Original Article

Screw elastic intramedullary nail for the management of adult forearm fractures

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Abstract

Background: The failure of the conventional nailing of both forearm bones or isolated fractures of radius and ulna pose a potential problem of nail migration and rotational instability, despite the best reduction. The purpose of this paper is to evaluate the results of screw elastic intramedullary nail for the treatment of adult diaphyseal fractures of both forearm bones, which effectively addresses the problems associated with the conventional nailing systems for the forearm fractures.

Materials and Methods: Seventy-six adults with forearm fractures (radius and ulna or isolated fracture of the single bone) were retrospectively evaluated. Fifty males and 26 females with the mean age of 38 years (range, 18-70 years) underwent closed reduction and screw intramedullary nail fixation. Ten patients required limited open reduction. The fractures were classified according to the AO/OTA system. The average followup was 12 months (range, 6 to 18 months).

Results: The mean surgical time was 45 minutes (35 to 65 minutes). The meantime to union was 14 weeks (10-21 weeks). The results were graded as excellent in 50, good in 18 patients, and acceptable in eight patients, using the criteria of Grace and Eversman. We had superficial infection in three cases, one case of delayed infection, painful bursa in two cases, delayed union in two cases, malunion with dislocation of the DRUJ in two cases, injury to the extensor tendon of the thumb in one case, and one case of incomplete radioulnar synostosis.

Conclusion: Closed reduction and internal fixation of forearm fractures by screw intramedullary nails reestablishes the near normal relationship of the fractured fragments. Screw intramedullary nail effectively controls both rotatory forces and the migration of the nail. It produces excellent clinical results in isolated fractures of either bones, as well as both bones of the forearm in adults.

Key words: Fracture radius and ulna, radius fracture, ulna fracture, diaphyseal fracture, screw intramedullary nail

Introduction

The goal of treatment of diaphyseal fractures of both bones of forearm in adults is to regain length, axial and rotational stability.[1] Open reduction and internal fixation (ORIF) with compression plates achieve a high percentage of union in about 96 to 98% of cases.[2-4] Fixation with a limited contact dynamic compression plate is considered to be more biological.[5,6] However it produces extentive soft tissue damage and the fracture haematoma is disturbed. The complications reported are, compartment syndrome, infection, nonunion, cross union, malunion, and nerve injuries.[2,7,8] Refractures after extraction of the plate have also been described.[9,10]

Intramedullary nailing with Kirschner wires, Steinman pins, and Rush pins have been tried with disappointing results and a high rate of nonunion precludes its routine use.[11,12] Unlocked closed intramedullary nailing (prebent triangular, square nails) respects the soft tissues and vascular supply compared with open reduction. Sage described improved results with prebent triangular design. However, unlocked nail may not adequately control rotation, especially in segmental fractures.[13,14]

The distinct advantage of locked intramedullary nailing technique is the capacity of preventing shortening in metaphyseal, comminuted, and segmental diaphyseal forearm fractures,[15,16] but the procedure is technically demanding and injury to posterior interosseous nerve is reported.

We report a concept of closed reduction and screw intramedullary nailing for the management of adult forearm fractures.

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Materials and Methods

Seventy six adult patients who were surgically managed during January 2007 to July 2010 were retrospectively reviewed. Of these patients, 26 were women and 50 were men. Forty-eight patients had fracture of the right forearm, whereas 28 had fracture of the left forearm. The mean age was 38 years (range 18-70 years).

The mode of trauma was road accidents (n=24), fall from height (n=17), industrial accidents (n=13), domestic accidents, (n=10) and direct blow (n=9). Fractures in three cases were due to trivial trauma in osteoporotic bones.

Fifty cases sustained high-energy trauma and 26 cases had low-energy trauma. Fifty-eight were closed fractures, 13 were grade I open fractures, and five patients had grade II open fractures. Fractures were classified using the classification proposed by AO/OTA. Forty-two cases were type A fractures and 25 cases were type B fractures. Nine were of Type C fractures. Twelve cases had multiple injuries. The anteroposterior and the lateral radiographs were analyzed to ascertain the fracture geometry, the extent of displacement, and the comminution [Table 1].

The duration from injury to surgery was 2 days (range, 1-5 days). The majority of the fractures were operated under brachial block (n=65) and the rest were given general anesthesia in which the brachial block could not achieve proper anesthesia (n=11). Tourniquet was used in fifty eight cases.

