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Clinical Outcomes of Chevron Osteotomy with Tension Band Wiring for Distal Humerus Fractures: A Prospective Study

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ABSTRACT

Objectives: Chevron osteotomy could be fixed using various techniques, each yielding different outcomes. This study aimed to determine the complications and outcomes caused by Chevron osteotomy fixed with tension band wire in distal humeral fractures.
Methods: In this prospective study, patients with distal intra-articular humerus fractures treated by Chevron osteotomy at Shahid Rajaei and Shahid Chamran Hospitals (Shiraz, Iran) from October 2018 to October 2023 were enrolled. Osteotomy fusion was evaluated radiographically using the Picture Archiving and Communication System (PACS). Additional complications were assessed during periodic patient follow-ups.
Results: The study included 60 patients with a mean age of 44.6±18.14 years, including 23 (38.3%) women. All cases demonstrated complete union of the olecranon osteotomy, with no cases of infection or fixation failure. In three cases, the applied pins and wires were removed. Hardware-related irritation was observed in 22 patients (36.7%).
Conclusion: The tension band wiring (TBW) method demonstrated acceptable clinical outcomes. Despite frequent hardwire irritation, this technique achieved high rates of bony union. However, future comparative studies evaluating multiple fixation techniques within a single center are warranted.

Keywords: Osteotomy, Distal humeral fracture, Olecranon Process, Tension band wiring, Treatment outcome.

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Introduction

Upper extremity fractures and dislocations are relatively common. Distal humerus fractures in adults account for approximately 2% of all fractures and one-third of all humerus fractures [1, 2]. These fractures typically result from high-energy trauma in younger patients or low-energy trauma in osteoporotic elderly. Depending on the position of the elbow, trauma magnitude, and bone quality, various fracture patterns might occur, potentially accompanied by neurovascular and soft tissue injuries [3, 4]. The Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification system

categorizes distal humerus fractures into three groups: Type A (extra-articular), Type B (partial articular), and Type C (complete articular) fractures [5, 6]. Non-surgical treatment is rarely indicated, being reserved for non-displaced fractures or surgically unfit patients. Inadequate osteotomy fixation may lead to non-union [7]. Rigid fixation with early range of motion represents the gold standard for distal humeral fracture management [8, 9]. Various surgical approaches, including paratricipital and triceps-splitting approaches, have been proposed for distal humeral fracture management [10]. The olecranon osteotomy, also known as Chevron osteotomy, provides direct articular surface visualization, making it the preferred technique for comminuted and displaced intra-articular fractures [11-14].

Several fixation options exist for olecranon osteotomy repair. Plate fixation involves securing bone fragments with a posterior ulnar plate, offering particularly stable fixation in patients with osteoporosis [15]. Intramedullary screw fixation requires less surgical exposure while minimizing implant prominence and potentially reducing revision rates [16, 17]. Tension band wiring (TBW) employs a figure-of-eight stainless-steel wire secured with Kirschner wires (K-wire), converting tensile forces to promote bone healing [18, 19]. However, TBW carries disadvantages, including wire irritation and frequent need for secondary removal procedures [20].

This study aimed to evaluate the clinical outcomes following olecranon fixation using K-wires and TBW. Based on available evidence, this study represented the first descriptive study examining the surgical outcomes of distal humerus fractures treated with Chevron osteotomy and TBW in the Iranian population.

Materials and Methods

This prospective descriptive study included all patients who underwent surgical treatment for distal intra-articular humerus fractures using Chevron osteotomy fixed with K-wires and TBW fixation at Shahid Rajaee and Shahid Chamran Hospitals in Shiraz, Iran, from October 2018 to October 2023. The study protocol was thoroughly reviewed by the specialized review board and was ethically approved by the Ethics Committee of Shiraz University of Medical Sciences (code: IR.SUMS.MED.REC.1402.357).

Patient selection began by identifying all surgically treated distal and intra-articular humerus fractures through the Hospital Information System (HIS). Using operative reports and postoperative radiographs available in the Picture Archiving and Communication System (PACS), we then selected cases treated with Chevron osteotomy followed by K-wire and TBW fixation. The remaining patients were prospectively followed through the HIS data after applying the exclusion criteria.

The study included patients who underwent Chevron olecranon osteotomy during the specified timeframe. Patients were excluded if they could not complete at least one year of follow-up or reach final outcomes due to death before fracture healing, loss to follow-up after discharge, or unwillingness to participate. Additional exclusion criteria included pre-existing abnormal olecranon anatomy, previous history of elbow pathologies, and concurrent olecranon and distal humerus fractures, or medical conditions that could impair bone healing, such as osteogenesis imperfecta or chronic systemic diseases.

Based on the available radiographs in the PACS, cases of union, non-union, and mal-union fractures were identified. Non-union was specifically defined as the absence of bony cortical bridging across three of four cortices within six months. Additional outcome measures were evaluated through in-person interviews and clinical examinations, including assessment of surgical site infection, irritation caused by olecranon pins and wires, need for hardware removal, and surgical failure. Hardware irritation was assessed clinically based on patient-reported localized pain, tenderness, or discomfort directly over the olecranon implant site during follow-up visits. This parameter was recorded as a binary outcome (present/absent) through clinical evaluation and patient symptom reporting, without employing standardized scoring systems.

