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Original Research Article

Fixation of acetabular fractures with quadrilateral plate involvement using intrapelvic reduction and buttress plate via modified stoppa approach: A clinico-radiological and functional outcome evaluation

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ABSTRACT

Background: Acetabular fractures with quadrilateral plate involvement form a heterogeneous group of fractures which are not specifically defined by any current classification system. Surgical treatment of these fractures poses a challenge to Orthopaedic surgeons. The aim of this study was to evaluate the efficacy, safety and outcomes of the fixation technique by using IRBP for acetabular fractures with quadrilateral plate involvement via single modified Stoppa approach.

Materials and Methods: A total of 30 patients with acetabular quadrilateral plate fracture, selected between January 2016 to June 2019, were managed by IRBP via modified Stoppa approach. This was a prospective study and all patients were followed up to a minimum of 2 years. The primary outcome measures were reduction quality and functional outcome which were evaluated according to Matta's radiological criteria and modified Merle d'Aubigné and Postel score respectively. Secondary outcomes were intra-operative conditions such as operative time and blood loss and post-operative complications.

Results: Anatomic reduction was obtained in 22 (73.3%), Imperfect in 6 (20%), and Poor in 2 (6.7%) cases. The modified Merle d'Aubigné and Postel score outcomes were Excellent to Good in 25 (83.3%) patients, Fair in 3 (10%), and Poor in 2 (6.7%) with the mean score being 16.07 ± 2.68. 21 (70%) patients did not have any complications. None of the cases had quadrilateral screws entering the hip joint.

Conclusion: The use of IRBP system is an effective and safe choice for acetabular fractures with quadrilateral plate involvement done via modified Stoppa approach as it has low rate of complications, addresses multiple fractures of acetabulum through a single approach and provides good functional and radiological outcomes over long term.

1. Introduction

The rise in high-speed motor vehicle accidents and high velocity injuries like fall from height have increased the incidence of polytrauma and pelvic injuries over the past decade. Developments in the field of emergency trauma care and healthcare infrastructure facilities have helped in increased survival of these polytrauma victims.

About 10% of pelvic injuries involve acetabulum of which more than 80% occur in road traffic accidents and more than 10% in fall victim injuries.[1] In recent years, however, an increased incidence of acetabular fractures caused by low-energy trauma have been reported, especially in older adults with osteoporotic bone.[2] The treatment of acetabular fracture has improved significantly over the last three decades,[1,3,4] resulting in better outcomes despite the fact that injuries from high-energy trauma usually leave a

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significant degree of disability.[5,6]

Acetabulum being important weight-bearing surface of hip joint, fixation of these fractures becomes extremely important to give congruous stable painless hip joint so as to provide early mobilization and avoid secondary osteoarthritis. Acetabulum fractures involving quadrilateral plate are very difficult to treat owing to its deep location, very thin shell of bone, complexity of fracture involving multiple column or wall along with comminution and osteoporosis specially in geriatric population.

With the latest advances in surgical methods, both direct and indirect reduction techniques have been implemented in surgical reconstruction. Implants are currently being used to address the reduction and fixation challenges of this particular anatomical area. However, it is extremely difficult to fix the quadrilateral plate directly using screws and slightly improper manipulation can cause screws to penetrate into the hip joint. To overcome these problems, several authors have proposed new fixing strategies, including an infrapectineal plate and several novel quadrilateral surface buttress or spring plates to support the quadrilateral plate.[7–9]

In view of these concerns, we used this Intrapelvic Reduction and Buttress Plate (IRBP) which is devoid of the risk of any intra-articular screw prominence along with an additional advantage of stabilizing the displaced anterior column with wall, addressing suprapectineal as well as infrapectineal fracture through a single modified Stoppa approach. Intraoperatively, while using this plate we paid more attention towards absolute reconstruction of the column along with buttressing of quadrilateral plate, prevention of protrusio and maintenance of Shenton's arc rather than fragment specific fixation.

The functional outcome of these fractures involves various factors such as age, injury duration, fracture pattern, superomedial dome impaction, femoral head dislocation at the time of injury, femoral head damage, delay in surgery, quality of reduction,intra-articular osteochondral fragments, pre-existing comorbidities, associated musculoskeletal complications along with injuries to vital structures and surgical approach.[10,11]

The objective of this study was to represent our experience comprising cases of acetabular fracture involving quadrilateral plate which were treated by open reduction and internal fixation using this plate to see whether the technique achieves acceptable reduction, stable fixation with decreased number of surgical procedures, minimum soft tissue damage, reduced operating time and blood loss in comparison to conventional pelvi-acetabular recon plates, achieves favorable radiological union without intra-articular implant prominence along with improved clinical and functional outcome.

