

Original Research Article

Functional outcome of forearm fractures treated by intramedullary tens fixation: A prospective study

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Abstract

Introduction: Most forearm fractures in adults are treated by Open Reduction and Internal Fixation with plates. Another treatment modality is intramedullary nailing but in clinical practice, this is rarely used. We conducted this study intending to evaluate the functional outcome of forearm fractures in adults treated with Intramedullary TENS Fixation

Methods: Patients with closed forearm fractures who were admitted to our Tertiary health care center between January 2019 to December 2022 and met the inclusion criteria were enrolled for the study. They were evaluated clinically and radiographically. Patients with both bone forearm or isolated radius or isolated Ulna fractures were included. Closed fracture reduction was done intra-operatively and the fractures were fixed with Intramedullary TENS (Titanium Elastic Nail System). Functional evaluation was done by Grace and Eversman evaluation criteria and DASH (Disabilities of Arm, Shoulder, and Hand) score. Range of motion of forearm in terms of Pronation and Supination and grip strength of forearm were evaluated. Patients were followed up for a period of a minimum of 1 Year.

Results: In our study, 27 patients were enrolled. 16 were males (59.26%), 11 were females (40.74%). The mean age was found to be 36.30 with the range found to be 19 to 55 years. Fractures were found to be in the right side of the forearm in 17 patients (62.96%) and on the left side of the forearm in 10 patients (37.04%). The mean time of union was 11.30 ± 3.62 weeks (range of 7 to 18 weeks). Mean grip strength was found to be 52.22 ± 13.75 in the operated forearm and 54.67 ± 13.81 in the contralateral forearm with the difference found to be statistically insignificant with a p-value of 0.323. Pronation was found to be $76 \pm 3.88^\circ$ in the operated forearm and $77.41 \pm 1.82^\circ$ in the contralateral forearm with the difference being statistically insignificant with a p-value of 0.363. Supination was found to be $80.56 \pm 4.36^\circ$ in the operated forearm and $82.56 \pm 1.91^\circ$ in the contralateral forearm with the difference being statistically insignificant with a p-value of 0.194. Grace and Eversman score was found to be Excellent in 20 patients (74.07%), Good in 6 patients (22.22%), and acceptable in 1 patient (3.7%). DASH (Disabilities of Arm, Shoulder, and Hand) score was found to be 14.78 ± 9.86 with a range of 4.2-34.2.

Conclusion: Intramedullary fixation of Forearm fractures with TENS is a reliable and minimally invasive technique and can be utilized to obtain good results.

Keywords: Forearm fractures, radius fractures, ulna fractures, intramedullary nailing, TENS, titanium elastic nail system

Introduction

Hand's position relative to the body is maintained by movements of the elbow and wrist as well as supination and pronation of the forearm. Therefore, any fracture of the forearm whether isolated ulna, radius, or both bones can lead to immense dysfunction^[1]. The average incidence of forearm fractures is 1.35 in 10000 patients^[1]. Most of the fractures are seen in males with a mean age between 24 to 37 years^[1, 2, 3, 4]. Various treatment methods are available to treat these fractures including conservative treatment with closed reduction and cast application, closed reduction and internal fixation (CRIF) with an intramedullary nail, and Open reduction and internal fixation (ORIF) with plates and screws. The majority of the fractures are treated with Open reduction and Plate fixation and this treatment protocol remains the gold standard^[1, 5]. Plating leads to anatomical fixation and has been shown to give consistent results^[5]. However extensive soft tissue dissection as needed in it can lead to scarring, infection, non-union, and postoperative stiffness^[1, 6]. Also, after the removal of the implant refracture can occur^[7].

Intramedullary nailing in forearm fractures is not new but an old technique. There are many studies in literature depicting the use of nails such as Rush nail and Enders nails^[8]. But very few of them have used TENS (Titanium Elastic Nail System) a relatively new implant, in the adult population. TENS made of Titanium, is highly elastic, and provides good fixation due to the three-point fixation principle^[9, 10, 11]. This contrasts with Rush nail and Ender's nail which were rigid in consistency.

