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A Review of Total Hip Replacement Following Acetabular Fractures

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Abstract
Purpose of Review The incidence of geriatric acetabular fractures is increasing with our aging population. Geriatric acetabular fractures offer unique challenges to treating physicians due to the complexity of fracture patterns, osteoporotic bone, and pre-existing joint arthritis. Controversy remains regarding the optimal reconstructive treatment of these injuries, and both acute and delayed total hip arthroplasty options exist in appropriate settings for these patients.
Recent Findings While early experience with acute THA led to poor clinical outcomes, several newer studies report improvements in survivorship and in clinical outcomes (HHS scores ranging from 87-93). Cementless acetabular components and porous metal cups show improved outcomes and survival rates (87–88% in short-midterm follow up) in delayed THA.
Summary In our review of recent literature within the past 5 years, we have found that modern surgical techniques and improvements in cementless acetabular fixation show promising results and improved clinical and radiographic outcomes for the treatment of acetabular fractures in older patients.

Keywords Acetabular fracture · Geriatric · Acute total hip arthroplasty · Delayed total hip arthroplasty

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Introduction

Geriatric acetabular fractures are complex intra-articular injuries with a diverse array of injury patterns that follow high- and low-energy trauma [1–3]. Older patients have limited physiologic reserve and healing capacity, which translates into risk for greater morbidity and mortality than younger patients [1, 2, 4]. Older patients with acetabular fractures are more likely to have radiographic features such as roof impaction, comminution, marginal impaction, and hip dislocation that are predictive of a poor outcome after internal fixation [5]. In addition, increasing age, pre-existing comorbidities, decreased cognitive function, and limited mobility routinely result in prolonged hospitalizations and immobilization periods [1]. Diverse physiologic activity level and the heterogeneous nature of the elderly population further complicate formulating an optimal treatment plan for the elderly acetabular fracture.

Controversy exists on treatment of choice among non-operative management, surgical fracture fixation, and total hip arthroplasty [6••]. After an acetabular injury, post-traumatic arthritis of the hip may develop due the articular damage, imperfect articular reduction, concomitant chondral injury, and/or avascular necrosis of the femoral head [7–9, 10•]. While anatomic open reduction and internal fixation of the fracture can reduce the risk of post-traumatic arthritis, fractures in older patients are more likely to have poor clinical outcome compared to younger cohorts due to presence of multiple medical problems, osteoporosis, and more impacted/comminuted fracture patterns [1, 2, 6••, 8, 9, 11]. While standard surgical treatment of acetabular fracture in a young patient is to restore anatomy to prevent post-traumatic arthritis, geriatric patients are already at an age at which arthroplasty may be appropriate and can obviate the risk for development of post-traumatic arthritis and further surgery [2, 6••, 12]. However, the reported outcomes and the survivorships of THA after acetabular fracture are inferior compared to THA after non-traumatic arthritis in similar age group [7, 9, 13].

This article is a literature review of the latest (within past 5 years) research findings and advances of total hip arthroplasty after acetabular fracture in the geriatric population.

Epidemiology

Due to the aging of the population, the incidence of acetabular fractures in patients is on the rise [1, 4, 5, 10•, 12, 14–18]. Geriatric acetabular fracture patients are the fastest growing subgroup of patients with acetabular fractures over the past two decades [1, 5]. A large study of Medicare patients revealed that there was 29% increase in geriatric acetabular fractures from 1998 to 2007 [14].

Acetabular fractures occur in a bimodal age distribution, typically in younger patients in high-energy trauma and in older patients with low-energy trauma in the setting of osteoporosis [3, 12]. Low-energy trauma is not consistently well defined, but injury resulting from a fall from body height or a chair is commonly considered as "low-energy trauma" [12]. In a recent systemic review and epidemiologic study of acetabular fractures in elderly patients, 50–61% was due to a fall and 37–39% was due to high-energy road traffic accidents [4, 5]. A recent multicenter study reported 16% 1-year mortality rate of acetabular fractures in elderly patients greater than 60 years of age, which is approximately half of the 1-year mortality associated with proximal femur fracture in similar population [2].

