CLINICAL ARTICLE

Cementless Revision for Infected Hip Arthroplasty: an 8.6 Years Follow-up

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Objective: To investigate cementless revision for postoperative infection after total hip arthroplasty (THA).

Methods: From November 1997 to December 2009, 10 patients (10 hips; four males, six females) of mean age 58 years (36–73 years) with infection after THA were treated. Six of the 10 hips underwent revision total hip arthroplasty, two only received new acetabular components and two underwent stem revision. One-stage revision was performed in six cases and two-stage revision in four. Consecutive radiographs were compared to evaluate component conditions. Harris hip scores were determined before surgery and at final follow-up. Erythrocyte sedimentation rate and C-reactive protein were assessed.

Results: All patients were followed up for a mean duration of 8.6 years (6.5–15.6 years). The mean Harris hip score improved from 35 (18–63) points preoperatively to 89 (60–99) points at final follow-up. No re-infection occurred. Femoral component exsersion was occurred in one asymptomatic patient. Hip joint pain resolved in seven cases; three patients had mild pain when walking long distances. At final follow-up, six patients still had slight limps. Heterotopic ossification developed in two hips. Mean polyethylene liner wear was 0.08 mm per year at final follow-up. Deep vein phlebothrombosis and nerve injury did not occur.

Conclusion: One- or two-stage revisions using cementless prosthesis can produce satisfactory clinical outcomes in patients with infection after THA. Whether the original prosthesis can be partially retained when attached tightly to the femur or acetabular bone needs further investigation.

Key words: Arthroplasty; Hip; Infection

Introduction

In this decade, although the incidence of periprosthetic infection after primary total hip arthroplasty (THA) has decreased to 0.3%–1.0%, it is still a devastating complication^{1,2}. Infection after hip replacement is a serious local complication that generally requires one- or two-stage revision arthroplasty. Many surgeons currently recommend two-stage revision arthroplasty with antibiotic-loaded spacer implantation after removal of the original components. Some authors consider two-stage revision as the gold standard, preferring to revise an infected THA in two stages because it allows for more options for the final reconstruction and has a higher rate of eradication

of infection. These surgeons believe that one-stage revision is unwise and risky^{3–5}. However, staged treatment of infected hip replacements is prolonged and frequently leads to functional sequelae or impairment. It is also expensive and imposes a heavy health care cost burden. Thus, one-stage revision arthroplasty is an attractive therapeutic option, requiring only one operation, having low morbidity, being free from the technical difficulties associated with delayed reconstruction and, if successful, offering a cost-efficient option. One-stage revision has been successful in treating infections; however, there are limited reconstructive options for dealing with bone loss. For these reasons, some authors have adopted a flexible approach,

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performing a one-stage procedure in less severe cases and a two-stage revision in more severe cases.

Traditionally, total hip revisions for infection have been carried out using cemented components to enable use of antibiotic-loaded cement. When a hip arthroplasty revision is thought appropriate, the use of strict selection criteria and antibiotic-impregnated cement for prosthesis fixation has been strongly recommended. However, the intermediate and long-term results when revision hip arthroplasty components are inserted with cement have not been encouraging, having unacceptable rates of failure and loosening⁶⁻⁸. Currently, an increasing number of surgeons believe that in revision hip arthroplasty, the medullary cavity become smooth and hard, leaving little trabecular bone to which cement can attach. As a result, many surgeons are now choosing cementless components for revision hip arthroplasty, with a reported survivorship rate of 95% at ten-year follow-up⁹. The results of two-stage revision arthroplasties performed with cementless prostheses in patients with infected hips are encouraging and comparable to those for cemented reconstruction¹⁰⁻¹². Therefore, cementless revision hip arthroplasty may have a role in the treatment of carefully selected patients with infected hip replacements. However, because the use of cemented components allows the surgeon to add antibiotics to the cement and thus help to prevent recurrent infection, there is some concern that, particularly when foreign-body-containing implants are used between stages, recurrent infection rates will be higher with cementless fixation, which does not allow addition of antibiotic to the implant.

