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 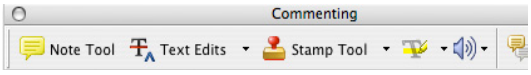

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 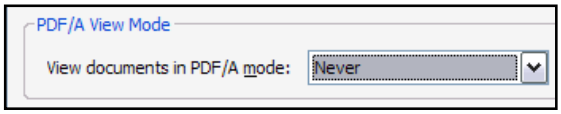

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 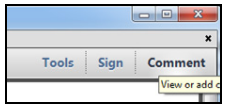

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 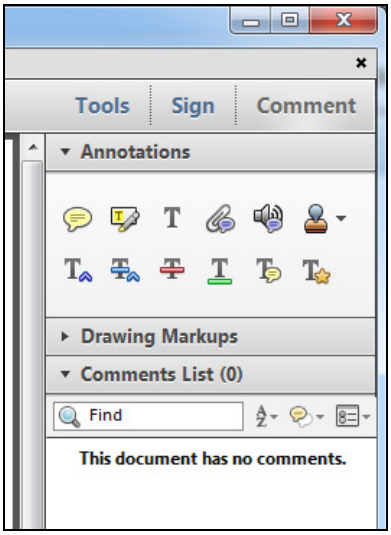
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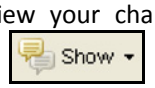
Review	To review your changes, click on the 'Show' button  on the Commenting tool bar. Choose 'Show Comments List'. Navigate by clicking on a correction in the list. Alternatively, double click on any mark-up to open the commenting box.	Your changes will appear automatically in a list below the Comment tool bar. Navigate by clicking on a correction in the list. Alternatively, double click on any mark-up to open the commenting box.
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Original Article

Delayed Total Hip Arthroplasty for Failed Acetabular Fractures: The Influence of Initial Fracture Management on Outcome After Arthroplasty

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ABSTRACT

Background: Total hip arthroplasty (THA) provides a successful salvage option for failed acetabular fractures. The complexity of arthroplasty for a failed acetabular fracture will depend on the fracture pattern and the initial management of the fracture. Our objective was to compare the midterm outcome of THA between patients who presented with failed acetabular fractures following initial surgical or nonsurgical treatment.
Methods: Forty-seven patients underwent cementless THA ± acetabular reconstruction following failed treatment of acetabular fractures. Twenty-seven were initially treated by surgery (group A) and 20 had nonsurgical treatment (group B). Intraoperative measures, preoperative and follow-up clinical, radiological, and functional outcomes were compared between the 2 groups.
Results: The mean surgical time, blood loss, and need for blood transfusion were significantly less in group A ($P < .05$). Acetabular reconstruction to address cavitary or segmental defects was needed in a significantly higher number of patients in group B ($P = .006$). Significant improvement in modified Merle d'Aubigne and Oxford scores was seen postsurgery in both groups. Acetabular component survival with aseptic loosening as end point was 98%. Overall survival rate with infection, revision, or loosening as end point was 93% at a mean follow-up of 7 years ± 17 months.
Conclusion: THA for a failed acetabular fracture is greatly facilitated by initial surgical treatment. Although functional results and survivorship were similar in both groups, failed nonsurgical treatment in complex fractures is associated with migrated femoral head and extensive acetabular defects requiring complex acetabular reconstruction.

Acetabular fractures in young patients are high-velocity injuries usually as a result of motor vehicle accidents. Acetabular fractures are associated with damage to the femoral head and acetabular cartilage, labral injuries, and possible disruption of the femoral head blood supply. It can lead on to potential irreparable complications like post-traumatic arthritis and femoral head osteonecrosis [1,2]. In spite of these nonmodifiable factors, it is well accepted that surgical intervention in the form of anatomic reduction and stable internal fixation provides the best opportunity for restoration of joint function and prevent long-term complications [3,4]. The expertise for optimal surgical treatment of these fractures is still lacking in a lot of places worldwide given the complexity of these fractures and the learning curve needed for acetabular fracture management. As a result, these fractures are still managed conservatively leading to early joint damage and poor functional outcome. Results following total hip arthroplasty (THA) for failed acetabular fractures have been variable with studies reporting good to excellent survival rates in the midterm [5-8]. With this

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background, we prospectively compared patients undergoing THA for failed acetabular fractures following initial surgical or conservative treatment for the fracture. We hypothesized that initial surgical treatment will minimize the complexity of THA and will achieve better midterm outcome with regard to function and survival rates.

