Comparative Results of External Fixation, Plating, or Nonoperative Management for Diaphyseal Clavicle Fractures

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Significance of the Study

- This study showed that both plate and external fixator treatment achieved better functional outcomes than conservative methods in patients with displaced clavicular fractures. Hence, external fixation could be considered as a good alternative for the surgical management of clavicular fractures.

Keywords

Clavicle fracture · External fixator · Malunion · Osteosynthesis

Abstract

Objective: The aim of this study was to compare the treatment outcomes of mid-diaphyseal clavicular fractures between an external fixator and more widely selected treatment options such as plate osteosynthesis or conservative methods. **Materials and Methods:** The medical records of 64 patients who were treated for mid-diaphyseal clavicular fracture in our clinic from 2009 to 2013 were reviewed. The inclusion criterion was mid-diaphyseal closed clavicular fractures with shortening of more than 2 cm. The Constant and DASH (disabilities of the arm, shoulder, and hand) scores at the final follow-up, initial displacement, nonunion, and complication rates were compared. Statistical differences between groups were assessed with the Kruskal-Wallis test, and pairwise comparison analysis was used to evaluate the differ-

ences within the groups. **Results:** Of the 64 patients, 24 (37.5%) were treated with plate osteosynthesis (group 1), 11 (17.2%) with an external fixator (group 2), and 29 (45.3%) conservatively with a figure-of-eight bandage (group 3). The mean follow-up periods were as follows: group 1: 37 ± 10.4 months, group 2: 33 ± 7 months, and group 3: 35 ± 9.4 months. The initial amount of displacement and DASH score were: group 1: 89.1 ± 7.8 , group 2: 89.1 ± 7.8 , and group 3: 6.1 ± 6.6 ($p = 0.079$). The Constant score of group 2 (93 ± 6.1) was significantly higher than that of group 3 (85 ± 8.4) ($p = 0.013$). No statistical difference was found in the distribution of nonunions ($p = 0.387$). However, in group 3, the number of malunions (11/29, 37.9%) was significantly higher compared to the other 2 groups (group 1: 1/24, 4.2%; group 2: 2/11, 18.2%) ($p = 0.006$). **Conclusions:** This study revealed that the treatment of acute clavicular fractures with an external fixator was a good alternative to plate osteosynthesis or conservative treatment.

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Introduction

Clavicular fractures make up 2–5% of all fractures, and 70% involve the mid-diaphyseal region [1–3]. Lateral and medial end fractures of the clavicle are seen less frequently and the treatment forms are different [3–6]. In many previous studies, shortening of 2 cm or more was mentioned as an indication for surgery for mid-diaphyseal clavicular fractures.

The majority of mid-diaphyseal clavicular fractures are treated conservatively [7–9]. However, several studies in the literature have emphasized complications such as malunion, nonunion, and reduced shoulder functional capacity [6, 7]. Although the functional results are better in anatomically reduced fractures applied with plate osteosynthesis, complications of this method have also been reported, such as infection, wound site scars, and implant irritation [5, 7, 9]. Previous reports have shown that the application of an external fixator to the clavicle is a preferred option for the treatment of nonunion and open fractures [8, 10]. A study by Shukla et al. [5] reported that they successfully applied external fixator treatment in acute clavicle fractures and achieved union at the appropriate position for all patients. Schuind et al. [11] also reported successful application of external fixator treatment in 5 multitrauma patients. Nonunion, malunion, and related cosmetic and functional complications that have been reported can be prevented by external fixator treatment [5, 11].

The basic reasons for the selection of fixation with an external fixator for the patients in the current study were to eliminate the disadvantages of conservative treatment and to reduce the surgical risks of the open reduction and plate fixation method. The aim of this study was to compare clavicular fracture treatment outcomes between external fixator treatment and more widely selected treatment options such as plate osteosynthesis or conservative methods.

