

Long Term Follow up of Operated Acetabular Fractures in Indian Population

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ABSTRACT

Introduction: The treatment of acetabular fractures is a complex area of Orthopaedics that is being continuously refined. The surgical reconstruction of acute displaced fractures has become the accepted treatment of choice for achieving best long term results following injury. Our study focuses on the Indian Population. Aim: To study the long term results of the surgical management of acetabular fractures in the Indian Population.

Material and methods: This was a retrospective study. Thirty patients were evaluated from February 2013 to June 2015. We included patients more than 16 years with closed acetabular fractures of less than three weeks duration. Patients with compound fracture pelvis, pathological fractures, previously operated cases and patients with other associated fractures were excluded.

Results: Two patients postoperatively developed loss of reduction and implant cut out. Three patients developed hypovolemic shock. One patient developed avascular necrosis and subsequently developed post traumatic arthritis. Two patients developed significant Heterotrophic ossification requiring radiotherapy. Anatomic reduction was obtained in 17 patients and satisfactory reduction in 10. Reduction was unsatisfactory in 3 patients. In our study, 23.33% of our patients had an excellent result with good results in 30%, fair results occurring in 33.33% and poor in 13.3% patients.

Conclusion: The most important aim of surgical treatment of acetabular fractures is to get a good reduction and a congruous hip and to limit the occurrence of complications. We conclude that open reduction and internal fixation is the treatment of choice for this type of injury.

Keywords: Operated Acetabular Fractures, Indian Population

INTRODUCTION

The treatment of acetabular fractures is a complex area of Orthopaedics that is being continuously refined. The surgical reconstruction of acute displaced fractures has become the accepted treatment of choice for achieving best long term results following injury.^{1 2 3 4 5} Adequate data is not available in the Indian literature about the incidence of these injuries, development of complications due to the fracture morphology or due to treatment given, including surgical complications and the functional outcome of these patients following operative treatment. The data available in the Western literature may not be applicable to Indian patients due to much better quality and rapid primary treatment and other expertise in the West. So, there is a constant need for a source of generating such data so that more standardized protocols can be formulated to treat these injuries in the

Indian population.

The long term functional outcome of a patient depends on a lot of factors. Long term results, no matter what approach is used or the fracture type involved, are directly related to the quality of reduction achieved⁶ and avoidance of intra operative complications like sciatic nerve damage by proper surgical technique and intraoperative monitoring.^{7 8 9} Postoperative complications like heterotrophic ossification treated by indomethacin therapy or radiotherapy^{10 11} are other factors which can be influenced by the surgeon.

In 1986 Matta and Mehne et al²³ published the early results of prospective study of operatively managed acetabular fractures. These findings indicate that in many patients who have a complex acetabular fracture, the hip joint can be preserved and post-traumatic osteoarthritis can be avoided if an anatomical reduction is achieved. In 2007 Bassi JL, Chandrajeet Dattal, Pankaj Mahindra, Navdeep Singh²⁸ studied 45 patients treated with open reduction and internal fixation of acetabular fracture. They concluded that, there is a positive relationship between quality of reduction and functional outcome. In 2010, Herscovici, Dolfi Jr DO; Lindvall, Eric DO; Bolhofner, Brett MD; Scaduto, Julia M ARNP³¹ concluded that combined hip procedure is an option for acetabular fractures in elderly patients. In 2012, T.A. El-khadrawe, A.S. Hammad³³ studied the indicators of outcome after internal fixation of complex acetabular fractures in 55 patients between May 2007 and December 2010. They concluded that fracture personality and not the fracture type is the main determinant of its complexity.

The aim of this study was to study the long term results of the surgical management of acetabular fracture in terms of function.