The design of the screw intramedullary nail

The screw intramedullary nail (Titanium nail manf. K-AIMS ORTHO Implants, Mumbai, India) is a smooth circular and is available in diameter of 2, 3, and 4 mm with beveled tip. A threaded head, blended with the nail, is positioned at the end of nail held in place by circular running notch located on the end of nail shaft. This design allows the self-cutting thread to be advanced and screwed in with a screw driver.[17] The distal beveled end of the nail aids in fracture reduction and helps in engaging in the subchondral area of the bone, thereby imparting stability [Figure 1]. By adequately burying the nail into the metaphyseal region the soft tissue irritation is prevented.

Table 1: Site of fracture

Fracture site	Males (n=50)	Females (n=26)	Total (n=76)
Upper 1/3 both bone forearm	8	3	11
Middle 1/3 both bone forearm	19	8	27
Lower 1/3 both bone forearm	4	3	7
Isolated ulna	4	7	11
Monteggia fracture dislocation	2	1	3
Isolated radius	5	2	7
Galeazzi fracture dislocation	7	1	8
Ulna segmental	1	1	2

Operative procedure

We prefer to address the ulnar fracture first due to its subcutaneous position. This might help in restoring length and alignment of the forearm. A 2 or 3 mm elastic screw nail is introduced through the tip of the olecrenon and negotiated across the fracture till it reaches subchondral bone. A 2 or 3 mm prebent elastic screw nail is then introduced through the styloid process of the radius and negotiated till it reaches the subchondral bone of radial head crossing the fracture. The stability is assessed while the nail is *in situ* and checked under the C arm. If the construct is unstable, then we advocate stacking the fracture site with an additional nail through the radius or ulna by creating a nail entry point adjacent to the previously passed nail [Figure 2]. We used this technique in nine cases. The average time for the surgery was 45 minutes (range 35-65 minutes). In four cases of delayed presentation, we did open reduction and bone grafting. Fracture distraction and iatrogenic comminution can be prevented by preoperative canal assessment and insertion of proper size nail.

One dose of third-generation cephalosporin was given preoperatively and two doses after surgery were given. An above-elbow cast was given for a period of six weeks. Active finger movements were started immediately after the operation. The cast was removed after six weeks and the radiographs were obtained. Physiotherapy for elbow and wrist, were initiated.

Results

The follow up time was average 12 months (range 6-18 months) [Figures 3-5]. The average union time was 14

Figure 1: Clinical photograph of implant (screw elastic intramedullary nail) (a) Showing the profile of the screw intramedullary nail, (b) Shows the serrations of the screw nail which engage into the metaphyseal region of the bone (c) The end on view which engages with the screw driver

weeks (range, 10-20 weeks). Closed fractures healed at an average of 12 weeks (range, 10-16 weeks) and open fractures healed at an average of 14 weeks (range, 12-20 weeks). We had superficial infection in (n=3) of grade 1 open fracture, painful bursa in (n=2) cases because of migration of the nail, delayed union (n=2) cases, malunion with dislocation of the DRUJ (n=2), delayed infection (n=1) injury to the extensor tendon of the thumb (n=1), and incomplete radioulnar synostosis (n=1). The patients refused corrective surgery, even after counseling, as they were comfortable performing activities of daily living.

Delayed infection occurred in a Grade II compound fracture radius and ulna which resolved after extraction of the screw, wound lavage, and antibiotic therapy. This complication had no effect on bone healing. The results were graded according to criteria given by Grace and Eversman.[18] An excellent rating meant that there is 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 rotator arc be present. For an acceptable result, union of the fracture and a minimum of 60% of normal rotation of the forearm has to be present. An unacceptable result meant that there was a nonunion or that the patient has <60% of normal rotation of the forearm. IIn our series of 76 patients, we had an excellent result (n=50) or good result (n=18), whereas eight had an acceptable result.