The classic geriatric acetabular fracture is an anterior column fracture with quadrilateral plate involvement, medialization of the femoral head, and superomedial roof impaction [1, 5, 19••]. In recent epidemiology study, authors found that the associated both-column variant type fracture is the most common fracture pattern (23–26%), followed by fractures involving anterior column (15–19%) and isolated anterior column fractures (11–19%) [4, 5]. Despite improvements in fracture management and surgical techniques, this subset of patients continues to be at increased risk of post-traumatic arthritis. Development of post-traumatic arthritis after fixation of acetabular fracture ranges from 12 to 67% [6••, 9, 20–22]. Borg et al. identified that patients greater than 60 years of age and patients with femoral head impaction have a relative risk of 4.2 and 15.2, respectively, and patients with these two risk factors are more likely to develop severe post-traumatic arthritis that would necessitate joint arthroplasty [9].

Clinical and Radiographic Evaluation

In order to help in determining treatment, it is important to understand the degree of hip pain, medical co-morbidities, history of cancer and radiation therapy, pre-injury activity l and ambulatory level, functional demands, living environment, and existence of pre-injury pain of the injured hip [19••]. It is important to keep in mind that in setting of severe osteoporosis, a simple fall may result in a comminuted acetabular injury, and geriatric acetabular fracture patients should be considered as any other patients with a fragility fracture [19••]. Vitamin D level and appropriate osteoporosis evaluation should be performed. Follow up for osteoporosis treatment must be carefully coordinated to prevent further fragility fractures.

Radiographic evaluation begins with AP pelvis and Judet radiographs (iliac oblique and obturator oblique views) [19••, 23–25]. The fracture can be further investigated with computed tomography (CT) scans and 3D reconstruction to gain a better understanding of the fracture pattern, displacement comminution, possible malunion/non-union, and existing (if any) orthopedic implants [19••]. CT scans are important to understand the amount of bone impaction and the presence of femoral head damage which are predictors of the need for hip replacement.

Treatment Options

Optimal treatment of acetabular fractures in geriatrics remain unclear, varying from non-operative management to internal fixation and arthroplasty [1, 12, 19••]. In a recent review of initial treatment of acetabular fractures, approximately 24.3% was treated with non-operative management [26]. Non-operative treatment for these patients seems to result in unsatisfactory functional outcome and unacceptably high mortality rates [4, 27, 28]. However, for some poorly functioning or medically unstable elderly patients and both-column fractures with secondary congruence, non-operative management with early mobilization may be appropriate [29]. Helfet et al. reported non-operative management of geriatric patients aged 60 or older with satisfactory results up to 80–94% in their study [30]. Delayed total hip replacement can always be considered if painful post-traumatic arthritis develops. Non-operative treatment should involve mobilization with limited weight bearing. Bed rest and traction should be avoided.

One major disadvantage of ORIF is the long duration of postoperative weight-bearing restriction (up to 12 weeks) [4, 12]. This restriction can lead to prolonged immobilization, with increased risk of deep vein thrombosis, pneumonia, and permanent loss of mobility. Elderly patients do not tolerate weight-bearing restrictions, and this also leads to long nursing home stays. ORIF is also associated with high rate of mortality (up to 70%) [31], as well as decreased likelihood (45%) of obtaining an anatomical reduction with surgery in geriatric patients [4]. In a large series of patients with operatively treated acetabular fractures, Tannast et al. reported 21%

conversion rate of ORIF to THA within 20 years [11], and a high rate of conversion to THA (as much as 31%) exists in older patients with acetabular fractures [6••, 9, 20, 21].

Arthroplasty

There are two main reconstructive arthroplasty options: acute (early) and delayed (late) total hip arthroplasty [26]. Acute or early THA refers to performing THA as a definitive treatment during the acute fracture setting where ORIF would predictably lead to a poor clinical outcome [32, 33]. Acute THA may require concomitant ORIF to stabilize the pelvis and allow for acetabular component stability. Delayed or late THA refers to performing THA for the treatment of post-traumatic arthritis after non-operative or operative management. Many challenges associated with THA after acetabular fractures include pelvic deformity, acetabular bone loss, risk of nerve injury, and difficulty in achieving acetabular component stability [7, 33–35]. Several risk factors for early failure for arthroplasty have been identified including male sex, age younger than 50 years, and large acetabular bone defects [3, 7, 13].

