Combined Anterior Pelvic (CAP) approach for fracture acetabulum fixation - Functional outcome evaluation and predictors of outcome

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ABSTRACT

Objective: Ilio-inguinal approach has been considered standard anterior approach for acetabulum fracture fixation. Different modifications of this approach have been described. This study analysed the patients treated using a Combined Anterior Pelvic (CAP) approach - minimal AIP (anterior intra-pelvic) with modified ilio-femoral along with 'anterior superior iliac spine' osteotomy. This combined approach provides wide exposure of pelvis to direct visualise the entire anterior column from sacroiliac joint to pubic symphysis, medial side of quadrilateral plate and entire iliac wing with minimal retraction of soft tissues required.

Methods: Data of patients treated from July 2014 to June 2018 for acetabulum fracture using CAP approach was retrieved from hospital record system. Inclusion criteria were - acetabulum fractures treated surgically using CAP approach. Exclusion criteria were - age less than 18 years, associated pelvis ring injury and incomplete peri-operative radiological record (pre-operative/post-operative antero-posterior, 45° obturator and 45° iliac oblique radiographs and pre-operative computed tomographic (CT) scans. 62 patients who met inclusion exclusion criteria were called in out-patient-department for final functional evaluation using Matta modified Merle d'Aubigne score.

Results: Out of 62 patients 47 patients who turned up for final functional evaluation were included in study. 19 patients had excellent, 15 had good, 2 had fair and 11 had poor results. Age less than 40 years, anterior column fracture pattern, Pre-operative fracture displacement >20 mm, fracture comminution and post-operative fracture reduction within 3 mm were the predictors of the functional outcome. When analysed using logistic regression model, post-operative fracture reduction was found to be the only significant predictor of functional outcome.

Conclusion: CAP approach is useful anterior approach to acetabulum. Fracture reduction is the independent predictor of functional outcome. Comparison of this approach with other anterior approaches to acetabulum can be area of further research.

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1. Introduction

Acetabulum fracture fixation is a technically demanding procedure. Surgical approaches to acetabulum may be anterior, posterior or combined. The choice of surgical approach depends upon the type of fracture, displacement of fracture fragments and the surgeon's preference. Ilio-inguinal approach has been the standard approach for anterior acetabulum fractures since it was first

described by Letournel et al., in 1964.¹ This approach provides access to most of the anterior acetabulum, iliac surface, pelvic brim and anterior sacroiliac joint. However meticulous dissection is required to prevent injury to major neurovascular structures like lateral femoral cutaneous nerve (LFCN) and the external iliac vessels. Also the learning curve is quite steep with this approach.² Different modifications of this approach have been described to decrease the extensive dissection and improve the exposure.^{3,4}

Smith-Petersen described an anterior approach to hip joint for pelvic osteotomy and arthroplasty in 1917 and 1949 respectively.^{5,6} This approach was popularised as ilio-femoral approach. Superficially the internervous plane of dissection was between sartorius and tensor fascia. The deep internervous plane was between rectus

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femoris and gluteus medius. The muscles from the medial aspect of crest were released to expose the inner side of pelvis. This approach has extra advantage of providing exposure to hip joint which is not possible with ilio-inguinal approach. Following years different modifications of this approach were described. Kloen et al. described a combination of ilio-inguinal and modified Smith-Petersen approach.³ The proximal part of approach was similar to lateral window of ilio-inguinal approach with medial retraction of iliacus muscle to expose inner aspect of ilium. Extending distally, the approach was like Smith-Petersen approach with complete exposure to hip joint. Additionally the osteotomy of 'anterior superior iliac spine' (ASIS) with retraction of attached Sartorius muscle and inguinal ligament provided wide distal exposure to anterior acetabulum. Sagi et al. also described lateral window of ilio-inguinal approach along with ASIS osteotomy.⁷ Since the authors did not extend the lateral window distally, the exposure was limited distally up to pubic root.

