RESEARCH PAPER

Outcome of humerus fracture treated by titanium elastic nail in adult age group

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ABSTRACT:

Background and objectives: Humeral shaft fractures are relatively common and are managed by a variety of surgical and non-surgical methods. Titanium elastic nails attracted attention for use in adult cases due to their non-invasive nature. This study evaluated the clinical, functional, and radiological outcomes of managing humeral shaft fractures in adults using titanium elastic nails.

Methods: A prospective cohort study was conducted, including 48 adult patients with humeral shaft fractures to be managed with titanium elastic nails. Inclusion criteria were adult patients aged 18 or older with closed fractures or Gustilo-Anderson type I open fractures. Union time was recorded using radiographs and clinical examinations.

Results: Falls from height accounted for 62.5% of injuries, and middle shaft fractures were the most common. The mean union time was 13.19 ± 5.49 weeks. 62.5% reported no to minimal disability, 31.3% reported mild disability, and the remaining 6.3% reported moderate disability on the Disability of the Arm, Shoulder, and Hand (Kurdish version) score. Postoperative complications occurred in only 18.7% of participants, with the most serious being non-union, which occurred in 3 participants. AO/OTA classification was significantly associated with longer surgery duration and showed a weak, non-significant positive correlation with DASH/KU score.

Conclusions: Titanium elastic nails can be used safely and effectively in selected cases of humeral shaft fractures in adults, with favorable outcomes, while more studies are required to establish standardized protocols.

Keywords: Fracture fixation, Humeral fractures, Humerus, Treatment outcome

How to site this article : Derin Awat Hamafaraj, Hamid Ahmad Mahmood, " Outcome of humerus fracture treated by titanium elastic nail in adult age group"Int J Drug Deliv Technol. 2026;16(89s): 1496-1503; DOI: 10.25258/ijddt.16.89s.157

1. INTRODUCTION:

A humeral shaft fracture, while not common, is a frequent incidence that a surgeon in the orthopedic department comes across.[1] With the increasing number of causes of bone fractures, this type is also increasing, estimated to account for about 5% of all bone fractures.[2] It can be managed successfully with both surgical and non-surgical approaches, but the latter has some drawbacks, as it requires prolonged immobilization, continuous patient cooperation, and multiple follow-ups.[3]

Elastic intramedullary nails, made of titanium, were originally introduced to fix children's and adolescents' long bone fractures for their bendability, which is advantageous in growing bones, and for their good rotational and bending stability.[4]. Their use for children has been supported by well-established evidence in the literature, whereas for adults, it was considered an empirical method due to insufficient evidence.[5] Then, titanium elastic nails TEN were suggested to treat adult humeral fractures to reduce the need for dissection, prevent intra-surgical complications, reduce the amount of blood loss, and improve the overall post-surgical healing compared to other methods used for the same purpose.[6] The surgical procedure is established upon the principle of flexible intramedullary nailing, which is performed either retrogradely or antegradely.[7] In the retrograde technique, two nails will be cut to a

length of 40% of the canal, and they will be bent to be inserted into the humerus distally, preserving the ulnar nerve at the same time.[5]

Considering individual adult patient characteristics, clinical judgment, and expected outcomes, choosing the appropriate technique for managing humeral fractures remains a matter of debate.[8] Traditional surgical interventions like plate osteosynthesis and rigid intramedullary nailing come with their own undesirable expectations, like dissecting soft tissue extensively, injury to the radial nerve iatrogenically, and consequent movement limitations.[3,9] On the other hand, titanium elastic nails are currently considered in cases of geriatric patients due to the presence of systemic diseases, challenging anatomies like obesity or other cases that necessitate minimal surgical approaches.[4] and they are not without limitations in adult patients, as they possess weak rotational stability, lack the ability to handle axial loads, have limited indications, especially in distal humeral fractures, and have insufficient rotational stability, which is the major drawback of elastic nails.[1] Furthermore, some authors advise against using titanium nails in certain cases, such as oblique, spiral, segmental, and comminuted fractures, as these fractures are more prone to nonunion.[3]

This prospective single-arm cohort study investigates the clinical outcomes of titanium elastic nail use in humeral fracture management. It will systematically evaluate the union rate, healing time, functional outcome, and complications to assess its merit in our regional surgical workflow, provide insight for local and broader orthopedic societies, and add another piece of evidence to the current literature.

