Should Total Hip Arthroplasty be Performed Acutely in the Treatment of Acetabular Fractures in Elderly or Used as a Salvage Procedure Only?

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Abstract

Background: Total hip arthroplasty (THA) is now an increasingly common procedure for people sustaining acetabular fractures. The incidence of acetabular fractures among the elderly population is increasing, and contemporary treatment aims to avoid the risks of prolonged incumbency associated with poor bone stock for fixation or inability to comply with limited weightbearing in this patient group. The concept of acute hip arthroplasty as a treatment for acetabular fracture is, therefore, becoming more topical and relevant. Our systematic review investigates whether THAs for acetabular fractures should be performed acutely, with a short delay, or as a late procedure for posttraumatic osteoarthritis (PTOA) if it develops. **Materials and Methods:** Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines were followed when undertaking this systematic review. Detailed searches were performed on three different databases, using keywords, such as "acetabular fracture," "acetabular trauma," "total hip arthroplasty," "hip arthroplasty," and "hip prosthesis." Studies from 1975 to September 2016 were included in the study. All studies included in the review were independently critically appraised by two of the authors. **Results:** Forty three studies were included in this review. Only two of them actually compared acute and delayed THAs for acetabular fractures with the rest focusing on one or the other. Results were comparable between acute and late THAs in terms of aseptic loosening, operative time, blood loss, Harris Hip Score, and ability to mobilize postoperatively without aid. Complication rates, however, were much higher in the acute group. **Conclusion:** Evidence based on this topic is scarce and therefore we have to be cautious about drawing a definitive conclusion. The findings of this systematic review do suggest, however, that acute THAs should be considered in elderly patients, where fixation is not possible, or when their health and ability to rehabilitate are poor. It should also be considered in patients where PTOA is very likely, or where there is already some preexisting degenerative osteoarthritis.

Keywords: *Acetabular fracture, elderly, posttraumatic osteoarthritis, total hip arthroplasty*
MeSH terms: *Fracture fixation, osteoarthritis, hip, arthroplasty, replacement, acetabulum*

Introduction

The incidence of acetabular fractures among the elderly is increasing with a 2.4-fold rise from 1997 to 2007.[1] Fragility fractures resulting from a fall from standing height account for 60.6% in this age group.[2] As the average age of those sustaining acetabular fractures is increasing, so is the potential role of total hip arthroplasty (THA) as a treatment method. Undisplaced fractures are commonly treated conservatively and equally, open reduction and internal fixation (ORIF) remains the gold standard for the young active population [Table 1]. However, for the older population, in a bid to avoid the risks of prolonged incumbency and inability to comply with limited weightbearing, should we follow in the footsteps of fracture neck of femur surgery and plan for one definitive procedure allowing the patient to be mobilized immediately postoperatively with confidence?

Late THA is the accepted salvage procedure for posttraumatic osteoarthritis (PTOA), avascular necrosis of the femoral head, or fixation failure.[8,18] There is a bimodal distribution for this indication with 67% being performed between 6 and 24 months post-ORIF, with a second peak after a delay of many years.[11,15,19] The incidence of PTOA following acetabular injury ranges from 12 to 57%.[6,8,20,21] Laird and Keating[3] report a significant decline in the decade up to 2003, with incidence falling from 31% to 14%. Rates of conversion to salvage THA following initial conservative management or fixation range from 6% to

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Table 1: Indications for different types of management

Nonoperative[3-5]	Fixation[6-9]	THA[5,10-17]
Comorbidity of severity to exclude surgical options	Displacement >5 mm	Absolute
Fractures which are minimally displaced <3 mm	Incongruity	Femoral head impaction
Fractures not involving the weight-bearing dome	Instability of the hip joint	Acetabular impaction – especially. If >40%
45° roof arc intact	Incarcerated fragments <15 days delay	Inability to adequately reduce fracture
10 mm subchondral CT arc intact		Intraarticular comminution
Small anterior or posterior wall fragment <20%-45% of posterior wall displaced		Full-thickness abrasive loss of the articular cartilage
Low anterior column fractures		Displaced fracture of the femoral neck or fracture of femoral head
Low transverse fractures		Loss of joint congruity
Both column fractures with secondary congruence		Osteopenia or osteoporosis
Nonambulatory		Preexisting severe osteoarthritis or AVN
Severe osteopenia		Pathological
Stable hip		Relative
		Delayed presentation
		High-risk fracture types; t-type, posterior column/posterior wall, and transverse posterior wall
		Comorbidities
		Obesity
		Advanced age
		Somatosensory, neurologic, or psychiatric impairment

AVS=Avascular necrosis, THA=Total hip arthroplasty, CT=Computed tomography

35%.[2,3,5,6,8,10,11,20,22,23] Predictive factors for the development of PTOA, conversion to THA and poor performance following THA, are shown in Table 2.[3,5,8,11,19]

Acute THA is being more frequently performed, particularly in older patients with fractures at high risk of developing PTOA, or in whom fixation would be insufficient to allow early mobilization. The advantages of acute THA include early mobility to avoid the high risks associated with the prolonged incumbency, smaller approaches, as the acetabulum is exposed by removing the femoral head, and nonanatomic reduction being more acceptable. It also precludes secondary surgery for PTOA.[17,24] However, some have reported high complication and revision rates with THA as an acute treatment.

