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Original Article

Two-stage arthroplasty using functional temporary prosthesis to treat infected arthroplasty and septic arthritis of the hip

Ibrahim El-Ganzoury^a, Ahmed Salem Eid^{b,c,*}

^a Assistant Professor, Department of Orthopaedic Surgery, Faculty of Medicine, Ain Shams University, Cairo, Egypt

^b Lecturer, Department of Orthopaedic Surgery, Faculty of Medicine, Ain Shams University, Cairo, Egypt

^c Department of Orthopaedic Surgery, Faculty of Medicine, El-Demrdash University Hospital Ramses St, Cairo, Egypt

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ABSTRACT

Aims: This study introduced a modified technique in two-stage revision arthroplasty to insert functional spacer using modular components coated with antibiotic-impregnated polymethylmethacrylate.

Methods: Since June 2006, we used the construct in twenty-three consecutive patients (17 with infected arthroplasty, and 6 with septic arthritis of the hip).

Results: Mean follow-up was 48 months (range 30–84 months). Two patients were excluded (no second stage), two patients had persistent infection, 19 patients received successful re-implantation at the second-stage.

Conclusion: The technique provides a construct that can be used safely and successfully as a functional, spacer in two-stage revision arthroplasty.

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1. Introduction

Sepsis after total hip arthroplasty (THA) is a potentially devastating complication that may result in major morbidity for the patient and adversely affecting the functional outcome. Further operations are usually required to control the sepsis, which despite the best efforts, can ultimately end in a disfiguring result. Different treatment strategies that have been employed to clear infection and leave the patient with a functioning joint include: Antibiotic treatment alone resulting

in resolution of infection (rarely achieved); prolonged suppressive antibiotics without removing the components (useful in the generally infirm with well-fixed components, highly sensitive organisms, and no systemic sepsis¹); surgical debridement with retention of the original prosthesis (in early infection); one-stage exchange arthroplasty; two-stage exchange with or without a temporary spacer.

Sepsis in the adult native hip is an uncommon problem that has an increased incidence in the elderly and immune-compromised population with chronic diseases, with haematogenous spread resulting from urinary tract infection,

* Corresponding author. Department of Orthopaedic Surgery, Faculty of Medicine, El-Demrdash University Hospital Ramses St, Cairo, Egypt. Tel.: +20 002 02 38344630; fax: +20 002 02 24845987.

E-mail address: ahmedsalem5474@yahoo.com (A.S. Eid).

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pneumonia, endocarditis and skin infections is the most common route of infection. Patients with diabetes mellitus, cirrhosis, rheumatoid arthritis, systemic lupus erythematosus (SLE), have abnormal white blood cell (WBC) response, decreased complement and antibody function, and immune system dysfunction. Patients with local articular disorders like osteoarthritis, avascular necrosis (AVN), previous trauma, seronegative arthritides, sickle cell disease, neuropathic Arthropathy, and crystal-induced arthritis² have alteration of the normal joint environment interrupting the exchange process of nutrients and waste, increase in synovial permeability allowing bacterial invasion. Pyogenic arthritis and sepsis in an arthritic joint can pose difficult management problems since the risk of infection after total hip arthroplasty is very high. Treatment modalities for patients with end-stage septic arthritis include: debridement and fusion, resection arthroplasty, and reconstruction with a total joint arthroplasty after resolution of the infection in a two-stage procedure.

Two-stage revision arthroplasty is the gold standard for treatment of infection at the site of a total hip arthroplasty and different techniques have been described to perform the two-stage procedure. After removal of prosthetic components and thorough debridement carried in the first stage, the surgeon is left with choice between leaving the joint space empty, or, much better, inserting antibiotic-loaded spacer whether static³ or functional.⁴ Functional articulating spacers have the advantages of maintaining soft tissue tension, providing sufficient stability, preventing muscle contracture, and allowing the patient to ambulate partial weight-bearing the day after surgery, but have the disadvantage of high expenses.