There have been multiple surgical techniques described for both acute and delayed arthroplasty: single versus multiple incisions and variety of surgical approaches from anterolateral, lateral, trans-trochanteric, posterolateral, Kocher-Langenbeck, and modified anterior approach [1, 12, 18, 26, 33, 35–37]. Despite wide variations in surgical techniques, no significant difference has been found in clinical outcomes or in complication rates due to surgical approach [26, 33]. The surgical approach is usually influenced by soft tissue integrity, previous surgical scars, and familiarity/preference of the operating surgeon.

Despite historic data on increased complications with arthroplasty in patients with acetabular fractures, Makridis et al. found comparable complication rates to data reported in primary THA, except for the overall infection rate of 5.6% [26].

Summaries of clinical outcomes of latest literature of acute THA and delayed THA are outlined in Tables 1 and 2.

Acute Total Hip Arthroplasty

While clear indications for acute total hip have not materialized, surgeons choose this option in the setting of severe comminution with fracture patterns unamendable to anatomic reduction/fixation, significant displacement, prolonged hip dislocation, severe impaction injuries of acetabulum and/or femoral head, and pre-existing degenerative arthritis, [9, 19••, 33, 38, 39]. In a systematic review of literature, Makridis et al. reported up to 36% of the patients with acetabular fractures that underwent acute THA with average median interval of 10 days from initial

Table 1 Outcomes of acute total hip arthroplasty published within the past 5 years

Study	Number of patients	Mean age (range)	Mean duration of follow up (range)	10-year survival rate	Mean functional scores	Cause for revision	Infection rate	Dislocation rate	Comments
Boelch et al. (2016)	9	80 (63–90)	4.5 months (2.5–9.5 months)	N/A	N/A	Instability [1], Aseptic acetabular loosening [1]	0%	0%	Short follow up (mean of 4.5 months) Used anti-protrusion cage
Chakravarty et al. (2013)	19	77 (57–90)	22 mo (2–80 months)	N/A	N/A	None	5%	5%	Percutaneous column fixation
Enocson et al. (2014)	15	75.5 (63–84)	4 years	N/A	87.6 (67–100) on HHS	None	0%	0%	Anti-protrusion cage
Herscovici	22	75.3 (60–95)	2.4 years (1–5.6)	N/A	78.6 (42–86) on HHS	Aseptic acetabular loosening [4]	5%	5%	
Lin et al. (2014)	33	60	3.9 years	94%	17 [12–32]on OHS	Aseptic acetabular loosening [1]	4%	4%	Inconsistent follow up ranging from 1 to 14 years
Malhotra et al. (2013)	15	64.5 (57–69)	6.8 years (1.2–10)	N/A	91.1 (72–97)on HHS	None	13%	7%	Used cage construct
Rickman et al. (2014)	24	77 (63–90)	2 years (8–38 months)	N/A	N/A	None	4%	0%	Short follow up
Salama et al. (2016)	18	66 (35–81)	21.7 months(12–36 months)	N/A	93 (80–100)	None	0%	0%	Short follow up
Solomon et al. (2015)	11	81 (76–87)	2 years	N/A	N/A	None	0%	0%	Short follow up

Table 2 Outcomes of delayed total hip arthroplasty of research published within the past 5 years