Intramedullary nailing has its own set of advantages. First, it is a minimally invasive technique with no periosteal stripping. Second, the chances of infection are low and additionally, there are less chances of refracture after implant removal as there is no bone weakening due to cortical atrophy seen around screws in plating^[12]. Third, it is a load-sharing device and leads to secondary healing with callus formation^[10]. In accordance with all the advantages afforded by intramedullary nailing, interest in this mode of fixation of forearm fractures in adults is on the rise.

In this study, we aimed to evaluate the functional outcome of patients with forearm fractures treated with Intramedullary TENS.

Methods

This Prospective study included patients of forearm fractures (isolated Radius or Ulna or Both Bone Forearm fractures) who were admitted in our tertiary health care centre between January 2019 to December 2022. The study was conducted in compliance with the rules of the ethical committee of the hospital.

Inclusion criteria

1. Closed Fractures.
2. Isolated Radius fractures.
3. Isolated Ulna Fractures.
4. Both Bone Forearm Fractures.
5. Comminuted Fractures.
6. Polytrauma Patients.

Exclusion criteria

1. Open fractures.
2. Non-union.

3. Pathological fractures.
4. Patients not willing to be included in the study.

The patients were analyzed pre-operatively with routine clinical investigations and X-rays of the Forearm (Antero-Posterior and Lateral views). Preoperatively Anaesthesia clearance was taken. Patients were explained about the Procedure and written informed consent was taken.

Surgical technique

Ulna nailing

The patient was placed Supine on the OT table with the elbow flexed on the radiolucent Hand table. Draping of the arm was done. The fracture was visualized under the C Arm. Closed reduction was done. A longitudinal skin incision was given on the proximal lateral aspect of Olecranon. Entry point was made along this incision in the metaphyseal region with an awl. TENS was inserted until the fracture site; the reduction was done, and the nail was inserted distally to the fracture site to 1cm within the distal articular surface of the Ulna. The final reduction was analyzed on C Arm, and the TENS was cut and buried flush with Olecranon^[8].

Radius nailing

The patient was placed Supine on the OT table with the arm extended on the radiolucent Hand table. Draping of the arm was done. The fracture was visualized under the C Arm. Closed Reduction was done with traction. We choose the Radial entry point for insertion of the TENS. It is located just proximal to the radius styloid on the Lateral side on the Antero Posterior and Lateral views. A longitudinal incision was given and the tendons of the Abductor pollicis longus and extensor pollicis brevis were retracted. Superficial radial nerve was isolated and protected. Entry point was made with awl 1 cm proximal to the articular cartilage under the guidance of the C Arm. TENS of appropriate size was inserted till the fracture site. Reduction was held by the assistant and after checking reduction under C Arm, TENS was passed proximally till the bicipital tuberosity of the Radius. The final reduction was analyzed on C Arm, and the TENS was cut and buried flush with the radius^[8].

After the Procedure, an above elbow slab was given to the patient for 3 weeks for soft tissue healing. Active range of motion of fingers was started from day 1. Active range of motion of wrist and elbow was started from Day 21. But patients were not allowed to lift objects with the operated forearm till 6 weeks. From 6 weeks to 3 months, patients were only allowed to lift light weight less than 5 Kg.

The patients were followed up for a minimum period of 1 year with regular check-ups at 2 weeks, 6 weeks, 3 months, 6 months, and 1 year.

Evaluation of outcome

Hand-held Dynamometer was used to calculate the grip strength. Range of motion of operated forearm in terms of Supination and Pronation was recorded. Both grip strength and Range of motion were compared to the contralateral limb. The Grace and Eversman score and DASH score were used to evaluate the functional outcome.

Grace and Eversman score^[6, 13]

This score is based on two criteria, the first is the union status of the fracture and the second is the rotational arc of the forearm present at the final follow-up. Grading is done according to the following chart.

