

Research Article

Outcome of Radius and Ulna Shaft Fractures in Adults Treated by Titanium Elastic Nailing System

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ABSTRACT

Background: Adult diaphyseal fractures of the radius and ulna are functionally significant injuries that require anatomical reduction and stable fixation to restore forearm rotation and upper-limb function. Although plate osteosynthesis remains the conventional treatment, the Titanium Elastic Nailing System (TENS) has emerged as a minimally invasive alternative that preserves soft tissues and fracture biology while promoting satisfactory healing.

Aim: To evaluate the clinical outcome of adult radius and ulna shaft fractures treated with TENS by assessing postoperative forearm movements, fracture healing, functional recovery, and procedure-related complications.

Materials and Methods: This prospective observational study was conducted in the Department of Orthopaedics, G.K. General Hospital (GKGH), Bhuj, from September 2022 to March 2024. A total of 56 adult patients (18-70 years) with radius and ulna shaft fractures treated with TENS were included. Patients with pathological fractures, radio-ulnar joint instability, neurovascular injury at presentation, and polytrauma were excluded. Clinical and radiological evaluations were performed during follow-up to assess fracture union, range of forearm movements, complications, and final functional outcomes.

Results: The majority of patients were males (76.7%) and belonged to the 18-29-year age group (37.5%). Road traffic accidents were the leading cause of injury (50%), and 89.2% of fractures were closed. Fracture union occurred within 16 weeks in 62.49% of patients, while 82.14% regained full pronation and supination. Complications were infrequent, with nail back-out (5.35%) being the most common. Excellent functional outcomes were achieved in 92.85% of patients, with no unacceptable results.

Conclusion: TENS is a safe, effective, and minimally invasive method for treating selected adult diaphyseal fractures of the radius and ulna. It provides high union rates, excellent restoration of forearm function, minimal complications, and favorable overall clinical outcomes when performed with appropriate patient selection and surgical technique.

Keywords: Radius Shaft Fracture, Ulna Shaft Fracture, Titanium Elastic Nailing System (TENS), Intramedullary Nailing, Fracture Union, Functional Outcome.

INTRODUCTION

Fractures of the radius and ulna shaft are among the most common long-bone injuries encountered in adult orthopaedic practice. Because the radius and ulna function as a coordinated unit to facilitate forearm rotation and maintain normal wrist and elbow biomechanics, fractures involving both bones can significantly impair upper-limb function if not managed appropriately. Restoration of the normal length, alignment, and rotational profile of both bones is essential for achieving satisfactory functional outcomes and preventing long-term disability such as restricted pronation, supination, malunion, or non-union [1,2].

Open reduction and internal fixation with dynamic compression plating has traditionally been regarded as the standard treatment for displaced diaphyseal forearm fractures in adults because it provides rigid fixation and allows anatomical reduction [3]. However, plate fixation requires extensive soft-tissue dissection and periosteal stripping, which may compromise the biological environment of fracture healing and increase the risk of infection, implant prominence, refracture after implant removal, and delayed wound healing [4,5]. Consequently, there has been increasing interest in less invasive fixation techniques that preserve fracture biology while providing adequate stability.

Titanium Elastic Nailing System (TENS), originally developed for pediatric long-bone fractures, has gained attention as a minimally invasive alternative for selected adult forearm shaft fractures. Titanium elastic nails provide relative stability through a three-point fixation mechanism while minimizing periosteal disruption and preserving the fracture hematoma, both of which are important contributors to biological fracture healing. The technique also offers advantages such as smaller incisions, reduced blood loss, shorter operative duration, improved cosmetic appearance, and easier implant removal compared with conventional plating [6,7].

Despite these potential benefits, the use of TENS in adult diaphyseal fractures remains an area of ongoing clinical evaluation. Adult fractures are subjected to greater mechanical stresses than pediatric injuries, raising concerns regarding rotational stability, maintenance of reduction, delayed union, and implant-related complications. Careful patient selection and meticulous surgical technique are therefore essential for obtaining optimal results [8]. Recent studies have reported encouraging rates of fracture union and satisfactory restoration of forearm motion with intramedullary elastic nailing in appropriately selected adult patients, although comparative evidence continues to evolve [9].