2. Materials and Methods

This was a prospective study conducted in accordance with the ethical standards of the institutional review board. 30 patients with quadrilateral plate fracture of acetabulum who were treated by open reduction and internal fixation using this IRBP-screw system via a single modified Stoppa approach in the Department of Orthopaedics, Peerless Hospital & B. K. Roy Research Centre, Kolkata from January 2016 to June 2019 and fulfilling the inclusion criteria were considered in this study.

2.1. Inclusion criteria

1. Skeletally mature patients above 18 years of age
2. Unstable acetabular fracture involving quadrilateral plate with or without displaced anterior column with wall fracture
3. Unilateral acetabular fracture
4. Closed injury
5. Fresh fracture (<3 weeks old)

2.2. Exclusion criteria

1. Undisplaced fractures
2. Pathological fractures
3. Fractures involving posterior column or wall requiring combination of Kocher–Langenbeck approach
4. Associated fracture of femoral head
5. Traumatic head injury or abdominal injury that definitely influence rehabilitation

2.3. IRBP design (Figures 1, 2 and 3)

The plate consists of 3 parts –

1. One pre-contoured side specific suprapectineal curvilinear part for fixation of anterior column. This is available in 2 variants – short and long. The additional part is for more extension towards the pubic symphysis for incorporation of larger extent of fracture.
2. One triangular infrapectineal part for buttressing quadrilateral plate and medial part of posterior column. This also has 2 varieties – small and large, the use of which is determined by extent and type of fracture for better buttress effect, and stature of the individual as well as size of the pelvic bone.
3. Two interconnecting bars for keeping the triangular part in 90^0 with the curvilinear part.

2.4. Operative procedure

The initial management of acetabular trauma followed the principles of the Advanced Trauma Life Support (ATLS).[12] After stabilization, the patients were subjected to a thorough history, clinical examination focusing on complete

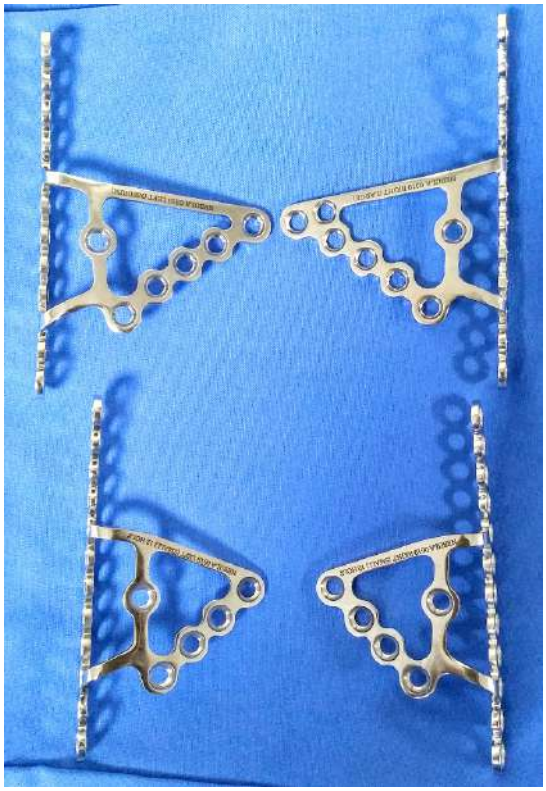


Fig. 1: IRBP available in two variants - long and short

Fig. 2: Plate position over acetabular surface showing suprapectineal curvilinear part for fixation of anterior column

Fig. 3: Triangular infrapectineal part of the plate buttressing quadrilateral plate and medial part of posterior column

neurological assessment of the lower limb followed by pre-operative routine laboratory investigations, which were supplemented by radiographs in antero-posterior and Judet view along with a 3D CT Scan of the pelvis for allowing more accurate characterization of the fracture. The patients were advised bed rest and upper tibial skeletal traction was applied using Steinman pin on ipsilateral lower limb to relieve pain and maintain the limb position until definitive surgery.

All the patients were operated under General anaesthesia. Patients were positioned supine on a radiolucent operating table and a bolster was placed beneath the knee of the injured leg to relax the psoas and vessels. The surgery was done via modified Stoppa approach.

