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Original Research Article

A PROSECTIVE STUDY TO EVALUATE FUNCTIONAL AND RADIOLOGICAL OUTCOMES IN CLOSED HUMERUS SHAFT FRACTURES TREATED BY LOCKING COMPRESSION PLATE AND ANTEGRADE INTRAMEDULLARY NAILING AT A TERTIARY CARE CENTRE

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Abstract

Aim & Objectives: The aim of this study was to compare the functional and radiological outcomes between open reduction and internal fixation (ORIF) by locking compression plate (LCP) and closed reduction and internal fixation (CRIF) with antegrade interlocking nail (ILN) for the treatment of diaphyseal fractures of the humerus.

Materials & Methods: This is a prospective comparative study, with closed diaphyseal fractures of the humerus treated by LCP in 30 patients and with ILN in 30 patients after randomization in Gadag Institute of Medical Sciences, Gadag from the period of December 2022 to December 2024. Patients were followed up to 9 months. The clinical and radiographic outcomes were assessed in terms of union, complications and functional outcome using Rodriguez- Merchan criteria.

Results: Union was achieved in 90% of patients in LCP group and 86.6% in ILN group with average union time of 15.7 weeks and 14.6 weeks respectively. The mean blood loss in LCP group was 336.4 ±14.9 ml and in ILN group was 121.5 ±16.4 ml. The Rodriguez- Merchan criteria showed excellent and good results in 27/30 and 25/30 patients in LCP group and ILN group respectively. Complication rates were higher in ILN group with radial nerve palsy in 4 patients compared to 2 patients in LCP group and also with shoulder stiffness.

Conclusion: Our study concludes that ORIF with Locking Compression Plate can be considered a better surgical option for the management of diaphyseal fractures of the humerus as it had lower incidence of complications and similar union rate. However, there is no significant difference between the two groups in terms of union time and functional outcome.

Keywords: Humerus shaft/ diaphysis fracture, ORIF, LCP, CRIF, ILN, Locking compression plate, Intramedullary interlocking nail

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INTRODUCTION

Fractures of the humeral diaphysis and their complications are a major cause of morbidity in trauma patients.[1] Fractures of the humeral shaft account for 20% of humeral fractures[2] and approximately 3% to 5% of all fractures.[3,4] Options for the treatment of humeral shaft fractures include functional bracing, intramedullary interlocking nailing (ILN), internal plate fixation, and external fixation.[5]

Plate fixation results in high rates of union but requires extensive open surgery with stripping of the soft tissues from the bone.[6] It also provides less secure fixation, especially in osteoporotic bone and if crutch walking is required.[7] However, some studies recommend ILN as a standard surgical method through either antegrade or retrograde nailing,[8,9] whereas other studies report that ILN may lead to damage of the shoulder joint[10] and a poor union rate.[11] Therefore, the efficacy of plate fixation and ILN is still debated.[12]

Many randomized, controlled trials have reported dynamic compression plate (DCP) fixation and ILN fixation of humeral shaft fractures.[1,4,8,12-18] However, it is unclear whether one method is more effective than the other. The newly developed locking compression plate (LCP) system, which has specially designed combinations of holes that allow the system to be used both as a conventional DCP[19] and as a locked internal fixator,[20] can offer improved fixation stability over conventional DCP.[21] The goal of the current study was to evaluate and compare the ILN and the LCP for the treatment of humeral shaft fractures with regard to union time, union rate, functional outcomes, and incidence of complications.

Materials & Method: A prospective comparative study was conducted in Gadag Institute of Medical Sciences, Gadag from the period of December 2022 to December 2024. All patients who were included in the study were thoroughly examined after history taking and an informed consent was taken. The patients were randomly assigned into either the plating or the nailing group. 30 of the patients underwent ORIF with locking compression plates and 30 underwent CRIF with intramedullary interlocking nails.

All patients aged more than 17 years (with humerus physes closed), with shaft humerus fractures less than 2 weeks old requiring surgery were included in the study. Patients aged less than 17 years, those with pathological fractures, open fractures, those with neurovascular deficits, patients medically unfit for surgery and compound fractures were excluded from the study.

