Clinico-Radiological and Functional outcome of anterior bridge plating with Minimally Invasive Plate Osteosynthesis (MIPO) in diaphyseal fracture humerus: A prospective study

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Abstract

Aim: The aim of our work is to assess the clinico-radiological and functional outcome in management of humerus diaphyseal fracture by anterior bridge plating with MIPO technique.

Methods: 21 patients of traumatic diaphyseal fractures of humerus were managed by Anterior Bridge Plating using MIPO technique between 2017-2018 in a series conducted at our center. The side affected, gender ratio, surgery time, fracture union time and complication were noted. UCLA shoulder and Mayo elbow performance score were used.

Results: The study population consisted of 11 (52.4%) males and 10 (47.6%) females. The mean age was 39.71±13.18 (Range = 18-65) years. Mean surgical time was 99.52 minutes. Road traffic injury was the most common mode. 1 case of infection 2 of non union and 3 cases of post op radial nerve palsy encountered and resolved accordingly. The mean UCLA shoulder and MEPS showed statistically significant improvement in functional outcome with time.

Conclusion: There is statistically significant improvement in clinico-radiological and functional outcome with time. Anterior Bridge plating with MIPO technique is a good technique which respects the biological fixation principles and causes minimal soft tissue assault while preserving the fracture haematoma and maintains periosteal blood channels for management of humeral diaphyseal fractures.

Keywords: Minimally invasive plate osteosynthesis (MIPO), Diaphyseal fracture humerus, Anterior bridge plating

Introduction

The humeral shaft is defined as the expanse between the proximal insertion of the pectoralis major and the distal metaphyseal flare of the humerus [1]. Cylindrical in shape, the shaft inherently provides strength and resistance to both torsional and bending forces. Distally the bone transitions into a triangular geometry with the base posterior which forms a supra-condylar region. This region maintains a narrow anterior-posterior dimension [1]. Diaphyseal fractures of the humerus occur frequently and represent three to five percent of the fractures of the human body [2]. Most of these fractures are caused by direct or indirect trauma [3,4]. Humerus fracture treatment has progressed from conservative methods like Hanging Cast technique [5] as discovered and popularized by Caldwell and Sarmiento functional brace [6] to internal fixation with intramedullary nailing or with plates and screws. There are no conclusive data showing the superiority of each other by respective techniques [7,8]. Evidence shows that biological fixation is preferable to a stable mechanical fixation [9]. This has led to the development and advancement of techniques for biological fixation of fractures, as well as the development of stabilization systems that help to achieve biological fixation [10,11].

As the surgical practices are evolving, more importance is now given to soft tissues preservation, and fracture hematoma which are major factors in fracture healing [12]. There has been a long standing conflict between the need for absolute anatomical reduction and, at the same time, the desire for soft tissue preservation. The limb’s immediate and continues function is now another leading major goal. The humerus can be considered the most versatile bone in the human body in view of the fact that it can be successfully approached by a variety of methods for fracture fixation [12-15]. The traditional open plating either through anterior or posterior approach is a rotator cuff safe technique; however, biological disruption of soft tissue, poor cosmetic scarring, and direct handling of the radial nerve have always been of concern. On the other hand, the classical intramedullary nailing is minimally invasive, but it has the main drawback of potentially damaging the rotator cuff and causing shoulder impingement [7,12,14,16,17].

In seeking minimally invasive techniques, a new therapeutic option has arisen for treating these fractures: Bridge plates [18]. The advantage of MIPO technique over conventional techniques is its following properties i.e. less soft tissue stripping, less iatrogenic neurovascular injury, less time consuming and cosmetically advanced technique.

As a result of technical advancement, Minimally Invasive Plate Osteosynthesis (MIPO) has gained popularity in recent years with satisfactory clinical outcomes. The present study was conducted to assess...
post-operative clinico-radiological and functional outcomes of anterior bridge plating with the MIPO technique in the treatment of humerus diaphyseal fractures.

