Superior versus anterior plating of midshaft clavicle fractures: 6 months follow up (union rates, risks, and complications: hardware irritation and need for removal)

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Background
Operative management of midshaft clavicle fractures is gaining popularity. The clavicle is a tubular bone with a flat lateral end. Open reduction and internal fixation could be achieved by the application of plates and screws either to the superior or anterior surface of the clavicle. However, there is no consensus in the literature to support one technique over the other. This study aims to compare the early functional and radiographic outcomes of anterior versus superior plating for the treatment of midshaft clavicle fractures.
Patients and methods
From March 2021 to November 2022, a prospective randomized clinical trial was conducted at our institute. We included all patients with isolated midshaft clavicle fractures. Thirty-six patients were randomized by the closed envelope technique, 18 were managed with superior plating (superior group), and the other 18 patients were managed using anterior plating (anterior group). All patients were followed up for 6 months. All patients were assessed clinically for union, range of motion, and functional scores. The secondary outcome measures included operative time, complications, hardware irritation, and the need for hardware removal or secondary procedure.
Results
The mean time to full union was 11.28 weeks in the anterior group and 11.72 weeks in the superior group. Mean constant shoulder score for the anterior group was 84.11 while for the superior group it was 82.67. No patients had skin and wound complications in the anterior group versus one patient in the superior group that got superficial infection successfully managed by repeated dressing and antibiotics. There was no statistically significant difference between superior and anterior plating regarding union, functional scores, return to ADLs, hardware problems, or complications.
Conclusion
Both superior and anterior plating of the clavicle fractures are safe treatment options for displaced midshaft clavicle fractures, and they lead to similar functional outcomes, functional scores, and complication rates. Moreover, the selection of the technique of plating depends on surgeon preferences.

Keywords:
anterior plating and superior plating, clavicle fractures, hardware irritation

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Introduction

Clavicle fractures account for around 2.6–4% of all fractures and up to 40% of fractures of the shoulder girdle. Middle-third fractures are the most common fractures, around 80% of all fractures [1].

There is a male dominance ~70%. Over one-third of clavicle fractures in males occur between the ages of 14 and 20 years [1].

Operative versus nonoperative management of clavicle fractures have been studied widely across the literature. There is a growing interest towards operative treatment, as it yields better union rates and overall shoulder function. Other advantages include early pain regression and early return of efficient shoulder functions [2].

Classically, most surgeons would prefer superior plating as it carries less risk of wound dehiscence or breakdown and less issues of hardware prominence. However, the close proximity of the neurovascular structures and the pleura put them at a relatively higher risk of injury.

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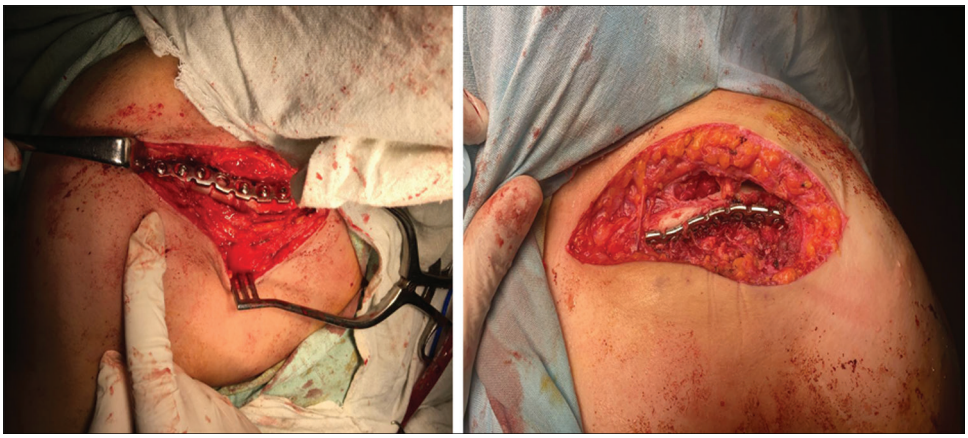
Figure 1



(a) Superior plating and (b) anterior plating.

