

Outcomes of Intra-Medullary Square Nail for Adult Both Bone Forearm Shaft Fractures

Dixit Savajiyani^{1*}, Nishant Chauhan¹, Shailesh Ramavat²

¹ Assistant Professor, Department of Orthopedics, Pandit Deen Dayal Upadhyay Medical College, Rajkot, India

² Professor, Department of Orthopedics, Pandit Deen Dayal Upadhyay Medical College, Rajkot, India

*Corresponding author: Dixit Savajiyani; Department of Orthopedics, Pandit Deen Dayal Upadhyay Medical College, Rajkot, India. Tel: +91-9909361626, Email: dixit.savajiyani@gmail.com

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Abstract

Background: Forearm shaft fractures are common in developing countries. Anatomical reduction of these fractures using plates and screws is considered an accepted treatment mode. Like other shaft fractures, this can be treated with intramedullary nails like square nails, Rush nails, and interlocking nails. This study evaluates radiological and functional treatment results using square nailing.

Methods: A prospective study was conducted on 100 adult patients with diaphyseal forearm fractures over 3 years. Out of 100 patients, 68 were men, and 32 were women. Patients were followed up at 2 weeks, 6 weeks, 8 weeks, and then every 3 months till 1 to 1.5 years. We have used criteria described by Anderson et al. and the shortened version of the Disabilities of the Arm, Shoulder, and Hand (QuickDASH) score for functional evaluation of the patients.

Results: Out of 100 patients, the union was achieved in 88 patients, while the rest 12 patients required re-surgery. 4 patients had delayed union, 4 patients developed an infection at the ulnar entry site, and 3 patients developed bursitis of olecranon bursa.

Conclusion: Intramedullary nailing of both bone forearm shaft fractures using square nails can give satisfactory results in most cases, comparable with treatment by plates and screws, and provides an alternative, cost-effective treatment of both bone forearm shafts fractures with good cosmesis owing to small incisions.

Keywords: Forearm Injuries; Intramedullary Nailing; Radius Fractures; Ulna Fractures

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Background

Forearm fractures, popularly known as both bone forearm fractures (BBFF), are common in developing countries. Normal anatomy of both forearm bones is important for elbow and wrist movements as well as for supination and pronation movement of the forearm. Following the fracture of these bones, their anatomic reduction is considered necessary for the restoration of these movements. Historically, these fractures were treated by non-operative methods like casting, but this is not recommended now as they were associated with complications like non-union, malunion like shortening, angulation, etc. (1-3).

With the advancement in orthopedics, various options exist for managing forearm shaft fractures in adults; however, treatment with open reduction and fixation internally with plates and screws is a gold standard treatment - because of the excellent post-operative functional outcome. Nevertheless, these also have disadvantages like bigger incision scar, high risk of wound infection, more blood loss, chances of non-union due to soft tissue insult, periosteal stripping, and re-fracture risk after removing the plate (4-6). Closed reduction and nailing of the forearm is usually done in children whose bones are still not matured, and it was discouraged in adults previously due to lack of rotational instability and risk of malunion of forearm bones (7). But due to changes in the design of forearm nails, like square nails and interlocking nails, they are being used to treat adult forearm fractures. Because of their square cross-section or interlocking mechanism, these nails provide

rotational stability to fractured fragments, and thus decrease the incidence of rotational malalignments.

This study aimed to evaluate the results of closed intramedullary nailing for diaphyseal fractures of the forearm bones in adults. Various parameters like time to achieve radiological union, rate of malunion and non-union, and functional evaluation in terms of wrist and forearm movements are evaluated to conclude.

Methods

After obtaining approval from the institutional ethical committee (registration no. of committee: ECR/635/INST/GJ2014, approval number: PDU/MCR/IEC/23275/2017), a prospective study was conducted on 100 patients with diaphyseal forearm fractures over 3 years. Patients with a matured skeleton having diaphyseal fractures and those who were followed up for at least one year were included, while patients who had a neurological or vascular deficit, Gustilo-Anderson type 3 and 4 fractures, fractures older than 15 days, fractures in bones with very narrow intramedullary canal, and a Glasgow Coma Scale (GCS) less than 8 were excluded from the study. Patients having any other fracture in the same limb or any previous fracture in the same forearm were also excluded. All the patients were explained about the study, and written informed consent was taken from each patient.