Sen et al. described ilio-femoral approach along with ASIS osteotomy.⁸ The approach provided wide exposure to anterior acetabulum and internal pelvis. The authors combined this exposure with medial window of ilio-inguinal to access whole pelvic brim from pubic symphysis to anterior sacroiliac joint, supra-acetabular part of iliopectineal eminence, quadrilateral plate and whole ilium internally along with visualisation of hip joint. The advantages of ASIS osteotomy in these approaches were lesser dissection, wide visualisation of anterior column along with hip joint access.^{3,7}

Other approaches like modified Stoppa and pararectus were described with advantage of quadrilateral plate access, joint visualisation and lesser morbidity.⁹ Hirvensalo et al., in 1993 and Cole and Bolhofner in 1994 independently described modified Stoppa approach to treat fracture acetabulum.^{10,11} The advantage of the approach is to access the acetabulum from within the pelvic cavity below the pelvic ring. The medial displaced fractures can be reduced and fixed along the vector of injury. Sagi et al. described modification of this approach and termed it as AIP (anterior intrapelvic) approach.¹² Rocca et al. combined the modified Stoppa approach with lateral window of ilio-inguinal approach and termed it as ACE (anterior combined endopelvic) approach.¹³ The authors argued that extra lateral approach reduces the soft tissue tension and injury to iliac vessels particularly in obese patients.

This study aimed to analyse the functional outcome and its predictors after fixing the acetabulum fractures using a Combined Anterior Pelvic (CAP) approach - minimal AIP with modified ilio-femoral along with ASIS osteotomy. This approach provides wide exposure to direct visualise the entire anterior column from sacroiliac joint to pubic symphysis, medial side of quadrilateral plate and entire iliac wing, without much retraction of soft tissue. Both supra-pectenial as well as infra-pectenial fixation is possible with this approach.

2. Materials and methods

This was a retrospective study of patients treated at our institution from July 2014 through June 2018 for fracture acetabulum using CAP approach. After getting clearance from institutional ethical committee, records of all such patients were retrieved from hospital record system. Inclusion criteria were - acetabulum fractures treated surgically using CAP approach. Exclusion criteria were - age less than 18 years, associated pelvis ring injury and incomplete peri-operative radiological record (pre-operative/post-operative antero-posterior, 45° obturator and 45° iliac oblique radiographs and pre-operative computed tomographic (CT) scans. Total 62 patients were found matching inclusion and exclusion criteria. Hospital record of all the patients

was analysed. Age, sex, mode of injury, delay in surgery, operative time, blood loss, hospital stay, fracture type, surgical approach, associated injuries, pre-operative fracture displacement, fracture comminution and post-operative fracture reduction according to Matta's method were recorded as independent variable.¹⁴ Variables affecting outcome were decided based upon the various studies in literature.^{15,16} Fractures were classified according to Judet and Letournel classification.¹ Pre-operative and post-operative fracture displacement was measured as the maximum displacement on any of the radiographs. The outcome variable was functional outcome according to Matta modified Merle d'Aubigne score at latest follow-up.¹⁷ For this all the patients were called in out-patient-department.

All the patients, when received in emergency department, were managed according to advanced trauma life support (ATLS) protocols. After initial resuscitation patients were evaluated for orthopaedic injuries. For acetabulum fractures antero-posterior and 45° oblique views of radiographs were obtained. CT scan with 3D reconstruction was done in all patients. Aspirin was started at the time of admission as deep vein thrombosis (DVT) prevention protocol of our department and continued for 3 weeks post-operatively.¹⁸ Fracture was fixed once patients were fit from medical point of view and till that time skeletal traction was given. The indications for fracture fixation were - fracture displacement >2 mm, Matta's roof angle <45° or unstable/non-concentric joint reduction. In all patients fracture was fixed by CAP approach. Modified ilio-femoral approach along with ASIS osteotomy (Fig. 1) was done as previously described by Sen et al.⁸ Unlike Sen et al. who added medial window of ilio-inguinal, AIP approach for intra-pelvic access as described by Sagi et al. was added.¹² The whole access was similar as described by Lee et al. as a part of biaxial reduction technique for fracture acetabulum reduction and fixation.¹⁹ Superomedial dome comminution, if present, was reduced through fracture window and fixed with screw (Fig. 2). The Kocher Langenbeck (KL) approach was added if it was not possible to fix the posterior fracture through same approach (low/comminuted fractures).

