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EVALUATING THE FUNCTIONAL RECOVERY OF HUMERAL SHAFT FRACTURES IN ADULTS TREATED WITH CLOSED INTERLOCKING NAILS

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ABSTRACT

Background: Humeral diaphyseal fractures are typical long bone trauma with an incidence of approximately 3 percent of all fractures and 20 percent of all humural fractures. Although compression plate osteosynthesis is still the standard, interlocking intramedullary nailing has become a reliable alternative with stable fixation with minimal soft tissue disturbance. This is a research that has been conducted to determine the functional outcome of adult humeral shaft fractures with closed interlocking nailing. Prospective study. This study was conducted at Bolan Medical Complex Hospital Quetta from July 2024 to July 2025.

Materials and Methods: In a prospective study, closed interlocking intramedullary nails were used to treat 120 adult patients who had humerus diaphyseal fractures. The Disabilities of the Arm, Shoulder and Hand (DASH) score and the Constant-Murley scoring system were used to evaluate the functional outcome. Other parameters were intra-operative variables, such as, operative time, blood loss, and post-operative complications.

Results: In all cases, radiological union was attained with the average time to union of about 16 weeks. Non-union of all the fractures but delayed union in some patients. The complications observed post-operation were stiffness of the shoulder in 7 patients, one instance of eminent nail and three instances of temporary radial nerve neuropraxia which had a full recovery. According to the functional assessment, excellent outcomes were achieved by 72% of the patients, good outcomes by 18% of the patients, and fair and poor outcomes by 7% and 3% respectively.

Conclusion: Closed interlocking nailing is a safe and less invasive biomechanical stable fixation of humeral shaft fractures in adults. It permits early mobilization, low complication rate and satisfactory functional recovery when used in conjunction with proper surgical procedure and rehabilitation after surgery.

Keywords: Humeral shaft fracture, Interlocking intramedullary nail, Functional outcome, DASH score, Constant-Murley score.

INTRODUCTION

The fracture of the humoral shaft is a fairly frequent trauma as it constitutes about 3 percent of all skeletal fractures and 20 percent of humoral fractures.[1] They happen in very broad age groups and are often the product of high-energy impact on the arm like road traffic crashes, falls, or direct blows to the arm.[2] Even low-energy injuries can

cause such fractures in elderly people because osteoporosis and decreased bone density cause such fractures.[3] Since the humerus is an essential part of the upper limb functional integrity, these fractures may result in a severe disability when not addressed appropriately.[4]

The main focus in the treatment of humeral shaft fracture is to have a stable fixation, regain limb positioning, and have early recovery of functioning with minimum complications.[5] Classically, conservative management in terms of functional bracing or hanging arm casts has been popular and there have been satisfactory union rates in selected cases.[6] But with long term immobilization one may suffer stiffness, malunion and delayed functional recovery especially in active adults who need to use the limb early.[7] Surgical fixation has, therefore, become more acceptable due to its capacity to produce early mobilization and a predictable outcome.[8]

A compression plate osteosynthesis is one of the surgical procedures that were historically taken as the gold standard of diaphyseal fractures of the humerus management.[9] It offers fixation that is rigid and superb anatomical reduction. Nevertheless, this is not the only method. The risk of infection and iatrogenic injury to the radial nerve can be caused by extensive dissection of the soft tissue during plating.[10] More so, postoperative scars and increased rehabilitation period may be an issue, especially when dealing with young and cosmetically minded patients.[11]

On the contrary, interlocking intramedullary nailing has proved to be a good substitute to plate fixation. The method has a range of benefits that include a limited disturbance of soft tissues, maintenance of fracture hematoma, reduction in the time taken during operation, and early mobility after operation.[12] The intramedullary fixation of the nail is also a load-sharing construct, and the transfer of forces along the mechanical axis of the humerus is possible, thereby increasing biomechanical stability, as well as that of more rapid union.[13] Further, the closed procedure can also help to eliminate the risk of infection and minimize blood loss, as opposed to those in an open procedure.[14]

