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Original Research Article

COMPARATIVE ANALYSIS OF OUTCOMES OF PLATE OSTEOSYNTHESIS AND ELASTIC NAIL FIXATION OF BOTH BONE FOREARM FRACTURES IN ADULTS

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Abstract

Background: The Objective is to evaluate and compare the clinical and functional outcomes between intramedullary and extramedullary fixation of both bone forearm fractures in adults. **Materials and Methods:** Range of motion, time to radiological sign of union, and validated outcome measure according to Grace and Eversmann rating, were assessed in a retrospective study of eighty-two adult patients (fifty-six male and twenty-six females with a mean age of 39.37 years) of both-bone forearm fractures. Of these, forty-one patients were treated with intramedullary elastic nail fixation and forty-one patients with extramedullary plate fixation each. The duration of follow-up was 6 months and standardized radiographs of the forearm were evaluated. **Result:** All fractures went for union clinically and radio-logically. The average time for union was 17.87±2.65 weeks (average 17.61±2.91 weeks for the plate osteosynthesis group and, 18.12±2.37 weeks in the nailing group). Out of 82 patients, 27 (32.93%) patients had excellent outcomes (the fracture had united, and at least 90 % of the normal forearm rotation was achieved), 47 (57.32%) patients had good outcomes (the fracture had united, and 80–89 % of the normal rotation was achieved), and 8 (9.75%) patients had acceptable outcomes (the fracture had united, and 60–79 % of the normal forearm rotation was present) at 6 months as measured by the Grace and Eversmann rating system. No patients had unacceptable outcome (non-union or <60 % of normal forearm rotation occurred). Among the 41 patients of the extramedullary fixation (plate osteosynthesis) group, excellent outcome was seen in 16 (39.02%) patients, good outcome in 22 (53.66%) patients and acceptable outcome in 3 (7.32%) patients. Among the 41 patients of the intramedullary fixation (elastic nailing) group, excellent outcome was seen in 11 (26.82%) patients, good outcome in 25 (60.98%) patients and acceptable outcome in 5 (12.20%) patients. The complications observed in the plate osteosynthesis group were superficial infection in 2 patients (4.88%), both of which resolved with oral antibiotics. In the nailing group we observed nail impingement at ulna nail entry site at olecranon tip in 3 patients (7.31%) with one patient developing olecranon bursitis secondary to nail impingement. All three patients were managed by removal of the ulna nail after satisfactory union. **Conclusion:** Extramedullary fixation of both fractures by open reduction and plate osteosynthesis allows for anatomical reduction and rigid fixation with maintenance of the radial bow resulting in good functional outcomes and has been considered a treatment of choice in literature. However, complications related to surgical exposure like, infection, local devascularisation, risk of neurovascular injuries and surgical scars have warranted alternative treatment with intramedullary fixation with nailing for select patients. We found comparable good outcomes of intramedullary elastic nail fixation. Although intramedullary nailing falls short in achieving anatomical reduction, it offers advantages of preservation of local biology and better cosmesis. Care has to be taken in selecting nail lengths so as to not damage tendons. An adequate surgical technique will minimize complications and an aggressive rehabilitation regime (active physiotherapy) will ensure the best possible result.

INTRODUCTION

The radius and the ulna play an important role in the cardinal movement of the upper extremity as the anatomical bow of the radius allows for rotation around a fixed ulna which is critical for supination – pronation. Hence, diaphyseal fractures of the radius and ulna, often referred to as both-bone forearm fractures, if treated with insufficient reduction or inappropriate implants results in restricted forearm rotation and also affects the wrist and elbow joint movements. The deforming effect of muscle forces, continuity of the radial incline, and interosseous membrane damage make it almost impossible to achieve stable fixation with conservative treatment. Due to such functional and anatomic features, diaphyseal fractures of the forearm must be evaluated as intra-articular fractures, with treatment planned accordingly.[1,2]

Several surgical methods have been described for their treatment including plate-screw osteosynthesis and intramedullary nailing.[3,4] Plate and screw fixation maintains axial and rotational alignment while allowing immediate mobilization.[5] A downside is an extensile approach with a degree of muscle and periosteal elevation that theoretically could contribute to delayed union or non-union.[6] Patients can also experience symptoms related to the hardware, and implant removal exposes them to the risks of nerve injury and refracture.[7-12]

Intramedullary nails are occasionally considered as a potential alternative to plate and screw fixation, with proposed advantages of smaller scars, less periosteal stripping, fewer symptoms related to the implants, and a lower risk of re-fracture after implant removal.[13-15]

In this study, we will evaluate the results and outcomes of the two treatment methods, i.e. - extramedullary fixation with plating and intramedullary fixation with elastic nailing - for both bone forearm diaphyseal fractures in adults.

