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A study on functional outcome of patients treated with interlock nailing in the forearm fracture bones

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Abstract

Introduction: The imperfect treatment of fractures of radius and ulna diaphyses leads to a loss of motion as well as muscle imbalance and poor hand function. Therefore, the present study was designed to evaluate the functional outcome of interlock intramedullary fixation in the fracture forearm bones.

Materials and Methods: Thirty two patients included after their consent. With the patient supine on a radiolucent table, and under general or regional anaesthesia the extremity was prepared and the surgery was performed using a standard procedure. If secure rigid fixation is required forearm POP splint is applied and kept in place for 2 weeks, thereafter a removable sugar-tong orthosis was worn until bridging callus is present, and the orthosis is removed frequently for exercise. Evaluation was done using DASH score and Grace and Eversman score. Grace & Eversmans score was based on the union of the fracture and rotation of the forearm as Excellent, Good, Acceptable and Unacceptable.

Results: There was statistically significant difference in the surgical time ($P<0.05$) and duration of post-operative immobilization differed statistically significantly ($P<0.001$) between the group of patients in whom locking was done and not done. The average DASH score was 9.95 and functional outcome of the patients undergone interlock nailing was excellent and good in 40.91% of patients whereas not acceptable in 4.54% of patients as per Grace and Eversmann score.

Conclusion: Complex fracture pattern like C type injuries were stabilized in an elegant manner without additional damage to soft tissues. This suggests that, interlock nailing provided cosmetically better suited and little risk of refracture after removal of the implant.

Keywords: Forearm Fracture, Interlock Nailing, Functional Outcome, Dash Score, Grace and Eversman Score.

Introduction

Forearm fractures are as important as articular fractures as slight deviations in the spatial orientation of the radius and ulna will decrease the forearms rotational amplitude and thereby impair the positioning and function of the hand.(1) Thus the management of these fractures and their associated injuries deserve special attention, imperfect treatment of fractures of the radius and ulna diaphyses leads to a loss of motion as well as muscle imbalance and poor hand function.

Mechanism of injury may be blunt trauma mainly road traffic accident assault and industrial injuries.(2) In diaphyseal fractures of radius and ulna normal rotational alignment is necessary if a good range of pronation and supination is to be restored and in addition to regaining of length, apposition and axial alignment. Any axial or rotatery malalignment or change of interosseous space or encroachment of callus into it or loss of normal configuration of radius especially the lateral bow leads to proportionate loss of supination and pronation.(3)

The radius and ulna function as a unit but come into contact with each other only at the two ends. During rotational movements, the radius rotates around the relatively immobile ulna. Besides coordinated muscle action, these movements also rely on the normal function of five articulations. At the elbow, the two bones articulate directly with the humerus to form the ulnohumeral and the radiocapitellar joints. At the wrist, only the radius articulates directly with the carpal bones to form the radiocarpal joint.(3,4) The two bones also articulate with each other proximally and distally at the proximal and distal radioulnar joints. The two bones are bound proximally by the capsule of the elbow joint and annular ligament and distally by the capsule of the wrist joint, the dorsal and volar radioulnar ligaments, and the triangular fibrocartilage complex. The interosseous membrane is frequently referred to as a separate joint of the forearm bones, and its disruption or contracture can lead to instability of stiffness.(5)

In order for the rotational movement to proceed smoothly the ulna has a relatively straight form, but the radius has a more pronounced curve. Sage measured the curves in cadaver radii and found that the proximal curvature averaged 13.1degrees apex medial and 13.1 degrees apex anterior in the coronal and sagittal planes, respectively. The distal curvature averaged 9.3 degrees apex lateral and 6.4 degrees apex posterior in the coronal and sagittal planes respectively. It was also pointed out the importance of maintaining these curves; especially the lateral bows of the radius.(6)

Interlock nail has been used in femur, tibia and humerus for many years; it's relatively newer method of fixation in forearm bones. Segmental fractures, poor skin condition(e.g. burns, large abrasions), multiple injuries, selected non-union or failed compression

plating, diaphyseal fractures in osteopenic patients, selected type I and type II open diaphyseal fractures, massive compound injuries for which ulnar nails used as an internal splint to maintain forearm length, are the indications of interlock nailing.[7,8]

Many surgeons reported that that the recovery of function after compression plate fixation of fractures of forearm bones is dependent on the return of rotation of the forearm, the maintenance of a functional range of motion of the elbow and wrist, and the recovery of grip strength.[9-13] The criteria for assessment of final results based upon functional outcome were different in various series.

