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Functional Outcome of Titanium Elastic Nailing System in Patients with Minimally Displaced Proximal Humerus Fractures

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Abstract

Background: Minimally displaced proximal humerus fractures, particularly Neer type 2 involving the surgical neck, are common in the elderly. Conservative management risks stiffness, while traditional fixation methods have limitations. This study evaluates the functional outcomes and complications of Titanium Elastic Nailing System (TENS) in adults with these fractures. ***Methods:*** Prospective study of 51 patients (>18 years) with minimally displaced proximal humerus fractures treated with closed reduction and retrograde TENS (some with additional cannulated cancellous screws for greater tuberosity avulsion) at a single institution (April 2024-April 2025). Functional outcomes assessed using Constant-Murley score at follow-up; union assessed radiographically. ***Results:*** Mean age 68 years; 58.8% female; 70% Neer grade 2. Union achieved in most by 6-8 weeks (41.2% at 8 weeks). Functional outcomes: excellent 11.8%, good 33.3%, fair 54.9%. Complications in 27.5% (mainly nail migration 21.6%; pin-site infection 5.9%). Significant association between Neer grade and outcome (p=0.04); no significant association with age (p=0.479) or gender (p=0.348). ***Conclusion:*** TENS provides stable, minimally invasive fixation with favorable union times and mostly good-to-fair functional recovery in minimally displaced proximal humerus fractures, especially Neer grade 2. Nail migration warrants careful technique and monitoring. TENS merits consideration for early mobilization in suitable cases.

Keywords: ***proximal humerus fracture, titanium elastic nailing, functional outcome, minimally displaced, Neer classification***

Introduction

Proximal humerus fractures represent 4-5% of all fractures and approximately 45% of humeral fractures, predominantly affecting elderly populations due to osteoporosis and low-energy trauma like falls [1]. These injuries, often classified using the Neer system based on displacement and parts involved, pose significant challenges to shoulder function and quality of life [2]. Epidemiological trends show a 2:1 female-to-male ratio, with 85% being minimally displaced, allowing conservative options such as slings or immobilizers [3]. However, prolonged immobilization risks stiffness, muscle atrophy, malunion, and nonunion, prompting exploration of surgical alternatives [4]. Traditional methods like Kirschner wires offer fixation but carry drawbacks including infection, migration, and limited stability [5].

Intramedullary devices, such as the Titanium Elastic Nailing System (TENS), provide biomechanical advantages through elastic three-point fixation, promoting stability with minimal soft tissue disruption [6]. Initially developed for pediatric long-bone fractures, TENS has shown promise in adults for humeral shaft injuries, facilitating early mobilization and reduced complications [7]. Despite this, literature on TENS for minimally displaced proximal humerus fractures in adults remains limited, with no large prospective studies addressing functional outcomes in Neer grade 2-3 cases involving the surgical neck [8].

This study aims to evaluate the functional outcomes of TENS in patients with minimally displaced proximal humerus fractures using the Constant-Murley score, assess associated complications, and identify factors influencing results, such as Neer classification, age, and gender.

Materials and Methods

Study Design

This prospective observational study was conducted over 1.5 years (April 2024-April 2025) at the Department of Orthopaedics, PSG Institute of Medical Sciences and Research, Coimbatore, India. Ethical approval was obtained from the institutional committee, and informed consent was secured from all participants.

Participants

Inclusion criteria encompassed adults (>18 years) with radiographically confirmed minimally displaced proximal humerus fractures (Neer grade 2-3, surgical neck ± greater tuberosity involvement). Exclusion criteria included patients <18 years and those with pathological fractures. Sample size (n=51) was calculated

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based on prior literature, assuming 88% power at 5% significance with 20% relative precision [9].

Surgical Technique

Under general anesthesia, patients were positioned in a beach-chair setup with fluoroscopic guidance. Closed reduction was achieved via traction, abduction, and external rotation. Retrograde TENS insertion involved lateral entry points 2-3 cm above the lateral epicondyle; pre-bent 2-2.5 mm titanium nails (diameter ~40% of medullary canal) were advanced for three-point fixation. Cannulated cancellous screws were added for greater tuberosity avulsion if present. Postoperative protocol included sling immobilization for 2-3 weeks, early pendulum exercises, and active range-of-motion at 3-4 weeks.

Outcome Measures

Fracture union was assessed radiographically at 4 and 8 weeks. Functional outcomes were evaluated using the Constant-Murley score, categorized as excellent (>80), good (60-80), or fair (<60). Complications (e.g., migration, infection) were recorded during follow-up.

Statistical Analysis

Data were analyzed using descriptive statistics (frequencies, percentages). Chi-square tests assessed associations between variables (age, gender, Neer grade) and outcomes ($p<0.05$ significant).

Results

This study included 51 patients with minimally displaced proximal humerus fractures treated with TENS. Demographic and clinical characteristics are summarized in Table 1, revealing a predominance of females (58.8%) and patients under 65 years (39.2%), consistent with osteoporotic fragility fractures. Neer grade 2 fractures comprised 70.6%, with most patients presenting within 24 hours (70.6%).

Table 1: Demographic and Clinical Characteristics of Study Participants (N=51)

Characteristic	n (%)
Age Group	
<65 years	20 (39.2)
66–70 years	11 (21.6)
71–75 years	10 (19.6)
>75 years	10 (19.6)
Gender	
Male	21 (41.2)
Female	30 (58.8)
Neer Grade	
Grade 2	36 (70.6)
Grade 3	15 (29.4)

Implant details and union times are presented in Table 2. TENS alone was used in 70.6%, with additional cannulated cancellous screws in 29.4% for greater tuberosity involvement. Fracture union occurred predominantly at 8 weeks (41.2%), followed by 6 weeks (27.5%), indicating efficient biological healing.

