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Staged Total Hip Arthroplasty: A Novel Technique in Managing Native and Periprosthetic Acetabular Insufficiency

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ABSTRACT

Background: There is no consensus on how to best address acetabular insufficiency. Several described techniques have a high rate of loosening and most rely on fixation to intact innominate bones. They also require extensive exposure and expensive implants. We present a novel technique for acetabular insufficiency management including discontinuity and a series with mean 6.5-year follow-up.

Material and Methods: After exposure, a femoral neck osteotomy is made, or the femoral component is removed. Bone graft is reverse reamed into the defect, and a porous coated acetabular shell is implanted with screws for supplemental fixation. In 3-6 months, after defect healing, the femoral component is implanted. All staged total hip arthroplasties for pelvic discontinuity from 2010 to 2015 by a single provider with minimum 5-year follow-up were identified. Implant survivorship, Merle d'Aubinge, and visual analog scale scores as well as complications were recorded.

Results: Nine patients were identified with mean 80.8-month follow-up (62-129). Merle D'Aubinge scores improved from 5.6 (4-8) to 15.3 (14-18), and Visual analog scale scores improved from 7.2 (6-9) to 0.8 (0-2). All implants were retained, and all patients were ambulatory at the terminal follow-up. There were 2 greater trochanter fractures, one calcar fracture managed with cerclage, and one patient developed heterotopic ossification.

Conclusion: Staged total hip arthroplasty can be used to address pelvic discontinuity with excellent short- to mid-term outcomes. This technique allows for a more limited exposure and the use of primary hip implants. Fixation is by ingrowth and does not rely on intact pelvic architecture.

Introduction

The management of acetabular fractures in younger patients is intended to restore the articular surface with the goal of preserving the native joint. The incidence of acetabular fractures in the aging population is increasing. These patients often have poorer bone stock, pre-existing coxarthrosis, or present with fractures about an acetabular component. Fractures in this population are typically comminuted, especially about the sourcil and medial wall and often present with protrusio or pelvic discontinuity. In the elderly population, low-energy insufficiency fractures of the acetabulum are often managed nonoperatively but can progress to protrusio or discontinuity as well. These factors have led to increased interest in the role of arthroplasty in the management of both native and periprosthetic acetabular fractures.

Pelvic discontinuity is an infrequent but challenging problem for the arthroplasty surgeon. Although rare, the incidence is expected to increase as primary and revision hip arthroplasty rates continue to rise. Some authors predict that more than 500,000 primary total hip arthroplasties will be performed annually in the United States by 2030 [1,2]. Many factors, including a growing elderly population and rise in obesity, play a role in this increase in demand for arthroplasty. Arthroplasty is also being offered to a younger population, which places greater demands on their implants and requires revision at a higher rate [1–5].

Pelvic discontinuity is defined by the defect traversing the anterior and posterior columns of the acetabulum such that the

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superior and inferior aspects of the pelvis are completely dissociated from one another [6]. This simple definition, however, often belies the extent of the bony deficits and the complexity of their reconstruction. Furthermore, pelvic discontinuity is a rather heterogenous condition from an etiologic standpoint. In the native hip, a discontinuity can develop from an acute acetabular fracture. In young patients, these fractures are typically managed with internal fixation. However, in the elderly population, low-energy insufficiency fractures of the acetabulum are often managed nonoperatively but can progress to protrusio or discontinuity. Neoplasia is another, albeit rare, cause of pelvic discontinuity in the native hip. The vast majority of cases occur in the setting of the prosthetic hip, with the most common cause being osteolysis [7]. Less commonly, a discontinuity can develop intraoperatively secondary to acetabular component impaction [8]. Bony destruction due to prosthetic joint infection must also be excluded.