Delayed THA can be necessary in polytrauma patients, where other injuries take precedence, or in patients with comorbidities that require optimization. Some advocate an initial period of bed rest, followed by a THA, in the hope that this may provide more stability and cause fewer complications.

Our review sets out to investigate if THA should be performed as a treatment for acetabular fracture; acutely – within 3 weeks of injury, delayed – more than 3 weeks but before union or late – for PTOA.

Materials and Methods

Population, Intervention, Comparison, Outcomes

Our systematic review followed Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines,[25] with the review question designed according to the Population, Intervention, Comparison, Outcomes (PICO) method. Our review focused on patients with acetabular fractures (population), who underwent an acute THA (intervention), as compared to a late THA (comparison). Our outcomes included revision rates, functional outcomes (e.g., Harris Hip Score [HHS]), operation time, blood loss, and complications (including mortality).

Literature searches

Literature searches were performed on three databases: Medline, EMBASE, and Cochrane Library. An extensive search strategy was used for each database. Search keywords included "acetabular fracture," "acetabular trauma," "cemented total hip arthroplasty," "uncemented total hip arthroplasty," "hip prosthesis," and "hip arthroplasty." Truncation symbols were used where appropriate. The search period extended from January 1975 to September 2016. Searches were independently performed by authors KH and GL, who also independently selected articles to be included in the systematic review. Any differences in opinion were resolved through discussion with the senior

Table 2: Factors predicting development of posttraumatic osteoarthritis and conversion to total hip arthroplasty following acetabular fracture

PTOA	Conversion to THA		Poor prognostic factors for late THA
	Significant	Factors not significant	
Cartilaginous damage	Nonanatomic reduction	Age	Age under 60
Nonanatomical fracture reduction	Transverse fracture patterns	Sex	Deformity or major bone loss
Hip instability	Posterior involvement due to high comminution	BMI	Failure to restore the anatomic center of rotation
Age over 40	Hip dislocation	Etiology	Sclerotic bone as a consequence of PTOA giving a poor bed for implantation
Anterior hip dislocation	Poor congruence at anterior and posterior walls	Associated injuries	Poor bone quality due to age-related changes or immobility
Posterior acetabular wall involvement	Interposed hardware, acetabular nonunion, and incarcerated fragments	Roof congruence	Complications from previous instrumentation
Acetabular impaction	Nonanatomic restoration of the hip center	Time to surgery	Soft tissue scarring
Presence of the seagull sign	Infection		Retained metalwork
Initial displacement >20 mm	AVNFH		Infection
Utilizing the extended iliofemoral approach	Contralateral THA		Contractures
Delay to fixation – longer than 10-15 days increases the risk of osteonecrosis of the femoral head and HO	Fixation versus functional treatment		HO
			AVN of the femoral head or the acetabulum
			Weight >80 kg

THA=Total hip arthroplasty, AVNFH=Avascular necrosis of the femoral head, PTOA=Posttraumatic osteoarthritis, HO=Heterotopic ossification, AVS=Avascular necrosis

clinician having the final say regarding inclusion in the event of any disagreement. We also reviewed review articles for potentially relevant papers and hand-searched journals for any studies that may fit our inclusion criteria.

Inclusion and exclusion criteria

Papers in English, published between 1975 and 2016, that fit our PICO criteria, were included in the study. Both retrospective and prospective studies were included in the study.

Papers other than in English language were excluded from the study. Studies that focused primarily on ORIF of the acetabulum were also excluded from the study. Papers that we could not access online, by hand-searching journals or via libraries, were excluded from the study.

Data extraction

Data extraction from selected studies was performed by KH using a uniform template, which included details on the population, intervention, comparisons, and outcomes. This was then used to generate a cumulative table with details of findings to ensure systematic reporting of the results.

Risk of bias assessment

As most studies were predicted to be nonrandomized, the Quality Assessment Tool for Observational Cohort and Cross-sectional Studies by National Heart, Lung, and Blood Institute was used.[26] This quality assessment tool contains 14 questions that facilitate the risk of bias assessment for any nonrandomized study. Each paper included in the review was quality assessed by KH and GL, to give an overall ranking of "good," "fair," or "poor."

Results

Study selection

Our search strategy yielded 209 papers on Medline, 131 on EMBASE, and none on Cochrane Library. Seventeen were duplicated and had to be excluded in the initial stages. Titles were then scanned to identify relevant articles for abstract review and subsequently, for full-text review. Forty seven papers were reviewed in full by GL and KH. Four of these had to be excluded: one paper had to be excluded because it was a reply letter, two – because they were both review articles, and another paper was found to be irrelevant after the full-text review. A total of 43 studies were then included in our systematic review. The PRISMA flow diagram[25] can be seen in Figure 1.