Material and methods

Twenty-two months prospective study from December 2017 to September 2019 was conducted in the Department of Orthopaedics, Teerthanker Mahaveer Medical College and Research Centre, Moradabad, Uttar Pradesh, India [21]. Patients having closed and Gustilo Anderson grade 1 diaphyseal fracture of humerus and age 18-65 years were included in the study. Patients having pathological fracture, pregnancy or any other fracture of the same extremity, radial nerve or brachial plexus injury, and life threatening co-morbid conditions were excluded. The type of fracture was evaluated and reported in accordance with the AO19 classification system after obtaining a skiagram– antero-posterior (AP) and a lateral view of the affected Arm. AO type (A) simple- 12A1-5 cases, 12A2- 4 cases,12A3- 8 cases, (B) wedge-12B2- 4 cases were taken. These radiographs were also used to decide the appropriate length of metal implant and for planning the surgery.

Statistical Analysis was done by (1) Statistical Package for Social Science Version 21.0 (SPSS) and (2) ANOVA test.

Surgical Technique:
The patients positioned supine with his affected arm rests over side table. Surgical approach is that described by Livani et al [20]. Acromion process was palpated and marked and 5 cm caudal to it a proximal incision of 2-3 cm between the medial border of deltoid and proximal biceps. Distally, around 5 cm proximal to the flexion crease, a 2-3 cm incision at the lateral border of the biceps was made (Fig 1). The deltopectoral interval was not required in any surgery but while applying longer plates we had to go a bit proximal and screws were put percutaneously.

Dissection carried out in the line of superficial incision and subcutaneous incision was made. retracting the biceps brachii muscle was done and the musculocutaneous nerve was identified, which overlies the brachialis muscle. The nerve was then retracted and brachialis muscle was split till bone was visible. A subbrachialis and extraperiosteal tunnel was created by using Bristow elevator and Locking Compression Plate was passed to the anterior face of the lateral humeral diaphysis column through the distal incision. (fig 1). Varus/vagus angulation, length and rotation of the fractured humerus restored by continues gentle traction and counter traction given by surgeon and assistant. The plate position and reduction was visualized on the C-arm image intensifier (Fig 1). Each side of the plate was secured with two-three screws i.e. combination of both cortical and locking screws in anterior to posterior direction. Tunneling was done carefully in anterior fashion to prevent iatrogenic radial nerve injury. Intra-operatively, the duration of surgery and number of images shot on the image intensifier was recorded.

Post operatively the operated limb was held in shoulder immobilizer and stitches were removed (i.e. 11th day) and successively patient were recommended to perform intermittent active gentle Shoulder and Elbow range of motion exercises as their pain control permits. Any complications were noted. Regular follow up was done at 6 weeks,
3 months, 6 months, and 9 months following surgery and all the patients were evaluated clinical, functional and radiological. Functional evaluation was done by using UCLA [21] Shoulder rating score and Mayo elbow performance score (MEPS) [22]. Antero-posterior (AP) and the lateral radiograph were taken at each follow-up for assessing fracture union and position of the implant. The fracture union and any complication were noted. Radiological callus formation at the fracture site, and alleviation of pain on movement with absence of tenderness at the fracture site was adopted as criteria for union [23].

Results
- 21 Out of 24 patients of diaphyseal fracture of humerus were included and treated by Anterior Bridge Plating by MIPO technique. The mean age of patients was 39.71±13.18 (Range = 18-65) years respectively. - The mean surgery time was 99.52±13.50 minutes (Range = 80-120) (table 2).
- The mean UCLA was compared at 6 weeks, at 3 months, at 6 months and at 9 months using the repeated measures ANOVA test. There was a significant difference in mean UCLA between at 6 weeks, at 3 months, at 6 months and at 9 months (table 2).
- The mean MEPS was compared at 6 weeks, at 3 months, at 6 months and at 9 months using the repeated measures ANOVA test. There was a significant difference in mean MEPS between at 6 weeks, at 3 months, at 6 months and at 9 months (table 4).