2. PATIENTS AND METHODS:

2.1. Study design and settings:

This prospective cohort study was initiated to assess functional, radiological, and clinical endpoints following humeral diaphyseal fractures treated with intramedullary titanium elastic nails. The study was conducted at Shar Teaching Hospital in Sulaymaniyah, the Kurdistan Region of Iraq, from April 2023 to April 2026.

A convenience sampling method was used to include all consecutive eligible patients who presented to the orthopedic department at Shar Hospital, and recruitment continued throughout the study period, resulting in 48 participants.

2.2. Inclusion and exclusion criteria:

Patients above 18 years were included in the study. Inclusion criteria were cases with closed fractures and Gustilo-Anderson type I open fractures that presented with intact shoulders and functioning elbows pre-surgically. Exclusion criteria were patients with neurovascular injury, Gustilo-Anderson Type II and Type III open fractures, long oblique, spiral, and comminuted fractures, which are unsuitable for elastic nails.[2] Ipsilateral conditions, such as forearm, clavicle, or scapula compartment syndrome and pathological fractures, were also excluded from the study.

Standardized surgical techniques were used for all procedures, which included closed retrograde insertion of elastic titanium nails under fluoroscopic guidance. At regular intervals, patients were assessed for union, complications, and alignment, both clinically and radiographically. Function was evaluated by the Disabilities of the Arm, Shoulder, and Hand (DASH/KU SCALE) score, and patients' satisfaction was recorded at the end of the assessment.[10]

2.3. Data collection and analysis:

Demographic gathered information were age, sex, and body mass index, as well as preoperative observations, complications, time to union, and functional outcomes. Union was defined radiographically by visualization of bridging callus in at least three cortices. Clinically, based on pain assessment, the patient should feel pain-free and have no tenderness.

2.4. Data analysis:

The collected data were refined and coded using the SPSS version 27 application for Microsoft Windows. The Chi-squared test was used to evaluate the relationship between categorical variables, and the Mann-Whitney U test was used to compare the means of numerical variables following the presentation of descriptive statistics such as means, frequencies, standard deviations, and percentages. Statistical significance is defined as a p value of ≤ 0.05.

2.5. Ethical approval:

Ethical approval for the study was received from the Committee of Research and Ethics of the Kurdistan Higher Council for Medical Specialties. A proposal was presented to the committee, and approval was later granted in a formal letter dated 14th Sep 2025 and numbered 2160. Informed consent was obtained from each enrolled participant, and the preservation of confidentiality was prioritized throughout the study. Participants were made aware that they

might leave the study at any moment, including during follow-up visits.

3. RESULTS:

The age of all 48 participants ranged from 18 to 56, with a mean of 35. 25 of them were male, and Table 1 shows frequencies for all categorical variables.

Table 1. Frequencies and percentages of categorical variables.