Risk of bias assessment

All 43 studies included in the review were independently quality assessed by GL and KH, as described in the methods section. Table 3 summarizes the outcome of the risk of bias assessment, with positive and negative

Table 3: Quality assessment of studies included in the review

Study	Quality rating	Comments, if applicable
Beaulé *et al*.[27]	Good	
Bellabarba *et al*.[28]	Good	
Berry and Halasy[29]	Good	
Boardman and Charnley[7]	Fair	Research question not defined explicitly
Boraiah *et al*.[30]	Good	
Bronsema *et al*.[31]	Good	A substantial followup period of 18 years
Chakravarty *et al*.[32]	Good	
Chana-Rodríguez *et al*.[33]	Good	
Chémaly *et al*.[34]	Good	Confounding factors clearly described
Enocson and Blomfeldt[35]	Good	
Flóris *et al*.[36]	Fair	HHS only, no radiological evaluation
Halawa and Sadek[37]	Fair	Short followup for some (6 months)
Herscovici *et al*.[38]	Good	
Huang *et al*.[39]	Good	
Huo *et al*.[40]	Good	
Iotov *et al*.[41]	Fair	Small sample size
Kamath *et al*.[42]	Good	
Lai *et al*.[43]	Good	
Lin *et al*.[44]	Fair	Lack of radiological followup
Liu *et al*.[45]	Good	
Lizaur-Utrilla *et al*.[46]	Good	Independent observers, two cohorts
Malhotra *et al*.[47]	Good	
Mears and Velyvis[13]	Good	A substantial followup period of 12 years
Morison *et al*.[48]	Good	Matched case–control and blinded outcome assessors
Mouhsine *et al*.[49]	Fair	HHS not used, methods not described in detail
Mouhsine *et al*.[50]	Fair	Methods not described in detail
Pritchett *et al*.[51]	Good	
Ranawat *et al*.[19]	Good	Independent evaluators, comparisons between groups
Rickman *et al*.[12]	Good	
Romness and Lewallen[21]	Fair	No functional outcomes, no clear explanation as to who assessed the outcomes and how
Sarkar *et al*.[52]	Fair	40% lost to followup
Sarkar *et al*.[17]	Fair	47% lost to followup, no radiological followup
Schnaser *et al*.[53]	Good	Control group, assessors trained providers that were not directly involved in the care
Schreurs *et al*.[54]	Good	
Sermon *et al*.[55]	Good	Two groups
Simko *et al*.[18]	Fair	Outcome measures not extensively defined
Solomon *et al*.[56]	Good	
Strauss[57]	Poor	Not enough information in methods to draw conclusions, small participant size, and not explained how selected
Tidermark *et al*.[58]	Fair	30% lost to followup
von Roth *et al*.[59]	Good	
Weber and Berry[60]	Good	A substantial followup period of 10 years
Yuan *et al*.[61]	Good	Independent assessors
Zhang *et al*.[62]	Good	

HHS=Harris Hip Score

comments where appropriate. In general, most studies were of good quality, with fairly low risk of bias, considering they were not randomized studies. Some had poorer quality, usually due to the fact that methods were not sufficiently explained to award them a low risk of bias rating. The original detailed quality assessment (rather than the overall quality rating) can be made available for each of the studies upon request.

Acute versus late total hip arthroplasty

Sermon *et al*.[55] and Chémaly *et al*.[34] are the only authors to directly compare acute and late THA. Their findings are summarized below.

Age

Sermon *et al*.[55] reported the only significant difference they found was the age of the patients, with the THA for

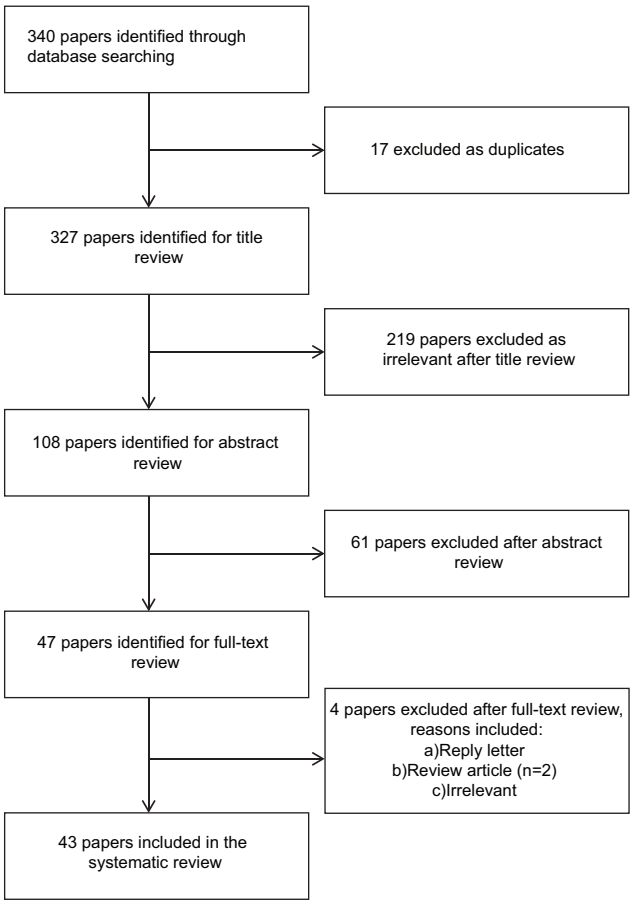

Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-analyses flow diagram

PTOA group being younger individuals, with a mean age of 53 years compared to 78 years.