In this study, we introduce a modified technique of two-stage arthroplasty for the management of patients with infected hip arthroplasty, and end stage septic arthritis of the hip. The technique described in this study has both advantages of using functional spacer after the first stage and low costs compared to other functional spacers.

2. Materials and methods

A prospective study was conducted using functional temporary hip prosthesis constructed by a modified technique since June 2006. The construct was used in twenty-three consecutive patients (15 men and 8 women) with a mean age of 45 years (Table 1); 17 patients with infected arthroplasty (15 patients with infected THA, and 2 patients with infected hemiarthroplasty) and 6 patients with adult native joint septic arthritis of the hip.

Two patients were excluded from the study (no second stage). Of the remaining twenty-one patients, only two patients had persistent infection after the first stage; nineteen patients received a successful re-implantation at the second-stage, and were followed for a mean of 48 months (range 30 months–84 months).

The diagnoses at the index operation in cases with infected arthroplasty are shown in Table 2

Data about each patient was documented and recorded onto case report forms. Data included patient's demographic data, medical history, index operation diagnoses, Harris Hip

Score (HHS) before first stage, postoperative courses, HHS after second stage. Patients were included in the prospective study population if they met the following criteria: (1) end stage arthritis with hip infection was confirmed or suspected; (2) the patient had infection following total hip replacement, or hemiarthroplasty. Diagnosis of infection was suspected through patient's medical history, risk factors for infection, and whether there were wound complications in the post-operative period following the index operation in arthroplasty cases, clinical examination for discharging sinuses, laboratory investigations including elevated white blood cell count, ESR, C-reactive protein (CRP). Hip aspiration was performed under sterile condition prior to the first stage surgery at least 4 weeks after cessation of all antibiotic therapy. According to Parvizi J, we diagnosed periprosthetic joint infection (PJI) if one of the following 4 criteria occurs: 1) draining sinus tract, 2) positive culture on solid medium (>5 colonies), 3) purulence seen intraoperatively, 4) 3 abnormal values out of the following 4: a) ESR > 30 mm/h, b) CRP 1 mg/dl (10 mg/L), c) Joint aspirate analysis show neutrophils >1170 cells/uL for chronic PJI or 10,700 cells/uL for acute PJI, d) neutrophil percentage in joint aspirate >65% for chronic PJI or >89% for acute PJI.⁵

Patient is positioned in the true lateral position. Direct lateral approach was used in all cases. In infected arthroplasty cases with cemented femoral component (12 cases), the cemented femoral stem was loose; the difficulty mostly came with cement removal due to strong interdigitation at the bone-cement interface. Cement is then removed antegrade and completed with "scaphoid osteotomy technique", where a carefully planned osteotomy of the anterolateral cortex of the femur is performed starting at the site of the distal plug and extending for 8 cm proximal with rounded corners to minimize stress raisers to remove distal plug and the remaining cement. At the completion of the procedure, the osteotomy is fixed with cerclage wires. The acetabular components were easier to remove. Meticulous debridement and intraoperative tissue biopsy is taken (3 specimens from acetabulum and another 3 specimens from femoral side. The temporary functional hip prosthesis consists of a standard polyethylene liner, and an inexpensive modular femoral component or the removed femoral implant, which is autoclaved. We use trials of the acetabular component to dictate the size of the acetabulum. On the femoral side, we use trials for spacer G (TECRES S.P.A.), of which only 3 sizes are available (Fig. 1), to dictate the size that best fits into the femoral canal diameter, which is equivalent to the planned stem diameter together with its cement mantle.

After determining the size of acetabulum (eg 54 mm), we use the acetabular reamer tray of the same size (54 mm) as a mold and a sterile sofratol sheet is used to line reamer tray, antibiotic-impregnated polymethylmethacrylate is then

Table 1 – Demographic data.

Gender			Age		
	N	Percent	Mean age	Minimum	Maximum
Male	15	65	49	27	65
Female	8	35	37	22	59
Total	23	100.0	45	22	65

Table 2 – Index operation diagnoses.