A wide variety of techniques have been described in managing acetabular fractures and pelvic discontinuity with no clear consensus among authors on implant choice, indications, or outcomes. This lack of consensus reflects the inherent challenge in managing these injuries. Porous metal components theoretically provide the most stable fixation with bony ingrowth [9–12]. While augments may be used to improve fixation at the acetabular rim, stable fixation may be difficult to obtain in the face of massive defects, extensive comminution, or loss of columnar support [9,12]. In the setting of acute fracture or fracture nonunion, multiple authors have reported good outcomes with single or dual column plating and the use of a press-fit implant with or without bone grafting [13–15]. Acetabular distraction with a porous “jumbo cup” relies on elastic recoil of the remaining bone on an oversized acetabular component wedged into a distracted defect [16,17]. Antiprotrusio cages and cup-cage constructs use malleable metal cages which span the defect and achieve fixation in the ilium and ischium. A polyethylene liner or metal shell with liner can then be cemented into the cage [18,19]. Finally, custom porous coated titanium “triflange” implants can be made from three-dimensional imaging of the patient’s pelvis. These implants can be fixed to the ilium, ischium, and pubis and may be the only viable means of reconstruction in patients with massive segmental bone loss [20,21].

In this article, we introduce a novel, staged technique that can be used to manage native or periprosthetic acetabular insufficiency. This technique was developed at our institution in response to technical challenges and morbidity associated with existing constructs. In addition to technical details, we present a case series with mid-term survivorship and clinical outcomes.

Material and methods

Indications

In general, staged total hip arthroplasty can be used to achieve durable acetabular component fixation in patients with native or periprosthetic acetabular insufficiency related to fracture, osteolysis, metabolic bone disease, iatrogenic bone loss, or otherwise poor bone stock. The decision to perform staged arthroplasty was typically made intraoperatively based on inability to achieve adequately stable fixation of a hemispherical acetabular component.

Surgical technique

The patient is positioned laterally on the operating table using a pegboard. An alcohol scrub followed by chlorhexidine prep is performed, and adhesive U-Drapes (Halyard; Alpharetta, GA) are applied followed by an impervious hip drape, a second chlorhexidine prep, and ioban over all exposed skin. In the case of a revision procedure, the original approach is used. If plating of the posterior column or wall was indicated, a posterior exposure is used. In the case of a native hip, an 8- to 10-cm incision is made centered over the greater trochanter, and the hip is exposed using a modified Hardinge approach. The femoral neck osteotomy is made, or in cases of periprosthetic acetabular insufficiency, the femoral component is removed, and the acetabulum is exposed. Any hardware, soft tissue, or fibrinous debris is removed from the acetabulum. Columnar fractures warranting fixation, if present, are plated. Femoral head autograft or crushed cancellous allograft, if needed, are reverse reamed into the defect, and a press fit, porous acetabular shell is impacted into place. Screws are used for supplemental fixation as bone stock allows. The capsule, vastus-abductor cuff, and IT band are repaired, and the skin is closed. Postoperatively, the patient is made toe-touch weight-bearing for 3-6 months until there is radiographic evidence that the defect is healed and the cup remains in stable position. At this time, the patient returns for placement of a press fit femoral component and is made weight-bearing as tolerated.

Retrospective review

All patients undergoing staged total hip arthroplasty for native and periprosthetic acetabular fractures during a 5-year period from 2010 to 2015 by a single surgeon ($n = 10$) were identified. Patients with less than 2-year follow-up were excluded. The primary endpoints were need for additional surgical procedures and implant survivorship. Merle d’Aubinge scores were calculated preoperatively and postoperatively, and modified visual analog pain scale scores as well as overall patient satisfaction and perioperative complications were documented.

Results

During the study period, 10 patients underwent staged total hip arthroplasty. One was excluded for inadequate follow-up, leaving 9 patients with a minimum 5-year follow-up (mean 80.8 months, 62-129 months). Mean age at index operation was 72.1 (59-82); 6 patients were female, and 3 were male (Table 1). Three staged procedures were performed for nonunion of native acetabular fractures that were initially managed nonoperatively and subsequently went on to nonunion with pelvic discontinuity and protrusio (Fig. 1). Two patients reported falls after primary THA and presented with comminuted acetabular fractures and medial protrusion of the cup. Three additional periprosthetic fractures were noted in the early postoperative period with no clear fall or injury. These likely represent missed intraoperative fractures (Fig. 2). The final patient was undergoing conversion from a cutout

Table 1
Patient demographic information and timeline associated with care.