Materials and Methods

Forty-seven patients who underwent uncemented THA for failed acetabular fractures between 2006 and 2010 were prospectively followed. The institutional review board approved the study and informed consent was obtained from all patients. Flowchart (Fig. 1) depicts patient recruitment, and inclusion and exclusion criteria. Patients were divided into 2 groups: group A—failed internal fixation and group B—failed conservative treatment. Cementless components were used in all patients. Patient and fracture demographics are tabulated in Table 1. Preoperative assessment included a 3-dimensional computed tomography scan in all patients and hip aspiration to rule out active sepsis in patients after open reduction internal fixation (ORIF).

Surgical Strategy

The surgical approach was not dictated by the previous surgery except when retained hardware or heterotopic bone had to be removed. Patients with reduced hip center were treated as primary hip arthroplasties if the fracture had united.

Acetabular defects were classified according to the Paprosky's classification [9] (Fig. 2). Contained bone defects were treated with impaction autografting from the femoral head and if insufficient augmented from the iliac crest. Uncontained posterosuperior wall defects were reconstructed with iliac strut/femoral head grafts and fixed with a plate/screws. Ununited posterior column fractures were debrided, bone grafted, and fixed with a pelvic reconstruction plate (Fig. 3). A porous coated hemispherical socket (cluster hole or a multi-hole) and a standard primary uncemented femur stem (fully hydroxyapatite coated or proximal porous coated) were used in all patients. Socket fixation was always augmented with use of multiple screws. The articulation was either metal or delta ceramic on highly cross-linked polyethylene with the head sizes 28/32/36 mm.

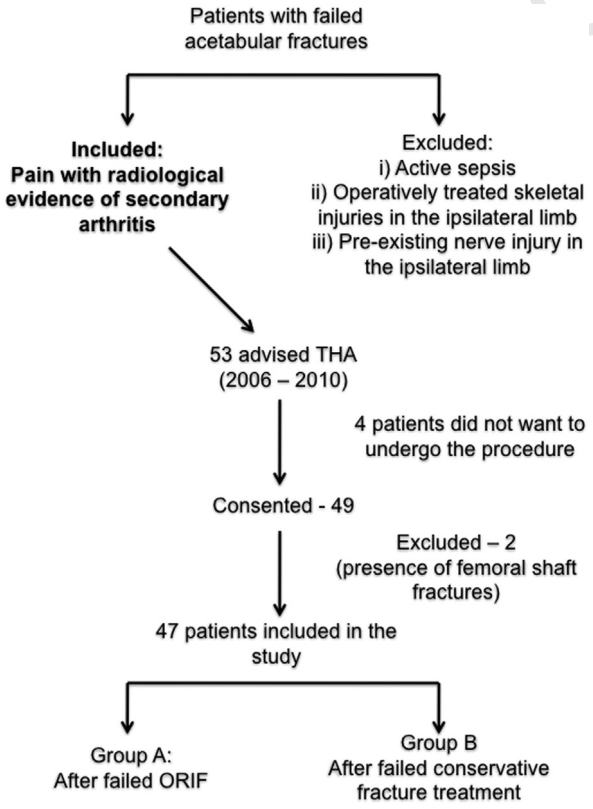

Fig. 1. Patient recruitment into the study. THA, total hip arthroplasty; ORIF, open reduction internal fixation.

Table 1
Patient and Fracture Data.

