International Journal of Research in Orthopaedics
Ramachandra HB et al. Int J Res Orthop. 2023 Mar;9(2):396-404
http://www.ijoro.org

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20230470

Case Series

Prospective study comparing between plate osteosynthesis and antegrade interlocking nailing its functional and radiological outcome in treating humeral shaft fractures

Harshavardhan Bhaktharahalli Ramachandra, Praveen Narayan, Surya Sri Karun Chintapalli, Pothuri Rishi Ram*

Department of Orthopaedics, Sanjay Gandhi Institute of Trauma and Orthopaedics, Bangalore, Karnataka, India

Received: 27 October 2022
Revised: 19 December 2022
Accepted: 17 January 2023

***Correspondence:**
Dr. Pothuri Rishi Ram,
E-mail: rishiram@gmail.com

ABSTRACT

Humeral shaft fractures are common injuries making upto 1-3% of all fractures. They are widely treated by conservative methods leading to higher rates of non-union. Henceforth surgeons tend to perform operative procedures to treat them. To statistically analyse and compare the functional and radiological outcome of two treatment modalities of humeral shaft fractures, they are plate osteosyntheis and antegrade intramedullary nailing. A total of 22 patients of humeral shaft fractures were operated by either of two methods 12 in plating (P) group ,10 in nailing (N) group and their radiological outcome was assessed by rate of union, time taken for callus formation etc and their Functional outcome was analysed based on Rodriguez Merchan criteria. The commonest age group of patients operated is 21-40 years (70%) majority being males (70%) and road traffic accident being commonest mode of injury. The plate osteosynthesis group stands superior than nailing group in terms of duration of union (20 weeks), rate, percentage of union (100%), least risk of non-union (0). Statistically significant ($p<0.05$) improvement in shoulder joint function with minimal complications. The plate osteosynthesis method is the most promising surgical procedure for treating humeral shaft fracture due to negligible rates of non-union and early recovery of motion. Though nailing group has minimal need of soft tissue dissection, preserves fracture biology, decreased operative time and early rehabilitation period it still stands inferior when it comes to complications like rotator cuff injury, shoulder impingement pain and restriction of shoulder movements. Ultimately the post operative quality of life is equally good in both techniques.

Keywords: Humeral shaft fractures, Intramedullary nailing, Plate osteosynthesis, Upper limb trauma

INTRODUCTION

Fracture of shaft of humerus represents 3 to 5% of all fractures.[1] Current analysis focuses on shaping the incidence and health care resources required to treat these fractures, redefining the indications for surgical intervention, decreasing the surgical failure rate through new implants and techniques, and minimizing the period and magnitude of disability post injury.

The booming treatment doesn't finish with bony union however the present emphasis is on a holistic approach of patient care. The treatment of the humeral shaft fractures demands a sound knowledge of anatomy, surgical indications, techniques and implants, and patient limb functions.

The treatment strategies for fracture shaft of humerus includes

Conservative treatment

Coaptation splint: It is indicated for acute humeral shaft fractures with mild shortening and for transverse or short

oblique fracture patterns. Patient's axilla irritation and splint slippage are the disadvantages of this method

Velpeau bandage (Thoracobrachial immobilization):[2] It is indicated for minimally displaced or non-displaced fractures that do not need reduction. It should be changed for useful bracing one to a pair of weeks post injury.

Hanging arm cast: It is indicated for displaced midshaft humeral fractures with shortening, significantly spiral or oblique patterns. The patient should stay upright of semi-upright at all times with the cast in an exceedingly dependent position for effectiveness.

Functional bracing: This uses the mechanism of hydrostatic soft tissue compression to impact and maintain fracture alignment whereas permitting motion of adjacent joints. It is usually applied 1 to 2 weeks after the fracture is treated with coaptation splint or hanging arm cast

Surgical management

Plate osteosynthesis, intramedullary nailing, external fixation. McKee divided the indications for operative treatment into three classes

Fracture indications

Failure to get and maintain adequate closed reduction, shortening >3 cm, rotation >30 degrees, angulation >20 degrees, segmental fractures, pathologic fractures, intra-articular extension, shoulder joint and elbow joint

Associated injuries

Open wound, brachial plexus injury, vascular injury, ipsilateral forearm fractures, ipsilateral shoulder or elbow fractures, lower extremity fractures requiring upper extremity weight bearing, high-velocity gun-shot injury, burns and chronic associated joint stiffness

Patient indications

Head injury Glasgow coma scale 8, multiple injuries-polytrauma, chest trauma, unfavorable body habitus, poor patient tolerance, compliance, large breast and Morbid fatness

The goal of operative treatment of humeral shaft fractures is to re-establish length, alignment and rotation with stable fixation that permits early motion with early weight bearing on fractured extremity.

