

Investigating the Outcomes of Adolescent Treatment for Humerus Fractures Using Elastic Titanium Nails

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Abstract

Introduction: Intramedullary interlocking nails are commonly used for humerus fracture fixation in children and adolescents. Although effective, this method can disrupt medullary blood flow and pose biomechanical challenges. Titanium elastic nails (TEN) offer a less invasive alternative with fewer complications, yet limited studies have compared TEN with other fixation methods in this age group. This study aimed to evaluate the outcomes of TEN for humerus fractures in pediatric patients.

Materials and Methods: In this cross-sectional study, pediatric patients who underwent humerus fracture fixation with TEN at Shafa Hospital (2019–2020) were assessed. Functional outcomes were evaluated using the Disability of Arm, Shoulder, and Hand (DASH) Score; pain was measured by the Visual Analog Scale (VAS), and elbow range of motion was measured with a goniometer. Complications, including infection and nerve injury, were recorded.

Results: Among the 23 patients treated with TEN, the mean age was 8.5 years. Postoperative complications occurred in 17.4% of cases, including hematoma, nail tip protrusion, and superficial infection. There were no significant differences in range of motion between male and female patients.

Conclusion: Titanium elastic nails provide a safe and effective option for humerus fracture fixation in children, offering favorable outcomes with minimal complications.

Keywords: Humerus fracture, Titanium elastic nail, Fixation, Adolescents

1. Introduction

Humerus fractures are common, with an incidence of approximately 105 cases per 100,000 individuals [1]. These fractures are typically a result of trauma [2] but can also occur due to pathological reasons

[3]. Treatment options for humeral fractures encompass both conservative methods, like bracing, and surgical procedures. However, surgical intervention is frequently favored, as conservative management typically demands extended immobilization periods [4,5,6]. In adult patients, fracture fixation is commonly performed

using plates or intramedullary interlocking nails [7]. Intramedullary interlocking nails are advantageous for humerus fracture fixation due to their reduced exposure to bending forces, minimizing the risk of fracture displacement. These nails also distribute loads and serve as a buffer against operative stress, which help prevent complications. Unlike plate fixation, intramedullary nails do not lead to cortical osteopenia at the implant ends, thus lowering the chance of re-fracture once the fixation device is removed. These benefits have made intramedullary interlocking nails a preferred choice over plate fixation among many orthopedic specialists for treating humeral fractures [8].

However, the use of intramedullary interlocking nails comes with its own concerns. They include potential damage to medullary blood flow and a lack of proper understanding of biomechanical principles by the intramedullary nail. Therefore, efforts to develop less invasive methods for humerus fracture treatment continue [9]. Titanium elastic nail (TEN) is a routine tool for fixing humerus fractures in children. Due to its finesse, easy insertion into the canal, and minimal damage to the bone canal and growth plate, this tool provides a less invasive alternative compared to intramedullary interlocking nails [10]. In adults, where the growth plate is closed, rigid fixation (using intramedullary interlocking nails) is commonly employed. However, this approach is associated with more complications [11]. Recent studies have suggested using titanium elastic nails instead of intramedullary interlocking ones for humerus fracture fixation, reporting minimal complications. Thus, it is recommended to use titanium elastic nails to minimize invasiveness [11,12].

Due to the limited number of studies conducted, however, there is insufficient evidence to fully support the use of titanium elastic nails instead of intramedullary interlocking nails for humerus fracture fixation in children and adolescents. Consequently, this study seeks to investigate the outcomes associated with the utilization of

titanium elastic nails for humerus fracture fixation in adolescents.

2. Materials and Methods

2.1 Patient Selection

The study includes all patients with humerus fractures (one-third distal to the humeral shaft) who sought treatment at Shafa Hospital between 2019 and 2020. Titanium elastic nail fixation was performed on these patients.

2.2 Inclusion and Exclusion Criteria

The inclusion criteria encompassed individuals aged 4 to 19 years with humeral shaft fractures. In contrast, exclusion criteria applied to those with specific conditions, including a prior history of arm surgery, neurovascular complications, the displacement of the humeral shaft fracture, pathological fractures, or concurrent fractures of the radius or ulna. Patients presenting with simultaneous elbow dislocation were also excluded. These criteria were designed to ensure a focused and homogenous study population, thereby enhancing the reliability and relevance of the research findings.

