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Results of midshaft clavicle fractures treated with expandable, elastic and locking intramedullary nails

Sinan ZEHİR[1], Turgut AKGÜL[2], Regayip ZEHİR[3]

[1]Department of Orthopedics and Traumatology, Faculty of Medicine, Hitit University, Çorum, Turkey;
[2]Department of Orthopedics and Traumatology, Istanbul Faculty of Medicine, Istanbul University, Istanbul, Turkey;
[3]Department of Orthopedics and Traumatology, Çarşamba State Hospital, Samsun, Turkey

Objective: The aim of the study was to present the results of osteosynthesis with elastic expandable intramedullary nail for clavicle fractures.

Methods: The study included 17 patients (11 males, 6 females; mean age 36.4 years, range: 21 to 54 years) who underwent surgery for a displaced clavicle fracture and had a shortening of more than 2 cm. The Constant Score and DASH (Disabilities of The Arm, Shoulder and Hand) scoring were used to determine the functional status of the patients.

Results: Mean operation time was 30.4 (range: 25 to 42) minutes and mean follow-up period was 10.3 (range: 8 to 19) months. Mean union time was 15.8 (range: 9 to 20) weeks. A superficial infection was treated with wound debridement and antibiotherapy in one patient. No patient suffered from neurovascular compromise, deep infection or implant irritation. Implant fracture developed at 2 months after surgery in one patient treated for Type B1 clavicle fracture and healed without any other intervention. There was no statistically significant shortening ($p>0.05$). In the final follow-up, the mean Constant Score was 94.3 (range: 86 to 97), and mean DASH score was 11.8 (range: 7.3 to 17.4).

Conclusion: Expandable elastic locking intramedullary nail appears to provide minimal complication and high success rate for the surgical treatment of non-comminuted displaced clavicle shaft fractures. Additional studies with large series are necessary for further investigation.

Key words: Clavicle; fracture; nail; shaft.

The clavicle is the one of the most commonly fractured bones, constituting approximately 5 to 15% of all fractures. Such fractures generally occur in young athletics. Approximately 80% of clavicle fractures are seen in the middle third of the bone, of which more than 50% are displaced.[1,2]

Conservative treatment is the traditional method for clavicle fractures even in cases of serious displacement.[1,3,4] Indications for surgical treatment include open fractures, severe displacement causing tenting of the skin, neurovascular deficit, floating shoulder, polytrauma, and fractures that were unable to heal with conservative treatment.[5] Surgical treatment is recommended for fractures that are totally displaced and have 2 cm of shortening.[2]

Correspondence: Turgut Akgül, MD. İstanbul Üniversitesi İstanbul Tıp Fakültesi, Ortopedi ve Travmatoloji Anabilim Dalı, Çapa, 34093 Istanbul, Turkey.
Tel: +90 212 – 414 20 00 e-mail: doktorturgut@yahoo.com

