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Use of the Extended Trochanteric Osteotomy in Treating Prosthetic Hip Infection

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Abstract: The goal of this study is to evaluate the efficacy of using an extended trochanteric osteotomy (ETO) as part of a 2-stage exchange procedure for prosthetic hip infections. Twenty-three consecutive infected total hip arthroplasties in which an ETO was used as part of a 2-stage exchange procedure were retrospectively reviewed. An ETO was used when the femoral component could not be extracted using standard techniques. Clinical and radiographic parameters were evaluated at an average of 49 months of follow-up. Postoperatively, 20 of 23 (87%) patients had resolution of their infection, with healing of the ETO in 22 of 23 patients at a mean of 11.5 weeks. Preoperative modified D'Aubigne and Postel score means of 2.4 for pain and 2.6 for walking ability significantly improved ($P < .001$) to 5.3 and 4.9. Use of an ETO as part of a 2-stage exchange arthroplasty can be performed safely and effectively in appropriately selected cases. **Key words:** prosthetic infection, extended trochanteric osteotomy.

Postoperative infection of a total hip arthroplasty (THA) is difficult to both diagnose and treat. Eradication of infection associated with THA is challenging, is costly, and involves substantial morbidity [1-3]. Currently, the standard of care for treating an infected THA in North America is a 2-stage revision, which has been reported as successfully eradicating infection in 80% to 95% of cases [1-7]. The extended trochanteric osteotomy (ETO) has been described as an extensile surgical approach that assists both implant and cement removal, improves exposure, and facilitates implantation of revision components at the time of revision THA. This approach is described in the literature for management of prosthetic infections, although not frequently [8].

Specific concerns in performing an ETO are osteotomy nonunion with trochanteric escape, intraoperative fracture, and postoperative fracture [9-12]. In the setting of a prosthetic hip infection, a secondary concern that remains is the persistent infection if hardware is used to repair the osteotomy [8]. In infected total hips in which the femoral component remains well fixed to host bone or if there is a large well-integrated cement mantle, a more extensive exposure, such as an ETO, may be required as part of the 2-stage exchange procedure. The purpose of this study is to examine the radiological and clinical outcomes of the technique involving the use of an ETO with immediate fixation in the setting of a 2-stage exchange THA.

Materials and Methods

The data for this study were gathered from the departmental database and the medical records of

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Table 1. Patient Demographics

Average age	61.7 (range, 30-85)
Sex	
Male	10
Female	13
Operative side	
Right	12
Left	11
Interval between surgery	14.3 wk (range, 7-28 wk)
Average follow-up	49.1 mo (range, 24-84 mo)
Preoperative component fixation	
Cemented	12
Cementless	11
Original diagnosis	
Hip fracture	4
Osteoarthritis	12*
Revision THA	3†
Inflammatory arthritis	2
Posttraumatic arthritis	2
Original implants	
Infected hybrid THA	8
Infected hemiarthroplasty	4
Infected cementless THA	11
Paprosky classification femur	
Type 2	12
Type 3A	5
Type 3B	2
Type 4	4
Paprosky classification acetabulum	
Type 1	1
Type 2A	8
Type 2B	5
Type 2C	3
Type 3A	4
Type 3B	1
Pelvic discontinuity	1

*One case of osteoarthritis with concomitant rickets disease.

†All 3 cases of revision had original diagnoses of osteoarthritis.

patients who had an ETO as part of a 2-stage exchange for the treatment of an infected THA. Authorization for this project was obtained from our hospital's Institutional Review Board. All patients presenting with a prosthetic hip infection between February 1997 and March 2003 were identified in our database. Further inclusion criteria included the use of an ETO as part of a 2-stage exchange arthroplasty, immediate fixation of the osteotomy at the time of cement spacer placement, a subsequent revision THA, and a minimum 2-year follow-up.

Sixty-three patients were treated with 2-stage exchange arthroplasty for prosthetic hip infections during the study period. Twenty-three consecutive infected THAs (23 patients) meeting our inclusion criteria were identified and included in this study; the remaining 40 patients underwent a 2-stage exchange arthroplasty without the use of an ETO. *Infection* was defined as the presence of 2 of the following 3 factors: (1) growth of bacteria on solid media on at least 2 culture specimens, (2) final histopathology with an average of more than 10 polymorphonuclear cells seen in the 5 most cellular fields [13], and (3) grossly infected appearing tissues observed at the time of surgery.

