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Functional outcome in surgical management of diaphyseal fracture of humerus treated by intramedullary interlocking nail in adults: A prospective study

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Abstract
Aims: In this study is a series of 30 cases of traumatic closed fracture of humerus shaft treated with closed antegrade intramedullary interlocking nailing and were followed up to register the clinical and radiological outcome and complications, its advantages and disadvantages were studied.
Methods: Our prospective study is a series of 30 cases of traumatic closed fracture of humerus shaft without any neurovascular injury either simple, wedge or complex types and treated with closed antegrade intramedullary interlocking nailing. This study is to be conducted over a period from December 2017 to May 2019 Cases were followed up for 6 months and the short term functional results were analysed by using Constant and Murley score, ASES score.
Results: Most common fracture pattern is transverse & oblique type. Mean radiological union in weeks was 13.97 There was no non union in our study. There were no instances infection. There was 1 case of delayed union which was treated by bone marrow injection at fracture site. Good or full range of mobility of shoulder & elbow joints was present in 25 patients.5 patients had poor or painfully restricted movement due to shoulder impingement.
Conclusion: Humerus intramedullary nailing technique is an excellent, least invasive surgical option available to manage humeral shaft fractures with early fracture consolidation and better union rates with advantages including minimal surgical exposure, better biological fixation, Minimal disturbances of soft tissues and early mobilization of neighboring joints, less chance of radial nerve injury.

Keywords: Intra medullary interlocking system, humeral shaft fractures, constant and murley scoring system, Ases score

Introduction
Humerus diaphyseal fractures are relatively a common type of fractures accounting for around 3-5 % of all fractures [1]. There was not much of treatment options and it was usually treated with external splint age for many centuries. The Egyptians used “palm bark” and “linen bandages” 5000 years back. Historically closed methods of treatment for humeral diaphyseal fractures have centered around one of the two principles 1] Thoracobrachial immobilization 2] Dependency ratio Thoraco brachial immobilization involved use of the body as a splint. This was achieved using body strapping or by shoulder arm spica cast application. This method of treatment was not reliable for maintaining the alignment of the bone and promotion of bone healing Then there was introduction of bracing etc, although complications are rare, non-operative management like closed reduction, functional cast bracing needs a long period of immobilization, which carries a risk of prolonged shoulder joint stiffness and may not be convenient for the patient. With the formation of the AO groups in 1958 the base for growth for internal fixation in skeletal surgery was set. Open reduction and internal fixation with ‘Rush nails’ and ‘Ender’s nails ‘Küntscher nailing’ resulted in stiffness of shoulder and elbow joints, nonunion and malunion of the fracture. To beat this AO group has come with rigid internal fixation using DCP/LC-DCP. Several authors have recognized the general superior outcome that occurs after compression plate fixation and considered the gold standard for

operative management of acute humeral diaphyseal fractures. The need for anatomic reconstruction and the absolute rigidity of AO techniques, however, simply leads to extensive soft tissue dissection. Iatrogenic radial nerve injury is a frequent complication of dynamic compression plating in humeral shaft fractures. In comminuted fractures, or if the bone is osteoporotic, stable plate osteosynthesis may be difficult to achieve. Surgical management of humeral diaphyseal fractures have gained a fresh hope with the development of intramedullary interlocking nailing system for the humerus with advantages like Least Surgical Exposure, Better Biological Fixation, least Disturbance of Soft Tissue, Reduced Rate of Infection, Early Mobilization of adjacent joint, Avoids issues like lack of rotational control, migration of nail and necessity of complementary bracing