To the best of our knowledge, most surgeons suggest that all implants in patients with deep infections around hip prostheses should be removed. Few reports have previously been published in an English-language journal on saving prostheses by performing cementless revision hip arthroplasty in patients with deep infections around hip prostheses. From November 1997 to December 2009, 10 patients with infection after THA were treated with cementless prostheses in our department, in four of which only cup or stem revision was performed, and the mid-term (6.5–15.6 years) results ascertained. The purpose of this study was to evaluate the clinical results of revision hip arthroplasty using cementless implants and whether the original prostheses can be retained in patients with infected hip arthroplasties.

Patients and Methods

Patient Data

From November 1997 to December 2009, 10 patients (10 hips; four male, six female) of mean age 58 years (36–73 years) with infections after THA were treated. The mean body mass index was 21 (18–25). The interval between the primary THA and revision ranged from 6 months to 11 years (mean, 3.6 years). The reasons for primary THA were osteonecrosis in five hips, femoral neck fracture in four and femoral tumor in one. All ten patients had normal body temperatures and white blood cell counts. Discharging sinuses developed in four hips. The pre-

operative mean erythrocyte sedimentation rate (ESR) and serum C-reactive protein (CRP) concentrations were 46 mm/1 h (16–62 mm/1 h) and 18.1 mg/L (13.3–28.6 mg/L) respectively. Eight patients had systemic disease such as diabetes and hypertension. Six of the 10 hips underwent revision THA, two only received new acetabular components and two only underwent stem revision because the original prosthesis was attached tightly to the femur or acetabular bone (Table 1).

The diagnoses of infection after THA were mainly based on: i) chronic hip pain; ii) high ESR and CRP concentrations; iii) pus found during exposure; iv) polymorphonuclear leukocytes >10/high power field on frozen sections of tissue obtained from the joint capsule or periprosthetic membrane; and v) positive results of bacterial culture or Gram staining of tissue and/or fluid obtained preoperatively or intraoperatively.

Treatment

The American Academy of Orthopaedic Surgeons and Paprosky classifications were used to evaluate the bone defects preoperatively. An appropriate prosthesis was selected according to the bone defect found during the operation after treating the bone-bed. Acetabular reinforcement rings, titanium threaded cups or hemispherical acetabular prostheses were used to reconstruct the acetabulum, titanium alloy rectangular revision stems as femoral components and bone grafting and circle wire as necessary.

One-stage revision was performed in six hips. These one-stage cementless revision hip arthroplasties were performed in selected patients strictly according to the following criteria: i) no chronic debilitating comorbidities; ii) no previous history of hip infection; iii) no evidence of acute systemic infection (e.g. fever); iv) no discharging sinuses; v) with adequate soft tissue and bone stock to achieve a closed wound and stable implant by revision; vi) with purulent or grossly inflamed tissue provided there was a negligible amount of pus (less than 5 mL); and vii) if checked, with pathogen of low virulence as determined by preoperative aspiration cultures. In such mildly infected patients, thorough debridement was performed and a cementless prosthesis implanted directly (Fig. 1).

Two-stage revision was performed in four hips. Unlike one-stage revision, two-stage revision was performed in seriously infected patients as identified by the following criteria: i) presence of discharging sinus and a great amount of pus during operation; ii) evidence of acute systemic infection; iii) severe soft tissue edema; and iv) inadequate soft tissue and bone stock. Meticulous debridement of all necrotic and infected tissue along with removal of all implants and cement was performed and a customized, antibiotic-impregnated, cement spacer was implanted. Postoperatively, patients were treated with intravenous antibiotics or combined intravenous and oral antibiotics, depending on the isolated organism(s) and antibiotic sensitivities, for 6–12 weeks. They were followed up by clinical examination, serial ESR and serum CRP concentrations, and aspiration to rule out persistent infection¹³. Intravenous antibiotics were continued until the ESR was