Burwell and Charnley (1964) reported excellent and good results with patients having less than 50% restriction of pronation and supination.[14] Grace and Eversmann (1980) reported excellent results with at least 90% of normal rotation of forearm, good result with 80% of normal rotation of forearm, and unacceptable result in patients who had less than 60% of normal rotation of forearm.[10] Hadden (1983) reported excellent and good results with no or slight impairment in strength of grasp and less than 30% loss of any movement.[11] Excellent to good functional results were reported by many surgeons after using compression plate fixation of forearm fractures.[11-13] Whether primary bone grafting for fresh fractures of forearm bones should be carried out at the time of open reduction and internal fixation is still debatable. However, fractures showing delayed union or nonunion are routinely grafted. Therefore, the purpose of the present study was to evaluate the functional outcome of Interlock intramedullary fixation in the fracture forearm bones.

Materials and Methods

The present study was a hospital based prospective interventional study on patient with fracture of diaphyses of forearm bones, admitted in department of orthopaedics of a tertiary care hospital. A total of 22 patients were included in the present study. The procedures followed were in accordance with the ethical standards of the responsible committee on institutional human experimentation and with the Helsinki Declaration of 1975, as revised in 1983 with informed and written consent from all the patients. All patients of fracture of forearm bones were included in this study. Whereas, patients with open physes (<18 years), Infected cases, open cases type IIIB and IIIC Gustilo-Anderson fracture, medullary canal <3 mm, failed earlier orthopedic intervention and fracture near articular margin of the bone were excluded.

All patients were evaluated clinically at the time of admission, with special reference to neuro-vascular status and first aid treatment was given. X-ray with true AP and true Lateral view of full length forearm including wrist and elbow was obtained. Patients were investigated completely for operative and anaesthesia purpose, any associated medical problems were taken care of before the patient taken up for surgery.

Preoperative Preparation: Pre-operative counselling of the patient and relatives regarding the both the method of treatment of fracture forearm bones was done, consent for surgery and for research study was taken for the patient included in the study group, x-ray of uninjured forearm full length in biggest film with distance between the forearm and x-ray tube 100cm was obtained, templating was done before getting the instruments autoclaved.

Surgical Procedure: With the patient supine on a radiolucent table, and under general or regional anaesthesia the extremity was prepared. With the elbow flexed at 90 degrees, a 1-cm incision is made at the olecranon. Under fluoroscopic control, a 1.9-mm Kirschner wire is driven into the ulnar medullary canal following closed reduction of the fracture. Using a 6-mm reamer, the entry point is drilled for approximately 2.5 cm. The medullary canal is enlarged using manual reamers wit 0.5-mm increments. Then a 2.4 mm guide wire is used to temporarily fix the fracture to enable reduction of the radial fracture. Another incision of 2cm long was made on the ulnar side of Lister's tubercle with the wrist and forearm prone. The medullary canal of radius is entered approximately 5-mm from articular surface and beneath the extensor pollicis longus tendon. Using a1.9mm Kirschner wire and a 6-mm cannulated reamer, the medullary canal is reamed. The last manual reamer was left in place. Using the x-ray of the uninjured forearm as a template, the length of intramedullary nail is calculated. Both nails are pre-bent to conform to the radial bow and the gentle S-shape of the ulna. First, a fully threaded 3.5mm self-tapping screw is used to interlock the nearest hole to the insertion handle and the stability is checked; a 1.5mm unicortical screw or k-wire may be used to lock the nail at the nondriving end if satisfactory stability is not achieved. The temporary ulnar wire is then removed and the ulna is fixed in the same fashion.

Postoperative Care: If secure rigid fixation is achieved forearm POP splint is applied and kept in place for 2 weeks, thereafter a removable sugar-tong orthosis is worn until bridging callus is present, and the orthosis is removed frequently for exercise. If fixation is not secure, a long arm cast is applied with the forearm in neutral rotation and the elbow in 90 degree of flexion for fracture in the distal half of the forearm, in supination when the fracture is in proximal half of the bone, the cast is worn until bridging callus is present, the patient is kept at guarded activity until fully healed with a follow-up every 2 weeks for 3months.

Final evaluation was done using DASH score and Grace and Eversman score. Grace & Eversmans score was based on the union of the fracture and rotation of the forearm as Excellent (Union of the fracture, at least 90% of normal rotation and arc of the forearm), Good

(Union of the fracture and minimum of 80% of the rotatory arc), Acceptable (Union of fracture and Minimum of 60% of normal rotation of the forearm and Unacceptable (Non Union and <60% of normal rotation of the forearm).