Figure 2: Anteroposterior and lateral radiographs of both bone forearm with wrist in a twenty six year old male (a) Preoperative xrays showing galeazzi fracture dislocation (b) postoperative radiographs after nailing, which required a stacked additional nail

Figure 4: (a) Anteroposterior and lateral radiographs of both bone forearm showing upper third diaphyseal fracture of both bones forearm in a sixty year old female. (b) radiographs taken 6 months after the operation showing satisfactory union and alignment

Discussion

Conservative or inadequate surgical management of

Figure 3: (a) Preoperative radiographs (anteroposterior and lateral view) showing a mid diaphyseal fracture of both bones forearm (b) radiographs taken 10 months after the operation showing satisfactory union and alignment

Figure 5: (a) Anteroposterior and lateral radiographs of both bones forearm in a twenty six year old male showing a mid-diaphyseal fracture (b) radiographs taken 6 months after the operation showing union

forearm bone fractures is often fraught with numerous complications.[13] Open reduction and plate fixation is one of the commonly employed method of treatment of forearm fractures. Various authors have shown good to excellent results with union rate ranging from 96% to 98% with 85% satisfactory results[2]; 97% union and 80% satisfactory function[3]; and 98% union rate and 93% patient satisfaction.[4] The limited contact dynamic compression plate (LCDCP) and the point contact fixator have been termed as biological fixation.[5] Excellent results are reported by Hass *et al*.[19] and Leung and Chow.[6]

Complications of the plates such as compartmental syndrome in 10%,[20] sepsis in 3 to 9%,[2,21] delayed union or nonunion in 2%,[2,3] and refractures after extraction of the plate in 3.5 to 22% of cases have been described.[4,9,10] High frequency of intraoperative nerve injuries has also been reported.[22] The reported incidence of transient dorsal nerve palsy is 7 to 10% of all patients with radius fracture treated by plate.[2,23] Incidence of radioulnar synostosis of the plate fixation reported in literature is 2% to 9%.[8] Though plating for both forearm bones fracture appears sound and adhering to the principles of osteosynthesis, straight plate is unable to maintain and preserve the radial bow, essential for the normal rotational movements of the forearm.[22]

The results with intramedullary nailing by Krishner wires, Steinman pins, and Rush pins have been disappointing and a high rate of nonunion (20%) has been reported by various authors.[11,12,22] Rush brothers had propagated the concept of three-point fixation in nailing long bone fractures. The flexible Rush pins follow and maintain the radial curve and impart stability by three-point fixation, but a thin nail fails to address the rotatory stability. The ends of Rush nails act as potential irritant to the tendons around the wrist, necessitating early removal.[23] Street introduced a square design to improve stability and fracture healing which dramatically changed the nonunion rates.[24] He reported a 93% union rate and 83.5% excellent to good functional results. Kuntschner propagated the concept of filling the medullary canal of the bones with a rigid and large nails. But unfortunately, it could not address the issue of the radial bow and stability till the eventual fracture union. Implant migration remained a constant concern till eventual union which is addressed by the screw nail. The concept of radial bow maintenance was put forth by Sage.[1,22] Moerman *et al*.[14] reported 94% union rate with the prebent radial nail which maintains the radial bow and its triangular cross-sectional shape prevents rotational instability.

In the locked intramedullary technique, prebending a straight nail and restoration of the normal radial bow is necessary to gain excellent forearm function.[25] With foresight interlocked nail, the reported mean time to union is 10 weeks for closed fractures and 14 weeks in open fractures. With locked intramedullary nails, excellent and good results have been reported to be 100% by Gao *et al*.,[15] 88.6% by Visna *et al*.,[26] 92% by Lee *et al*.,[25] whereas De Pedro *et al*.[16] reported a 100% union rate in forearm. In a comparative series of plating *vs* interlocking nailing, the authors found no significant difference between the union rates and functional outcome.[27] However, the closed interlocking nailing is a demanding procedure that has a costly instrumentation.[28] Iatrogenic posterior interosseous nerve injury may be observed during locked intramedullary nailing.[29]

Crenshaw *et al*.[3] reported that the belief that the forearm interlocking intramedullary nails always be interlocked was wrong; the screw elastic intramedullary nail works on the principle of three-point fixation and maintenance of the radial bow, addressing the issues with the DRUJ.[22] The screw nail is an interlocking nail with distal static fixation and proximal end in a subchondral bone in a dynamic situation The screw intramedullary nail has a threaded head blended with the nail. The dynamic effect is achieved by the soft tissue integrity of the limb, the exercises which are initiated after the surgery, thereby creating a dynamically favourable environment. The screwed end of the nail locks at the metaphyseal end of the radius and ulna. It imparts relative stability which aids in a good callus formation.