Study	Number of patients	Mean age (range)	Mean duration of follow up (range)	10-year survival rate	Mean functional scores	Cause for revision	Infection rate	Dislocation rate	Comments
Chiu et al. (2014)	56	52 (18–81)	10 years (5–15)	87%	N/A	Aseptic acetabular component loosening [6••]	5%	0%	All patients were previously treated with ORIF fx, porous metal cup was used in eight patients
Dunet et al. (2013)	25	41 (16–90)	6.8 years (0.25–11)	N/A	N/A	N/A	N/A	N/A	
Kamath et al. (2013)	12	57 (24–88)	20 months	N/A	79 on WOMAC and 5.25 UCLA	Aseptic acetabular component loosening [1]	0%	0%	Porous metal cups in all patients
Khurana et al. (2015)	62	58 (31–90)	4.3 years (4 months-10.5 years)	N/A	81.3 (34.1–100.1) on HHS	Infection [2] Dislocation [1] Dissociation of acetabular lining [1]	6%	3%	Combined proximal femur fx (41, 65%) and acetabular fx (22, 35%)
Lai et al. (2011)	31	51 (42–60)	6.3 years (3.1–8.4)	100% at 6.3 year follow up	89 (84–94) on HHS	None	0%	6%	
Lizaur-Utrilla et al. (2012)	24	56.4 (28–77)	8.4 (5–15)	89.7% at 12 years (cup only)	77 (45–94) on HHS	Infection [1] Aseptic acetabular loosening [3], aseptic femoral component loosening [1]	4%	0%	
Morison et al. (2016)	74	51 (25–75)	8 years (2–23)	78%	N/A	Aseptic acetabular component loosening [13], instability [8], infection [2], periprosthetic femur fx [1], aseptic femoral component loosening [1], recurrent dislocation [1]	7%	11%	Previous ORIF 58 (78%), Previous non-op 16 (22%)
Schnaser et al. (2014)	17	69 (60–81)	6 years	N/A	70 on HHS (19–95)	Symptomatic hardware [1], instability [1]	0%	12%	
von Roth et al. (2015)	25	79 (56–99	20 (3–42)	87% (10 years) 57% (20 years)	80 (51–100) on HHS	Aseptic acetabular/femoral component loosening [19••], osteolysis [7], instability [1]	0%	0%	
Yuan et al. (2014)	30	45 (23–75)	5 years (2–11)	N/A	82 (21–100) on HHS	Infection [5]	11%	7%	5-year survival rate of 88%, porous metal cup used in all patients
Zhang et al. (2011)	53	46.6 (22–65)	5.3 years (2.7–10.3)	N/A	90.1 (56–100) on HHS	Aseptic acetabular component loosening [1]	0%	2%	5-year survival rate of 100%

injury [26]. The advantages of acute THA are earlier mobility and rehabilitation and decreased soft tissue-related complications by the single surgical setting [10•, 12]. Several studies reported encouraging radiographic outcomes, improved functional scores, low complication rates, and acceptable survivorship, despite greater blood loss and increased operative time [40–43]. The midterm 10-year survivorships of both acetabular (81%) and femoral components (95%) of acute THA were found to be superior to that of delayed THA (76 and 85%, respectively). The reason for such outcome is not clear; however, this may be due to the delayed THA studies having longer follow-up duration, as well as inclusion of studies that used cemented acetabular components, which were found to have a risk factor for early component loosening [1, 7].

The surgical goal of acute total hip replacement is to obtain a stable, rigid construct of the acetabular bone stock for acetabular cup placement. A stable cup will allow fracture healing and long-term stability of the component [19••, 26, 33]. However, fracture comminution and pre-existing osteoporosis can make it very difficult to obtain adequate fixation at the fracture site for THA components [32, 43], which can lead to component loosening and early revisions.

There have been numerous surgical techniques described over the years, including cerclage cable fixation around anterior column and quadrilateral plate [32, 38], combined ORIF and THA [10•, 41, 43, 44], limited percutaneous fixation followed by THA [32, 40], and cup-cage/anti-protrusion cage reconstruction [12, 36••, 42, 45].

There is a growing popularity of using more ORIF and percutaneous techniques for fixation of the acetabular fracture [10•, 41, 43, 44]. Authors attribute this to improved surgical instruments and modern fracture fixation techniques [10•, 41, 43, 44].