Discussion
This study was done to assess the post-operative clinical, radiological and functional outcomes of anterior bridge plating with Minimally Invasive Plate Osteosynthesis (MIPO) technique in the treatment of humeral shaft fractures. Deepak S et al [23] in their study discussed that Minimally invasive technique for fracture treatment has evolved based on the idea that with the preservation of fracture haematoma and the vascularity around the fracture site, the new bone is laid down in the form of callus, a fact which was recognised by Albrecht Haller’s (1708-1777) in their work [23].

In our study, the mean age of the study population was 39.71±13.18 with a range of 18-60 years. The mean surgery time of 99.52±13.50 minutes (Range = 80-120) was recorded in the present study. When we started this technique at our centre there were few hurdles which we came across while performing surgery like indirect fracture reduction, placement of the plates while maintaining the fracture reduction. We prevailed these hurdles by patience and consistence till we mastered this technique in a course of time. The study by Kulkarni et al [12] reported mean surgical time of 116±17 minutes and while the similar study conducted by Shetty et al [24] (2011) has the comparable mean surgical time of 91.5 minutes (range: 70–120 minutes), Ibrahim and Rathod [25] (2018) and Lal et al (2019) [26] reported a mean surgical time of 80 minutes and 90 minutes (range: 60-100 min), The mean operating time was 52 (range, 40–82) minutes as recorded by Sanjeevaiah and Reddy [27].

Assessment and tabulation of the functional status outcome at each successive follow up were done by UCLA SHOULDER rating scale and the Mayo Elbow Performance Score. In our study, 76.2% showed excellent to good outcome, followed by fair results by 9.5% and poor by 14.3% subjects. This was quite similar to the studies by Deepak et al [23] where excellent shoulder scores were reported in 26 (86.7%) of the cases and good outcome in four cases. This was quite similar to the study by Oh et al [28] where mean UCLA scores of 34.3 was reported. This was lesser than the study by Kulkarni et al [12] where average UCLA score was 18.3±4.0. Sharma et al [29] assessed functional outcome in eleven cases and found an excellent to good shoulder function in 9 cases (81.8%) and fair in 1 case (9.1%) on the UCLA score.

Results

| Radiological Assessment | 6 weeks | 3 months | 6 months | 9 months |
|-------------------------|---------|----------|----------|----------|
|                         | Frequency | Percent | Frequency | Percent | Frequency | Percent | Frequency | Percent | p-value |
| Callus                  | 15       | 71.42%   | 18       | 85.6%    | 18       | 85.6%    | 18       | 85.6%    | < 0.001* |
| Angulation (>150)       | 1        | 4.8%     | 2        | 9.5%     | 2        | 9.5%     | N/A      |          | 0.001*   |
| Displacement (>2mm)     | 1        | 4.8%     | 2        | 9.5%     | 2        | 9.5%     | N/A      |          | 0.001*   |
| Screw Backout           | N/A      |          | 1        | 4.8%     | 1        | 4.8%     | N/A      |          | 0.001*   |
| Roundening of Margins   | N/A      |          | N/A      |          | 2        | 9.5%     | N/A      |          | < 0.001* |
| Sclerosis               | N/A      |          | N/A      |          | 2        | 9.5%     | N/A      |          | < 0.001* |

Table 7: Comparison of Radiological Assessment at 6 weeks, 3 months, 6 months and 9 months (N/A - not available)
cases (86.6%), fair in 1 case (6.67%) & poor 1 case (6.67%) shoulder function on the UCLA score. Our study evaluated an excellent to good outcome by 71.4% cases, fair by 14.3% cases and poor by 14.3% cases on MEPI score. This had concurrence with the studies by Deepak et al [23] where the MEPI rating elbow test shows excellent outcome in 24 cases (80%) good outcome in six cases (20%). Shetty et al [24] recorded the excellent results in 26 cases (81.2%), good results in five cases (15.6%), and a fair result in one case (3.1%) with an apparent fracture in the olecranon in one case as assessed by MEPI score.

The union time found in our study was 13.94±1.89 weeks (Range = 12-18 weeks) which is similar to the mean fracture union (radiological) time of 13.7 weeks reported by Sharma et al [29] in their study. Shetty et al [24] reported the mean union time of 13 weeks for radiological fracture union. Ibrahim and Rathod [25] reported the mean fracture union (radiological) time was 11.6 weeks (range: 10–18 weeks) while Lal et al [26] reported mean fracture union time of 10.6 weeks (range: 10–18 weeks) in their respective study.