Patient	Hip	Approach	Time between stages	Total follow up
68-y/o Female	Native	Posterior	5.21 mo	71 mo
82-y/o Male	Native	Lateral	4.25 mo	88 mo
72-y/o Female	Prosthetic	Lateral	6.53 mo	129 mo
82-y/o Female	Prosthetic	Posterior	4.28 mo	77 mo
78-y/o Male	Prosthetic	Lateral	6.28 mo	67 mo
83-y/o Female	Native	Lateral	9.14 mo	65 mo
64-y/o Female	Prosthetic	Posterior	4.67 mo	67 mo
59-y/o Male	Prosthetic	Posterior	5.80 mo	102 mo
61-y/o Female	Native	Lateral	3.85 mo	62 mo
72.11 y/o			**5.56 mo**	**80.8 mo**

Second stage performed after radiographic evidence of defect healing noted.
The final row denotes averages.

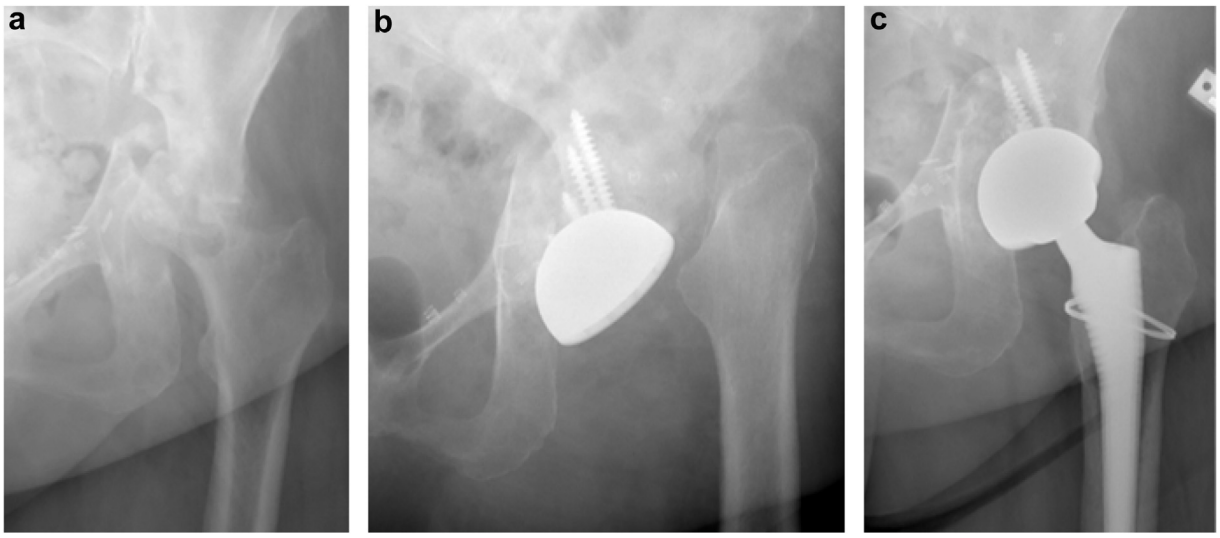

Figure 1. A 68-y/o female presented 6 months after nondisplaced native acetabular fracture which failed conservative management and went on to pelvic discontinuity (a). Planned reduction and fixation before arthroplasty failed due to callous making reduction impossible. Acetabulum was prepared in situ with femoral head autograft (b), and the procedure was staged (c).

cephalomedullary device to total hip arthroplasty. Poor bone stock was noted during reaming, and upon impaction of the cup, a transversely oriented fracture was noted across the acetabulum, and the decision to stage the procedure was made intraoperatively. Conventional cementless revision acetabular components were used in all cases (Table 2).