MATERIALS AND METHODS

For this study, data of patients operated between July 2020 and May 2022 at a tertiary care hospital was retrospectively analysed. Both bone forearm fractures were defined as simultaneous diaphyseal fractures of the radius and ulna. The radial shaft fractures are defined as those occurring between the radial neck proximally and the junction of the metaphysis and diaphysis distally, approximately 3 cm proximal to the distal articular surface. The ulnar shaft fractures are defined as those occurring between the distal aspect of the coronoid proximally and the ulnar neck distally.

Patients who have consented for study with skeletally mature, closed simultaneous radius and ulna shaft fractures were included. Those with age < 18 years or > 65 years; open fractures; associated ipsilateral upper limb injury; Galeazzi or Monteggia fracture-dislocations; patients requiring hybrid fixation of nailing and plating; old ipsilateral limb fracture; segmental diaphyseal fracture and fractures extending beyond the pre-defined definition of radius and ulna shaft were excluded from study.

Based on these criteria, a total of 82 patients included in study and divided in two group based on mode of treatment they received. Relevant clinical and radiological findings were noted and the fractures were classified as per the level of the fracture. Pre-operatively well-informed verbal as well as written consent taken. In the first group (41 patients), fractures managed by intramedullary fixation with elastic nailing of both bones and in second group (41 patients) extramedullary fixation with plating of both bones were included. All the patients were followed up for a minimum of 6 months to assess the time to radiological union and complications, and the functional outcome was assessed by the Grace and Eversmann scoring systems at the end of the study.

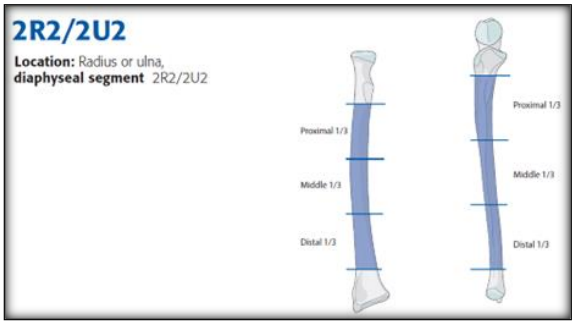

Figure 1: Fracture classification as per the level of fracture

Operative Considerations

Surgery was done in supine position with the operative limb on radiolucent arm support. The fracture with less comminution in reference to the radius and ulna was fixed first to facilitate the reduction and restore length in both groups. For open reduction, fractures of the radius were accessed via volar approach of Henry or posterior Thompson approach depending on the fracture and surgeon's preference. The ulna fracture was approached along its subcutaneous dorsomedial ridge in the interval between extensor carpi ulnaris and flexor carpi ulnaris. The entry for intramedullary nailing of ulna was taken at the olecranon tip and for radius the entry was taken on radial side of Lister's tubercle between the second and the third extensor tendon compartment. A 3.5 mm DCP or LC-DCP was used for the plate osteosynthesis group while titanium elastic nailing was used for the intramedullary nailing group.

Post-Operative protocol

Rehabilitation

All patients of intramedullary elastic nailing group were immobilized with an above elbow plaster for 4 weeks followed by sugar tong type of below elbow cast for 2 weeks and asked to perform active finger

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movements. After that all movements gradually permitted. In patients of plate osteosynthesis group, slab was discontinued post operatively and mobilisation of fingers, wrist, forearm supination and pronation. elbow and shoulder by gentle active and assisted physiotherapy was initiated.