MATERIAL AND METHODS

This was a retrospective study of patients who sustained

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fracture of acetabulum, who were admitted in our hospital from the period of Aug 2008 to July 2011. This would enable us to know the long term outcome of operative intervention in these patients, who were evaluated during follow up from February 2013 to June 2015. Formal consent was taken from each patient pre operatively and at each follow up visit at 3, 6, 12, 24 and 36 months. The inclusion criteria were all patients with acute fractures involving the acetabulum only, closed fractures, patients with fractures less than 3 weeks duration, age group >16 years or fused triradiate cartilage. The exclusion criteria included patients with compound fracture of pelvis, acetabular fractures in children, pathological fractures, those with a visible triradiate cartilage, patients with fractures > 3 weeks old, previously operated cases, fractures with neural and vascular compromise and with severe soft tissue injury like Morel-Lavelle Lesion, acetabular fractures with associated other fractures. A sample size of 30 was selected for evaluation. Various scoring systems have been designed to judge the clinical and radiological outcome following acetabular fracture surgery. These include the Joel Matta score²¹, the d'Aubigne Postel score¹³ and Musculoskeletal Functional assessment. The Joel Matta score has clinical and radiological criteria. D'Aubigne Postel score has only clinical criteria. Both Joel Matta and d'Aubigne Postel scores take into account the pain, ambulation and range of motion. All the movements are considered in Joel Matta score while only flexion at the hip compared to the opposite normal hip in d'Aubigne Postel score¹³. Out of these, the d'Aubigne Postel¹³ is the most widely used score and the MFA is the most reliable one³⁶.

In each case, after initial evaluation and stabilization, anteroposterior views and Judet views and CT scan of the pelvis was done in detail to understand the morphology of the fracture. Predominantly displaced column was identified to plan the surgical approach. Matta's roof arc measurements were done in each case on both the anteroposterior view and the Judet view. A Kocher Langebeck approach was used in all the posterior wall, and isolated posterior column fractures. It was also used in those bicolumnar, transverse or T shaped fractures with predominant posterior column displacement and those with associated posterior wall fractures. Anterior column fractures and bicolumnar, transverse or T shaped fractures with predominant anterior column involvement were treated by anterior ilio-inguinal approach. Those complex both column fractures with displacement of both the columns were approached either by combined anterior plus posterior or one of the extensile approaches. After exposing the fracture site, reduction of the fracture was achieved. The joint was opened to look for any intra-articular fragments. If direct reduction was not possible, special techniques like using special acetabular reduction clamps, using femoral distracters, using Steinman pin to lever fragments, etc. were used to achieve reduction. Trochanteric osteotomy was done to increase the exposure whenever required. The reduction was temporarily fixed with k-wires and then inter fragmentary screws were passed. One or more reconstruction plates of appropriate size were contoured to fit the curves of

the pelvis and were applied in retro-acetabular area in K L approach and on superior pubic ramus, ilio-pubic eminence onto the ileum in ilio inguinal approach. In complex fractures, multiple Interfragmentary screws were sometimes used for fixing the multiple pieces of ilium. In fractures involving the Quadrilateral plate, sometimes a spring plate was used to keep the piece of quadrilateral plate down and to avoid tendency of the femoral head to dislocate centrally. In cases where predominant displacement of posterior column with marginal displacement of the anterior column was present, a posteroanterior screw was passed to fix the anterior column through the K L approach to avoid anterior exposure. A suction drain was used in all cases and closure was achieved in layers.

The patients were immobilized for at least 6 weeks in a Thomas splint with or without skeletal traction. They were given five days of intravenous antibiotics and then ten days of oral antibiotics. First dressing with drain removal was done after 48 hrs, second on 5th post op day, third on 8th post-op day. Those with extensive dissection including, those in which K. L. approach and extensile approaches were used were given Indomethacin postoperatively to prevent heterotopic ossification. Gentle hip ROM and non weight bearing walking was started after 6 weeks. Patient was discharged after suture removal on post operative day 15 if no complications arised during the stay. Weight bearing was gradually started after 12 weeks. Initially only partial weight bearing was allowed and full weight was not allowed until evidence of complete radiological union. But the immobilization protocol was flexible according to the morphology of the fracture, patient factors like age, intelligence and compliance, and radiological union. The pre-op, intra-op and post-op data was recorded. The patients were followed up every monthly for first three months and then after every three months for one year and finally at two years. The D'Aubigne Postel score was calculated at each follow up and final score taken at one year. X-rays of pelvis with both hips and JUDET views were taken at each follow. The quality of reduction was judged as anatomic if postoperative x-ray showed <1mm step, satisfactory if 2-3 mm and unsatisfactory if > 3 mm.²³ Fracture was considered united when there was no pain on weight bearing/ palpation and radiologically good callus bridging the fracture site. They were followed up even after fracture healing for development of late complications. D'Aubigne Postel score was used for determining the functional outcome of all the patients at each follow-up with final score at two years. Patients developing any complication during hospital or during follow up were noted. Comparison of results was done with other studies like MAYO, MATTA, De Ridders.