TABLE 1 Data on patients with infection after primary hip arthroplasty

Case	Primary diagnosis	Primary prosthesis	Revision	Revision prosthesis	Bacterial culture	Systemic disease	Duration of follow-up (years)	Result
1	Fracture	Cementless THA	One-stage	Alloft-Zimmer cup	Clostridium	Diabetes	7.8	Excellent
2	Osteonecrosis	Hybrid THA	One-stage	CLS-Zimmer stem	—	Tuberculosis	8.0	Very good
3	Osteonecrosis	Cementless THA	One-stage	Bicon-Plus cup	<i>S. epidermidis</i>	Diabetes	8.4	Excellent
4	Fracture	Hybrid THA	Two-stage	ARR (Müller) SLR-Plus stem	<i>S. epidermidis</i>	Hypertension	6.6	Very good
5	Osteonecrosis	Cement bipolar	One-stage	Bicon-Plus cup SLR-Plus stem	<i>E. cloacae</i>	—	7.3	Loosening stem
6	Tumor	Cement THA	Two-stage	ARR (Müller) SLR-Plus stem	<i>S. aureus</i>	Giant cell tumor of bone	6.5	Good
7	Osteonecrosis	Cementless THA	Two-stage	Bicon-Plus cup SL-Plus stem	<i>S. epidermidis</i>	Diabetes	15.6	Excellent
8	Osteonecrosis	Hybrid THA	One-stage	SLR-Plus stem	—	Hypertension	8.3	Very good
9	Fracture	Cement THA	Two-stage	Bicon-Plus cup SLR-Plus stem	<i>S. epidermidis</i>	Diabetes	10.5	Good
10	Fracture	Cementless THA	One-stage	Bicon-Plus cup SLR-Plus stem	<i>S. epidermidis</i>	—	6.9	Excellent

Manufacturer details: Bicon-plus, Sirth & Nephew, Memphis, TN, USA; ARR, acetabular reinforcement ring; *E. cloacae*, *Enterobacter cloacae*; *S. aureus*, *Staphylococcus aureus*; *S. epidermidis*, *Staphylococcus epidermidis*; THA, total hip arthroplasty. BICON-Plus, Rotkreuz, Switzerland; SLR-Plus, Rotkreuz, Switzerland; ARR-Centerpulse, Winterthur, Switzerland; alloft cup and CLS stem-Zimmer, Warsaw, IN, USA.

<20 mm/1 h and CRP concentration <5 mg/L. The average length of hospital stay was 26 days. Three to six months after the first stage, the cement spacer was removed and a cementless prosthesis implanted (Fig. 2).

Follow-up

Both clinical and radiological evaluations were performed during follow-up. Harris hip scores (HHS) were determined before surgery and at final follow-up; HHS scores >90 were classified as excellent, 80–90 as very good, 70–80 as good, 60–70 as fair and <60 as poor. Other clinical items assessed were functional capabilities, ESR, CRP concentrations and complications, whereas radiological follow-up included checking for heterotopic ossification, radiolucent lines and osteolysis. Data collection and evaluation were performed by two independent investigators. Radiolucent lines and osteolysis on the acetabular side were assessed according to DeLee and Charnley's criteria¹⁴ and on the femoral side according to Gruen *et al.*'s criteria¹⁵. Heterotopic ossification was defined according to Brooker *et al.*¹⁶. Changes in component position (migration, tilting and subsidence) were determined by comparing consecutive radiographs. Implant stability was defined according to the criteria described by Engh *et al.*¹⁷.