An angulation of less than 10 degrees in any plane has been shown not to interfere with any limitation in forearm range of motion.[14] In 90% of our cases, the angulations was less than 10 degrees. Being a closed procedure (most of the times) and applying an above elbow (AE) cast postoperatively does not jeopardize the final functional outcome. The secondary periosteal callus formation is evident due to the stress shielding properties of the implant.[12] Nonunion, iatrogenic neurovascular injury and compartment syndrome were not observed in this study.

Bone grafting had been advocated in comminuted fracture treated by nailing.[2,20,22] Static interlocking guarantees adequate stability in all fracture types and does not require bone grafting.[30] No bone grafting was carried out in the fresh cases but used frequently in patients with delayed presentation. We believe that the comminuted fragments after the closed nailing neither require bone grafting, nor do they need supplemental marrow injection for union. The principle is based on maintaining the biological integrity with minimal traumatic insult to the medullary canal and the soft tissues.

In this study, an anatomic, unreamed intramedullary nail

for the radius and ulna produced minimal deformity, well within the established limits for good functional outcome. Intramedullary stabilization has the potential to maintain satisfactory reduction of diaphyseal forearm fractures. A long intramedullary self-tapping screw counteracts the problem of implant migration. In some of the cases, additional nail is required to achieve stability. We do agree that in the isolated proximal third of the fracture radius, Galeazzi fracture dislocation, or a part of both fracture bones, there is a translation of the fragment after inserting the nail. This is easily addressed by negotiating a smaller diameter nail and jamming it across the fracture site.[31] The stability is achieved by the anchorage they gain in the small or wider medullary canal. It also aids in the patient comfort and often is an important tool in the management of osteoporotic fractures of the forearm. Our results are comparable with series reported in literature.[2,3,25-27] Compared with standard plates, this device is less invasive and minimizes soft tissue dissection. The exposure of the surgeon and the surgical team to radiation beam may be a disadvantage of the method. The screw end after it is buried into the metaphyseal region of the bone imparts stability and prevents migration and irritation of the overlying structures. The method highlights the utility of a minimally invasive and biologically balanced technique of three-point fixation and screw fixation at the end of bone with promising results.

Conclusion

Screw elastic intramedullary nail is an implant with a short learning curve. It effectively controls both rotatory forces and the migration of the nail. The procedure can be undertaken at any district-level hospital with minimal instrumentation. This implant addresses the biological concept of the fracture healing.