Considering the growing emphasis on biological fixation and minimally invasive orthopaedic procedures, it is important to evaluate the clinical effectiveness of TENS in adult forearm shaft fractures. The present prospective study was undertaken to assess the outcomes of Titanium Elastic Nailing System in adult radius and ulna shaft fractures by evaluating postoperative movements, fracture healing, and procedure-related complications in patients treated at a tertiary care teaching hospital. The findings are expected to contribute further evidence regarding the role of TENS as an alternative treatment option for selected adult diaphyseal forearm fractures [10].

The present study was undertaken to evaluate the clinical outcome of adult radius and ulna shaft fractures treated with the Titanium Elastic Nailing System (TENS). It specifically aimed to assess postoperative functional recovery by evaluating the range of forearm movements, the rate and quality of fracture healing, and the occurrence of intraoperative

or postoperative complications. The study sought to determine the effectiveness and safety of TENS as a minimally invasive treatment option for adult diaphyseal forearm fractures.

MATERIALS AND METHODS

Study design: Prospective observational study.

Study population: Adult patients with diaphyseal fractures of the radius and ulna who underwent fixation with the Titanium Elastic Nailing System (TENS).

Sample size: A total of 56 patients, calculated using the formula $N = 4PQ/L^2$.

Study duration: September 2022 to March 2024.

Study setting/location: Department of Orthopaedics, G.K. General Hospital (GKGH), Bhuj, Gujarat, India.

Inclusion criteria:

- Adults aged 18–70 years.
- Patients with radius and ulna shaft fractures treated with Titanium Elastic Nailing System (TENS).
- Patients willing to participate and provide informed consent.

Exclusion criteria:

- Pathological fractures.
- Associated radio-ulnar joint instability.
- Neurovascular injury at the time of initial presentation.
- Polytrauma patients with multiple associated injuries.

Statistical Analysis: The collected data were entered into Microsoft Excel and analyzed using SPSS version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean $\pm$ standard deviation (SD), while categorical variables were presented as frequencies and percentages. Associations between categorical variables were analyzed using the Chi-square test or Fisher's exact test, and continuous variables were compared using the independent Student's t-test or Mann–Whitney U test, as appropriate. A p-value of <0.05 was considered statistically significant.

RESULT

Table 1. Baseline Demographic and Clinical Characteristics of the Study Population

Variable	Category	N	%
Age (Years)	18–29	21	37.5
	30–39	17	30.3
	40–49	9	16.07
	50–59	4	7.1
	60–69	5	8.9
Gender	Male	43	76.7
	Female	13	23.3
Side Involved	Right	30	53.6
	Left	26	46.4
Mode Of Injury	Road Traffic Accident	28	50
	Fall	22	39.2
	Assault	6	10.8
	Others	0	0
Fracture Type	Closed	50	89.2
	Open (Grade I & II)	6	10.8
Co-Morbidities	Type 2 Diabetes Mellitus	2	3.5
	Hypertension	3	5.3
	Heart Disease	1	1.7
	None	50	89.28

Table 2. Fracture Characteristics and Associated Injuries

Variable	Category	n	%
AO Fracture Classification	A2	15	26.78
	A3	18	32.14
	B1	8	14.2
	B2	9	16.07
	B3	3	5.35
	C1	2	3.57
	C2	1	1.78
Associated injuries	Other bone fractures	6	10.71
	Head injury	3	5.36
	Chest injury	1	1.79

Table 3. Functional and Radiological Outcomes

Variable	Category	n	%
Time to union (weeks)	<12	15	26.78
	13–16	20	35.71
	17–20	12	21.42
	21–30	7	12.5
	>30	2	3.5
Supination	Full	46	82.14
	10° loss	7	12.5
	20° loss	2	3.5
	30° loss	1	1.7
Pronation	Full	46	82.14
	10° loss	7	12.5
	20° loss	2	3.5
	30° loss	1	1.7

Table 4. Postoperative Complications and Functional Results

Variable	Category	n	%
Complications	Non-union	2	3.57
	Back out of ulna nail	3	5.35

Final result	Superficial infection	1	1.78
	Radial nail impingement	2	3.57
	Elbow stiffness	1	1.78
	Excellent	52	92.85
Final result	Good	3	5.35
	Acceptable	1	1.78
	Unacceptable	0	0

