RESEARCH ARTICLE

Comparison of Surgical Treatment of Clavicle Fractures Using Superior and Anterior Plates: A Clinical Trial

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Abstract

Objectives: Clavicle fractures are the most common injuries of the scapular girdle. These fractures can be treated surgically using two primary methods: open reduction with internal plate fixation or intramedullary fixation. Plate fixation can be performed in two commonly used positions: anterior and superior. This randomized, double-blind clinical trial aimed to compare the outcomes of superior versus anterior plate fixation in the treatment of clavicle fractures.

Methods: This randomized, double-blind clinical trial focused on patients with clavicle fractures who underwent internal plate fixation between 2020 and 2021. The patients were divided into two groups: the anterior group, which received internal plate fixation using an anterior-inferior plating technique, and the superior group, which received internal plate fixation using a superior plating technique.

Results: A total of 75 patients were included in this study, with an average age of 42.32 years in the anterior group and 40.92 years in the superior group. Sixty-three (84%) of the patients were male, and 39 (52%) of the patients sustained their fractures as a result of vehicle accidents. Patients in the anterior group reported a satisfaction score of 96.68 (±1.13), compared to 58.08 (±12.32) in the superior group ($p<0.05$). Ten (20%) patients in the superior group reported plate-related irritation after three months, while only four (16%) patients in the anterior group experienced irritation ($p<0.05$). Two patients in the superior group developed non-union and required re-surgery. No cases of infection or pneumothorax occurred due to the surgery. Out of the 75 patients included in the study, two in the superior group and one in the anterior group reported a loss of function at the three-month follow-up.

Conclusion: Anterior plating is usually correlated with higher rates of patient satisfaction.

Level of evidence: I

Keywords: Bone plates, Clavicle fractures, Fracture fixation, Orthopedic procedures, Postoperative complications, Quality of life, Surgical technique

Introduction

Clavicle fractures are among the most common fractures, accounting for approximately 2.6% to 5% of all adult fractures and 35% of fractures in the shoulder girdle.[1,2] These fractures make up 10% to 15% of all fractures in athletes and are particularly prevalent in sports such as cycling, skiing, and contact sports.[3,4] In young adults, a clavicle fracture can significantly affect shoulder function, limit physical activity, and reduce quality of life, particularly for those who are active in sports or physically demanding professions.[5]

There are two primary mechanisms of injury for clavicle fractures. The most common is a fall onto the outer side of the shoulder, which accounts for approximately 90% of cases, followed by a fall onto an outstretched arm.[6,7] The

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impact of a clavicle fracture can be significant, as improper healing may lead to long-term complications, including nonunion and malunion. These complications can occur in up to 15% of cases and result in chronic pain, deformity, and reduced shoulder function.[8] Studies show that 30% to 40% of patients experience persistent pain or limited range of motion after inadequate treatment, with up to 20% of athletes reporting long-term functional impairments that hinder their ability to return to their previous level of performance.[9] These complications highlight the need for optimal treatment.

Clavicle fractures are typically nondisplaced and are, therefore, commonly managed nonoperatively. However, there are definite indications for surgery, including absolute indications such as open fractures, neurovascular injury associated with the fracture, or severe comminution. Relative indications for surgical intervention include clavicle shortening >2 cm, displacement >100%, severe comminution, or patient-related factors such as excessive functional demands or cosmetic deformity. High-energy fractures, such as shoulder impaction fractures, are also evaluated for surgery based on their specific characteristics and circumstances.[10-12]

Surgical intervention is typically performed using two primary methods: open reduction with internal plate fixation or intramedullary fixation.[13,14] Plate fixation provides immediate rigid fixation and rotational stability, while intramedullary fixation is less invasive and generally results in a better cosmetic outcome. Intramedullary fixation was previously limited by issues such as implant migration, technical difficulty, and specific complications. However, recent meta-analyses and randomized controlled trials have confirmed that intramedullary fixation is a valid alternative to plate fixation, offering comparable union rates, faster operating times, lower scarring, and excellent cosmetic results in specific patient groups. While plate fixation remains more common, particularly for rigid fixation of comminuted fractures, intramedullary fixation is increasingly recognized as a minimally invasive technique with excellent outcomes.[15-18] Consequently, internal plate fixation could arguably be considered the gold standard for clavicle fracture surgery.[19]