Materials and Methods

In this prospective study 30 cases of traumatic humerus shaft fractures admitted to our institute between December 2017 to May 2019 after obtaining the permission from the Institutional Ethical Committee. Patients selected were more than 18 years of age, diagnosed with diaphyseal fracture shaft of humerus who were willing to give written informed consent for surgery. Patients aged less than 18 years of age, having an associated radial nerve palsy or paralysis of the limb, Patients who are medically unfit for surgery, associated fractures in the same limb, Open fractures, With Periarthritis shoulder were excluded. After pre op evaluation and fitness, patients were operated with intra medullary nail, standard post-operative protocol followed. Instruments used were nails of size 6mm which is solid nail, 7 and 8 mm cannulated nails length 20-40 cm with 2cm difference. Postoperatively the patients were asked to flex and extend the wrist and fingers Pendular motion exercise, supported and active abduction exercise, circumduction exercise, flexion exercise of elbow. They were adviced from not to lift weight or putting extra stress on the operated limb. Stapler removal done on around 12th postoperative day during follow up and check x-ray in anterio-posterior and lateral views were obtained. All the patients were followed up and serial x-rays in 6th, 10th and 16th post-operative week, thereafter depending on the X ray picture at 10 and16 weeks, and functional status of the upper limb, further follow up. They were examined in detail clinically and special stress was laid on shoulder and elbow range of movements and subjective complaints. The fracture was considered to be radio logically united, when there was no visible fracture line and evidence of callus bridging the fracture site. A clinical proforma was used to evaluate the patient and keep an accurate follow up record. A scoring system was used to evaluate shoulder function as devised by Constant and Murley (used by the European society for shoulder and elbow surgery). Constant-Murley scoring system was chosen for its preciseness and reproducibility. Functional status of the upper limb as a whole was assessed using the A.S.E.S. (American Shoulder and Elbow Surgeons) score. This score was chosen for its focus on functional status of the whole upper limb and for its ease of application. Total outcome score is calculated.

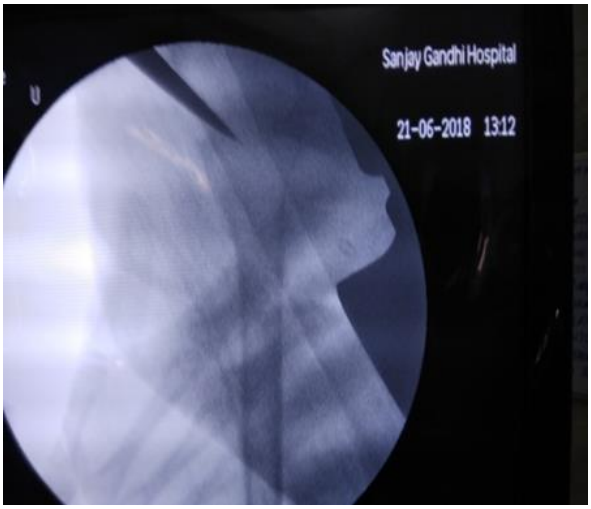

Fig 1: entry point with awl

Fig 2: Nail insertion

Fig 3: proximal locking

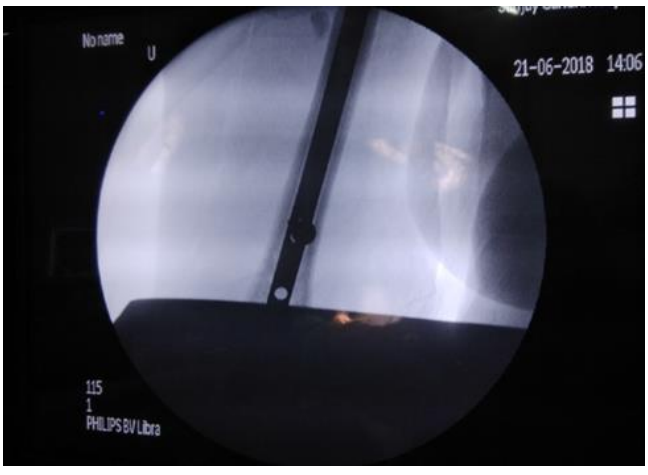

Fig 4: distal locking

Results

1. **Age distribution:** Higher percentage patients belonged to age 26-35 years (23.3%)

Table 1: Age wise distribution of study participants

		Frequency	%
Age Group	Less than 25 years	5	16.7%
	26-35 Years	7	23.3%
	36-45 Years	6	20.0%
	46-55 Years	6	20.0%
	More than 55 Years	6	20.0%

2. **Sex distribution:** Incidence was more in males (73.3%)

Table 2: Distribution of study subjects based on gender

		Frequency	%
Sex	Female	8	26.7%
	Male	22	73.3%

3. **Mode of injury:** Most frequent was from fall (60%)

