



Dorsal nail plate fixation of distal radius fractures

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Intramedullary fixation of distal radius fractures is an emerging concept. The Dorsal Nail Plate is a new device that links a specifically designed stem to a small distal plate; bone fixation is supported by fixed-angle screws. The device is inserted dorsally using a minimally invasive technique; its indications are unstable dorsally displaced extra-articular or simple articular distal radius fractures.

To evaluate the results obtained with this implant, we retrospectively studied 47 extra-articular (36 cases) or simple articular (11 cases) dorsally displaced distal radius fractures in 46 patients treated with this technique. Patients had a mean follow-up of 11 months and were evaluated radiographically and clinically using the Mayo Wrist Score and the DASH score systems. The minimally invasive operative technique is described.

Complications occurred in three cases. Two were observed intra-operatively – partial rupture of extensor pollicis longus tendon - and one postoperatively - loosening of one epiphyseal screw. Excellent reduction was obtained at operation in all but two patients; loss of initial reduction was observed in 2 fractures. All fractures were considered healed radiologically at 40 days.

Average final DASH score was 6 (0-20). According to the Mayo Wrist score, 29 patients had excellent, 12 good and 5 satisfactory results.

The Dorsal Nail Plate (DNP) has shown to effectively stabilize distal radius fractures with dorsal displacement, leading to an early satisfactory functional recovery. Accurate surgical technique minimizes soft tissue dissection and reduces the risk of complications.

Keywords : distal radius fractures ; nail plate fixation.

INTRODUCTION

Fracture of the distal radius is a common injury; treatment options range from non-operative methods to a variety of operative techniques. In recent years, internal fixation has become increasingly popular. New plate designs were shown to be effective in stabilising unstable fractures and restoring functional anatomy, allowing early functional use of the hand; clinical studies reported good or excellent functional results in most patients (18,20, 23). Volar plate fixation has proved to give better clinical results with a lower rate of complications as compared to dorsal fixation (13,24). However fixed angle volar plate fixation requires extensive surgical dissection and complications of this technique, although few, are noted in all series (2,14,21).

In order to combine stable fixation with minimal soft tissue dissection, new intramedullary devices have been developed (4,19). These implants link a specifically designed stem, inserted into the radial diaphyseal canal, to a distal part where divergent

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fixed angle screws support the subchondral bone of the distal epiphysis ; they use minimally invasive techniques to allow early patient rehabilitation. These devices are indicated in unstable dorsally displaced fractures of the distal radius without or with minimal articular involvement where early mobilisation and minimal surgical morbidity is required. Early results of this method seem promising but very few reports focused on the outcome of these techniques (6,12,19). We report our experience through a retrospective study on 46 patients treated with the Dorsal Nail Plate (DNP, Hand Innovation, LLC, Miami, FL, USA).

MATERIAL AND METHODS

Forty-seven distal radius fractures fixed with the Dorsal Nail Plate® (DNP) in 46 patients were studied. Patients included in the study had a recent, untreated, closed, dorsally displaced unstable fracture without or with minimal articular involvement (fractures A2, A3 or C1 according to the AO classification). Patients with open fractures or receiving delayed treatment (> 20 days from the trauma) or previously treated with other systems were excluded from the study.

The study included 29 female and 17 male patients ; ages ranged from 27 to 83 years with a mean age of 64 ; ten patients were older than 75. The dominant hand was affected in 30 cases ; all fractures were closed. Two patients had bilateral wrist fractures ; a bilateral DNP was performed in one of these, while the contralateral fracture was fixed with a volar plate in the other. According to the AO classification, 36 fractures were extra-articular (A2 in 17 cases and A3 in 19) while 11 were classified as C1 articular fractures. All fractures were operated under regional anaesthesia using a tourniquet.

Time interval between injury and operation averaged 3 days (0-8 days). All fractures were operated by the senior author (MR).