We have identified nine recent studies on acute THA (both retrospective and prospective) in English literature (Table 1) [10•, 12, 36••, 40–45]. Most of the follow-up periods in these studies were relatively short ranging from 2 months to 10 years, and only five studies reported functional outcomes in their patients. In addition, there was a large heterogeneity of results and outcomes reported, and the cohorts studied in these studies were small with a mean of 19 patients (range 9–24) in each study. Three studies showed excellent functional outcomes in Harris Hip scores (mean of 90), which is comparable to outcomes in primary THA [10•, 42, 45]. Two of these studies (Malhotra et al. and Enocson et al.) were able to achieve excellent mean HHS (93 and 87.6, respectively), by using cup-cage constructs [42, 45].

Overall, these studies have excellent short-term follow up with only 7 revisions out of 166 patients (4%). Six revisions were performed due to aseptic acetabular loosening and one revision was performed due to persistent instability. These studies also reported low complications with an infection rate of 4% and a dislocation rate of 2% (Table 1).

Delayed/Late Total Hip Arthroplasty

The difficulties associated with delayed THA for the salvage of failed surgical fixation of acetabular fractures include the presence of previous approaches, soft tissue scarring, impaired vascularity, bone deficiency, retained orthopedic implants, heterotopic ossification, presence of acetabular non-union or malunion, and risk of undetected deep infection [10•, 13, 19••, 33, 44]. Others reported adverse perioperative parameters such as, increased blood loss, operative, and transfusion rates when compared to primary total hip arthroplasty [7, 18, 35, 37, 46]. Many authors agree that these cases should be treated similar to a revision total hip arthroplasty by a surgeon who is familiar with both trauma reconstruction and complex revision hip arthroplasty [3, 18, 19••, 41]. Winemaker et al. reported a deep infection rate of 3.8%, superficial infection rate of 4.5%, periprosthetic fracture rate of 6.2%, dislocation rate of 11.4, early implant failure rate of 1.5%, and early revision rate of 10.9% [47]. Such high complication rates following conversion to THA reflect the complexity and challenges of surgery in this group of patients.

In patients with operatively treated fractures, the treating surgeon should be mindful of pre-existing/quiescent deep infection, and infection work up should be initiated by ordering laboratory work up (erythrocyte sedimentation rate and C-reactive protein). Hip aspiration should be ordered if these lab values are elevated and/or in the setting of rapidly progressing post-traumatic arthritis [19••, 33]. There should be a low threshold for staged total hip arthroplasty if the infectious work up is positive, and definitive hip implants should not be placed until the infection is eradicated with a course of intravenous antibiotic therapy (guided by intraoperative cultures) and placement of antibiotic spacer [33, 37].

Intraoperatively, placement of acetabular component within the safe zone [48, 49] is challenging due to distorted anatomy, bone deficiency, and pelvic deformity, and pre-operative templating should be utilized to help the surgeon to identify the true acetabulum [37]. If there is a large acetabular bone loss (either cavitary or segmental), femoral head can be used as an autograft to augment the defect, and good outcomes from this technique have been reported [1, 26, 33, 37]. In addition, anatomical landmarks such as the transverse acetabular ligament may be distorted or absent due to previous injury or surgical procedure, and intraoperative x-ray may be helpful to confirm appropriate positioning of the cup [33]. Furthermore, suboptimal component positioning, soft tissue impingement, and previous soft tissue disruption can lead to instability. Dual mobility cups may be appropriate for complex cases where intraoperative stability is difficult to achieve [33].

Previous orthopedic implants may interfere with acetabular reaming or component fixation, and these metal screws or plates can be selectively removed by high-speed burrs without performing extensive dissection [22, 26, 35]. Appropriate initial ORIF allows for restoration of columns of the acetabulum to permit easier placement of an acetabular component (Fig. 1).