A 10-15 cm curvilinear skin incision was given 2 cm above the pubic symphysis. The linea alba and rectus fascia were incised at the midline and split vertically. Protecting the bladder with a mop, the rectus abdominis muscle was then retracted laterally. Care was taken not to incise the peritoneum as the entire approach was through pre-peritoneal space. The medial part of the rectus muscle was partly detached from the upper and anterior part of the symphysis on the side of the fracture to allow the rectus to retract. Following this, blunt dissection using fingers was carried out laterally along the pelvic brim without incising the fascia. Here the corona mortis was encountered which was identified and ligated. Dissection of the periosteum was continued along the iliopectineal line using a diathermy to expose the fracture site. The obturator neurovascular bundle was identified at this level. These structures were protected throughout the duration of surgery. The dissection was continued up to ipsilateral sacro-iliac joint for proper

placement of the plate. Extreme precaution was exercised so as not to injure the external iliac vessels. On proper exposure of the fracture site, anatomical reduction was attempted and internal fixation was performed using IRBP system. The appropriate plate size was selected according to extent of fracture and the shape of pelvic inlet in which the plate can fit accurately. Intra-operative stability was checked and acceptable alignment along with joint congruency was confirmed under fluoroscopic guidance. Hemostasis was secured. Surgical wound was closed in layers over an in-situ suction drain. Sterile dressings were applied to the surgical incisions (Figures 4, 5, 6, 7 and 8).

Fig. 4: Pre-operative anteroposterior radiograph showing acetabular fracture with quadrilateral plate involvement

2.5. Rehabilitation

Postoperatively, all the patients were encouraged to do isometric contraction training of the lower limbs along with passive and active ipsilateral hip flexion or extension motion. Non weight bearing ambulation and exercises with a pair of crutches or walker was started at 6 weeks post-op and full weight bearing was allowed after 3 months.

2.6. Follow-up

The patients were regularly followed up for a minimum period of 2 years at an interval of 2 weeks, 6 weeks, 3 months, 6 months, 9 months, 1 year, 1.5 year and 2 years.

At each visit, the patients were examined clinically and radiologically. Clinical examinations included checking range of movement at the hip joint, status of ambulation and adequate muscle strength especially quadriceps, hamstrings and gluteus. The radiological examination was done at different intervals to look for bony union, adequacy of fixation, protrusio, avascular necrosis of femoral head and any other complications. The functional outcome was evaluated according to modified Merle d'Aubigné and Postel score at the final follow-up.

Fig. 5: CT scan of pelvis with 3D reconstruction

2.7. Statistical analysis

The data was collected in Microsoft Excel (Windows 10; version 2016) and statistical software SPSS version 20 was used for the analysis. Categorical variables were expressed as number of patients and percentage of patients and compared across the groups using Fisher's Exact Test. Continuous variables were expressed as mean, median and standard deviation and compared across the groups using Kruskal Wallis Test. An alpha level of 5% was taken, i.e., if any p value is less than 0.05 it was considered as significant.

3. Results

3.1. Age distribution

Overall, 86.6% patients were between the age group of 18-50 years. The youngest patient was 22 years old and the eldest patient was 67 years old. The mean age in this study was 36.83 ± 12.32 years.

3.2. Sex distribution

24 patients were male and 6 patients were female in this study. Majority (80%) of patients were male.

3.3. Side of injury distribution

All fractures were unilateral on the Right side in 17 (56.7%) hips and on the Left in 13 (43.3%).

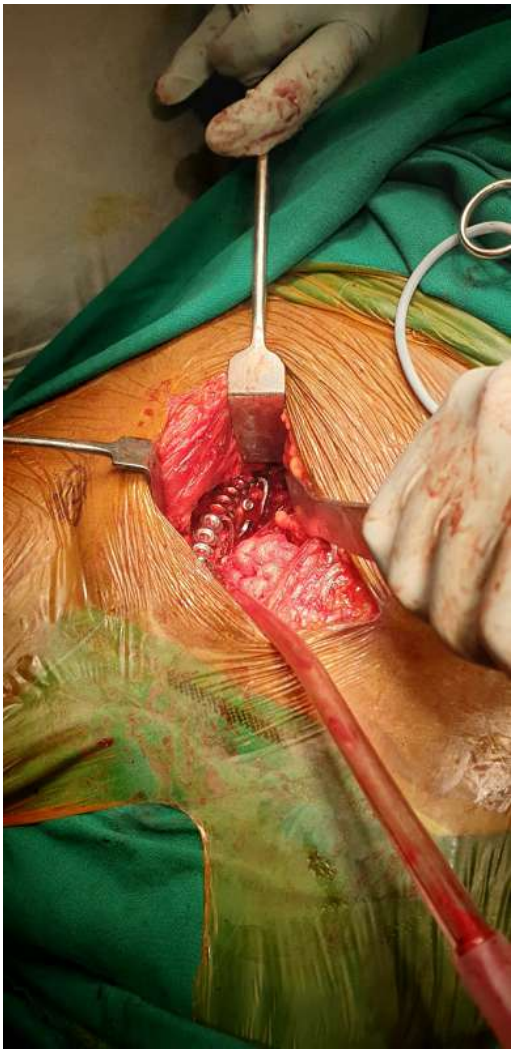


Fig. 6: Intra-operative view showing plate placement via modified Stoppa approach