Toe touch weight bearing (20% body weight) walking was started on post-operative day 1 and partial weight bearing (40%) walking was allowed after 6 weeks. Full weight bearing walking was allowed after 3 months of surgery. No prophylaxis for heterotrophic ossification (HO) was given in any patient.

Statistical analysis: Continuous independent variables were described as mean $\pm$ standard deviation. Categorical independent variables were described as number and percentage. Statistical analysis was done to determine the association between Matta modified Merle d'Aubigne score and independent variables. All the independent variables were first analysed for association using chi-square or Fisher's exact test. For this analysis, patients were divided into two groups for each independent variable. Variables found to be significant were further analysed using logistic regression analysis. Statistical analysis was done using SPSS version 23. Logistic regression analysis was done as 'binary logistic' by selecting all independent variables simultaneously as covariates and using 'Enter' method. For all the calculations significant difference was defined as less than 0.05.

3. Results

Out of 62 patients 15 patients were lost to follow-up. Total 47 patients were included in this study who turned up for final functional outcome analysis. Mean age of patients was 36.76 ± 12.16 years, mean delay in surgery was 4.97 ± 1.91 days, mean operative time was 2.67 ± 1.01 h, mean blood loss was 429.78 ± 173.04 ml and mean hospital stay was 6.08 ± 2.01 days.

Fig. 1. (a) Exposure after osteotomy and medial retraction of anterior superior iliac spine. Easy placement of clamp and fracture held with wire. (b) Fracture fixed with plate.

Fig. 2. (a) Pre-operative radiograph showing anterior column posterior hemitransverse fracture. (b) CT scan showing comminution of superomedial dome. (c) Superomedial dome fracture on intra-operative image. (d) Fracture reduced by pushing the fragment over femur head. (e) Reduction held with clamp. (f) Wire put to hold the reduction. (g) Post-operative radiograph showing fracture reduction and fixation. (h) Post-operative CT scan showing reduction and fixation of superomedial dome comminution.

Mean follow-up was 25.42 ± 16.30 months. Details of categorical independent variables are shown in Table 1. On final follow-up 19 patients had excellent, 15 had good, 2 had fair and 11 patients had poor outcome. Out of 47 patients, CAP approach alone was done in 34 patients. In 13 patients KL approach was added to CAP approach. Among these 13 patients where KL approach was added, 7 had transverse with posterior wall fracture, 3 had anterior column with posterior hemitransverse fracture, 2 had T type fracture and 1 had both-column fracture. There were 15 patients where posterior column screw was put through the anterior approach to fix the posterior column. 10 patients had anterior column with posterior hemitransverse fracture and 5 patients had transverse fracture pattern.

Variables affecting the functional outcome were analysed (Table 2). Age less than 40 years, anterior column fracture pattern, Pre-operative fracture displacement <20 mm, non-comminution of fracture and post-operative fracture reduction within 3 mm were the predictors of the excellent or good functional outcome. When these variables were further analysed using logistic regression analysis, post-operative fracture reduction was found to be a significant independent predictor of functional outcome (Table 3). In 2 cases there was surgical site infection (SSI). Both patients had discharge from wound without any systemic signs or symptoms. The infection was superficial and resolved with intravenous antibiotics according to culture sensitivity. In both the cases the causative organism was methicillin sensitive staphylococcus aureus.

4. Discussion

CAP approach, used in this study, provides wide exposure to directly visualise the entire anterior column from sacroiliac joint to pubic symphysis, medial side of quadrilateral plate and entire iliac wing (Fig. 3). This extended exposure also helps in reduction and fixation of pelvic ring fractures when associated with acetabulum fractures. Exposure to both endopelvic and iliac region makes fixation easier on both supra-pectenial as well as infra-pectenial surface without much retraction of tissues. This is helpful particularly in obese patients. In addition osteotomy of ASIS makes medial retraction of ilio-psoas muscle along with iliac vessels easier. This decreases chances of iliac vessels trauma and thrombus formation. Distally the exposure can be extended till ilio-pectineal eminence which is not possible with lateral window alone. Sagi et al. described that ASIS osteotomy provides better visibility and work space along with better placement of reduction clamp onto the quadrilateral plate.⁷ Also it was described that chances of LFCN injury were less. However the authors did not extend this approach distally. Distal extension as ilio-femoral approach can expose the hip joint for intra-articular inspection. Unlike ilio-femoral approach there is no need to isolate sensitive anatomical structures so the learning curve is comparatively easy.

