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Results of Closed Intramedullary Nailing using Talwarkar Square Nail in Adult Forearm Fractures

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ABSTRACT

The aim of the study was to evaluate results of closed intramedullary nailing using Talwarkar square nails in adult forearm fractures. We prospectively evaluated 34 patients with both bone forearm fractures. The average time to union was 12.8 (SD +3.2) weeks with cast support for a mean of 8.2 weeks. Union was achieved in 31 out of 34 patients. Using the Grace and Eversmann rating system, 17 patients were excellent, 10 were good, and 4 had an acceptable result. Three patients had non-unions, 2 for the radius and one for the ulna. There were two cases of superficial infection, one subject had olecranon bursitis, and one case of radio-ulnar synostosis. Complication rates associated with the use of square nails were lower compared to plate osteosynthesis and locked intramedullary nails. To control rotation post-operatively, there is a need for application of an above-elbow cast after nailing.

Key Words:
Adult radius-ulna fractures, square nail, closed intramedullary nailing, radius-ulna nailing

INTRODUCTION

Fractures of the forearm bones are not uncommon. The general consensus in the treatment of fractures of both bones of the forearm in adults is for operative treatment; and there are various modes of internal fixations available, the choice of which rests with the treating surgeon [1].

Conservative treatment of forearm fractures is fraught with complications of casting, compartment syndrome, malunion, and bayonet apposition [2]. Plate osteosynthesis is the most commonly used technique for the treatment of diaphyseal forearm fractures in adults. However, application of a plate can disrupt the periosteal blood supply and necessitates skin incisions that may be unsightly; there is also is a risk of refracture if the implant is removed [3].

The use of intramedullary devices to stabilize fractures is not new. Ivory pins, the Kuntscher nail, the Rush nail, and Ender nails have all been in use [4]. Nailing of the forearm, beginning with Schöne, predates nailing of the femur and tibia. Its slower technical development appears to be due to anatomic problems of the radius, the interdependence of the two bones, and the strong torque loads from pronators and supinators [5]. In 1959, Dr. Sage used prebent triangular nails for the fixation of radius fractures with good results [6]. In 1959, Dr. Talwarkar designed and performed fixation of both bones of forearm fractures with flexible square nails [7].

Intramedullary nailing comes with its own sets of advantages and disadvantages. The chances of infection are significantly decreased, as it is a closed procedure and uses the least amount of periosteal stripping. It also has lower refracture rates after implant removal.

The aim of this study was to assess, in adults, the result of closed nailing and to evaluate the anatomical and functional acceptance of the procedure using Talwarkar square nails.

MATERIALS AND METHODS

The study was conducted in AMC MET Medical College, L.G.Hospital, Ahmedabad after getting clearance from the ethics committee. All study participants gave written informed consent for participation in this study. The study was conducted from January 2009 to January 2012 on patients admitted from the emergency department or presenting in the outpatient department of the hospital.

We evaluated 34 patients (24 males and 10 females) who met the inclusion and exclusion criteria. The inclusion criteria were: (1) age more than 18 years; (2) patient not subjected to any other form of treatment; and (3) all open and closed fractures without neurovascular deficit. Exclusion criteria were: (1) skeletally immaturity; (2) very narrow intramedullary canal; (3) fractures older than 10 days before treatment; (4) single bone fractures; (5) presence of neurovascular deficit; (6) fractures in the proximal and distal metaphysis; (7) patients with associated injuries such as distal radioulnar joint (DRUJ) disruption and other fractures in the same limb; and (8) patient with head injuries. All study participants were followed up for a minimum of one year and maximum of two and a half years.

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Implant Design
316L stainless steel Talwarkar Square nails were used for all patients for both radius and ulnar repair. Nail diameters were 2.0mm, 2.5mm, 3.0mm, or 3.5mm, with nail lengths from 16cms to 36 cm for all surgical procedures. The ulnar nail is straight with a trocar tip, while the radius nail has a bevelled edge with a 1 cm notch for the tip. This adds to the flexibility and ease of negotiation along the radial bow (Figure 1). The nails have a threaded end for ease of insertion and removal. The threaded end also helps prevent bending during insertion

Preoperative planning
Radiographs were evaluated for each patient for type and location of fractures. The size of the nails was estimated on the normal limb radiograph. An ulnar nail was placed along the ulnar border of the uninjured forearm to estimate nail size. Alternatively, the length of the ulnar nail was measured from the tip of the olecranon to the ulnar styloid minus 1 cm. The radius nail was measured from the Lister's tubercle to the lateral epicondyle minus 3cm. The length of the radius nail is usually 2 cm shorter than the ulnar nail. The diameter of the nail is also estimated on the pre-op x-ray and verified intraoperatively under the c-arm.