The plate osteosynthesis remains the gold standard of humeral shaft fractures fixation against which different strategies may be compared. Although it has high union rate, it involves extensive soft tissue dissection and periosteal stripping, chance of radial nerve injury and infection is there.

The intramedullary interlocking nailing has the advantage of very minimal surgical exposure and soft tissue dissection, with stable fixation and rotational. It can be done by either antegrade or retrograde manner.

CASE SERIES

Case 1

Age/sex-37/F, mode of injury-fall, extremity left, associated injury-none, type of fracture (AO)-A, time interval between injury-18 days, and surgery, nail size-7×240 mm, reduction-closed, post-op period-uneventful, mobilisation started-3rd day, time of union-20 weeks, range of movements-full, complications-nil, Rodriguez-Merchan criteria-excellent.

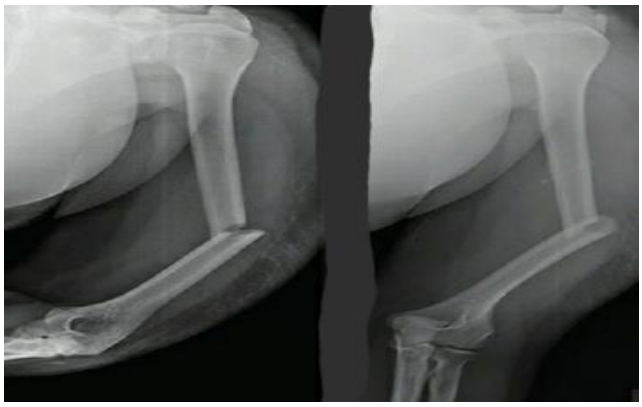

Figure 1: Pre-op (Case 1).

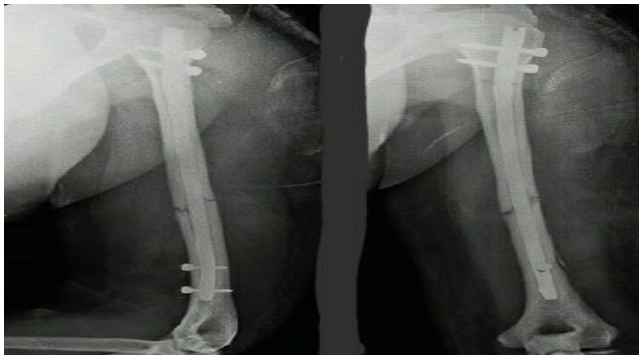

Figure 2: Immediate post op (Case 1).

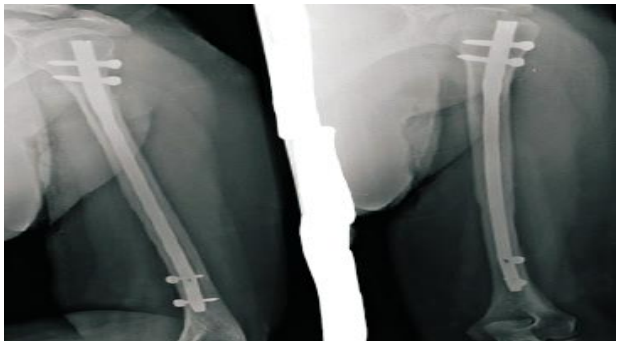

Figure 3: Six months follow up X-ray.

Case 2

Age/sex-60/M, mode of injury-RTA, extremity-left, associated injury-none, type of fracture (AO)-A, time interval between injury-10 days, and surgery, plate size-10 holed broad DCP, reduction-open, post-op period-uneventful, mobilisation started-10th day, time of union-18 weeks, range of movements, full complications-nil, Rodriguez-Merchan criteria-excellent.

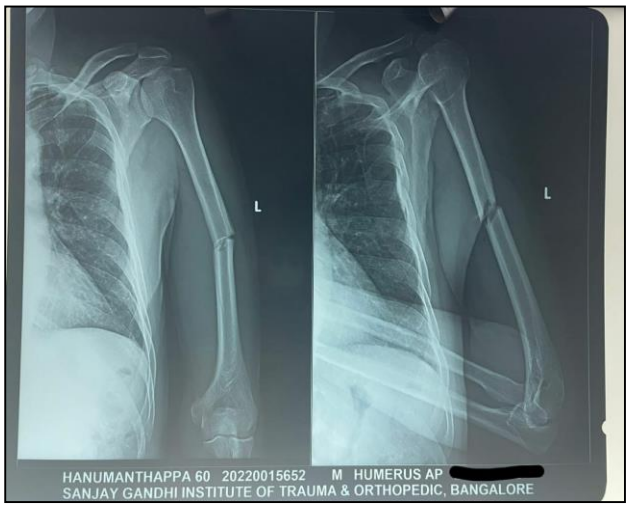

Figure 4: Pre-op (Case 2).