Grading	Union of fracture	Rotational Arc of Forearm
Excellent	Union Present	At least 90% Present
Good	Union Present	At least 80% present
Acceptable	Union Present	At least 60% Present
Unacceptable	Non-Union	Less than 60%

DASH ^[14] (Disabilities of Arm, Shoulder, and Hand) score is a patient-rated outcome questionnaire. In DASH there are thirty questions with nine pertaining to symptoms and twenty-one of them evaluate the ability to perform specific activities. In DASH low score is associated with a better outcome with the maximum score being 100.

Data were described in terms of range; mean \pm standard deviation (\pm SD), frequencies (number of cases), and relative frequencies (percentages) as appropriate. To determine whether the data were normally distributed, a Kolmogorov-Smirnov test was used. Comparison of quantitative variables between the study groups was done using Mann Whitney U test for independent samples for non-parametric data. A probability value (p-value) less than 0.05 was considered statistically significant. All statistical calculations were done using (Statistical Package for the Social Science) SPSS 21 version (SPSS Inc., Chicago, IL, USA) statistical program for Microsoft Windows.

Results

In our study, a total of 27 patients were enrolled. They were followed up for a minimum period of 1 year.

Out of the total twenty-seven patients included sixteen (59.26%) were males and eleven were females (40.74%).

The mean age of the group was found to be 36.30 years with the range found to be 19 years to 55 years.

When analyzed based on right or left side fracture it was found that the Right side was involved in 17 patients (62.96%) and the left side was involved in 10 patients (37.04%).

The mean time of Union time in our study was found to be 11.30 ± 3.62 weeks with a range of 7 to 18 weeks.

Mean grip strength was found to be 52.22 ± 13.75 in the operated forearm and 54.67 ± 13.81 in the contralateral forearm with the difference found to be statistically insignificant with a p-value of 0.323.

Pronation was found to be $76 \pm 3.88^\circ$ in the operated forearm and $77.41 \pm 1.82^\circ$ in the contralateral forearm with the difference being statistically insignificant with a p-value of 0.363.

Supination was found to be $80.56 \pm 4.36^\circ$ in the operated forearm and $82.56 \pm 1.91^\circ$ in the contralateral forearm with the difference being statistically insignificant with a p-value of 0.194.

When the functional outcome was evaluated based on Grace and Eversman score ^[6, 13] it was found to be Excellent in 20 patients (74.07%), Good in 6 patients (22.22%) and acceptable in 1 patient (3.7%).

DASH ^[14] score was found to be 14.78 ± 9.86 with a range of 4.2-34.2.

There were two cases of superficial infection at the ulnar entry site and one case of superficial infection at the Radial entry site. All of them were treated with oral antibiotics with no resultant complications.

There was no loss of reduction in any case and all the fractures united without any need for further intervention.

Discussion

Functions of the Hand are dependent on the normal physiology of the wrist, Forearm, and elbow ^[1]. The surgeon should have an arsenal of techniques to operate forearm fractures according to the different circumstances he faces in the real life. Plating and intramedullary nailing spearhead these techniques.

Plating is associated with complications such as soft tissue injury, scarring, infection, non-union, stiffness, and compartment syndrome ^[1, 6, 13]. There are chances of refracture after plate removal due to cortical atrophy around screw holes ^[15]. Moreover, it has been documented that forearm plating is associated with a reduction in the strength and active range of motion of the forearm ^[16]. This is due to soft tissue fibrosis, skin scarring, and adhesions seen in plating ^[15].

Intramedullary nailing has been in use for a very long time in forearm fractures in children. For adults, it is an upcoming technique. It is a minimally invasive technique. These days inclination is more towards biological fixation and Intramedullary nailing remains at forefront of it ^[17]. It leads to the preservation of fracture hematoma, and periosteum, and results in good callus formation because of its load-sharing properties ^[6, 15]. It has added benefits such as less operative time, and low chances of infection, and in fact, it is considered as one of the ideal implant for comminuted fractures and those with severe soft tissue injury ^[12].

