

Clinical and radiological comparison of single and double-plate fixation in comminuted clavicular shaft fractures

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ABSTRACT

Aim: In this study, we compared the single-plate technique (with suturing of small fragments) and the double-plate technique, that we applied to patients who underwent surgery for comminuted clavicle fractures, in terms of fracture healing, early return to work, and the need for secondary surgery due to plate irritation.

Materials and Methods: All patients who underwent surgery due to clavicle fracture between 2018 and 2023 were evaluated retrospectively. A total of 107 patients who came for regular check-ups and were under our follow-up were evaluated. Fifteen patients with comminuted shaft fractures who were fixed with a 3.5 mm plate superiorly and a 2.4 mm mini plate anteriorly, and 19 patients who were fixed with a 3.5 mm single-plate superiorly and 2.0 Ethibond sutures, were included in the study. Patients were divided into two groups according to single/double-plate application. Patients in Group 1 received a 3.5 mm Locking Compression Plate (LCP) single-plate application superiorly followed by a doubled-suture Nice knot (described by Boileau et al.) (Figure 1). In Group 2, patients received a superior 3.5 mm LCP plate followed by an anterior 2.4 mm mini plate (Figure 2).

Results: Significant differences were observed between patients with single-plate and double-plate applications in terms of various clinical recovery times, return to work times, and plate removal requirements. The clinical recovery time was significantly faster in the double-plate group [6 (IQR: 5-7) weeks vs. 4 (IQR: 4-5) weeks, $p < 0.001$]. The time to return to work was similarly shorter in the double-plate group [8 (IQR: 7-8) weeks vs. 7 (IQR: 6-7) weeks, $p = 0.001$]. The need for plate removal was significantly higher in the double-plate group ($p = 0.016$), with 73.3% ($n=11/15$) of patients requiring plate removal, compared to 31.6% ($n=6/19$) in the single-plate group.

Conclusion: In addition to superior plating in the fixation of comminuted clavicle fractures, the application of a mini plate from the anterior for fixation of the butterfly fragment allows for earlier rehabilitation and a rapid return to work. However, the risk of a second operation due to plate irritation should also be considered. No negative effect of fixation of small fragments with sutures on fracture union was observed. If the situation of the soft tissue is not well, a single-plate can be used in comminuted fractures. However, in cases where fixation is not enough, double-plate is a procedure that can be applied safely.

Keywords: Clavicle, double-plate application, fracture, outcome

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INTRODUCTION

Clavicle shaft fractures are serious injuries that typically occur in active individuals due to a direct blow to the shoulder. Although the traditional view is to treat conservatively, it results in a 15% rate of nonunion, malunion, and decreased functional capacity (1). While most clavicle fractures are treated conservatively, severely displaced or comminuted fractures may require surgical fixation. The most commonly preferred surgical treatment is the 3.5 mm Locking Compression Plate (LCP). Other fixation options are intramedullary pinning with Kirschner wires, cannulated screws, compression plates, precontoured clavicle locking plates, and external fixation (2). Although these techniques are sufficient for fixation of the main fragments in the distal and proximal areas, they are inadequate for the fixation of small fragments in the fracture line.

It is difficult to fix small fragments in the fracture line with a lag screw, as it often leads to bone fragmentation. In surgical practice, these fragments can be tied using absorbable sutures (3), or anterior plating (4) can be added to the procedure to solve these problems.

Biomechanical studies have shown that dual plating techniques using mini-fragment plates have superior biomechanical properties compared to single superior/anterior plating techniques (5). Despite this biomechanical superiority, there are comparative clinical and radiological studies indicating that there is no difference in healing rates between patient groups (6). An important consideration when evaluating early fracture healing and return to work in clavicle fractures is plate irritation and the need for secondary surgery. This rate is reported as 9-64% in the literature (7,8).

In this study, we compared the single-plate technique (with suturing of small fragments) and the double-plate technique, that we applied to patients who underwent surgery for comminuted clavicle fractures, in terms of fracture healing, early return to work, and the need for secondary surgery due to plate irritation.