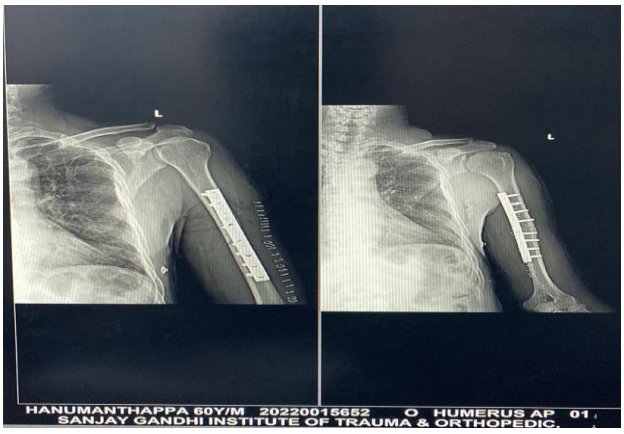

Figure 5: Immediate post op (Case 2).

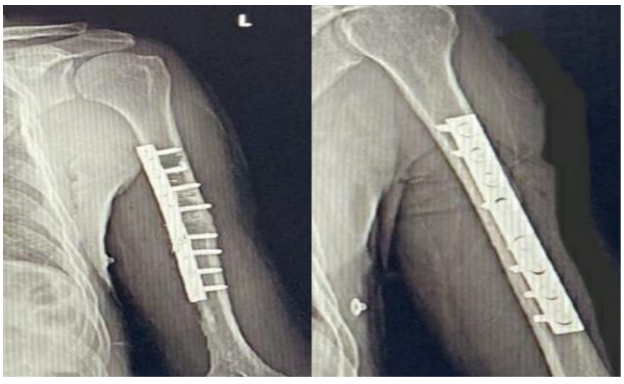

Figure 6: 3 months follow up X-ray.

Case 3

Age/sex-29/M, mode of injury-RTA, extremity-right, associated injury-none, type of fracture (AO), A time interval between injury-5 days, and surgery, plate size-10 holed broad DCP, reduction-Open, post-op period-uneventful, mobilisation started-14th day, time of union-16 weeks, range of movements, full complications-nil, Rodriguez-Merchan criteria-excellent.

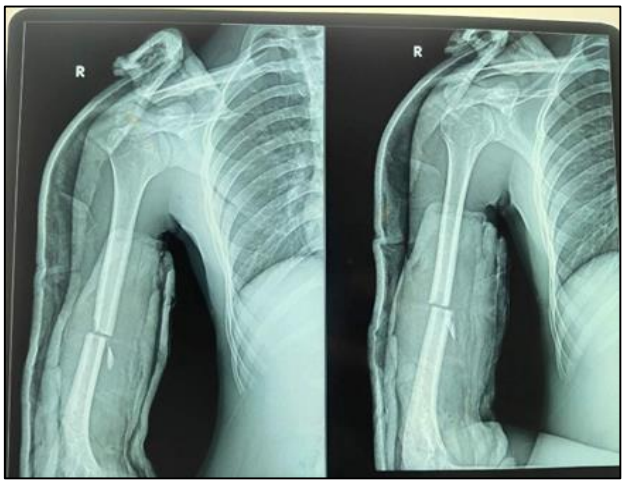

Figure 7: Pre op (Case 3).

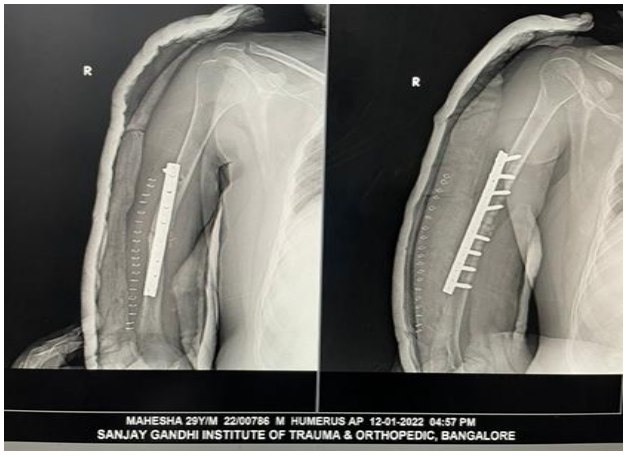

Figure 8: Immediate post op (Case 3).