A number of studies have claimed a high level of success with closed interlocking nailing, where the more or less union rates and the function of the shoulder and the elbow were made satisfactory.[15] Nevertheless, there have been apprehensions about possible complications that may arise like shoulder impingement, rotator cuff, and distal screw related problems especially in case of antegrade nailing.[16] Nevertheless, there have been improvements in surgical procedures, the design of implants and postoperative rehabilitation regimens, which have allowed most of these issues to be allayed and this has made interlocking nailing a very popular option.[17]

The functional recovery after the humoral nailing is customarily evaluated with the help of the standardized scoring systems, including the Disabilities of the Arm, Shoulder and Hand (DASH) score and the Constant-Murley score.[18] The tools offer objective pain, range of motion, strength, and daily function measurements, which enable a full assessment of the results of treatment.[19] The dependability of nailing has been demonstrated through constant reporting of high functional scores after nailing.[20]

Since there is still controversy on whether to use plating or nailing to fix humeral shaft fractures, more evidence based research is needed to determine the relative advantages of each technique. The objective of the study is to determine the functional outcome of diaphyseal humerus fractures in adults that are treated with closed interlocking intramedullary nails whereby the DASH and Constant-Murley scoring systems are used as instruments to assess them. With a large sample of 120 patients, this prospective study will attempt to present some significant information on union rates, functional outcomes, and complication patterns with this approach. Finally, the results can be used to improve treatment regimens and provide orthopedic surgeons with safer and more efficient management methods of humoral shaft fractures.

MATERIALS AND METHODS

It was a prospective clinical study carried out among 120 adult patients who had been diagnosed with fractures of the humerus diaphyses. All the patients were treated surgically with closed interlocking intramedullary nailing and followed after the operation to measure both functional and radiological outcome. The research population consisted of adults who were 18 years or older and who had isolated humeral shaft fractures as a result of trauma. Only medical fit patients who gave an informed written consent were included. Pathological fractures and prior humural surgeries, open fractures with excessive soft tissue loss, related ipsilateral fractures of the limbs, and prior shoulder and elbow pathologies were eliminated.

Included were patients of the outpatient and emergency departments who were recruited after a comprehensive clinical assessment procedure. Each patient was given an elaborate history including a close focus on the mechanism of injury, the related trauma, and the previous medical conditions. General, systemic and local examination were conducted to exclude the possibility of other injuries. A U-shaped plaster slab and arm pouch sling were used in order to stabilize the affected limb initially. Sufficient analgesia and medical care needed to deal with comorbidities were also administered before surgery.

The radiological analysis was conducted using standard X-rays of the humerus, the shoulder and elbow joints in an anteroposterior and lateral position. Through these radiographs, the diagnosis

was confirmed, the fracture pattern was categorized as well as the surgical strategy was planned. The preoperative examination involved complete blood counts, serum electrolytes, renal function tests and coagulation profile, chest X-ray, ECG among others depending on the needs of the specific patient. All patients were pre-operatively assessed properly and given the green light to undergo surgery after proper medical and cardiological examination.

The nature of the study, surgical procedure, potential benefits, risks, and potential complications were well informed to the patients and their families. The process, the process of rehabilitation and the anticipated results were expounded and written consent was signed. Every surgery was done under general anesthesia and endotracheal intubation.

The patients were all placed on a radiolucent operating table in the supine position with the shoulder resting close to the edge to provide a free movement of the C-arm. The affected arm was draped in sterilized way and prepared. The composition of the nail was calculated, basing on the extension of the nail by a centimeter below the articular surface of the humural head to a level of about two and a half centimeters above the olecranos fossa. The radiographic canal width at the smallest section of the humural shaft was used to estimate the appropriate nail diameter.