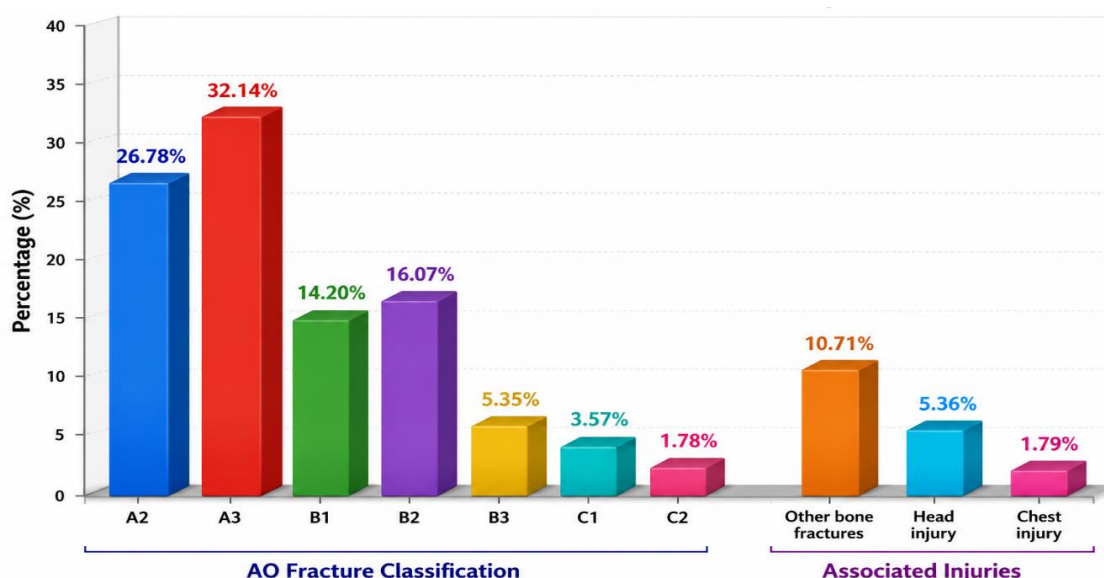


Figure: 1. Distribution of AO Fracture Classification and Associated Injuries

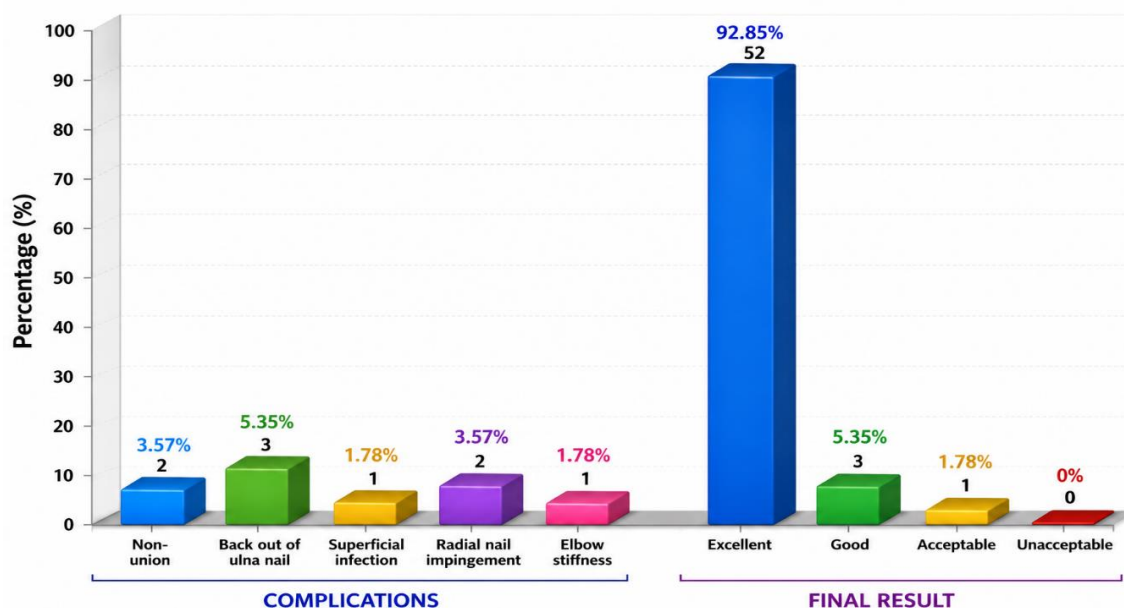


Figure: 2. Distribution of Complications and Final Functional Results

A total of 56 adult patients with radius and ulna shaft fractures treated using the Titanium Elastic Nailing System (TENS) were included in the study. The largest proportion of patients belonged to the 18–29 years age group (21, 37.5%), followed by those aged 30–39 years