2.3 Data Collection

Patients meeting the inclusion criteria were assessed at four time points (two weeks, four weeks, two months, and six months postoperatively) through physical examinations, relevant checklists, and specific questionnaires. Hand function was evaluated using the Disability of the Arm Shoulder and Hand Score (DASH), comprised of 30 questions addressing upper limb symptoms and function related to orthopedic and neurological disorders. In addition to the 30 questions, the DASH questionnaire includes two sets of four-item questions labeled DASH Sport/Art and DASH Work, scored similarly. In this study, the DASH Sport/Art section was utilized based on the relevance and content of the questions and previous studies. The reliability and validity of the DASH questionnaire were confirmed in the study by Beaton et al. [13]. Additionally, the questionnaire was translated into Persian and validated by Mosavi et al. in 2008 [14]. The Visual Analog Scale (VAS) was used to assess patient pain. Flexion, extension, supination, and pronation of the elbow were assessed using a goniometer. Surgical complications, including hematoma, bleeding, infection, non-union, and nerve damage, were extracted from patient records.

2.4 Statistical Analysis

All collected data were entered into SPSS version 24,

and statistical analyses were conducted to evaluate the information. Descriptive statistics and analytical tests were used as appropriate for data analysis.

3. Results

For this research, a total of 23 patients treated for humerus fractures with Titanium Elastic Nails were examined. Among them, 17 patients were male (73.9%), and 6 patients were female (26.1%), resulting in a male-to-female ratio of 4.5. According to the results presented in Table 1, the treated patients had an average age of 8.5 ± 2.33 years, with the youngest being 5 years old and the oldest being 14 years of age. All fractures were closed and without neurovascular damage.

All patients underwent surgery within 3 to 48 hours of the fracture. Titanium Elastic Nails were used for the fixation of humerus fractures in all patients. Union occurred between 12 to 20 weeks, and the nails were

removed after 6 months. The treatment success rate in the evaluated individuals was 82.6%, and 17.4% (4 patients) experienced postoperative complications. Among them, two patients had hematomas, one patient experienced protrusion of the TEN tip, and another had superficial infection [Table 1].

Due to the non-normal distribution of the data, non-parametric tests were used to compare the means between the male and female groups. According to the Mann-Whitney U test presented in Table 2, no significant difference was observed in the flexion angles between the male (145.88 ± 7.12) and female (145.36 ± 36.8) groups ($P = 0.86$). Similarly, there was no significant difference in the mean extension degree of the elbow between the male (59.12 ± 23.12) and female (67.11 ± 4.19) groups ($P = 0.51$). Based on these results, no significant difference was found in the mean DASH score between the two gender groups ($P = 0.1$) [Table 2].

Table 1. Frequency Distribution of Patients Treated with Titanium Elastic Nails for Humerus Fractures

| | Age | Pain Level | Elbow Extension | Elbow Flexion | Gender | Complications | DASH |
|----|-----|------------|-----------------|---------------|--------|---------------|------|
| 1 | 12 | 2 | 0 | 150 | 1 | 0 | 90 |
| 2 | 10 | 1 | 10 | 150 | 1 | 0 | 90 |
| 3 | 8 | 2 | 0 | 150 | 1 | 0 | 85 |
| 4 | 6 | 3 | 50 | 150 | 2 | 1 | 90 |
| 5 | 9 | 2 | 0 | 150 | 2 | 0 | 95 |
| 6 | 7 | 3 | 0 | 150 | 1 | 0 | 85 |
| 7 | 8 | 1 | 0 | 150 | 1 | 0 | 95 |
| 8 | 6 | 2 | 10 | 150 | 1 | 0 | 85 |
| 9 | 10 | 2 | 0 | 150 | 1 | 1 | 90 |
| 10 | 8 | 3 | 10 | 130 | 1 | 2 | 70 |
| 11 | 6 | 1 | 0 | 140 | 2 | 0 | 85 |
| 12 | 12 | 2 | 0 | 150 | 1 | 0 | 100 |
| 13 | 5 | 2 | 50 | 150 | 1 | 0 | 90 |
| 14 | 7 | 3 | 10 | 150 | 2 | 0 | 85 |
| 15 | 9 | 4 | 0 | 150 | 1 | 0 | 95 |
| 16 | 8 | 1 | 0 | 150 | 1 | 0 | 100 |
| 17 | 6 | 1 | 0 | 150 | 1 | 0 | 100 |
| 18 | 7 | 3 | 10 | 130 | 2 | 0 | 75 |
| 19 | 8 | 1 | 5 | 140 | 1 | 0 | 85 |
| 20 | 9 | 2 | 0 | 140 | 1 | 0 | 85 |
| 21 | 10 | 3 | 10 | 130 | 1 | 3 | 75 |
| 22 | 12 | 4 | 0 | 140 | 1 | 0 | 85 |
| 23 | 14 | 1 | 0 | 150 | 1 | 0 | 95 |