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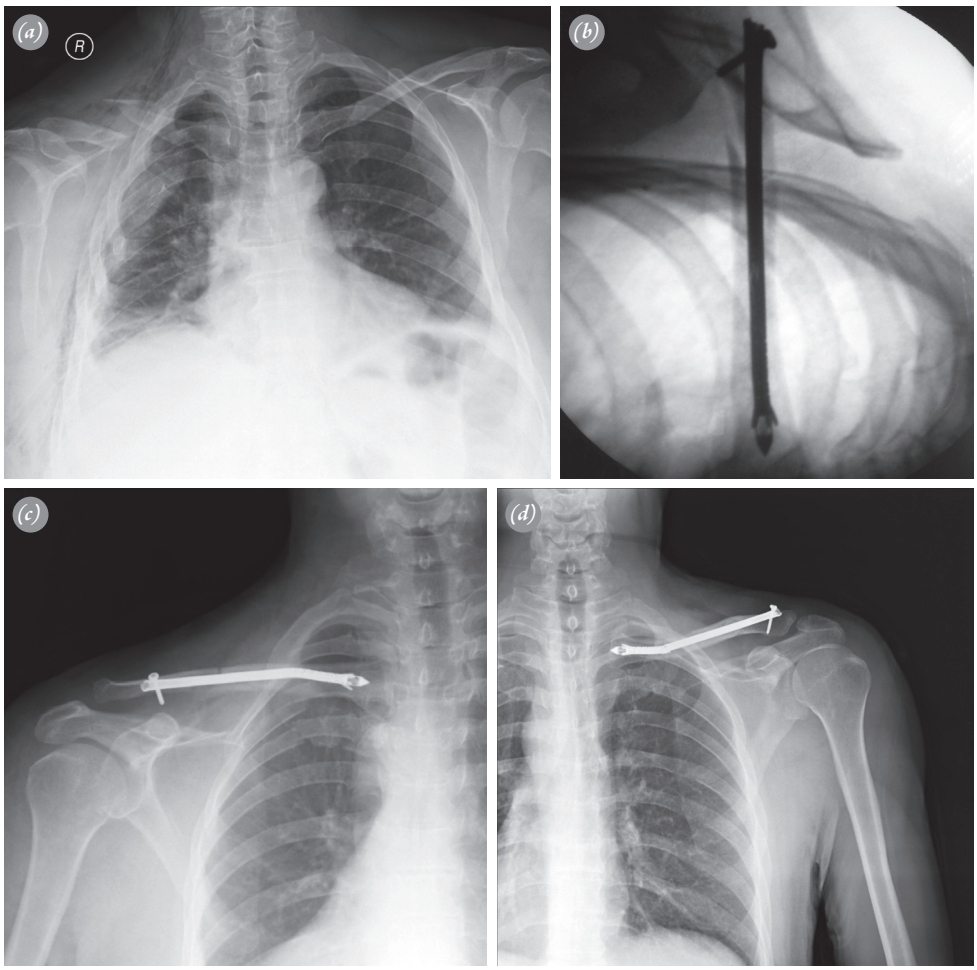

Fig. 1. **(a)** Radiograph showing a midshaft clavicle fracture. **(b)** Perioperative fluoroscopy image for Type B2 clavicle fracture and **(c)** postoperative radiographic view. **(d)** Radiograph showing the broken elastic intramedullary nail.

In the literature, complications such as pseudarthrosis, permanent shoulder pain, bad aesthetic appearance and strength loss have been reported following conservative treatment of clavicle fractures. Failure rates of 30% have been reported for the conservative treatment of clavicle fractures, which supports the effectiveness of surgical treatment.[1,4,6,7]

Osteosynthesis with plate and screw fixation is the first treatment choice in cases that require surgical treatment. Currently, there is no consensus on surgical treatment modalities for displaced midshaft clavicle fractures.[1,8,9] Intramedullary fixation devices such as Knowles pin, Rockwood pin and titanium elastic nail have been used for osteosynthesis. However, complications such as nonunion, implant related problems and shortness have been reported with these methods in the literature. Due to its minimally invasive approach, low complication rates and high patient contentment, locked clavicle intramedullary nails have become popular.[8,10]

The aim of our study was to evaluate the clinical and radiological results of a new generation, expandable, elastic and locking intramedullary nails used in the surgical treatment of displaced clavicle fractures.

Patients and Methods

The study retrospectively reviewed 31 patients who underwent surgery for displaced clavicle shaft fractures in our clinic between 2011 and 2013. Of these, 19 patients were operated via intramedullary elastic nails for displaced clavicle fracture. Two patients; one with scapula and humerus fractures and the other with degenerative arthritis and cervical disc disease, were excluded from the study. A total of 17 patients (11 males, 6 females; mean age: 36.4 years, range: 21 to 54 years) were included. Indications for surgery were total displacement and clavicle shortening of more than 2 cm. Patients with neurovascular compromise and patients lost during fol-

low-up were excluded.

Patients with clavicle fractures included in the study were diagnosed using 15° cephalic view radiographs of the clavicle (Fig. 1a). All operations occurred within 24 hours of injury. After administration of 1st generation cephalosporin for surgical prophylaxis, patients were positioned in the beach chair position with the wounded upper extremity free for surgery. Intramedullary nailing was performed according to standard protocols. In B2 type fractures, the butterfly fragment was stabilized using non-absorbable sutures in cases in which stability could not be achieved after reduction of clavicle fracture (Fig. 1b, c).