RESULTS

Total of 30 patients were included in the study. 25 were males and 5 were females. Two patients were less than 20 years age, 26 were between 20 and 60 years, two patients were more than 60 years age. 20 patients had right sided fractures while the remaining ten had left sided fractures. 28 were due to road

traffic accidents and 2 were due to fall from height. There were 10 isolated posterior lip type fractures, 07 posterior column type fractures, 04 anterior column type fractures, 09 transverse type of fractures according to Letournel and Judet classification. Preoperative Matta's angle was more than 45 degrees in only 5 patients in which operation was performed because of the posterior lip element and associated instability rather than involvement of the weight bearing region of the acetabulum. The rest had preoperative Matta's angle of less than 45 degrees and involved the weight bearing portion of the acetabulum. Majority of the patients required 1 to 2 hours of operative time with more than two hours required in 8 patients. 25 patients required a single operation, two required two operative procedures and three required more than two operative procedures. Kocher Langenback approach was used in 26 patients while ilioinguinal approach was used in 4 patients. Complications in our series included one infection, two postoperative nerve injuries (foot drop) and no Intraarticular implant. Two patients postoperatively developed loss of reduction and implant cut out. Three patients developed hypovolemic shock.

On post operative follow-up, one patient developed avascular necrosis and subsequently developed post traumatic arthritis. The complications occurring post-operatively like loss of reduction, nerve palsy, avascular necrosis and post traumatic osteoarthritis, heterotrophic ossification also determine the clinical outcome. We had two patients having significant Heterotrophic ossification requiring radiotherapy. Both were following Kocher Langenbecks approach. Anatomic reduction was obtained in 17 patients a Majority of patients were immobilized for 6 weeks (21 patients). Full weight bearing was not started before 3 months in 28 (93.33% patients). Satisfactory reduction in 10 and reduction was unsatisfactory in 3 patients. In our study, 23.33% of our patients had an excellent result with good results in 30%, fair results occurring in 33.33% and poor in 13.3% patients The Standard Values of the Test Statistic at 5% level of significance are 1.645 for one – sided alternative, 1.96 for two – sided alternative. If the calculated value of the test statistic is greater than the standard value, then the Null Hypothesis is rejected. The Alternative Hypothesis may be accepted.

DISCUSSION

The functional outcome of patients with acetabular fractures treated by open reduction and internal fixation depends on multiple factors. These factors have been studied in the past by many authors including Letournel, Matta, Mayo, deRidders, Moed etc.

Matta and Mehne et al ²³, de Ridder²⁴, Mayo KA ²⁵ reported their results in acetabular fractures treated by open reduction and internal fixation. All these studies had used the D'Aubigne Post clinical grading system except Matta's series which has used the Joel Matta score which is similar to the D'Aubigne Postel score except for minor differences in measuring ROM which might also have a significant impact. These studies have consistently given the following factor which determines the prognosis of the patients with acetabular fractures. Pre operative factors like type of acetabular fracture, associated pelvic ring injury/ hip dislocation/ fracture head or neck of femur/ impaction injury to the cartilage, distal neural or vascular damage, other systemic injuries like head injury, spinal injury, abdominal or thoracic injury, extremity trauma, associated hypovolemia, associated Moralle Lavelle lesion, pre hospital care and initial treatment, surgical planning. Intraoperative factors include injury surgery interval – including time after which the dislocation was reduced, surgical skills and experience of the surgeon and facilities available in the institute, quality of reduction, avoidance of complications of surgery – use of preventive measures like Somatosensory evoked potentials, DVT prophylaxis, prophylaxis of Heterotrophic ossification, the approach used – only Anterior / only posterior / extensile, use of trochanteric osteotomy, placement of implants-avoiding the joint, post operative factors like quality of reduction, postoperative complications like infection, nerve palsy, development of avascular necrosis and degenerative arthritis, implant failure.