Anterior acetabulum fracture is the most common acetabulum fracture pattern in elderly patients with most common mode of injury as fall from standing height.^{20,21} The present study had relatively younger population with average age 38.53 years with

Table 1
Independent variables (categorical).

Variables	n (%)
Modified Merle d'aubigne score	
Excellent	19 (40.42%)
Good	15 (31.91%)
Fair	02 (4.25%)
Poor	11 (23.40%)
Mode of injury	
Road traffic accident	42 (89.36%)
Fall from height	03 (6.38%)
Fall from stairs	02 (4.25%)
Fracture type	
AC	19 (40.42%)
AC + PH	13 (27.65%)
Transverse + PW	07 (14.89%)
Transverse	05 (10.63%)
T	02 (4.25%)
Both-column	01 (2.12%)
Approach	
CAP	34 (72.34%)
CAP + KL	13 (27.65%)
Associated injuries	
Galeazzi	01 (2.12%)
Lateral malleolus	01 (2.12%)
PCL avulsion	01 (2.12%)
Proximal humerus	01 (2.12%)
Scaphoid	01 (2.12%)
Segmental femur	01 (2.12%)
Shoulder dislocation	01 (2.12%)
Temporal bone fracture	01 (2.12%)

AC – anterior column; PH – posterior hemitransverse; PW – posterior wall; CAP – combined anterior pelvic; KL – Kocher Langenbeck; PCL – posterior cruciate ligament.

most common mode of injury as high energy road traffic accidents. This predominance of relatively young patients with most common mode of injury as road traffic accident was also reported by other authors in our country.^{15,22} Also, elderly age is considered as a poor prognostic factor for functional outcome.¹⁷ Moed et al. reported age more than 55 years as a poor prognostic factor after fixation of posterior acetabulum fractures.²³ Tannest et al., in 2012 and Ziran et al., in 2019 reported that age more than 40 years was a poor prognostic indicator after operatively treated acetabulum fractures.^{16,24} Similar to these previously reported results, the present study also found that age more than 40 years was a prognostic indicator of poor functional outcome. Briffa et al. reported that acetabulum fractures after road traffic accident had poorer prognosis as compare to fractures after fall from height.²⁵ Present study did not find such difference.

Matta et al. analysed 262 acetabulum fractures with mean follow-up of 6 years.¹⁷ The authors found excellent results with 18 mm fracture gap, good results with 21 mm gap, fair results with 17 mm gap and poor results with 23 mm gap. There was no significant effect of fracture gap on eventual outcome. However other authors reported that pre-operative fracture displacement ≥ 20 mm is considered as a poor prognostic indicator after acetabulum fracture fixation.^{15,16,24,26} Meena et al. argued that pelvis is well surrounded by muscles and neurovascular structures and a wide gap at fracture site indicates a high energy injury.¹⁵ Similar to these previous reported results, present study found that pre-operative fracture displacement ≥ 20 mm was significantly associated with poor functional results.

Importance of fracture reduction in achieving good functional outcome after acetabulum fracture is well documented in literature.^{14,15,24,27} Matta et al., in 1986 in their retrospective analysis of 204 acetabulum fractures reported that fracture reduction is correlated with clinical results.²⁷ Matta et al., in 1996 in another study analysed 262 acetabulum fractures with mean follow-up of 6

years and reported that clinical results were closely related to anatomical reduction and joint congruity post-operatively.¹⁷ Present study analysed post-operative reduction according to Matta's method.¹⁴ It was found that fracture reduction within 3 mm on post-operative radiographs was a predictor of excellent to good functional outcome. Results in present study are similar to Ziran et al. who also reported poor outcome with fracture reduction >3 mm.¹⁶

Articular impaction, comminution and cartilage damage associated with fracture acetabulum are common in elderly patients and are indicator of poor outcome. Patients in present study were of relatively younger age group. 9 out of 47 patients had comminution at superomedial dome. Though it was found to be significant predictor of outcome, when compared with logistic regression it was not found to be statistically significant independent predictor of outcome. Iqbal et al. divided fracture acetabulum into simple and associated types according to Letournel classification.²⁶ The authors found a significant difference between the two groups when compared for radiological criteria. Present study found that simple anterior column fractures had better functional outcome than other fracture patterns.