Fig. 7: Fluoroscopic view of fracture reduction and fixation using IRBP-screw system

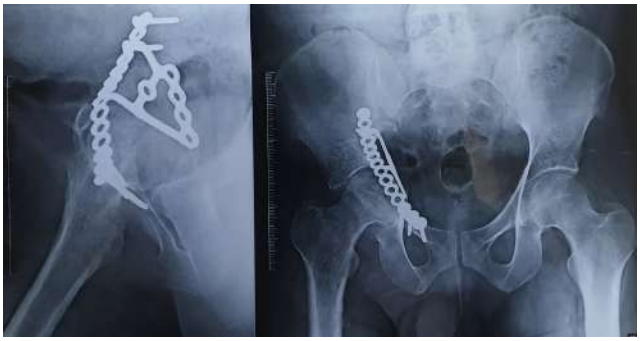


Fig. 8: Post-operative radiograph showing anatomical fracture reduction status with plate in situ

3.4. Mode of injury distribution

20 (66.7%) patients were involved in Motor vehicle accident, 6 (20%) in Pedestrian run over and 4 (13.3%) patients suffered a fall from height.

3.5. Surgery time

Operating time was defined as the duration from incision to the closure of skin. The average time for surgery was 140 ± 22.01 mins [Range: 105-190 mins].

3.6. Amount of blood loss

Blood loss was assessed by used mops and the amount of blood in the suction bottle. The average loss of blood was 370 ± 56.93 ml [Range: 300-520 ml].

3.7. Matta's fracture reduction criteria

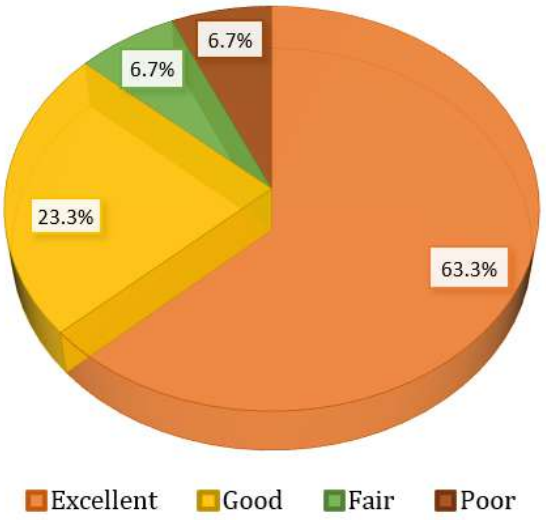
The evaluation of reduction quality of quadrilateral plate fracture and hip joint congruency was done by two independent senior Orthopedic surgeons according to Matta's radiological fracture reduction criteria and accordingly, 22 cases (73.3%) were graded as Anatomical reduction, 6 cases (20%) as Imperfect and 2 (6.7%) as Poor (Table 1).

Table 1: Matta's fracture reduction criteria

Fracture reduction	No. of Patients	Percentage (%)
Anatomic (0-1 mm)	22	73.3
Imperfect (2-3 mm)	6	20
Poor (>3 mm)	2	6.7
Total	30	100.0

3.8. Matta's radiological outcome grading

Radiographic outcome according to Matta revealed Excellent results in 19 (63.3%) hips, Good in 7 (23.3%), Fair and Poor in 2 (6.7%) hips each (Graph 1).



Graph 1: Matta's radiological outcome grading

3.9. Modified Merle d'Aubigné and postel score

The average Modified Merle d'Aubigné and Postel score of 30 patients at the end of 2 year follow-up was 16.07 ± 2.68 [Range: 8-18].

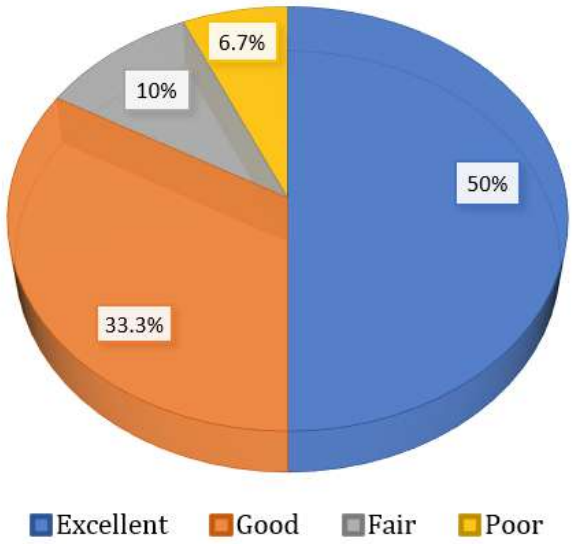
3.10. Final modified Merle d'Aubigné and postel score outcome

15 (50%) patients showed Excellent and 10 (33.3%) patients had Good results at the end of 2 year follow-up, whereas 3 (10%) patient had Fair outcome and 2 (6.7%) patients demonstrated Poor surgical result (Graph 2).

