Original Article

Journal of Orthopedic Education
Volume 6 Number 3, September–December 2020
DOI: http://dx.doi.org/10.21088/joe.2454.7956.6220.8

Comparative Study between Anterior Bridge Plating and Posterior Plating for Fracture Shaft Humerus

Pradeep Choudhari[1], Neeraj Jain[2], Yogesh Patel[3]

Author Affiliation: [1]Professor and Unit Head, [2]Assistant Professor, [3]Yogesh Patel, PG Resident, Department of Orthopedics & Traumatology, Sri Aurobindo Institute of Medical College & Post Graduate Institute Indore, 452003, Madhya Pradesh, India.

Corresponding Author: Pradeep Choudhari, Professor and Head, Department of Orthopedics and Traumatology, Sri Aurobindo Institute of Medical College and Post Graduate Institute Indore, Madhya Pradesh 453555, India.

E-mail: pchoudhari@rediffmail.com

How to cite this article:

Pradeep Choudhari, Neeraj Jain/Comparative Study Between Anterior Bridge Plating And Posterior Plating For Fracture Shaft Humerus. J orth. Edu. 2020;6(3):65–71

Abstract

Introduction: Fractures of the humeral shaft are common, accounting for approximately 3% of all orthopaedic injuries. With improved and newer implants design and surgical techniques, surgical management of humeral shaft fractures has increasingly become accepted.

The purpose of this study is to compare the functional and clinical outcomes of conventional open reduction and internal fixation (ORIF) by posterior plating with minimally invasive plate osteosynthesis (MIPO) done by anterior approach in patients with fractures in humeral shaft.

Patients and Methods: In the current prospective-retrospective study, 30 patients with humeral shaft fractures were treated using ORIF (15 patients) or MIPO (15 patients) in our institute & followed up for 12 months.

Comparison made between surgical duration, mean blood loss, time of union and complications in these two groups. Also, Mayo Elbow performance indexes (MEPI) and simple shoulder test (SST) questionnaire were used to compare the functional outcomes between the two groups.

Results: In our study, for MIPO group, the mean blood loss was 118.67 ± 34.98 ml, while in the ORIF group it was 357.33 ± 51.61 ml. For MIPO group, the mean duration of surgery was 79.33 ± 10.15 min, while in the ORIF group it was 111.00 ± 13.91 min. The mean union time in MIPO was 12.73 ± 1.75 weeks, while in ORIF group it was 15.87 ± 1.88 weeks. The difference was found to be statistically significant ($p<0.05$), showing a higher mean duration of surgery in the ORIF with posterior plating group.

The mean Mayo Elbow Performance Index at the end of 12 month follow up for the

MIPO group was 94.67 ± 7.19, while in the ORIF group was 92.33 ± 6.51. The difference was found to be statistically not significant ($p>0.05$). The mean points for the SST (max 12) for MIPO group and ORIF group were 11.73 ± 0.46 and 11.73 ± 0.59.

Conclusions: The MIPO technique provides early union time, to some extent fewer complication rate than open plating and similar functional and clinical outcomes, the authors recommend to use the MIPO technique in treating the humeral shaft fracture.

Keywords: Humeral Shaft; Minimally Invasive Surgical Procedures; Internal Fracture Fixation.

Introduction

Fractures of the humeral shaft are common; accounting for approximately 3% of all orthopaedic injuries.[1]With improved implant designs and surgical techniques, operative management of humeral shaft fractures has increasingly become accepted.[2,3]

Plate and screw fixation remains the gold

standard for surgical treatment[4].Generally; the anteromedial approach is avoided due to the vulnerable positioning of the brachial artery and median nerve with respect to the humeral shaft. Comparing to anterolateral and posterior approach, posterior approach is more preferred due to plate application on tensile surface.

The main advantage of compression plate fixation for humeral shaft fractures is that it is a very rigid stabilization technique. The rotation, length and angulation of the fracture site can all be strictly controlled using this method, and numerous studies have documented the effectiveness of this method in treating humeral shaft fractures5,6,7,8.