References

1. Schemitsch EH,Richards RR. The effect of malunion on functional outcome after plate fixation of fractures of both bones of the forearm in adults. J Bone Joint Surg Am 1992;74:1068-78.
2. Anderson LD, Sisk D, Tooms RE, Park WI 3rd. Compression-plate fixation in acute diaphyseal fractures of the radius and ulna. J Bone Joint Surg Am 1975;57:287-97.
3. Chapman MW, Gordon JE, Zissimos AG. Compression-plate fixation of acute fractures of the diaphyses of the radius and ulna. J Bone Joint Surg Am 1989;71:159-69.
4. Hadden WA. Reschauer R, Seggi W. Results of AO plate fixation of forearm shaft fractures in adults. Injury 1985;15:44-52
5. Perren SM. The concept of biological plating using the limited contact – dynamic compression plate (LCD-DCP). Scientific background, design and application. Injury1991;22(suppl 1)1-41.
6. Leung F, Chow SP. Locking compression plate in the treatment of forearm fracture A prospective study. J Ortho Surg [Hong kong] 2006;14;291-4.
7. Dodge HS. Cady GW. Treatment of fractures of the radius and ulna with compression plates; A retrospective study of one hundred and nineteen fractures in Seventy-eight Patients. J Bone Joint Surg Am 1972;54;1167-76.
8. Stern PJ, Drury WJ. Complications of plate fixation of forearm fractures. Clin Orthop Relat Res 1983;175:25-9.
9. Rosson JW, Shearer JR. Refracture after the removal of plates from the forearm. An avoidable complication. J Bone Joint Surg Br 1991;73:415-7.
10. Hidaka S, Gustilo RB. Refracture of bones of the forearm after plate removal. J Bone Joint Surg Am 1984;66:1241-2.
11. Smith H, Sage FP. Medullary fixation of forearm fractures. J Bone Joint Surg Am 1959;39:91-8.
12. Crenshaw AH, Zinar DM, Pickering RM. Intramedullary nailing of forearm fractures. Instr Course Lect 2002;51:279-89.
13. Langkamer VG, Ackroyd CE. Internal fixation of forearm fractures in the 1980s: Lessons to be learnt. Injury 1991;22:97-102.
14. Moerman J, Lenaert A, De Coninck D, Haeck L, Verbeke S, Uyttendaele D, *et al*. Intramedullary fixation of forearm fractures in adults. Acta Orthop Belg 1996;62:34-40.
15. Gao H, Luo CF, Zhang CQ, Shi HP, Fan CY, Zen BF. Internal fixation of diaphyseal fractures of the forearm by interlocking intramedullary nail: Short-term results in eighteen patients. J Orthop Trauma 2005;19:384-91.
16. De Pedro JA, Garcia-Navarrete F, Garcia De Lucas F, Otero R, Oteo A, Lopez-Duran Stern L. Internal fixation of ulnar fractures by locking nail. Clin Orthop Relat Res 1992;283:81-5.
17. Roth W, Weber M. A new concept in the treatment of fibular fractures with intramedullary implants. Practice of intramedullary locked nails. New developments in techniques and applications. Berlin, Heidelberg: Springer -Verlag; 2006. p. 145-54.
18. Grace TG, Eversmann WW Jr. Forearm fractures: Treatment by rigid fixation with early motion. J Bone Joint Surg Am 1980;62:433-8.
19. Haas N, Hauke C, Schutz M, Kääb M, Perren SM. Treatment of diaphyseal fractures of the forearm using the point contact fixator (PC-Fix): Results of 387 fractures of a prospective multicentric study. Injury 2001;32(suppl 2)51-62.
20. Moed BR, Kellam JF, Foster RJ, Tile M, Hansen ST Jr. Immediate internal fixation of open fractures of the diaphysis of the forearm. J Bone Joint Surg Am 1986;68:1008-17.
21. Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: Retrospective and prospective analyses. J Bone Joint Surg Am 1976;58:453-8.
22. Sage FP. Medullary fixation of fractures of the forearm. A study of the medullary canal of the radius and a report of fifty fractures of the radius treated with a prebent triangular nail. J Bone Joint Surg Am 1959;41:1489-516.
23. Ono M, Bechtold JE, Merkow RL, Sherman RE, Gustilo RB. Rotational stability of diaphyseal fractures of the radius and ulna fixed with Rush pins and/or fracture bracing. Clin Orthop Relat Res 1989;240:236-43.
24. Street DM. Intramedullary forearm nailing. Clin Orthop Relat Res 1986;212:219-30.
25. Lee YH, Lee SK, Chung MS, Baek GH, Gong HS, Kim KH. Interlocking contoured intramedullary nail fixation for selected

diaphyseal fractures of the forearm in adults. J Bone Joint Surg Am 2008;90:1891-8.
26. Visńa P, Beitl E, Pilný J, Cizmár I, Vlcek M, Kalvach J, *et al*. Interlocking nailing of forearm fractures. Acta Chir Belg 2008;108:333-8.
27. Ozkaya U, Kiliç A, Ozdoğan U, Beng K, Kabukçuoğlu Y. Comparison between locked intramedullary nailing and plate osteosynthesis in the management of adult forearm fractures. Acta Orthop Traumatol Turc 2009;43:14-20.
28. Weckbach A, Blattert TR, WEISSER CH. Interlocking nailing of forearm fractures. Arch Orthop Trauma Surg 2006;126:309-15.
29. Tabor OB Jr, Bosse MJ, Sims SH, Kellam JF. Iatrogenic posterior interosseous nerve injury: Is transosseous static locked nailing of the radius feasible? J Orthop Trauma 1995;9:427-9.
30. Lee YH, Lee SK, Chung MS, Baek GH, Gong HS, Kim KH. Interlocking contoured intramedullary nail fixation for selected diaphyseal fractures of the forearmin adults. J Bone Joint Surg Am 2008;90:1891-8.
31. Gadegone WM, Salphale Y, Magarkar D. Percutaneous osteosynthesis of Galeazzi fracture-dislocation. Indian J Orthop 2010;44:448-52.

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