Preoperative patient demographics and components removed were obtained from the patients' records (Table 1). Intraoperative data collection included estimated blood loss, ETO length, number of cables/wires to fix osteotomy, and allograft utilization. Infecting organisms identified at the first-stage procedure are presented in Table 2. Preoperative and postoperative modified D'Aubigne and Postel scores were determined and compared using a Student *t* test, with a *P* value of less than .05 set as the significance level.

Patients were seen and radiographs were obtained at 3, 6, and 12 weeks; at 1 year; and annually thereafter. Serial radiographs (anteroposterior pelvis, and anteroposterior and lateral of the operative hip) were evaluated for osteotomy healing, osteotomy migration, distal gap at the osteotomy site, stability of the femoral component, and evidence of recurrent infection. Time to trochanteric union was determined based upon bridging bone on orthogonal radiographic views with absence of proximal migration or fixation failure.

Acetabular and femoral defects were classified using the Paprosky classification, according to their radiographs before reimplantation (Table 1) [14,15]. Cementless femoral stem stability was assessed and graded per the criteria of Engh et al [16]. In the 2 cases of a cemented femoral revision, the criteria of Harris and McGann were used to define component stability [17]. Acetabular component stability was based on the criteria of Udomkiat et al (radiolucent lines appearing after 2 years, progression of radiolucent lines, radiolucent lines in all 3 zones, 2 mm or greater radiolucent lines in any zone, component migration) [18]. Complications

Table 2. Specific Organisms Isolated at the Time of Intraoperative Cultures

Organism Isolated	No. of Cases*
MRSA	5
MSSA	8
MRSE	3
MSSE	1
Proteus mirabilis	2
Pseudomonas aeruginosa	1
Streptococcus milleri	1
Culture negative	5

*In 15 cases, one organism was identified; and in 3 cases, the infection was polymicrobial.

including persistent/recurrent infection, postoperative instability, stem subsidence, and the need for further revisions were recorded. Kaplan-Meier calculations were performed to generate survivorship curves with recurrence of infection and revision surgery as the end points (Graphpad Prism version 4.00 for Windows; Graphpad Software, San Diego, Calif).

Surgical Technique

The first stage of the procedure involved a resection arthroplasty performed via a posterior approach with an ETO as described by Paprosky and Sporer [19]. In all cases, we attempted to remove the femoral component using standard techniques (femoral extraction devices, ribbon osteotomes, ultrasound devices, etc), resorting to the use of an ETO only after these methods had failed. Common indications for using an ETO for femoral component removal included well-fixed extensively coated femoral components, precoated cemented implants, and cemented implants with a long distal cement mantle. Intraoperative cell count, cultures, and frozen tissue sections were collected and analyzed in all cases. The ETO length was determined based on preoperative templating to allow for safe component extraction while maintaining adequate intact distal diaphyseal bone for the second-stage reconstruction. Care was taken to minimize soft tissue detachment from the osteotomized fragment.

The acetabular component was then removed using standard techniques, and a thorough debridement of the femoral canal was performed including the use of flexible reamers distally. In all cases, an antibiotic-impregnated cement spacer was then fashioned according to the senior surgeon's preferences (14 nonarticulating and 9 articulating spacers); and the osteotomy was reapproximated using between 1 and 4 wires or cables (average, 2.5 wires/cables). The choice of cables or wires and the number used for ETO fixation were based on each surgeon's preference. Luque wires, cerclage wires, and braided cables were used for osteotomy fixation in 6, 12, and 6 cases, respectively (in one case, both cables and wires were used).