Table 3: Distribution of mode of fall among study subjects

		Frequency	%
Mode of Injury	Fall	18	60.0%
	RTA	12	40.0%

4. **Level of injury:** Common level of fracture in this series was in the middle 1/3rd 18 cases (60%)

Table 4: Distribution of the study subjects based on level of fracture

		Frequency	%
Level of Fracture	Middle 1/3RD	18	60.00%
	Upper 1/3RD	12	40.0%

5. **Type of fracture:** Most of the cases in our series were transverse type i.e. 14 (46.7 %)

Table 5: Type of fracture among the study subjects

		Frequency	%
Type of Fracture	Complete	2	6.7%
	Fragment	1	3.3%
	Irregular	1	3.3%
	Oblique	11	36.7%
	Segmental	1	3.3%
	Transverse	14	46.7%

6. **Follow up duration:** Most follow up (19 patients - 63.3%) was done for 6 months. For some it extended till 8 months to get

Table 6: Follow up among study subjects

		Frequency	%
Follow UP	6 Months	19	63.3%
	7 Months	4	13.3%
	8 Months	7	23.3%

7. **Duration for union and mean duration of radiological union:** Mean radiological union was around 13.97 weeks with SD of 3.78

Table 7: Mean duration for radiological union

	Mean	Standard Deviation
Radiological Union In Weeks	13.97	3.78

Out of 30, 25 patients (83.3%) had full range of motion, 5 had restriction.

Table 8: Distribution of range of movements among study subjects

		Frequency	%
Range Of Movements	Full	25	83.3%
	Restricted	5	16.7%

8. **Overall results:** 25 cases (83.3%) had excellent result, 1 case (3.3%) had good result and 4 patients had poor result (13.3%). (Table16 and Graph 15).

Table 9 Distribution of functional outcome among study subjects

		Frequency	%
Functional Outcome	Excellent	25	83.3%
	Good	1	3.3%
	Poor	4	13.3%

Discussion

Functional brace treatment has been standard in the conservative treatment of humerus shaft fractures. However, it has many disadvantages like higher rates of malunion and nonunion. Surgical management significantly decreases the complication rates of it. Open reduction plating and intramedullary nailing are the most accepted methods in the surgical management of humerus shaft fractures. There have been many controlled, randomized studies done for these two surgical methods. Each method has its own advantages and disadvantages. While higher rates of union with plate and screw fixation, there are some drawbacks like greater soft tissue dissection and radial nerve damage. It is possible to avoid these problems with nailing. Biomechanically, nailing is stronger and it is possible to apply the method with less soft tissue dissection. There are few studies in the literature related to locked, compressive humerus nailing. When IMN is applied appropriately, closed and compressive, the rate of union is at least as high as that of plate-screw and the possibility of soft tissue and neurovascular damage can be considered to be less than in plate-screw application.

In this study 30 patients with acute Humeral Diaphyseal Fractures with antegrade intramedullary interlocking nail to determine clinical outcome and complications of nailing. We have evaluated our outcome and compared them with those obtained by various other studies opting different modalities of treatment for fracture diaphyseal of humerus including intramedullary interlocking nailing. Our analysis is as follows:

1. **Age Distribution:** Fractures of the diaphyseal of humerus are commonly seen in young adults. The average age in our series was 40.43 years with the maximum number of patients in 3rd, 4th and 5th decades. This finding was similar to the observation of Bell M J *et al.* (1985) [2], Griend R V *et al.* (1986) [3], Tingstad E M *et al.* (2000) [4], Rommen *et al.* (1995) [5], Rodriguez (1995) [6] and Shyamasunder Bhat N (2005) [7]
2. **Sex Distribution:** There was male predominance in this series which is also observed in other studies. Bell M J *et al.* [2] had male to female ratio of 27:11, Grient R V Tomasin J and Ward E F [3] had 21 males out of 36 total subjects, Rommen *et al.* [5] had 20 males out of 39. Rodriguez [6] had 17 males out of 20 subjects. Our study had 22 males out of 30 subjects.
3. **Mode of injury:** Majority of the fractures were sustained due to self-fall i.e. 18(60%) patients in our study and in

comparison to the other study it appears to be the second most common cause of Inury, however in other studies Road traffic accidents was the commonest mode of injury.