Anterior plating is considered safer, yet it is associated with a greater risk of skin complications, hardware prominence, and need for later removal. The ideal surface of the clavicle to plate remains controversial [3].

A study was conducted to biomechanically compare superior and anterior plate positioning for clinically relevant midshaft clavicle fracture patterns. Constructs were loaded in axial compression, torsion, and cantilever bending to determine construct stiffness for comparison of plate positioning. Results showed that, for all fracture patterns, more construct stiffness was achieved in axial compression and torsion with a superior plate, whereas more construct stiffness was achieved in cantilever bending with an anterior plate. Absolute recommendations for either superior or anterior plates cannot be made [3].

Patients and methods

From March 2021 to November 2022, a prospective randomized clinical trial was conducted at our institute. A total of 36 patients with simple, isolated midshaft clavicle fractures were enrolled in the trial after obtaining informed consent to participate. Randomization was done using the closed envelope technique, and 18 of the patients were treated with superior plating, and the other 18 received anterior plating. Patients with pathological or open fractures, associated neurovascular injury, scapulothoracic dissociation, and prior surgery to the shoulder were all excluded from the study. All patients were followed up for a mean of 6 months. This study was approved by Ethical Committee of Kasr Alaini (Code: MS-565-2021).

The mean age of the patients was 31.2 years (SD±11.4 years) in the superior group and 30.8 years (SD±9.6 years) in the anterior group. Seven (38.9%) females and 11 (61.1%) males were included in the superior group, six (33.3%) females and 12 (66.7%) males in the anterior group.

Four patients in the superior group were smokers versus five in the anterior group.

Preoperative

Careful history taking and clinical examination were performed for all patients, then radiographs were done. An informed written consent was obtained from all patients to participate in the study.

Operative

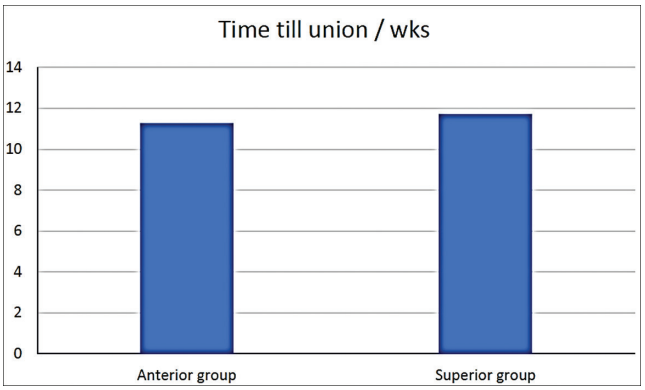
All patients were operated under general anesthesia in the beach chair position under image intensifier guidance, 1 g of ceftriaxone was given on induction to all patients. Diluted adrenaline (1:200 000) was injected subcutaneously to control bleeding. Skin incision over clavicle was performed, the fascia was sharply dissected as a separate layer. The fracture ends were identified, refreshed then either direct or indirect reduction was achieved depending on the fracture pattern. Small fragment set was used for fixation using 3.5 mm reconstruction plates contoured to match the surface it is applied on (Fig. 1). Minimal of six cortices; three proximal and three distal to the fracture site was achieved.

The wound was then closed in layers (platysma, clavipectoral fascia, and the skin). Local anesthetic was infiltrated at the wound edges.

Postoperatively

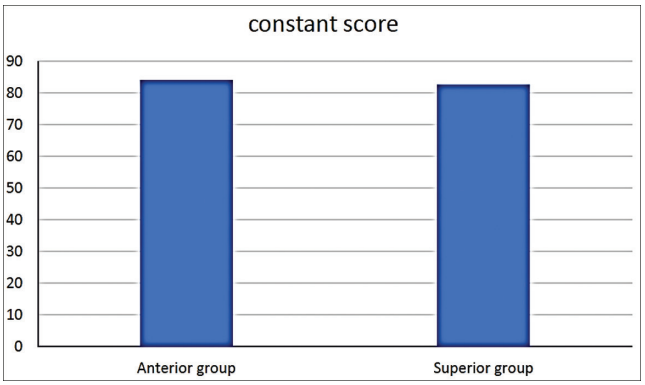
Two doses of i.v. ceftriaxone were given postoperatively. The patient was discharged after a postoperative radiograph was reviewed. Sutures were removed after 2 weeks. Plain radiographs were obtained at 4, 8, and 12 weeks and finally at 6 months. All patients were

Figure 2



Time till union by weeks.