The surgical technique was that described by Orbay *et al* (19). A 3 to 4 cm longitudinal incision was made on the dorsum of the wrist over Lister's tubercle. The tendon sheath of the Extensor Pollicis Longus (EPL) was exposed and released. Branches of the dorsal radial sensory nerve were identified and protected. The EPL tendon was retracted radially, and the dorsal radial surface and the fracture site were exposed subperiosteally. The distal aspect of the DNP was positioned 4 mm proximal to the joint line. Lister's tubercle was reduced with a rongeur ; the proximal medullary canal was then entered

with an awl through the fracture site. The DNP was inserted and advanced into the medullary canal of the proximal fragment ; a needle inserted in the radiocarpal joint was used to guide the correct position. The neck of the implant was positioned against the edge of a notch created in the dorsal cortex. The correct position of the implant and the fracture fragments was then checked under fluoroscopy. The implant was fixed to the bone by first inserting the most distal screw or buttress peg ; next, the implant was fixed to the proximal fragment with three unicortical screws. The three remaining distal screws or pegs were inserted finally. The final fluoroscopic images assessed the reduction and the position of the DNP within the bone. Operative time ranged from 25 to 60 minutes (average time 37 minutes).

Postoperatively the wrist was immobilised in neutral position in a removable splint, until the removal of stitches to allow adequate soft tissue healing. The stability of fixation was considered insufficient in five cases with more comminuted fractures ; these patients had the splint for 4 weeks. Average time of splinting was 15 days (range 10-28).

All patients were evaluated, postoperatively with standard PA and lateral radiographs, with the wrist and forearm in neutral position, at 7 and 40 days from operation and at final follow-up. Radiological examination included measurement of radial inclination, volar tilt, radial length and ulnar variance, and articular congruity ; mean values and range were recorded.

Clinical outcome was assessed with the Mayo Wrist score system (1) and the Disabilities of the Arm, Shoulder and Hand (DASH) (11) score at 40 days and at final follow-up (6 to 24 months ; mean F-U 11 months). Passive ROM of the wrist (flexion, extension, radial and ulnar deviation) and active forearm pronation and supination were evaluated using a double-armed goniometer (15). A Jamar dynamometer was used to test grip strength (16). Data were recorded keeping the upper extremity in a standardised position (patient seated with the shoulder adducted and neutrally rotated, elbow flexed at 90°, forearm and wrist in neutral position) ; values were compared to those in the contralateral hand.

Pain was evaluated through a verbal scale (no pain – mild pain – severe pain).

RESULTS

Complications were observed in three cases. Two patients had an intra-operative partial laceration of the EPL tendon : the tendon was not accurately protected and was damaged between the dorsal

cortex of the radius and the implant during introduction of the nail. The tendon was sutured and the thumb was kept in slight extension with a soft elastic bandage ; the patient was invited to move gently and carefully. The thumb was no immobilised. No functional impairment in the thumb was noted at follow-up. One patient had a loose distal locking screw ; the screw was removed at 35 days from operation leaving the nail in place.

Initial postoperative radiographs showed excellent reduction – average radial inclination 20° (limits 18-22°), volar tilt 10° (8°-12°), radial length 10 mm (8-12), ulnar variance neutral, no articular step-off – in all but 2 patients in which palmar tilt (1 case) and articular congruity (1 case) were not completely restored. All fractures were considered radiographically healed at 40 days.

Comparison of immediate postoperative radiographs with those taken at 40 days showed that the initial reduction was maintained in 45 of 47 wrists (fig 1 & 2).

The initial reduction was lost in two patients. In one of these, the palmar angulation was not maintained (from 10° palmar to 10° dorsal tilt) (fig 3). In the other, a 1 mm stepoff of the articular surface. was initially overlooked. The final results, according to the Mayo wrist score, were respectively fair and good.

The average DASH score was 25 (range 15-50) at 40 days.