Variable	Category	n (%)
Hand dominance	Right-handed	45 (93.8)
	Left-handed	3 (6.2)
Side of fracture	Right arm	35 (72.9)
	Left arm	13 (27.1)
Mechanism of injury	Fall from height	30 (62.5)
	Road traffic accident	10 (20.8)
	Direct blow	4 (8.3)
	Sports injury	2 (4.2)
	Fall on the ground	2 (4.2)
AO/OTA classification	12A2b	27 (56.3)
	12A3b	10 (20.8)
	12B2b	6 (12.5)
	12B3b	5 (10.4)
	12A1b	0
Fracture location	Middle third	30 (62.5)
	Proximal third	10 (20.8)
	Distal third	8 (16.7)
Fracture type	Closed fracture	40 (83.3)
	Gustilo type I open fracture	8 (16.7)
Time from injury to operation	1 day	8 (16.7)
	Two days	30 (62.5)
	Three days	10 (20.8)
Type of anaesthesia	General anaesthesia	40 (83.3)
	Regional anaesthesia	8 (16.7)
Entry approach technique	Antegrade (proximal)	4 (8.3)
	Retrograde (distal)	40 (83.3)
	Both	4 (8.3)
DASH/KU SCALE score	1 (none or mild difficulty)	30 (62.5)
	2 (mild)	15 (31.3)
	3 (moderate)	3 (6.3)
Post-surgical complication	No complication	39 (81.3)
	Superficial infection	1 (2.1)
	Elbow Stiffness	1 (2.1)
	Malunion	1 (2.1)
	Delayed union	1 (2.1)
	Non-union	3 (6.3)
	Hardware irritation	2 (4.2)

There were no participants with comorbidities or preoperative radial nerve injury. Arm immobilization was performed for all participants, and post-surgical physiotherapy was prescribed. The duration of the surgery ranged from 29 to 67 minutes, and the time to union ranged from 10 to 48 weeks, with a mean of 13.19, a standard deviation of 5.49, and a mode of 12. The cumulative percentile reached 62.5% at week 12 and 91.7% at week 14. A representative case from pre-operative time to 8 months post-operatively following treatment with titanium elastic nails is shown in Fig. 1.