Our study used square nails to treat forearm fractures (Figure 1). After properly evaluating the general condition and associated injuries, patients were selected for inclusion in the study. Informed consent was obtained from all the patients for study participation.



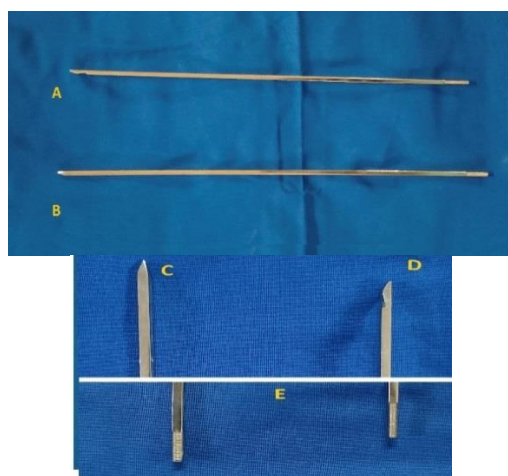


Figure 1. Square nails for radius (A) and ulna (B); tip of radius and ulna nails are shown in images C (ulna nail) and D (radius nail), and E shows the ends of radius and ulna nail.

Antero-posterior (AP) and lateral radiographs were obtained from each patient for pre-operative planning, including the nails' length and diameter. Surgeries were performed in regional anesthesia, i.e., brachial plexus block or general anesthesia, based on pre-operative evaluation and pre-aesthetic fitness. Surgeries were performed in a supine position with the limb to be operated kept on a radiolucent board on the side of the table. Usually, ulna nailing was done first to obtain the length of the ulna bone. The Ulna nail was introduced from the olecranon process in the direction of proximal to distal.

Approximately 1 cm of skin over the center of the olecranon process is incised in vertical fashion directed towards olecranon fossa from the tip of the olecranon. Then triceps insertion is split and entry in the medullary canal was taken with an awl. Ulna nail of appropriate size and diameter based on length on ulna and width of medullary canal is selected and introduced through entry point and advanced across fracture after indirect reduction of the fracture using traction and counter traction under the guidance of C-arm image intensifier (Figure 2).

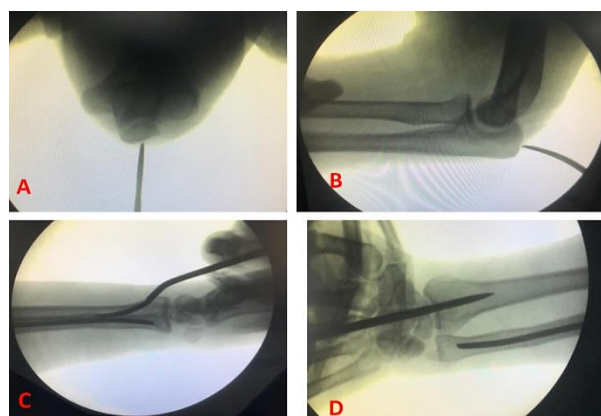


Figure 2. The entry point for the ulna nail [A: Antero-posterior (AP) view, B: Lateral view] and radius nail [C: Lateral view, D: AP view] using an awl

Radius nail was inserted from distal to proximal direction. A skin incision of 2 cm was kept on the dorsal surface of the forearm starting from just lateral to Lister's tubercle, and the incision was extended proximally in the vertical direction. Tendons from the 2nd and 3rd

compartments were separated on either side, and entry from dorsal cortex was taken using entry awl inserted at 45 degrees angle and then it was advanced proximally taking care of not perforating the volar cortex. After selecting a nail of proper size and diameter based on width of medullary canal and length of radius bone, tip of nail is bent so that it passes easily through the bone entry into the medullary canal. The fracture was reduced by indirect reduction of the fracture using traction and counter traction under the guidance of a C-arm image intensifier and advanced just proximally to the radial tuberosity. If reduction was not achieved by indirect methods in a closed manner, open reduction was done to reduce the fracture. Care was taken to avoid injury to the extensor pollicis longus tendon while final punching the radius nail. Protrusion of the ulna nail was avoided at entry site to prevent post-operative olecranon bursitis.