When talking about stability we have studies comparing the same. Lee *et al.* ^[18] compared restoration of radial bow treated by Plating or Nailing in the injured radius compared with contralateral radius. They reported that though plating of the radius fracture leads to more anatomical restoration of the radial bow, it had no final say in the final clinical outcome in the patients ^[18].

In the current study mean age was found to be 36.30 years. This is comparable to that stated in the Rockwood and Green Fractures in adults that they are more common in the first 4 decades of life ^[1].

In our study, a greater number of male patients were seen with forearm fractures as compared to females. This is similar to as seen by Streubel PN, Pesántez RF ^[1]; De Boeck *et al.* ^[2]; Behnke NMK *et al.* ^[3]; Chapman MW *et al.* ^[4].

We found more fractures in the right forearm as compared to the Left forearm. This is similar to that seen by Köse A *et al.* ^[15] and in contrast to that seen by Lil NA *et al.* ^[13]. This may be attributed to the right forearm being the dominant side in most adults and it being used for protection.

Mean union time in our study was comparable to that seen by Gadegone W *et al.* ^[6], Lil NA *et al.* ^[13], and Köse A *et al.* ^[15]

We evaluated Grip strength in the operated forearm and compared it to the contralateral limb and found the result to be statistically insignificant with a P-value of 0.323. This is identical to the result seen by Köse A *et al.* ^[15].

Supination and pronation as recorded in our study were found to be statistically insignificant when compared to the contralateral limb with a P-value of 0.194 and 0.363 respectively. This echoes the finding of those seen by Köse A *et al.* ^[15] and Yaradılmış YU *et al.* ^[19] who also found no statistical difference between the operated and contralateral limb.

Functional outcome based on the Grace and Eversman score was found to be comparable to the studies previously done by Lil NA *et al.* ^[13] and Lee SK *et al.* ^[18].

DASH score was comparable to the results seen by those of the Lil NA *et al.* ^[13], Köse A *et al.* ^[15], Yaradılmış YU *et al.* ^[19].

We in our study found the TENS to be a very versatile implant. The incisions given for insertion of the implant were very small, and healing was good with a low incidence of infection. Moreover, there was no concern about unsightly long scars on the forearm. Though we had to give slab for 3 weeks for soft tissue healing, this had no adverse on the outcome.

Callus formation was good with an early union. There was no incidence of Non-union or refracture seen. There were two cases of superficial infection at the ulnar entry site and one case of superficial infection at the Radial entry site. All of them were treated with oral antibiotics with no resultant complications.

Based on finding in the current study we can confidently say that the intramedullary fixation of Forearm fractures is one of the promising and dependable techniques. Grace and Eversman scoring in our study acknowledges the good results seen in patients treated by the Forearm TENS fixation and the DASH score cements the satisfactory results noticed by the patients.

Table 1

	Male	Female
Number of Patients	16	11
Percentage	59.26%	40.74%

Table 2

	Left	Right
Number of Patients	10	17
Percentage	37.04%	62.96%

Table 3

	N	Minimum	Maximum	Mean	Std. Deviation
Age	27	19.00	55.00	36.30	10.45
Union time	27	7.00	18.00	11.30	3.62

Table 4

	Operated Forearm				Contralateral Forearm				Z	p-value
	Minimum	Maximum	Mean	Std. Deviation	Minimum	Maximum	Mean	Std. Deviation		
Supination	71.00	85.00	80.56	4.36	80.00	85.00	82.56	1.91	-1.298	0.194
Pronation	68.00	80.00	76.00	3.88	75.00	80.00	77.41	1.82	-0.909	0.363
Grip strength	35.00	92.00	52.22	13.75	40.00	97.00	54.67	13.81	-0.987	0.323

Table 5

	N	Minimum	Maximum	Mean	Std Deviation
DASH Score	27	4.20	34.20	14.78	9.86



Picture A: Post-operative X-ray of Radius treated by Intramedullary TENS (Titanium Elastic Nail System) **Picture B:** Union of the radius seen at 12 weeks

Conclusion

Intramedullary Fixation of the Forearm fractures in adults by TENS is a reliable technique and it should be one of the options in the planning and treatment of forearm fractures.

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