Two central locations are used for plate insertion: the superior or anterior surface of the clavicle. Superior plate insertion is the older, more commonly used method, while anterior plate insertion has been gaining popularity due to its safer approach and reduced irritation.[20] Superior plate fixation has traditionally been the standard due to its straightforward application and the familiarity of most surgeons with this technique. Despite its widespread use, superior plating is associated with several notable complications, including hardware prominence and irritation in patients with lower body mass, as well as a higher risk of neurovascular compromise due to the plate's proximity to critical structures.[21] Additionally, superior plating may not provide adequate biomechanical support for fractures with complex patterns, potentially leading to delayed healing or nonunion.[22] These limitations suggest that, while effective in many cases, the superior plating method may not be ideal for all patients, particularly those with high physical demands or specific fracture types. In contrast, anterior plate insertion offers better biomechanical stability and easier bending during fixation.[23,24] with comparable postoperative outcomes in terms of malunion, complications, and infections.[23,25,26] Some studies[25,27] have attempted to compare the two methods and identify the optimal approach for clavicle fracture fixation; however, the results have been inconclusive, with no clear preference for one technique over the other. Therefore, this study was designed to assess the complications and outcomes of clavicle fracture treatment using either anterior or superior plate fixation. The choice of surgical technique remains controversial, as each approach has distinct advantages and limitations.[27] Evidence directly comparing the outcomes of superior and anterior plating remains limited, with few high-quality studies evaluating long-term complications, functional recovery, or patient-reported outcomes, such as pain and quality of life. The findings from this study have the potential to significantly influence patient outcomes by guiding the choice between superior and anterior plating for clavicle fractures. If one technique demonstrates superior biomechanical stability and comfort, it could lead to faster recovery times, with patients regaining full shoulder function more quickly. Additionally, identifying the plating method that minimizes hardware-related discomfort could reduce postoperative pain, resulting in fewer instances of hardware irritation and a decreased need for secondary surgeries. A reduction in complication rates, such as nonunion or hardware prominence, would likely lower the risk of chronic pain and enhance long-term shoulder mobility. Ultimately, selecting the optimal plating method based on this evidence could improve patients' overall quality of life, facilitating a more comfortable, active recovery and reducing the likelihood of long-term disability or functional limitations.

Materials and Methods

This randomized, double-blind clinical trial, approved by the Isfahan Committee of Ethics, focused on patients with clavicle fractures undergoing internal plate fixation between 2020 and 2021 at Kashani Hospital in Isfahan, Iran. Blinding was partially achieved in this study to minimize potential bias in outcome assessment. Patients were blinded to their treatment group and were not informed whether they received superior or anterior plating. To maintain blinding, incisions and bandaging were kept consistent between groups, making it difficult for patients to identify the plating technique used. However, blinding of caregivers was not feasible due to the specific surgical approaches required for each technique. The visibility of the surgical approach and the location of the incision made it impractical to fully blind the surgical team. To address this limitation and minimize bias, postoperative care protocols were standardized across both groups. Caregivers followed identical pain management, physical therapy, and follow-up schedules, ensuring consistency in post-surgical treatment. To minimize assessment bias, independent assessors, who were not involved in the surgical team and were unaware of the treatment group assignments, were responsible for evaluating patient outcomes, including pain scores, range of motion, and patient satisfaction. These assessors conducted follow-up evaluations at designated intervals and documented results without knowledge of the plating technique used. While complete blinding was not possible due to the nature of the surgical intervention, the use of independent, blinded assessors for outcome evaluations and standardized postoperative care protocols helped reduce potential bias and enhance the overall validity of the study.

Participants eligible for this study were: 1) Adults aged 18 to 65 years with a midshaft clavicle fracture, as this is the most common type requiring surgical intervention. 2) Patients with displaced or comminuted fractures, as classified by radiographic analysis, who require surgical stabilization. 3) Individuals in good general health, with no significant comorbidities that could interfere with healing or affect outcomes, such as uncontrolled diabetes or chronic inflammatory conditions.