At the same date wrist motion was satisfactory : average flexion 46° (range : 20-70°), extension 54° (range : 20-80°), radial deviation 12° (range : 5-20°), ulnar deviation 22° (range : 10-30°), supination 72° (range : 30-80°) and pronation 78° (range : 60-90°).

At final follow-up, mean flexion improved to 72° (30-90°), extension to 75° (40-90°), radial deviation to 22° (10-25°), ulnar deviation to 32° (20-35°), supination to 84° (50-90°) and pronation to 85° (70-90°). Mean grip strength of the affected side was 85% of the contralateral hand (range : 65-100%). Mild pain after heavy manual activities was present in three patients.

ROM and grip strength were at least 75% of the healthy wrist in the 41 patients who had no history of a previous trauma.

Final radiological evaluation revealed a mean radial inclination of 20° (range : 18°-22°), volar tilt of 8° (from 10° dorsal tilt to 12° volar tilt), radial height 10 mm (7-12 mm), ulnar variance 0 mm (-1 / +1 mm), articular incongruity with 1 mm stepoff in 2 cases.

Average final DASH score was 6 (0-20). According to the Mayo Wrist score, 30 patients had excellent results (score 90-100), 12 good (80-90) and 5 fair (60-80). Bilateral wrist fractures resulted both in excellent results. The 10 patients older than 75 years of age had excellent (7 cases) and good (3 cases) results.

The mean duration of rehabilitation was 2.4 weeks (range : 0-4 weeks). Return to previous activities or work ranged from 6 to 12 weeks from operation. Seven patients practiced recreational sports involving the use of hands, before trauma ; 6 returned to their sporting practice at their previous levels.

Five patients had previously presented a fracture of the contralateral wrist. All were dorsally displaced extra-articular fractures and had been treated with closed reduction under regional anaesthesia and immobilisation in a long cast ; in two cases the procedure had been repeated and augmented with K-wire pinning for a secondary displacement. All these patients stated that DNP fixation resulted in earlier return to their previous quality of life and was more comfortable than their previous treatment with cast immobilisation. No differences were noted as to function at final follow-up between the two wrists.

DISCUSSION

Operative treatment of distal radius fractures is indicated in extra-articular unstable fractures and in displaced intra-articular fractures. Surgical methods range from minimal invasive closed techniques to open reduction and internal fixation.

Closed reduction and extra- or intrafocal pinning is an effective option, mainly indicated in adult individuals ; in elderly individuals, the poor quality of the bone may lead to loss of reduction and radial shortening (7,17). Disadvantages of this method are prolonged immobilisation, discomfort and pin tract



Fig. 1. — Extrarticular distal radius fracture in a 67-year-old female (A, B). Radiographs at 45 days (C, D)



Fig. 2. — Articular fracture in a 78-year-old female (A, B). Radiographs at 45 days (C, D)

infections. External fixation, especially in the non-bridging technique (10), can be indicated in extrarticular and highly comminuted metaphyseal fractures where the risk of radial shortening is high.

Open reduction and internal fixation is becoming a more widely used technique and has proved to give excellent results both in young and elderly patients (5,17).

Intramedullary fixation of fractures of the distal radius is an emerging concept. The basic concepts

of nailing, defined by Tarr and Wiss (26), have been adapted for distal radius fractures and specific implants have been designed in the last decade. Two devices are presently available, the MICRONAIL® (Wright Medical Technologies, Arlington TN, USA) and the Dorsal Nail Plate® (Hand Innovation LLC, Miami, FL, USA). Results with the MICRONAIL implant have been reported by Tan *et al* (25) in a prospective study on 23 patients, mostly aged more than 60, with extrarticular A2-A3 and



Fig. 3. — Loss of palmar tilt in a 38-year-old male; radiographs at 30 days.

intra-articular C1-C2 distal radius fractures. Wrist motion and DASH scores were graded highly satisfactory even at the early time point. One patient had revision surgery and conversion to volar plating due to fracture collapse which occurred in the initial period; two more patients showed loss of reduction (dorsal angulation and articular step) with respect to initial postoperative radiographs. DASH score was 29 (range 19-47) at one month and 8 (range 0-23) at a 6 months follow-up.