	Group A	Group B	*P* Value
Age (y)	47 ± 9	49 ± 9	.56
Sex (male:female)	18:9	13:7	.9
Body mass index	29 ± 4.8	28.2 ± 5.2	.09
Follow-up (mo)	82 ± 117	85 ± 16	.47
Interval between injury and surgery	33 ± 10	24 ± 10	**.005**
Fracture classification			
Elementary			
Posterior wall	8	1	
Posterior column	2	3	
Anterior wall	0	1	
Anterior column	1	3	
Transverse	5	4	
Associated			
Posterior wall + column	2	2	
Transverse + posterior wall	3	1	
Anterior column + posterior hemitransverse	1	1	
T type	3	2	
Both column	2	2	

Patients were either allowed immediate weight-bearing as tolerated or kept on protected weight-bearing for 6 to 12 weeks depending on the complexity of reconstruction. Thromboembolic prophylaxis with low-molecular-weight heparin was used for 2 weeks starting 12 hours postsurgery. Indomethacin 25 mg twice daily was used for 6 weeks to prevent heterotopic ossification (HO).

Follow-up assessment was performed at 6 weeks, 6 and 12 months, and every year thereafter. Preoperative and final follow-up clinical assessment (modified Merle d'Aubigne scores), functional assessment scores (Oxford hip score) were done by blinded trainees. Radiological assessment of the acetabular component was performed at last follow-up to assess radiolucencies (DeLee and Charnley [10]) and component fixation (Dorr et al [11]). HO was classified according to the Brooker's classification.

Statistical Analysis

Operative variables (surgical time, blood loss, need for blood transfusion, and iliac crest autografts), outcome measures

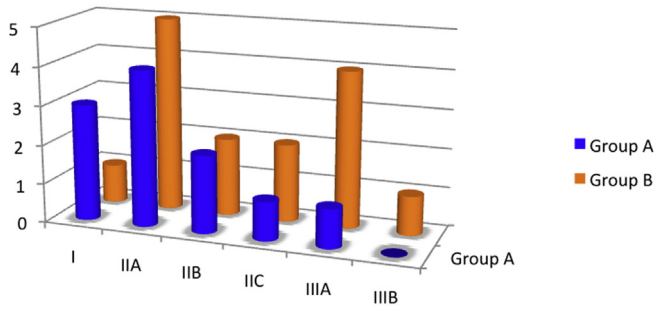

Fig. 2. Distribution of acetabular defects according to the Paprosky system.

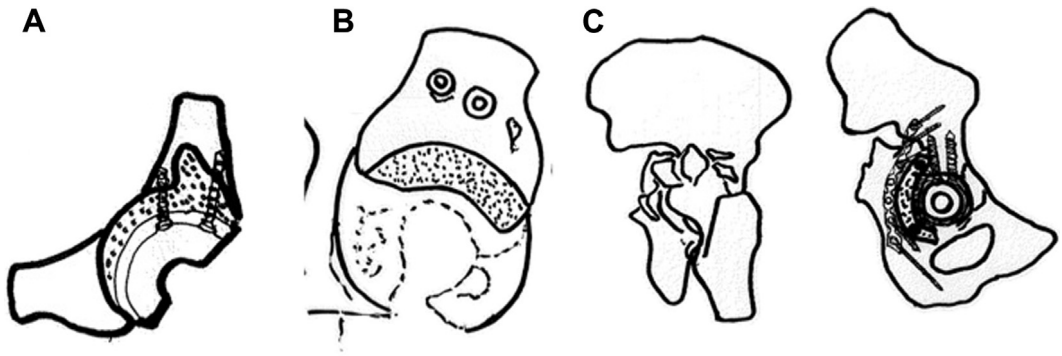

Fig. 3. Methods of acetabular defect reconstruction. (A) Contained defects were treated by impaction grafting, (B) smaller posterior wall defects were treated with fig of 7 femoral head grafts, and (C) larger wall defects were reconstructed with iliac crest strut graft and stabilized with a plate.

(modified Merle d'Aubigne scores and Oxford hip scores), and complications were compared between 2 groups using relevant statistical measures (SPSS 16 for Windows; Chicago, IL). Categorical variables were assessed using the chi-square test or Fischer exact test for statistical significance, and continuous variables were assessed using the *t* tests. The level of significance was set at $P < .05$. Acetabular component survival was assessed using the Kaplan-Meier survivorship analysis.