Diagnosis	N	Percent
DJD	10	59
Fracture	3	18
Avascular necrosis	4	23
Total	17	100

mixed and applied in the doughy phase in the tray reamer which is lined with sofratol, and definite polyethylene liner (the smallest diameter that matches 28 mm head) is inserted in the tray reamer till polymerization is completed to get in-vitro cemented polyethylene construct (Fig. 2).

For the femoral component: the stem of the trial spacer G, that mimics the femoral canal diameter, is wrapped entirely with Vaseline paper found within the sterile sofratol pack, and polymethylmethacrylate is applied over the trial spacer stem, till polymerization is completed and the trial spacer is then extracted to get a polymethylmethacrylate mold for the femoral canal diameter (Fig. 3).

The smallest definite femoral stem is then cemented with antibiotic-impregnated polymethylmethacrylate within the mold which is lined from the inside with Vaseline paper. After polymerization, the outer mold is peeled from around the cemented stem which now has a cement mantle that fits into the femoral canal diameter (Fig. 4).

The final construct is cemented in place with antibiotic-impregnated polymethylmethacrylate and inserted during the late stages of polymerization to minimize osseous interdigitation to facilitate later removal in the second stage. As regards the femoral component, cementation is limited to the proximal 3 cm of the femoral canal. We add 2 g of vancomycin powder for each bag of antibiotic-impregnated polymethylmethacrylate (40 g). In all patients, one bag is used to make acetabular construct, and another to form the cement mantle around the femoral stem, and finally a third bag to cement the components to bone. Joint stability is checked with trial heads, then definite head is applied.

Extramedullary rod formed of K-wire with antibiotic-impregnated polymethylmethacrylate cured around is inserted sub-muscular to provide elution of antibiotic extramedullary, followed by closure in layers (Fig. 5). In septic hip

Fig. 1 – Trials for spacer G (TECRES S.P.A), only 3 sizes are available.

arthritis the same technique is used after osteotomy of the neck and debridement of the infected and devitalized tissues.

In the first stage, all necrotic and devitalized tissues are removed, and the functional temporary prosthesis is inserted using the technique described. Tissue biopsy (5-6 specimens from acetabulum and femur) are collected and sent for extended cultures for 2 weeks.⁶ If the positive growth on culture was suspected to be due to contamination, as is the case when only one of five culture specimens is positive, we counted the case as a confirmed infection. This approach was taken to ensure the safety of the procedure.

During the interval period between the two stages: patient is allowed to mobilize and ambulate partial weight-bearing with frame the day after surgery, intravenous antibiotics are administered for a minimum of 6 weeks, combined with oral rifampicin. The patient is followed clinically, laboratory for ESR and C-RP and radiologically; provided wound healing and inflammatory mediators levels are satisfactory (ESR < 30 mm/h and C-RP < 10 mg/L),⁷ antibiotics discontinued and second stage performed. Numerous intraoperative samples are obtained for microbiological analysis during the second stage. A successful treatment outcome was defined as implantation of a total hip prosthesis at the time of the second-stage operation with no growth of a microorganism on any culture specimen obtained from the operative site during the second-stage surgery and no reoperations resulting from a recurrent or persistent infection of the affected hip during the follow up at a minimum of one month postoperatively (Fig. 6).

3. Results

All the twenty-three patients showed positive growth on extended cultures of intraoperative specimens taken during the first-stage. *Staphylococcus aureus* was the most frequent infecting organism found in 11 patients (48%) of 23 patients. *Staphylococcus epidermidis* was the second most common pathogen found in 7 patients (30%) of 23 patients, streptococcus species in 3 patients (13%) of 23 patients, *Pseudomonas aeruginosa* in 1 patient (4%) of 23 patients, and polymicrobial in 1 patient (4%) of 23 patients (Table 3).

Two patients did not have a second-stage operation for implantation of the permanent prosthesis and retained the temporary prosthesis.

Two of twenty-one cases showed persistent infection (pathogen was *P. aeruginosa* in one case and polymicrobial in the other case) and required another second stage debridement with re-insertion of another temporary construct followed by intravenous antibiotics and later implantation of permanent prosthesis after 6 months interval at third stage. No other complications occurred after the first stage (Table 4).