A small cut, with the length of about three centimeters, was made at the anterolateral margin of the acromion. The deltoid muscle was divided to open the supraspinatus tendon that was cut along the line of the fibres in order to reach the humeral head. The guide wire was inserted medial to the greater tuberosity and with the axis of the medullary canal using the fluoroscopic images in anteroposterior and lateral views. An entry portal was then made through a cannulated awl passed over the guide wire.

The insertion handle assembled the intramedullary nail and the fracture reduced using the image intensifier. The nail had been carefully pushed over the fracture point into the distal fragment, where it had to be in place. Where the medullary canal was small, a series of reaming was carried out to fit the nail and where poller screws were employed where required to keep everything in line. Interlocking (proximal) was performed using the jig that was used on the insertion handle, whereas interlocking (distal) was done using the freehand method under fluoroscopy. All screws were inspected to ensure that they had been firmly fixed and positioned correctly.

Deltoid, subcutaneous tissue, and skin were repaired in layers with absorbable sutures in the supraspinatus tendon, then, the skin and deltoid. This was covered with a sterile dressing and put the limb in an arm pouch sling. Patients were advised to exercise their fingers and the wrist within the same day of surgery after the completion of surgery. The first postoperative day was used as the starting point of pendular shoulder exercises and light exercises involving the elbow range-of-motion. Check-up dressing was done on the third day of surgery and the patients were usually discharged on the fourth day with the follow-up instruction that they needed to do physiotherapy but not to lift the weight or impose any stress on the operated arm.

The first follow-up visit was two weeks following surgery where the sutures were removed. Follow-ups were planned as follows; 6 weeks then after every six weeks within the next six months and then three monthly visits were planned up to one year. Radiographs of the entire humerus with the shoulder and elbow joint were made at each visit in order to determine the progress of fracture union. Pain, range of motion, muscle strength and resuming daily activities were the areas of clinical assessment. Functional outcomes were determined with the Disabilities of the Arm, Shoulder and Hand (DASH) score and the Constant-Murley scoring system.

All data was collected and statistically analyzed to find out the relationship among the parameters of the surgery and the functional outcome. The key outcome measures were time to fracture union and overall functional recovery with the secondary outcome measure being the intraoperative measures that comprised operative time and blood loss and postoperative complications such as infection, shoulder stiffness, impingement or neurological deficits.

This systematic approach to the process guaranteed the presence of a unified protocol in the surgical procedure, the quality of the follow-up, and objective assessment of the outcome and offered a useful dimension of the effectiveness of closed interlocking intramedullary nailing in humurally shaft fracture treatment in adults.

RESULTS

This was a prospective study that involved 120 adult patients who had humerus diaphyseal fractures and were treated using closed interlocking intramedullary nailing. Follow-up was done on all patients and no patient lost in the study period. The statistical data were processed using predictive demographic trends, fracture features, intraoperative and postoperative results, radiological fusion, complication, and functional outcomes according to the Constant Murley and DASH grades.

The age of patients was 39.4 years with the range of 18-68 years and mean age is 39.4 years with a standard deviation of 11.6. Most of the cases (54.2) fell in the age group of 21-40 (years); there was definite dominance of youthful, energetic adults. The sample size consisted of 120 patients (65:35) males and females, respectively, which means it is about 1.8:1 (male-to-female ratio).

Road traffic accident (RTA) was the most common cause of injury, 61.6% then domestic falls (23.3) followed by falls from height (10%) and physical assault (5%). Sixty four patients (53.3) had a fracture on the left side and 56 (46.7) fractures on

the right. Fracture was most likely to occur in the middle third portion of the shaft (57.5%), and most common pattern was transverse (60%), oblique (26.7) and spiral (13.3).

Radiological union occurred in 120 cases and the mean time of union was 15.9 weeks (range: 13-25 weeks). There was delayed union in 4 (3.3) percent of patients, but no non-union. The final functional outcome at the six-month follow-up was measured by the Constant, and Murley scores which were the Constant and DASH score.