3.11. Complications

21 (70%) patients did not have any complications. 1 (3.3%) patient developed a superficial wound infection which subsided with a course of intravenous antibiotic and regular aseptic dressing for 14 days. 1 (3.3%) patient had a pre-operative sciatic nerve neuropraxia which gradually recovered by the end of 1 year. Malunion was seen in 2 (6.7%) patients. 2 of the patients (6.7%) developed post-traumatic secondary osteoarthritis of the hip joint after surgery and had to undergo a Total Hip Arthroplasty later in due course. None of the cases had quadrilateral screws entering into the hip joint.

None of the operations resulted in major intra-operative complications. Vascular injury occurred in 3 patients – 2



Graph 2: Final modified Merle d'Aubigné and postel score outcome

patients suffered corona mortis vessel injury prior to ligature during soft tissue dissection in which excess bleeding control was achieved by coagulation using bipolar cautery and 1 patient had external iliac vein injury in which repair was done by vascular surgeon. All 3 were managed intra-operatively without any consequences in the further clinical course.

Other complications such as deep vein thrombosis (DVT), pulmonary embolism, heterotopic ossification, obturator nerve injury, subcutaneous hematoma, urological complications, loss of reduction, implant breakage or screw loosening were not seen in any of the patients (Figures 9 and 10).

Fig. 9: Hip flexion at final follow-up

4. Discussion

Fractures of the acetabulum are most common in young, active people[13] and are known to be associated with a high degree of disability and poor functional outcome owing to variable degree of involvement of

Fig. 10: Squatting at final follow-up

the hip joint.[14–16] Complex pelvic anatomy, difficulty in surgical access and proximity to the hip joint makes acetabular fracture treatment extremely challenging.[17] The operative management of acetabular fractures is technically demanding and has many potential complications.[18–20] The aim of treatment of displaced acetabular fractures is to obtain a stable anatomical reduction with a functional, mobile and pain-free hip while avoiding complications.[21]

Previous studies have shown that the reduction of the quadrilateral plate fracture played an important role in the surgical results and failure to restore the quadrilateral plate with good reduction and stable fixation would inevitably lead to a high incidence of complications such as joint dysfunction or post-traumatic arthritis.[22–24] As the presence of quadrilateral surface injury probably plays a decisive role in outcomes, optimal treatment of the quadrilateral fracture is very important. However, due to the deep location, thin plate of bone, and being surrounded by many important blood vessels and nerves, quadrilateral plate fracture has always been a constant challenge to orthopedic surgeons.[25,26]

In our study, 30 patients were included and majority of the patients were young males. This may be due to the fact that most of these fractures result from high velocity trauma (RTA) and increased involvement of young males in outdoor and sports related activities makes them more vulnerable to accidents and trauma.

Operative complications were comparable to other major Orthopaedic procedures and other international acetabular fracture series. DVT prophylaxis was given with Inj. Enoxaparin 40 mg subcutaneously once daily post-operatively, till the patient was actively mobilized from the bed. No case of DVT was reported in our study and early mobilization of patient and aggressive physiotherapy of the patient should be done to prevent DVT.

The cause of infection in 1 patient could not be clearly identified and may be related to the magnitude of the initial injury along with added soft tissue and osseous trauma imposed surgically. However, patient selection, antibiotic prophylaxis and appropriate intra-operative management help to reduce the infection rates. Second generation cephalosporin should be routinely given intraoperatively and postoperatively at least for 48 hours and suction drain should be placed in every recess of wound.

Restoration of articular congruity with stable fixation is the most significant predictive factor of post-traumatic osteoarthritis in acetabular fractures. We found that quality of reduction had significant effect on the final outcome. All patients (6.7%) who had poor reduction had poor clinical score (100%). But despite anatomical reduction, 54.5% of patients had excellent, 36.4% had good and remaining 9.1% had fair clinical outcome. However, 50% patients with imperfect reduction quality demonstrated excellent outcome at the final follow-up (Table 2). Poor quality of reduction in the weight-bearing dome of acetabulum definitely carries a poor prognosis,[27] but anatomical reduction doesn't always result in a good outcome (Table 3). High impact of trauma resulting in intraosseous oedema and avascular necrosis of the adjacent bone is also an important prognostic indicator of the final functional outcome. Associated cartilage damage, muscle injury, surgical morbidity and factors beyond surgeon's control play a major role in predicting the outcome although, prolonged intra-operative time, poor soft tissue handling and excessive bleeding during surgery also play pivotal indicators of poor outcome (Table 4). In comminuted or impacted marginal fractures, the impacted fragments are lifted up to restore articular congruency leaving a large void or gap in the metaphyseal region. This metaphyseal malreduction is acceptable, but the fragments lining the articular surface must be secured adequately in such conditions as they have a high chance of collapse during post-operative rehabilitation.