Revision

Sermon *et al*.[55] reported revision rates of 21% in their late group and 8% in the acute group; however, this was not statistically significant. Chémaly *et al*.[34] did not have any patients in either group who required revision.

Functional scores

Sermon *et al*.[55] reported HHS 76% good or excellent in the late group versus 58% in the acute group, which did not reach significance. Chémaly *et al*.[34] only reported functional scores for those in the acute group, as it related to poor functional status with Brooker Grade 3 heterotopic ossification (HO). Only 43% had good or excellent scores compared to 88% of those with grade 0–2. They found HO occurred eight times more in the acute group; however, in Sermon *et al*.'s[55] work, HO occurrence was 76% in the late group and 28% in the acute group and the two groups were not significantly different.

Complication rate

Chémaly *et al*.[34] had a complication rate of 25% in the acute group and 15% in the late group, but this was not analyzed statistically. Sermon *et al*.[55] reported a 25% overall complication rate but did not divide this between the two groups.

Blood loss and operating time

Chémaly *et al*.[34] found more than double the blood loss (992 ml vs. 416 ml) and operating time (171 min vs. 76 min) in the acute group. Sermon *et al*.[55] did not report on these outcomes.

Acute total hip arthroplasty

Acute THA does not have a large evidence base. Around 300 cases are reported by the papers in our review, and more than 70% of the papers we found had less than twenty patients and 5-year followup. The results for each study can be seen in Table 4.

Revision

Aseptic loosening of the acetabular component has classically been the concern with regard to performing an acute THA for acetabular fracture. Across the papers, we reviewed revision for aseptic loosening occurred at a rate of 2.3% (range 0%–10%) albeit with a mean followup of only 53.7 months (range 18–81.5 months).

Functional scores

Functional outcomes were varied. The average HHS was 87 (range 42–99), but the proportion of good and excellent results varied from 100% to just 60%. Postoperatively, 74% of patients were mobile without walking aids or had returned to their preinjury status.

Complication rate

The overall complication rate was 20.1% ranging from no complications to 59%. The complications for each paper are shown in Table 5. The mean mortality was 9%, with some authors reporting no deaths and the highest 58% at 3 years, with 26% in the first year.[32]

Blood loss and operating time

These cases are technically demanding with an average operative time of 174 min (range 45–510 min) and blood loss of 964 ml (range 200–5000 ml).

Cemented versus uncemented

The results comparing cemented with uncemented are shown in Table 6. The two groups are comparable, with the notable exception being complication rate, which is 40% in the cemented group and 16% in uncemented; and mortality, which is 11% in the cemented group and 2.4% in the uncemented.

Delayed

Delayed THA is performed more than 3 weeks from injury but before union. The published evidence is very limited – our search only found two abstracts from meeting

Table 4: Results from Acute THA studies

Variable	Mixed						Cemented			Uncemented									Total
	Herscovici *et al.* 2010[26]	Sarkar *et al.* 2004[17]	Chakravarty *et al.*[29]	Simko *et al.* 2006[27]	Lin *et al.*[31]	Strauss *et al.* 2004	Tidermark *et al.* 2003[25]	Mousine *et al.*[33]	Enocson *et al.*[30]	Malhotra *et al.* 2013[24]	Boraiah *et al.*[32]	Rickman *et al.* 2012[3]	Beaule *et al.*[34]	Mears and Velyvis 2002[13]	Mouhsine *et al.* 2004	Chana-Rodriquez *et al.* 2012	Soloman *et al.* 2012	Chemalay *et al.* 2015	All studies
N	22	35	19	10	33	11	10	12	15	15	18	12	10	57	18	6	11	20	334
Av age	75.3	74	77	71	66.2	NR	73	79	75.5	64.5	71	75	61	69	76	77	81	60	71.3
Age range	60-95	41-91	57-90	60-83	47-92	67-78	57-87	65-93	63-84	57-69	55-86	63-90	50-85	26-89	65-93	70-85	72-87	NR	26-95
FU (m)	29.4	72	22	36	67	NR	38	24	48	81.5	47	18	36	97	36	24+	18	31.2	53.7
RAC%	20	42	NR	0	6	0	0	0	0	0	5.5	0	0	1.8	0	0	0	0	7.3
AS	10	5.7	NR	0	6	0	0	0	0	0	5.5	0	0	0	0	0	0	0	2.3
Op time (m)	232	100	231	100	200	300	159	120-180	149	135	NR	200	180	NR	165	NR	NR	171	174
Blood L.(ml)	1163	NR	700	1000	852	3 U	1100	NR	665	835	NR	1233	1060	NR	NL	NR	NR	992	964
HHS	82.6	NR	NR	NR	NR	NR	85	NR	88	91.1	88	NR	NR	70/87	NR	NR	NR	NR	87
G/Ex (%)	NR	NR	NR	100	84.8	NR	60	100	NR	87	81	NR	NR	79	100	83	NR	NR	94%
CR (%)	59	17	42	0	15	9	NR	NR	40	33	5.5	8	20	10.5	5.6	16.6	18	25	20.1%
LOS (d)	8.1	16	13/40	NR	NR	NR	NR	10	NR	NR	NR	19	NR	NR	13	NR	17	NR	15.4
Mobility (%)	NR	NR	NR	100	NR	12.5	80	91	53	66	NR	100	NR	NR	83	100	NR	NR	74
Mortality (%)	0	9	58	0	18	27.2	0	0	27	0	0	8.3	0	0	5.6	0	9	5	9.3
Stability	ORIF	ORIF/roof rings	Screws only	Cage ORIF	Screw in cup	Cage + screws	Ring Screws Without red	cables	Ring/ cage	Octopus ring	orif	ORIF	ORIF	Cables Screws Cup as plate	cables	Cage + screws	Cup cage	+ orif	
HO	1-2	NR	4 (no class)	1-2	1-5	0	1/2-4	1-3	1-1	1-0	1-0	NR	1-0	1-2	1-6	1-0	NR	1-2	Overall 20%
	2-1			2-0	2-1		3-0	2-0	2 –2	2-2	2-0		2-1	2-3	2-0	2-1		2-2	1-9.7%
	3-0			3-0	3-3		4-0	3-0	3-1	3-0	3-1		3-0	3-0	3-0	3-0		3-8	2-4.7%
	4-1			4-0	4-0			4-0	4-0	4-0	4-0		4-0	4-1	4-0	4-0		4-0	3-4.7%
																			4-0.7%