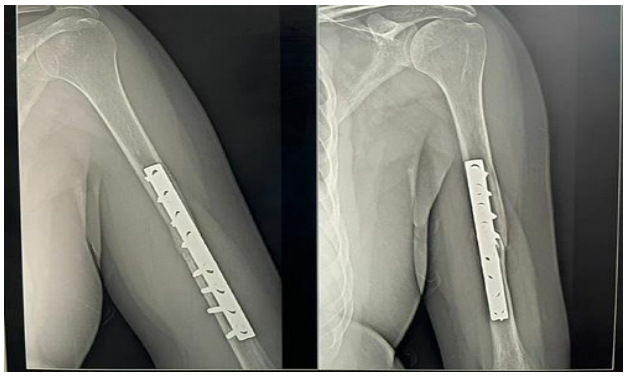

Figure 9: Three months follow up X-ray.

This is a prospective comparative study of 22 patients with humeral shaft fractures treated with plate osteosynthesis and intramedullary interlocking nailing done in the department of orthopaedics, in Sanjay Gandhi institute of trauma and orthopedics, Jayanagar, Bengaluru from August 2020 to August 2022.

Patients with scute fractures of humeral shaft, patients aged above 18 years, fractures 2 cm below surgical neck and 3 cm above olecranon fossa, multiple injuries, neurovascular involvement, osteoporotic bone, angulation more than 15 degrees, non-compliance in conservative treatment were included in the study.

Patients with open physis, age less than 18 years and fractures involving proximal 2 cm and distal 3 cm of the humeral diaphysis were excluded from the study.

Management

All cases are initially assessed for head injury and other associated injuries and resuscitated. Initial management was done with U-slab till the patient is fit for surgery.

Implant used for interlocking nailing

The nails are available in diameters of 6.0mm that are non-cannulated solid nails and the 7 mm cannulated nails. They can be inserted over 2.4 mm thick guide wire. The nails are available in various lengths starting from 160 mm onwards at increments of 10 mm. The proximal locking is provided from lateral to medial direction. The distal locking is 2 in number and both are static for the 6 mm solid nails and the proximal being dynamic and distal static for the 7 mm cannulated nails.

The distal locking is in the anteroposterior direction. The nail size is measured with the full-length x-ray from tip of greater tuberosity to 3cms above the proximal tip of olecranon fossa. Clinically it is measured by subtracting 5 cm from the tip of acromian to the lateral epicondyle of humerus. The best method is by a scanogram. It is a must to have all nail sizes and appropriate instrumentation. It is mandatory to have the C- arm image intensifier and a good technician. Bone graft was done in 1 patient where fracture was reduced by open method.

Surgical technique of IM nailing

Antegrade humerus nailing by closed method

Position of the patient

The patient is positioned supine on a fracture table with a sand bag under the shoulder and the whole upper limb is prepared and draped to keep the limb free.

Anesthesia

General anesthesia or regional block used.

Approach

Through lateral deltoid splitting approach with the image intensifier the entry point is made just medial to the greater tuberosity and in the area at junction between the articular surface of the head and greater tuberosity with a k-wire and passed into the medullary canal.

After splitting the deltoid, the Rotator cuff is exposed and split at the tendon of the supraspinatus. The entry point reamer is used over the k-wire and is enlarged, 45 cm guide wire is introduced through the entry point and is passed into the distal fragment after reducing the fracture closed and under the guidance of C-arm image intensifier. Progressive reaming was done over the guide wire upto 1 mm more than the desired nail size.

Nail insertion

The appropriate nail is mounted on the zig and inserted through the guide wire. The nail size should be carefully selected because over size nail may end up splintering the distal fragment. The nail is pushed to a level where the nail is not protruding out through the articular surface of the proximal humerus.

Distal locking

The size of nail are the 7 mm cannulated nails. The distal locking for the 7 mm cannulated nail was 4.5 mm self-tapping locking screws for which 3 mm drill bits were used. The distal locking is antero-posterior locking. Under image guidance a stab incision is made at the anterior aspect of forearm, the bicep and brachialis is split to expose the surface of the bone. Under image guidance appropriate drill bit is used and the distal screws are inserted.

Proximal locking

This is done using the proximal jig that is mounted with the nail. Care must be used to avoid the axillary nerve. The proximal locking is in the mediolateral plane.

Open reduction of fractures

This technique was used for fixing old fractures. Fracture site is exposed by anterolateral approach. Skin incision is made in the groove between the prominences of biceps brachii and deltoid. Cephalic vein is identified and ligated. Plane is created between the muscle bulk of biceps and deltoid. Brachialis is split in the middle to expose the fracture site. Fracture site is exposed as well as the freshened. Bone grafting may be placed to the promote fracture union.