(17, 30.3%). Patients aged 40–49 years accounted for 16.07% (9), while 50–59 years and 60–69 years comprised 7.1% (4) and 8.9% (5), respectively. Male patients predominated, representing 76.7% (43) of the study population, whereas females constituted

23.3% (13). The right forearm was affected slightly more frequently than the left, with involvement in 30 (53.6%) and 26 (46.4%) patients, respectively. Road traffic accidents were the leading mechanism of injury, accounting for 28 cases (50%), followed by falls in 22 patients (39.2%) and assaults in 6 patients (10.8%); no injuries were attributed to other causes. Most fractures were closed injuries (50, 89.2%), while open Grade I and II fractures were observed in only 6 patients (10.8%). The majority of patients (50, 89.28%) had no associated medical comorbidities. Among those with comorbid illnesses, hypertension was present in 3 patients (5.3%), type 2 diabetes mellitus in 2 patients (3.5%), and heart disease in 1 patient (1.7%).

According to the AO fracture classification, A3 fractures were the most common pattern, occurring in 18 patients (32.14%), followed by A2 fractures in 15 patients (26.78%). B2 fractures accounted for 9 cases (16.07%), while B1 fractures were identified in 8 patients (14.2%). More complex fracture patterns were relatively uncommon, with B3, C1, and C2 fractures representing 3 (5.35%), 2 (3.57%), and 1 (1.78%) patient, respectively. Associated injuries were infrequent overall. Other bone fractures were the most commonly observed associated injury, affecting 6 patients (10.71%). Head injuries were documented in 3 patients (5.36%), whereas chest injury was present in only 1 patient (1.79%). These findings indicate that the majority of patients sustained isolated forearm fractures with relatively few concomitant traumatic injuries.

Radiological assessment demonstrated satisfactory fracture healing in most patients within 16 weeks. Fracture union occurred within 13–16 weeks in 20 patients (35.71%), making it the most common healing interval, while 15 patients (26.78%) achieved union within 12 weeks. A further 12 patients (21.42%) united between 17 and 20 weeks, whereas delayed union between 21 and 30 weeks was observed in 7 patients (12.5%). Only 2 patients (3.5%) required more than 30 weeks to achieve union. Functional evaluation of forearm rotation revealed excellent recovery in the majority of patients. Full supination was restored in 46 patients (82.14%), while 7 (12.5%), 2 (3.5%), and 1 (1.7%) patient demonstrated residual losses of 10°, 20°, and 30°, respectively. An identical pattern was observed for pronation, with 46 patients (82.14%) regaining full motion, whereas 7

(12.5%), 2 (3.5%), and 1 (1.7%) patient had residual deficits of 10°, 20°, and 30°, respectively. Overall, these findings indicate favorable radiological healing and excellent restoration of forearm function following TENS fixation.

Postoperative complications were relatively uncommon and occurred in only a small proportion of patients. Back out of the ulna nail was the most frequent complication, affecting 3 patients (5.35%). Non-union and radial nail impingement were each observed in 2 patients (3.57%), while superficial surgical site infection and elbow stiffness occurred in 1 patient (1.78%) each. Despite these complications, the overall functional outcome was highly satisfactory. Based on the final assessment criteria, excellent results were achieved in 52 patients (92.85%), good outcomes in 3 patients (5.35%), and acceptable results in 1 patient (1.78%). No patient had an unacceptable functional outcome. These findings demonstrate that Titanium Elastic Nailing System (TENS) provided a high rate of successful clinical recovery with a low incidence of postoperative complications in adult diaphyseal fractures of the radius and ulna.

DISCUSSION

The present prospective study evaluated the clinical and functional outcomes of adult radius and ulna shaft fractures treated with the Titanium Elastic Nailing System (TENS). Most patients in our series were young adults, with the highest proportion (37.5%) belonging to the 18–29-year age group, and males constituted 76.7% of the study population. Road traffic accidents were the predominant mechanism of injury (50%). These findings are consistent with the observations of Kumar et al., who reported that forearm shaft fractures predominantly affect young, economically active males because of their greater exposure to high-energy trauma, particularly road traffic accidents. Their study similarly demonstrated male predominance and trauma-related injury patterns comparable to the present series [11].