Figure 3



Constant score for both groups.

assessed functionally by constant score and visual analog scale at 6 months postoperatively.

Rehabilitation program

The first 4 weeks, patients used arm sling, passive range of the shoulder joint, active and passive range of elbow were allowed.

The second 4 weeks, if the radiograph showed signs of union, sling was removed and active assisted range of motion (ROM) exercises were started.

After 12 weeks, if radiographs showed complete union, full active range, strengthening exercises, gradual rehabilitation, and return to daily activities were allowed.

Statistical analysis

Sample size: 36 patients were randomized into two groups:

Anterior group: 18 cases of anterior plates.

Superior group: 18 cases of superior plates.

Data were coded and entered using the statistical package for the Social Sciences (SPSS), version 28 (IBM Corp., Armonk, New York, USA). Data was summarized using mean, SD, median, minimum, and maximum in quantitative data and using frequency (count) and relative frequency (percentage) for categorical data. Comparisons between quantitative variables were done using the nonparametric Mann–Whitney test [4]. For comparing categorical data, χ^2 test was performed. Exact test was used instead when the expected frequency is less than 5 [4]. *P* values less than 0.05 were considered as statistically significant.

Results

A total of 36 patients were operated upon and followed up for a mean of 6 months.

Union

The average time to full union was 11.28 weeks (SD 1.9) in anterior group and 11.72 weeks (SD 2.32) in superior group. This showed no statistically significant difference between both groups with a *P* value of 0.534 (Fig. 2).

Constant score

The average score was 84.11 (SD±5.35) for anterior group and 82.67 (SD±6.78) for superior group. There was no statistically significant difference between both groups, with a *P* value of 0.483 (Fig. 3, Table 1).

Visual analog scale score

The average score was 1.28 (SD±1.02) for anterior group and 1.44 (SD±1.25) for superior group. There is no statistically significant difference (Table 2).

Operative time

Average time for anterior group was 61.94 min (SD±8.6) and for superior group was 65.83 min (SD±9.59). Time for superior plating was slightly longer but there was no significant difference between both groups, *P* value 0.209.

Range of motion of shoulder joint

In the anterior group; 17 (94.4%) patients had full ROM and one (5.6%) patient had limitation of final 20° in forward flexion and abduction not affecting activities of daily living. In the superior group, 16 (88.9%) patients had full ROM and two (11.1%) patients had limitation of final 15° in forward flexion and abduction not affecting activities of daily living. There was no statistically significant difference with a *P* value of 1.

Superficial infection

The anterior group had no superficial infections and only one (5.6%) patient of the superior group got superficial infection that was managed successfully by repeated dressing and oral antibiotics.

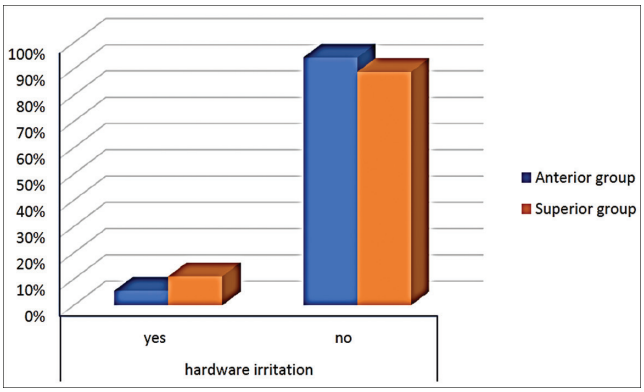
Table 1 Constant score for both groups

Constant score	Anterior group					Superior group					*P* value
	Mean	SD	Median	Minimum	Maximum	Mean	SD	Median	Minimum	Maximum	
	84.11	5.35	82.50	75.00	90.00	82.67	6.78	82.50	70.00	90.00	0.483

Table 2 Visual analog scale score for both groups

	Anterior group					Superior group					*P* value
	Mean`	SD	Median	Minimum	Maximum	Mean	SD	Median	Minimum	Maximum	
Visual analog scale score	1.28	1.02	1.00	0.00	3.00	1.44	1.25	1.00	0.00	4.00	0.791

Figure 4



Hardware irritation in both groups.