The patients in the plating group were operated with either the posterior approach or antero-lateral approach. The posterior approach was preferred in fractures of middle- distal third of shaft humerus where it was possible to identify and secure the radial nerve before fixation. The antero-lateral approach was preferred for fractures in the upper- middle third region fractures. The fracture was fixed with a 4.5mm Locking Compression Plate. A minimum of 6 cortices were purchased on either side of the fracture with 4.5 mm cortical screws or 4.5 mm locking screws.

The patients in the nailing group were operated with antegrade nailing using a humerus intramedullary nail. After taking an appropriate incision and entering the bone with an awl,

serial medullary reaming was done and the nail with largest possible diameter was inserted over a guide wire. Before inserting the proximal locking bolts, the soft tissues were meticulously dissected, and any overlying neurovascular bundles were retracted. The nail was then locked proximally and distally with cortical bolts under guidance of image intensifier.

Postoperative radiographs were taken to confirm adequate reduction. The patients were given injectable antibiotics and analgesics for 3 days and then switched onto oral medication. The patients were kept in an arm sling following surgery and encouraged to perform pendulum exercises and passive followed by active range of movements of the elbow from the 1st post operative day. The patients were discharged on 4th to 7th postop day once they were pain free and adequately mobilized. The patients were followed up in the outpatient department at 2 weeks, 1 month, 3 months, 6 months and 9 months.

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

Table 1. Rodriguez- Merchan criteria

The patients were examined clinically at each visit to look for signs of surgical wound infection, range of movements at elbow and shoulder and any other complications. At every visit a plain radiograph was taken and signs of hardware failure, screw back out and signs of union were looked for. The fracture was said to have united if bridging callus was visible on at least two orthogonal view radiographs. The normal union time was taken as 4 months, delayed union as that occurring between 4 to 6 months and non-union as no signs of fracture union beyond 6 months. The functional status of each patient was assessed at the end of 9 months using the Rodriguez- Merchan criteria (Table 1). The results were tabulated and finally a comparative analysis was done between patients belonging to the two groups.

Statistical Analysis: The quantitative data was represented as their mean ± SD. Categorical and nominal data was expressed in percentage. The t-test was used for analysing quantitative data, or else non-parametric data was analysed by Mann Whitney test and categorical data was analysed by using chi-square test. The significance threshold of *p* value was set at <0.05. All analysis was carried out by using SPSS software version 21.

Results: In our study, 30 patients underwent CRIF with interlocking nailing (ILN), and 30 with ORIF and locking compression plates (LCP). The baseline demographics were as shown in

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Table 2. No statistically significant difference was noted between the two groups when the baseline demographics were compared making the two groups comparable.

The perioperative parameters were compared and the results tabulated as shown in Table 3. A statistically significant difference was noted in the average duration of surgery, average blood loss and average duration of hospital stay after surgery ($p<0.05$) between the two groups, all in favour of the nailing group.

The nailing group had 2 and plating group had 4 patients with surgical wound superficial infection, which were all treated by appropriate antibiotics and debridement. No deep infections or osteomyelitis cases were reported in either group.

Table 2. Demographic data

Characteristics	**ILN**	**LCP**
Male : female ratio	17 : 13	14 : 16
Average age (range)	45.3 (18 – 76)	49.5 (20 – 71)
Mode of injury:		
RTA	40% (12)	53.3% (16)
Fall from height	33.3% (10)	16.6% (5)
Direct trauma	10% (3)	16.6% (5)
Others	16.6% (5)	13.3% (4)
Pre-existing comorbidities:		
Diabetes Mellitus	13.3% (4)	23.3% (7)
Cardiac diseases	6.6% (2)	6.6% (2)
Respiratory diseases	10% (3)	6.6% (2)
Fracture classification:		
AO type A	63.3% (19)	56.6% (17)
AO type B	23.3% (7)	33.3% (10)
AO type C	13.3% (4)	10% (3)

Table 3. Perioperative parameters

Characteristics	**ILN**	**LCP**
Average delay between admission and surgery	6.4 days	7.5 days
Average Duration of surgery	43.6 ±12.33 min	68.2 ±15.78 min
Average blood loss	121.5 ± 16.44 ml	336.4 ± 14.96ml
Average duration of hospital stay after surgery	6.3 ± 2.02 days	12.2 ± 2.45 days
Surgical wound infection	2 patients	4 patients

The functional and radiological outcome and complications that were recorded at each follow up were recorded and compared. Radiological outcome of union is shown in Figure 1. Average duration for normal radiological union was 14.6 weeks (± 2.33) for ILN group & 15.7 weeks (±3.88) for LCP group. Most patients in both the groups had union on X-rays before the 16^{th} week of follow up after surgery. 2 cases of delayed union were seen in both the groups that eventually went on to unite. 2 cases of non-union in the nailing group were treated with nail removal and internal fixation with compression plates with autogenous bone graft. The one case of non-union in the plating group was treated with autogenous bone grafting. All these cases ended up with union of the fracture.