Table 2. Comparison Values between Male and Female Groups of Mean

| Variable Gender | Male | Female | P.value |
|--------------------|----------------|----------------|---------|
| Flexion Degree | 145.88± (7.12) | 145± (8.36) | 0.86 |
| Extension Degree | 5.59± (12.23) | 11.67± (19.40) | 0.51 |
| DASH | 88.24± (7.89) | 88.33± (8.75) | 1.0 |

4. Discussion

The present study aimed to further investigate the outcomes of using titanium elastic nails for the fixation of humerus fractures in adolescents. Treatment approaches for humerus fractures in adolescents vary, and pediatric traumatology textbooks have limited classifications, treatments, and outcomes for these injuries[15]. As indicated in other studies on fractures of the midshaft or distal third of the humerus, the preferred treatment involves using humeral nail techniques, particularly in younger ages, with initial conservative management or initial treatment with plates or flexible nails. The use of flexible nails in long bones is considered a viable treatment option for pediatric patients, specifically in fractures like those of the humerus.

A study found that closed antegrade intramedullary titanium elastic nailing is a safe and effective approach for stabilizing upper humeral shaft fractures in adults. This technique promotes early fracture healing, achieves high union rates, minimizes complications, supports quicker rehabilitation, and shortens hospital stays[8].

In a follow-up averaging 29 months, all fractures healed with proper alignment, and no intraoperative complications, infections, or vascular injuries occurred. Two patients experienced nail migration, with one case leading to skin protrusion. Out of 13 patients, 12 returned to full sports and activities without limitations. This study concludes that TEN fixation is an effective method for pediatric humeral shaft fractures, achieving high union rates with minimal complications, and is a familiar technique for orthopedic surgeons specializing in pediatric care[16].TEN is an effective and low-complication method for treating severely displaced humerus fractures in children, facilitating quick healing and full functional recovery[17].

The results of this study demonstrated that, similar to previous research, treatment with flexible humeral nails using two nails led to excellent healing and outcomes in one-third and distal one-third humerus fractures. This aligns with the findings of similar studies[18,19]. Since the outcomes of this study were favorable, it is recommended to conduct further studies on adults, where open surgery or plating/nailing may pose higher risks. The use of elastic nails, applied through a small distal incision, should be investigated in adult populations, considering the limited data in this regard. Given that this treatment is not applicable to all adults and lacks extensive information, additional studies in this area are warranted.

The study results indicated no significant differences in DASH scores and the range of hand motion between genders after treatment with the elastic nail method, which is consistent with other studies [19]. Despite the excellent restoration observed in the majority of patients, only four patients experienced complications, indicating a very low complication rate compared to similar studies[18]. It is noteworthy that union occurred between 12 to 20 weeks, and the nails were removed after 6 months.

Limitations of this study include the small sample size treated with this surgical approach, suggesting the need for larger, more comprehensive studies. Another limitation is the lack of periodic follow-up of patients, and all patients were evaluated only once postoperatively. In contrast, other studies have assessed patients periodically[19].

5. Conclusion

In light of the limitations of this cross-sectional study, it is not possible to establish a definitive cause-and-effect relationship or to conclude that this surgical method is superior to other treatment options.

However, this study suggests that elastic nailing shows promising clinical outcomes and therapeutic potential in children and adolescents with closed humeral shaft fractures. Conservative treatment also remains a viable approach for this injury type, as supported by existing literature. Therefore, both surgical and conservative methods should be carefully considered based on individual patient characteristics and the specifics of the injury, rather than favoring one approach over the other.

Ethical Considerations

Compliance with ethical guidelines

This study was conducted in accordance with the ethical standards of and with the 1964 Helsinki Declaration and its later amendments. Ethical approval was obtained from [the ethics committee or institutional review board, if applicable], and informed consent was obtained from all individual participants (or their guardians) included in the study.

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Author's contributions

Morteza Nakhaei Amroodi and Pouria Tabrizian contributed to the conceptualization and design of the study. Masoud Bahrami and Mansour Karimi and Khatere Mokhtari collected and analyzed data. Milad Hajiagha Bozorgi and Mohammadreza Bahaeddini contributed to data interpretation and manuscript drafting. All authors read, revised, and approved the final manuscript.

Conflict of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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