Postoperatively, patients were instructed to maintain touchdown weight bearing until the time of reimplantation. Intraoperative cultures results were used to tailor the postoperative antibiotic regimen. An infectious disease specialist was consulted, and a minimum of 6 weeks of organism-specific intravenous antibiotics was administered. Patients were then reevaluated clinically and with repeated laboratory tests 10 to 14 days after completion of the intravenous antibiotic course and scheduled for the second-stage procedure within the following 2 weeks. Resolution of the infection was confirmed by return of laboratory values to normal (or near-normal) levels, healing of the operative wound, a diminishing pain pattern, and absence of systemic symptoms. In 2 cases, a second irrigation and debridement were performed before the reimplantation of prosthetic components; both cases were found to have osteotomies that were not healed and were infected with methicillin-resistant *Staphylococcus aureus* (MRSA).

During the second stage of the procedure, repeated cell count, frozen section, and cultures were obtained in all cases. Cell counts with greater than 3000 white blood cells and frozen sections with greater than 10 white blood cells per high-powered field were considered to have persistent infection [20]. In 12 hips (52%), it was necessary to reopen the osteotomy site for exposure and proper insertion of the revision femoral component; an average of 2.2 cables/wires (range, 2-4 cables) were used for fixation. For these patients, difficulty with acetabular exposure, inability to insert a straight implant (varus remodeling), and/or insertion of a large proximal body for a modular-tapered stem necessitated reopening the prior osteotomy. In those cases in which the ETO was healed and repeated osteotomy was unnecessary, the fixation hardware was left intact. Fully porous coated, diaphyseal engaging stems were used in 18 cases, a cemented femur in 2 cases (including an allograft prosthetic composite in one), and modular-tapered stems in 3 cases. These included the use of ten 6-in stems, one 7-in stem, five 8-in stems, four 10-in stems, and 3 modular stems.

Cementless acetabular components were used in all cases, with an average outer diameter of 64 mm (range, 54-78 mm) and a mean of 3 screws (range, 0-5 screws) for supplemental fixation. Standard modular acetabular components were used in 21 cases, a porous tantalum revision shell in 1 case, and a double bubble cup in 1 case. Constrained acetabular liners were used in 2 cases for abductor insufficiency and instability at the time of revision. Allograft struts were used in 2 cases, at the time of reimplantation, for proximal femoral support and reconstitution of bone stock.

Touchdown weight bearing with an assistive device was enforced for the first 6 postoperative weeks. Progression to full weight bearing with an assistive device was allowed between 6 and 12 weeks, with weaning to an unassisted ambulatory status starting at 12 weeks after surgery. Active abduction was restricted for the first 6 weeks

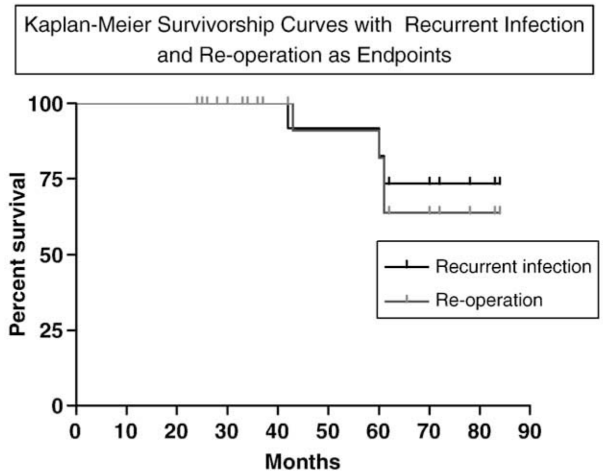

Fig. 1. Kaplan-Meier survivorship curves with infection and revision surgery as end points.

and resisted abduction for the first 12 weeks after surgery.

Results

Clinical Results

The average length of follow-up was 49.1 months (range, 24-84 months). Intraoperative blood loss averaged 1267 mL (range, 500-3500 mL) and 1414 mL (range, 500-2600 mL) for stage 1 and stage 2 procedures, respectively. Preoperative modified D'Aubigne and Postel hip scores improved from a mean of 5.3 (range, 2-10) to a mean of 10.0 (range, 7-12) at the time of final follow-up ($P < .001$). Each component of the modified hip score improved significantly ($P < .001$). Pain scores increased from a mean of 2.7 preoperatively to 4.8 postoperatively; and functional scores followed a similar trend, improving from a mean of 2.3 to 5.3. Kaplan-Meier survivorship curves with recurrent infection and revision surgery as end points were generated at latest follow-up (Fig. 1).