Using a posterior elbow approach, the ulnar nerve is identified and protected before exposing the proximal ulna's subcutaneous border. The non-articular portion of the greater sigmoid notch (the "bare area"), located between the olecranon and the coronoid articular facet, should be clearly identified. This identification is achieved through subperiosteal dissection along the olecranon's medial and lateral sides, providing access to the ulno-humeral joint. The dissection must remain proximal to avoid compromising collateral ligament insertions. Medial and lateral retractors are then positioned within the ulno-humeral joint to protect surrounding soft tissues and optimize visualization of the "bare area."

The surgical procedure was initiated by marking an apex distal Chevron osteotomy on the subcutaneous border of the ulna, extending into the bare area. Using a micro-sagittal saw, two-thirds of the osteotomy cut was completed. To prevent unpredictable propagation of the osteotomy, the remaining third was carefully perforated using a K-wire drill hole. Controlled fracture completion was then achieved by applying leverage to the olecranon fragment using two osteotomies, one inserted into each arm of the chevron, which cleanly fractured the remaining cortical bridge.

For definitive fixation, two parallel 1.5 mm K-wires were inserted from the tip of the olecranon to the ulna's anterior surface under fluoroscopic guidance.

This construct was then reinforced with a figure-of-eight tension band wire configuration [18], completing the osteotomy stabilization.

All six qualitative variables were expressed as frequencies and percentages and presented in tables. Age distribution was reported using mean±standard deviation (SD). For complications with sufficient cases, the age and sex distribution were compared between groups. Statistical analyses were performed using SPSS software (version 22), employing an Independent Samples t-test for continuous variables (age differences between patients with/without implant irritation) and Chi-square tests for categorical variables (sex association with irritation presence). Statistical significance was set at $p<0.05$ for all analyses.

Results

This study included 60 patients with a mean age of 44.6±18.14 years. Among these patients, 23 (38.3%) were women, and 37 (61.7%) were men. All patients underwent Chevron osteotomy and were fixated using the TBW technique. The patients' demographic and clinical characteristics are presented in Table 1.

As shown in Table 2, no cases of soft tissue infection were observed. After careful evaluation of the radiologic X-rays, all patients achieved union at the olecranon osteotomy site, with no cases of non-union or fixation failure.

Regarding hardware irritation, 22 (36.7%) cases reported irritation symptoms, and 38 (63.3%) cases reported no signs of irritation. Among the cases with hardware irritation, only 3 cases (5%) required surgical removal of the hardware.

The mean age of the patients without hardware irritation was 40.34±17.28 years, whereas the mean age in the group with implant irritation was 51.95±17.57. This difference was statistically significant ($p=0.014$), indicating that irritation was associated with older age.

Sex distribution showed 11 females and 27 males in the non-irritation group, versus 12 females and 10 males in the irritation group. This difference was statistically significant ($p=0.049$), indicating higher irritation prevalence among female patients (Table 3).

The TBW technique demonstrated successful fixation following Chevron osteotomy, with no observed cases of infection or fixation failure. However, higher rates of implant irritation and hardware removal were noted, particularly among older patients and females. These findings indicated that while the TBW technique was effective, it required greater attention to potential side effects and proper management, which will be discussed in the subsequent discussion.

Table 1. Patient characteristics

Characteristics	Value
Number of patients	60
Mean age (mean±SD)	44.6±18.14
Female patients, n (%)	23 (38.3%)
Male patients, n (%)	37 (61.7%)

Table 2. Outcomes of tension band wire fixation of the Chevron osteotomy site in supracondylar fracture of the humerus

Outcome	Number of patients n (%)
Soft tissue infection	0 (0%)
Osteotomy union	60 (100%)
Fixation failure	0 (0%)
Implant irritation	22 (36.7%)
Removal of surgical hardware	3 (5%)

Discussion

The present study evaluated the clinical outcomes and complications following Chevron osteotomy fixed with TBW in patients with distal intra-articular humerus fractures. Our findings demonstrated a 100% union rate at the osteotomy site, with no cases of soft tissue infection or fixation failure, confirming the overall efficacy and reliability of TBW as a fixation method. This finding was in agreement with existing literature, including a systematic review by Feinstein *et al.,* that demonstrated non-union of the olecranon osteotomy site after TBW fixation, with most cases occurring in transverse rather than Chevron osteotomies [21]. However, implant-related irritation was observed in a considerable proportion of patients, particularly among older individuals and females. In three cases, the implants were surgically removed in a secondary procedure, while other patients maintained their implants during follow-up, although this might be necessary in the future. Notably, literature suggested that plate fixation more commonly required hardware removal than TBW [21].