Materials and Methods

The medical records of 87 patients who were treated for clavicular fracture in our clinic between 2009 and 2013 were reviewed. Exclusion criteria were incomplete records, bilateral medial third, lateral end, or open fractures, multitrauma, age <14 years or >65 years, and time from fracture to treatment >21 days. Based on these criteria, 24 patients were excluded. The remaining 64 patients were included in the study based on a mid-diaphyseal closed fracture and shortening of 2 cm or more in the fracture ends. The choice of surgical treatment method was based on the surgeon's preferences.

Constant [12] and DASH (disabilities of the arm, shoulder, and hand) scores [13] at the final follow-up examination, the amount of shortness in the clavicle, the initial displacement amount, the time to full functional use, and skin irritation were obtained from the medical records.

The radiographs taken during follow-up examinations of the patients were evaluated by a single researcher (B.Ö.) on a screen using a digital method on the Infinitt PACS system (Infinitt Healthcare Co., Seoul, South Korea). The time to union and the amount of shortness compared to the contralateral clavicle were evaluated on the radiographs. At the last follow-up, the presence of pain and/or absence of radiographic findings of callus in the clavicle were accepted as nonunion. The presence of bridging callus in at least 3 anatomic planes on the control radiographs was considered as a union. Patients with inadequate healing were evaluated with computed tomography. After union, shortening of more than 2 cm and/or skin irritation due to angulation defects were accepted as a malunion.

External Fixator Surgical Technique

The patients were positioned supine with a silicone cushion below the scapula. After sterile draping, the areas in the proximal and distal main fragments of the clavicle where the pins were to be placed were marked with the tip of an injector. For the medial and lateral fragments, a total of 4 (as 2 pairs) of 3-mm Schanz screws were placed according to the distant-distant and close-close principle. The fragments were evaluated under fluoroscopic imaging to avoid posterior migration of the screws. Using the applied screws as a joystick, under image intensifier guidance, first the pins close to the fracture line and then the distant pins were fixed with a trauma-type pin to bar fixator rods. Finally, by fixing these rods with a third rod, stability was increased. Fluoroscopic images were taken to check the procedure (Fig. 1). When bridging callus was observed in at least 3 anatomic planes the external fixator was removed immediately in the clinic without any complications.

Plate Osteosynthesis Surgical Technique

After the patients were placed in the beach chair position on the operating table, sterile surgical covering was done. An oblique incision of approximately 7–10 cm was performed. Care was given to the supraclavicular nerve, which was protected throughout the procedure. Fracture reduction was performed with bone fixation clamps. After confirmation of satisfactory reduction using fluoroscopy, fixation was achieved with a 3.5-mm anatomic plate and screws.

Conservative Treatment Method

Conservative treatment of the patients in the study was done with either figure-of-eight bandages or standard slings. In the literature, there is no radiological or functional difference between the 2 methods [14, 15]. After 3 weeks of treatment, active shoulder range-of-motion exercises were initiated to increase the functional capacity and strength of the patients in the early period.

Statistical Analysis

Statistical analysis was done using SPSS 15.0 software (Statistics Program for Social Sciences; SPSS Inc., Chicago, IL, USA). Normality of the distribution of variables was tested with the Kolmogorov-Smirnov test. For the evaluation of categorical variables between groups (Constant score, Dash score, full function use,

Fig. 1. A mid-shaft clavicle fracture. **a** Patient in a supine position. **b** Proximal and distal fragments marked with the tip of an injector. **c** Placement of 4 Schanz screws. **d** After the reduction trauma-type fixator was fixed.

union time), the Kruskal-Wallis test was used. A pairwise comparison test was used to evaluate the differences in each group. The distribution of nonunion and malunion was assessed with the Fisher exact test. A p value <0.05 was considered to be statistically significant.

Results

Of the 64 patients, 24 (37.4%; 18 males, 6 females) were treated with plate osteosynthesis (group 1), 11 (17.2%; 8 males, 3 females) were treated with an external fixator, and 29 (45.3%; 25 males, 4 females) were treated conservatively with a figure-of-eight bandage. The corresponding mean age of the patients was of 28.5 ± 8.5 , 31 ± 12.8 , and 31 ± 12.8 years. The demographic data of the patients including age, gender, cigarette smoking status, affected side, and follow-up duration are presented in Table 1.