One problem associated with this technique is that it requires a fairly wide surgical incision and thus increases the risk of infection and longer scar. Pre-operative prophylactic antibiotics help in reducing this risk.

The humeral shaft fractures can be successfully treated with minimally invasive plating osteosynthesis (MIPO)9-13. This technique has benefits of less soft tissue damage and avoids exposure of the radial nerve; thus, there is also minimum risk of intra operative radial nerve palsies10. The purpose of our study is to compare the functional and clinical outcomes of open reduction and internal fixation (ORIF) by posterior approach with minimally invasive plate osteosynthesis (MIPO) in patients with humeral shaft fractures.

Patients and method: Present study consists of 30 patients, undergoing fracture shaft humerus surgery, were included in the study and after prior informed written consent in tertiary centre. Patients operated from January 2013 to June 2017 were included. The criteria used for selection were: 1.Closed Fracture shafts humerus in Adult and 2.Transverse, oblique and spiral fracture of shaft humerus. The exclusion criteria were: 1.

Patients with brachial plexus injury, who were not able to do the active flexion extension of the elbow,. 2. Proximal humeral shaft fractures extending to the humeral head and fracture extending to distal humerus. 3. Pathological fractures. 4. Compound fractures. 5. Comminuted fractures.

AO/OTA classification was used, which is based on increasing severity according to the complexities of the fracture (type A-simple, type B-wedge, type C-comminuted). The patients were treated either by the MIPO technique (group A) and or by open reduction and plating internal fixation (ORIF)(group B).There were 15 cases in group A (9 males, 6 females) with average age of 38.80 ± 12.98 years (25-70 years). The left arm was involved in eight cases and the right arm in seven. Causes of injuries were road traffic accidents in 11 patients, and falls in four. According to AO-OTA classification, 11 patients had 12-A and 4 patients had 12-B classification.

There were 15 cases in group B (nine males and six females) with mean age of 37.47 ± 11.91 years

(23-64 years).The left and right arms were involved in 11 & four cases respectively. Five cases were caused by injury from a fall and ten by road traffic accident. Nine fractures were involving the middle third humeral shaft and six were at the distal third. One case in this group was associated with traumatic radial nerve palsy; intra-operatively complete nerve transaction was found and repaired.According to AO classification, 9 patients had 12-A and 6 patients had 12-B classification in this group. Demographic and injury characteristics were similar in two groups of treatment ($P > 0.05$).

Surgical approaches: Minimally Invasive Plate Osteosynthesis (MIPO): Closed reduction was the crucial step in the whole procedure, which was done under image intensifier guidance.Two small incisions, a 3 to 4 cms longitudinal incision starting just below the coracoid process of scapula, running down in the line of the deltopectoral groove and another 3 to 4 cms longitudinal incision, overlying the lateral border of the biceps brachii muscle in the lower third of the arm, were made on the anterior side of the arm. A sub-muscular plane was prepared between the brachialis muscle and periosteum with help of periosteum elevator inserted from the proximal incision distally and then from the distal incision proximally. A 4.5mm narrow dynamic compression plate (DCP, 10-12 holes) was inserted from the distal incision, passing the fracture site while maintaining the reduction, and up to the

Proximal incision: At least three screws and six cortices were inserted in either side of fracture fragments. The radial nerve was not exposed during the whole procedure. Wound closure was done in the standard way, no drain tube is required.

Posterior Approach (ORIF): The patient is positioned in the lateral decubitus position with the arm abducted 45-60 degrees on a radiolucent arm support. A longitudinal incision is given in the midline of the posterior aspect of the arm. There is no true inter-nervous plane; dissection involved separating the two heads of the triceps brachii muscle, all are supplied by the radial nerve.Incision is given on the deep fascia of the arm in line with the skin incision. To identify the gap between the

lateral and long heads of triceps muscle, begin proximally, above the point where the two heads fuse to form a common tendon. At the proximal part of incision the space between the two heads of triceps is developed by blunt dissection of muscle, retracting the lateral head laterally and the long head to the medial side.