The limb was kept above the elbow slab and in neutral rotation for 4-6 weeks post-operatively. Suture removal was done in week 2. After that, elbow flexion and extension movements were started. Supination and pronation movements were encouraged at the 8th week post-operatively. Patients were followed up at 2 weeks, 6 weeks, 8 weeks, and then every 3 months till 1 to 1.5 years.

Callus was usually seen around 6 to 10 weeks post-operatively, and that was considered a sign of radiological union, while clinical union was judged by the absence of pain and tenderness at the fracture site. Outcomes were measured for each patient at each follow-up, and results were obtained accordingly. We have used the criteria described by Anderson et al. and the shortened version of the Disabilities of the Arm, Shoulder, and Hand (QuickDASH) score for the functional evaluation of the patients (8) (Table 1).

Result	Union	Flexion and extension at wrist joint	Supination and pronation
Excellent	Present	<10° loss	<25% loss
Satisfactory	Present	<20° loss	<50% loss
Unsatisfactory	Present	<30° loss	>50% loss
Failure	Non-union with or without loss of motion		

Results

A total of 100 patients were selected for the study; out of them, the union was achieved in 88 patients, while the rest 12 patients required re-surgery in the form of plating and bone grafting. Table 2 shows the patients' demographic data and fracture characteristics, and table 3 lists QuickDASH score details in patients according to Anderson et al.'s criteria.

Total number of patients	100
Mean age (year)	42.82
Mean age (men)	40.09
Mean age (women)	48.63
Demography	
No. of men	68
No. of women	32
Mode of injury (%)	
RTA	48
Falling down	38
Assault	14
AO classification (%)	
A3	52
B3	26
C1	16
C3	6
Type of reduction	
Open	6
Closed	94

RTA: Road traffic accident

Table 3. Average score of Disabilities of the Arm, Shoulder, and Hand questionnaire, shortened version (QuickDASH) at 6 weeks, 3 months, 6 months, and 1 year in the patients with excellent, satisfactory, unsatisfactory, and failure results according to Anderson et al.'s criteria

Anderson et al.'s criteria	n	Average QuickDash at 6 weeks	Average QuickDash at 3 months	Average QuickDash at 6 months	Average QuickDash at 1 year
Excellent	60	71.78	43.90	23.03	2.61
Satisfactory	18	73.36	49.75	26.89	9.34
Unsatisfactory	10	75.00	57.04	36.59	36.14
Failure	12	75.00	70.45	56.81	54.92

There was delayed union in 4 cases which were protected with allowance on the range of motion (ROM) exercise.

4 patients developed an infection at the ulnar entry site, which was managed by local incision and drainage. 3 patients developed bursitis of olecranon bursa that was managed with ice application and anti-inflammatory medication (Table 4). Out of 100 patients, 20 patients had associated injuries in other body parts. 10 patients had a fracture of the tibia, 6 patients had a chest injury, and 4 patients had a fracture of the femur bone.

Table 4. Complications (22 patients had complications out of 100)

Complications	Number
Delayed union	4
Non-union	12
Infection at ulnar entry site	4
Bursitis	3
Radioulnar synostosis	2
> 50% restriction of ROM of the affected forearm	10
Extension pollicis longus tendon injury	2

ROM: Range of motion

Figure 3 shows a patient's pre-operative, post-operative, and union time radiographs.



Figure 3. Pre-operative radiograph antero-posterior (AP) (A) and lateral (B), post-operative radiograph AP (C) and lateral (D)

Discussion

Open reduction and internal fixation (ORIF) using plates and screws by compression plating are considered a gold standard treatment for BBFF - owing to anatomical reduction by this method (9). Managing these fractures by intramedullary nailing has advantages over plate fixation like less blood loss, good cosmetic scar, union by secondary bone healing and callus formation, less risk of infection, and less fracture risk after removal of implants. At the same time, it has disadvantages like the inability for immediate mobilization and concerns about the maintenance of reduction and rotational stability. In addition, there is a very high risk of injury to the proximal interosseous nerve in fractures of the proximal radius treated by open reduction and plate fixation (7). The

incidence of transient dorsal nerve palsy is reported as 7% to 10% among all the patients with radius bone fracture treated by plating (10). The frequency of radio-ulnar synostosis of the plate fixation is around 2% to 9% according to the literature (11). The sound practice of BBFF treatment is plating as it adheres to the osteosynthesis principle, it is difficult to maintain a radial bow with a straight plate which is essential for normal rotational movements of the forearm (7). While intramedullary nailing decreases the magnitude of the radial bow, a reduction of up to 2 mm of the radial bow does not influence the functional outcome (12). However, early reports of intramedullary nail fixation with Kirschner wires (K-wires), Steinmann pins, or Rush rods resulted in high non-union rates due to a lack of rotational control (7, 13), while square nails owing to their cross-section shape provide rotational control.