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The Rodriguez- Merchan criteria at 9 months follow up showed an excellent result in both the groups in majority of the patients, 76% in nailing group and 80% in plating group as shown in Figure 2.

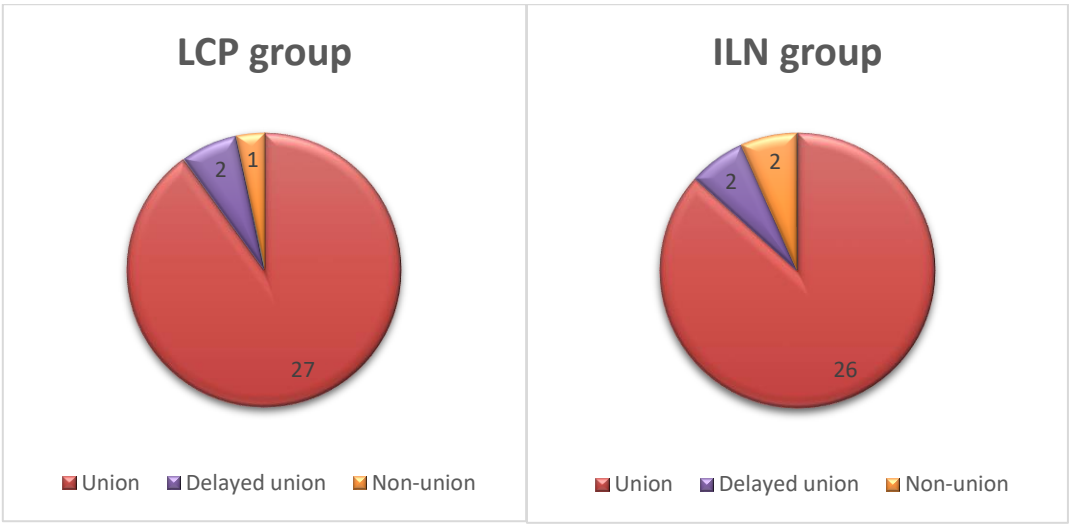

Figure 1: Radiological outcome of union

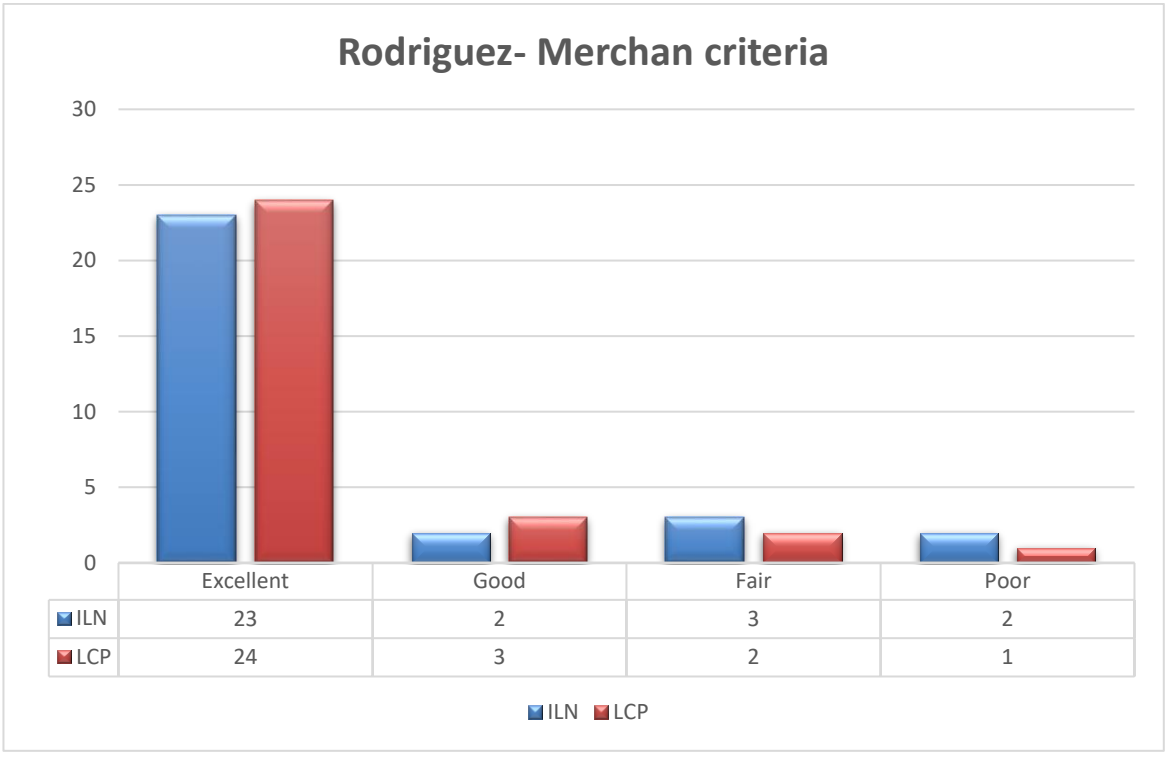

Figure 2: Rodriguez- Merchan criteria for functional outcome assessment

The most common complication observed in the nailing group was shoulder stiffness, which was treated with physiotherapy and gradual range of movements exercises. All patients recovered and had a good functional range of movements at shoulder at the end of 9 months following surgery.

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We recorded 6 cases of post-operative radial nerve palsy which were all neuropraxias. 4 were seen in the nailing group and were attributed to manipulation of fracture during surgery. 