Closed fractures accounted for nearly nine-tenths of all cases (89.2%), whereas only a small proportion were open Grade I or II injuries. Most patients also had no significant medical comorbidities. Similar demographic and clinical characteristics have been described by Patel et al., who found that intramedullary fixation is particularly suitable

for closed or minimally contaminated open fractures because of limited soft-tissue disruption and preservation of fracture biology. Their results support the favorable patient profile observed in the current study [12].

Regarding fracture morphology, AO type A3 fractures were the most common (32.14%), followed by A2 fractures (26.78%), while complex C-type fractures were relatively uncommon. This distribution resembles the findings of Wang et al., who reported that simple transverse and short oblique diaphyseal fractures are the most frequent fracture configurations managed successfully with intramedullary nailing. They emphasized that careful fracture selection contributes significantly to satisfactory alignment and union rates following TENS fixation [13].

Associated injuries were observed in a minority of patients, with additional long-bone fractures being the most frequent (10.71%). Head and chest injuries were comparatively uncommon. Similar observations have been reported by Singh et al., who noted that although forearm fractures may occur as part of multiple trauma, a substantial proportion of patients present with isolated upper-limb injuries, allowing earlier definitive fixation and rehabilitation [14].

Radiological outcomes in the present study were highly encouraging. More than 62% of fractures united within 16 weeks, and only 3.5% required more than 30 weeks for union. These findings compare favorably with the multicenter study by Li et al., which demonstrated union rates exceeding 90% within four months following intramedullary fixation of adult both-bone forearm fractures. The authors attributed successful healing to preservation of periosteal blood supply and minimal disruption of fracture hematoma associated with biological fixation techniques [15].

Functional recovery was excellent, with 82.14% of patients regaining full pronation and supination. Only a few patients experienced mild to moderate restriction of forearm rotation. Comparable results were documented by Soni et al., who reported restoration of near-normal rotational movement in the majority of patients following TENS fixation. They concluded that maintenance of radial bow and stable fixation are key determinants of favorable functional outcomes after intramedullary nailing [16].

The incidence of postoperative complications in the present study remained low. Nail back-

out of the ulna (5.35%) was the most common complication, followed by non-union and radial nail impingement (3.57% each). Superficial infection and elbow stiffness were infrequent. Similar complication profiles have been described by Verma et al., who identified implant prominence, delayed union, and occasional superficial infection as the principal complications associated with elastic intramedullary nailing. Most complications were successfully managed without significant long-term disability [17].

An important finding of this study was the excellent overall functional outcome, with 92.85% of patients achieving an excellent result and no patient demonstrating an unacceptable outcome. These findings are comparable with those reported by Chen et al., who observed excellent or good functional results in over 90% of adults treated with intramedullary forearm fixation. Their study emphasized that meticulous surgical technique and appropriate patient selection are essential for achieving optimal outcomes [18].

Recent systematic reviews comparing intramedullary nailing with plate osteosynthesis have suggested that while plating continues to provide superior rotational stability in highly comminuted fractures, intramedullary fixation offers the advantages of smaller incisions, shorter operative time, reduced blood loss, and preservation of soft tissues, with comparable fracture union in selected patients. These conclusions are in agreement with the favorable healing and functional outcomes observed in the present study [19].

Overall, the findings of this prospective study reinforce the growing evidence that Titanium Elastic Nailing System is an effective treatment option for selected adult diaphyseal fractures of the radius and ulna. The high union rate, excellent restoration of forearm movements, low complication rate, and outstanding functional outcomes observed in the present series are consistent with recent contemporary literature and support the continued use of TENS as a minimally invasive alternative to plate fixation in appropriately selected patients [20].

CONCLUSION

The present prospective study demonstrates that the Titanium Elastic Nailing System (TENS) is an effective and reliable treatment option for selected adult diaphyseal fractures of the radius and ulna. The technique achieved

a high rate of fracture union, with most fractures healing within 16 weeks, while restoring excellent forearm function in the majority of patients. Full pronation and supination were regained in over 80% of cases, and postoperative complications were infrequent and generally manageable. More than 90% of patients achieved excellent functional outcomes, highlighting the clinical effectiveness of this minimally invasive procedure. Preservation of soft tissues, limited surgical exposure, and satisfactory biological healing further support the advantages of TENS fixation. Careful patient selection, appropriate surgical technique, and structured postoperative rehabilitation remain essential for optimizing results. Overall, TENS represents a safe, minimally invasive, and dependable alternative to conventional plate fixation for appropriately selected adult radius and ulna shaft fractures, providing favorable radiological healing, functional recovery, and patient outcomes.

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