Meena et al. reported in their study of 108 patients that associated musculoskeletal injuries in acetabulum fractures had poor prognosis.¹⁵ The authors reported that 50% patients with associated injuries had poor or fair outcome while only 16% of patients without associated injuries had poor or fair outcome. Iqbal et al. in their study of 50 patients found that fracture acetabulum patients with associated injuries had poorer radiological outcome than patients who did not have associated injuries.²⁶ However when compared for functional outcome, there was no significant difference between the two groups. Results in present study were similar to the results by Iqbal et al. In present study 13 out of 47 patients had poor or fair outcome. Out of these 13 patients 3 had associated musculoskeletal injuries. In comparison 5 patients had associated injuries out of 34 patients who had excellent or good results. There was no significant difference between patients, with or without associated musculoskeletal injuries in terms of functional results.

Letournel et al. reported that outcome after fixation was worse when acetabulum fractures were more than 3 weeks old.²⁸ Iqbal et al. also reported that fracture acetabulum if fixed within 7 days of injury had better outcome than fractures fixed beyond that period.²⁶ Meena et al. in their study found that outcome was better when acetabulum fractures were fixed within 2 weeks of injury.¹⁵ Ziran et al. reported poor outcomes when surgery was delayed for >5 and >15 days in case of associated and elementary fractures respectively.¹⁶ Similarly poor results with delay in surgery were reported by other authors also.^{17,29,30} Present study did not have any neglected acetabulum fracture. Average delay in surgery after fracture was 4.97 ± 1.91 days. Patients were divided in two groups according to delay in surgery – up to 3 days or >3 days. No significant difference between two groups in terms of functional outcome was found.

In present study out of 47 patients, 34 (72.34%) had excellent or good outcome when assessed by Matta modified Merle d'aubigne score. Age less than 40 years, anterior column fracture pattern, Pre-operative fracture displacement <20 mm, non-comminution of fracture and post-operative fracture reduction within 3 mm were the predictors of the excellent or good functional outcome. However when compared using logistic regression analysis only post-operative fracture reduction within 3 mm was found to be significant predictor of excellent or good functional outcome. In 13 out of 47 patients KL approach was added to the anterior approach. In present study delay in surgery, surgical time or hospital stay were not found to be predictor of outcome (Table 2).

There are certain complications that may occur after surgical

Table 2
Predictors of outcome – univariate analysis.

	Matta score		p value	Odd ratio (95% C.I.)
	Excellent or Good (n)	Fair or Poor (n)		
1	Age(years)			
	0–40	30	0.00	8.75 (1.93–39.57)
	> 40	04		
2	Sex			
	Male	21	0.51	1.88 (0.51–6.85)
	Female	13		
3	Mode of injury			
	RTA	30	1.0	0.62 (0.06–6.18)
	Others	04		
4	Associated injuries			
	Present	05	0.66	0.57 (0.11–2.85)
	Absent	29		
5	Fracture type			
	AC	17	0.04	5.50 (1.05–28.63)
	Others	17		
6	Fracture displacement (mm) (pre-operative)			
	0–20	20	0.00	1.92 (1.34–2.77)
	> 20	14		
7	Comminution			
	Present	02	0.00	0.05 (0.009–0.32)
	Absent	32		
8	Delay in surgery (days)			
	0–3	07	1.0	0.86 (0.18–4.01)
	>3	27		
9	Surgical approach			
	CAP	22	0.18	2.93 (0.78–10.98)
	CAP + KL	12		
10	Operative time (hours)			
	0–3	29	0.11	3.62 (0.83–15.70)
	>3	05		
11	Blood loss (ml)			
	0–300	13	0.17	3.40 (0.64–17.86)
	>300	21		
12	Fracture reduction (mm) (post operative)			
	≤3	33	0.00	396.00 (22.91–6842.29)
	>3	01		
13	Hospital stay (day)			
	0–5	12	1.0	0.87 (0.23–3.26)
	>5	22		

RTA – road traffic accident; AC – anterior column; CAP – combined anterior pelvic; KL - Kocher Langenbeck.