N=Number of participants, FU=Average follow up period in months, RAC=Revision any cause, AS=Revision for aseptic loosening, HHS=Harris Hip Score, CR=complication rates, LOS=Length of stay in days, G/Ex = % of patients achieveing good or excellent functional outcomes, HO=Heterotopic Ossification by Brooker Grade, NR=Not reported, Av=Average, Op=Operation

Table 5: Complication incidence by study

Study	Dis	Nerve	VTE	Vessel	Superficial infection	Deep infection	Fracture
Beaulé *et al*.[27]	1	-	-	-	-	-	-
Bellabarba *et al*.[28]	0	-	-	-	-	0	-
Berry and Halasy[29]	1	-	-	-	1	-	3 (femoral)
Boardman and Charnley[7]	-	-	6	-	1	-	-
Boraiah *et al*.[30]	-	1	-	-	1	-	-
Bronsema *et al*.[31]	-	-	-	-	-	-	-
Chakravarty *et al*.[32]	1	1	2	-	1	-	-
Chana-Rodríguez *et al*.[33]	1	-	-	-	-	-	-
Chémaly *et al*.[34]	1	-	-	-	0	0	-
Enocson and Blomfeldt[35]	0	1	1	-	-	0	0
Flóris *et al*.[36]	3	1	1	-	-	2	-
Halawa and Sadek[37]	-	-	-	-	-	-	-
Herscovici *et al*.[38]	3	0	-	-	0	0	-
Huang *et al*.[39]	-	1	-	-	-	2	-
Huo *et al*.[40]	1	1	-	-	-	-	1 (calcar)
Iotov *et al*.[41]	-	-	-	-	-	-	-
Kamath *et al*.[42]	-	-	-	-	-	-	-
Lai *et al*.[43]	2	1	1	-	-	-	-
Lin *et al*.[44]	1	0	0	-	1	1	-
Liu *et al*.[45]	1	1	1	-	-	-	-
Lizaur-Utrilla *et al*.[46]	6	-	-	-	-	1	-
Malhotra *et al*.[47]	1	1	-	-	2	-	-
Mears and Velyvis[13]	2	0	3	-	-	0	-
Morison *et al*.[48]	8	1	-	-	-	5	-
Mouhsine *et al*.[49]	1	0	-	0	0	0	0
Mouhsine *et al*.[50]	0	0	0	0	0	0	0
Pritchett and Bortel[51]	0	1	-	-	0	0	-
Ranawat *et al*.[19]	-	-	-	-	3	3	-
Rickman *et al*.[12]	0	0	0	-	1	0	1 (GT)
Romness and Lewallen[21]	-	-	-	-	-	-	-
Sarkar *et al*.[52]	4	-	-	-	-	-	-
Sarkar *et al*.[17]	2	-	-	-	1	2	-
Schnaser *et al*.[53]	2	-	3	-	1	-	-
Schreurs *et al*.[54]	0	-	-	-	-	-	-
Sermon *et al*.[55]	4	6	-	1	11	8	
Simko *et al*.[18]	-	-	-	-	-	-	-
Solomon *et al*.[56]	0	-	2	-	0	0	-
Strauss[57]	-	-	-	-	-	1	-
Tidermark *et al*.[58]	1	-	1	-	-	-	-
von Roth *et al*.[59]	0	-	-	-	-	0	-
Weber and Berry[60]	3	1	1	-	-	0	-
Yuan *et al*.[61]	-	0	-	-	0	0	1 (GT)
Zhang *et al*.[62]	1	3	-	-	-	0	-

Dis=Dislocation, VTE=Venous thromboembolism, GT=Greater Trochanter fracture only

presentations with this as their focus. Iotov *et al*.[41] only included patients with significant displacement, whereas Halawa and Sadek[37] also included patients who had had failed fixation – both of these factors may predispose to poorer results.

