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Mid to long term results of surgical fixation of mid-shaft clavicle fractures

Klavikula cisim kırıklarının cerrahi tedavisinin orta-uzun dönem sonuçları

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ABSTRACT

Aim: The aim of the study is to represent surgical and functional outcomes of plate fixation of mid-shaft clavicle fractures (MCF) via anatomical locking plate, in a large patient population including highly active patients.
Methods: We retrospectively evaluated 94 patients surgically treated for MCF between May 1st 2011 and October 30th 2017. Patients with minimum one-year of follow-up were included to the study. The mean follow-up was 42 ± 27.7 months (12 to 83) months. All patients were followed up until radiological and clinical healing was achieved. All fractures were classified according to the OTA classification. Medical charts were retrospectively reviewed for demographic data, cause of injury, time to surgery, athletic activity, operative complications, radiographic and functional healing time. Constant score was applied to patients at final follow-up to evaluate functional outcomes.
Results: The mean age at the time of injury was 31.4±15.4 (11 to 74) years. Ninety-one clavicles (96.8%) demonstrated radiologic and functional healing in a mean of 62 ± 33 days. The mean Constant score at the final follow-up was 91 ± 6.6 (76 to 100). The major underlying cause was sports related injuries (n=53, 56.3%) followed by motorcycle accidents (n=17,18.0%) and low falls (n=12, 12.7%). Forty-three patients (45.7%) were involved in regular athletic activity at least 3 times weekly. The overall complication rate was 19.1% (n=18). The most common complication was implant irritation in 11 patients (11.7%), 6 of which underwent implant removal surgery. The overall non-union rate was 3.2% (n=3).
Conclusion: Operative treatment of displaced mid-shaft clavicle fractures with precontoured locking plate provides high union rates and satisfactory mid to long-term functional outcomes. However, one should consider the significant, potentially serious operative complications.

Key words: mid-shaft clavicle fracture, treatment, anatomical locking plate, athlete, complication

ÖZ

Amaç: Bu çalışmanın amacı klavikula cisim kırıklarında cerrahi tedavinin orta-uzun dönem sonuçlarını, aktivite seviyesi yüksek hastaların dahil olduğu geniş bir popülasyonda değerlendirmektir.
Yöntemler: Klavikula cisim kırığı nedeniyle 1 mayıs 2011 ile 30 ekim 2017 tarihleri arasında cerrahi olarak tedavi edilmiş, en az bir yıl takipli 94 hasta retrospektif olarak incelendi. Ortalama takip suresi 42 ± 27.7 (12 – 83) aydı. Hastalar radyolojik ve klinik iyileşme sağlanana kadar takip edildi. Tüm kırıklar OTA sınıflamasına göre sınıflandı. Hasta dosyaları demografik bilgiler, yaralanma nedeni, ameliyata kadar geçen süre, komplikasyonlar, radyolojik ve fonksiyonel iyileşme zamanları açısından tarandı. Fonksiyonel sonuçları değerlendirmek için hastalara Constant skorlama sistemi uygulandı.
Bulgular: Yaralanma anındaki ortalama yaş 31.4 ± 15.4 (11-74) yıl idi. Doksan-bir klavikula (%96.8) ortalama 62 ± 33 günde radyolojik ve fonksiyonel iyileşme gösterdi. Son takipteki ortalama Constant skoru 91 ± 6.6 (76 -100) idi. En sık altta yatan sebep sporla ilişkili yaralanmalar (n=53, %56.3) ardından motosiklet kazaları (n=17, %18.0) ve düşmeler (n=12, %12.7) olarak saptandı. 43 (%45.7) hastanın haftada en az 3 defa sportif aktivitede bulunmaktaydı. Genel komplikasyon oranı %19.1 (n=18) idi. En sık görülen komplikasyon implant irritasyonu (n=11, %11.7) idi. Bu hastaların altısında implant çıkarma ameliyatı uygulandı. Kaynamama oranı %3.2 (n= 3) olarak hesaplandı.
Sonuç: Klavikula cisim kırıklarının anatomik kilitli plaklar ile cerrahi tedavisi yüksek kaynama oranı ve orta-uzun dönemde başarılı fonksiyonel sonuç sağlamaktadır. Ancak, cerrahi planlanmasında potansiyel ciddi komplikasyonlar göz önüne alınmalıdır.