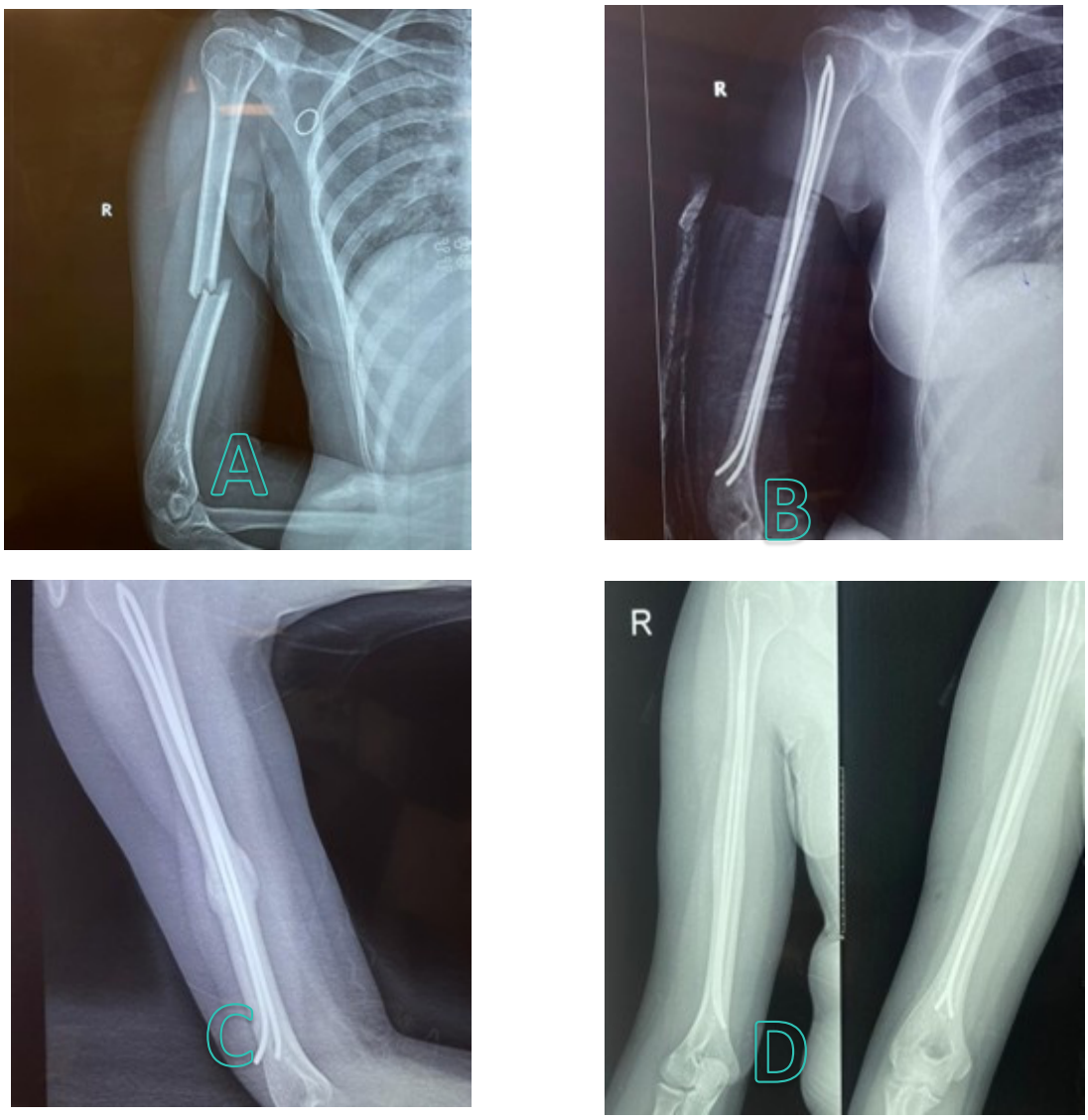


Figure 1. A series of radiographs showing an adult patient treated with titanium elastic nails after a humeral shaft fracture in different stages of healing: (A) pre-operative radiograph, (B) day 1 post-operative, (C) 8 weeks post-operative, and (D) 8 months post-operative.

The duration of surgery was normally distributed. When the mean was compared against grouping variables using t-tests and ANOVAs, no significant results were found, except for the AO/OTA classification. 12B3b recorded the highest mean: 57 minutes, while 12A2b recorded the lowest mean: 43.74; this difference reached a significant level, $p = 0.016$.

The time from injury to operation and the time to achieve union were not normally distributed, and no statistically significant findings were observed in the associations between them and categorical variables. The DASH/KU SCALE score was tested against the presence of post-surgical complications, and we found that the presence of complications was associated with a higher DASH/KU SCALE score $p = 0.0001$.

Postoperative complications occurred in only 18.7% of participants; the most serious was non-union, which occurred in 3 participants, followed by hardware irritation at 4.2%, while other complications like infection, malunion, delayed union, and elbow stiffness occurred in only 1 patient each. However, these complications weren't statistically associated with any of the variables.

Falls from height were a more frequent mechanism of injury, occurring more in females than in males (19 vs 11), and this finding was statistically significant by Fisher's exact test (p =

0.009). When the shaft fracture classification was tested against the DASH/KU SCALE score using Fisher's exact test, the 12A2b class had a higher frequency of no or mild difficulty on the DASH/KU SCALE score, and this difference turned out to be significant, p = 0.028. The same scenario was observed for post-surgical complications, as 12A2b was more common without complications p = 0.033. Other than these, no associations were found in cross-tabulation.

AO/OTA showed a strong positive Spearman correlation with the duration of surgery, r = 0.41, p = 0.004. Additionally, a weak positive Spearman correlation was observed with the DASH/KU SCALE score, r = 0.27, but the latter couldn't reach the statistically significant level, p = 0.054. No more important correlations were found to report.

