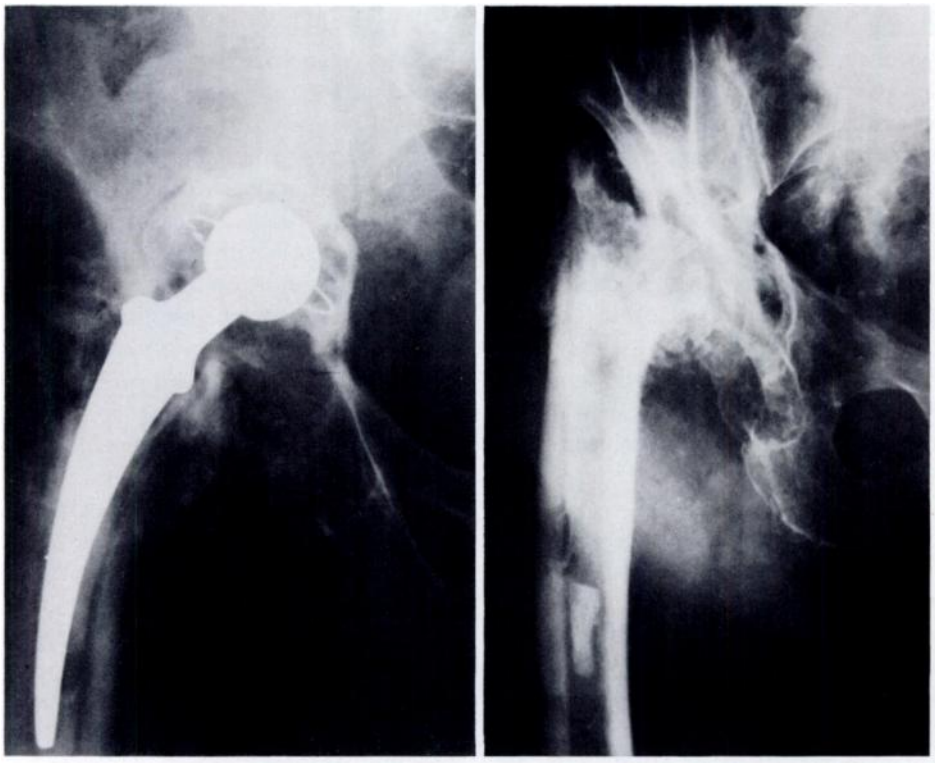

FIG. 3-A FIG. 3-B

Fig. 3-A: Preoperative radiograph of a hip with a chronic infection, loosening of both components of the total hip replacement, and intrapelvic protrusion of the acetabulum.

Fig. 3-B: Postoperative radiograph showing that the femoral neck has been inadequately resected and all of the cement has not been removed.

after infection in patients with total hip replacement.

We also evaluated several factors that had previously been advocated as affecting the outcome of excisional arthroplasty. Eradication of infection, producing a dry surgical wound, is mandatory for a successful excisional arthroplasty, and complete removal of cement has been recommended as a prerequisite to achieving this end. Seventeen (89 per cent) of the nineteen hips with excisional arthroplasty from which all cement was removed had no recurrence of infection, and ten (71 per cent) of the fourteen hips from which all cement was not removed had eradication of infection. The differences between the groups were not statistically significant, using the Fisher analysis. Moderate to severe pain and poor function have contributed to poor results with excisional arthroplasty. In our series, each of the ten hips in which a true Girdlestone arthroplasty was performed had a clinically successful result. Only 43 per cent of the twenty-three hips in which a Girdlestone procedure was not performed had a clinically successful result.

The results in our patients seem to have been better than those reported in most other series. In addition to the more comprehensive follow-up, there are several reasons for this. Many orthopaedists use the term "Girdlestone procedure" loosely to include all types of excisional arthroplasty, instead of just those that strictly conform with Girdlestone's operation and postoperative regimen. A portion of the femoral neck or acetabular rim may be left behind, or the postoperative management may include some shortcuts. Figures 3-A and 3-B show a hip in which there had not been adequate resection of the femoral neck and, despite use of a lateral window, cement remained in the medullary canal. In our ten patients in whom a true Girdlestone procedure was performed, a deliberate attempt was made to remove all visible cement and infected bone. It is doubtful, however, that an absolutely complete débridement is ever accomplished. From our data it is impossible to determine whether the key element for success is the surgical débridement of cement and bone or the formation of the Girdlestone pseudarthrosis. We wish to emphasize that the surgeon and the patient should have reasonable expectations for this procedure and should be aware of its limitations. Shortening, instability, an abductor lurch, and the need to use a single cane should not be construed as indicators of failure. Elimination of infection, good motion, acceptable function, and little or no pain are the appropriate goals of this procedure.