Anahtar kelimeler: klavikula cisim kırığı, tedavi, anatomik kilitli plak, sporcu, komplikasyon

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INTRODUCTION

Clavicle fractures are seen in approximately 2.6% of all adult fractures and the incidence is rising among adults (1, 2). Sports related injuries account for 45% of clavicle fractures (3) and the treatment of displaced mid-shaft clavicle fractures (MCF) has been evolving in last decades. Traditionally, MCF were treated non-operatively (4), however treatment trends have shifted towards surgery as a result of a non-union rate of up to 15% following non-operative treatment (5, 6). Additionally, surgical treatment results in faster return to activity (7) and non-union and malunion of MCF cause a significant functional deterioration of the shoulder girdle (8). Surgical treatment of MCF allows the anatomical reduction of the clavicle and has been shown to decrease non-union rates and increase the functional outcomes (9). Thus, surgical treatment of MCF is recommended in highly active individuals (10).

Anatomic locking plates are the most widely used implants for surgical treatment (11), although few studies have reported the surgical results of these on high-demand patients (12). Despite the successful results in the treatment, little is known about long-term functional results and complication rates (13). The aim of the study was to represent the mid to long-term functional results of open reduction and internal fixation (ORIF) of MCF, via anatomical locking plate, in a large population that included athletes and high-demand patients.

MATERIALS AND METHODS

The study included patients treated with ORIF for MCF by 5 different orthopedic surgeons between May 1, 2011 and October 30, 2017 in our institution. The Institutional Review Board (IRB) approval was obtained prior to the start of the investigation (IRB: 1/4/2019, 2018-7932). The inclusion criteria were displaced MCF, closed fracture, surgery within four weeks of injury and a minimum one-year of follow-up. Patients with open fractures or a concomitant serious injury causing delayed surgery were excluded. Medical charts were retrospectively reviewed for demographic data, smoking status, athletic activity, cause of injury, time to surgery, operative complications, radiographic and functional healing time. The Orthopaedic Trauma Association (OTA) clavicle fracture classification was used to evaluate MCF on preoperative radiographs (Figure 1) (14). Indications for surgical treatment were displaced/angulated or comminuted fractures and non-unions after 6 months of conservative treatment. Constant shoulder score was used to evaluate functional outcome (15). Patients who had regular workouts 3 times weekly or more was considered as athletes (competitive or recreational) and 94 patients fulfilled the criteria. Patients and their families were informed about surgical and conservative treatment options and they selected the treatment options themselves, after the nature of the procedure was fully explained.

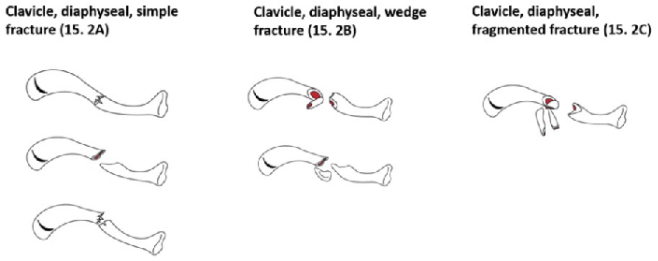

Figure 1. OTA Classification of mid-shaft clavicle fractures

The procedure was performed under general anesthesia in beach-chair position with a pad behind the ipsilateral scapula. A horizontal incision was centered over the fracture site. The supraclavicular nerve, if seen, was dissected and preserved during exposure. The fracture was anatomically reduced and a 3.5 mm anatomical locking plate was applied on the superior side (Depuy Synthes, Rynham, Massachusetts) and interfragmentary screws were used in the presence of a third fragment. The plate was fixed to the clavicle via 3 screws on each end. The quality of reduction and clavicle length was confirmed with the non-operative side on intraoperative radiographs.

Postoperatively, the operative arm was immobilized in a sling for 2 weeks. Pendulum exercises started immediately for 4 times a day, whereas shoulder elevation over 90 degrees and heavy lifting (over 10 pounds) was avoided for the first three weeks. Patients were followed at 1st, 4th and 6th week and then monthly, until the fracture consolidation was obtained (Figure 2). Radiologic evaluation was performed anterior-posterior with a 45 degrees up-tilted radiograph.

Three bridging cortices in these two radiographs were needed for radiographic healing (16). The criteria for functional healing were a non-tender fracture site and painless ROM (17) and once achieved, strengthening exercises were allowed. Return to sports criteria were radiographic and clinical fracture healing, full shoulder ROM and shoulder strength near 100% compared to the uninjured side. Non-union was considered to be the absence of bony bridging at the 6th month's follow-up.