The mean follow-up periods were: group 1: 37 ± 10.4 months, group 2: 33 ± 7 months, and group 3: 35 ± 9.4 months. On the preoperative radiographs, the length of

displacement was as follows: group 1: $2.4 \pm 0.5.7$ cm, group 2: $2.4 \pm 0.5.6$ cm, and group 3: 2.3 ± 0.6 cm. Based on fracture type, in group 1 (24 patients), 13 (54%) were simple fractures, 8 (33%) wedge, and 3 (12%) complex. In group 2 (11 patients), 3 (27%) were simple fractures, 5 (45%) wedge, and 3 (27%) complex. In group 3 (29 patients), 18 (62%) were simple fractures, 8 (27%) wedge, and 3 (10%) complex.

No statistically significant difference was found between the groups regarding the initial amount of displacement of diaphyseal clavicle fracture prior to surgery ($p = 0.803$), gender ($p = 0.54$), age ($p = 0.244$), duration of follow-up ($p = 0.755$), DASH score ($p = 0.079$), and week of radiological union ($p = 0.283$).

In the Kruskal-Wallis test, there was a statistically significant difference between the groups regarding the Constant score (group 1: 89.1 ± 7.8 , group 2: 93 ± 6.1 , group 3: 85 ± 8.4) ($p = 0.014$) and time to full functional use ($p = 0.039$). In the pairwise comparison analysis, when the difference within the group was examined, the Constant score of group 2 (93 ± 6.1) was significantly

Table 1. Demographic data of the patients

	Age, years		Follow-up, months		Amount of displacement, cm		Patients (F/M), <i>n</i>	Right/left side, <i>n</i>	Dominant side, <i>n</i>	Smokers, <i>n</i>
	mean $\pm$ SD	median (range)	mean $\pm$ SD	median (range)	mean $\pm$ SD	median (range)				
Group 1 (plate osteosynthesis)	28.5 $\pm$ 8.5	27.5 (16–44)	37 $\pm$ 10.4	32.5 (24–61)	2.4 $\pm$ 0.5.7	2 (2–4.2)	24 (18/6)	14/10	15	11
Group 2 (external fixator)	31 $\pm$ 12.8	28 (14–52)	33 $\pm$ 7	33 (25–46)	2.4 $\pm$ 0.5.6	2 (2–3.5)	11 (8/3)	15/6	5	3
Group 3 (conservative treatment)	34 $\pm$ 12.3	33 (16–61)	35 $\pm$ 9.4	35 (23–55)	2.3 $\pm$ 0.6	2 (2–4)	29 (25/4)	14/15	18	9

Table 2. Statistical results of functional evaluations

Variables	Group 1 (plate osteosynthesis)		Group 2 (external fixation)		Group 3 (conservative)		<i>p</i> value
	mean $\pm$ SD	median (range)	mean $\pm$ SD	median (range)	mean $\pm$ SD	median (range)	
Constant score	89.1 $\pm$ 7.8	90 (70–98)	93 $\pm$ 6.1	96 (80–98)	85 $\pm$ 8.4	87 (63–98)	0.014
DASH score	4.6 $\pm$ 3.7	3.05 (1.7–14.2)	2.1 $\pm$ 1.9	2 (0–7)	6.1 $\pm$ 6.6	3.3 (0–25)	0.079
Full functional use, months	4 $\pm$ 1.06	4 (2–6)	5.09 $\pm$ 1.13	5 (3–7)	4.8 $\pm$ 1.5	5 (3–7)	0.039
Union time, weeks	9 $\pm$ 2.6	8 (6–15)	9 $\pm$ 2.6	11 (4–14)	10 $\pm$ 3.3	11 (6–17)	0.283
Nonunion, <i>n</i>	1/24 (4%)		0/11 (0%)		4/29 (13%)		0.387
Malunion, <i>n</i>	1/24 (4%)		2/11 (18%)		11/29 (37%)		0.006