Results

Thirty-one men and 16 women underwent THA during the study period. The mean age was 48 ± 9 years. The mean follow-up was 84 ± 17 months. Three patients were lost to follow-up leaving 44 evaluable patients (24 in group A and 20 in group B) for final radiological and functional analysis. Two patients were not traceable, and 1 patient died due to an unrelated cause. The mean duration between initial fracture and subsequent need for arthroplasty was significantly less in group B, 24 ± 10 months in group B compared to 33 ± 10 months in group A ($P = .005$).

Posterior approach was used in 39 patients, and a modified Hardinge approach was used in 8 patients. None of the hips had a positive aspiration for infection preoperatively. Most of the fractures in group A had united (25/27) and the hip center had been restored <1 cm of the opposite hip in 22 of 27 patients at the time of arthroplasty. In group B, 11 fractures had united and the hip center was found at a level <1 cm of the opposite hip only in 6 of 20 patients. Eleven patients (46%) in group A required acetabular reconstructive procedures to address bony defects compared to 15 patients (75%) in group B. The difference was statistically significant ($P = .006$). The mean surgical time, blood loss, and the need for blood transfusion were significantly less in group A ($P < .05$, Table 2). Details of the surgical procedures performed in both groups are summarized in a flowchart (Fig. 4).

Radiological and Survivorship Analysis

The hip center was anatomically restored in all patients. All defects had consolidated and ununited column fractures had united. There was no evidence of graft resorption. Asymptomatic aseptic loosening of the acetabular socket in all 3 zones was seen in 1 patient in group B and was revised. The acetabular component survival rate was 98% with aseptic loosening and 93% with revision due to instability, infection, or loosening as end point (Fig. 5). The survival rate was similar in both groups ($P = .47$): 95.8% in group A and 90% in group B. Zone 1 radiolucencies (<2 mm) were seen in 3 patients. No osteolysis was seen. No loosening, osteolysis, or subsidence of the femoral component was evident at follow-up.

Table 2
Intraoperative Variables.

Intraoperative Measures	Group A	Group B	*P* Value
Surgical time (min)	86 ± 24	115 ± 38	**<.01**
Blood loss (mL)	448 ± 105	652 ± 212	**<.01**
Transfusion	6	13	**.03**
Iliac crest grafts	2	5	.09

Functional Outcome

After surgery, the mean modified Merle d'Aubigne scores had improved from 9.7 ± 1.2 to 15.1 ± 1.7 in group A and 7.4 ± 2.1 to 14.5 ± 1.5 in group B at follow-up. The scores were graded as excellent in 2, good in 28, and fair in 14 patients. The Oxford hip scores improved from 16.7 ± 2.8 to 41.9 ± 3.1 in group A and 9 ± 3.7 to 41.5 ± 3.5 in group B. The improvement in functional scores was statistically significant postsurgery ($P < .001$). The scores were similar between both groups ($P = .2$) for modified Merle d'Aubigne score and ($P = .68$) for Oxford scores (Table 3). Graft site pain at the iliac region was evident in 2 patients in group B. The mean limb length discrepancy at follow-up was <1 cm and was similar between both groups ($P = .47$). Patients in group A returned to work much sooner compared to patients in group B ($P = .004$).

Complications

HO was seen in 17 patients (39%; group A, 11 and group B, 6). Two dislocations were seen, 1 in each group. One patient settled with initial closed reduction, whereas 1 patient in group B required acetabular component reorientation and increase in head size following a failed closed reduction. One patient in group A underwent a successful 2-stage revision hip arthroplasty to control late-onset deep sepsis. Sciatic nerve palsy was seen in 2 patients in group B: 1 patient had completely recovered whereas 1 patient had to undergo a tendon transfer procedure to address ankle drop. Deep vein thrombosis was seen in 2 patients in group B. The overall incidence of procedure-related complications was similar in both groups ($P = .64$, Fig. 6).