Operative procedure
Under general or regional anaesthesia (axillary block), the patient was positioned supine on the operating table with a radiolucent arm board. The shoulder was abducted and the elbow flexed 90 degree for the nailing of the ulna whereas for the nailing of the radius, the arm was extended. Traction was needed to reduce the fragments. A tourniquet cuff was applied but inflated only if open reduction was required.

We nailed the ulna first, thereby providing a more stable forearm for retrograde nailing of the radius. The ulna was approached from the radial side of the olecranon tip. An incision of 1cm over the olecranon tip was made deep down to the bone. Entry was made with an awl suited for the radius-ulnar nail diameter. The position of the awl was checked under C-arm image intensifier in the anteroposterior and lateral view. No reaming was performed with insertion of the square nails. An ulnar nail of appropriate size was selected and loaded over a T-handle. The nail was pushed free hand into the medullary canal of the ulna while the assistant applied traction in the position favouring reduction, depending on the type of fracture. If the nail did get jammed, it was hammered lightly so that it made its way into the medullary canal. The position was checked using the C-arm. The distal end of the nail was usually within 1 cm of the tip of ulna. The end of the nail was buried inside the olecranon.

The radius was approached through the Lister tubercle. A 2 cm incision was made just ulnar to the Lister Tubercle on the dorsal surface and the soft tissue was divided. The 3rd extensor compartment was opened. The tendon of the extensor pollicis longus (EPL) was identified and retracted toward the ulna (Figure 2), and the radial shaft was in view. The entry into the medullary canal was made with an awl, 1cm proximal to the articular surface. A radius nail of appropriate size was selected and pre-bent to match the radial contour. The radius nail is loaded over the T-handle with a Jacob's chuck and pushed with the bevelled edge of the radius nail sliding over the volar surface of the radius. The assistant hold and assisted in reduction of the fracture. The position of the nail was checked repeatedly under C-arm in both planes during the procedure. We inserted the radial nail up to the proximal border of the bicipital tuberosity of the radius. Distally the nail was buried flush with the bone. If in any case the reduction was difficult to achieve, a mini-open reduction was performed.

All patients were immobilized with an above elbow slab and asked to perform active finger movements. Movement of the thumb was especially checked for any injury to the EPL tendon during surgery. Patients were discharged on the 3rd to 4th day post-op. Suture removal took place in two weeks and an another above elbow cast was applied.

Patients were evaluated weekly and radiographically at 4-weekly intervals till union and then at 3-monthly intervals. Results were assessed on the basis of the time to union, functional recovery and complications. Union was defined as the presence of bridging bone or trabeculae spanning the fracture site. The patients were also evaluated clinically for fracture site tenderness and pain on rotation. All patients were prescribed physiotherapy for range of motion and strengthening exercises.

At the last assessment, the degree of forearm rotation was measured with a goniometer. Functional outcome was calculated using the system described by Grace and Eversman[9]. An excellent rating meant that there was union of the fracture and at least 90% of normal rotation arc of the forearm. A good rating required that the fracture be united and that a minimum of 80% of the rotatory are be present. For an acceptable result, union of the fracture and a minimum of 60% of normal rotation of the forearm were present. An unacceptable result meant that there was a nonunion or that the patient had less than 60% of normal rotation of the forearm. Patient-rated outcome was assessed with the Disability of the Arm Shoulder Hand questionnaire (DASH) [10,11]. Statistical analysis was performed with SPSS version 17.0 software for Windows.

RESULTS

The patients were followed up for a minimum of one year and maximum of two and a half years postoperatively with a mean follow up time of 1.8 years. The mean age of study participants was 38.1 years, with a mean age in males of 36.2 years (range, 18- 62 years) and a mean age in the females of 39.9 years (range, 18- 57 years). The right limb was fractured in 14 subjects (m=11;46%; f=3; 30%) and the left limb was fractured in 20 subjects (m=13;54% f=7;70%).