Hardware irritation and/or prominence

One (5.6%) case of the anterior group suffered from hardware irritation and two (11.1%) cases of superior group and no one of these patients had limitation of his activities of daily living (Fig. 4).

Need for removal

There was no need for early removal in both groups during the period of the study.

Neurovascular injury

There were no neurovascular injuries in both groups.

Discussion

The most important finding of this study is that there is no significant difference between anterior and superior plating of the clavicle. The choice of which surface to plate is the mere decision of the surgeon depending on his/her experience, the fracture pattern and the plate design available.

Although midshaft clavicle fractures are common upper limb fractures, there is no consensus regarding its management. It can be treated nonoperatively or operatively, however the recent literature has suggested higher nonunion rates and lower functional outcome scores with nonoperative management [5].

There is therefore a growing interest in fixing fractures of the clavicle. That said, there is no consensus on the ideal surface to apply the plate on.

Formaini and colleagues performed a retrospective review in 2013 on a consecutive series of patients who underwent plate fixation for a displaced midshaft clavicle fracture. They concluded that both superior and anterior techniques resulted in a similar time to radiographic union (12.6 ± 4.8 vs. 11.3 ± 5.2 weeks, respectively) and identical union rates (95%) [6].

This is consistent with the findings of this study. It is also worth noting that their mean time to full union was similar to this study. However, in this study, full union was achieved in all patients (100%) versus 95% in their series.

Nourian and colleagues performed a meta-analysis of studies comparing both types of fixations. Results demonstrate that plating along the superior and anterior aspects of the clavicle lead to similar operative outcomes with respect to union (*P*=0.41) and functional scores [7].

In this study, there was also no significant difference between superior plates and anterior plates regarding time to full union. This is consistent with their conclusion.

Ai and colleagues performed in 2017 a meta-analysis of three studies with 199 patients contributed to the analysis of constant score, operative time, and the infection rate. All these variables showed no significant statistical difference in both anterior and superior plating [8]. Martin and colleagues performed a randomized clinical trial on 40 patients comparing both positions of plates and found same results [9,10]. Again their findings were consistent with the findings of this study.

Regarding operative time, Venkatachalam and colleagues, Dhaliwal together with Nourian in 2017 stated that there is no significant difference regarding return to activities and full ROM in both techniques [7,11].

Venkatachalam *et al.* [11] in a nonrandomized retrospective study on 49 patients, reported that there was a total of six implant removals out of which five were in the superior group due to prominent hardware. According to their findings there was higher rates of hardware irritation in the superior group which warranted removal.

Higher rates of asymptomatic patients with the plate still in place were observed in the anterior group also in the study of Hulsmans and colleagues [9,10]. Pointing to higher rate of hardware irritation and implant removal in the superior group.

This study showed similar findings. It is a paradox from what is classically described, where hardware irritation is more expected with anterior plating. It is an observation that is worth further analysis. It might be dependent on the type of plate used. Reconstruction plates might be better conforming when contoured to the anterior surface as compared to the superior surface. The use of the anatomically designed plates might prove differently. Plate designs and manufacturing are continuously evolving to improve implant durability and fracture management, reduction, fixation and respecting the soft tissues. There are new anatomical locked plates designed to be over the superior surface at the lateral end of the clavicle, and over the anterior surface over the medial one-third. This design improves conformity and minimizes hardware irritation.

Conclusion

No significant difference exists between anterior and superior plating of the clavicle. Each has its advantages and disadvantages. However; both achieve equivalent union rates and functional results. The choice of which surface to plate is merely up to the surgeon depending on his/her expertise, the plate design available.

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Nil.

Conflicts of interest
Nothing to declare.

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