Table 1: Distribution of patients by age and sex

Age Group (years)	Male	Female	Total	Percentage
18–20	6	3	9	7.5%
21–40	43	22	65	54.2%
41–60	22	11	33	27.5%
>60	7	6	13	10.8%
Total	78	42	120	100%

Table 2: Mechanism and mode of injury

Mechanism	Number of Cases	Percentage
Road traffic accident	74	61.6%
Domestic fall	28	23.3%
Fall from height	12	10.0%
Physical assault	6	5.0%
Total	120	100%

Table 3: Fracture characteristics

Parameter	Type	Cases	Percentage
Fracture location	Upper third	19	15.8%
	Middle third	69	57.5%
	Lower third	32	26.7%
Fracture pattern	Transverse	72	60.0%
	Oblique	32	26.7%
	Spiral	16	13.3%

Functional assessment showed promising results. According to the Constant–Murley score, 85 patients (70.8%) achieved excellent results, 22 (18.3%) had good outcomes, 9 (7.5%) had fair, and 4 (3.3%) had poor functional recovery. The mean Constant–Murley score across all patients was 88.2 ± 7.4. Based on the DASH scoring system, 82 patients (68.3%) had a score below 20 (excellent), 25 (20.8%) scored between 21–40 (good), 9 (7.5%) between 41–60 (fair), and 4 (3.3%) above 60 (poor).

Table 4: Functional outcome according to Constant–Murley and DASH scores

Grade	Constant–Murley (n=120)	Percentage	DASH Score (n=120)	Percentage
Excellent	85	70.8%	82	68.3%
Good	22	18.3%	25	20.8%
Fair	9	7.5%	9	7.5%
Poor	4	3.3%	4	3.3%

The majority of fractures (88.3%) united within 14 to 18 weeks, 6.7% between 19 to 22 weeks, and 3.3% after 22 weeks.

Table 5: Radiological union

Union Time (weeks)	No. of Patients	Percentage
14–18	106	88.3%
19–22	8	6.7%
>22	4	3.3%
Total	120	100%

Minor complications were observed in a few cases. Four patients (3.3%) developed postoperative shoulder stiffness, which improved with physiotherapy. Three patients (2.5%) experienced transient radial nerve neuropraxia that resolved spontaneously within eight weeks. There were no cases of deep infection or implant failure. One patient (0.8%) had a prominent nail tip, which was later addressed with nail removal after union.

Table 6: Postoperative complications

Complication	No. of Patients	Percentage
Shoulder stiffness	4	3.3%
Radial nerve neuropraxia	3	2.5%
Superficial infection	0	0%

Delayed union	4	3.3%
Non-union	0	0%
Prominent nail	1	0.8%
Total complications	12	10.0%

Overall, 93 patients (77.5%) returned to their pre-injury occupation within three months of surgery, while 27 (22.5%) required prolonged physiotherapy before resuming work. Shoulder and elbow mobility were near normal in the majority of patients by the final follow-up.

These findings demonstrate that closed interlocking nailing provides excellent stabilization and allows early functional recovery with minimal complications in adult diaphyseal humeral fractures.

DISCUSSION

The current prospective study compared the functional outcome of humeral shaft fracture of adults who received closed interlocking intramedullary nails. The results were found to be of an excellent outcome in most cases, with 72 and 18 percent recording an excellent and good functional outcome, respectively, according to the Constant and Murley and DASH systems of scoring, respectively. All patients were radiologically united and there was an average of 16 weeks to get to the union phase. These findings do confirm once again that closed interlocking intramedullary nail is an effective and very minimal invasive aspect of fixation that enables early mobilization and good functional outcome.

The results of the current research are in line with those of McCormack et al,[21] who formulated a randomized trial of dynamic compression plating versus intramedullary nailing of humeral shaft fractures. Their results showed that there were no significant differences in the rate of union and the outcome of the function between both techniques, and the nailing group had the advantage of having less exposure to the surgeon and fewer violations of the soft tissue. According to their research, the average time to union was 17 weeks, which is similar to that of the current research of 16 weeks.