4. **Level of fracture:** Our findings are in accordance with those of various other authors who found that middle third was the most commonly affected site. Bell M J *et al.* [2] had 38.5% subjects in upper and middle third, Grient R V Tomasin J and Ward E F [3] had total 23 out of 36 subjects with middle third fracture, Rommen *et al.* [5] had 14 subjects with middle third fracture out of 39. This study had 18 out of 30 with middle third shaft fracture.
5. **Fracture union:** 28 (93.33%) patients had sound union in less than 6 months, 2 (6.66%) patients had delayed union and required bone marrow injection to augment union and union was achieved at the end of 7th month and there was no cases of non union seen. While in other series of intramedullary interlocking nail done by Rommen *et al.* (1995) [5], Rodriguez *et al.* (1995) [6] and Shyamasunder Bhat N (2005) [6] non-union was seen more commonly (7 Cases) than delayed union (2 Cases) out of 140 cases.
6. **Range of mobiliy of the elbow and shoulder:** 25 patients (83.3%) recovered full range of motion of shoulder and elbow joint while 5 (16.7%) patient had poor range of movements due to shoulder impingment by proximal end of the nail. In the intramedullary interlocking series conducted by Rommen *et al.* (1995) [5], Rodriguez (1995) [6], Mc Cormack R G *et al.* (2000) [8], Syamasunder Bhat (2005) [7], the range of mobility of shoulder and elbow movements are comparable with the results obtained by the present series. Shoulder stiffness was not a major setback in most of the intramedullary interlocking series and was comparable with plate fixation done by various authors.
7. **Overall result:** This study had 26 (90%) patients with excellent or good result out of 30 patients in our series. In this series our result was comparable to the results achieved by the other authors. The causes for poor result were because of the impingement of the nail over the rotator cuff caused the stiffness of the shoulder and pain with movement.

This could be avoided by proper selection of the nail size and burying the nail well inside the bone and proper repair of the rotator cuff before closure and active commencement of shoulder and elbow Excercises postoperatively. Patient education and a well planned rehabilitation programme are required to obtain better results. If these principles are adhered intramedullary interlocking nail fixation of humerus diaphyseal fractures results in fewer complication and greater patient satisfaction.

Table 10: Overall result comparison to other studies

Study	No of patients	Method of treatment	Excellent/Moderate result
Rodriguez [6]	20	Intramedullary nailing	95%
Mc Cormack R G *et al.*. [8]	44	Intramedullary nailing	95.7%
Syamasunder Bhat [7]	37	Intramedullary nailing	92%
Rommen *et al.*. [5]	39	Retrograde Intramedullary nailing	95%
Bell M J *et al.*. [2]	34	AO plating	91.2%
Tingstad E M *et al.*. [4]	83	AO plating	94%
Gongol T& Mracek D [9]	32	Functional brace	93.8%
Koch PP, Gross D F and Gerber C [10]	67	Sarmiento brace	82%
Present study	30	Intramedullary nailing	86.6%

Conclusion

Based on our study and results, we conclude the following.

- All closed humerus diaphyseal fracture extending between 2cm from the surgical neck to 3cm proximal to the olecranon fossa can be treated with closed intramedullary nailing. It is an outstanding method of treating comminuted and unstable humeral diaphyseal fractures
- Excellent results were seen in patients with associated injuries when humerus shaft fractures were treated with intramedullary interlocking nail as shown in the reduction in operative time and early rehabilitation.
- Closed intramedullary interlocking nailing is the least invasive surgical technique compared to other surgical modalities, and has got least chance of post-operative infection and also reduces the hospital stay.
- Humerus nailing reduces the time required for callus formation, since it does not disturb the fracture hematoma, and achieves high rates of fracture union.
- Complications like delayed union can be managed with bone marrow injection at fracture site to boost fracture union. By impaction before distal locking and avoiding distraction at fracture site complications like non union can be reduced.
- Certain procedural techniques like burying the proximal end of the nail at the entry portal and selecting appropriate length of the nail is essential in preventing impingement and to gain better shoulder function.
- Hence we conclude that closed intramedullary interlocking nailing by ante grade technique is a safe and reliable technique in the management of humerus diaphysis fractures.

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