Distally, the muscle is divided by sharp dissection along the line of the skin incision.As medial head of the triceps muscle lies below the other two heads of muscle; the radial nerve lies proximal to it in the spiral groove. The radial nerve, which runs just proximal to the origin of the muscle in the spiral groove, is taken care of by feeding tube separating it from the zone of surgery and hence preserved. The medial head is incised in the midline, continuing the dissection deep up to the periosteum of the humerus.The fracture site is exposed and hematomais removed. The fractures are reduced and plate is applied to fix the fractures. The stability of the bone-plate construct is checked by doing passive motion at the shoulder and elbow. The wound is closed after placing a drainage tube sub-muscularly (if required).

Post-operatively, patients treated by either ORIF or MIPO were kept their arm placed in an arm pouch. Those with stable internal fixation started their physiotherapy 2 to 3 days after the operation with shoulder and elbow movements, as tolerated.

Patients operated with MIPO technique, flexion and extension of the elbow and pendulum exercises of the shoulder allowed, but rotation of the arm should be started after 4-6 weeks. Routine follow-up radiographs were taken at 1 month, 3 months, and 6 months and 12 months postoperatively.

For data collection, surgical duration was defined as time between skin incision and skin suturing.

Other parameters used for the comparison were union time, complications, blood loss during the procedure and functional assessment. Union at fracture is defined as the absence of pain and the presence of bridging callus in at least three out of four cortices seen on the antero-posterior and lateral radiographic views of the humerus.

Functions were assessed using the Mayo elbow performance index (MEPI), which evaluates patients on a 100-point scale regarding pain (45 points), range of motion (20 points), stability (10 points) and function (25 points). Function of the joint is classified as excellent (>90 points), good (75 to 89 points), fair (60 to 74 points) or poor (<59 points).

The Simple Shoulder Test (SST) contains a series of 12 “yes” or “no” questions, the patient answers about the function of the involved shoulder. The answers to these questions provide a standardized way of recording the function of a shoulder after treatment. The Simple Shoulder Test is standardized, simple, short and practical. The success of a treatment method is determined largely by its ability to restore function.The SST provides a practical method for evaluating results. Independent sample t test and One-way ANOVA test were used to compare the result of patients’ age, surgery duration, bone healing time and score of SST and MEPI. p value < 0.05 was considered statistically significant.

Results

There was no significant difference in mean age (t=0.293, P=0.772).The mean duration of injury to surgery interval for group A was 3.00±1.19 days (range 1-7 days), while for group B it was 3.27±1.62 days (range 1-5 days). There was no statistical significance between the two groups (t=0.512, P=0.613). The mean operation time was 79.33±10.15 minutes (range 70-100) in group A and 111.00±13.19 minutes (range 95-150) in group B (t=-7.121, P=0.000). The difference was found to be statistically significant (p<0.05), showing a higher mean duration of surgery in the ORIF by posterior plating group. The mean blood loss was 118.67±34.98 ml (range 140-250) in group A and 357.33±51.61 ml (range 300-450) in group B (t=-10.601, P=0.000). The difference was found to be statistically significant (p<0.05), showing a higher mean blood loss in the ORIF with posterior plating group. The mean union time in group A was 12.73 ± 1.75 weeks, while in group B it was 15.87 ± 1.88 weeks (t= -3.211, P=0.003). The difference was found to be statistically significant (p<0.05), showing a longer union time in the ORIF with posterior plating group. The mean SST in group A was 11.73 ± 0.46, while in group B was 11.73 ± 0.59.The difference was found to be statistically not significant (p>0.05), showing a comparable mean SST between the two groups. The mean Mayo Elbow Performance Index in group A was 94.67 ± 7.19, while in group B was 92.33 ± 6.51. The difference was found to be statistically not significant (p>0.05), showing a comparable mean Mayo Elbow Performance Index between the two groups. Also, the comparison of mean union time in relation to age group was found to be statistically not significant (p>0.05), showing that the mean union time was comparable between the age groups. Two patients from each

group developed superficial infection and all the patients had recovered.