If the Girdlestone procedure is to be successful, then ideally it should include, as already discussed, complete excision of the neck of the femur and the rim of the acetabulum. Unfortunately, this presents the surgeon with a therapeutic dilemma, in that although the procedure will give the best result it also makes it more difficult to replace the total hip at a later date. When the surgeon is reluctant to leave the patient with a Girdlestone arthroplasty permanently, he or she has two options. First, the components and all cement may be removed without sacrificing the calcar or acetabulum. The majority of patients who are treated in this way have a poor result and may later request reimplantation of a total hip prosthesis, assuming that the infection has been eradicated. In our series of patients who had a non-Girdlestone excisional arthroplasty, the 43 per cent success rate (ten of twenty-three hips) was comparable with the rates in other reported series. Second, the surgeon may elect to perform a true Girdlestone arthroplasty and accept the fact that at a later date reimplantation of a prosthesis will be more difficult, but not impossible. All of our Girdlestone arthroplasties were clinically successful and none of the patients elected to undergo reimplantation. In addition, the patient who has undergone multiple attempts at revision surgery may be left with an insufficient proximal end of the femur for the performance of a proper Girdlestone pseudarthrosis. The surgeon must weigh these factors when making surgical decisions.

Our data on primary revision (five hips) represent too few patients to be of significance, and the actual results of primary revison can best be evaluated by reviewing several other publications[4,5,16,17,20,28]. Buchholz et al. reported a 77 per cent success rate in 583 patients and Carlsson et al. reported a 78 per cent success rate in seventy-seven patients. Our data were insufficient to substantiate the recommendation that there be a delay after excisional arthroplasty, during which time the patient is treated with antibiotics and traction, and that the prosthesis then be reinserted unless there is reasonable evidence that the infection has not been eradicated[13,25].

Conclusions

There was a significant increase in the rate of infection in patients who had undergone other operations on the hip before the total arthroplasty. Also, infection will eventually develop in many patients with postoperative wound complications or an unusual elevation of temperature after total hip replacement. Such patients must be treated early and with extreme caution. Measures should be instituted to diagnose the possible presence of a deep infection, even when it is not apparent. A significant number of delayed infections will develop through hematogenous spread from distant septic foci, and efforts to identify and treat such foci also should be instituted early and adequately in an attempt to prevent spread of the infection to the hip. Once infection develops in the hip, treatment with antibiotics alone or with antibiotics and surgical drainage will be successful in only a small percentage of patients. These measures should, therefore, be used for only short periods. Ingress and egress tubes should be avoided because they often result in secondary infection. Prompt removal of the prosthetic components and all of the cement, combined with appropriate antibiotic treatment, will eradicate the infection in most patients. In addition, it is advisable to perform a true Girdlestone arthroplasty and to follow the prescribed postoperative regimen carefully. This procedure will improve the functional results considerably, and will often eliminate the need for a later operation, although if another total hip replacement is eventually needed it may be more difficult to insert.