Radiographic Results

The ETO healed in 22 of 23 hips (96%) at a mean time of 11.5 weeks (range, 8-16 weeks) from the time of last repair (Fig. 2). There was no significant difference ($P = .2$) in time to ETO healing for the 12 patients requiring reopening of the osteotomy, 11.3 weeks (range, 8-14), compared with the remaining 10 patients, 12.4 weeks (range, 10-14). The average osteotomy length at the time of prosthesis removal was 125 mm (range, 80-170 mm). In the 12 patients requiring mobilization of the osteotomy at reimplantation, the average length was 131 mm (range, 90-185 mm). In 2 of these cases, the osteotomy length was increased compared with the original ETO. There were no statistical differences in osteotomy healing, implant stability, or functional outcomes in comparing those patients requiring reopening of their osteotomy at the second stage and those in which the osteotomy was left intact. The distal gap identified on the postoperative radiographs between the osteotomy fragment and the remainder of the femur averaged 1.86 mm (range, 0-12 mm). In 3 cases, proximal migration of the osteotomy was noted, averaging 3 mm (range 2-3.5 mm), without subsequent complication or delayed healing.

Eighteen of 21 (86%) cementless femoral components demonstrated evidence of bone integration,

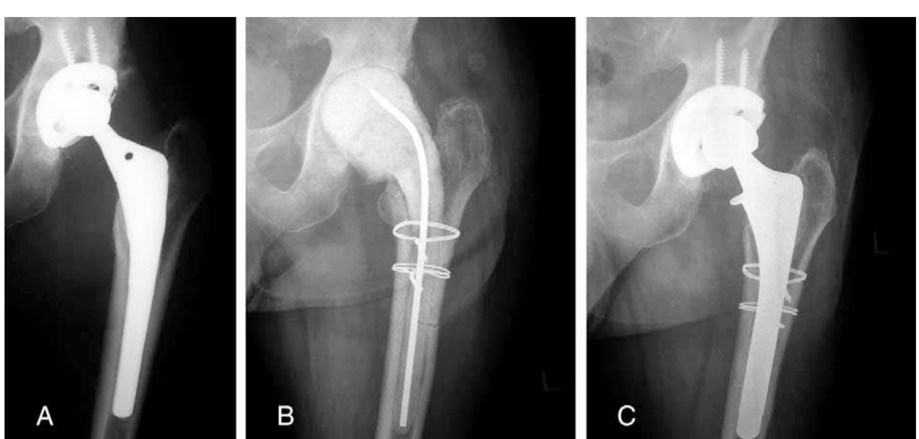

Fig. 2. Case of successful 2-stage exchange with an ETO. (A), Preoperative radiographs. (B), Postoperative radiographs after removal of the implant; an ETO was necessary to remove this well-fixed stem after traditional methods failed. (C), Final follow-up radiographs at 36 months.

and 3 components (14%) were graded as fibrous stable; 2 of these 3 stems were in patients with persistent infections [16]. The fibrous stable stems included one 10-in cementless stem, one 6-in cementless stem, and the other a modular-tapered stem. The 2 cemented revision THAs were stable without evidence of loosening at latest follow-up [17]. There was one case of early femoral subsidence in a patient treated with a modular-tapered implant. This patient experienced 4-mm subsidence in the first 6 weeks, with subsequent stabilization and evidence of a fibrous stable femoral stem at latest follow-up.

Twenty-two of 23 acetabular components (96%) were noted to be stable without evidence of loosening at latest follow-up. The one patient who developed aseptic loosening of a cementless acetabular component had a 3B acetabular defect that was re-revised at 42 months postoperatively using a trabecular metal acetabular component (Zimmer, Warsaw, Ind); there have been no further complications, and the patient maintains a modified hip score of 10. There were no cases of progressive osteolysis or radiolucent line development identified at latest follow-up.