2 cases were seen in the plating group and were attributed to irritation by hardware. All the patients recovered completely within 3 months with splinting and physiotherapy.

The nailing group had an overall increased complication rate as compared to the plating group, though not statistically significant.

Table 4: Complications

Parameter	ILN	LCP
1. Radial nerve palsy	4	2
2. Superficial infections	2	3
3. Deep infections	0	0
4. Delayed union	2	2
5. Non-union	2	1
6. Implant failure	2	1

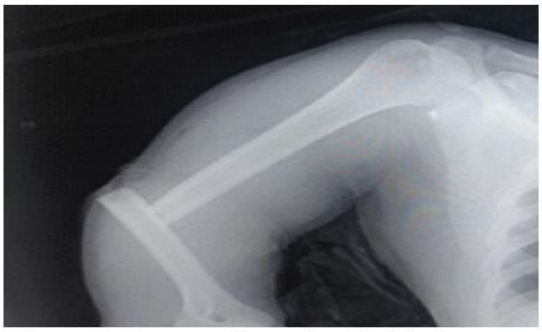

Figure 3. Preop radiograph of Right humerus shaft fracture of 29-year-old female.

Figure 4. Intraoperative picture of ORIF with LCP.

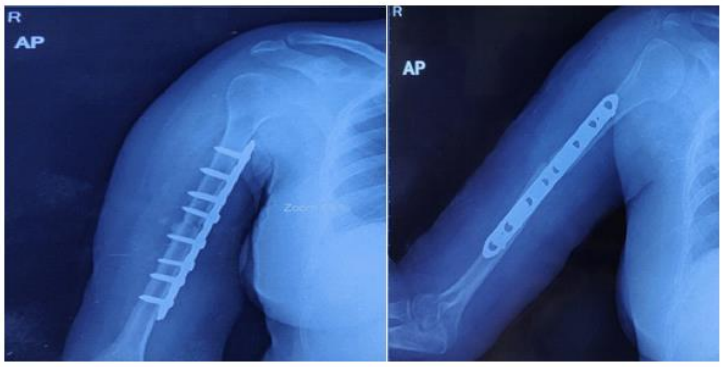

Figure 5: Immediate postop radiograph.

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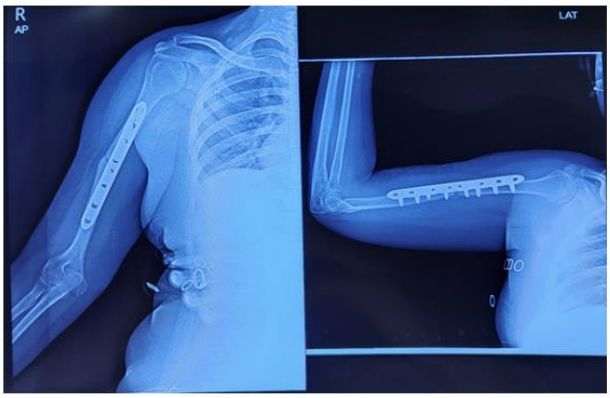

Figure 6: 3 months follow-up radiograph.

