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Utilization of Nitinol Shape Memory Plates in the Surgical Treatment of Displaced Clavicle Fractures

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Abstract

Aim: While conservative and surgical options exist for treating displaced clavicle fractures, surgical intervention is often necessary, particularly in cases of comminuted fractures. This study aimed to assess the outcomes of surgical treatment using nitinol plates for displaced clavicle fractures.

Materials and Methods: A retrospective analysis was conducted on 19 patients with displaced midshaft clavicle fractures who underwent surgery with shape memory nitinol plates for clavicle fixation, all performed by the same surgeon. Data collection spanned a 7-year period from 2014 to 2021. Radiological and clinical assessments were conducted at a minimum 1-year follow-up.

Results: Nineteen patients (19 males), with a median age of 40.4 (range: 18-67) years, were included in the study. No major complications were observed during follow-up. Results indicated that 18 of 19 patients (94.7%) had fully recovered clinically and radiologically at the 1-year follow-up.

Conclusion: The use of nitinol plates in the surgical treatment of displaced clavicle fractures demonstrated successful outcomes. We believe that it can be safely preferred in selected cases because of its low complication rate.

Keywords: Displaced clavicle fracture, clavicle fracture fixation, shape memory nitinol plate

Introduction

The occurrence of a clavicle fracture indicates severe trauma, with clavicle fractures constituting 4% of all fractures and 35% of fractures in the shoulder region (1). The clavicle is anatomically divided into the medial, midshaft, and lateral regions (2). The midshaft, which constitutes the narrowest part of the clavicle, is the most commonly affected region, with approximately 80% of fractures occurring in this region. Various materials, including plaques and intramedullary implants, are available for surgical treatment, with a preference for surgical intervention and nitinol plates, especially for midshaft fractures (3). Nitinol alloy plates, which are characterized by high biocompatibility and minimal tissue reaction, are promising biomaterials (4). This study evaluated the outcomes of surgical treatments for displaced clavicle fractures using nitinol plates at our clinic.

Materials and Methods

This retrospective study involved the review of medical records from 29 patients with clavicle fractures who presented to the emergency department. Excluding four patients requiring intensive care unit follow-up and six patients with multiple traumas, we analyzed records from 19 patients with displaced midshaft clavicle fractures who underwent surgery using shape memory nitinol plates for clavicle fixation, all performed by the same surgeon. Data spanning a 7-year period (2014-2021) were collected, and radiological and clinical outcomes were evaluated with a minimum 1-year follow-up. The study was approved by the University of Health Sciences Turkey, Medeniyet University, Göztepe Training and Research Hospital Ethics Committee (decision no: 2023/0603, date: 20.09.2023).

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Statistical Analysis

Statistical analysis was conducted using Statistical Package for the Social Sciences (SPSS) 17.0 (IBM Inc Relased 2008). SPSS Statistics for Windows Chicago, USA) program. In descriptive statistics, continuous variables are expressed as mean±standard deviation, and categorical variables are expressed as percentages.

Surgical Technique

Patients were positioned supine under general anesthesia with antibiotic prophylaxis and underwent oropharyngeal intubation with a single lumen tube. The fractured arm was positioned parallel to the body, and the shoulder was elevated with support under the scapula. The position was adjusted accordingly. An incision line was marked on the clavicle to stabilize the fracture, and the surgical field was prepared using Betadine solution. With a 5-6 cm incision parallel to the clavicle, minimal dissection was performed to deperiostealize the clavicle, the fractured bone ends were aligned, and the nitinol plates, thawed with frozen physiological serum and opened with special clamps, were placed on the clavicle. Sterile physiological serum heated to +45-50 °C was diffused onto the plate delays, causing the plate delays to curve and grasp the clavicle, stabilizing the fracture site. Following anatomical closure of the subcutaneous tissues and skin, the operation was concluded. No complications were observed, and none of the patients required intensive care or postoperative mechanical ventilation. Pain control was achieved through acetaminophen and tramadol injections. Postoperative motor and sensory examinations of the upper extremities were normal (Figures 1, 2).