Results

Clinical Results

All 10 patients were followed up as described above. No re-infection was found. The mean duration of follow-up was 8.6 years (6.5–15.6 years). The mean HHS improved from 35 (18–63) points preoperatively to 89 (60–99) points at the time of final follow-up. Hip joint pain resolved in seven cases; three patients had mild pain when walking long distances. All patients had moderate to severe limps before revision. At the time of final follow-up, six patients still had slight limps, three of them having limb length inequality and three pelvic tilts. Deep vein phlebothrombosis and nerve injury did not occur. At the time of latest follow-up, all patients had normal ESR, CRP concentrations and routine blood tests (Fig. 2).

Radiographic Results

Nine hips had excellent/good results. Femoral component exertion occurred in one patient, who was asymptomatic; re-revision was required (Fig. 3). Brooker grade 2 heterotopic ossification developed in two hips.

Discussion

Use of Cementless Prostheses in Revision of Infected Hip Arthroplasties

Infection after hip replacement is a serious local complication that generally requires revision arthroplasty. Today, many surgeons recommend two-stage revision arthroplasty with antibiotic-loaded cemented prosthesis; this procedure is considered the gold standard. However, increasing numbers of surgeons are recognizing that there are varying degrees of

Fig. 1 One-stage revision of an infected THA. (A) Anteroposterior radiograph of the pelvis of a 67-year-old woman who developed septic loosening of a prosthesis 1 year after undergoing cementless primary THA for femoral neck fracture. (B) One-stage revision, only the acetabular component has been replaced because the original femoral component was fixed tightly to the femur. (C) The prosthesis is stable 6 years postoperatively, no radiolucent lines have developed.

Fig. 2 (A) Radiograph of hip of a 39-year-old woman who developed septic loosening of a prosthesis 6 months after primary THA for osteonecrosis. Bacterial culture revealed *Staphylococcus epidermidis*. (B) The prosthesis has been removed and an antimicrobial-loaded cement spacer put in place. (C) Two-stage revision with Zweymüller cup and stem 8 weeks after infection had been controlled. (D) 15.5 years postoperatively, the prosthesis is stable; ESR and CRP are normal, and there is no evidence of infection. The Harris score was 94.

structural bone defect around the prosthesis in patients undergoing revision hip arthroplasty. The medullary cavity becomes smooth and hard and little trabecular bone to which cement can attach is left. The interface shear strength is reduced to 6.8%–20.6% of the primary strength¹⁸. Therefore, initial and long-term stability are compromised if cemented prostheses are used.

The achievement of initial stability has been a major problem with cementless stem revisions. Because a large amount of bone has been lost from the medullary cavity, cementless stems do not have tight contact with trabecular bone. Particularly in patients with the severe osteolysis, it is hard to achieve initial stability even with bone grafting. Use of step-less stems (SL-tapers) is one way of solving this problem. SL stems have proved effective clinically^{19,20}. According to both early and long-term follow-up studies, the stability provided by SL stems is superior to that of anatomic or cylindrical prostheses.

The Zweymüller stem (SL-Plus, Rotkreuz, Switzerland) is a tapered, rectangular, grit-blasted, titanium alloy stem. When in tight contact with the femoral medullary cavity, SL

Fig. 3 A failed case. (A) Radiograph of a 50-year-old man who developed septic loosening of a right-sided prosthesis 11 years after cemented primary semi hip arthroplasty for femoral head necrosis. Bacterial culture revealed *Enterobacter cloacae*. (B) One-stage total hip revision with Zweymüller SLR-Plus cementless prosthesis. (C) The femoral component has loosened 7.3 years postoperatively, radiolucent lines have developed. (D) Asymptomatic femoral component exertion has occurred, ESR and CRP concentration normal. The patient refused to undergo a re-revision.

stems are able to not only control subsidence, but also prevent rotating migration. Yoo *et al.* reported only one recurrence of infection and one aseptic stem loosening in 12 patients who had undergone one-stage cementless prosthesis revisions. The success rate was 83.3%, infection recurrence or component loosening being regarded as failure. The rate of recurrence of infection was no greater than with antibiotic-loaded cement revisions²¹. Masri *et al.* reviewed 29 patients with infected THAs treated with two-stage revision using cementless components. Three patients (10.3%) had recurrent infection at the site of the prosthesis; the resultant recurrence rates were similar to those of revisions in which at least one of the components had been fixed with antibiotic-loaded cement in the second stage²². In this study, all stems achieved sufficient initial stability for early weight-bearing.