Mean preoperative Merle D'Aubinge score was 5.6 (4-8) and graded as poor in all patients. Mean preoperative visual analog scale pain scores were 7.2 (6-9), and only 3 patients were able to ambulate for short distances with a walker before the first stage. Postoperatively, mean Merle D'Aubinge score was 15.3 (14-18) and rated fair in 4, good in 4, and excellent in one patient. Mean postoperative visual analog scale pain score was 0.8 (0-2), and all patients were ambulatory postoperatively. Four required a walker, 2 used a cane for long distances, and 3 required no assistive devices at terminal follow-up. All implants were retained at the final follow-up (Table 3).

There were 2 fractures of the greater trochanter during the second stage which were managed conservatively. There was also one intraoperative calcar fracture managed with cerclage. An additional patient developed Brooker stage I heterotopic ossification which did not limit them clinically and required no treatment. Leg length was restored in all cases, and there were no traction nerve injuries. There were no dislocations, implant failures, or deep infections. One patient developed a superficial surgical site infection managed with oral antibiotics. There were no perioperative medical complications, although one patient died of unrelated causes 7 years after the second stage (Table 4).

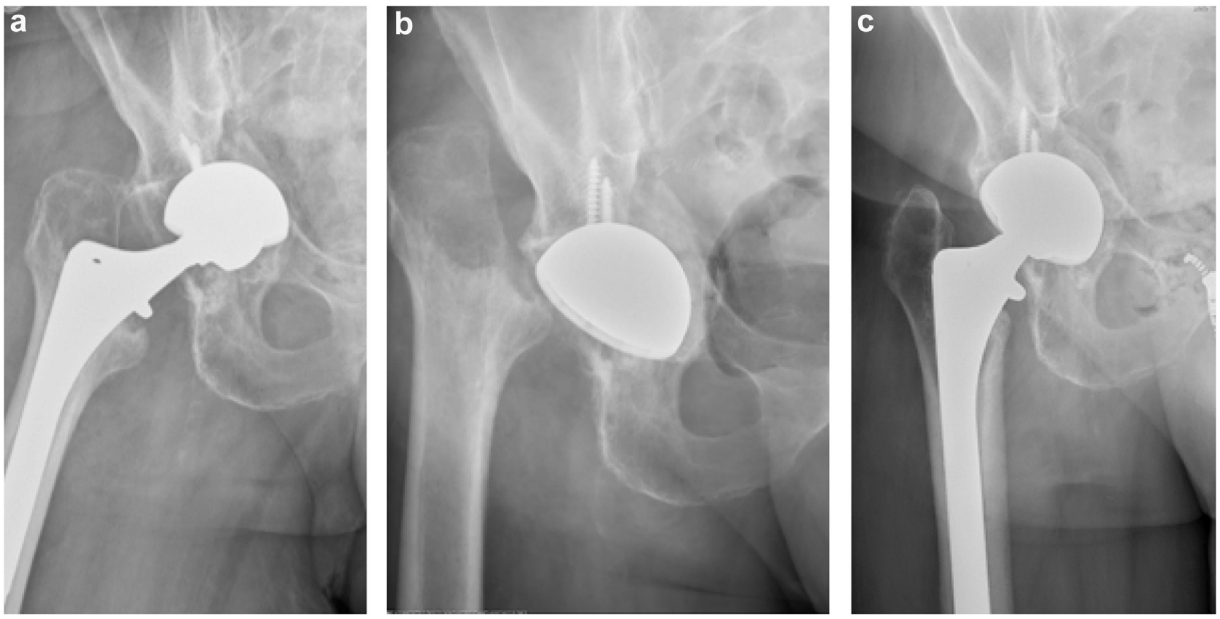

Figure 2. Patient underwent conversion from hemiarthroplasty to total hip arthroplasty at an outlying facility. Acetabular fracture with protrusion noted at 6-week follow-up with no reported history of fall or trauma (a). Referred to tertiary center and staged procedure with allograft performed electively (b-c).