We achieved anatomic reduction in 22 cases (73.3%), good reduction with 6 cases (20%) and poor reduction in 2 cases (6.7%). The results according to Modified Merle d'Aubigné and Postel scoring system was excellent in 15 (50%), good in 10 (33.3%) cases contributing to 83.3%. Matta radiological scoring system results were excellent to good in 26 cases (86.6%), fair to poor in 4 (13.4%) cases. Our results are comparable with other published outcomes. Briffa N et al.[27] reported results according to the Modified Merle d'Aubigné and Postel scoring system was excellent in 75 patients (47%), good in 41 (25%), fair in 12 (7%) and poor in 33 (20%). Meena UK et al[11] performed a retrospective analytical study in Indian population and reported clinical outcome as excellent in 27 (22.9%), good

Table 2: Correlation between Matta's fracture reduction criteria and modified merle d' Aubigné and postel score outcomes

		Matta's Fracture Reduction Criteria			Total	P value
		Anatomical	Imperfect	Poor		
Modified Merle d'Aubigné and Postel score outcome	Excellent	12 (54.5)	3 (50)	0 (0)	15 (50)	0.024
	Good	8 (36.4)	2 (33.3)	0 (0)	10 (33.3)	
	Fair	2 (9.1)	1 (16.7)	0 (0)	3 (10)	
	Poor	0 (0)	0 (0)	2 (100)	2 (6.7)	
Total		22 (100)	6 (100)	2 (100)	30 (100)	

Table 3: Correlation between Matta's radiological outcome grading and modified Merled' Aubigné and postel score outcomes

		Matta's Radiological Outcome Grading				Total	P value
		Excellent	Good	Fair	Poor		
Modified Merle d'Aubigné and Postel score outcome	Excellent	10 (52.6)	5 (71.4)	0 (0)	0 (0)	15 (50)	0.014
	Good	7 (36.9)	1 (14.3)	2 (100)	0 (0)	10 (33.3)	
	Fair	2 (10.5)	1 (14.3)	0 (0)	0 (0)	3 (10)	
	Poor	0 (0)	0 (0)	0 (0)	2 (100)	2 (6.7)	
Total		19 (100)	7 (100)	2 (100)	2 (100)	30 (100)	

Table 4: Correlation of modified Merle d'Aubigné and postel score outcome with continuous variables

Modified Merle d'Aubigné and Postel score outcome	Age (years)	Duration of surgery (min)	Blood loss (ml)	Modified Merle d'Aubigné and Postel score
Excellent	37.47 ± 10.41	131.67 ± 14.60	350 ± 29.76	18 ± 0.0
Good	34.3 ± 13.61	141.5 ± 26.78	371 ± 73.70	15.6 ± 0.84
Fair	34 ± 11.14	151.67 ± 12.58	396.67 ± 25.17	13 ± 0.00
Poor	49 ± 24.04	177.5 ± 3.54	475 ± 35.36	8.5 ± 0.71
P value	0.505	0.054	0.060	0.001

in 52 (44.2%), fair in 20 (16.9%), and poor in 19 (16.1%, 10 patients who underwent THR for secondary arthritis were considered as poor outcome) patients with a mean score of 15.7 ± 2.2. A similar study by Jakob M et al.[28] showed that 17 (85%) patients had good to excellent results and 3 (15%) patients had poor results along with anatomic and satisfactory reduction achieved in 13 out of 14 patients. In another study by Sagi HC et al,[29] 70% of the reductions were graded excellent, 22% were graded good and 8% poor. Clinical outcomes (Merle d'Aubigné) at 1 year were 36% excellent, 55% good and 10% poor. A study of Cole JD et al[30] also showed similar results with radiographic grades being excellent (64%), good (25%), fair (7%) and poor (4%) and clinical results being excellent (47%), good (42%), fair (9%) and poor (2%). Kim HY et al[31] in their study showed that the clinical results were excellent in 3 cases, good in 13 cases, and poor in 4 cases, while the radiographic results were excellent in 5 cases, good in 13 cases, and poor in 2 cases.