Assessment

Patients were followed up with regular visits every 4–6 weeks after stitch removal till at least 6 months and were assessed for radiological union and incidence of any complications at each visit. Fracture healing was determined as fracture bridging seen on plain radiographs of the operated forearm taken in standard anteroposterior and lateral views. Functional outcomes were assessed at 6 months with use of the Grace and Eversmann rating system,[16] which is based on fracture union and forearm rotation. The result was rated as ''excellent'' when the fracture had united, and at least 90 % of the normal forearm rotation was achieved; as ''good'' when the fracture had united, and 80–89 % of the normal rotation was achieved; as ''acceptable'' when the fracture had united, and 60–79 % of the normal forearm rotation was present; and as ''unacceptable'' when non-union or <60 % of normal forearm rotation occurred.

Statistical analysis

The differences between the two groups were tested using the unpaired sample T-Test for time to union. The chi-square test was used to examine the differences in the number of functional outcomes (Grace and Eversmann rating system). The data are presented as the mean ± standard deviation. A value of $p<0.05$ was considered statistically significant.

RESULTS

Our study included 82 patients of closed both bone-bone forearm fractures between the age group of 18 to 65 years treated with extramedullary fixation with plate osteosynthesis and intramedullary fixation with elastic nailing followed up for a minimum of 6 months. The mean age of patients was 39.37 years with maximum incidence recorded in age group of 31-40 years. Majority of the patients were male (M:F=2.15:1) and the most common mode of injury is due to road traffic accident with majority of the fractures reported in the middle third region. The demographic findings of our study are shown in Table 1. All patients of both groups obtained fracture union (100 % union rate). The average time to union was 17.87 ± 2.65 weeks (range, 12 weeks to 23 weeks). The mean time to radiological union in the extramedullary fixation (plating) group is 17.61 weeks with a standard deviation of ±2.91 weeks. The mean time to radiological union in the intramedullary fixation (elastic nailing) group is 18.12 weeks with a standard deviation of ±2.37 weeks. The two-tailed p-value equals 0.3851. By conventional criteria, this difference is considered to be not statistically significant.

Table 1: Patient demographics.

Variables	Plate osteosynthesis group	Intramedullary nailing group
Patients (n)	41	41
Mode of injury		
Road traffic assault	19	18
Domestic fall	11	10
Assault	11	13
Level of fracture		
Distal third	11	11
Middle third	25	26
Proximal third	5	4
Gender (M/F)	27/14	29/12
Age (years)	40.44 (12.44)	38.29 (10.31)
Values are mean (±SD)		

Table 2: Results

Variables	Plate osteosynthesis group	Intramedullary nailing group	p value
Patients (n)	41	41	-
Time to radiological union (weeks)	17.61 (± 2.91)	18.12 (±2.37)	0.3851
Functional outcome*			0.445433
Excellent (n, %)	16 (39.02)	11 (26.82)	
Good (n, %)	22 (53.66)	25 (60.98)	
Acceptable (n, %)	3 (7.32)	5 (12.20)	
Unacceptable (n, %)	0	0	
Values are mean (±SD)			

*As per Grace and Eversmann rating system

According to the Grace and Eversmann rating system, the extramedullary fixation (plate osteosynthesis) group showed excellent outcome in 16 (39.02%) patients, good outcome in 22 (53.66%) patients and acceptable outcome in 3 (7.32%) patients. The intramedullary fixation (elastic nailing) group, showed excellent outcome in 11 (26.82%) patients, good outcome in 25 (60.98%) patients and acceptable outcome in 5 (12.20%) patients. No patients had unacceptable outcome. A

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chi-square test of independence was performed to examine the relationship between the choice of fixation and functional outcome. The chi-square statistic is 1.6174. The p-value is 0.445433. The result is not significant at $p < 0.05$. The results are summarised in [Table 2].

In the plate osteosynthesis group, two patients had a superficial infection, which resolved after the administration of oral antibiotics. In the intramedullary elastic nailing group, two patients had nail impingement and one patient had olecranon bursitis secondary to nail impingement. All three patients were managed by removal of the ulna nail after satisfactory union. No cases of deep infection, radioulnar synostosis between the forearm bones, compartment syndrome, and failure of fixation or breakage of a device (plate, a nail, or a screw) were observed in both groups.

