Background: One of the modern techniques for the treatment of clavicle fracture (Fx) is elastic titanium intramedullary nailing. But, there are different opinions about this technique. We studied this technique in 12 patients with clavicle Fx and assessed its outcome.

Objectives: We aimed to study the prognosis of midshaft clavicular Fx treated via minimally invasive stable elastic intramedullary nailing.

Patients and Methods: We operated on 13 clavicle Fx in 12 patients from 2008 through 2012. We used a new technique called minimally invasive titanium elastic intramedullary nailing for operating patients with midshaft clavicular Fx.

Results: Clinical union was achieved 3-5 weeks after the operation with no pain over Fx sites upon physical examination. Radiologic union appeared at 6 to 12 weeks. We did not encounter nonunion or infection, but one of the comminuted Fx united 1 cm shorter; however, it had a solid union with a good score. All but two patients had good scores.

Conclusions: Although controversy exist regarding intramedullary nailing of clavicle Fx, our results using this technique for minimally comminuted midshaft clavicular Fx were very good.

Keywords: Fracture Fixation, Intramedullary; Clavicle; Elastic nail
for insertion of the nail, an entry point was made in the anterior cortex of the bone by a 3.2 mm drill. After preparation of the entry hole, a nail (2 to 3 mm in diameter) was advanced into the medullary canal of the medial segment of the clavicle and passed through the fracture site and lateral segment via oscillation using a universal chuck and T-handle (Figure 3).

In most instances, another small skin incision was made at the Fx site to help fracture reduction. The elastic titanium nails with curved tips were passed into the clavicle. After reduction and fixation of the distal fragment, the nail was cut into the proper size and placed under the skin. During the postoperative period, patients were free to move their shoulders as much as they could. Immobility was not required, but over-head activity was restricted for 3-4 weeks. We followed the patients until union was achieved radiographically (Figure 4). The elastic nails were removed after three months.

4. Results

We used Constant Score to assess the clinical outcomes of our patients after union of the Fx (16). Clinical union was achieved in 3-5 weeks and radiographic union appeared in 6-12 weeks. One of the comminuted Fx united 1 cm short and its constant score was 90 with solid union. We had no infection or nonunion. All except two of our scores were excellent. Fractures of 4 patients with comminuted Fx united short (0.5 cm in 3 and 1 cm in one fracture) because of high-energy trauma. In 4 patients the length of scars was 1 cm over the entry point of the nail and in 9 patients an additional scar was present over the Fx site of open reduction. Two patients had long scars. Because one of them had simultaneous acromioclavicular joint dislocation and another had segmental fracture. Characteristics of patients are summarized in Table 1.
Table 1. Characteristics of the Patients With Intramedullary Nailing of Clavicle Midshaft Fractures With Elastic Titanium Nails