Table 2: Implant Details and Fracture Union Times (N=51)

Detail	n (%)
Time Since Injury	
<24 hours	36 (70.6)
>24 hours	15 (29.4)
Implants Used	
TENS alone	36 (70.6)
TENS + CC screws	15 (29.4)
Union Duration	
4 weeks	6 (11.8)
6 weeks	14 (27.5)
7 weeks	10 (19.6)
8 weeks	21 (41.2)

Functional outcomes and complications are detailed in Table 3. Excellent outcomes were achieved in 11.8%, good in 33.3%, and fair in 54.9% based on Constant-Murley scores. Complications affected 27.5%, primarily nail migration (21.6%) and pin-site infections (5.9%).

Table 3: Functional Outcomes and Complications (N=51)

Outcome/Complication	n (%)
Functional Outcome (Constant-Murley)	
Excellent	6 (11.8)
Good	17 (33.3)
Fair	28 (54.9)
Complications	
None	37 (72.5)
Nail migration	11 (21.6)
Pin-site infection	3 (5.9)

Association analyses (Table 4) showed no significant links between age (p=0.479) or gender (p=0.348) and functional outcomes. However, a significant association existed with Neer grade (p=0.04), where grade 2 cases had higher excellent/good rates compared to grade 3, underscoring fracture complexity's impact on recovery. These findings highlight TENS's role in stable fixation, with union and function aligning with minimally invasive principles.

Table 4: Associations with Functional Outcomes (N=51)

Variable	Excellent n (%)	Good n (%)	Fair n (%)	p-value*
Age				**0.479**
≤70 years	5 (13.9)	13 (36.1)	18 (50.0)	
>70 years	1 (6.7)	4 (26.7)	10 (66.6)	
Gender				**0.348**
Male	3 (14.3)	8 (38.1)	10 (47.6)	
Female	3 (10.0)	9 (30.0)	18 (60.0)	
Neer Grade				**0.04**
Grade 2	6 (16.7)	14 (38.9)	16 (44.4)	
Grade 3	0 (0.0)	3 (20.0)	12 (80.0)	

**p<0.05 is significant.*

Discussion

The study demonstrates favorable functional outcomes with TENS for minimally displaced proximal humerus fractures, with 45.1% achieving excellent/good Constant-Murley scores and union by 6-8 weeks in most cases. This aligns with epidemiological data showing higher incidence in elderly females,[3] where osteoporosis exacerbates risks [4]. TENS's biomechanical stability via elastic three-point fixation minimizes soft tissue damage, promoting early mobilization unlike conservative approaches that risk stiffness [5].

Compared to literature, our complication rate (27.5%, mainly migration) is consistent with intramedullary nailing studies; for instance, Sink *et al*. (2005) reported similar migration in pediatric femurs, emphasizing technique's role [10]. Hunter (2005) highlighted TENS's principles for rotational stability, supporting our union times [11]. Moroz *et al*. (2006) in multicenter femur trials noted low infections (comparable to our 5.9%), attributing to closed insertion [12]. Lascombes *et al*. (2006) warned of abuses in adolescents, mirroring our trend toward better outcomes in younger patients, though nonsignificant [13].

Fernandez *et al*.(2009) and Lieber *et al*. (2009) in pediatric proximal humerus series reported excellent function in >80%, higher than ours, possibly due to adult osteoporosis in our cohort [14,15]. Saglam *et al*.(2010) and Pogorelić *et al*.(2011) extended TENS to adult humeri, with union rates akin to ours but fewer migrations via refined bending [16,17]. Murray *et al*.(2011) reviewed classifications, validating Neer grade's prognostic value (p=0.04 here) [7]. Charles *et al*.(2014), Bhuyan (2014), and Kose *et al*.(2014) in humerus/pediatric studies showed good outcomes in displaced cases, supporting TENS expansion to adults [6,18,19]. Khairouni *et al*.(2015), Handoll *et al*.(2015), and Jamaluddin *et al*.(2015) meta-analyzed interventions, noting TENS's minimally invasive edge over plates, with similar complications [9,2,20]. Kancherla *et al*.(2017) advocated acute management, aligning with our early presentations [5]. Recent reviews by Foruria *et al*.(2021) and Voigt *et al*.(2021) emphasize evolution toward intramedullary options for better prognosis in minimally displaced fractures [3,4]. Limitations include single-center bias and unassessed osteoporosis, warranting multicenter trials.

Conclusion

In conclusion, this prospective study affirms the Titanium Elastic Nailing System (TENS) as an effective, minimally invasive treatment for minimally displaced proximal humerus fractures in adults, particularly Neer grade 2 surgical neck cases. With union achieved by 6–8 weeks in the majority and functional outcomes rated excellent or good in 45.1% via Constant-Murley scores, TENS facilitates stable fixation, early mobilization, and reduced hospital stays. Complications, primarily nail migration (21.6%), were manageable and highlight the need for precise surgical technique, especially in osteoporotic bone. The significant association between lower Neer grades and better outcomes underscores fracture severity as a key predictor, while age and gender showed no influence. Overall, TENS offers a valuable alternative to conservative or more invasive methods, improving patient recovery quality and shoulder function. Future research should explore long-term follow-up and comparative trials to further validate its role in orthopedic practice.

Declarations

Ethical Approval

The study was conducted after obtaining approval from the Institutional Ethics Committee, and informed consent was obtained from all participants.

Conflict of Interest

The authors declare no conflict of interest.

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