DISCUSSION

The commonly used treatment methods for both-bone forearm fractures are intramedullary fixation with various types of nails and extramedullary fixation with plate and screws. The choice of which technique to use depends on the specific characteristics of the fracture, as well as the preference of the surgeon.

Extramedullary fixation by open reduction and plate osteosynthesis of forearm fractures is an accepted treatment option and has shown good functional results since many years. In 1975, Anderson,[17] reported a 97% union rate with satisfactory or excellent function in 85%, while Chapman,[18] reported a union rate of 98%, with satisfactory or excellent functional outcomes in 91%. Goldfarb,[19] evaluated the functional outcomes of 23 patients a mean of 2.8 years after plate fixation of a both-bone forearm fracture and found pronation and supination were 10° less than those of the uninjured arm. Droll,[20] reviewed the functional outcomes of 30 patients at a mean of 5.4 years after plate fixation for both-bone forearm fractures and demonstrated 15% to 38% less forearm and wrist strength compared to the uninjured arm and 9% to 18% less forearm and wrist motion.

Early reports of intramedullary fixation yielded unacceptably high non-union rates.[21-23] Rush brothers had shown 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.[24] Street,[25] introduced a square design to improve stability and fracture healing which reported a 93% union rate and 83.5% excellent to good functional results. With locked intramedullary nails, excellent and good results have been reported to be 100% by Gao,[26] 88.6% by Visna,[13] 92% by Lee.[15] Iatrogenic posterior interosseous nerve injury may be observed during locked intramedullary nailing.[27]

Zhao,[28] conducted a meta-analysis which included a total of 13 studies (involving 854 patients) and found that compared with ORIF, IM nailing significantly reduced the operation time and complication rate. However, no significant differences were observed between the two surgical techniques in time to union, union rate, radial bow magnitude, and loss of forearm rotation.

Open fractures of radius and ulna are treated exclusively with intramedullary nailing at our institute and hence were not included in the study. In the case of the plate osteosynthesis, a more accurate reduction was possible for healing by direct contact. Intramedullary elastic nailing, poses technical difficulties in closed reduction and manoeuvring of nail through fracture fragments and requires post-operative immobilisation for a further 6 weeks. Even though no statistical significance was observed in terms of time to radiological union and functional outcome at 6 months between the two groups, patient satisfaction with respect to regained range of motion was higher in the plate osteosynthesis group.

CONCLUSION

In our study, no significant statistical difference was observed between extramedullary fixation with plate osteosynthesis and intramedullary fixation with elastic nailing in terms of time to radiological union and functional outcome at 6 months. We conclude that while extramedullary fixation with plate of both-bone forearm fractures offers superior reduction and fixation with early mobility and resumption of daily activities making it the treatment of choice, intramedullary fixation with nailing offers similar functional outcomes with lower chances of complications and hence, can be considered as a treatment option for select patients with sufficient intramedullary canal and compliant to longer period of immobilisation.

REFERENCES

1. Crenshaw AH. Fractures of shoulder, arm and forearm. In: Canale ST, Daugherty K, Jones L, editors. Campbell's operative orthopaedics. 10. St. Louis: Mosby; 2003. p. 3049–58.
2. Markolf, Keith L. Ph.D.; Lamey, David M.D.; Yang, Steven M.D.; Meals, Roy M.D.; Hotchkiss, Robert M.D., Los Angeles, California. Radioulnar Load-Sharing in the Forearm. A Study in Cadavera*. The Journal of Bone & Joint Surgery 80(6):p 879-88, June 1998.
3. Schulte LM, Meals CG, Neviaser RJ. Management of adult diaphyseal bothbone forearm fractures. J Am Acad Orthop Surg. 2014;22:437–46.
4. Bartoníček J, Kozánek M, Jupiter JB. History of operative treatment of forearm diaphyseal fractures. J Hand Surg Am. 2014 Feb;39(2):335-42. doi:10.1016/j.jhsa.2013.06.020. Epub 2013 Dec 11. PMID: 24332651.
5. Dodge HS, Cady GW. Treatment of fractures of the radius and ulna with compression plates. J Bone Joint Surg Am. 1972 Sep;54(6):1167-76. PMID: 4346961.
6. Rand JA, An KN, Chao EY, Kelly PJ. A comparison of the effect of open intramedullary nailing and compression-plate fixation on fracture-site blood flow and fracture union. J