Discussion

THA has been reported as a successful salvage procedure for failed acetabular fractures. Failed acetabular fractures after ORIF often have extensive scarring, HO, and avascular acetabular bone and soft tissues, which may increase the surgical morbidity during THA [12-14]. Similarly following initial nonoperative treatment,

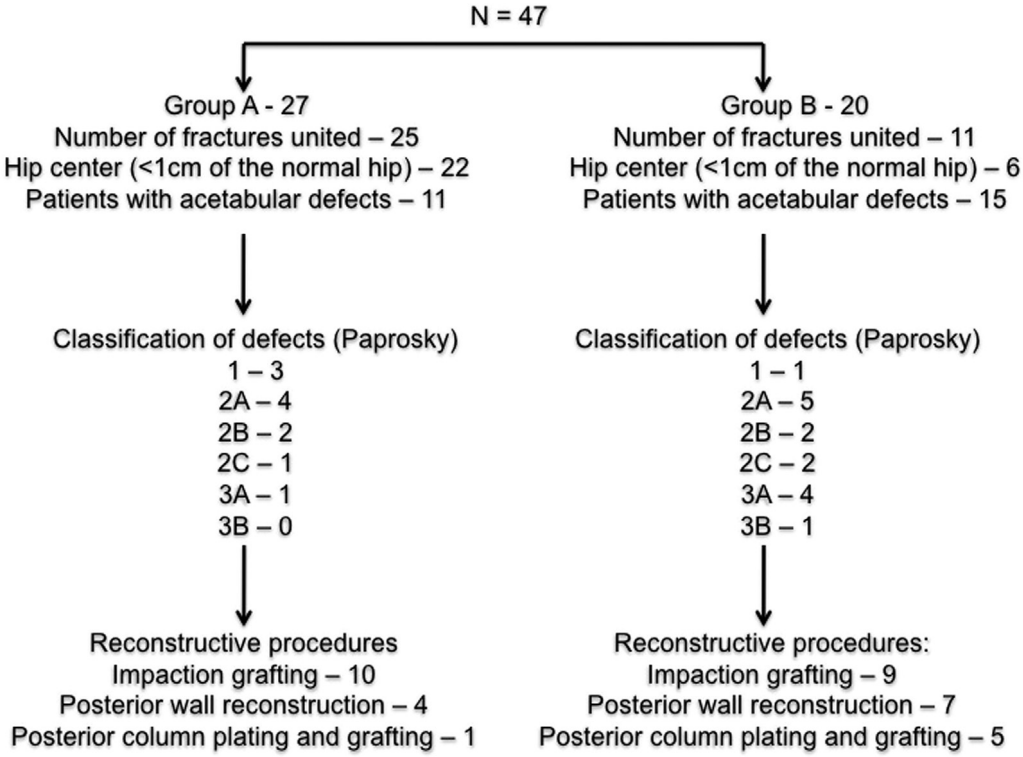

Fig. 4. Details of acetabular reconstructive techniques used in both groups.

patients often present with a high-riding hip center, protrusion, ununited fractures, and column defects as evident in our study. In both situations, performing a THA becomes more difficult leading to increased surgical times, blood loss, and unsatisfactory component placement. The long-term survival may also be affected, leading to early loosening and failure [6,15].

Initial ORIF helps restore bony anatomy, which decreases the complexity of THA and may help improve component survival. ORIF helped most of the patients in the present study to restore the hip center which made the surgical procedure technically easy in spite of the scarring compared to conservatively treated patients. The most common defect seen in the ORIF group was cavitary that was easily addressed using morselized grafts from the femoral head.

On the contrary, THA in conservatively treated failed fractures needed extensive acetabular reconstructions to successfully implant a primary cementless acetabular component at the anatomic hip center. Fixation of ununited posterior column and biological reconstruction of wall defects led to increased surgical times, blood loss, graft site morbidity, and delayed return to work.

The data from this study were contradictory to published data by Zhang et al [16], who had reported more extensive acetabular defects and need for reconstructive procedures in the surgically treated group. The most likely reason for the difference is in selection of patients in the 2 studies. In the study by Zhang et al, the number of associated fractures that are more complex than elementary fracture types was significantly higher in the ORIF group compared to the conservative group, whereas in the present study more number of patients with associated fracture patterns were treated conservatively leading to initial poor results.