Overall, the patients expressed satisfaction with the temporary prostheses. They functioned well during the interval between 1st and 2nd stages. The mean time between the first and second-stage procedures was 10.5 weeks (range, 6 weeks to 6 months).

At the second-stage operation, all nineteen patients received a cementless femoral and acetabular component as their permanent prosthesis. The two cases with persistent infection after the first stage had successful second stage

Fig. 2 – A–F Steps of getting in-vitro cemented polyethylene construct.

debridement and successful implantation of permanent prosthesis at third stage 6 months later and were followed for a mean of 48 months (range 30 months–84 months). Following the definition for successful treatment outcomes, 19 of 21 patients were treated successfully, and were followed up for a mean of 48 months (range 30 months–84 months), with an overall success rate of 90%. No patient had clinical, laboratory, or radiographic evidence of infection at the final follow-up. Seventeen of nineteen patients (89%) had an improvement of Harris hip score of at least 30 points.

4. Discussion

Infection of a total hip replacement (THR) is considered a devastating complication. It is generally accepted, that implants and necrotic tissue are covered with bacterial colonies that show inherent resistance to both host defence mechanisms and antimicrobial chemotherapy making the treatment extremely difficult. Uncertainty on the most effective approach has lead to several suggestions for treatment. Long-term antibiotic suppression may be useful

in the generally infirm¹ Surgical debridement with implant retention is limited to very selected cases with early infection. In the case of established deep sepsis persisting or occurring more than few weeks after the index operation, it is almost impossible to retain the prosthetic components and most authors consider thorough removal of all implants and necrotic tissue a prerequisite for cure and either one- or two-stage exchange is the only reliable option for eradicating infection.

One-stage exchange revision is one of the treatment strategies employed to clear infection. It has the advantages of achieving the principles of the treatment of musculoskeletal infection in one procedure as all infected tissue is removed along with the implant, and the dead space created is filled with a new cemented prosthesis containing antibiotics that will be leached out locally. The implant is securely fixed to bone, stabilizing any bone prosthetic interface, and the presence of the biomechanically restored hip articulation stabilizes the soft tissues around the joint, facilitating the body's ability to eradicate soft-tissue infection. The early experience with one-stage reimplantation has been poor. Murray⁸ reviewed 151 infected total hip arthroplasties in the 1970s.

Fig. 3 – A–E Steps of forming polymethylmethacrylate mold for the femoral canal diameter.

Fig. 4 – A–D Femoral stem with cement mantle fits into the femoral canal diameter.

Fig. 5 – Insertion of A – Polyethylene cup, B – femoral stem, C – extramedullary rod of antibiotic-impregnated polymethylmethacrylate.

The success rate for one-stage exchange using antibiotic-loaded bone cement was only 46.7%, compared with 92% with the two-stage exchange method (with antibiotic-loaded bone cement). The historical justification for one-stage exchange is found primarily in the work of Buchholtz (in Germany) who reported the results of one-stage exchanges performed for infection in 869 patients in 1984.⁹ The surgeries included extensive debridement of infected tissue and the use of antibiotic-loaded cement and had a success rate of 77% for first attempts and 90% for subsequent exchange procedures. Buchholz reported specific infections with *Pseudomonas*, *Streptococcus* group D, and *Escherichia coli* and inadequate antibiotic dosage in the cement as factors associated with failure. Johnson's one-stage exchange series from 1977 to 1983 in (Iowa) demonstrated infection-free rate of 91.7% at 10-year follow-up.¹⁰ In a review of their 12-year experience with reimplantation without the use of antibiotic-loaded bone cement, Salvati et al found the recurrence rate with single-stage exchange was between 10% and 15% compared to 6% in the two-stage exchange group. Their contraindications for a one-stage exchange arthroplasty were Gram-negative infections, mixed flora, open wounds and draining sinuses and the intraoperative findings of severe inflammation and supuration.¹¹ Elson et al¹² reported a 12.4% failure rate with the one-stage method, compared with a 3.5% failure rate with the two-stage method. Hope et al¹³ reported an infection recurrence rate of 13% with the single-stage method and concluded that the role for a one-stage exchange arthroplasty should be highly selective. When a highly selective approach is adopted, the success rate rises as supported by Callaghan's 10-year

follow-up study.¹⁰ A one-stage revision was performed in 24 infected cases; the selection criteria included patients without draining sinuses, immunocompromise, or bone stock loss. When these criteria were fulfilled, a 91.7% success rate was achieved. Overall, it appears that the success rate for two-stage exchange is higher and more predictable, despite the disadvantages of an extended time interval and a second operation.

