Surgical Treatment of Mid-Shaft Clavicle Fractures: Plate Fixation and Clinical Outcomes

Klavikula Cisim Kırıklarında Cerrahi Tedavi: Plak Tespiti ve Klinik Sonuçlar

Klavikula Cisim Kırıkları / Midshaft Clavicle Fractures

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Özet

Bu çalışmada klavikula kırığı nedeniyle, açık redüksiyon ve anatomik plak ile internal tespit yöntemi uygulanan hastaların klinik, radyografik sonuçlarıyla birlikte ilişkili komplikasyonları değerlendirildi. Çalışmaya 27 (64.2%) erkek, 15 (35.7%) kadın toplam 42 hasta dahil edildi. Hastaların ortalama yaşı 31 (dağılım 19-51), ortalama takip süresi 16.2 ay (dağılım 9-26 ay) idi. Hastaların 23' ünde (54.7%) sağ klavikulada, 19' unda (45.2%) sol klavikulada kırık mevcuttu. Hastaların takip sonunda ortalama Constant skoru 85.2 (dağılım: 65-96) idi. Postop beş (%11.9) hastada implant yetmezliği, iki (%4.7) hastada implant irritasyonu saptandı. İmplant yetmezliği gelişmeyen hastaların takip sonundaki ortalama klavikular uzunluğu 164.45 mm (dağılım 124.78-188.19), sağlam taraf klavikulaların ortalama uzunluğu 165.82 mm (dağılım 124.17-189.04) olarak tespit edildi (p=0.41). İmplant yetmezliği gelişen hastaların ortalama klavikula uzunluğu 161.93 mm (dağılım 137.16- 172.54), sağlam taraf klavikulaların ortalama uzunluğu 171.05 mm (dağılım 149.49- 181.72) olarak tespit edildi (p=0.02). Kortikal temasın kaybolduğu deplase klavikular kırıkların plak ile anatomik restorasyonu klavikular uzunluğu korumakta ve fonksiyonel olarak iyi sonuçlar sağlamaktadır.

Anahtar Kelimeler

Klavikula Kırığı; Plak Tespiti; Kısalma; Tedavi; Komplikasyon

Abstract

In the present study, we assessed the clinical and radiographic results and complications in patients who underwent open reduction and internal fixation using a plate for clavicle fracture. A total of 42 patients were enrolled in the study, including 27 men (64.2%) and 15 women (35.7%). The mean age was 31 years (range, 19–51 years), and the mean follow-up time was 16.2 months (range, 9–26 months). Twenty-three patients (54.7%) had left clavicle fractures, and 19 patients (45.2%) had right clavicle fractures. The mean constant score was 85.2 (range, 65–96) at the end of follow-up. In the post-operative period, implant failure was detected in five patients (11.9%), and implant irritation was detected in two patients (4.7%). In patients without implant failure, the mean clavicular length was measured as 164.45 mm (range, 124.78–188.19 mm) on the treated side and 165.82 mm (range, 124.17–189.94 mm) on the intact side after follow-up (p = 0.41). In patients with implant failure, the mean clavicular length was measured as 161.93 mm (range, 137–172.54 mm) on the treated side and 171.05 mm (range, 149.49–181.72 mm) on the intact side (p = 0.02). We conclude that anatomical restoration using plates in displaced mid-shaft clavicle fractures with loss of cortical contact spares clavicular length and provides better functional outcomes.

Keywords

Clavicle Fracture; Plate Fixation; Shortening; Treatment; Complication

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Introduction

Clavicle fractures are frequently encountered orthopaedic injuries. Clavicle fractures comprise 5–15% of all fractures and 44% of fractures involving the shoulder region [1-6]. This injury is more common in young, active men [6]. The mechanism of injury generally involves direct impact to the shoulder, such as that occurring during falls [6, 7]. Approximately 70–80% of clavicle fractures occur as mid-shaft fractures [2, 4, 6, 8-12]. The mid-shaft is the thinnest part of the clavicle and is not stabilized by strong ligaments and muscles as in the lateral and medial aspects [12]. However, the mid-shaft has lower bone density compared with the medial and lateral aspects of the clavicle, and its anatomical structure makes it more vulnerable to external lateral forces [6, 13].