Post-operative protocol

Immediately after surgery the limb is supported with an arm sling. Wound inspection was done on 2nd post

operative day, suture removal on 12th post operative day. In cases of nailing, active elbow and shoulder exercises started on 3rd day under the supervision of the physiotherapist.

Surgical technique of plate osteosynthesis

Implants used

The most commonly used plate for fixation of humeral shaft fractures is broad, 4.5-mm dynamic compression plate, occasionally, narrow, 4.5-mm, DCP is used for smaller bones.

For spiral or oblique fractures, the ideal construct consists of a lag screw with a neutralization plate, whereas transverse fractures are ideally suited for a compression plating technique. Bone graft was done in 3 cases.

Procedure[25]

Anaesthesia

General or regional block used.

Position of the patient

Lateral position with elbow flexed over a pillow and forearm hanging by the side.

Approach

Through posterior approach incision was made in midline upto the tip of olecranon in line with the humerus. The dissection is carried down to the triceps fascia and the fascia is incised. The radial nerve is identified and freed proximally and distally to allow for mobilization. The triceps is incised off the periosteum and the fracture site is exposed. After the fracture ends are freshened, the fragments are reduced and held with bone clamps or with a lag screw

Then it is fixed with 4.5 mm broad or narrow DCP in neutralization or compression mode.

Post-operative protocol

Wound inspection done on 2nd post op day. Suture removal done on 12th day in cases of plating, active shoulder and elbow started on 5th to 6th day once the pain level decreases under physiotherapist guidance and tolerability of the patient.

Observation and results

Majority of patients for the study both in the Interlocking nailing group and in the plating group are in the age group of 21 to 40 years (70-75%). Majority of the patients who sustained fracture shaft of humerus are males in both the interlocking nailing group and in the plating group.

Table 1: Age distribution.

Age (years)	Interlocking nailing	Plate osteosynthesis
21-40	6	8
41-60	3	1
61-80	1	3

Table 2: Sex distribution.

Sex	Interlocking nailing	Plate osteosynthesis
Male	7	9
Female	3	3

Table 3: Mode of injury.

Mode of injury	Interlocking nailing	Plate osteosynthesis
RTA	6	8
Fall	3	4
Assault	1	0

The commonest mode of injury in most of the cases in both the groups are due to road traffic accidents (60% in IL nailing group and 67% in plating group). The remaining are due to fall assault.

Table 4: Side of injury.

Side involved	Interlocking nailing	Plate osteosynthesis
Right	7	8
Left	3	4

60-70 % of the patients in the study have involvement of the right dominant side in both groups. The most common type of fracture in our study in both the groups is type A according to AO classification. The next frequent type is type B.

Table 5: fracture type.

AO type	Interlocking nailing	Plate osteosynthesis
Type A	6	7
Type B	4	5
Type C	0	0

Table 6: Associated injuries.

Associated injuries	N
Fracture both bones forearm on contralateral side	1
Fracture distal radius	2
Radial nerve injury	1

Comparison between plate osteosynthesis and interlocking nailing was done for a) Time taken for union, b) percentage of union, c) functional outcome and d) complications. Minimum time taken for union in group treated with interlocking nailing is 16 weeks and maximum is 28 weeks with average of 22 weeks, 1 case went in for non-union.

The minimum time for union in the group treated with plate osteosynthesis is 16 weeks and the maximum is 24 weeks with average of 20 weeks. All cases united within this period in this group. One case which is not united is due to distraction at the fracture site which was planned for exchange nailing.

Table 7: Time taken for union.

Surgical procedure	Time taken for union (Weeks)		Average (Weeks)
	Minimum	Maximum	
Interlocking nailing	16	28	22
Plate osteosynthesis	16	24	20

Table 8: Percentage of union.

Methods	Total no. of cases	United fractures	Percentage of union (%)
Intra-medullary nailing	10	9	90
Plate osteosynthesis	12	12	100

Table 9: Functional outcome.

Rating	Elbow rom	Shoulder rom	Pain	Disability
Excellent	Extension 5, flexion 130	Full rom	None	None
Good	Extension 15, flexion 120	<10% loss of total rom	Occasional	Minimum
Fair	Extension 30, flexion 110	10% to 30% loss	With activity	Moderate
Poor	Extesion 40, flexion 90	>30 % loss	Variable	Severe

Rodriguez Merchan criteria.

The functional range of movements in shoulder joint after nailing is excellent and good in 90% of patients and fair in 1 patient (10%). The decrease in movement in 1 patient is due to the impingement of nail. The elbow function recovered in almost all patients with 90% excellent result and 10% has good recovery. In this study 92% of cases have excellent and good results in shoulder function and 1 case had fair result. All patients treated with plate osteosynthesis had excellent to good functional outcome in elbow joint.