Thus there are certain factors where the surgeon has no control and certain on which the surgeon has full control. In our study also, analysis has revealed similar results table-1,2.

The choice of approaches depends on the type of fracture and the degree of displacement of individual fractures.^{1,2,3}

Indications of Iliioinguinal approach include anterior column and anterior wall fractures, associated anterior column

Classification	Current Series	Mayo ²⁵	Matta ²³	D deRidder ²⁴
Isolated Posterior Lip	10	14	20	14
Isolated Posterior Column	07	04	15	04
Anterior lip	00	00	02	07
Isolated Anterior Column	04	06	22	04
Transverse	09	10	20	03
Posterior column with posterior lip	00	04	07	01
Transverse with posterior Lip	00	32	67	03
T shaped	00	12	71	06
Anterior column with posterior hemitransverse	00	07	22	05
Both Column	00	67	127	04
Total	30	163	422	51

Table-1: Type of Acetabular fracture

and posterior hemitransverse, most both column fractures, a minority of transverse and T shaped fractures having significant anterior displacement.

- Indications of Posterior Kocher Langenbeck approach are all posterior lip and column fractures, all associated fractures like T shaped or transverse fractures with associated lip fractures and those with more significant posterior displacement.
- Combined anterior and posterior approaches are indicated when complete reduction of both columns cannot be achieved by a single approach. The simultaneous use of both approaches in floppy lateral approach is full of complications and is never used. Instead the other column is exposed and reduced after closure of the previous column wound and changing the position.
- Extensile approaches like Illofemoral, extended Illoinguinal and triradiate are indicated in those complex acetabular fractures in which reduction is less likely to be possible by a non extensile approach.

Delay in the open reduction more than 21 days is also difficult and due to the early union of fracture in unreduced

position, more exposure may be required and an extensile approach may be indicated.

It is evident from the table-3 that the highly experienced authors of these studies used Kocher Lagenbeck and extensile approaches more often than in our study. It is well known that some complex fractures may require more extensile approaches to achieve anatomic reduction. In these complex fractures, the probability of anatomic reduction is increased by using these extensile approaches. These extensile approaches by an inexperienced surgeon can lead to a steep rise in complication rate. Quality of reductions obtained in this series is comparable to these series with more than 80 % patients getting at least satisfactory reduction

Our series showed complications similar to other series table-4, although the total number of patients in these series was much more than our series. The follow up in our series is also much less and hence the delayed complications like posttraumatic arthritis may not be truly comparable and more of our patients might develop post traumatic arthritis on subsequent follow-up.

The comparison in functional outcome between our series and other series is shown in table 5. The difference could

Classification	Current Series		Mayo		Matta		Deriders	
	No. of Cases	Proportion	No. of Cases	Proportion	No. of Cases	Proportion	No. of Cases	Proportion
Isolated Posterior Lip	10	0.33	14	0.41	20	0.23	14	0.56
Isolated Posterior Column	07	0.23	04	0.12	25	0.29	04	0.16
Isolated Anterior Column	04	0.13	06	0.18	22	0.25	04	0.16
Transverse	09	0.30	10	0.29	20	0.23	03	0.12
Total	30		34		87		25	

Table-2: Proportion of number of cases out of total number of cases

Approaches	Present Series	Matta ²³	Mayo ²⁵	deRidders ²⁴
Illoinguinal	04	116	86	18
Kocher Langenbeck	26	159	58	22
Both	00	3	7	03
Extensile	00	95	26	04

Table-3: Approaches used in our series and in the other series

Complication	Present Series	Matta ²³	Mayo ²⁵	deRidder ²⁴
Infection	01	03	07	03
Nerve injury	02	-	04	
AVN	01	-	01	03
Heterotrophic ossification	02	-	04	06
DVT- embolism	00	03	04	01
Death	00	01		03
Implant cutout-loss of reduction	02	-	03	02
Post traumatic Arthritis	00	-	23	-