In clavicle fractures, displacement occurs due to an imbalance in muscular strength. The displacement of the medial fragment is superior and posterior due to forces applied by the sternocleidomastoid muscle, while the displacement of the lateral fragment is anterior and inferior due to forces applied by the pectoralis major and deltoid muscles [11]. In adults, limited remodelling, persistent clavicular shortening and angulation can develop after clavicle fracture.

Traditional management of clavicle fractures is conservative [1, 4, 11]. In preliminary studies, a lower incidence of non-union and better functional outcomes were reported with conservative treatment [7, 14, 15]. In particular, conservative treatment can yield good or excellent functional outcomes in clavicle fractures with preserved cortical contact in children and adolescents [16, 17]. However, good outcomes reported in conservative treatment are not universal. Recent findings suggest that the shoulder can be at high risk for residual pain, non-union and shoulder dysfunction after conservative treatment [8, 16]. Thus, it is recommended that management of clavicle fractures should be individualised on the basis of the characteristics of the fracture and the patient's expectations [8, 16].

When only conservative treatment is provided, non-union or symptomatic mal-union are highly common in clavicle fractures, including deformities such as shortening above 20 mm, displacement, angulation above 30° or fragmentation after high energy traumas [18]. This may cause a significant reduction in the patient's satisfaction due to shoulder asymmetry and poor cosmetic appearance [19].

In the present study, we assessed clinical and radiographic results as well as related complications in patient who underwent open reduction and internal fixation using a plate due to midshaft clavicle fracture.

Material and Method

Patients who underwent surgery due to clavicle fracture between October 2010 and November 2013 were retrospectively reviewed. Patients with isolated mid-shaft clavicle fracture without cortical contact between primary fracture fragments were included in the present study. Based on Orthopedic Trauma Association (OTA) classification [20], there were 20 patients (47.6%) with OTA type 15-B1 clavicle fracture, 17 patients (40.4%) with OTA type 15-B2 and five patients (11.9%) with OTA type 15-B3 fracture. There was clavicular shortening >2 cm in 31 patients (73.8%) and fragmented segmental fracture in 11 patients (26.2%). All patients underwent surgery within three days after trauma. The study was conducted in accordance with the Declaration of Helsinki.

Surgical technique

Operations were performed under general anaesthesia in a semi-standing position through a transverse incision over the fracture line. During surgery, care was taken to avoid excessive smooth tissue and periosteum injuries. The supraclavicular nerve was dissected and spared (Figure 1). After reduction of fracture, fixation was achieved superior to the clavicle using a clavicular plate. No auto-graft or allograft was used during surgery.

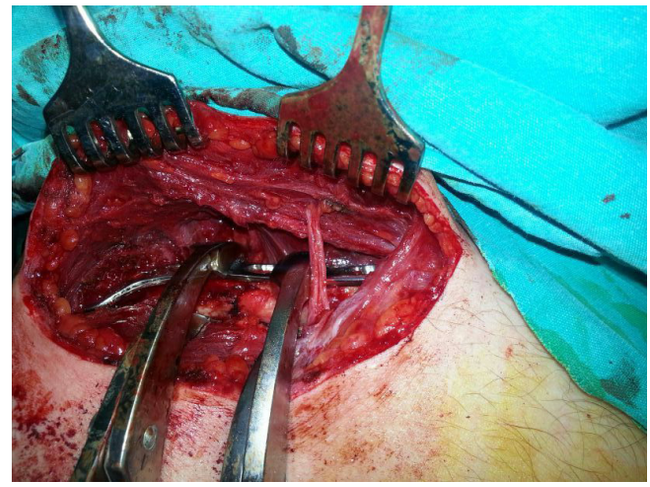


Figure 1. Reduction of fracture fragments in clavicle and appearance of the dissected supraclavicular nerve.

Post-operative care

After surgery, all patients used an arm sling pouch for three weeks. Passive shoulder exercises were initiated at the end of the first week, while active shoulder range of motion exercises were initiated after three to four weeks, depending on the patient's tolerance. After four months, all activities were allowed without any limitations.

All patients were assessed for wound site, superficial and profound infections, neurovascular complications and irritation problems related to implants in the early post-operative period. In the late post-operative period, complications such as delayed union, non-union, mal-union, implant failure and keloid formation at the incision site were assessed.