| No. | Age, y | Sex | Side | Type of Trauma | Diagnosis | Duration of X-ray Union, wk | Pain (15) | Shortening, cm | Activities + Positioning (20) | ROM (40) | Power Constant Score (100) |
|-----|--------|-----|------|----------------|-----------|-----------------------------|---------|----------------|-----------------------------|---------|-----------------------------|
| 1   | 29     | F   | Lt   | HE            | Midshaft (simple) | 12            | 15                      | 0             | 20                         | 36              | 24                           | 95                      |
| 2   | 29     | F   | Rt   | HE            | Midshaft FX (simple) + ACJ dx | 8            | 14                      | 0             | 18                         | 36              | 22                           | 90                      |
| 3   | 25     | F   | Lt   | HE            | Midshaft FX (comminuted) | 12            | 15                      | 0             | 20                         | 40              | 25                           | 100                     |
| 4   | 28     | F   | Lt   | LE            | Midshaft (simple) | 8            | 15                      | 0             | 20                         | 40              | 25                           | 100                     |
| 5   | 30     | F   | Lt   | HE            | Midshaft + distal end FX (segmental) | 10            | 15                      | 0             | 20                         | 40              | 25                           | 100                     |
| 6   | 34     | F   | Lt   | HE            | Midshaft (simple) | 10            | 15                      | 0             | 20                         | 40              | 25                           | 100                     |
| 7   | 17     | M   | Lt   | LE            | Midshaft (simple) | 6            | 15                      | 0             | 20                         | 40              | 25                           | 100                     |
| 8   | 42     | F   | Lt   | HE            | Midshaft FX (comminuted) | 9            | 15                      | 0.5           | 20                         | 40              | 25                           | 100                     |
| 9   | 36     | F   | Rt   | LE            | Midshaft (simple) | 7            | 15                      | 0             | 20                         | 40              | 25                           | 100                     |
| 10  | 35     | F   | Lt   | HE            | Midshaft FX (comminuted) | 8            | 15                      | 0             | 20                         | 40              | 25                           | 100                     |
| 11  | 35     | M   | Rt   | HE            | Midshaft FX (comminuted) | 9            | 15                      | 0.5           | 20                         | 40              | 25                           | 100                     |
| 12  | 38     | M   | Rt   | HE            | Midshaft FX (comminuted) | 8            | 15                      | 0.5           | 20                         | 40              | 25                           | 100                     |
| 13  | 34     | M   | Rt   | HE            | Midshaft FX (comminuted) | 10           | 12                      | 1             | 16                         | 38              | 24                           | 90                      |

Abbreviations: ACJ: acromioclavicular joint; dx, dislocation; F, female; FX, fracture; HE, high energy; LE, Low energy; LH, low energy; Lt, left; M, male; ROM, range of motion; Rt, right

5. Discussion

Clavicle Fx are not infrequent and account for approximately 2.6% of all Fx. The majority of clavicle fractures (80% to 85%) occur in the midshaft (17, 18). Clavicle fractures can be treated conservatively, but evidence regarding the superiority of operative treatment over conservative treatment is mounting. Duan and his colleagues evaluated the effect of plating vs. intramedullary pinning or conservative treatment for midshaft clavicular Fx (1). They concluded that there were no differences between plating and intramedullary pinning in therapeutic effects, but plating had a higher complication rate than pinning. Plating was also associated with improved functional results compared to conservative treatment.

In a meta-analysis of the literature 2144 Fx in thirty years (1975-2005), Złowodzki and his colleagues showed that nonunion rate decreased from 15.2% to 2% by primary intramedullary nailing (8). In studying 31 midshaft clavicular Fx treated by intramedullary nailing with titanium elastic nail (TEN), Mueller et al. (6) concluded that intramedullary fixation of midshaft clavicle fracture with TEN was a safe and minimally invasive. This technique produced excellent cosmetic and functional results; thus, it could be an alternative to plate or screw fixation or non-surgical treatment.

However, some are against intramedullary nailing. Frigg et al. reported 34 patients treated with intramedullary nailing from April 2004 to March 2007 (2). They concluded that intramedullary nailing of midshaft clavicular fractures using the TEN had various complications postoperatively and was technically demanding. They also reported that in 70% of the patients, problems or complications occurred (seven medial perforations, seven laterals penetrations, one nail breakage, one nail dislocation, and hardware irritation in seven patients).

Plating is the standard technique for operation of clavicle Fx when surgery is required, but fixation of clavicle Fx by elastic titanium nails is a new technique and can be used on some occasions. We had favorable results with this technique in cases with midshaft clavicular fracture. This technique is demanding and we do not recommend it in old comminuted clavicular fractures. Our study had some limitations namely the low number of patients.

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Authors’ Contributions

Study concept and design: Dr. Naderi; acquisition of data: Dr. Hassan Keihan Shokouh; analysis and interpretation of data: Dr. Hassan Keihan Shokouh; drafting of the manuscript: Mahsa Keihan Shokouh; critical revision of the manuscript for important intellectual content: Dr. Naderi; statistical analysis: Mahsa Keihan Shokouh; ad-
Ministrative, technical, and material support: Dr. Hassan Keihan Shokouh; study supervision: Dr. Naderi.

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