4. DISCUSSION:

This study demonstrated that titanium elastic nails in the management of fractures of the humerus may be an viable option, as they provide favorable clinical and radiological outcomes in selected adult cases, with a high union rate, short operative time, and good functional post-operative outcomes in most patients. 12-14 weeks of union time and no to mild functional limitation post-surgically, according to the DASH/KU SCALE score, were recorded for the majority of patients in this study. Furthermore, post-operative complications were reported relatively infrequently. These results support the use of titanium elastic nails in select cases for managing diaphyseal fractures in adults, especially when preserving soft tissues or reducing operative time is a priority.

The presented article builds upon earlier work by Alany et al. in 2017 in Erbil city, Kurdistan region, which prospectively evaluated 40 patients with humeral mid-shaft fractures who were managed with TIN. The reported mean union time was 12.2 weeks, and the study concluded that titanium elastic nails are associated with favorable clinical results in treating fractures of the humeral shaft, although complications such as shoulder pain, superficial infection, shoulder stiffness, and non-union may occur. Our findings are generally consistent with their work. However, we expanded the work by adding a larger cohort, using a validated Kurdish version of the DASH SCALE for assessment, as well as radiographic and clinical evaluations, and investigating the influence of AO/OTA fracture classification on operative duration.

Humeral fractures can be classified into proximal fractures, which occur near the shoulder and are more common in older populations, and diaphyseal fractures, which account for 1-5% of all fractures.[5] Treatment choices for adults are decided based on the pattern, the patient's general health, and functionality.[8] Non-surgical management, like splinting, is always considered, as the humerus bone can tolerate some degree of malunion radiographically because it is not a weight-bearing bone.[11] Functional bracing can also be considered, which stabilizes the fracture with allowance for early shoulder movement.[11] While surgical treatments are more suitable options in cases of open fractures, comminuted, segmental, or polytraumatic fractures.[9] the gold standard among surgical approaches is plate osteosynthesis, which is internal fixation of the fractured bone and maintains it with screws to achieve a high union rate accurately, while this technique requires thorough dissection of soft tissues that puts the radial nerve at risk of iatrogenic trauma.[1] Intramedullary nailing and rigid interlock nailing are also among surgical approaches with good outcomes, and they are less traumatic than other methods, but they are usually associated with post-operative shoulder pain.[12] Other surgical methods include arthroplasty, which is used mostly in elderly patients with complex or multiple fractures when complete reconstruction of the fractured bone is not possible,[8] and external fixation when significant soft tissue damage is observed and the fracture is open.[13] Among the surgical approaches, one of them is minimally invasive and was initially reserved for pediatric patients, but it has gained more popularity in adults for cases where general anesthesia is to be avoided or soft tissue preservation is a priority, and it is called elastic stable intramedullary nailing or titanium elastic nailing.[5,14]

Falls from height are the most common mechanism of injury, and this may reflect local environmental and socioeconomic conditions, as a similar study in Erbil city has recorded the same pattern.[11] While internationally, the most frequent cause of humeral fractures is traffic accidents, and falls come in second place.[9,15]

Several studies in the literature reported favorable outcomes with elastic titanium nails in the management of humeral fractures in adults; our findings are generally consistent with these reports. Regarding the union time, we reported that most of the patients achieved union of the fractured site between 12 and 14 weeks, and this period is quite close to the reported union time for the same technique, which ranged between 10 and 17 weeks, with 12-14 weeks being the

most frequently mentioned period.[16] Fig 1 shows a set of radiographs of a 25-year-old female patient that represent the radiographic healing process after titanium elastic nails were used to treat a humeral shaft fracture.