Revision

Halawa and Sadek[37] had three patients (7.9%) requiring revision due to uncoupling of metal–backed, cemented acetabular components, whereas Iotov *et al*.[41] report all-cause revision at 21.4% and for aseptic loosening – 14.3%.

Functional scores

The average HHS in Iotov *et al*.'s[41] patients was 78, improving from 54, whereas Halawa and Sadek[37] used the Merle d'Aubigne score, which improved in all the cases, from a range of 4/5 to 15/18.

Table 6: Comparison of results between cemented and uncemented total hip arthroplasty

Variable	Acute		Late	
	Cemented	Uncemented	Cemented	Uncemented
Av age	76.0	69.5	55.0	50.5
Followup (months)	37.5	58.6	120.2	75.4
RAC%	0.0	1.2	14.3	11.0
AS	0.0	0.6	11.1	5.7
Operation time (months)	152	168	NR	117.9
Blood loss (ml)	839	1013	NR	805.1
HHS	86.8	90	87.5	86.4
CR (%)	40	16.1	12.5	12.7
LOS (days)	10	16	NR	NR
Good/excellent (%)	81.8	84	NR	81.8
Mobility (%)	72.6	84	NR	42.2
Mortality (%)	10.9	2.4	15	3.2

AS=Revision for aseptic loosening, HHS=Harris Hip Score, NR=Not reported, LOS=Length of stay, CR=Complication rate, RAC=Revision any cause

Complication rate

Neither report gave details regarding complications. However, Chémaly *et al*.[34] did note in their report that the highest risk of heterotopic ossification occurred when THA was performed 2–8 weeks postinjury.

Blood loss and operating time

This is only reported by Iotov *et al*.[41] with blood loss between 850 and 2200 ml and operating time of 3–7 h.

Late

Late, THAs for acetabular fractures have historically performed poorly compared to THA for degenerative osteoarthritis (DOA), but they are improving over time. The results for all the studies are collated in Table 7.

Age

Revisions for loosening occur at double the rate in patients under 60 (17.2%) as opposed to those over 60 (7.7%).[21]

Revision

Across all papers, the average revision rate for any cause was 10.9% (range 0%–43%) and 6.9% (range 0%–25.3%) for aseptic loosening, with a mean followup of 6.3 years. The highest revision rates were in the earliest papers, and if studies published before 2000 are excluded the average is 5% for aseptic loosening, but similar for any-cause revision at 10.1%, with a mean followup of 6 years.

Functional scores

The average HHS was 86.7 (range 70–93), the proportion of good and excellent results varied from 54% to 94%. HHS correlated with age but not fracture pattern, previous treatment, or model of component.[46] Overall, 77% of patients were mobile with no walking aids.[7,29]

Complication rate

The complication rate was 13.8% overall, with the highest at 24%.[53] The complications for each paper are shown in Table 5. The mean mortality was 9%, with some authors reporting no deaths and the highest 55.5% at 20 years.[59]

Blood loss and operating time

The average operative time was 137.8 min (range 60–315 min) and blood loss was 768.9 ml (range 100–2900 ml).

Cemented versus uncemented

The results comparing cemented with uncemented are shown in Table 6. The two groups are comparable, with the notable exception of mortality, which is 15% in the cemented group and 3.2% in the uncemented group.

Initial management

Comparing the results following THA by their initial management, it has been found that previous fixation resulted in a longer index procedure and greater blood loss.[28,43] It was also noted that elevated acetabular liners were used more often, and the development of HO was twice as likely after previous fixation. Bone grafting was less common than in the conservative group in one study[28] and more common in another.[62] There was found no difference in HHS, radiographic stability, complication rates, acetabular nonunion, radiolucency or anatomic hip center reconstruction, clinical outcomes, loosening, or nonunion between different treatments.[19,28,43]

Post traumatic osteoarthritis versus degenerative osteoarthritis

Outcomes for THA performed for PTOA are worse than for DOA. The PTOA THAs had a longer operative time, higher blood loss, and complication rates.[28,53] Functional outcomes were comparable in Bellabarba *et al*.'s[28] series, but Schnaser[53] found they were significantly worse. The presence of radiolucent lines was significantly higher in the PTOA group than the DOA group; however, this did not affect the 10-year survival, which was similar with 97% in the PTOA and 99% in the DOA.[28] Morison