Table 10: Complications.

Complications	Interlocking nailing (%)	Plate osteosynthesis (%)
Non union	1 (10)	0
Infection	1 (10)	2 (16)
Shoulder impingement	1 (10)	0

Non union

In the group of patients treated with interlocking nailing 1 case went in for non-union (10%), for which subsequent exchange nailing was planned. In the group treated with plate osteosynthesis all cases united with an average period of 20 weeks.

Shoulder impingement and pain

In interlocking nailing group, 1 patient had shoulder impingement due to protrusion of nail due to prominence of the nail at the proximal end. In plate osteosynthesis group, no cases had shoulder impingement/ stiffness or pain.

Infection

In patients treated with interlocking nailing, 1 patient in whom the fracture reduction was done by open reduction had superficial infection which settled with parentral antibiotics. In patients who were treated by plate osteosynthesis, 2 patients developed superficial infection which settled with parentral antibiotics and all fractures went in for union.

DISCUSSION

Fractures of the humeral shaft comprises 3% to 5% of all fractures. The treatment choices range from conservative treatment like coaptation splint, velpeau bandage, hanging arm cast, functional brace etc. to surgical treatment like plate osteosynthesis, interlocking nailing and external fixation.

The indications for primary surgical management of these fractures are-patient with neuro vascular deficits, Holstein Lewis type of fracture with radial nerve palsy, if alignment cannot be maintained by closed methods, bilateral fractures, polytrauma patients, pathological fractures, floating elbow etc.

Although there are several studies regarding the fixation methods of humeral shaft fractures, it's still inconclusive regarding the definitive technique to be adopted for these fractures to get best outcome.

This study is principally to check the union rate of the fractures and functional outcome between the patients treated with plate osteosynthesis and those treated with interlocking nailing for fracture shaft of humerus.

In this study, the age group of patients in both the treatment method group ranges from 20 to 70 years with a mean age of 45 years.

Majority of the patients in this study are males and therefore the most common mode of injury is because of road traffic accident (around 70%) in both groups.

In this study one patient within the interlocking nailing group went for non-union (10%) and further needed secondary procedure. In a study by Putti et al showed a non-union rate of 8% in patients treated with interlocking nailing.[9]

This study shows no important distinction between the time of union with an average of 20 weeks within the Plating group and a mean of 22 weeks within the interlocking nailing group. Raghavendra et al in their study of 31 patients compared the time of union between the patients treated with plating and with interlocking nailing summarised that there's no significant distinction between the 2 groups.[10]

The anatomical configuration of the humerus shaft bone makes it prone for residual fracture site distraction. In our study the fracture site distraction occurred in 1 patient (10%) treated with nailing. In a study by Bhat et al, they showed distraction at the fracture site while nailing in about 8.1% of cases.[26]

In this study shoulder pain occurred in 1 out of 10 patients (10%) because of nail impingement. This is corresponding to the study by Stannard et al where they showed a happening of mild to moderate shoulder pain in a about 20% of the patients.[27] Additionally in a study done by Chapman et al there's significant reduction in shoulder movement within the nailing group.[6]

Bhandari et al have done another meta-analysis comparative study between compression plating and intramedullary nail fixation for fracture shaft of humerus and concluded that Plate fixation decrease the danger of reoperation and shoulder impingement.[3]

Heineman et al have done a meta-analysis of patients with fracture of humeral shaft treated with plate fixation and people treated with intramedullary nail fixation and noted that there is no important distinction between two groups.[4]

McCormack et al have done a randomized trial in 44 patients comparing fixation of fracture shaft of humerus with dynamic compression plate and with intramedullary nail and summarised that open reduction and internal fixation with a DCP remains the most effective treatment for unstable fractures of the humerus shaft and fixation by a IM nail could also be indicated for specific conditions, however is technically demanding and includes higher rate of complications.[5]

Chapman et al in a randomised control trial study of 84 patients comparing plate osteosynthesis and intramedullary interlocking nail fixation for fracture of humerus shaft summarized that both strategies achieve similar fracture stabilization and wound healing.[6]

Lazcarro et al in their study compared the prevalence of radial nerve injury when fixation of humeral shaft fractures with dynamic compression plate and intramedullary nailing and concluded that the surgical technique with DCP represents higher incidence of nerve injury may be due exposure and proximity to radial nerve throughout surgery.[7]

Flinkkila et al studied regarding the recovery of shoulder joint function after humeral shaft fracture comparing treatment between plate osteosynthesis and antegrade IM nailing and concluded that shoulder joint ROM does not recover to normal after humeral shaft fracture and antegrade IM nailing if performed properly is not responsible for shoulder joint impairment.[8]