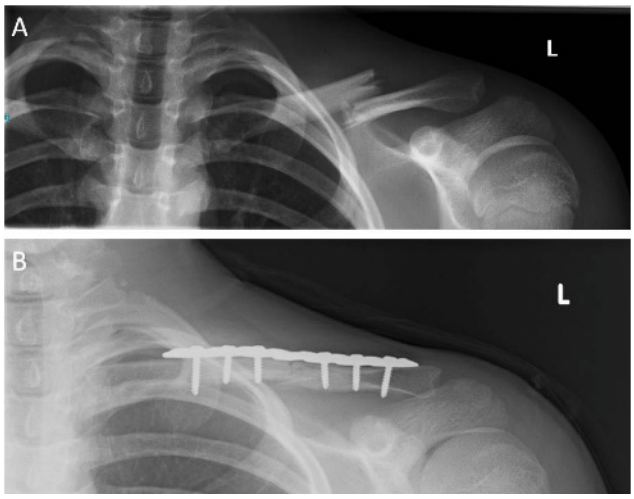

Figure 2. A) Radiograph of a 14-year-old male patient demonstrating OTA 15.2B mid-shaft clavicle fracture with significant shortening. B) Surgical fixation with pre-countered anatomical plate at postoperative 4th week showing bony bridging.

Statistical analysis: Descriptive statistics of continuous numerical variables were expressed as mean ± standard deviation, while categorical variables were expressed as number of patients and percentage.

RESULTS

There were 73 males (77.6%) and 21 females (22.4%) in our study. The left clavicle was fractured in 57 patients (60.6%) and the right clavicle in 37 patients (39.4%). The mean age at the time of injury was 31.4 ± 15.4 years (11 to 74 years old). According to the OTA classification, 11 fractures were classified as subtype 15.2A, 36 fractures were classified as subtype 15.2B and 47 fractures were classified as subtype 15.2C. There were no open fractures and neurovascular injuries at the time of the surgery. The mean time to surgery was 6.6 ± 3.3 days. Forty-three patients (45.7%) had 3 or more regular workouts weekly and were considered to be athletes. Tobacco smoking was noted in 22 of the patients (23.4%) (Table 1).

Table 1. Demographics of the patients

Gender	73 (77.6%) male
Operative side	57 (60.6%) left
Age	31.4 ± 15.4 (11 to 74) years
Athletic status	43 (45.7%) athlete
Smoking status	22 (23.4%) smoker
Classification of fractures	
15.2A	11
15.2B	36
15.2C	47

Sports related injuries was the primary underlying cause (n=53, 56.3%) followed by motorcycle crashes (n=17, 18.0%), motor vehicle accidents (n=12, 12.7%) and low falls (n=12, 12.7%). Associated injuries were noted in 26 patients (27.6%). Rib fractures (n=11, 11.7%) were the most common associated injury followed by pneumothorax (n=5, 5.3%) and scapula fracture (n=4, 4.2%) (Table 2).

Tablo 2. Distribution of the patients according to mode of injuries and additional injuries

Cause of injury	Number (%)
Sports related	53 (56.3%)
Motorcycle crush	17 (18.0%)
Motor vehicle accidents	12 (12.7%)
Low fall	12 (12.7%)
Associated injuries	26 (27.6%)
Rib fracture	11 (11.7%)
Pneumothorax	5 (5.3%)
Scapula fracture	4 (4.2%)
Femur shaft fracture	2 (2.1%)
Iliac wing fracture	2 (2.1%)
Hemothorax	1 (1.0%)
Glenohumeral dislocation	1 (1.0%)
Tibia plateau fracture	1 (1.0%)
Sternum fracture	1 (1.0%)

The mean follow-up was 42 ± 27.7 months (12 to 83 months). Ninety-one patients (96.8%) showed radiologic and functional healing at the final follow-up. The mean time to radiologic union was 62 ± 33 days. The mean Constant score at the latest follow-up was 91 ± 6.6 (76 -100). The mean Constant score was 90.4 ± 6.5 among smokers. One of the 22 smoking patients (4.5%) underwent revision surgery for non-union at 6th month.

Table 3. Distribution of operative complications in study cohort

	N (%)
Complications	18 (19.1%)
Implant irritation	11 (11.7%)
Non-union	3 (3.2%)
Deep infection leading non-union	2 (2.1%)
Hypertrophic non-union	1 (1.0%)
Implant failure	2 (2.1%)
Superficial skin infection	1 (1.0%)
External jugular thrombophlebitis	1 (1.0%)
Brachial plexopathy	1 (1.0%)
Hypertrophic scar	1 (1.0%)

The overall complication rate was 19.1% (n=18) in this study (Table 3). The most common complication was implant irritation in 11 patients (11.7%), 6 (6.4%) of which underwent implant removal surgery. Refracture was noted in 1 patient 3 weeks after the implant removal surgery, that was successfully treated with ORIF. Non-union was observed in 3 patients (3.2%). Two of them suffered a deep infection: those requiring removal of the plate, decortication of the union site, irrigation and debridement. The patients received intravenous antibiotics for 6 weeks and revision ORIF with an iliac bone graft was performed, once the infection was eradicated. One patient suffered hypertrophic non-union at the 6th month and treated with removal of the plate and decortication of the union site: a longer precontoured plate was applied with an iliac bone graft. The most serious complication was an external jugular vein thrombophlebitis in one of the infected patients. Brachial plexopathy was noted in 1 patient following surgery, that was attributed to prolonged preoperative immobilization of the shoulder; nerve symptoms resolved after 6 months of oral gabapentin and physical therapy. Hyperthrophic scar formation was observed in 1 patient. A superficial propionibacterium acne skin infection was treated with intravenous antibiotics in 1 patient. Implant failure was observed in 2 patients, one of which suffered from a mental disability and failed to follow the instructions, whereas the other resulting from a deep infection at the postoperative 2nd week.