Table 7: Results from Late THA studies

Variable	Mixed								Cemented			Uncemented													Total
	Schnaser *et al.* 2014[39]	Sarkar *et al.* 2001[15]	Liu *et al* 2008	Flóris *et al.* 2013[41]	Von roth *et al.* 2015	Boardman and Charnley 197[89]	Weber *et al* 1998[42]	Zhang *et al.* 2011[46]	Romness and Lewallen 1990[36]	Schreurs *et al.* 2005[43]	Bronsema 2014	Huo *et al.* 1999[45]	Ranawat *et al.* 2009[35]	Berry and Halasy 2002[3r]	Huang *et al.* 2016 TM	Huang *et al.* 2016 tit	Lizaur-Utrilla *et al.* 201237	Chemaly *et al.* 2015	Belabarba *et al.* 2001[44]	Yuan *et al.* 2015	Pritchett and bortel 1991	Kamath *et al* 2013	Lai *et al.* 2011[40]	Morrison *et al.* 2016	All Studies
N	17	22	15	39	30	66	66→	55	55	20	20	21	32	34	39	44	24	20	30	30	19	12	31	74	785
Av age	72	44	48.2	45	52	55	52	46.6	56.2	53.3	53.3	52	52	49.7	47.3	45.4	56.4	60	51	45	49	57	51	51	51.2
Age range	60-94	20-74	36-72	25-73	19-80	24-77	19-80	22-65	19-91	35-75	35-75	23-78	20-87	19-78	22-70	NR	28-77	NR		23-75		24-88	27-74	25-75	19-94
FU (m)	77	72	51	31	240	42	115.2	64	87.6	114	216	65	56.4	143	58.4	58.4	100.8	28.8		60	24+	39	75.5	96	76.6
RAC%	6	22	0	5.1	43	0	26.9	1.8	15.6	10	15	5	21	13.6	5.1	0	16.7	0		12	0	0	0	30	10.9
AS%	0	8	0	0	29	0	25.3	1.8	13.7	5	10	0	3	7	0	0	NR	0	NR	0	0	0	0	23	6.9
RL%	NR	0	20	NR	3	14.3	13.6	0	52.9	35	25	19	0	0	0	6.8	13.1	NR	0	26-86	0	1	0	0	
OT	NR	NR	NR	NR	-	NR	170	NR	NR	NR	NR	97	NR	NR	NR	NR	81	76	179	63	NR	145	98-138	NR	137.8
BL	668	NR	NR	NR	-	NR	NR	NR	NR	NR	NR	960	718	NR	NR	NR	NR	416	898	3	NR	512	525-726	NR	768.9
HHS	70	NR	84	81	80	NR	93	90.1	NR	93	82	90	82	NR	91	90.1	77	NR	88	82	84	NR	89	NR	86.7
CR%	24	8	20	23.1	-	15	15.9	7.5	NR	0	25	NR	NR	14.7	7.6	9.1	NR	15	NR	20	0	8.3	13	17	13.8
TTA (y)	NR	3.1	20.2	NR	-	15	NR	NR	7.8	20	NR	NR	3	NR	6	6.5	3	NR	7.7	8.9	NR	1.6	5.58	8	
Mobility	NR	81	NR	NR	NR	93.7	NR	NR	NR	NR	NR	NR	NR	42.2	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	77
G/EX hhs	NR	35.1	NR	59	NR	92.3	NR	88.7	NR	NR	NR	90.4	81	NR	87.1	80	79.2	NR	90	54	NR	NR	94	NR	79.9
Cement	MIX	MIX	MIX	MIX	MIX	MIX	MIX	MIX	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	
Mortality	7.6	2.7	6.7	0	54.5	4.5	NR	0	NR	10	20	0	15.6	12.1	0	0	0	10	0	0	0	0	6.4	9%	4.8
HO	NR	1-0	3 (No class)	NR	NR	NR	1-15	1-7	NR	1-8	1-8	1-2	1-4	NR	1-3	1-7	1-1	1-2	1-5	1-0	NR	NR	1-12	1/2-30	Overall 24%
		2-0					2-2	2-6		2-0	2-0	2-2	2-3		2-2	2-6	2-0	2-0	2-8	2-0			2-6	3-0	1-11.3%
		3-5					3-8	3-3		3-1	3-1	3-2	3-5		3-1	3-3	3-1	3-1	3-0	3-5			3-0	4-2	2-6.4%
		4-3					4-1	4-0		4-0	4-0	4-0	4-2		4-0	4-0	4-0	4-0	4-0	4-0			4-0		3-4.6%
																									4-1%

N=Number of participants, FU=Average follow up period in months, RAC=Revision any cause, AS=Revision for aseptic loosening, RL=Clinical or radiological loosening, OT=Operating time in minutes, BL=Blood loss in ml, HHS=Harris Hip Score, CR=Complication rates, TTA (y)=Time to arthroplasty in years, G/Ex = % of patients achieveing good or excellent functional outcomes, NR=Not reported, HO=Heterotopic Ossification by Brooker Grade, Av=Average

et al.,[48] however, found higher rates of survival in the PTOA group (70% vs. 90%) and when only considering aseptic loosening – 77% versus 90%. Complication rates are higher in the PTOA group, equivalent to revision procedures,[28] and Morison *et al*.[48] had an infection rate of 7% in their PTOA group versus no infections in DOA group – they noted previous fixation was a risk for infection. Fracture type did not affect clinical outcomes, the stability of the acetabular component, operative time, or blood loss for late THA.[40,43]

Comparison

Results from acute and late THA studies [Table 8] show comparable findings for aseptic loosening, operative time, blood loss, HHS, and ability to mobilize postoperatively without aid. Complication rates are, however, much higher in the acute group, with deep infection being almost 50% more common.