Radiological assessment was done by subsequent radiographs on each follow up. In current study, callus was reported among significant (p<0.001) cases 15 (71.42%) at 6 weeks, 18 (85.6%) at 3 months, 18 (85.6%) at 6 months and 18 (85.6%) at 9 months. It was concurrent with the study by Oh et al [28] where Twenty-eight of the 29 (90.5%) MIPO patients showed callus formation. Angulation (>15°) was reported among 1 (4.8%) at 6 weeks, 2 (9.5%) at 3 months and 2 (9.5%) at 6 months in our study (p<0.001). An average alignment of less than 5° of varus was found in most cases in our study. In present study, displacement (>2mm) was reported among 1 (4.8%) at 6 weeks, 2 (9.5%) at 3 months and 2 (9.5%) at 6 months (p<0.001).

In this study, screw backout was reported among 1 (4.8%) at 3 months and 1 (4.8%) at 6 months due to infection. Roundening of Margins was reported among 2 (9.5%) at 6 months and Abnormal Mobility was reported among 2 (9.5%) at 6 months in our study. Infection was reported among 1 (4.8%), Non- Union among 2 (9.6%) and Radial Nerve Palsy among 3 (14.4%) cases. There was one case of infection reported by us in our study which in similar to the complication reported by Oh et al [28] which was due to poor tissue handling. We managed the case by implant removal and U slab application with concurrent antibiotics for a period of time and final fixation with ORIF with locking compression plate was done only after absence of any signs of infection.

We encountered two cases of non-union after MIPO technique and the cause to non-union we concluded was an inadequate fracture reduction. Cases of non-union were reported by concha et al [30] in their study. Later these cases were managed by open reduction and internal fixation with locking compression plate.

Concha et al [30] reported six cases cases of post-operative radial nerve palsy (neuroparaxia) which is greater than RNP reported by our study. Risk of iatrogenic radial nerve injury is low but still persists if the appropriate surgical technique is not used. The radial nerves were intact and recovered within 12 weeks of injury with post op rehabilitation in form of active/active assisted range of movement exercises and dynamic cock up splint in our study.

Kurup et al [15] reviewed five small trials comparing dynamic compression plates with locked intramedullary nailing which involved 260 patient and evidence shows that there was a statistically significant increase in shoulder impingement following nailing when compared with plating (five trials, RR 0.12; 95% CI 0.04 to 0.38). Oh et al [28] compared standard conventional plating with versus minimal invasive plating and concluded that minimally invasive plate osteosynthesis may achieve comparable
results with the open plate osteosynthesis method in simple as well as complex fractures of humeral shaft. Hence, the traditional open plating is a rotator cuff safe technique; however, biological disruption of soft tissue, poor cosmetic scarring, and direct handling of the radial nerve have been always of concern. On the other hand, the classical intramedullary nailing is minimally invasive, but it has the main drawback of potentially damaging the rotator cuff and causing shoulder impingement \cite{7,12,14,16,17}. On contrary MIPO technique with anterior approach is a technique which respects the biological fixation principles and causes minimal soft tissue assault while preserving the fracture haematoma and periosteal blood supply which aids in fracture healing. Considering the advantages and drawbacks of all procedures, MIPO emerges as a better option with regard to patient functional and radiological outcome, and is more reliable in comminute fractures of the diaphysis of humerus.

Conclusions

Anterior Bridge Plating with MIPO technique is a technically demanding surgical technique which has a long learning curve. There were few hurdles which we came across while performing surgery like indirect reduction of the fracture, placement of the plates while maintaining the fracture reduction. We prevailed these hurdles by patience and consistence till we mastered this technique in a course of time. The radiological and functional assessment was increased significantly with time. However more studies have to be done to standardize the protocol. To conclude Anterior Bridge Plating with MIPO technique is an acceptable modality of treatment.

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