higher than that in group 3 (85 $\pm$ 8.4) (p = 0.013). With respect to the time to full functional use, although the within-group significance was low (p = 0.015), group 1 time (4 $\pm$ 1.06 months) was seen to be significantly lower than that of group 2 (5.09 $\pm$ 1.13 months) (p = 0.039). While no statistically significant difference was seen between the groups with respect to rates of nonunion (p = 0.387), the number of malunion patients in group 3 was significantly higher compared to the other 2 groups (p = 0.006) (Table 2). Skin irritation was determined in 9 (37%) of the patients treated with plate osteosynthesis and 10 (34%) of the conservatively treated patients. In group 1, 5 (20%) patients had the implant removed due to plate irritation, and 2 (8%) patients due to wound site problem. Patients did not develop deep infection-osteomyelitis. Three (27%) patients with an external fixator had superficial pin site infection that was treated with oral antibiotics. No cosmetic complaints due to scarring or malunion were found in or reported by patients with an external fixator (Fig. 2). No postoperative refracture was seen in any of the groups. Two patients who had nonunion in group 3 were treated with plate osteosynthesis with autograft. Malunion required 4 corrective osteotomies, but the patients did not accept this treatment.

Discussion

In this study, the 3 different treatment methods of clavicular diaphyseal fractures revealed similar good outcomes in radiological union time and DASH scores. However, the Constant score and the malunion rate had better outcomes in the surgical treatment groups than with the conservative method, which was consistent with previous studies [5, 16–18].

In the present study, the time to full functional use in the external fixator group was significantly greater than that in the plate osteosynthesis group, which could be due to the discomfort effect of the external fixator applied during the treatment period. This can also be explained by the achievement of similar functional scores in both of the surgically treated groups after the removal of the external fixator.

In this study, although no statistically significant difference was found between the groups regarding nonunion, a significant number of malunion cases occurred in the conservative treatment group, which was consistent with previous studies [5, 17, 19]. However, in a multicenter, randomized, controlled study, the number of malunion and nonunion cases were statistically significantly higher in the group with conservative treatment

Fig. 2. A mid-shaft clavicle fracture. **a** Preoperative radiography. **b** Fluoroscopic image. **c** Trauma-type fixator fixed. **d** Late postoperative radiography. **e, f** Good functional outcome at final follow-up.

compared to the osteosynthesis group [1]. There are studies in the literature which have reported that clinical results are negatively affected by shortening of >2 cm or >10 – 13% reduction after treatment compared to the contralateral clavicle [1, 5, 6, 20, 21]. In the current study, when there was malunion after conservative treatment, there was a significant reduction in the Constant score compared to the other groups, but this did not prevent full functional use of the extremity. The anatomical arrangement provided by surgery solved the cosmetic dissatisfaction associated with malunion.

In the current study, implant irritation was found in 37% of the patients treated with plate osteosynthesis, and 5 patients had to undergo plaque removal due to irritation. In the literature, the most common complications of plate osteosynthesis in the clavicular fracture have been hypertrophic scar tissue, implant irritation, and implant-related infection [2, 6, 16, 18]. On the other hand, pin site infection is another problem after external fixator surgery. In our study, no cosmetic complaints related to the fixator pin entry sites were reported or found in group 2, except in 3 patients, who had superficial pin site infection that responded to oral antibiotic treatment. In the literature, after external fixator pin site infections, pin loosening, implant instability, and osteomyelitis developed at

rates of 4–10% [22, 23]. It is thought that the external fixator was removed immediately after the 3 anatomic planes of the bridging callus were seen, and that this procedure could have protected the patients from the complications of pin site infection. This study showed that the treatment of acute close clavicular fracture with an external fixator can avoid the complication risks associated with plate osteosynthesis with similar functional results.

The limitations of the current study include its retrospective nature, the lack of cost analysis for the different treatment methods, the low number of patients in the external fixator group, and the fact that more than one surgeon performed the operations in the plate osteosynthesis group.

Conclusion

This study revealed that the surgical treatment of acute clavicular fractures with an external fixator was a good alternative to plate osteosynthesis, and that surgical treatment was better than conservative treatment, in clavicular fractures with more than 2 cm displacement. Hence, external fixation in the surgical treatment of clavicular fractures could be considered as a good alternative.

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