Two-stage exchange arthroplasty has been claimed being the gold standard and the treatment of choice and more widely practiced than one-stage arthroplasty in most centers for treating infection, mostly in combination with spacers in the form of antibiotic loaded polymethylmethacrylate (PMMA). After removal of prosthetic components and thorough debridement carried in the first stage, the surgeon is left with choice between leaving the joint space empty or rather inserting antibiotic-loaded spacer whether static or functional.

Static spacers, like antibiotic impregnated cement-coated rush pin or intramedullary nail, antibiotic-impregnated cement beads have the theoretical advantage of increased antibiotic elution due to their large surface area, yet these spacers have the disadvantages of: skeletal traction being required for 2–3 weeks postoperatively till muscle scarring takes place, with resulting muscle shortening; pain; joint instability; limited mobility; bone surface degradation through bone-on-bone contact or by toggling and abrasion by the static cement spacer.¹⁴

On the contrary, functional articulating spacers have the advantages of maintaining soft tissue tension, providing

Fig. 6 – A – Infected hemiarthroplasty, B – postoperative AP radiograph after 1st stage with functional temporary prosthesis in place, C & D – AP radiograph of the hip twenty-four months postoperative after 2nd stage revision showing preservation of bone stock of the acetabulum with osseointegration of the cup.

sufficient stability, preventing muscle contracture, and allowing the patient to ambulate partial weight-bearing the day after surgery. Many varieties have been described, like PROSTALAC device available in a single size (42 mm outer diameter, 32 mm inner diameter with a snap-fit design) and femoral component with several molds differing in size, femoral offset, neck length, and stem length⁴; spacer G

(TECRES S.P.A.) which is constructed entirely from gentamicin-loaded cement available in 3 sizes.

In this study, we presented a modified technique to form a custom-made articulating spacer with antibiotic elution through the antibiotic-impregnated cement used in both components of the construct. The technique gives versatility in forming a construct with different sizes that can match

Table 3 – Pathogens confirmed after first stage.

Pathogen	N	Percent
<i>S. aureus</i>	11	48
<i>S. epidermidis</i>	7	30
<i>Streptococcus</i> species	3	13
<i>P. aeruginosa</i>	1	4
Others (polymicrobial)	1	4

different sizes of acetabula and femoral canals to a great extent. This match between the spacer and bone anatomy is of ultimate importance to prevent toggling of the spacer within bone and consequently decrease bone resorption during the interval period, and at the same time maintain motion at the joint. Success rate using the technique used in this study was 91.6% which is comparable to results of Garvin et al³ (92.7%), compare favorably with results of Tsukayama et al¹⁵ (85.3%), and inferior to Younger et al⁴ (95%).

This study has, however, some limitations. First, this is not a randomized controlled study. No control group was assigned randomly to preformed spacers; therefore, no definitive statement on treatment differences can be made. Second, bias could have been introduced as the observer who collected and analyzed data was not masked to the study and data of the patients. However, strict adherence to the standardized methods in obtaining and analyzing these data may have reduced bias to a minimum.

Strength of the current study stems from the fact that it is a prospective study, and to the best of our knowledge this is the first report in the English literature describing this technique.