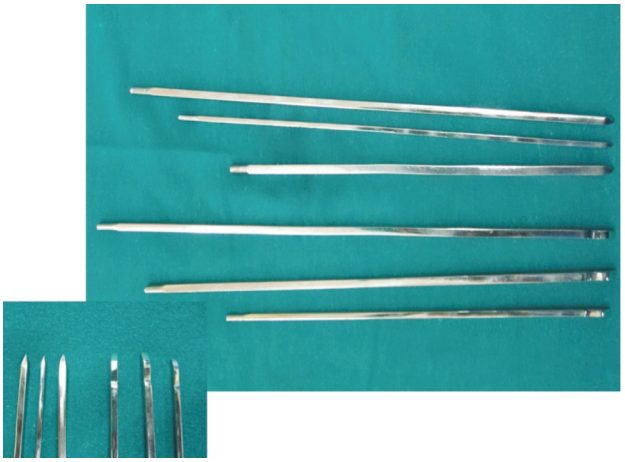

Fig. 1: Design of implant. The ulnar nails above with a trocar tip and the radius nail below with the bevelled tip in various lengths and diameters. Inset shows tips of the nails.

Fig. 2: Isolation of the extensor pollicis longus.

Fig. 3: Radiograph showing radio-ulnar synostosis.

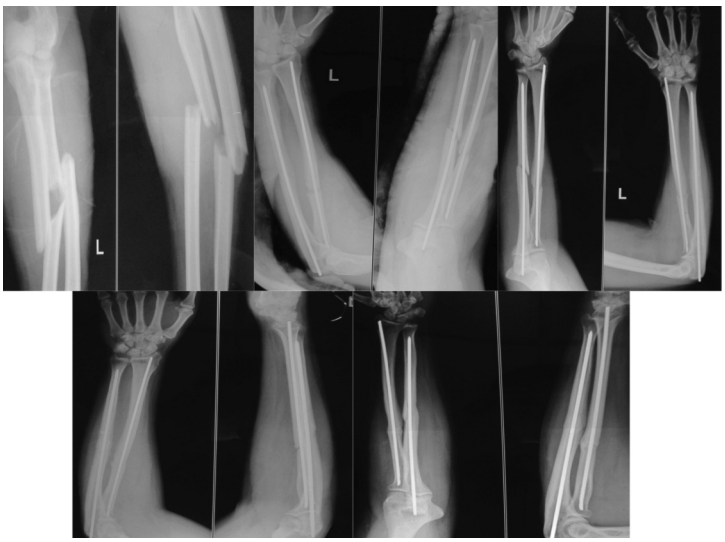

Fig. 4: Radiographs of a subject ranging from pre-operative stage through various stages of radiological union.

Fig. 5: Subject demonstrating range of motion. There was no loss of supination or pronation.

Fig. 6: Scar at the level of wrist is at the insertion site while the scar at the proximal site is that of the mini-open reduction required in this patient.

The most common mode of injury was road traffic accidents 44% (m=10;42%;f=5;50%), followed by assault 29% (m=9;37.5%;f=1;10%), falls 18% (m=2;8.5%;f=4;40%) and occupational injuries 9% (m=3).

Short oblique fractures were the most common type of fracture in the present study followed by transverse and comminuted fractures. There were two cases with open fractures, Gustillo-Anderson type II. These patients were treated with debridement, primary closure and nailing in the same sitting. Twenty-six patients underwent surgery within 24 hours of the accident, 6 patients within 1-3 days and 2 patients were operated within 3-5 days. The middle one-third of the bone was the most common site of fractures (radius n=25; ulna n=27), followed by distal one-third (radius n=8; ulna n=5), proximal one-third (radius n=1; ulna n=2). Three patients required limited open reduction of the radius. All these three patients had an uneventful post-operative period and union.

The average operative time was 42 minutes (range, 31-47min), and average fluoroscopy unit exposure was 4.35 min. (range, 2- 12 min). No intraoperative complication occurred nor was any nailing converted to some other method of fixation. The average hospital stay was 3 days (range, 2- 5 days).

There were two (5.88%) cases with superficial infection at the ulnar entry site that subsided with oral antibiotics for one week and deep infection was noted. One subject had olecranon bursitis at long term follow-up. The bursa was excised and the implant was removed. The patient was symptomless at the end of 7 months follow-up after implant removal. There was one case (2.9%) of radio-ulnar synostosis (Figure 3). This patient did not need surgery as the fusion was in mid-prone position. There was no implant breakage or irritation due to nail or implant back-out.

The average time to union was 12.8 weeks (range, 10-28 weeks). Cast support was maintained for a mean of 8.2 weeks (range, 5- 12 weeks) and continued till radiographic union was seen. There was one case of delayed union, which subsequently showed radiographic union at 28 weeks. There were two cases of non-union in the radius and one case of non-union in ulna. These subjects required autologous bone grafting.