Discussion

There are several methods of surgical intervention for humerus shaft fractures fixation, the internal

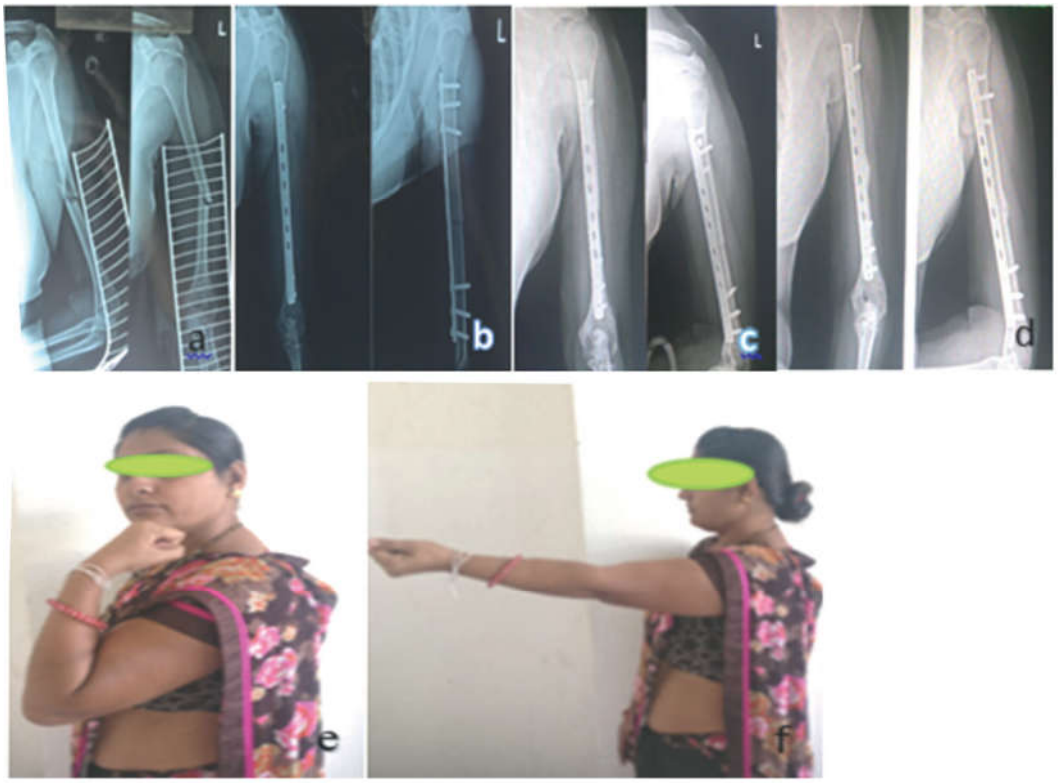

Fig. 1: A 29-year-old female, trauma due to road traffic accident was treated with the MIPO technique. a Preoperative radiograph shows a mid-third humeral shaft fracture (OTA 12-A2). bpost operative, c 3 months follow up, d 12 months follow up radiographs. e& f clinical images performing function at elbow joint.