In this study, rate of union was 88%. While a study done by Nadeem et al. had a union rate of 91% (14), and Street reported a union rate of 93% (13). The cause of non-union was open injury with periosteal damage, open reduction method, and distraction at the fracture site. The mean QuickDash score was 13.45 in our study at the end of one year, which is comparable to other studies.

Street had taken 107 patients with 137 fractures of the forearm in his study, out of which 10 patients (7%) reported a non-union using a square nail, and 4 patients (3%) developed an infection. Out of 107, 71 (69%) patients had an excellent result, 15 (14.5%) patients had satisfactory results, 8 patients had unsatisfactory results, and 9 patients had a failure according to Anderson et al.'s criteria (13). While in this study, 60 patients had excellent results, 18 patients had satisfactory results, 10 patients had unsatisfactory results, and 12 patients had a failure.

Hong et al. described 32 fractures treated in 18 patients with interlocking intramedullary nail (ForeSight, Smith & Nephew, Memphis, TN, USA) fixation (15). 8 patients had open fractures, and 3 of them required a skin graft; all patients were immobilized for at least 2 to 3 weeks in a splint or long arm cast. All fractures healed, and the average score of Disabilities of the Arm, Shoulder, and Hand (DASH) was 19 (range: 4-72). Overall complication rate was 22%: one synostosis, 4 superficial infections, 2 patients with loosening of distal interlocking screws in the ulna nail. While in this study, complication rate was 22% (22/100 patients), and 11 patients had more than one complication (Table 4).

Weckbach et al. described 34 fractures treated with locked intramedullary nailing without immobilization (16). There was one non-union (3%) and 2 radioulnar synostoses (6%). Nineteen nails (48%) were removed, with no re-fractures noted at an average of 18.3 months after removal. The average DASH score was 14 (range: 0-63).

Lee et al. described a contoured locking intramedullary nail (Acumed, Hillsboro, OR, USA) that used one interlocking screw and a blade tip to provide rotational stability. A total of 27 patients with 38 fractures were treated and among them, 7 fractures were open (17). Complication like superficial infection and non-union were noted but no radioulnar synostoses, deep infections, or hardware failures were seen. In this study, average DASH score was 15 with range of 5 to 61 and 92% excellent or good results.

Ozkaya et al. have retrospectively evaluated a total of 42 patients with fracture of diaphysis of forearm; among them 20 were internally fixed with intramedullary nail, while 22 fractures were treated with plating (18). Fracture

type and etiology were common in both groups. Bone grafting was required in the 3 patients of plate fixation but none required this in intramedullary fixation with nail. Removal of implant was done in 12 (55%) patients treated with plating, while only 5 (25%) patients treated with nailing needed implant removal. There were no statistically significant differences in function, with excellent or good results in 82% and a mean DASH score of 15 (range: 4-30) in patients treated with a plate compared to excellent or good results in 90% and a mean DASH score of 13 (range: 3-25) in patients treated with rods.

Visna et al. reported the results of a prospective study evaluating 80 patients with 115 forearm fractures treated with either plate or nail fixation (19). There was one re-fracture following plate removal. There were 2 cases of incomplete synostosis and 2 cases of partial migration of the interlocking screw in the nail group. No significant differences in functional outcomes were detected.

Conclusion

Intramedullary nailing of both bone forearm shaft fracture using square nails can give satisfactory results in most cases, and its results are comparable with treatment by plates and screws. Due to the small incisions, it provides an alternative, cost-effective treatment of both bone forearm shaft fractures with good cosmesis.

Conflict of Interest

The authors declare no conflict of interest in this study.

Acknowledgements

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