Radiological evaluation

Radiologically, callus formation beyond 24 weeks was defined as delayed union, while the presence of pain and pathological movement at fracture line without callus tissue was defined as non-union [21, 22]. Mal-union was defined as the presence of asymmetry with impaired anatomical alignment of clavicle [22]. Implant failure was defined as impaired reduction of fracture with breaking or bending of the plate or screws [22].

At the final follow-up, posteroanterior thoracic radiographs were obtained to compare length differences between the intact clavicle and fracture site [23]. At the final follow-up visit, functional assessment was performed on the basis of the Constant score [24].

Statistical analyses

All statistical analyses were performed using SPSS version 16.0 (SPSS Inc., Chicago, USA) for Windows (Microsoft Corporation, Redmond, USA). Paired Student's t-tests and Mann–Whitney U-tests were used to analyze data. $P < 0.05$ was considered to be statistically significant.

Results

A total of 42 patients were enrolled in the study, including 27 men (64.2%) and 15 women (35.7%). The mean age was 31 years (range, 19–51 years), and the mean follow-up time was 16.2 months (range, 9–26 months). Twenty-three patients (54.7%) had left clavicle fractures, and 19 patients (45.2%) had right clavicle fractures (Table 1). Clavicle fractures were caused by falls in 29 patients (69%), accidents in 11 patients (26.1%) and sports injuries in two patients (4.7%). In addition to clavicle fractures, one patient had a humerus fracture, six patients had rib fractures and one patient had compartment syndrome of the hand with phalanx fractures (Figure 2).

Table 1. Demographic characteristics of patients.

Patient, n	42
Age, mean ± SD (range)	31±8.4 (19-51)
Gender, n (%)	
Female	15 (35.7%)
Male	27 (64.2%)
Follow-up, months, mean±SD (range)	16.2±3.9 (9-26)
Location, n (%)	
Right	23 (54.7%)
Left	19 (45.2%)
Fracture class, n (%)	
15-B1	20 (47.6%)
15-B2	17 (40.4%)
15-B3	5 (11.9%)

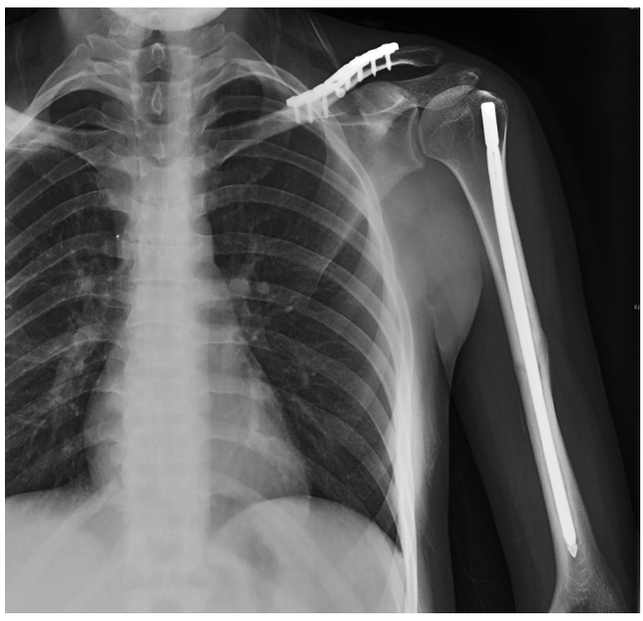


Figure 2. Radiograph at post-operative month 15 in a patient with clavicle fracture accompanied by humerus shaft fracture.

No neurovascular complications were observed after surgery. No superficial or profound infections were detected during the postoperative period. At the final follow-up visit, no keloid formation was observed at the incision sites. After three months, implant failure was detected in five patients (11.9%). Screw pull-out and reduction loss at the fracture line was observed in one patient, while implant breakage was observed in four patients (Figure 3). Autogenous grafting and plate fixation was performed in these patients following removal of implants. Implant irritation was detected in two patients (4.7%); thus, implants were removed after union.