Putti et al in their study of comparison between locked intramedullary nailing versus dynamic compression plating for humeral shaft fractures showed that complication rates were higher in intramedullary nailing group but functional outcome were equal in each modality.[9]

Raghavendra et al in their study on internal fixation of the shaft of humerus by dynamic compression plating or intramedullary nail have concluded that though there was no remarkable distinction between plating or nailing in terms of union, compression plating is that the most well acceptable method with better preservation of joint function and lesser requirement for secondary bone grafting.[10]

Maksod et al in their study compared both methods and reported that dynamic compression plating of humeral shaft fractures resulted in a higher rate of union in less duration of time with less complications than antegrade intrmedullary interlocking nailing.[11]

Rodriguez-Merchan showed in their study that functional outcome is higher in compression plating group and need for second surgical procedure was higher in nailing group while treating closed humeral shaft fractures.[12]

Changulani et al in their study inferred that complications like infection were found higher in plating group compared to shortening of the arm and restriction of shoulder movements because of impingement seen higher in the interlocking group.[13]

Singisetti et al in their prospective comparative study on nailing versus plating in fractures of humerus shaft reported that plating group had excellent results in terms of union.[14]

Stern et al in their study concerning intramedullary fixation of humeral shaft fractures found that complications developed in 67% of cases and 64% required a minimum of one extra secondary operative procedure.[15]

Jinn in his article on treatment of humeral shaft fractures with locked nailing and comparison with plate fixation showed that humeral locked nailing is a less invasive surgical procedure with much favorable treatment results than did plate fixation.[16]

Ingman et al showed in their study that closed locked intramedullary nailing for humeral shaft fractures provide stable fixation with minimal risks and advised as an alternative treatment method for osteoporotic and pathological fractures.[17]

Meekers et al from their study suggested that the plate fixation as the most favourable and recommended primary treatment for fractures of the humeral shaft except for pathological fractures, obese patients and open fractures.[18]

Niall et al in their study regarding compression plating outcome in humeral shaft fractures 49 patients showed no complications with union rate of 96% and concluded plating as the surgical treatment of choice.[19]

Kesemenli et al in their study comparing the results of intramedullary nailing and compression plate fixation in the treatment of humerus fractures showed that even with higher non-union rates, intramedullary nailing is the method of choice in humerus shaft fractures treatment due to low morbidity, minimal soft tissue dissection and easy application.[20]

Ajmal et al studied regarding the outcome in 33 patients treated with ante grade intramedullary nailing of humeral shaft fractures resulted in high risk of non-union and impairment of shoulder movements.[21]

Arpacioglu et al studied regarding the outcome of intramedullary interlocking nailing in 43 patients and showed that it provides adequate fixation and early mobilization and results in expected radiographic and functional results.[22]

Baltov et al compared both treatment strategies and inferred that interlocking nailing reduces the danger of nerve injury and infection and provides a lot of stability in segmental, complex fractures and juxta articular fractures and no important differences in terms of duration of healing in both groups.[23]

Daryll et al compared the 2 procedures and suggested plating for shaft of humerus fractures with distal extension, vascular injury or nerve injury and nailing for fractures with proximal extension, segmental or comminuted fractures and pathologic fractures.[24]

CONCLUSION

By the end of our study, we came to the conclusion that plate osteosynthesis required extensive dissection and had chances of infection and risk of nerve injury but provided adequate compression at the fracture site with very less chances of non-union and almost no need for secondary procedure.

In our study, nailing proved to have lesser operative time and required minimal soft tissue dissection and also the incidence of infection is less in closed reduction and interlocking nailing group patients than in the patients treated with plating. On the contrary nailing causes distraction of the fracture site which results in non-union and the nail tip prominence at the entry site is the reason for the shoulder joint impingement and movement restriction in this group.

When two methods were compared in terms of duration of fracture union significant difference was not found.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

REFERENCES

1. Egol KA, Koval KJ, Zuckerman JD. Humeral Shaft Fractures. Handbook of Fractures, 4th Edition. 2019;203-13.
2. Mckee MD. Humeral Shaft Fractures. Rockwood and Green's Fractures in Adults, 7th Edition. 2012;1001-36.
3. Bhandari M, Devereaux PJ, McKee MD, Schemitsch EH. Compression plating versus intramedullary nailing of humeral shaft fractures-a meta-analysis. Acta Orthopaedica. 2006;77(2):279-84.
4. Heineman DJ, Poolman RW, Nork SE, Ponsen KJ, Bhandari M. Plate fixation or intramedullary fixation of humeral shaft fractures An updated meta-analysis. Acta Orthop. 2010;81(2):216-23.
5. McCormack RG, Brien D, Buckley RE. Fixation of fractures of the shaft of the humerus by dynamic compression plate or intramedullary nail. J Bone Joint Surg [Br]. 2000;82(3):336-9.
6. Chapman JR, Henley MB, Agel J, Benca PJ. Randomised prospective study of humeral shaft