Results

All patients in this study were male, with ages ranging from 18 to 67 (mean: 40.4). All fractures were displaced and located in the middle third of the clavicle. Nitinol plates were used in the surgical treatment of all patients. Four cases (21%) presented with rib fractures, and one case (10.5%) had a scapula fracture accompanying the clavicle fracture. Clavicle fractures were identified on the right side in 10 patients (52.6%) and on the left side in 9 patients (47.4%) (Table 1).

Thirteen cases (68.4%) had a history of traffic accidents, whereas 5 cases (26.4%) reported a history of motorcycle accidents. One case (5.2%) was admitted to the emergency room because of an occupational accident (Table 1).

The average surgical duration (from incision to closure) was 46±5 minutes, and the length of hospital stay ranged from 4±1 days. During the 3-month follow-up, accompanying additional injuries were observed to prolong the hospitalization time.

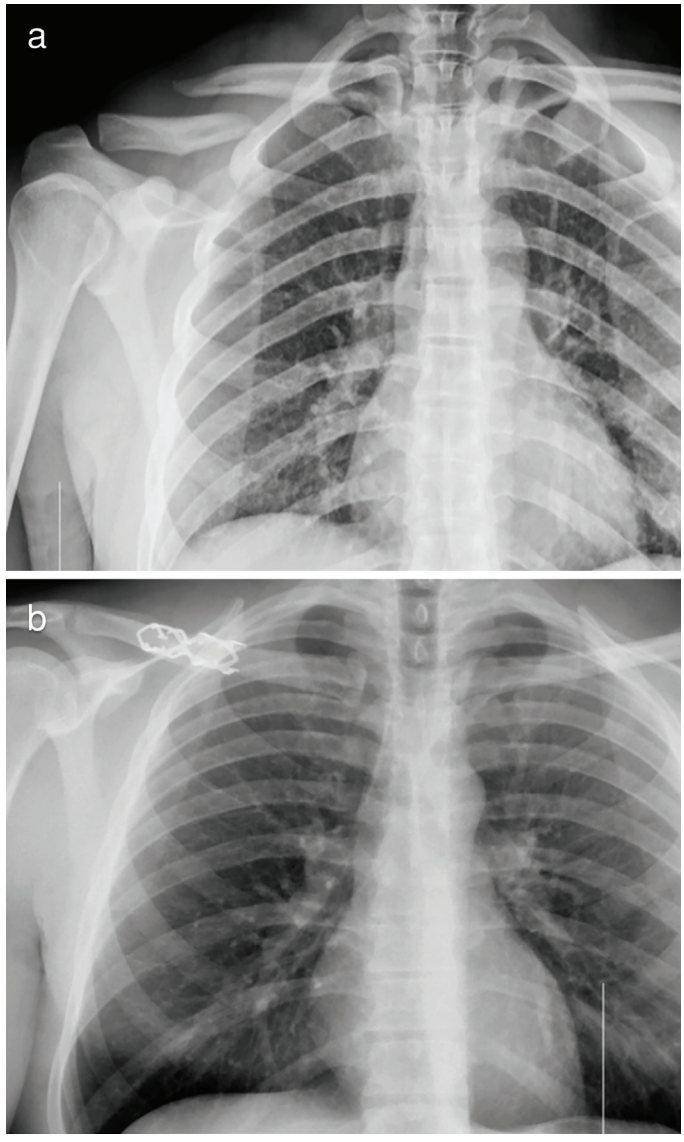

Figure 1. a) Preoperative postero-anterior chest radiography. b) Postoperative postero-anterior chest radiography