Complications

Four patients had bacterial growth on solid media from their intraoperative cultures at the time of second-stage reimplantation; all 4 had a negative intraoperative frozen section and/or cell count. The organisms identified in these patients included 2 cases of *Staphylococcus epidermidis* (one methicillin sensitive [MSSE] and one resistant [MRSE]), one case of *Pseudomonas aeruginosa*, and one case of MRSA. In each of these patients, the organisms cultured at the time of reimplantation were the same as at the time of resection arthroplasty, except for the case of MRSE (this patient was originally infected with MSSE). All were treated with an additional 6-week course of intravenous antibiotics followed by a course of oral antibiotics as dictated by the infectious disease consultant. Three of the 4 cases remained symptom-free off of antibiotics, whereas the fourth patient required a repeated irrigation and debridement with modular component exchange at 6 months. The patient's ETO was healed at the time of reimplantation, and the same wires were left in place at the time of the second-stage reconstruction. This was followed by another 6 weeks of intravenous antibiotics and a prolonged course of oral antibiotics. The patient currently remains asymptomatic and has completed oral antibiotics without any further operations.

Two additional patients had clinical evidence of recurrent infection, giving a total of 3 recurrent prosthetic infections. The second case involved the patient who developed a nonunion of the ETO and, at the time of reimplantation, was treated with an allograft prosthetic composite; and the wires from the first stage were removed. This patient had a complicated history of a childhood injury that resulted in dysplasia of the proximal femur. The patient developed persistent drainage from his wound and underwent an irrigation and debridement 6 weeks after his second-stage reimplantation and remains on long-term suppressive oral antibiotics. His original infecting organism was methicillin-sensitive *S aureus* [MSSA]; and at the debridement, cultures grew *S epidermidis*. The third infection occurred in a patient who refused surgical intervention and is currently on oral amoxicillin for long-term suppression treatment of a pansensitive enterococcus organism. Initially, this patient was treated for an MSSA infection and appeared to have recovered fully over the first 36 months after surgery. She subsequently developed elevated laboratory values and recurrent pain in her operative hip. Cultures of an aspirate from the patient's hip at this time grew enterococcus. The patient has minimal pain and at latest follow-up maintains a modified D'Aubigne and Postel score of 8.

In the 3 cases of recurrent infection in our series, there were an average of 2.3 wires (range, 2-3) used to secure the osteotomy; and all were composed of 18-gauge cerclage wire (zero persistent infections with Luque wires or cables). Although this represents a trend, we were unable to show statistical significance between the type of cable/wire used for osteotomy fixation and recurrent infection with the small patient population ($P > .20$).

There were 2 intraoperative fractures of the osteotomy fragments during the first stage; both were fixed with wires/cables and healed without adverse sequelae. In 2 cases, the femoral cortex was perforated (one anterior and one medial perforation) during the first stage of the revision. In both cases, the defect was bypassed with a fully porous coated femoral prosthesis at the time of reimplantation without further complication. A femoral strut allograft was used in one case to further support the area of perforation.

There were 2 postsurgical dislocations (8.7%), both occurring 6 weeks after their revision THA. Both were treated with closed reduction and an abduction orthosis for 6 weeks. One patient remained stable without further dislocations or treatment. The second patient dislocated in the abduction orthosis and subsequently underwent revision to a constrained acetabular liner.

Discussion

During revision THA, an ETO can provide excellent exposure of both the acetabulum and proximal femur. In the setting of a 2-stage exchange arthroplasty, when conventional methods are unsuccessful, an ETO allows relative ease of component removal as well as wide visualization for a complete and thorough debridement. If meticulous surgical technique is followed, the osteotomy fragment remains well vascularized from its surrounding soft tissue attachments and was associated with a high rate of union in our series. Morshed et al recently validated the use of an ETO for treating prosthetic infections but used a different technique than we describe where the osteotomy was fixed only at the time of the second-stage reconstruction [8]. Despite delayed fixation of the ETO, they reported 100% healing of the osteotomy site. Infection was eradicated in 10 of 13 cases (77%) in their series.