Two-stage arthroplasty is considered to be the gold standard for management of such cases. Meticulous surgical debridement during first stage combined with insertion of the functional spacer as described in the technique, followed by appropriate intravenous antibiotics then carefully planned re-implantation of the permanent prosthesis result in high success rate. While static spacers result in limited mobility and arthrofibrosis which makes re-implantation difficult, the preformed articulating spacers like PROSTALAC and spacer G allow mobility and provide stability but are expensive. The modified technique described in this study provide a

functional temporary spacer formed of inexpensive femoral component or the autoclaved extracted stem articulating with polyethylene acetabular liner with high versatility to match bony anatomy preventing bone resorption that may, potentially, result if static spacers are used. The construct allow range of movement, weight bearing, with low cost as a joint-preserving spacer in the awaiting period between the two stages in management of infected hip arthroplasty and septic arthritis of the hip.

Conflicts of interest

All authors have none to declare.

REFERENCES

- Rao N, crossett LS, Sinha RK, et al. Long-term suppression of infection in total joint arthroplasty. *Clin Orthop Relat Res.* 2003;414:55–60.
- Steinberg ME, ed. *The Hip and its Disorders*. Philadelphia: WB Saunders; 1991.
- Garvin KL, Evans BG, Salvati EA, et al. Palacos gentamicin for the treatment of deep periprosthetic hip infections. *Clin Orthop.* 1994;298:97–105.
- Younger AS, Duncan CP, Masri BA, et al. The outcome of two-stage arthroplasty using a custom-made interval spacer to treat the infected hip. *J Arthroplasty.* 1997;12:615–623.
- Parvizi J, Bauer TW, Kobayashi N, Krebs V. Diagnosis of periprosthetic infection. *J Bone Jt Surg Am.* 2006;88:869–882.
- Atkins BL, Athanasou N, Deeks JJ, et al. Prospective evaluation of criteria for microbiological diagnosis of prosthetic-joint infection at revision arthroplasty. *J Clin Microbiol.* 1998;36:2932–2939.
- Spanghel MJ, Masri BA, O'Connell JX, Duncan CP. Prospective analysis of preoperative and intraoperative investigations for the diagnosis of infection at the sites of two hundred and two revision total hip arthroplasties. *J Bone Jt Surg Am.* 1999;81:672–683.
- Murray WR. Treatment of established deep wound infection after hip arthroplasty: a report of 65 cases. In: Leach RE, Hoaglund FT, Riseborough EJ, eds. *Controversies in Orthopaedic Surgery*. Philadelphia: WB Saunders; 1982:382–398.
- Buchholz HW, Elson RA, heinert K. Antibiotic loaded acrylic cement; current concepts. *Clin Orthop Relat Res.* 1984;190:96–108.
- Callaghan JJ, Katz RP, Johnson RC. One-stage revision surgery of the infected hip: a minimum 10-year follow up study. *Clin Orthop Relat Res.* 1999;369:139–143.
- Salvati EA, Callaghan JJ, Brause BD. Prosthetic reimplantation for salvage of the infected hip. *Inst Course Lect.* 1986;35:234–241.
- Elson R, Norman P, Scott I, et al. Exchange cemented joint arthroplasties for deep infection. *J Bone Jt Surg Br.* 1992;74(Supp 3):295.
- Hope P, Kristinsson KG, Norman P, et al. Deep infection of cemented total hip arthroplasties caused by coagulase-negative staphylococci. *J Bone Jt Surg Br.* 1989;71:851–855.
- Fehring TK, Odum S, Calton TF, et al. The Ranawat Award. Articulating versus static spacers in revision total knee arthroplasty for sepsis. *Clin Orthop.* 2000;380:9–16.
- Tsukayama DT, Estrada R, Gustilo R. Infection after total hip arthroplasty: a study of the treatment of one hundred and six infections. *J Bone Jt Surg Am.* 1996;78:512–523.

Table 4 – Complications that occurred during and after the first-stage operation.

Description	First stage intraoperative/ postoperative complications
	N
Persistent/recurrent deep infection	2
Bone fractures (intra-operative)	0
Dislocation/Subluxation	0
Bone fractures (post-operative)	0
Wound healing (Dehiscence, Skin Necrosis, Superficial Infection)	2
Femoral perforation	0
Component insertion difficulty	0
Component loosening	0
Cement fracture	0
Pain	2
Acetabular perforation	0