Table 2
All patients were managed with conventional porous coated acetabular shells (Continuum, Zimmer) and conventional bearings.

Components used			
Patient	Shell	Head	Femur
68-y/o Female	52 mm Multihole	32 mm CoCr	Metaphyseal tapered wedge
82-y/o Male	66 mm Multihole	36 mm CoCr	Diaphyseal fully bead coated
72-y/o Female	58 mm Multihole	36 mm CoCr	Metaphyseal/diaphyseal modular
82-y/o Female	56 mm Multihole	36 mm CoCr	Diaphyseal fully bead coated
78-y/o Male	62 mm 3-Hole	36 mm CoCr	Diaphyseal fully bead coated
83-y/o Female	52 mm 3-Hole	32 mm CoCr	Metaphyseal tapered wedge
64-y/o Female	58 mm Multihole	36 mm Ceramic	Diaphyseal fully bead coated
59-y/o Male	60 mm 3-Hole	36 mm Ceramic	Diaphyseal fully bead coated
61-y/o Female	64 mm 3-Hole	36 mm CoCr	Metaphyseal tapered wedge

A mixture of tapered wedge (Avenir, Zimmer) fully coated diaphyseal (Versys, Zimmer) and modular (AcuMatch, ExacTech) femoral components was used.

Discussion

Management of native and periprosthetic acetabular fractures in older patients or those with poor bone quality is one of the most challenging problems in hip arthroplasty. No single described technique is appropriate in every setting, and each has its own set of limitations. In this study, we present a novel technique with a minimum 2-year follow-up that can be added to one's armamentarium when faced with acetabular fractures or pelvic discontinuity.

Arguably, the most difficult part of managing these fractures from an arthroplasty standpoint is achieving stable fixation. Biologic fixation to a porous acetabular component provides the most durable fixation, but obtaining a press fit is often not feasible [9–12]. Although cup cage constructs aim to achieve bony ingrowth spanning the defect, these constructs as well as traditional antiprotrusio cages rely on cemented fixation of the acetabular bearing [18,19]. Fixation with caged constructs as well as jumbo cup and custom triflange constructs also requires intact pelvic architecture proximal and distal to the defect [16,17,20,21]. In the setting of ipsilateral fractures to the ischium or pubic rami, it may be impossible to achieve stable fixation with a defect spanning construct [18,19]. In addition, without sufficient elastic recoil in the setting of pelvic ring injuries, it may be impossible to achieve adequate fixation with distraction osteosynthesis [16].

Many of these described approaches require extensive exposure and soft-tissue stripping. This can lead to altered gait mechanics and poorer functional outcome. Likewise, these techniques involve much larger and extensively secured implants that may make subsequent revision difficult if not impossible [4]. When performing an acetabular reconstruction using a staged technique, a much more limited exposure can be used. Furthermore, after bone grafting, exceptional press fit of the acetabular component is not necessary. Standard porous coated revision acetabular shells can be fixed with screws while the defect heals and the component incorporates. Eliminating joint contact forces derived from the femoral component allows even quite tenuous fixation to mature before the second stage. In several of our patients, the decision to stage the procedure was made intraoperatively because of the inability to achieve adequate press fit of the acetabular component. A 3- to 6-month period between stages allows for radiographically demonstrable healing of the defect and ingrowth of the component. Should additional revision be required in the future, the patient retains relatively normal bone stock and standard revision components.