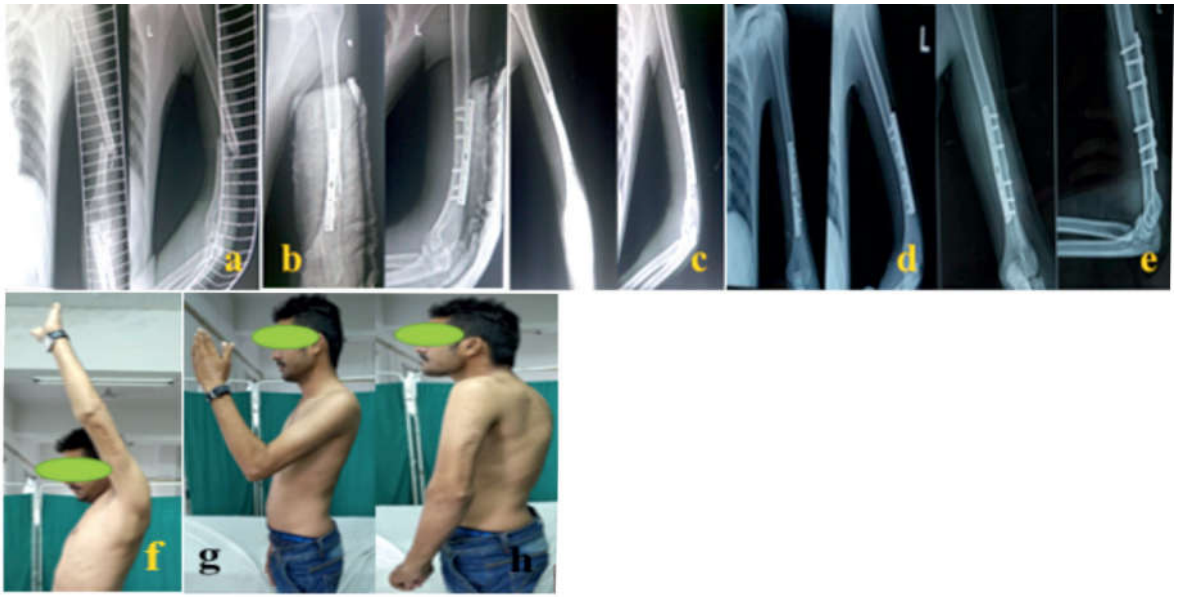

Fig. 2: A 23-year-old male, trauma due to road traffic accident was treated with the ORIF technique. a Preoperative radiograph shows a humeral shaft fracture (OTA 12-B2). bpost operative, c 1 month follow up, d 3 months follow up, e 12 months follow up radiographs. f, g & h clinical images performing function at shoulder and elbow joint.

fixation methods can be broadly grouped as plating or intra-medullary techniques.

Interlocking nailing is preferred in comminuted, segmental and pathological fractures, while plating may be the preferred option where exploration of radial nerve is contemplated.[14,15,16] Conventional plating techniques involve an extensive surgical exposure for open reduction of fracture, but good results from minimally invasive plating methods have been reported recently.[12,17,18] Infection, nonunion and radial nerve palsy are general concerns found in the plating group [19,20,21] But in a published meta-analysis, results of plate fixation from pooled data did not show higher risks of nonunion, infection, or radial nerve palsy.[2]Restriction of shoulder movements and risk of delayed union have been suggested as concerns with the intramedullary techniques.[2,3,14,19-22] Restriction of shoulder function with the ante-grade interlocking nails could be because of impingement due to proximal migration of nail, rotator cuff injuries, adhesive capsulitis or due to an unexplained cause.[18,22,23,24] This problem can be minimized by using a retrograde nailing technique but there is also a risk of elbow movement restriction and fracture at the insertion point.[18,19,21] Few articles says increased incidence of elbow stiffness with the plating group.[22] Hunter (1728-1793) supported Albrecht Haller's (1708- 1777) theory that bone was deposited in response to injury from the vascularity around the reparative zone.[24]

Minimally invasive methods for fracture treatment are evolving and becoming increasingly popular. Krettek and Tscherne first published report of MIPO for supracondylar femoral fractures in 1996.[25] Long plates were bridging large zone of comminution, with only short fixation on either side of the bone, will withstand considerable deformation forces.As bending stresses are distributed over a long segment of the plate, the stress per unit area is correspondingly low, leading to reduction of the risk of plate failure.[26,27] MIPO for humeraldiaphyseal fractures has been reported earlier[9,10,11,28] with fair results.

MIPO gives benefit over open reduction and plate fixation of humerus fractures by decreasing trauma to the soft tissue during surgery and maintaining the periosteal circulation.