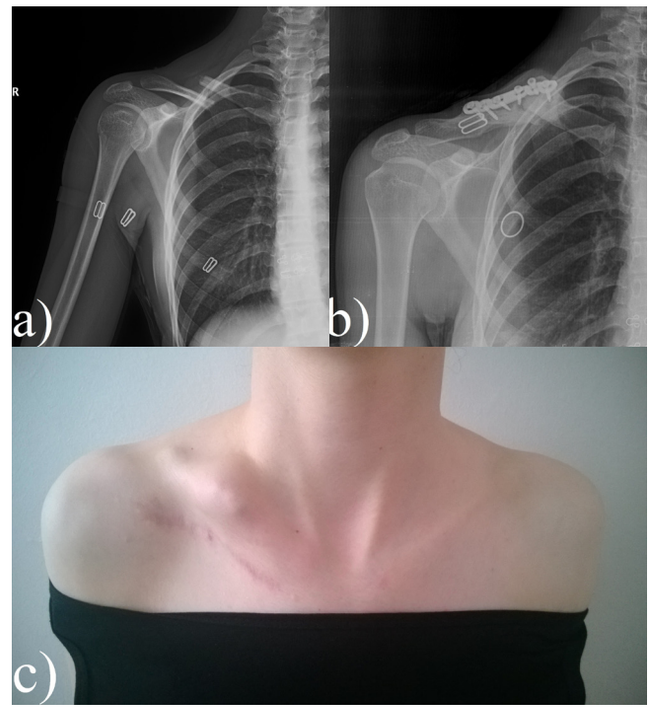


Figure 3. A patient with implant failure after surgical treatment of clavicle fracture: a) Pre-operative radiograph. b) Radiograph at post-operative month 16. c) Poor cosmetic result.

In patients without implant failure, the mean clavicular length was measured to be 164.45 mm (range, 124.78–188.19 mm) on the treated side, while it was 165.82 mm, (range, 124.17–189.94 mm) on the intact side ($p = 0.41$) (Figure 4). In the five patients (11.9%) with implant failure, the mean clavicular length was measured to be 161.93 mm (range, 137.16–172.54 mm) on the treated side, while it was 171.05 mm (range, 149.49–181.72 mm) on the intact side ($p = 0.02$).

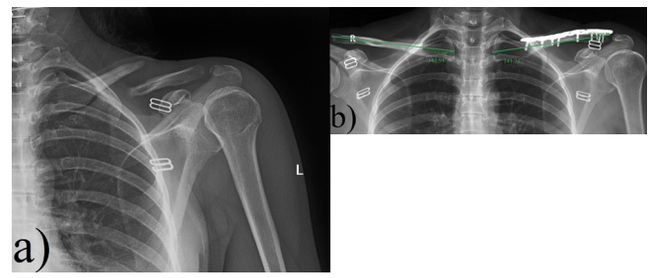


Figure 4. Measurement of clavicular length at fractured and intact sites in a patient who underwent surgical treatment: Pre-operative radiograph (A). Clavicular length of 145.94 mm on the right and 141.71 mm on the left after completion of follow-up (B).

The mean Constant score was 85.2 (range, 65–96) in the final follow-up visit. The mean Constant score was 74.8 (range, 65–89) in seven patients (16.6%) with complications (five patients

with implant failure and two patients with implant irritation), while it was 89.2 (range, 83–96) in those without complications. The mean Constant score was found to be significantly lower in patients without complications compared with those with complications (p = 0.001).

Discussion

The aim of clavicle fracture treatment is to ensure healing with minimal dysfunction, morbidity and cosmetic deformity [16]. In the present study, we observed that clavicular length was preserved with minimal shortening. We believe that this shortening will not cause shoulder dysfunction. In addition, good functional outcomes were achieved in our study. However, complications did occur, particularly implant failure together with non-union and requirement of implant removal during the post-operative period.