Likewise, Raghavendra and Bhalodiya,[22] compared intramedullary nailing to dynamic compression plating in 60 patients and the results showed that 96 percent of patients in the nailing group united with an average of 15 weeks of time. They also noted that fewer complications were experienced among patients who were nailed. The complication rate of 10 percent, primarily minor and temporary, in the present study is consistent with their findings in showing that interlocking nailing reduces postoperative morbidity in the case of carefully applied surgical technique and physiotherapy.

Lin et al,[23] made a comparison of the humeral locked nails and plate fixation and the results showed that the nailing group had shorter operation time, reduced intraoperative blood loss and quicker rehabilitation. The benefits of our study are that low blood loss and reduced time taken to complete the operation was consistently recorded. Moreover, the rate of shoulder stiffness was low in both studies and it is responsive to physiotherapy which supports the significance of early mobilization.

In a group of 51 patients treated with intramedullary nails Flinkkilä et al,[24] the union was reached in all patients, the mean time to union was 16 weeks and 84% of patients had excellent or good functional results. They had a slightly higher complication rate of 12% compared to the current study (10%), which may have arisen because of previous designs of implants. Nevertheless, the two studies believe in the safety and efficacy of closed nailing in humeral shaft fractures.

Changulani et al,[25] also compared dynamic compression plating and intramedullary nailing in a randomized controlled trial and real-world results showed that both had a similar union rate and union functionality outcomes but the nailing group had lower postoperative pain and lower cosmesis. The current research also noted the early resumption of daily activities, and near-normal shoulder functioning of the majority of the patients and this is a further indication of nailing as a beneficial procedure, especially among younger and active persons.

Reddy et al,[26] study of 50 humeral fractures treated by antegrade interlocking nails revealed a mean Constant score of 86.4, 76% of the patients had an excellent or good outcome, which is closely similar to that of the current study (89.1% excellent or good outcome). Though in some instances, stiffness in the shoulder was observed as a result of the entry point via supraspinatus, all healed with physiotherapy. These data support the fact that minor complications of the shoulder associated with the antegrade nailing technique can be overcome by early rehabilitation and a cautious surgical technique.

Taken altogether, the results of the current and other similar studies support that closed interlocking intramedullary nailing gives firm fixation with little disturbance of the soft tissues, aids fast fracture union, and enables an early recovery of functions. Even the comparatively low percentage of shoulder stiffness and radial nerve neuropraxia in the present study also proves that surgical meticulousness and compliance with rehabilitation guidelines can maximize the results.

CONCLUSION

In adults, closed interlocking intramedullary nailing is a reliable technique of managing the diaphyseal fractures of the humerus. It has offered great rates of fracture union, early shoulder and elbow functions restoration and low rate of complications in this

research. It took about 16 weeks to have a mean of 16 weeks to union and most patients had excellent to good functional outcome that was measured with the Constant Murray and DASH scores. There were some minor postoperative complications that included shoulder stiffness and transient radial nerve neuropraxia, which were solved through relevant physiotherapy. When the surgery is done with appropriate surgical technique and similar procedure supported by a well-organized rehabilitation, the closed interlocking nailing suture provides stable fixation, less soft tissue injury, and early mobilization with the result in excellent patient satisfaction and functional restoration. According to the findings of this research, interlocking nailing may be prescribed as a modality of choice in adult patients who have their humeral shaft fractured, especially in active persons who would want to resume their functions promptly. It is recommended to conduct future comparative studies that include bigger multicenter samples and extend the treatment follow-ups to assess long-term outcomes and to optimize treatment protocols.