Plate application on the bone by an open technique interferes with the local vascularization, leading to osteonecrosis beneath the implant, which can lead to delayed healing or non-healing (the reported rate of non-union being 5.8%).[29] The primary bone healing without callus formation is not very strong and there exists a real risk for re-fracture after removal of the implant[30,31] in the open technique.

In the present study, we compared the functional and clinical result between MIPO and ORIF with plating. Surgery was performed primarily on patient selected based on our inclusion criteria and patient were regularly followed up. As indicated by our outcomes, in both groups, fracture healing occurred in all the patients, and the functional outcomes were also excellent based on the Mayo scoring system. Therefore, we trust that MIPO is a safe and very effective method for humeral shaft fractures.

In our study, we observed significant difference in the union rate and no difference in radial nerve safety between the ORIF and MIPO groups. An et al[32] reported that compared with conventional plating techniques, MIPO offers advantages in terms of the reduced incidence of iatrogenic radial nerve palsies and accelerated fracture union.Even in simple fractures, MIPO showed an excellent union rate, which may have potentially resulted from the biologic superiority with less stripping and the preservation of vascularity. However, An et al32's study shows higher incidence of iatrogenic radial nerve palsy (31.3%) in the conventional plating group, whereas the incidence in the MIPO group was 0%.

In our study, we observed no cases of iatrogenic radial nerve palsy in either group. Minimal invasive plate osteosynthesis have small incisions and it is relatively safer with no extensive soft tissue and fracture site opening compared to open reduction with plate fixation. In study by Sanjeevaiahet al[33], mean blood loss was 85 ml for MIPO group. In study by Lu S et al[34], mean blood loss for ORIF group was 278.33 ml. In our study, for MIPO group, the mean blood loss was 118.67 ± 34.98 ml, while in the ORIF group it was 357.33 ± 51.61 ml.

The range of mean surgery duration of 92.3 to 125.2 mins for MIPO group and 103.1 to 116 mins for ORIF group in other studies[32,35,36,37,38]. In our study, for MIPO group, the mean duration of surgery was 79.33 ± 10.15 min, while in the ORIF group it was 111.00 ± 13.91 min. The difference was found to be statistically significant ($p<0.05$), showing a higher mean duration of surgery in the ORIF with posterior plating group.

This parameter mainly depends on the technique used and skill of surgeon to that specific technique performed. We have compared the functional outcome with Mayo Elbow Performance Index

(MEPI) and Simple Shoulder Test questionnaire (SST). The MEPI has the excellent results in 12/15 patient in MIPO group and 10/15 patient in ORIF group.

The mean Mayo Elbow Performance Index at the end of 12 month follow up for the MIPO group was 94.67 ± 7.19, while in the ORIF group was 92.33 ± 6.51. The difference was found to be statistically not significant ($p>0.05$), showing a comparable mean Mayo Elbow Performance Index between the two groups and is consistent with the other studies.32,35,36,37,38 The mean points for the SST (max 12) for MIPO group and ORIF group were 11.73 ± 0.46 and 11.73 ± 0.59.

Conclusion

We compared the functional and clinical result between MIPO and ORIF with plating. Surgery was performed primarily on patients, selected based on our inclusion criteria and patient were regularly followed up. As indicated by our outcomes, in both groups, fracture healing occurred in all of the patients, and the functional outcomes were also excellent based on the Mayo scoring system. Therefore, we trust that MIPO is a safe and very effective method for humeral shaft fractures.