Table-4: Complications

Result	Present Series		Mayo ²⁵		Matta ²³ (JM score)		deRidder ²⁴	
Excellent	07	23.33	23	14	30	37	18	35
Good	09	30	101	61	38	47	20	39
Fair	10	33.33	25	16	11	14	-	-
Poor	04	13.33	14	09	02	02	-	-

Table-5: Results

be due the reflection of the significant associated injuries in majority of our patients and to the fact that ours is a smaller series and thus every complication occurring amounts to a greater percentage. This could also be an expression of the learning curve in the treatment of acetabular fractures with better radiological and clinical results occurring in hands of more experienced surgeons (table-5).

In conclusion, acetabular fractures are a relatively uncommon fracture type. The most important aim of surgical treatment of acetabular fractures is to get a good reduction and a congruous hip and to limit the occurrence of complications. Thus after analyzing the results of this study and comparing it with other studies, we would like to conclude that open reduction and internal fixation is the treatment of choice for this type of injury. Anatomical reduction with rigid fixation as early as possible is the immediate goal of surgical treatment.

REFERENCES

- Letournel E. The treatment of acetabular fractures through the ilioinguinal approach, *Clin Orthop* 1993; 292:62.
- Letournel E, Judet R, eds. *Fractures of the acetabulum*, ed 2, Berlin, 1993, Springer-Verlag.
- Letournel E. The treatment of acetabular fractures through the ilioinguinal approach. *Clin Orthop* 1993;292:62.
- Matta JM, Anderson LM, Epstein HC, Hendricks P. Fractures of the acetabulum: a retrospective analysis, *Clin Orthop* 1986; 205:230.
- Matta JM, Merritt PO: Displaced acetabular fractures, *Clin Orthop* 1988; 230:83.
- Eric E. Johnson, Joel M. Matta, Jeffrey W. Mast, and Emile Letournel, Delayed reconstruction of acetabular fractures 21-120 days following injury. *Clin Orthop* 1994; 305:20.
- Moed BR, Maxey JW, Minster GJ. Intraoperative somatosensory evoked potential monitoring of the sciatic nerve: an animal model, *J Orthop Trauma* 1992; 6:59.
- Helfet DL, Hissa EA, Sergay S, et al. Somatosensory evoked potential monitoring in the surgical management of acute acetabular fractures, *J Orthop Trauma* 1991; 5:161.
- Helfet DL, Schmeling GJ. Somatosensory-evoked potential monitoring in the surgical treatment of acute, displaced acetabular fractures: results of a prospective study, *Clin Orthop* 1994; 301:213.
- Moed BR, Maxey JW. The effect of indomethacin on heterotopic ossification following acetabular fracture surgery, *J Orthop Trauma* 1993; 7:33.
- Moed BR, Letournel E. Low-dose irradiation and indomethacin prevent heterotopic ossification after acetabular fracture surgery, *J Bone Joint Surg* 1994; 76B:895.
- Letournel E. Acetabulum fractures: classification and management, *Clin Orthop* 1980;151:81.
- D'Aubigne RM, Postel M: Functional results of Hip Arthroplasty with acrylic prosthesis. *J Bone Joint Surg* 1954;36a:451.
- Brooker AF, Bowerman JW, Robinson RA, et al. Ectopic ossification following total hip replacement: incidence and a method of classification, *J Bone Joint Surg* 1973; 55A:1629.
- Mears DC, Rubash HE. Extensile exposure of the pelvis, *Contemp Orthop* 1983; 6:31.
- Reinert CM, Bosse MJ, Poka A, et al. A modified extensile exposure for the treatment of complex or malunited acetabular fractures, *J Bone Joint Surg* 1988; 70A:329.
- Routt MLC Jr, Swiontkowski MF. Operative treatment of complex acetabular fractures: combined anterior and posterior exposures during the same procedure, *J Bone Joint Surg* 1990;72A:897.
- Romness DW, Lewallen DG. Total hip arthroplasty after fracture of the acetabulum: long-term results, *J Bone Joint Surg* 1990;72B:761.
- Helfet DL, Borrelli J Jr, DiPasquale T, et al: Stabilization of acetabular fractures in elderly patients, *J Bone Joint Surg* 1992;74A:753.
- Cole JD, Bolhofner BR. Acetabular fracture fixation via a modified Stoppa limited intrapelvic approach: description of operative technique and preliminary treatment results, *Clin Orthop* 1994; 305:112.
- Weber TG, Mast JW. The extended ilioinguinal approach for specific both column fractures, *Clin Orthop* 1994; 305:106.
- Starr AJ, Watson and Reinert et al. Complications following the " T extensile " approach: a modified extensile approach for acetabular fracture surgery – report of forty-three patients. *J Orthop Trauma* 2002;8: 535-42.
- Matta JM, Mehne DK, Roffi R. Fractures of the acetabulum: early results of a prospective study, *Clin Orthop* 1986; 205:241.
- de Ridder VA, de Lange S, et al: Results 75 consecutive patients With an Acetabular fractures. *Clin Orthop* 1994; 305:53-57.
- Mayo KA, Letournel E, Matta JM, et al. Open Reduction and internal fixation of acetabular fractures. Result of 163 fractures., *Clin Orthop* 1994; 305:31-37.
- Fica G and Cordova M et al. Open reduction and internal fixation of acetabular fractures. 1998;22: 348-51.
- Elmali N, Ertem K et al. Clinical and radiological results of surgically treated acetabular fractures. *Acta Orthop Traumatol Turc* 2003;37:97-101.
- Bassi JL, Chanderjeet Dattal, et al. Open reduction and internal fixation of posterior wall acetabular fractures: a study of 45 cases. *J.orthopaedics* 2007;4:e17.
- Dean DB, Moed BR. Late salvage of failed open reduction and internal fixation of posterior wall fractures of the acetabulum: *J Orthop Trauma*. 2009;23:180-5.
- Boraiah S, Ragsdale M, et al. Open reduction and internal fixation and primary total hip arthroplasty of selected acetabular fractures: *J Orthop Trauma*.2009;23:243-8.
- Herscovics, Dolfi Jr. Do; Lindvall, et al. The combined hip procedure: Open reduction and internal fixation combined with Total hip arthroplasty for the management of acetabular fractures in the elderly: *Journal of Orthopaedic Trauma*: 2010;24:291-296.
- Oberst, Michal, Hauschild, et al. Effects of three-dimensional navigation on Intraoperative management and early postoperative outcome after open reduction