MATERIALS AND METHODS

Before starting the study, Bolu Abant İzzet Baysal University Clinical Researches Ethics Committee Approval was received (No: 2020/238 Date: 29/09/2020). All patients who underwent surgery due to clavicle fracture between 2018 and 2023 were evaluated retrospectively. A total of 107 patients who came for regular check-ups and were under our follow-up were evaluated. Fifteen patients with comminuted shaft fractures who were fixed with a 3.5 mm plate superiorly and a 2.4 mm mini plate anteriorly, and 19 patients who were fixed with a 3.5 mm single-plate superiorly and 2.0 Ethibond sutures, were included in the study. Patients with two-part fractures, patients using different implants, patients who smoke, patients using drugs that may impair fracture healing (such as steroids, NSAIDs, quinolones, bisphosphonates), and patients lost to follow-up due to irregular check-ups were excluded from the study.

Patients were divided into two groups according to single/double-plate application. Patients in Group 1 received a 3.5 mm LCP single-plate application superiorly followed by a doubled-suture Nice knot (described by Boileau et al.) (Figure 1) (9). In Group 2, patients received a superior 3.5 mm LCP plate followed by an anterior 2.4 mm mini plate (Figure 2).

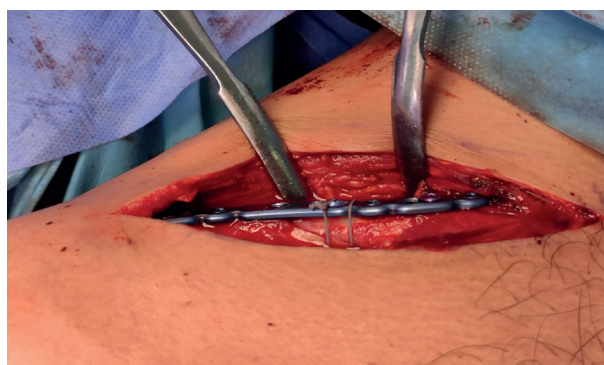


Figure 1. Single-plate application followed by a double-suture.

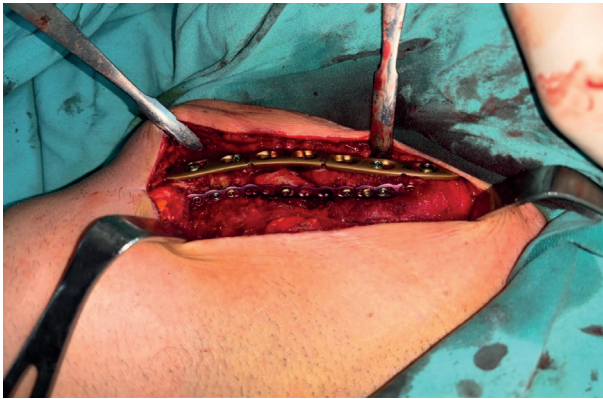


Figure 2. Anterior and superior plate application.

Postoperatively, a velpau bandage was applied for one month, and elbow and passive range of motion exercises were started. After 30 days, the bandage was removed, and active range of motion exercises were started. After the third month, strengthening exercises were started.

The condition of the patients who came for regular monthly check-ups in the postoperative period was recorded. Patients who did not have pain in the fracture line were considered to have clinical union. Radiological union was accepted when three cortex continuity was detected in the anteroposterior and 45° oblique radiographs taken during the controls. In addition, the time taken for the patients to return to work, the need for a second operation due to plaque irritation, and the presence of infection were also

evaluated. Annual controls were performed after six months postoperatively.

Statistical analysis

Continuous variables were presented as mean \pm standard deviation (SD) or median [Interquartile range (IQR): 25th - 75th percentile], and categorical variables were presented as frequency and percentage (%). The normality distribution of continuous variables was assessed using the Shapiro-Wilk test. To assess differences between two independent groups, the independent sample t-test was used for continuous variables with normal distribution, and the Mann-Whitney U test was used for variables without normal distribution. Differences between categorical variables were analyzed using Pearson's chi-square test. All statistical analyses were performed using SPSS 26.0 and the significance level was set at $p < 0.05$.