Mal-union and shortening are frequently observed complications in clavicle fractures [17]. Non-union rates are 15–20% in displaced, fragmented fractures, while mal-union can be seen in up to 14–36% of patients who underwent conservative treatment [6, 25]. Hill et al. reported that the risk for adverse consequences and non-union was higher in clavicle fractures with a shortening of >2 cm initially treated with conservative treatment [3]. In that study, poor results were reported in 31% of patients, while non-union was reported in 15% of the patients. In a meta-analysis, Zlowodzki et al. reported a non-union rate of 15.1% in clavicle fractures after non-surgical therapy [26]. In an anatomical and functional study, Ledger et al. reported a mean shortening of 21.4 mm in 10 patients with clavicle fracture after conservative treatment [11]. In addition, authors also detected significant decreases in VAS scores and limitations in adduction and internal rotation of the involved shoulder. Lazarides et al. reported shortening in 120 patients at a mean follow-up of 30 months after conservative treatment among 132 patients with displaced mid-clavicular fractures [10]. The authors found that the extent of shortening was 14.4 mm in men and 11.2 mm in women. They also found impaired shoulder movements in 13.6% and decreased strength in 16% of the patients. In a study conducted by Robinson et al., the non-union rate was found to be 21% in displaced mid-shaft fractures of the clavicle [27]. In addition, Nowak et al. found permanent problems and weakness in 46% of 208 patients with clavicle fracture after conservative treatment [28].

Mal-union with a shorter clavicle leads to abnormal biomechanical stress and glenohumeral and scapulothoracic dysfunction [29]. It is believed that mal-union and clavicular shortening cause rotation in the glenoid fossa, which, in turn, results in disruption of the glenohumoral joint and scapular rotation [10, 19, 30]. It has been reported that limitations in extension and abduction develop in disordered glenohumoral joints. Some authors have suggested that clavicular shortening enhanced angulation upwards to the sternoclavicular joint and anterior scapular version; in turn, resultant static changes in anatomy can cause limited function of the shoulder [19, 29].

Smekal et al. measured clavicular length in mid-shaft fractures using different imaging modalities [22]. Based on their findings, the authors suggested the use of posteroranterior thoracic radiography to detect clavicular shortening. In our study, we compared clavicular length between intact and operated clavicles using posteroanterior thoracic radiographs. We measured the amount of shortening due to surgery at the end of follow-up. We found that the mean shortening was 1.37 mm in patients without implant failure. This shortening is markedly smaller than those reported after conservative therapy in the literature; in addition, it does not cause functional impairment in the shoulder.

Recent studies have demonstrated that surgical therapy is more effective than non-surgical management with regard to non-union, mal-union and patient satisfaction [31]. In a multicentre study, it was found that radiological union developed less than 12 weeks after surgery in clavicle fractures. The authors reported lower rates of non-union and no cases of mal-union in the surgery group and better functional outcomes one year after surgery [20].

There is a progressive increase in the number of patients undergoing surgery. However, surgical management is not free from risk, with reported complication rates of 15–27% [10, 17, 21, 25, 32]. Complications include infection, skin problems, non-union, implant failure and poor cosmetic results [25, 33-35].

Bostman et al. reported complication and re-operation rates of 43% and 14%, respectively [34]. In a study involving 20 patients, Kulshrestha et al. reported that implants were removed due to implant irritation in four patients (9%) and that mal-union was detected in four patients (4.4%) [8]. In a study comparing a conservative approach with surgical therapy, Mırzatolooei et al. detected non-union secondary to infection in one patient (3.4%) and mal-union in four patients (13.7%) among 29 patients in the surgery group. The authors also reported implant removal in two patients (6.8%). In their study, the Constant score was reported as 89.8, and there was a mean shortening of 4 mm compared with the intact clavicle [36]. In a study comparing locking intramedullar fixation and plate fixation, Ferran et al. reported a Constant score of 88.7 in the plate group and implant removal in eight patients (53%) after a mean follow-up of 12.4 months [33].

Infraclavicular hypoaesthesia secondary due to supraclavicular nerve injury with reported incidence of 10–29% is the most common complication following surgical therapy [5, 21]. However, no nerve injuries were detected after surgery in our patients. In the literature, it has been emphasized that re-operation would be required for removal of the implant in the majority of cases treated surgically [7, 16, 17, 25, 31, 34-36]. In our study, implants were removed due to implant irritation in two patients (4.7%), and five patients (11.9%) underwent re-operation due to implant failure.

In conclusion, surgical therapy allows rapid anatomic restoration with stable fixation and early mobilization, although there is no consensus on choice of treatment in mid-shaft clavicle fractures. The present study has some limitations, including the lack of a control group for comparison. Based on our results, we believe that clavicular shortening and resultant potential shoulder dysfunction can be avoided by anatomical restoration with a plate in displaced mid-shaft clavicle fractures with loss of cortical contact.

Competing interests

The authors declare that they have no competing interests.

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