In this series, we chose to secure the osteotomy during the first stage of the protocol at the time of cement spacer placement with multiple wires or cables. It was felt that, with a concomitant complete debridement and antibiotic spacer placement, these wires/cables represented minimal risk for persistent infection and that, overall, this early fixation would not affect infection eradication rates and provide adequate ETO healing. Using this technique, we were able to eradicate infection in 20 of the 23 cases (87%), which is similar to current literature on 2-stage exchange arthroplasty [1-7]. Early fixation afforded the reconstitution of a tubular structure to the proximal femur that can greatly facilitate the second-stage reconstruction as well as minimize fragment migration. This allowed insertion of a femoral stem, at the time of reimplantation, without disturbing the osteotomy site in 11 cases. Furthermore, in 10 of these 11 cases, we were able to use a standard 6-in, fully coated femoral stem at the time of reimplantation.

In most hips, anatomical reduction of the osteotomy was achieved and secure fixation was obtained. In one hip, a 12-mm gap was noted intraoperatively and on postoperative radiographs. Subsequently, this patient developed bridging callus about the osteotomy site and was pain-free in this area, indicating ETO healing at approximately 13 weeks after revision THA. Overall, there were no cases of progressive ETO proximal migration. Therefore, we found that immediate fixation of an ETO during the first stage of a 2-stage exchange arthroplasty can afford high union rates similar to those in revision THA and that braided cables, Luque wires, or 18-gauge cerclage wire can be successfully used for fixation [10,21,22].

There was one case of osteotomy nonunion associated with a dysplastic proximal femur secondary to a childhood injury. In the remaining 22 cases, osteotomy healing occurred at an average of 11.5 weeks compared with approximately 15.5 weeks in the study by Morshed et al [8]. Early fixation might be responsible for this more rapid time to osteotomy union. Because of the small sample size, we were unable to find a correlation to the type of fixation used and recurrent infection.

Intraoperative fractures occurred in 8.3% of our cases and included 2 fractures of the ETO fragment. This rate is comparable with previous studies reporting intraoperative fracture rates of 13% to 23% [8,22,23]. In all cases of intraoperative fracture, a well-fixed cementless component was removed during the first stage of the procedure. The integrity of the proximal femur is often compromised during extraction of these cementless implants, leading to this increased incidence of intraoperative fracture (27%) vs cemented (0%) or loose stems (0%), which is also comparable with previous studies [8,24]. For the 2 patients sustaining an intraoperative fracture, the ETO and the fracture sites were consolidated and healed by 12 weeks postoperatively. Neither of these patients experienced subsidence of their femoral components, and both were classified as osseointegrated by the criteria of Engh et al [16]. The average modified D'Aubigne and Postel scores at latest follow-up for these patients was 11 (range, 10-12).

One of the most common complications after revision THA is postoperative dislocation. Dislocation rates after revision THA using an ETO has been reported to be 10.2% [22]. In series of 2-stage exchange arthroplasty for prosthetic infection, the reported rate of dislocation ranges from 10% to 31% [1,3, 8]. Morshed et al reported a 31% rate of dislocation in treating prosthetic infections with an ETO [8]. In the absence of osteotomy migration, this rate appears relatively high; however, they also used relatively small, 28-mm femoral heads during reimplantation in all cases. All of these cases went on to recurrent instability and were revised. It is also possible that some level of abductor dysfunction occurred during the period of delayed fixation, leading to this higher rate of dislocation. In our study, there were 2 dislocations (9%), with one patient requiring revision to a constrained liner. This rate of dislocation is more consistent with those of standard revision THA and 2-stage exchange arthroplasties. It is possible that early fixation of the ETO, maintenance of the abductor integrity, and use of larger femoral heads may have led to the lower rate of dislocation in our series.

Some of the limitations of the current study include the retrospective nature of data collection and the relatively small sample size. Despite these limitations, this study represents the largest series evaluating the use of an ETO in treating prosthetic infections. Our clinical and radiographic results are comparable with prior studies on 2-stage exchange arthroplasty for prosthetic infection of the hip. Rates of infection eradication, intraoperative complications, and postoperative complications were also consistent with previous studies. In the setting in which conventional measures fail in attempting to extract a well-fixed cementless or cemented femoral stem during 2-stage exchange arthroplasty, the authors recommend the use of an ETO with immediate fixation at the time of spacer placement. This technique provides wide exposure for debridement and removal of implants. Meticulous surgical dissection and maintenance of a well-vascularized osteotomy fragment allow for a high rate of union and an acceptable rate of infection eradication.

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