- and internal fixation of displaced acetabular fractures: *Journal of Trauma and Acute care surgery*: 14 June 2012
33. T. A. El-Khadrawe, A. S. Hammad, et al. Indicators of outcome after internal fixation of complex acetabular fractures: *Alexandria Journal of Medicine*. 2012;48:99-107.
 34. Webb LX, Rush PT, Fuller SB, Meredith JW. Greenfield filter prophylaxis of pulmonary embolism in patients undergoing surgery for acetabular fracture, *J Orthop Trauma* 1992; 6:139.
 35. Olson SA, Matta JM. Surgical treatment of acetabulum fractures. In Browner BD, Jupiter JB, Levine AM, Trafton PG, eds: *Skeletal trauma; fractures, dislocations, ligamentous injuries*, ed 2, Philadelphia, 1998, WB Saunders.
 36. Olson SA, Matta JM. The computerized tomography subchondral arc: a new method of assessing acetabular articular congruity after fracture (a preliminary report), *J Orthop Trauma* 1993;7:402.
 37. Vrahas MS, Widding KK, Thomas KA. The effects of simulated transverse, anterior column, and posterior column fractures of the acetabulum on the stability of the hip joint, *J Bone Joint Surg* 1999; 81A:966.
 38. Moed BR, Yu PH, Gruson KI. *J Bone Joint Surg Am*. 2003; 85 A:1879-83.
 39. Helfet DL, Schmeling GJ. Management of complex acetabular fractures through single nonextensile exposures, *Clin Orthop* 1994; 305:58-60.

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