REFERENCES

1. Sarmiento A, Latta LL. Functional fracture bracing: a review. Clin Orthop Relat Res. 2006;430:108–115.
2. Tytherleigh-Strong G, Walls N, McQueen MM. The epidemiology of humeral shaft fractures. J Bone Joint Surg Br. 1998;80(2):249–253.
3. Court-Brown CM, Caesar B. Epidemiology of adult fractures: A review. Injury. 2006;37(8):691–697.
4. McKee MD, Miranda MA, Riemer BL, et al. Management of humeral shaft fractures. J Am Acad Orthop Surg. 2009;17(7):423–433.
5. Bhandari M, Devereaux PJ, McKee MD, Schemitsch EH. Compression plating versus intramedullary nailing of humeral shaft fractures—A meta-analysis. Acta Orthop. 2006;77(2):279–284.
6. Sarmiento A, Kinman PB, Galvin EG, Schmitt RH, Phillips JG. Functional bracing of fractures of the shaft of the humerus. J Bone Joint Surg Am. 1977;59(5):596–601.
7. Denard A Jr, Richards JE, Obremskey WT, Tucker MC, Floyd M, Herzog GA. Outcome of nonoperative vs operative treatment of humeral shaft fractures. Orthopedics. 2010;33(8):552–556.
8. 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.
9. Heim D, Herkert F, Hess P, Regazzoni P. Surgical treatment of humeral shaft fractures—the Basel experience. J Trauma. 1993;35(2):226–232.
10. Livani B, Belangero WD. Bridging plate osteosynthesis of humeral shaft fractures. Injury. 2004;35(6):587–595.
11. Reddy AR, Lakshmaiah V, Al-Mousawi A, Hemmady MV, Bass A. Antegrade interlocking nailing of humeral shaft fractures. Int Orthop. 2004;28(4):249–252.
12. McCormack RG, Brien D, Buckley RE, et al. Fixation of fractures of the shaft of the humerus by dynamic compression plate or intramedullary nail: A prospective, randomized trial. J Bone Joint Surg Br. 2000;82(3):336–339.
13. Chapman's Orthopaedic Surgery. 3rd ed. Lippincott Williams & Wilkins; 2001.
14. Lin J. Treatment of humeral shaft fractures with humeral locked nail and comparison with plate fixation. J Trauma. 1998;44(5):859–864.
15. Changulani M, Jain UK, Keswani T. Comparison of the use of the humeral intramedullary nail and dynamic compression plate for the management of diaphyseal fractures of the humerus. A randomized controlled study. Int Orthop. 2007;31(3):391–395.
16. Flinkkilä T, Hyvönen P, Lakovaara M, Linden T, Väätäinen U. Intramedullary nailing of humeral shaft fractures: Results of 51 patients. J Trauma. 2004;56(2):433–439.
17. Roulot E, Galmiche J, Reiss E. Antegrade interlocking nailing of humeral shaft fractures. Clin Orthop Relat Res. 2002;403:40–50.
18. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: The DASH. Am J Ind Med. 1996;29(6):602–608.
19. Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. Clin Orthop Relat Res. 1987;214:160–164.
20. Ikpeme JO, Udosen AM, Okereke CE, Urom SE, Ihekire O. External fixation of fractures of the shaft of the humerus in a tropical environment. Niger J Clin Pract. 2008;11(2):121–125.
21. 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: A prospective, randomized trial. J Bone Joint Surg Br. 2000;82(3):336–339.
22. 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.
23. Lin J. Treatment of humeral shaft fractures with humeral locked nail and comparison with plate fixation. J Trauma. 1998;44(5):859–864.
24. Flinkkilä T, Hyvönen P, Lakovaara M, Linden T, Väätäinen U. Intramedullary nailing of humeral shaft fractures: Results of 51 patients. J Trauma. 2004;56(2):433–439.
25. Changulani M, Jain UK, Keswani T. Comparison of the use of the humeral intramedullary nail and dynamic compression plate for the management of diaphyseal fractures of the humerus. Int Orthop. 2007;31(3):391–395.
26. Reddy AR, Lakshmaiah V, Al-Mousawi A, Hemmady MV, Bass A. Antegrade interlocking nailing of humeral shaft fractures. Int Orthop. 2004;28(4):249–252.