Satisfactory post-operative functional recovery was observed; 62.5% of patients reported no to minimal disability, and 6.3% reported moderate disability on the DASH/KU SCALE score. Closely related findings have been reported: younger patients report lower DASH/KU SCALE scores after fracture management with TEN,[6] whereas older patients show higher postoperative DASH/KU SCALE scores.[4] The low infection rate as a complication may be in relation to the procedure's non-invasiveness, and some surgeons exclusively keep TEN in their options for this reason.[7,17] one important point on complications is hardware irritation that remains in some cases, as the prominent end of the nails irritate the skin in way that in some studies, this complication reached 20% and requires nail removal occasionally.[18,19] on the other hand, the most important complication is this procedure is non-union in 6.3% of our participants, while it happened in only three patients, but it remains clinically significant because they require additional surgery and prolonged recovery time to restore function.[3] The non-union rate in our study is comparable with the rate mentioned in the literature, which ranges from 4% to 10%.[15,16] The complications encountered were managed as follows: Open reduction and internal fixation with plate fixation along with bone grafting were used to treat non-union patients., which is considered a standard procedure.[20] The malunion did not result in significant functional impairment or limitation of activities of daily living and was deemed appropriate by the surgical team and the patient. Elbow stiffness improved and eventually resolved with continued physiotherapy. The superficial infection was successfully managed with daily wound dressing and antibiotic therapy. Hardware irritation was treated with implant removal after radiographic and clinical evidence of fracture union was achieved, in accordance with recommendations in the literature.[21,22]

Fracture morphology showed influence on the surgical outcomes; AO/OTA fracture configuration type 12-A has more favorable outcomes, and Ma et al. provided strong evidence that this pattern of fracture, including oblique and transverse fractures, is more suitable for titanium nailing management; they even showed better functional recovery than plating in their study.[16] on the other hand, a study calls for caution regarding using titanium nails in oblique and spiral fractures, because they are prone to non-union more than other patterns of bone fracture.[3] However, the complexity of humerus fractures has proven to be predictive of post-operative functional outcomes in both children and adult age groups,[3,23] but in our cohort, the correlation between fracture complexity and post-operative functional outcome was weak and was not significant. Furthermore, the AO/OTA pattern also predicts the duration of surgery, as more complex procedures require more maneuvers for reduction.[6] We established a significant positive association between fracture complexity and the time spent on the operation based on AO/OTA classification, which corresponds with claims from other authors.[4,14]

The strengths of this study include a prospective design, standard procedures, and uniform follow-up protocols, and both functional and radiological evaluations postoperatively, making it one of the few studies on elastic titanium nails in the Kurdistan region and Iraq. Convenience sampling, a single-center study, a comparatively small sample size, and the lack of a comparison group are some of the drawbacks, which limit the ability to compare this approach with other surgical techniques.

5. CONCLUSIONS:

Titanium elastic nails appear to be a safe and effective management option in selected cases of adult humeral fractures, with favorable healing times, limited disability, and relatively low complication rates. These findings support titanium elastic nails as a less intrusive substitute in select cases; however, further investigations, such as comparative and longitudinal research, are needed to establish a protocol for this method.

6. AUTHOR CONTRIBUTION STATEMENT:

Conceptualization and methodology: D.A.H. and H.A.M.; data collection, statistical analysis, writing, and review: D.A.H.; supervision and editing: H.A.M. Both authors read, reviewed, and accepted accountability for the manuscript.

7. ETHICAL STATEMENT:

This study was approved by the Committee of Research and Ethics of the Kurdistan Higher Council for Medical Specialties, with a formal letter numbered 2160, on 14th Sep 2025. All participants provided written informed consent prior to their involvement. Participants' anonymity and confidentiality were strictly maintained throughout the study, and the research was conducted in accordance with the

ethical standards set forth in the Declaration of Helsinki.

8. FUNDING:

This research did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

9. AI USAGE DECLARATION:

During the preparation of this work, the authors used Grammarly in order to correct the grammar of the manuscript. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication

10. ACKNOWLEDGEMENTS:

The authors declare no conflicts of interest and thank anyone who helped and the anonymous reviewers for their valuable feedback on the manuscript.

11. CONFLICT OF INTEREST:

The authors declare no conflict of interest regarding this article.

12. DATA AVAILABILITY STATEMENT:

The dataset related to this study will be available for sharing upon a reasonable request.

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