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Bone Joint Surg Am. 1981 Mar;63(3):427-42. PMID: 7204443.
7. Bednar DA, Grandwilewski W. Complications of forearm-plate removal. Can J Surg. 1992 Aug;35(4):428-31. PMID: 1498745.
8. Labosky DA, Cermak MB, Waggy CA. Forearm fracture plates: to remove or not to remove. J Hand Surg Am. 1990 Mar;15(2):294-301. doi: 10.1016/0363-5023(90)90112-5. PMID: 2324461.
9. Deluca PA, Lindsey RW, Ruwe PA. Refracture of bones of the forearm after the removal of compression plates. J Bone Joint Surg Am. 1988 Oct;70(9):1372-6. PMID: 3182889.
10. Hidaka S, Gustilo RB. Refracture of bones of the forearm after plate removal. J Bone Joint Surg Am. 1984 Oct;66(8):1241-3. PMID: 6490698.
11. Rosson JW, Shearer JR. Refracture after the removal of plates from the forearm. An avoidable complication. J Bone Joint Surg Br. 1991 May;73(3):415-7. doi: 10.1302/0301-620X.73B3.1670441. PMID: 1670441.
12. Rumball K, Finnegan M. Refractures after forearm plate removal. J Orthop Trauma. 1990;4(2):124-9. doi: 10.1097/00005131-199004020-00004. PMID: 2358925.
13. Visńa P, Beitl E, Pilný J, Cizmár I, Vlcek M, Kalvach J, Valcha M. Interlocking nailing of forearm fractures. Acta Chir Belg. 2008 May-Jun;108(3):333-8. doi: 10.1080/00015458.2008.11680232. PMID: 18710109.
14. Weckbach A, Blattert TR, Weisser Ch. Interlocking nailing of forearm fractures. Arch Orthop Trauma Surg. 2006 Jul;126(5):309-15. doi: 10.1007/s00402-006-0122-9. Epub 2006 Mar 9. PMID: 16525808.
15. 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 Sep;90(9):1891-8. doi: 10.2106/JBJS.G.01636. PMID: 18762649.
16. Grace TG, Eversmann WW Jr. Forearm fractures: treatment by rigid fixation with early motion. J Bone Joint Surg Am. 1980 Apr;62(3):433-8. PMID: 7364814.
17. 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 1975;57A:287–297.
18. Chapman MW, Gordon JE, Zissimos AG. Compression-plate fixation of acute fractures of the diaphysis of the radius and ulna. J Bone Joint Surg 1989;71A:159–169.
19. Goldfarb CA, Ricci WM, Tull F, Ray D, Borrelli J Jr. Functional outcome after fracture of both bones of the forearm. J Bone Joint Surg 2005;87B:374 –379.
20. Droll KP, Perna P, Potter J, Harniman E, Schemitsch EH, McKee MD. Outcomes following plate fixation of fractures of both bones of the forearm in adults. J Bone Joint Surg 2007;89A:2619 – 2624.
21. Smith H, Sage FP. Medullary fixation of forearm fractures. J Bone Joint Surg Am 1959;39:91-8.
22. Crenshaw AH, Zinar DM, Pickering RM. Intramedullary nailing of forearm fractures. Instr Course Lect 2002;51:279-89.
23. 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.
24. 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.
25. Street DM. Intramedullary forearm nailing. Clin Orthop Relat Res 1986; 212:219-30.
26. 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.
27. Tabor OB Jr, Bosse MJ, Sims SH, Kellam JF. Iatrogenic posterior interosseous nerve injury: Is transosseous static locked nailing
28. Zhao L, Wang B, Bai X, Liu Z, Gao H, Li Y. Plate Fixation Versus Intramedullary Nailing for Both-Bone Forearm Fractures: A Meta-analysis of Randomized Controlled Trials and Cohort Studies. World J Surg. 2017 Mar;41(3):722-733.

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