Recent advances in acetabular fracture surgery have involved both novel surgical approaches and fixation constructs in part to meet the demands posed by young as well as aging osteoporotic patient population. Less invasive surgical exposures with lower morbidity to the patient such as the modified Stoppa approach was developed to give access to direct visualization of anterior column, quadrilateral plate and medial surface of posterior column through a single midline incision. With improved access to the quadrilateral surface and the medial aspect of the posterior column, more effective means of buttress plating the medial wall and spanning fixation of anterior columns has become possible.[32] Thus, the impetus is for newer plate designs that function to - (1) provide a buttress to the quadrilateral surface and prevent medial subluxation of the femoral head, and (2) span fixation from posterior to the anterior column.[33] The IRBP used in our study fulfills both these functions.

The IRBP also displayed a high level of anatomical fitting for all patients. Furthermore, just because of the plate design, the procedure becomes simple, reliable and highly effective. Conventionally, intra-operative alteration of the shape of recon plate is a complicated and time-consuming procedure for most surgeons which can be avoided by this procedure. The multipurpose use of this plate, that it neutralizes fractures of the anterior column and provides a good buttress to the entire quadrilateral plate through a less invasive modified Stoppa approach, presents an alternative method of fixation in resisting motion at the fracture and medial subluxation.

Limitations of our study include single institution bias, small group of patients, short follow-up period and a lack of Control group. A multicentre study with more patients is

essential to substantiate benefits of this treatment method.

5. Conclusion

In properly selected patients with quadrilateral plate of acetabulum fracture, an open reduction and internal fixation using IRBP via a single modified Stoppa approach appears to be a simple, safe and effective surgical procedure for the stabilization of pelvis, with a low failure rate and encouraging outcomes. This plate can fit with the surface of acetabulum, which saves time for remodeling of a plate during operation and facilitate fracture reduction. It also has low morbidity with good clinical and functional results over the long term.

In terms of reduction, fixation strategy and functional outcomes, standard reconstruction plates have similar results. The IRBP-screw system has the advantages of short operating time, reduces the effort of pre-operative planning, addresses multiple fractures of acetabulum through a single approach, decreased intraoperative bleeding and blood transfusion requirement and it is worth further promotion for increased usage.

A larger well-designed study is required to be conducted across the country to corroborate the findings of our study.

6. Source of Funding

None.

7. Conflict of Interest

The authors declare no conflict of interest.