Discussion

THA is well established as the treatment for PTOA. Its use as a primary definitive treatment in the acute setting is controversial but is gaining momentum in certain circumstances, where it may provide the best outcome. Using this review, we feel that acute THA should be considered:

1. In elderly patients in whom the acetabular fracture configuration, bone stock, or quality would not allow for fixation with immediate mobilization. As with arthroplasty as a treatment for neck of femur fractures, it may provide a suitable definitive treatment and avoid the relative risks of prolonged incumbency in this age group
2. In elderly patients in whom fixation is possible but that their health, life expectancy, or ability to rehabilitate would increase the risks or negate the benefits of fixation
3. When the damage to the articular surface is severe, and thus the development of PTOA is likely, and the patient is over 65
4. If there is preexisting DOA severe enough to warrant a THA, then it should be considered.

Difficulty exists in providing the answer for the younger patients, with indications for a THA. Until robust evidence is provided to further clarity on this small subgroup of patients, the trend is to proceed with fixation in the majority of cases and deal with PTOA in the future if it occurs.

In clinical practice, a delayed THA is often used. This negates the need to gain initial stability or negotiate a previous surgical site. However, whether this prevents the higher rates of complications and infection seen in acute THA, is still not known. The evidence we do have suggests a higher risk of heterotopic ossification, blood loss, and longer operation time, particularly if the fracture is significantly displaced. It also needs to be considered that bed rest requires intensive nursing, has its own complications, and may delay recovery without improving outcomes.

Strengths and weaknesses

We believe that this is a useful systematic review on a topic that may be controversial and definitely requires more evidence base, which we are hoping this systematic review, at least in part, provides. A clear and succinct search strategy was used to make sure that all relevant articles were identified. A lengthy study period was used, and journals were also handsearched, in addition to including relevant papers from review articles. This was all performed by two authors, minimizing the risk of errors and bias. This ensured that this review is as systematic and as detailed as possible. Extensive summary tables of all study findings were designed; ensuring that data are reported consistently, and any differences between studies or the way results were reported would be obvious.

Weaknesses of our review include the fact that studies used numerous different implants and surgical techniques and reported outcomes using different methods and scales. There are not many studies that actually compare acute and delayed THAs, and there were no randomized controlled trials. This made it relatively difficult to summarize the findings of all the studies included in our review. There were not many studies overall focusing on this topic, making it difficult to draw definitive conclusions from our systematic review.

Table 8: Results from acute versus late total hip arthroplasty studies

Variable	Acute[12,13,15,17,18,38,41,47,58]	Delayed[36,40]	Late[7,19,21,27,28,35,39,42,45,51,52,58,60]
AS (%)	2.3	9.6	6.9
Operation time (months)	174 (45-510)	180-420	137.8 (60-315)
Blood loss (ml)	964 (200-5000)	850-2200	768.9 (100-2900)
HHS			
Absolute	87	78	86.7
Proportion good/excellent (%)	60-100	NR	35.1-94
Mobility without aid (%)	74	NR	77
Complication rate (%)	20.1	NR	13.8
Deep infection (%)	2.3	1.9	1.5

AS=Revision for aseptic loosening, HHS=Harris Hip Score, NR=Not reported

Further work

There is a paucity of high-level evidence in this area. Further work in the field is needed, especially more studies focusing on acute versus delayed THAs in acetabular fractures to help guide future clinical practice. However, acetabular fractures amenable to acute THA are relatively rare, and there are inherent difficulties in designing randomized trials for trauma. No joint registry specifically reports on the performance of THA following acetabular fracture and given the relatively low number of this procedure; it may be the only way to collect meaningful data. Universal assessment method for both functional and radiological outcomes would be useful, as this would allow potential future meta-analyses to be performed, therefore allowing more definitive conclusions to be drawn from the systematic review.

Conclusion

We feel that THA as an acute treatment option should be performed for elderly patients in whom the risks of poor quality fixation, inability to comply with limited weightbearing, and risks of prolonged incumbency outweigh the potentially increased risks of the procedure. Once the decision to perform an acute THA has been made, gaining bony stability is vital. The majority of modern papers combine arthroplasty with augments such as concomitant fixation or ring reinforcement, and the trend is moving from "fix or replace" toward "fix and replace," It should be undertaken by a surgeon familiar with both pelvic fixation and revision hip arthroplasty, often requiring a specialist pelvic and acetabular trauma surgeon working with an arthroplasty specialist to be equipped to deal with the highly technical demands of the procedure.

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Conflicts of interest

There are no conflicts of interest.

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