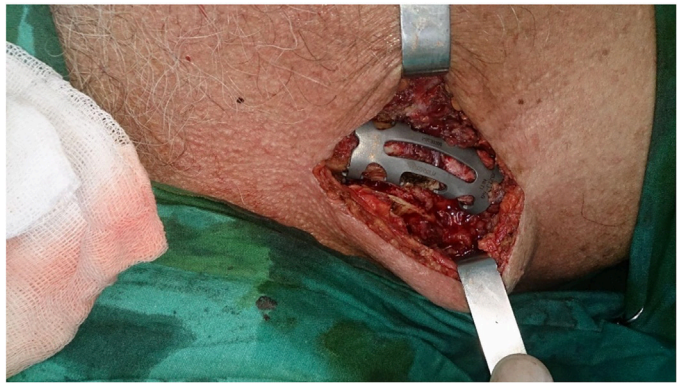

Figure 2. Intraoperative Imaging. The image shows fixation of a right clavicle fracture using nitinol plates on a posteroanterior chest radiography

Table 1. Demographic features	
Characteristics	**Patients**
Gender Male Female	 19 0
Mean age	40.4 (18-67)
Fracture side Left Right	 9 (47.4%) 10 (52.6%)
Middle third of clavicle fracture	19
Nitinol plates	19
Traffic accidents	13 (68.4%)
Motorcycle accidents	5 (26.4%)
Occupational accident	1 (5.2%)

After 3 months, one patient developed a complication. The plate lags became disconnected from the clavicle and could be palpated through the overly tense skin. Radiological evaluation revealed union at the fracture line. Consequently, additional treatment was deemed unnecessary, and the plate was subsequently removed.

Discussion

Conservative treatment methods, such as simple arm slings and figure-of-eight bandages, are commonly used for the nonsurgical management of clavicle fractures. However, the success of these methods, particularly in cases of displaced and comminuted fractures, may be limited. The occurrence of complications such as shoulder movement restriction or persistent pain often prompts a shift toward surgical intervention (5). Numerous studies have identified risk factors for nonunion fractures, including old age, female gender, comminuted fractures, and clavicle shortening exceeding 2 cm after fracture (6,7).

Considering these risk factors, surgical treatment becomes a consideration for fractures prone to non-union or malunion. Malunion resulting from conservative treatment in patients with right displaced mid-shaft clavicle fractures may lead to thoracic outlet syndrome (TOS), as suggested by some studies (4). Instances of neurogenic TOS due to clavicle malunion have also been reported (8).

Surgical intervention, particularly using nitinol plates, is preferred for midshaft fractures of the clavicle (3). Various material options, including plaques and intramedullary implants, are available for surgical treatment. A randomized controlled study involving 132 patients advocated primary plate fixation in completely displaced midshaft clavicle fractures (9).

Studies suggest that plate application promotes faster healing, especially in multi-part fractures (10). Existing literature indicates that primary surgical fixation enables a more rapid functional recovery, particularly in patients with displaced fractures (11).

While the need for further studies with larger patient cohorts is evident, our study suggests that the surgical procedure conducted with a nitinol plate can be successfully applied in selected cases. This approach is characterized by minimal dissection, short operation time, and low complication rates.

Study Limitations

However, our study's limitations are the small number of participants and the absence of a control group.

Careful surgical planning is crucial for accurately assessing the fracture pattern and ensuring the correct surgical approach.

Conclusion

Surgical treatment, although an invasive method with inherent complications, demonstrates significant success following rigorous radiological and clinical evaluations. The potential complications associated with conservative methods, especially in displaced clavicle fractures, such as TOS, should not be overlooked. Our research results indicate that the application of nitinol plates in the surgical treatment of displaced clavicle fractures can be successfully executed. We believe that this approach can be safely preferred in selected cases because of its minimal dissection, short operation time, and low complication rates.

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Ethics

Ethics Committee Approval: The study was approved by the University of Health Sciences Turkey, Medeniyet University, Göztepe Training and Research Hospital Ethics Committee (decision no: 2023/0603, date: 20.09.2023). This study was conducted in accordance with the principles of the Declaration of Helsinki.

Informed Consent: Retrospective study.

Authorship Contributions

Concept: A.G.A., T.Ş.E., Design: A.G.A., Data Collection or Processing: A.G.A., Analysis or Interpretation: T.Ş.E., Literature Search: T.Ş.E., Writing: A.G.A.

Conflict of Interest: No conflicts of interest were declared by the authors.

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