Shoulder sling was applied to all patients for two weeks postoperatively. Active-assisted shoulder motion was initiated in a tolerable arc movement at the second postoperative day. Full range of motion was achieved in the second week and patients were followed with non-assisted, active movements. In the sixth postoperative week, shoulder strengthening exercises were initiated. Patients were followed up at the postoperative 4th to 8th and 12 weeks and once every three months. Union was evaluated using standard radiography for the clavicle. The clavicle length was evaluated using computed tomography in which the patient was positioned in the supine position, with the arms stretched to both sides.

At the final follow-up, patients were examined for functional and clinical status by one physician who had no prior knowledge of the patients. The Constant Score[11] and DASH (Disabilities of The Arm, Shoulder and Hand) scoring[12] were used to determine functional status.

All analyses were completed using the SPSS 15.0 for Windows (SPSS Inc., Chicago, IL, USA) statistics program. The Mann-Whitney U test was used for statistical analysis. P values of less than 0.05 were accepted as statistically significant.

Results

Fracture etiology was determined falling in 12 (70.6%), car accidents in four (23.5%) and sports injury in one (%5.9). According to the AO classification, 14 patients had B1 and three patients had B2 type clavicle fractures.

The mean operation time was 30.4 (range: 25 to 42) minutes and the mean follow-up period was 10.3 (range: 8 to 19) months. Mean time to union was 15.8 (range: 9 to 20) weeks.

The injured clavicle was 1.9 (range: 0 to 7) mm shorter than the non-fractured contralateral clavicle. However, this difference was not statistically significant ($p>0.05$). Malunion with 10 degrees of deformity was determined in one patient who had implant failure. None of the patients required implant extraction during follow-up. The mean incision length of the whole group was 3.7 (range: 3 to 5) cm and 3.3 (range: 3 to 4) cm in Type B1 fractures and 4.1 (range: 3 to 5) cm in Type B2 fractures. There we no statistical differences between Type B1 and B2 fractures in radiological and clinical evaluation ($p>0.05$).

A superficial infection occurred in one patient and was treated with wound debridement and antibiotherapy. None of the patients suffered from neurovascular compromise, deep infection or experienced implant irritation. Implant failure developed in one patient with a Type B1 clavicle fracture, in which the nail's elastic side broke at the point on the fracture line at the second postoperative month (Fig. 1d). All fractures united during the follow-up without the need for any other intervention. None of the patients suffered from implant migration or keloid formation.

At the final follow-up, the mean Constant Score was 94.3 (range: 86 to 97), and DASH score was 11.8 (range: 7.3 to 17.4).

Discussion

Complications following clavicle fractures may lead to important functional losses.[13,14] In the literature, some surgeons prefer surgical treatment due to the disadvantages of conservative treatment.[1,2,14,15] A meta-analysis study of displaced clavicle fractures by McKee et al.[15] reported a non-union rate of 15% in conservatively treated patients and of 1% following surgical treatment. It was proposed that shoulder pain diminished at an early stage and better functional results were obtained with surgery. Osteosynthesis is commonly performed with plate-screw combination or intramedullary nailing for displaced clavicle fractures.[1] Osteosynthesis with plate-screw combination has been reported to provide a biomechanically rigid fixation and achieve earlier rehabilitation. An additional advantage is the lack of need to remove the implant.[1] However, plate-screw osteosynthesis requires a fair amount of soft tissue dissection. Complications of conventional plate-screw fixation, such as infection, hypertrophic scarring, nonunion, implant loosening, refracture, and implant-related skin irritation have been reported. The complication rate in patients with conventional plate-screw fixation was 43%, major complication rate was 15% and plate removal rate was necessary in 74%.[1,2] Studies comparing locking clavicle plates and classic dynamic compression plates (DCP) suggested that locking plates were functionally more successful and had lower complication rates than DCP.[16,17]

In the literature, the Knowles pin, Rockwood pin, elastic stable intramedullary nail (ESIN) and titanium elastic nail have been reported as possible alternatives to intramedullary nailing.[2,18-26] The advantages of intramedullary nailing in the treatment of clavicle fractures include minimal damage to soft tissues and minimal periosteal disruption that is important for union, high rates of union, low rates of infection, and fast progression in shoulder functions. Disadvantages include technical difficulties, implant migration, need of open reduction in 50% of cases, inability to apply compression force to fracture line, and requirement of implant removal.[1,2,22,26]