Although patients with plate fixation suffer from hardware irritation, the intramedullary screw fixation has the advantage of lower irritation risks. Ocalan *et al.,* demonstrated that while both TBW and screw fixation methods are viable, TBW provides greater stability [14]. This finding was supported by the findings of Ren et al.'s meta-analysis, which confirmed TBW's superior stability despite its higher complication rate than plate fixation [22].

Table 3. Comparison of irritation vs. non-irritation groups in terms of age and sex

Variable		Irritation (n=22)	No irritation (n=38)	*p* value
Sex, n (%)	Male (n=37)	10 (27%)	27 (73%)	0.049
	Female (n=23)	12 (56.5%)	11 (44.5%)	
Age (mean±SD)		51.95±17.57	40.34±17.28	0.014

Haglin *et al.,* found no significant differences in healing time, elbow range of motion, or Mayo Elbow Performance Index (MEPI) scores between plate fixation and TBW, with TBW demonstrating marginally superior extension at follow-up [23].

The complete absence of soft tissue infections in the present study highlights strict adherence to surgical protocols and rigorous aseptic techniques, which are crucial in reducing postoperative complications [24]. Furthermore, achieving a 100% healing rate at the osteotomy site demonstrated the capability of TBW to provide stable fixation, ensuring optimal bone healing.

The observed 36.7% incidence of implant irritation was consistent with other studies on TBW, where implant prominence and irritation were common issues. The significant association between older age and implant irritation suggested that factors such as thinner soft tissues and decreased tissue resilience contributed to this discomfort. Previous studies reported similar age-related trends, with reported irritation rates varying from 18% to 44% [14, 25-28]. Additionally, women experienced higher rates of irritation, likely due to anatomical differences. Heyer *et al.,* reported similar findings on sex-specific complication patterns in orthopedic procedures [29].

Using TBW enables early elbow joint movement and typically yields optimal clinical outcomes. Tak *et al.,* reported 100% union rates, while documenting complications including 8.5% infection, 19% soft tissue irritation, and a significant rate of hardware removal [30]. In contrast, Butala *et al.,* found no complications with TBW [31]. Our findings demonstrated a 5% implant removal rate, primarily due to patients' discomfort rather than severe complications, suggesting that while irritation is common, most patients tolerate the implants. Older adults and female patients appear more likely to require removal surgery. These results emphasized the importance of preoperative counseling regarding individualized management strategies, considering patient-specific conditions and socio-economic factors. Technical modifications to minimize implant prominence and optimize soft tissue coverage should be considered during surgical procedures.

Finally, TBW remains one of the most cost-effective surgical options for olecranon osteotomy fixation, particularly when compared to more expensive alternatives, such as plate fixation or intramedullary screw systems [32, 33]. TBW utilizes low-cost, widely available materials (K-wires and stainless-steel wire), making it particularly valuable in resource-limited settings. Moreover, the ability of TBW to consistently achieve osteotomy union and facilitate early mobilization could contribute positively to functional recovery and quality of life, especially in healthcare environments where access to advanced implant systems and revision surgeries might be limited. These attributes of affordability, reliability, and favorable union rates establish TBW as a practical solution across diverse clinical settings [32].

In the present study, TBW selection for olecranon osteotomy fixation was primarily influenced by surgeon preference, institutional protocols, and practical considerations. In the participating centers, TBW has been routinely used due to its accessibility, low implant cost, and technical simplicity, particularly beneficial in high-volume public hospitals with limited resources.

This study on Chevron osteotomy and the TBW technique had several limitations. The relatively small sample size and potential selection bias might have influenced our ability to control for confounding factors. The lack of a control group and dependence on subjective outcome measures precluded comparative analyses. As a single tertiary referral center, the results might be subject to selection bias and limited generalizability to other clinical settings or diverse patient populations. Future research should focus on larger, randomized studies to validate these findings, directly compare TBW with other fixation methods, and assess long-term outcomes. Research directions could also include the development of improved hardware designs, comprehensive cost-effectiveness analyses, and the investigation of minimally invasive approaches to enhance surgical outcomes and patient satisfaction.

The primary strength of this study lies in being the first Iranian investigation to evaluate the clinical outcomes and complication profile of Chevron osteotomy fixed with TBW for distal humerus fractures. Conducted prospectively across two major tertiary referral centers over a five-year period, the study standardized surgical protocols, ensuring consistency in operative technique and reliable data collection.

The Chevron osteotomy technique with TBW fixation proved to be a reliable method for managing distal humerus fractures, providing a high rate of bone union and presenting minimal major complications, such as infection and fixation failure. However, the significant incidence of implant irritation, particularly among elderly patients and women, calls for consideration of alternative osteotomy fixation methods in certain patients. Despite frequent irritation in some of the patients, surgical removal of the hardware was rarely required in the minimum one-year follow-up period. Multicenter studies are recommended to validate these findings.

Declaration

Ethics approval and consent to participate: This study was approved by the Ethics Committee of Shiraz University of Medical Sciences (Ethics approval code: IR.SUMS.MED.REC.1402.357) and adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines and the World Medical Association Declaration of Helsinki.

Consent for publication: Informed consent was obtained from the patients regarding publishing their data and photographs for scientific purposes.

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