Acetabular component survival in both groups was similar with regard to aseptic loosening at a mean follow-up of 7 years. The complex reconstructions in group B did not affect component

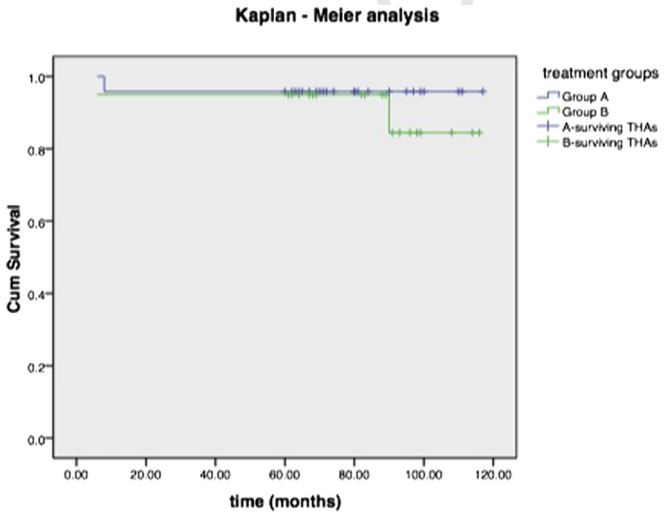

Fig. 5. Survival plot showing revised and surviving hips in both groups.

Table 3
Functional Outcome Assessment. Q5

Outcome Measure			*P* Value
Merle d'Aubigne score	Preoperative	Follow-up	
Group A	9.7 ± 1.2	15.1 ± 1.7	**<.001**
Group B	7.4 ± 2.1	14.5 ± 1.5	**<.001**
Oxford hip score	Preoperative	Follow-up	
Group A	16.7 ± 2.8	41.9 ± 3.1	**<.001**
Group B	9 ± 3.7	41.5 ± 3.6	**<.001**
Graft site pain	Group A: 0	Group B: 2	.29
Limb length discrepancy (cm)	Group A: 0.53 ± 0.42	Group B: 0.62 ± 0.39	.47
Return to work (wk)	Group A: 16 ± 5	Group B: 23 ± 10	**.004**

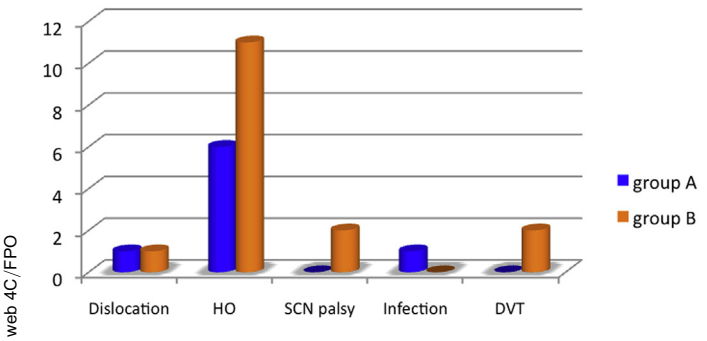

Fig. 6. Complications. HO, heterotopic ossification; SCN, sciatic nerve; DVT, deep vein thrombosis.

survival and none of the hips had been revised for aseptic loosening. Ranawat et al [7] and Weber et al [12] have reported similar survivorship results in surgically and nonsurgically treated patients. Use of cementless acetabular components [17,18], autografts for acetabular reconstruction [16], and accurate placement of the socket at the anatomic hip center [19] could be probable reasons for excellent survivorship in these patients. Use of biological reconstruction methods also preserves the acetabular bone stock for possible future revision surgery in these young patients.

The study has its limitations, the sample size was small and the follow-up is still relatively short considering that delayed arthroplasty for failed acetabular fractures has been shown to have a higher failure rate after 10 years [6,19]. Our cohort was relatively young and active, so they need more follow-up to ascertain longevity. To conclude, patients with acetabular fractures benefit from surgical treatment. Nonsurgical treatment leads to rapid deterioration of hip function necessitating arthroplasty. THA is less morbid in patients treated with ORIF compared to initial nonsurgical treatment. However, initial fracture treatment does not influence component survival at midterm follow-up.

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