Thyagarajan et al.[2] reported that patients operated with intramedullary nails (Rockwood pin) were more satisfied aesthetically and hospitalization period was shorter. According to these results, the authors recommend intramedullary nails in the treatment of clavicle fractures.[2]

Although Chen et al.[18] reported excellent cosmetic and functional results with ESINs for the treatment of clavicle fractures, the authors also reported five skin irritation problems related with the nails and one implant failure requiring revision. In another study of 15 cases, the authors reported excellent functional results with ESIN and encountered skin irritation in four cases and acromioclavicular displacement in one.[8] In a series of 87 patients operated with ESIN, Kettler et al. encountered implant migration in 4 patients and non-union in 2 patients and reported implant removal in 82 of 87 patients.[19] In a study including 14 athletes treated with ESIN, while excellent functional results and early return to sports activities were reported, mean shortening was 1.7 mm and one patient experienced refracture.[21]

Jubel et al.[10] reviewed 84 midshaft clavicle fractures operated using intramedullary nail at the sixth month follow-up and reported skin irritation in the proximal part of the clavicle where the nail was inserted in five patients and 1.5 cm shortening in one. The authors concluded that the method should be an alternative to the conservative approach. In another study on intramedullary nailing, eight superficial skin infections, three refractures, two delayed unions, two non-unions and patient dissatisfaction due to surgical scars were reported.[22] In a study evaluating the treatment results of ESIN, Smekal et al. reported seven cases of nail protrusion from the medial side and two cases of implant failure.[23] In another study, ESIN was recommended in simple and intermediate pieced fractures but not recommended in cases of advanced pieced fractures due to serious shortening.[24]

King and Ikram reported union time of 13 weeks in patients treated with elastic locked intramedullary nailing and six weeks of immobilization, along with two implant failures and one infection, and stated that the surgical technique was simple with a short learning curve.[25] In our study, the mean time from fracture to union was 15.8 weeks. Nail fracture was seen in one case. However, union was achieved spontaneously and no further operation was needed in that patient. Functional and clinical results were good and the patients reported good satisfaction, similar to other studies reported in the literature. The low complication rate might be explained by the short follow-up or small number of patients.

Intramedullary nailing for clavicle fracture is an alternative treatment modality to conservative treatment and plate-screw osteosynthesis.[4] Some studies have suggested superior outcomes with intramedullary nailing in comparison to other surgical modalities.[1,2,4,20,23]

When compared with plate osteosynthesis, intramedullary fixation is technically more difficult to perform and has serious disadvantages and complications such as migration. However, migration was caused by the use of the old, rigid intramedullary equipment due to its lack of a locking system and inability to penetrate into the clavicle because of its anatomic sigmoid shape.[2] We use a locked and semi- elastic intramedullary device and such a combination may resolve the disadvantages of the old intramedullary nails. More studies with larger patient series are needed to prove the implant's efficiency. In addition, problems of fixation and shortening in advanced segmental fractures have not yet been overcome.

Expandable elastic locking intramedullary nails can be locked in the medial or lateral side, preventing nail migration and shortening. The nail can be inserted easily by the elastic part with a minimal incision that protects the soft tissues around the clavicle. Excellent functional and aesthetic results can be obtained using the proper techniques. Although opening of the fracture site might be seen as a disadvantage, 50% cases of open reduction in addition to excessive soft tissue damages had been reported with the other intramedullary fixation methods.[1-18] After open and closed intramedullary nailing, there were no significant differences in shoulder functions.[26] Disadvantages of our study include the small patient number and lack of a randomized controlled study.

In conclusion, expandable elastic locking intramedullary nailing appears to be a useful surgical method for non-comminuted displaced clavicle shaft fractures, with a minimal complication rate. These implants have superior technical properties in comparison to other nails, including the ability to lock the nail from both the lateral and medial side and the inclusion of an elastic part suitable for the anatomical shape of the clavicle. Additional long-term studies are necessary to ascertain any

problems that might occur during nail removal due to its winged structure.

Conflics of Interest: No conflicts declared.

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