There was no loss of flexion or extension in any of the patients as compared to the other arm. Pronation and supination was restricted in three patients (8.8%). One subject (2.9%) had radio-ulnar synostosis with severe restriction of pronation and supination.

Using the rating system of Grace and Eversmann, 17 patients had an excellent or good (n=10, 29.4%) result, 4 (11.76%) had acceptable results. Three patients (8.8%) had non-unions, two in radius and one in ulna (Figure 4, 5 and 6). The mean DASH score in the study was 15 points (range, 4-36pts); there was severe limitation in forearm pronation in one patient, the subject who had radio-ulnar synostosis.

Implant removal was performed in 6 patients at a mean of 19 months post operatively and no re-fractures were reported even after an average of 9 months after implant removal.

DISCUSSION

Plate fixation has been considered the gold standard for fixation of both bone forearm fixation. Several studies have shown good results [12]. Droll et al compared injured arms to uninjured arms, following internal fixation of the forearm fractures, and found that injured arms had reduced strength of forearm pronation (70%) of that of the normal arm, forearm supination (68%), wrist flexion (84%), wrist extension (63%), and grip (75%). In addition, the injured arms had a significantly reduced active range of forearm supination (90%), forearm pronation (91%) and wrist flexion (82%) [14].

Possible complications include compartmental syndrome [15], delayed union or nonunion [18] and re-fractures after extraction of the plate [12]. A high frequency of intraoperative nerve injuries has also been reported [6]. The reported incidence of transient dorsal nerve palsy is 7 to 10% of all patients with radius fracture treated by plating [16]. Incidence of radio-ulnar synostosis of the plate fixation is reported in the literature is 2% to 9% [13]. Though plating for both forearm bones fracture is a sound practice and adheres to the principles of osteosynthesis, a straight plate is unable to maintain and preserve the radial bow, essential for normal rotational movements of the forearm [6].

Closed nailing has many advantages, including early union, low incidence of infection, small scars, less blood loss, and, frequently a relatively short operating time with minimal surgical trauma. In our experience, the main complications during surgery were due to improper nail size. Another important advantage of intramedullary implants is their stress-sharing behaviour, which facilitates secondary periosteal callus formation [18].

In the present case series, the average operating time and the average fluoroscopy exposure for fixation of both forearm fractures was comparable to other studies [8]. In our series, exposure and operating times were higher in fractures located at the proximal 1/3rd.

We achieved union in 31 out of 34 patients (91%) compared to Street *et al* who reported a 93% union rate with the use of square nails in forearm fixation [5]. Moerman *et al*, achieved 94% union, using the same evaluation criteria; union time with the intramedullary technique was shorter than with

other techniques[16]. Three cases in our series had non-union; all bone grafted and achieved union at 6 months follow up. The cause of non-union in our study was distraction at the fracture site in two cases, one each in radius and ulna, and inadequate immobilization in one subject in the radius.

Cast support was given to patients for a mean 8.2 weeks (range 5 to 12 weeks). As most cases were closed procedures and an above elbow (AE) cast was used postoperatively, final functional outcomes were improved [20].

Ozkaya *et al* conducted a study on 42 patients in which the mean operation time was 65 minutes with plate-screw fixation, and 61 minutes with intramedullary nailing ($p>0.05$). The mean time to union was significantly shorter with intramedullary nailing (10 weeks vs. 14 weeks; $p<0.05$). Results according to Grace-Eversmann criteria were excellent or good in 18 patients (81.8%) and acceptable in four patients (18.2%) treated with plate screw fixation, compared to 18 patients (90%) and two patients (10%), respectively, treated with intramedullary nailing. Mean DASH scores were 15 (range, 4- 30) and 13 (range, 3- 25), respectively. The two groups did not differ significantly with respect to functional results and DASH scores ($p>0.05$). Postoperative complications were seen in three patients (13.6%) and two patients 10%) with plate-screw fixation and intramedullary nailing, respectively [19]. The mean DASH score in our study with square nails of 15 points (range, 4-36) is thus comparable to other studies [8].

Implant removal was performed in 6 patients at mean 19 months post operatively and no re-fractures were reported even after an average of 9 months post removal which is lower than those associated with plate removal [12,21].

CONCLUSION

Use of Talwarkar's design of the square nail has resulted in and continues to result in predictable and good results. Complication rates are lower as compared to plate osteosynthesis and even locked intramedullary nails, although application of above-elbow cast after nailing is a downside of the procedure. The square nail still has a future in repair of forearm fracturing considering its complications rates, cost and acceptable results.

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