The DASH questionnaire included questionnaire about symptoms as well as ability to perform certain activities, Work module involving questions ask about the impact of arm, shoulder or hand problem on ability to work and high performance including the questions related to the impact of your arm, shoulder or hand problem on playing musical instrument or sport or both.

Results

The average period of follow up in the present study was 10.2 months. The average age of patients was 38.90 years (range 19-71years) and the males were predominant by seven times. The major mode of injury was Road Traffic Accident (59.09%) followed by assault (36.36%). Open fractures were operated on the same day of presentation, 41% of patients were operated within week of injury, only three patients were operated after a week and one patient was operated after 3 weeks as patient presented late to hospital. Almost three fifth of the patients had right side involvement; all of our patients were right handed. More than half of patients had closed fractures and rest was open fractures, of which Gustilo Anderson type II were in majority (Table 1).

Table 1: Patient characteristics

Age group (in yrs)	n (%)
• < 40	Male: 10 (45.45%), Female: 2 (9.09%)
• ≥ 40	Male: 9(40.91%), Female: 1(4.54%)
Mode of Injury	
• RTA	13(59.09)
• Assault	8(36.36)
• Fall	1(4.54)
Interval between Injury & Operation	
• ≤ 1day	9(40.91)
• 2-7 days	10(45.45)
• ≥ 8 days	3(13.64)
Side involvement	
• Right side	13(59.09)
• Left side	9(40.91)
Nature of injury	
• Closed	12(54.54)
• Open	
- type-I	3(13.64)
- type-II	6(27.27)
- type-III	1(4.54)

There was statistically significant difference in the surgical time (P<0.05) as it was almost double in patients where locking of non-driving end was done. Duration of post-operative immobilization differed statistically significantly (P<0.001) between the group of patients in whom locking was done and not done (Table 2).

Table 2: Comparison of surgical time period and Post-op immobilization with according to surgical time & type of reduction locking non-driving end

	Locking (Mean ± SD)		P-value
	Done	Not done	
Surgical time (in min)	61.00±28.92	34.92±15.62	<.05
Post op immobilization (in weeks)	2.00±0.00	6.92±2.56	<.001

The patients with different types of complications and union time in the postoperative period were depicted in Table 3. Thirteen (59.09%) patients had uneventful postoperative period. Out of which 18.18% had superficial infection, 13.64% had pain at k wire site, and 9.09% had pain at olecranon i.e. ulnar nail insertion site. Proximal screw back out was seen in 09% patients, tourniquet palsy in one patient who recovered in 3 weeks of time. The average duration of time to union was 14.2 weeks (range 10-22 weeks). Two third of patients achieved union before or at 14 weeks; one patient went into non-union.

Table 3: Number of patients with complications and union time in the postoperative period

Complications	n (%)
• Superficial infections	4 (18.18%)
• K wire site pain	3(13.64%)
• Ulna nail end pain	2(9.09%)
• Proximal screw back out	2(9.09%)
• Tourniquet palsy	1(4.54%)
• Scar on ulnar side of forearm	1(4.54%)
Union time in minutes	
• ≤ 14	
-Open	6(28.57%)
-Closed	6(28.7%)
-Closed and open radius	2 (9.52%)
• <14	
-Open	5(23.08%)
-Closed	2(9.52%)
-Closed and open radius	0(0.00%)

Range of motion in degrees in patient's undergone interlock nailing as compared with the normal side was explained in Table 4. Two patients had no loss in rotation arc; maximum loss of rotation arc was 59 degrees, average loss of rotation arc was 20 degrees. Average rotation arc was 87.44% as compared to normal side. One patient had fixed flexion deformity of

elbow of 15 and in two patients; one each had difficulty in ulnar deviation and dorsiflexion of wrist because of associated injuries to muscles involved.

Table 4: Range of motion in degrees on comparison with the normal side

Loss of rotation arc compared to normal side	n (%)
• 0-10 degrees	7 (33.11%)
• 11-20 degrees	6(28.57%)
• 21-30 degrees	5(23.08%)
• 31-40 degrees	2(9.52%)
• 41-50 degrees	0(0.00%)
• 51-60 degrees	2(9.52%)

The DASH score of the patients were tabulated in Table 5. Average DASH score in this study was 9.95 (range 3-25). One patient who had DASH score 25 was due to non-union and prolonged immobilization leading to stiffness and decreased range of motion. The functional outcome of the patients undergone interlock nailing was excellent and good in 40.91% of patients whereas not acceptable in 4.54% of patients as per Grace and Eversmann score (Table 6).