Figure 7. 6 months follow-up radiograph and clinical pictures showing range of motion.

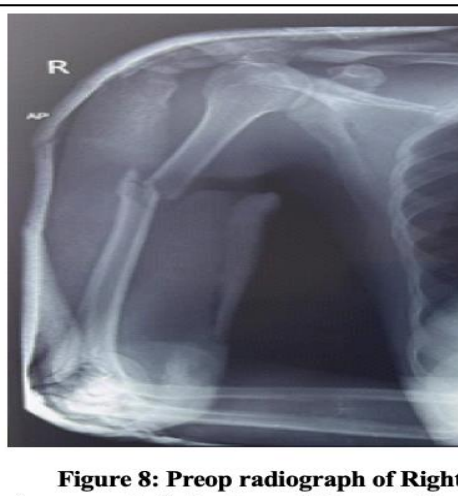

Figure 8: Preop radiograph of Right humerus shaft fracture of 36-year-old male.

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Figure 9. Immediate postop radiograph.

Figure 10. 3 months follow-up.

Figure 11. 6 months follow-up radiograph and clinical pictures showing range of motion.

Discussion:

Many randomized, controlled trials have reported DCP fixation and ILN fixation of humeral shaft fractures.[1,4,8,12-18,22] To our knowledge, there has been no consensus on the efficacy of these 2 methods. Therefore, we evaluated and compared the ILN and the LCP for the treatment of humeral shaft fractures with regard to union time, union rate, functional outcomes, and incidence of complications. Of these, intraoperative blood loss, operative time, duration of hospital stay, and average union time were significantly less in the ILN group compared with the LCP group. In addition, no statistically significant differences were found in Rodriguez-Merchan criteria, union rate, and incidence of complications between the 2 groups. The lower values for intraoperative blood loss, operative time, and duration of hospital stay in the ILN

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group may indicate that ILN may be a better internal fixation technique than LCP, hastening patient recovery and increasing patient satisfaction.

Restriction of shoulder movements and risk of delayed union have been suggested as concerns with ILN techniques.[23-25] Impairment of shoulder function with antegrade ILN may be a result of impingement due to proximal nail migration, rotator cuff violation, adhesive capsulitis, or an unexplained cause.[8,24,26] However, the current study found no significant difference in functional scores between the 2 groups, which was contrary to the findings of previous studies.[1,14,26] This may be explained by careful intraoperative manipulation and postoperative rehabilitation.

In previous reports of plate fixation, the incidence of non-union has ranged from 2% to 10%.[27-29] In the current study, non-union occurred in 1 (3.33%) of 30 patients in the LCP group. Retrospective studies of ILN fixation quote incidences of non-union ranging from 0% to 8%.[14,27,30] Hems and Bhullar[31] suggested that antegrade nailing affects fracture healing by distracting the fracture and soft tissues. In the current study, non-union was seen in 2 (6.67%) patients in the ILN group. This patient was managed by autogenous bone grafting. In addition, no difference was found in the union and non-union rates between the 2 groups, which is consistent with the findings of previous reports.[8,17,32]

The incidence of radial nerve palsy with humeral shaft fractures varies from 6% to 15%.[33-35] In the LCP group, 2 (6.67%) patients had radial nerve palsy. They were managed by neurotrophic drugs followed by bracing and passive dorsiflexed movements of the wrist joint, and they recovered fully within 3 months postoperatively. The ILN group had 4 (13.33%) patients with radial nerve palsy which was also managed in similar fashion and were fully recovered within 3 months.

Conclusion:

Based on our operative results and follow up of cases, we concluded that ORIF with locking compression plates had an overall better result, lesser complications and was a better suited implant to treat shaft humerus fractures, despite having a significantly higher intra-op blood loss and duration of surgery and a higher incidence of wound infections. CRIF with intramedullary nailing reported an overall higher incidence of complications, implant failure and shoulder stiffness which makes it less preferable an option as compared to plating. However, there is no significant difference between the two groups in terms of union time and functional outcome.

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