Table 3
Predictors of outcome – logistic regression analysis.

	B	S.E.	p value	Exp(B)	95% C.I. for Exp(B)	
					Lower	Upper
Age	18.408	8372.409	.998	98715745.615	.000	.
Fracture type	18.074	8372.408	.998	70703012.554	.000	.
Fracture displacement	33.032	9754.913	.997	221700976334543.280	.000	.
Fracture reduction	3.317	1.549	.032	27.583	1.325	574.094
Fracture comminution	17.275	6637.538	.998	.000	.000	.

treatment of acetabulum fractures like SSI, HO, thromboembolism and iatrogenic nerve injury.² The occurrence of SSI after operative intervention ranges between 3 and 5%.^{2,31} The long duration of surgery, increased body mass index (BMI), increased blood transfusion requirements, Morel-Lavallée lesion, long intensive care unit (ICU) stay and pre-operative angioembolization are associated with increased risk of post-operative infection.^{2,31,32} In present study there were 2 cases of SSI. The infection was superficial and resolved with intravenous antibiotics and regular dressings.

HO is a frequent post-operative complication.³³ Dual approach and extensile approach increases the risk.³⁴ Sagi et al. recommended 1 week course of indomethacin prophylaxis for prevention of HO without risk of non-union.³⁵ In present study there was no HO in any patient. Copious irrigation with saline, careful dissection and less retraction might be the reason. There is increased risk of post-operative thromboembolism after operative management of acetabulum fractures.³⁶

DVT incidence varies between 9% and 58% but symptomatic

Fig. 3. (a) Wide exposure of pelvis from sacroiliac joint to pubic symphysis, medial side of quadrilateral plate and entire iliac wing with (b) two incisions.

pulmonary embolism occurred in 2% patients after pelvis or acetabulum fractures.³⁷ There are no specific guidelines for DVT prophylaxis in acetabulum fracture patients. In present study aspirin 150 mg daily starting at the time of admission continuing for 3 weeks post-operative was given.⁶ No patient had symptomatic DVT or pulmonary embolism.

LFCN innervates the skin on lateral aspect of thigh. Injury to this nerve manifests as meralgia paraesthetica. This nerve originates from lumbar plexus and passes about 2 cm medial to ASIS. A high incidence of injury to this nerve has been reported after ilio-inguinal and extended ilio-femoral approaches.³⁸ Though there are no comparative data regarding lesser incidence of LFCN injury after ASIS osteotomy, Sagi et al. suggested that medial retraction of ASIS along with Sartorius muscle prevent post-operative nerve palsy.⁷ This study did not have post-operative LFCN palsy in any patient. Iatrogenic sciatic nerve injury is also a known complication after acetabulum fracture fixation. None of the patients in present study had post-operative sciatic nerve palsy.

Corona mortis is an anastomosis between obturator and external iliac or inferior epigastric vessels. A recent systematic review of literature has reported the prevalence up to 46%.³⁹ This anastomosis is encountered during intra-pelvic approaches to acetabulum and may causes serious bleeding if injured. In current study no patient encountered corona mortis injury. Careful dissection to identify and secure ligation prevents injury to this vessel.

The limitations of present study include its retrospective design, small sample size and short term follow-up. Also the decision of adding KL approach to anterior approach was not based upon some fixed protocols. We advise a better designed study with long term follow-up. However we are not aware of any other study at present with more number of patients than us treated with this combined approach. Lee et al. used similar approach but the number of patients was 5 only.¹⁹ Furthermore in present study the cartilage injury at the time of trauma was not taken into consideration. Briffa et al. described that primary articular cartilage damage at the time of injury is the deciding factor in achieving functional outcome despite after perfect fracture reduction.²⁵ However literature is deficient on this topic and further research is required in this field.

5. Conclusion

In conclusion present study found CAP approach a useful anterior approach to acetabulum. As in case with other approaches,

fracture reduction at post-operative radiographs is an independent predictor of the functional outcome when fracture acetabulum is treated with this approach. Comparison of this approach with other anterior approaches to acetabulum can be an area of further research in future.

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Declaration of competing interest

None.

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