References

1. http://www.who.int/entity/violence_injury_prevention/publications/road_traffic/world_report/chapter2.pdf
2. Bhandari M, Devereaux PJ, McKee MD, Schemitsch EH. Compression plating versus intramedullary nailing of humeral shaft fracturesda meta-analysis. ActaOrthop 2006; 77: 279- 84.
3. Chapman JR, Henley MB, Agel J, Benca PJ. Randomized prospective study of humeral shaft fracture fixation: intramedullary nails versus plates. J Orthop Trauma 2000; 14: 162-6.
4. Crenshaw AH, Perez EA. In S. Canale T, Beatyj H. Campbell's Operative Orthopaedics, 11th ed, Mosby, Philadelphia, 2008.
5. Heim D., Herkert F., Hess P., Regazzoni P. Surgical treatment of humerus shaft fractures – the Basel experience. J.Trauma, 1993; 35: 226-232.31
6. Dabezies EJ, Banta CJ, Murphy CP, d'Ambrosia RD. Plate fixation of the humeral shaft for acute fractures with and without radial nerve injuries.J Orthop Trauma 1992; 6:10-3.
7. Bell MJ, Beauchamp CG, Kellam JR, McMurtRY. The results of plating humeral shaft fractures in patients with multiple injuries: the Sunnybrook experience. J Bone Joint Surg [Br] 1985; 67-B: 293-6
8. Vander Griend RA, Tomasin J, and Ward EF. Open reduction internal fixation of humeral shaft fractures: results using AO plating techniques. J Bone Joint Surg (Am). 1986; 68-A: 430-433.
9. Apivatthakakul T, Arpornchayanon O, Bavornratanavech S. Minimally invasive plate osteosynthesis (MIPO) of the humeral shaft fracture. Is it possible? A cadaveric study and preliminary report. Injury 2005; 36(4):530–538.
10. Zhiquan A, Bingfang Z, Yeming W et al. Minimally invasive plating osteosynthesis (MIPO) of middle and distal third humeral shaft fractures. J Orthop Trauma 2007; 21(9):628–633.
11. Ziran BH, Belangero W, Livani B et al. Percutaneous plating of the humerus with locked plating: technique and case report. J Trauma Inj Infect Crit Care. 2007; 63(1):205–210.
12. Livani B, Belangero W, Andrade K et al (2008) Is MIPO in humeral shaft fractures really safe? Postoperative ultrasonographic evaluation. IntOrthop.doi:10.1007/s00264–008–0616-x.
13. Ji F, Tong D, Tang H et al (2008) Minimally invasive percutaneous plate osteosynthesis (MIPPO) technique applied in the treatment of humeral shaft distal fractures through a lateral approach. IntOrthop. 2008 doi:10.1007/s00264–008–0522–2.
14. McCormack RG, Brien D, Buckley RE, McKee MD, Powell J, Schemitsch EH. Fixation of fractures of the shaft of the humerus by dynamic compression plate or intramedullary nail.Aprospective, randomized trial. J Bone Joint Surg Br. 2000; 82(3):336–339.
15. Pollock FH, Drake D, Bovill EG, et al. treatment of radial neuropathy associated with fracture shaft of humerus. JBJS (A) 1981; 63: 239-243.
16. Chao TC, Chou WY, Chung JC, Hsu CJ.Humeral shaft fractures treated by dynamic compression plates, Ender nails and interlocking nails. IntOrthop. 2005;29(2):88–91. doi: 10.1007/s00264-004-0620-8.
17. An Z, He X, Zeng B. [A comparative study on open reduction and plating osteosynthesis and minimal invasive plating osteosyn¬thesis in treating mid-distal humeral shaft fractures]. ZhongguoXiu Fu Chong JianWaiKeZaZhi. 2009;23(1):41–4.
18. Stern PJ, Mattingly DA, Pomeroy DL, Zenni EJ, Jr, Kreig JK. Intramedullary fixation of humeral shaft fractures. J Bone Joint Surg Am. 1984;66(5):639–646.
19. Hall RF, Panrovick. Ender nailing of acute fractures of the humerus. J Bone Joint Surg. 1987; 69A: 558 - 567.
20. Rodriguez. Fixation of fractures of the shaft of the humerus by dynamic compression plate or intramedullary nail. J. Bone Joint Surg (Br)Volume 82-B (7), September 2000, p 1085
21. Tsai CH, Fong YC, Chen YH, Hsu CJ, Chang CH, Hsu HC. The epidemiology of traumatic humeral

shaft fractures in Taiwan. IntOrthop. 2009;33(2):463–467.