DISCUSSION

The treatment of displaced MCF still remains controversial. Since suboptimal outcomes following non-operative treatment methods have been published, surgical treatment methods have become increasingly popular. Recent meta-analyses comparing surgical versus non-operative treatment methods following displaced MCF, revealed lower non-union and malunion rates and superior functional outcomes (18).

We aimed to evaluate mid to long term functional outcomes and examine complications of plate fixation in a population that included patients with a high degree of activity. We found a 96.8% union rate in a mean of 62 ± 33 days. The functional results were satisfactory in mean Constant score (91) at mean follow-up of 42 months. All fractures consolidated at final follow-up and this finding is predictable and parallel to the literature (6, 19). Guerra et al. published a recent meta-analysis of 14 randomized controlled trials comparing surgical versus non-operative treatment of displaced clavicle fractures. They reported lower risk of non-union (10%; 95% CI, 6%-18%, P<0.001) and 5.1 weeks shorter time to union with surgery (P= 0.007). Additionally, long-term functional scores were significantly better in the surgery group: the overall Constant score mean difference was 5.3 points (P<0.001), and the DASH index mean difference was 4.3 points (P =0.04) (20).

The factors affecting the clavicle fracture healing were previously demonstrated (21-23): tobacco smoking, age, female gender and fracture comminution were associated with delayed healing and non-union following clavicle fractures (21). Murray et. al found a 3.76 folds increased risk of non-union in smokers (22). Moreover, Napora et al. reported decreased American Shoulder and Elbow Surgeons (ASES) scores (83.6±18.4 versus 74.1±23.0) indicating that smoking is responsible for decreased functional outcomes following clavicle fractures (23). In our study the rate of tobacco smoking was 23.4%. The mean Constant score was 90.4 ± 6.5 and the complication rate was 22.7% among smokers. However, our study was not designed to study the effect of smoking on fracture healing and outcomes.

Treatment of MCF in highly active individuals and athletes deserves special attention. The aim is always to obtain fracture union and fast return

to activity (10), however, anatomic reduction is mandatory as shortening of the clavicle deteriorates shoulder girdle mechanics and decreases shoulder strength (24). Ranalletta et. al reported a 98% union rate, a mean Constant score of 94.1 and a 94% return to sports rate in 68 days (5 to 180) following plate fixation of 54 displaced MCF (12). Mckee et al. conducted a meta-analysis comparing the functional outcomes of operative and non-operative treatment of MCFs. There were 3 studies using the Constant score. The average Constant score for the operative group was 94.3, and the average Constant score for the non-operative group was 90.2 (n = 222 total patients) at one year (25). In our study, the mean Constant score for surgical treatment for MCF was 91 ± 6.6 at 42 ± 27.7 months follow-up.

Despite the decreased non-union/malunion rates and satisfactory functional outcomes, surgical treatment is associated with a high risk of complications (7) (11) (26). Fridberg et al. reported 30% implant-related complications with non-anatomical locking plates (27). Verborg et al. published a 90% union rate, however this included an 18% wound infection rate and a 5% refracture rate following surgical treatment of the clavicle fracture. In our study, the overall complication rate was 19.1% and the most common complication was implant irritation in 11.7% of patients, that led implant removal surgery in 6.4% of them. The refracture rate was 1.1% and the postoperative infection rate was 3.2% (3 patients). The most serious complication was an external jugular venous thrombophlebitis caused by deep cervical infection in one patient. Overall, 11 patients (11.7%) required secondary surgeries due to operative complications.

Our study has some limitations, the most important one of which was its retrospective design. Additionally, the study lacked a control group and our study cohort was heterogeneous, including trauma patients, motor vehicle accidents and athletes. Surgical indications in different groups might vary, as our threshold for surgical treatment in athletes, for instance, is lower. The strength of our study was a large number of patients from a tertiary center with midterm and long-term functional outcomes. It should be noted that although the study population included many athletes, no sports specific evaluation was performed.

In conclusion, operative treatment of displaced clavicle fractures with precontoured locking plate, provides high union rates and satisfactory midterm/long-term functional outcomes. However, one should consider the significant, potentially serious operative complications.

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