One- or Two-stage Revision

Whether revisions of infected THAs should be performed in one- or two-stages has been extensively discussed. Staged treatment of infected hip replacements is prolonged and frequently leads to functional impairment. It is also expensive and imposes a heavy health care cost burden²³. One-stage revision of infected hip replacements is an attractive technique because it potentially reduces morbidity, decreases costs and avoids the technical difficulties of staged revision surgery.

Sergio *et al.* reported 32 patients with infected THAs who underwent revision with bone graft in one-stage procedures²⁴. The mean follow-up was 103 months and infection recurred in two cases (6.2%). They found no difference between cemented, cementless, or hybrid techniques when recurrence of infection was the end point.

In our study, we adopted a flexible approach to treating infected THAs, using one-stage procedures in less severe cases and two-stage revisions in more severe cases. The latter category includes patients with severe comorbidities, previous surgery, poor soft tissue condition, major bone loss and infection with the so-called more virulent bacteria^{22,25}. We performed one-stage cementless revision in six patients who had no obvious soft tissue edema, no evidence of acute systemic infection and no discharging sinuses. In these 6 patients, only thorough debridement was performed and cementless prostheses were implanted directly. In the other four cases, a great amount of pus and poor soft tissue condition was found; accordingly, debridement with removal of all implants and cement was performed and customized antibiotic-impregnated cement spacers implanted. After 3–6 months, the second stage of these revisions was performed. No recurrence of infection was found with a mean duration of follow-up of 8.6 years.

Retention of Parts of Original Prostheses

Although most surgeons recommend removal of all implants and cement in revision procedures^{12,26}, we tried to retain original prostheses that were fixed tightly to femur or acetabular bone and have encountered no recurrence of infection so far. We attribute the success of partial one-stage cementless revision to several factors.

Firstly, we performed the procedure only in strictly selected patients and did not treat patients with severe infection in this manner. Only in patients whose original prosthesis was cementless, fixed tightly with bone and showing no evidence of loosening on radiographic assessment did we retain the original prosthesis, replacing only the loosened cup or stem. Although infective residues may have been left *in situ* when the original prostheses were retained, removal of the stable cup or stem could have reduced the risk of bacterial proliferation.

Secondly, if we found a gap between the prosthesis and bone during surgery, all of the prosthesis was removed, even it was fixed tightly and seemed stable, because bacteria may have been present in the gap. Therefore, we suggest that surgeon

should carry out exploration carefully to determine whether there is any gap between the prosthesis and bone.

Thirdly, extensive and meticulous debridement and wound washing should be performed to reduce bacterial loading to an absolute minimum; we consider this step an important aspect of successful partial revision. We used antibiotics intraoperatively (beginning after specimens had been collected for culture) and for a long period (a mean of eight weeks) postoperatively. In this study, six hips underwent revisions of THAs, whereas four hips only received new acetabular or stem components. No re-infection was found at the final follow-up and all of the prostheses retained during revision had good stability at the latest follow-up. However, we have so far performed too few revision procedures by this method to

claim it should be a standard procedure for treating infected hip arthroplasties.

A limitation of the study is that it includes too few cases. There were only six one stage procedures. Pre-selection for one- (six) or two-stage (four) would have created marked bias, thus preventing coming to a convincing conclusion.

In summary, this study has shown that it is possible to achieve satisfactory clinical outcomes by performing one- or two-stage revisions using cementless prostheses for postoperative infection after THA. The mid-term results of partial revision are acceptable; However, more experience is needed to determine whether the original prosthesis can be partially retained when fixed tightly to the femur or acetabular bone.

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