RESULTS

According to the results of Table 1, significant differences were observed between patients with single-plate and double-plate applications in terms of various clinical recovery times, return to work times, and plate removal requirements. The clinical recovery time was significantly faster in the double-plate group [6 (IQR: 5-7) weeks vs. 4 (IQR: 4-5) weeks, $p < 0.001$]. The time to return to work was similarly shorter in the double-plate group [8 (IQR: 7-8) weeks vs. 7 (IQR: 6-7) weeks, $p = 0.001$]. The need for plate removal

Table 1. Comparison of patients with single and double-plate application

Variables	Group 1 (n=19)	Group 2 (n=15)	p
Age (year)	42.7 \pm 12.1	39.7 \pm 11.3	0.472
Follow-up period (week)	33.8 \pm 6.6	35.3 \pm 5.9	0.520
Clinical union (week)	6 (5 - 7)	4 (4 - 5)	<0.001
Radiological union (week)	16 (12 - 16)	16 (12 - 16)	0.758
Return to work(week)	8 (7 - 8)	7 (6 - 7)	0.001
Implant removal			0.016
No	13 (%68.4)	4 (%26.7)	
Yes	6 (%31.6)	11 (%73.3)	

Data are summarized as mean \pm SD, median (25th-75th percentile) and n(%) values. Bold p-values indicate statistical significance for Mann-Whitney U test or Pearson's chi-square test.

was significantly higher in the double-plate group ($p=0.016$), with 73.3% ($n=11/15$) of patients requiring plate removal, compared to 31.6% ($n=6/19$) in the single-plate group.

DISCUSSION

Among the various fixation options used in the surgical treatment of clavicle fractures, superior LCP plates are the most commonly used implant. Nonunion, delayed union, implant failure, infection, and brachial plexus injury are expected complications. Possible risk factors for construct failure include implant type and fracture type. In particular, fixation failure is observed in 5-7% of cases due to poor bone quality and inadequate technique (10,11).

Kitzen et al. compared the superior single 3.5 mm plate application with different double-plate applications. In terms of axial stiffness, the application of a double-plate consisting of a 2.4 mm superior and a 2.7 mm anterior plate was found to be significantly superior. No difference was observed between the different implant combinations in terms of torsional stiffness or load to failure (5). Boyce et al. conducted a biomechanical study comparing a 3.5 mm superior plate, a 3.5 mm superior + 2.8 mm anterior plate, and two 2.8 mm mini plates. According to the results of the study, double orthogonal fixation with mini plates showed lower stiffness and durability than traditional superior 3.5 mm plate fixation. The addition of an anterior miniplate to the traditional superior 3.5 mm plate fixation improved construct stiffness and may play a role in patients seeking an early return to activity (12). Similar results were found in this study. Patients in the double-plate group were found to return to work significantly earlier.

Clinically, it is emphasized that the fracture healing rates of single-plate and double-plate applications are similar, 2.9% vs. 0.8%, respectively. Complication rates such as infection and neurovascular injury are also similar (5). It is emphasized in the literature that the need for a second operation due to implant irritation is higher in 3.5 mm plates placed superiorly, with a rate of 30% (13). The application of small fragment plates by contouring increases the need for secondary surgery

due to implant irritation from 8% to 20% (9). In this study, plate irritation rates were found to be higher in the patient group that received double-plates.

Fixation of free bone fragments in the shaft poses a serious problem due to insufficient cortical support. Although most authors recommend lag screw fixation after reduction for these fragments, it results in inadequate fixation due to fragmentation of the bone tissue (14). The doubled-suture Nice knot described by Boileau et al. is another current fixation technique used. 2.0 Ethibond sutures with locked sliding knots are semi-stable but can be easily applied (15). Wu et al. retrospectively followed 56 patients who underwent suture-knotted plate fixation for a mean of 25.6 months. They reported that bone healing was complete in all patients. They also emphasized that the combination of the suture knots and plate screws fixation technique is reliable and effective (16).

This study had several limitations. Although the small number of patients and the retrospective design are shortcomings of the study, the fact that all surgeries and patient follow-ups were performed by the same researcher is an advantage.

In conclusion, in addition to superior plating in the fixation of comminuted clavicle fractures, the application of a mini plate from the anterior for fixation of the butterfly fragment allows for earlier rehabilitation and a rapid return to work. However, the risk of a second operation due to plate irritation should also be considered. No negative effect of the fixation of small fragments with sutures on fracture union was observed.

Ethical approval

This study has been approved by the Bolu Abant İzzet Baysal University Clinical Researches Ethics Committee (approval date 29/09/2020, number 2020/238). Written informed consent was obtained from the participants.

Author contribution

Surgical and Medical Practices: TA, HAÜ; Concept: TA, HAÜ, OK; Design: TA, HAÜ, OK; Data Collection or Processing: TA, HAÜ; Analysis or Interpretation:

OK; Literature Search: TA; Writing: TA, HAÜ, OK. All authors reviewed the results and approved the final version of the article.

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Conflict of interest

The authors declare that there is no conflict of interest.

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