fractures fixation: Intramedullary nailing vs plating. J Orthop Trauma. 2000;14:162-6.
7. Huerta Lazcarro J, Luna Pizarro D., A comparision of the prevalence of radial nerve lesion after fixation of humeral shaft fractures with dynamic compression plate versus intramedullary nailing. Acta Ortop Mex. 2008 22(5): 287 – 91
8. Flinkkila T, Hyvonan P, Siira P, Hamalainen M. Recovery of shoulder function after humeral shaft fractures. A comparative study between antegrade intramedullay nailing and plate fixation. Arch.Orthop. Trauma Surg. 2004;124(8);537-41.
9. Putti AB, Uppin RB, Putti BB. Locked intramedullary nailing versus dynamic compression plating for humeral shaft fractures. J Orthop Surg. 2009;17(2):139-41
10. Raghavendra S, Bhalodiya HP. Internal fixation of fractures of the shaft of the humerus by dynamic compression plate or intramedullary nail: A prospective study. IJO. 2007;41(3):214-8.
11. Maksod MG, Gaballa MA. Interlocking Nailing Versus Plating of Humeral Shaft Fractures. Pan Arab I Orth Trauma. 2010;6(1):17-23.
12. Rodriguez-Merchan EC. Compression plating versus hackethal nailing in closed humeral shaft fractures failing nonoperative reduction. JOrthop Trauma. 1995;9(3):194-7.
13. 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 randomized controlled study. Int Orthop. 2007;31(3):391-5.
14. Singisetti K, Ambedkar M. Nailing versus plating in humerus shaft fractures: A prospective comparative study. Int Orthop. 2010;34(4):571-6.
15. 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):639-46.
16. Jinn L. Treatment of Humeral Shaft Fractures with Humeral Locked Nail and Comparison with Plate Fixation. J Trauma Injury Infect crit Care. 2005;44(5):859-64.
17. Ingman AM, Waters DA. Locked Intramedullary Nailing of Humeral Shaft Fractures. Implant Design. Surgicl Technique, and Clinical Results. JBJS (Br). 1994;76-B(1):23-9.
18. Meekers FSL, Broos PLO. Operative Treatment of Humeral Shaft Fractures-The Leuven Experience. Acta Orthopædica Belgica. 2002;68-5.
19. Niall DM, O'Mahony J, McElwain JP. Plating of humeral shaft fractures- has the pendulum swung back? Injury. 2004:(35):580-6.
20. Kesemenli CC, Subasi M, Arslan H, Necmioglu S, Kapukaya A. Comparison between the results of intramedullary nailing and compression plate fixation in the treatment of humerus fractures. Acta Orthop Traumatol Turc. 2003:(37):120-5.
21. Ajmal M, O'Sullivan M, McCabe J, Curtin W. Antegrade locked intramedullary nailing in humeral shaft fractures. Injury. 2001:(32):692-4
22. Arpacioglu MO, Pehlivan O, Akmaz I, Kiral A, Oguz Y. Interlocking intramedullary nailing of humeral shaft fractures in adults. Acta OrthopTraumatol Turc, 2003;(37):19-25.
23. Baltov AG, Tzachev NN; Tivchev NP, Iotov AM. Operative Treatment of Humeral Shaft Fracture-Interlocking Nailing versus Plating. J Bone Joint Surg. 2010;91-B(I):180.
24. Daryll DC, Richard KF, Andrew SH. Operative Treatment of Humeral Shaft Fractures: Plates Versus Nails. Techniques in Shoulder and Elbow Surgery. 2001;2(3):194-209.
25. Beaty C. Open Reduction and Internal Fixation of the Humeral Shaft Fracture. Campbell's Operative Orthopaedics, 11th ed. 1986;3392-4.
26. Bhat SN, Rao SK. The Functional Outcome of Antegrade Unreamed Humeral Interlocking Nailing in Adults. J Orthop. 2005;2(1)e2.
27. Stannard JP, Harris HW, McGwin Jr G, Volgas DA, Alonso JE. Intramedullary nailing of Humeral Shaft Fractures with a locking Flexible Nail. JBJS Am. 2010;85:2103-10.

Cite this article as: Ramachandra HB, Narayan P, Chintapalli SSK, Ram PR. Prospective study comparing between plate osteosynthesis and antegrade interlocking nailing its functional and radiological outcome in treating humeral shaft fractures. Int J Res Orthop 2023;9:396-404.