References

1. Giannoudis PV, Grotz MR, Papakostidis C, Dinopoulos H. Operative treatment of displaced fractures of the acetabulum. *J Bone Joint Surg Br*. 2005;87(1):2–9.
2. Peter RE. Open reduction and internal fixation of osteoporotic acetabular fractures through the ilio-inguinal approach: use of buttress plates to control medial displacement of the quadrilateral surface. *Injury*. 2015;46(Suppl 1):2–7.
3. Templeman DC, Olson S, Moed BR, Duwelius P, Matta JM. Surgical treatment of acetabular fractures. *Instr Course Lect*. 1999;48:481–96.
4. Pantazopoulos T, Mousafiris C. Surgical treatment of central acetabular fractures. *Clin Orthop*. 1989;246:57–64.
5. Liebergall M, Mosheiff R, Low J, Goldvirt M, Matan Y, Segal D. Acetabular fractures: clinical outcome of surgical treatment. *Clin Orthop Relat Res*. 1999;366:205–16.
6. Moed BR, Willsoncarr SE, Watson JT. Results of operative treatment of fractures of the posterior wall of the acetabulum. *J Bone Joint Surg Am*. 2002;84(5):752–8.
7. Qureshi AA, Archdeacon MT, Jenkins MA, Infante A, Dipasquale T, Bolhofner BR, et al. Infrapectineal plating for acetabular fractures: A technical adjunct to internal fixation. *J Orthop Trauma*. 2004;18(3):175–8.
8. Sen RK, Tripathy SK, Aggarwal S, Goyal T, Mahapatra SK. Comminuted quadrilateral plate fracture fixation through the iliofemoral approach. *Injury*. 2013;44(2):266–73.
9. Boni G, Pires RE, Sanchez GT, Reis FD, Yoon RS, Liporace FA. Use of a stainless-steel locking calcaneal plate for quadrilateral plate buttress in the treatment of acetabular fractures. *Eur J Orthop Surg Traumatol*. 2019;29(5):1141–5.
10. Magu NK, Gogna P, Singh A, Singla R, Rohilla R, Batra A, et al. Long term results after surgical management of posterior wall acetabular fractures. *J Orthop Traumatol*. 2014;15(3):173–9.
11. Meena UK, Tripathy SK, Sen RK, Aggarwal S, Behera P. Predictors of postoperative outcome for acetabular fractures. *Orthop Traumatol Surg Res*. 2013;99(8):929–35.
12. Frank CJ, Zacharias J, Garvin KL. Acetabular fractures. *Nebr Med J*. 1995;80(5):118–23.
13. Beaulé P, Dorey FJ, Matta JM. Letournel classification for acetabular structures: assessment of interobserver and intraobserver reliability. *J Bone Joint Surg [Am]*. 2003;85(9):1704–9.
14. Rommens PM, Giménez MV, Hessmann MH. Is the posterior wall avulsion the simplest acetabular fracture? *Eur J Trauma*. 2000;26(4):144–54.
15. Giannoudis PV, Tziopis C, Moed BR. Two-level reconstruction of comminuted posterior-wall fractures of the acetabulum. *J Bone Joint Surg Br*. 2007;89(4):503–9.
16. Giannoudis PV, Tzioupis CC, Pape HC, Roberts CS. Percutaneous fixation of the pelvic ring: an update. *J Bone Joint Surg Br*. 2007;89(2):145–54.
17. Sen RK, Tripathy SK, Aggarwal S, Goyal T, Meena DS, Mahapatra S. A safe technique of anterior column lag screw fixation in acetabular fractures. *Int Orthop*. 2012;36(11):2333–40.
18. Baumgaertner MR. Fractures of the posterior wall of the acetabulum. *J Am Acad Orthop Surg*. 1999;7(1):54–65.
19. Brueton RN. A review of 40 acetabular fractures: the importance of early surgery. *Injury*. 1993;24(3):171–4.
20. Matta JM. Fractures of the acetabulum: accuracy of reduction and clinical results in patients managed operatively within three weeks after injury. *J Bone Joint Surg Am*. 1996;78(11):1632–45.
21. Matta JM, Mehne DK, Raffi R. Fractures of the acetabulum: early results of a prospective study. *Clin Orthop Relat Res*. 1986;205:241–50.
22. Letournel E. Acetabulum fractures: classification and management. *Clin Orthop Relat Res*. 1980;151:81–106.
23. Mardian S, Rau D, Hinz P, Wittenberg S, Giesecke M, Schwabe P. Acetabular fractures in an advanced age-current knowledge and treatment options. *Acta Chir Orthop Traumatol Cech*. 2017;84(4):241–6.
24. Chang JK, Gill SS, Zura RD, Krause WR, Wang GJ. Comparative strength of three methods of fixation of transverse acetabular fractures. *Clin Orthop Relat Res*. 2001;392:433–41.
25. Bastian JD, Tannast M, Siebenrock KA, Keel MJ. Mid-term results in relation to age and analysis of predictive factors after fixation of acetabular fractures using the modified Stoppa approach. *Injury*. 2013;44(12):1793–8.
26. Elnahal WA, Karim MA, Khaled SA, Abdelazeem AH, Abdelazeem H. Quadrilateral plate fractures of the acetabulum: proposition for a novel classification system. *Injury*. 2018;49(2):296–301.
27. Briffa N, Pearce R, Hill AM, Bircher M. Outcomes of acetabular fracture fixation with ten years' follow-up. *J Bone Joint Surg Br*. 2011;93(2):229–36.
28. Jakob M, Droeser R, Zobrist R, Messmer P, Regazzoni P. A less invasive anterior intrapelvic approach for the treatment of acetabular fractures and pelvic ring injuries. *Journal of Trauma and Acute Care Surgery*. 2006;60(6):1364–70.
29. Sagi HC, Afsari A, Dziadosz D. The anterior intra-pelvic (modified rives-stoppa) approach for fixation of acetabular fractures. *J Orthop Trauma*. 2010;24(5):263–70.
30. Cole JD, Bolhofner BR. Acetabular fracture fixation via a modified Stoppa limited intrapelvic approach. Description of operative technique and preliminary treatment results. *Clin Orthop Relat Res*. 1994;305:112–23.
31. Kim HY, Yang DS, Park CK, Choy WS. Modified Stoppa approach for surgical treatment of acetabular fracture. *Clin Orthop Surg*. 2015;7(1):29–38.
32. Qureshi AA, Archdeacon MT, Jenkins MA, Infante A, Dipasquale T, Bolhofner BR. Infrapectineal plating for acetabular fractures:

a technical adjunct to internal fixation. *J Orthop Trauma*. 2004;18(3):175–8.
33. Kistler BJ, Smithson IR, Cooper SA, Cox JL, Nayak AN, Santoni BG. Are quadrilateral surface buttress plates comparable to traditional forms of transverse acetabular fracture fixation? *Clin Orthop Relat Res*. 2014;472(11):3353–61.

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