Table 5: Number of patients on the basis of DASH score

DASH Score	n (%)
• <5	1 (4.54%)
• 5-10	10(45.45%)
• 10-15	8(36.36%)
• 15-20	2(9.09%)
• ≥20	1(4.54%)

Table 6: Number of patients on the basis of Grace and Eversmann score

Grace and Eversmann score	n (%)
• Excellent	9 (40.91%)
• Good	9 (40.91%)
• Acceptable	3(13.64%)
• Not Acceptable	1(4.54%)

Discussion

In our series we studied 22 patients with an average age of 38.90 years (range 19 -71 years), including 19 male and 3 female patients. Average follow up was of 10.2 months (range 6 -15.5 months); Weckback A et al they treated 33 forearms in 32 patients, in whom 23 were male and 9 female, for an average follow up of 31.4 months;[15] Gao H et al studied 18 patients, with average age of 46 years (range 29-70 years) included 14 males and 4 females for mean follow up period of 13 months;[16] Young Ho Lee et al In a group of 27 patients, with 19 men and 8 women with mean age of 32 years (range 21-53 years), he followed up for 17 months.[17]

In present study close reduction of fracture was done in less number of patients as compared to other studies, which could be explained as more number of our patients had open injury. Open method was resorted whenever fracture presented open or close reduction was not successful. When open reduction was done, it was by small incision without much periosteal stripping.

In our study, complication rate was 40%, thirteen patients had uneventful postoperative period. Four (18.18%) had superficial infection, who had open fractures and it subsided with course of oral antibiotic therapy. 3(13.64%) had pain at k wire site, it was addressed by removal of k wire; once union was attained. 2(9.09%) had pain at olecranon i.e. ulnar nail insertion site.

Proximal screw back out was seen in two (9.09%) patients, this complication had no effect on bone healing, tourniquet palsy in one patient who recovered in 3 weeks of time. Tourniquet palsy was due to prolonged operative time. Rate of complications in our study was more as compared to other studies, in the literature. As we used k wires for locking the nondriving end of the nail, k wire caused local irritation and pain.

Weckback A et al had come across 2 patients of delayed union and one patient of non-union, 2 patients had radio-ulnar synostosis;[15] Gao H et al 22% of patients had superficial infection and one patient had radio ulnar synostosis, 11% had screw back out;[16] Young et al saw one superficial infection and non-union.[17] Visna P et al reported that 5.85% of fractures had screw back out, one patient developed compartment syndrome, 3 patients had radio ulnar synostosis. Superficial infection was seen in one patient and prolonged healing in four fractures.[18]

Complication like radio ulnar synostosis, compartment syndrome was not met in our study. Several authors removed the nails after the union of the fracture, if the patients desired for that or if the nail caused the symptoms; no refracture was documented in any study. We did not undertake removal of nails, as no patients desired for the same.

Final outcome as evaluated according to DASH score and Grace and Eversmann score. In our study average DASH score in our series was 9.95 (range 3-25). One patient (case no 17) who had DASH score 25 was due to non-union and prolonged immobilization leading to stiffness and decreased range of motion.

Eighteen patients (81.8%) in our study had excellent or good results according to Grace and Eversmann score. Three patients (13.6%) had an acceptable result whereas one (4.5%) patient had an unacceptable result cause of non-union. Grace and Eversmann score in our series was in accordance with the other published studies.[10] Higher DASH scores in

the different series were due to associated injuries to mention fracture of ipsilateral humerus and nerve injuries. Lower DASH scores in the present study could be explained, as very few patients had associated fractures of the humerus and nerve injury, no patient in the series had associated trauma to the humerus and elbow which would increase the DASH score and disability.

According to our own experience so far, the interlocking nail is considered a favorable alternative to standard plate osteosynthesis in fracture of forearm bones. Anatomical reduction is essential in forearm especially for the radius; the nails curvature must be individually adjusted to the anatomical situation to avoid misalignment. In other words the nail corresponds to the anatomy and not vice versa. Restoration of the correct length of forearm bones is essential as well, especially if the pattern of injury include the distal or proximal radioulnar joint.

Advantages of Interlocking nail are high rate of bony consolidation along with minimized surgical approaches, cosmetically better suited and little risk of refracture after removal of the implant. Mainly complex fracture pattern AO (C type injuries) is stabilized in an elegant manner without additional damage to soft tissues. Disadvantages are a fiddling surgical technique along with prolonged times during which fluoroscopy is needed.

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