22. Changulani M, Jain UK, Keswani T. Comparison of the use of the humerus intramedullary nail and dynamic compression plate for the management of diaphyseal fractures of the humerus. A randomised controlled study. IntOrthop. 2007;31(3):391–395. doi: 10.1007/s00264-006-0200-1.
23. Raghavendra S, Bhalodiya HP. Internal fixation of fractures of the shaft of the humerus by dynamic compression plate or intramedullary nail: A prospective study. Indian J Orthop. 2007;41(3):214–218. doi: 10.4103/0019-5413.33685.
24. Hunter J. Collected works. In: Palmer JF, editor. $4 Vol. London: Longman Rees;1837.
25. Krettek C, Schandelmaier P, Tscherne H. Distal femoral fractures: Trans-articular reconstruction, percutaneous plate osteosynthesis and retrograde nailing [in German]. Unfallchirug 1996;99:210.
26. Schmidtmann U, Knopp W, Wolff C, Stürmer KM. Results of elastic plate osteosynthesis in polytraumatized patients: An alternative procedure. Unfallchirurg 1997;100: 94956.
27. Sturmer KM. Elastic plate osteosynthesis, biomechanics, indications and technique in comparison with rigid osteosynthesis. Unfallchirurg 1996;99: 816 7.
28. Fernandez DellOca AA. The principle of helical implants: Unusual ideas worth considering. Injury 2002;Suppl 33:A1 27.
29. Paris PH, Tropiano P, D'orval BC, Chaudet H, Poitout DG. Systematic plate fixation of humeral shaft fractures: anatomical and functional results in 156 cases and a review of the literature. Revue de chirurgieorthopédique; 2000; 86; 346-359.
30. Breederveld RS, Patka P, Van Mourik JC. Refractures of the femoral shaft.Neth J Surg 1985; 37:114.
31. Broos PL, Sermon A. From unstable internal fixation to biological osteosynthesis a historical overview of operative fracture treatment.ActaChirBelg 2004;104: 396400.
32. An Z, Zeng B, He X, Chen Q, Hu S. Plating osteosynthesis of mid-distal humeral shaft fractures: minimally invasive versus con¬ventional open reduction technique. IntOrthop. 2010;34(1):131–5.
33. Sanjeevaiah, Praneeth Reddy. "Minimally Invasive Plate Osteosynthesis (Mipo) in Humeral Shaft Fractures– Biomechanics–Design–Clinical Results". Journal of Evolution of Medical and Dental Sciences 2015; Vol. 4, Issue 54, July 06; Page: 9449-9456, DOI:10.14260/jemds/2015/1368.
34. Shun Lu, Junwei Wu, ShihongXu, Baisheng Fu, Jinlei Dong, Yongliang Yang, Guodong Wang, MaoyuanXin,Qinghu Li, Tong-Chuan He, Fu Wang, and Dongsheng Zhou. Medial approach to treat humeral mid-shaft fractures: a retrospective study. J OrthopSurg Res. 2016; 11: 32
35. Oh CW, Byun YS, Oh JK, Kim JJ, Jeon IH, Lee JH, et al. Plating of hu-meral shaft fractures: comparison of standard conventional plating versus minimally invasive plating. OrthopTraumatolSurg Res. 2012;98(1):54–60.
36. Esmailiejah AA, Abbasian MR, Safdari F, Ashoori K. Treatment of Humeral Shaft Fractures: Minimally Invasive Plate OsteosynthesisVersus Open Reduction and Internal Fixation. Trauma Mon. 2015 August; 20(3): e26271.
37. Kim JW, Oh CW, Byun YS, Kim JJ, Park KC. A prospective randomized study of operative treatment for non-comminuted humeral shaft fractures: conventional open plating versus minimal invasive plate osteosynthesis. J Orthop Trauma. 2015;29(4):189–94.
38. Wang C, Li J, Li Y, Dai G, Wang M. Is minimally invasive plating osteosynthesis for humeral shaft fracture advantageous compared with the conventional open technique? J Shoulder Elbow Surg. 2015;24(11):1741–8.