The principal drawback to staged arthroplasty is that the patient is committed to a secondary procedure. The literature suggests that staged revision for prosthetic joint infection carries with it an increased risk of morbidity and mortality. Theoretically, staged arthroplasty in the setting of acetabular fracture or pelvic discontinuity would carry a similar risk. An additional challenge is restoring leg length during the second stage. Without a head and neck to maintain length, the proximal femur often migrates proximally between stages one and 2. Although we encountered little difficulty restoring length, required no shortening osteotomies, and encountered no sciatic nerve traction injuries in this series, it is reasonable to anticipate these difficulties, especially if the second stage is delayed for a longer period of time. Furthermore, this procedure is not suited for every case of pelvic insufficiency, specifically those with massive bone loss which may necessitate a bridging construct. The literature is clear that early mobilization is an important factor in mitigating pulmonary complications after lower extremity fracture surgery in the aging population. In our series, all patients were able to mobilize with a walker for short distances and participate in therapy between stages. However, we recognize that limited activity between stages could pose a significant risk. In spite of these potential drawbacks, where indicated, staged total hip arthroplasty is a viable option in managing native

Table 3
Merle d'Aubinge scores were available at initial preoperative visit and at yearly follow-up.

Patient	Preoperatively		Final follow-up		
	Merle d'Aubinge	VAS	Merle d'Aubinge	VAS	Implants
68-y/o Female	4	8	16	2	Intact
82-y/o Male	4	9	14	1	Intact
72-y/o Female	6	8	14	1	Intact
82-y/o Female	4	8	15	0	Intact
78-y/o Male	7	5	16	0	Intact
83-y/o Female	7	7	14	2	Intact
64-y/o Female	7	6	18	0	Intact
59-y/o Male	4	8	17	0	Intact
61-y/o Female	8	6	14	2	Intact
72.11 y/o	**5.66**	**7.22**	**15.33**	**0.88**	**100%**

Visual analog scale (VAS) scores recorded at every visit. All implants functioning and all patients ambulating at the terminal follow-up.
The final row denotes averages.

Table 4
Single superficial surgical site infection managed with cephalexin.

Complications				
Complications	Stage I	Stage II	Final follow-up	Total
Stitch/Wound	0	1	0	1
Deep infection	0	0	0	0
Hematoma	0	0	0	0
Greater trochanter fracture	0	2	0	2
Calcar fracture	0	1	0	1
Acetabular fracture	N/A	0	0	0
Failure of fixation	0	0	0	0
Dislocation	N/A	0	0	0
Heterotopic ossification	0	1	0	1
Leg length inequality	N/A	0	0	0
Thromboembolic	0	0	0	0
Cardiac events	0	0	1*	1*
Pulmonary complications	0	0	0	0

Both greater trochanter fractures remain nondisplaced at the terminal follow-up. One patient developed Brooker stage 1 heterotopic ossification which required no treatment. * [21] A final patient died 7 years after stage 2 of unrelated cardiac event.

and periprosthetic acetabular fractures as a bone-sparing and soft tissue–sparing alternative to more extensive reconstruction options previously described in the literature.

We acknowledge that this study has several limitations. First, the series is relatively small at only 9 patients and may not be adequately powered to detect failures or unforeseen complications. Second, follow-up is limited to a mean of 80.8 months. Although the short- to mid-term survivorship and clinical outcomes reported here are quite good, there exists no long-term data. Further study with larger numbers, prospective data collection, and longer follow-up is needed to further understand the long-term viability of this approach.

Conclusions

Native and periprosthetic acetabular fractures in the aging population remain a major obstacle for the arthroplasty surgeon to overcome. There is no clear consensus on how to best manage these defects. A variety of techniques have been described with satisfactory outcomes, but each technique has its limitations. Staged total hip arthroplasty serves as a useful tool to add to one's armamentarium in managing these fractures, even in the setting of pelvic discontinuity, in patients with poor bone stock. The procedure does not require extensive exposure, allows for the use of conventional implants with fixation by bony ingrowth, and does not rely on intact innominate bones in the setting of fracture. In our series, short- to mid-term outcomes were excellent, but further study will be needed to address long-term outcomes and implant survivorship.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

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