References

1. ANDERSON, L. D.: Infections. *In* Campbell's Operative Orthopaedics, edited by A. A. Edmonson and A. H. Crenshaw. Ed. 6, pp. 1070-1072. St. Louis, C. V. Mosby, 1980.
2. ANDREWS, H. J.; ARDEN, G. P.; HART, G. M.; and OWEN, J. W.: Deep Infection after Total Hip Replacement. J. Bone and Joint Surg., **63-B(1):** 53-57, 1981.
3. BECKENBAUGH, R. D., and ILSTRUP, D. M.: Total Hip Arthroplasty. A Review of Three Hundred and Thirty-three Cases with Long Follow-up. J. Bone and Joint Surg., **60-A:** 306-313, April 1978.
4. BUCHHOLZ, H. W.; ELSON, R. A.; ENGELBRECHT, E.; LODENKÄMPER, H.; RÖTTGER, J.; and SIEGEL, A.: Management of Deep Infection of Total Hip Replacement. J. Bone and Joint Surg., **60-B(3):** 342-353, 1981.
5. CARLSSON, A. S.; JOSEFSSON, GÖRAN; and LINDBERG, LARS: Revision with Gentamicin-Impregnated Cement for Deep Infections in Total Hip Arthroplasties. J. Bone and Joint Surg., **60-A:** 1059-1064, Dec. 1978.
6. CHARNLEY, JOHN: Postoperative Infection after Total Hip Replacement with Special Reference to Air Contamination in the Operating Room. Clin. Orthop., **87:** 167-187, 1972.
7. CLEGG, J.: The Results of Pseudarthrosis after Removal of an Infected Total Hip Prosthesis. J. Bone and Joint Surg., **59-B(3):** 298-301, 1977.
8. EFTEKHAR, N. S.: Principles of Total Hip Arthroplasty, pp. 141-146. St. Louis, C. V. Mosby, 1978.
9. FITZGERALD, R. H., JR.; NOLAN, D. R.; ILSTRUP, D. M.; VAN SCOY, R. E.; WASHINGTON, J. A., II; and COVENTRY, M. B.: Deep Wound Sepsis following Total Hip Arthroplasty. J. Bone and Joint Surg., **59-A:** 847-855, Oct. 1977.
10. GIRDLESTONE, G. R.: Acute Pyogenic Arthritis of the Hip. An Operation Giving Free Access and Effective Drainage. Lancet, **1:** 419-421, 1943.
11. HARRIS, W. H.: Traumatic Arthritis of the Hip after Dislocation and Acetabular Fractures: Treatment by Mold Arthroplasty. An End-Result Study using a New Method of Result Evaluation. J. Bone and Joint Surg., **51-A:** 737-755, June 1969.
12. HUGHES, P. W.; SALVATI, E. A.; WILSON, P. D., JR.; and BLUMENFELD, E. L.: Treatment of Subacute Sepsis of the Hip by Antibiotics and Joint Replacement Criteria for Diagnosis with Evaluation of Twenty-Six Cases. Clin. Orthop., **141:** 143-157, 1979.
13. HUNTER, G. A.: The Results of Reinsertion of a Total Hip Prosthesis after Sepsis. J. Bone and Joint Surg., **61-B(4):** 422-423, 1979.
14. HUNTER, GORDON, and DANDY, DAVID: The Natural History of the Patient with an Infected Total Hip Replacement. J. Bone and Joint Surg., **59-B(3):** 293-297, 1977.
15. HUNTER, GORDON, and DANDY, DAVID: Diagnosis and Natural History of the Infected Total Hip Replacement. *In* The Hip: Proceedings of the Fifth Open Scientific Meeting of The Hip Society, pp. 176-191. St. Louis, C. V. Mosby, 1977.
16. JAMES, E. T. R.; HUNTER, G. A.; and CAMERON, H. U.: Total Hip Revision Arthroplasty: Does Sepsis Influence the Results? Clin. Orthop., **170:** 88-94, 1982.
17. JUPITER, J. B.; KARCHMER, A. W.; LOWELL, J. D.; and HARRIS, W. H.: Total Hip Arthroplasty in the Treatment of Adult Hips with Current or Quiescent Sepsis. J. Bone and Joint Surg., **63-A:** 194-200, Feb. 1981.
18. LINDBERG, LARS; CARLSSON, ÅKE; and JOSEFSSON, GÖRAN: Use of Antibiotic-Containing Cement in Total Hip Arthroplasty Done in the Presence of or after Deep Wound Infection. *In* The Hip: Proceedings of the Fifth Open Scientific Meeting of The Hip Society, pp. 170-175. St. Louis, C. V. Mosby, 1977.
19. LOWELL, J. D.: Complications of Arthroplasty and Total Joint Replacement in the Hip. *In* Complications in Orthopaedic Surgery, edited by C. H. Epps, Jr. Vol. 2, pp. 935-937. Philadelphia, J. B. Lippincott, 1978.
20. MILEY, G. B.; SCHELLER, A. D., JR.; and TURNER, R. H.: Medical and Surgical Treatment of the Septic Hip with One-Stage Revision Arthroplasty. Clin. Orthop., **170:** 76-82, 1982.
21. MÜLLER, M. E.: Preservation of Septic Total Hip Replacement Versus Girdlestone Operation. *In* The Hip: Proceedings of the Second Open Scientific Meeting of The Hip Society, pp. 308-318. St. Louis, C. V. Mosby, 1974.
22. NELSON, J. P.: Deep Infection following Total Hip Arthroplasty. J. Bone and Joint Surg., **59-A:** 1042-1044, Dec. 1977.
23. NOLAN, D. R.; FITZGERALD, R. H., JR.; BECKENBAUGH, R. D.; and COVENTRY, M. B.: Complications of Total Hip Arthroplasty Treated by Reoperation. J. Bone and Joint Surg., **57-A:** 977-981, Oct. 1975.
24. PETTY, WILLIAM, and GOLDSMITH, STUART: Resection Arthroplasty following Infected Total Hip Arthroplasty. J. Bone and Joint Surg., **62-A:** 889-896, Sept. 1980.
25. SALVATI, E. A.; CHEKOFSKY, K. M.; BRAUSE, B. D.; and WILSON, P. D., JR.: Reimplantation in Infection: A 12-year Experience. Clin. Orthop., **170:** 62-75, 1982.
26. STEINBERG, M. D.: Personal communication.
27. TAYLOR, R. G.: Pseudarthrosis of the Hip Joint. J. Bone and Joint Surg., **32-B(2):** 161-165, 1950.
28. WILSON, P. D., JR.; AGLIETTI, PAOLO; and SALVATI, E. A.: Subacute Sepsis of the Hip Treated by Antibiotics and Cemented Prosthesis. J. Bone and Joint Surg., **56-A:** 879-898, July 1974.