With the same device Ilyas and Thoder (12) reported satisfactory functional results but a high incidence of complications (50% - 5 of 10 patients). There were two cases of transient superficial radial sensory neuritis and three cases of screw penetration in the distal radio-ulnar joint, one of these leading to symptomatic arthritis.

Good functional results have been reported in other studies on Dorsal Nail Plate (DNP) (6,19). DNP can be considered a hybrid implant that associates a small distal plate and an endomedullary nail. The device uses 4 distal locked 2.7 mm fixed angle screws to support the subchondral bone of the distal radius through a specific divergent orienta-

tion. The medullary stem is fixed to the dorsal cortex of the radius by three unicortical screws. Orbay *et al* (19) described the surgical technique of DNP and reported their experience in over 200 cases. Very few clinical data are presented in their paper. The authors conclude that clinical results were excellent in most cases with recovery of wrist motion at the pre-injury level at 4 months, even though wrist flexion, presumably because of the dorsal approach, may take longer to return. Complications were “relatively infrequent”; they reported cases of wound haematoma that required drainage, implant removal due to persistent surgical site discomfort, loss of fixation, and hypertrophic scarring. Espen *et al* (6) reported a similar low rate of complications (2 cases over 32 patients).

This technique demonstrated to be safe in our series, as complications occurred in only 3 cases (6.3%). Intra-operative injury of the EPL tendon occurred in two early cases, due to incomplete release and protection of the tendon.

The design and volar placement of the implant ensure that attritional damage of tendons is minimal; delayed rupture of tendons has been reported in one case only (12). The distal part of the device, which lies on the dorsal surface of the radius, has a smooth and rounded surface; it is located radial to the Extensor Communis Digitorum (ECD) tendons and proximal and radial to the EPL so that generally it does not interfere with their sliding.

Our data show that DNP can effectively stabilize distal radius fractures with dorsal angulation; excellent radiological results were obtained in 43 of 47 wrists with adequate radial height maintained in all cases. In 4 cases reduction was not perfect at operation or was lost during after-treatment; articular fractures or extra-articular fractures with severe initial displacement seemed to be more prone to less satisfactory radiographical results; loss of palmar tilt and articular stepoff were the more common features observed.

Clinically most patients had good or excellent results (90%) and none was graded as poor. Our study group was not homogeneous with respect to age, as there was a mix of young and older patients; however, no differences in outcome were noted between elderly and young patients.

Correct patient selection remains mandatory to achieve good results. Unstable extra-articular fractures with dorsal displacement reduced by closed methods or without extensive dissection are the main indication. Fractures with undisplaced and stable articular fragments can be also treated but accurate preoperative evaluation must confirm stability of the fragment.

This treatment should certainly be considered when early functional recovery is requested or in polytrauma and patients with multiple fractures, in which surgical time and bleeding must be kept to a minimum, and in bilateral wrist fractures or patients who do not tolerate cast immobilisation.

The advantages of internal fixation over conservative treatment in the management of wrist fractures in elderly and less active people are disputable (2); cast immobilisation is still considered the preferred method in this age group. However, our data show that even patients over 75 years of age can be treated satisfactorily and safely with this method.

Our experience suggests that DNP is a very useful option in the treatment of unstable distal radius fractures with dorsal displacement. Stable fixation is achieved with the benefit of minimally invasive dissection and short operative time: these advantages make the device competitive, compared with volar plating or pinning and cast methods in selected fractures and patients.

This study has some methodological shortcomings: the small size of the study group and absence of a control group; further prospective randomized studies will be necessary to assess the exact role and place of this technique in the management of distal radius fractures.

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