Early experiences with delayed THA using cemented cups resulted in unacceptably high rates of acetabular component loosening, possibly due to sclerotic bone bed in the acetabulum after previous acetabular fractures [22, 37, 50]. Berry et al. also attributed early failure of cemented cups due to relatively younger age of the patients undergoing THA [34]. Fortunately, recent studies of cementless fixation for acetabular components with multiple screws have demonstrated superior outcomes to cemented cups with reduced rates of mechanical failure [21, 34, 35, 37]. Clinical outcomes and the Kaplan-Meier survival rate reported by Bellabarba et al. (97% 10-year survival rate and mean of 88 on HHS) and Ranawat et al. (97% 5-year survival rate and mean of 82 on HHS) are the best results to date [35, 37].

We have identified 11 recent studies on delayed THA (both retrospective and prospective) from the English Literature (Table 2) [3, 13, 18, 20, 21, 50–55]. Compared to the acute THA studies, these studies had longer duration of follow ups and larger number of patients (166 vs. 409) (Table 2). Eight out of 11 studies included functional outcomes and 7 out of 11 studies included short- to mid-term survivorship of the hip implants. In particular, von Roth et al. reported a 20-year follow up study from Weber et al. study on delayed THA using cemented acetabular component and reported 57% survivorship [7, 20].

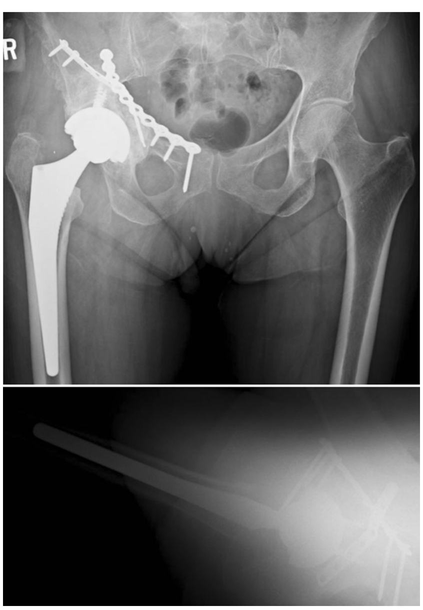

Fig. 1 AP and lateral radiographs are shown of a total hip performed after anterior acetabular fracture fixation. The hip was replayed in a delayed fashion after the fracture had healed. This restored the anterior bone stock. The plate and screws were left in situ during hip replacement and uncemented components were used

Multiple studies found no difference in survivorship and complication rates between the patients who was initially treated non-operatively versus those who were treated with ORIF [3, 18, 26, 50]. The implant survivorship (76–90% at mid-term) and the functional outcome scores (mean of 81 on HHS) were overall slightly inferior to matched cohorts. The patients with previous ORIF often required a larger exposure than did standard THA with more soft tissue scarring, worse bone quality secondary to prolonged disuse/immobilization of the affected extremity, often with loss of bone stock, retained hardware, and muscle weakness [3, 13, 18, 21]. These reasons may have contributed to poor functional and clinical outcomes observed when compared with primary THAs. In the identified 11 delayed THA studies, we found an infection rate of 4% and a revision rate of 19% which is comparable to the results found by a recent systematic review [26].

The usage of porous metal surface has shown promising results with better osteointegration and low rate of aseptic loosening compared to standard uncemented acetabular fixation [13, 21, 54, 56]. Yuan et al. reported 88% 5-year survivorship and Chiu et al. reported 87% 10-year survivorship using porous metal acetabular components [13, 21]. However, the authors also noted high rate of radiographic lucencies around the acetabular components [21, 54].

Conclusions

Due to prevalent osteoporosis, articular damage, surface comminution, and high risk for osteonecrosis and development of post-traumatic arthritis, surgical management of geriatric acetabular fractures remains a challenge for treating surgeons. The objective goal with an elderly patient with this injury should be to create a stable and painless hip that allows for early mobilization.

Treatment options include non-operative treatment, ORIF, and THA with either delayed or acute or combined ORIF/THA options. Reconstructive surgeries are often met with challenges such as bone loss, distorted anatomy, and higher rate of failure compared to non-traumatic arthritic patients undergoing THA. Recent studies in acute and delayed THA show promising results and favorable outcomes for the geriatric acetabular fracture patients.

Compliance with Ethical Standards

Conflict of Interest Simon Mears and Kwan Park declare no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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