To ensure consistency and minimize confounding factors, the following exclusion criteria were applied: 1) Pediatric or elderly patients (under 18 or over 65 years), as bone density, healing rates, and treatment protocols differ significantly in these age groups. 2) Patients with open fractures or those with fractures extending to the distal or proximal clavicle, as these types require alternative treatment approaches that standard superior or anterior plating techniques may not effectively address. The fractures included in this study were midshaft clavicle fractures with comminution or displacement, as determined by standard radiographic assessment. These fractures were not further subclassified beyond the basic descriptions using the AO/OTA system. We recognize that incorporating a more detailed classification system would enhance fracture characterization and increase compatibility with other research. 3) Individuals with prior shoulder surgeries or pre-existing shoulder pathologies, which could complicate postoperative recovery and skew functional outcome assessments. 4) Patients with neurological or musculoskeletal conditions affecting shoulder or upper body function, as these could confound the study's focus on fracture healing and mobility.

Study protocol

Participants were recruited from the orthopedic and trauma departments of Kashani Hospital in Isfahan, Iran, a central healthcare facility serving a diverse population. Recruitment involved screening patients presenting with clavicle fractures at the hospital, followed by a thorough review of their medical history and imaging to assess eligibility. All participants were provided with detailed information about the study's objectives, procedures, and potential risks, and informed consent was obtained before enrollment. Patients were randomly assigned to the anterior or superior plating groups using a computer-generated randomization list in a 1:1 ratio. Group assignments were placed in sealed opaque envelopes and were only opened at the time of surgery by a surgical coordinator who was not involved in patient follow-up or outcome assessment. This process ensured proper allocation concealment and minimized selection bias. Patients were divided into two groups: the anterior group, which underwent internal plate fixation using an anterior-inferior plating technique, and the superior group, which underwent internal plate fixation using a superior plating technique. All procedures were performed by two senior orthopedic trauma surgeons, each experienced in both anterior and superior plating. Both surgeons had an equal number of cases to avoid performance bias.

Surgical Procedure and Techniques:

1- Preoperative Preparation: Patients were placed under general anesthesia, and the affected arm was positioned to provide full access to the clavicle. The patients were positioned in a supine position with a small roll placed between the scapulae to elevate the chest and facilitate maximum exposure of the clavicle. The injured arm was crossed over the abdomen to further enhance access to the clavicle. Standard antiseptic protocols were followed to sterilize the surgical area, and sterile drapes were applied to isolate the surgical site. A preoperative antibiotic (e.g., cefazolin) was administered intravenously 30 minutes before the incision to reduce the risk of infection.

2- Incision and Exposure: For superior plating, a horizontal incision approximately 6-8 cm in length was made over the superior aspect of the clavicle, centered on the fracture site. The subcutaneous tissues were gently retracted to expose the bone surface. For anterior plating, a vertical incision of approximately 6-8 cm was made along the anterior surface of the clavicle. The incision followed the natural contour of the clavicle to maintain cosmesis and minimize hardware prominence postoperatively.

3- Type of Plate Used: In both approaches, a pre-contoured 3.5 mm locking compression plate (LCP) was used to stabilize the fracture. This plate was selected for its strength and its ability to closely conform to the natural contour of the clavicle, thereby enhancing stability.

4- Fixation Technique:

Fracture Reduction: Using reduction clamps, the fracture was carefully aligned to restore anatomical positioning. Temporary K-wires were then inserted to hold the fragments in place during fixation.

Superior Plating Fixation: In the superior group, the LCP was positioned directly on the superior surface of the clavicle. Screws were inserted both proximally and distally across the fracture line, with at least two screws on each side to achieve stable fixation. Bicortical screws were used to provide additional stability [Figure 1].

Anterior Plating Fixation: For anterior plating, the LCP was positioned on the anterior surface of the clavicle. The plate was secured using bicortical screws placed on both sides of the fracture, with at least two screws on each fragment. Care was taken to avoid over-tightening the screws to prevent stress on the bone. [Figure 1.]

In all instances, the fixation technique aimed to achieve final stability through the restoration of anatomical reduction and rigid fixation using pre-contoured locking compression plates (LCP). Direct compression was applied over the fracture line whenever possible, utilizing compression slots or lag screws, especially in simple or wedge fractures. In comminuted fractures, where direct compression was not advisable, bridging plating was performed, maintaining a stable construct. Bilaterally, bicortical screws were inserted into the fracture to provide added stability and reduce micromotion.

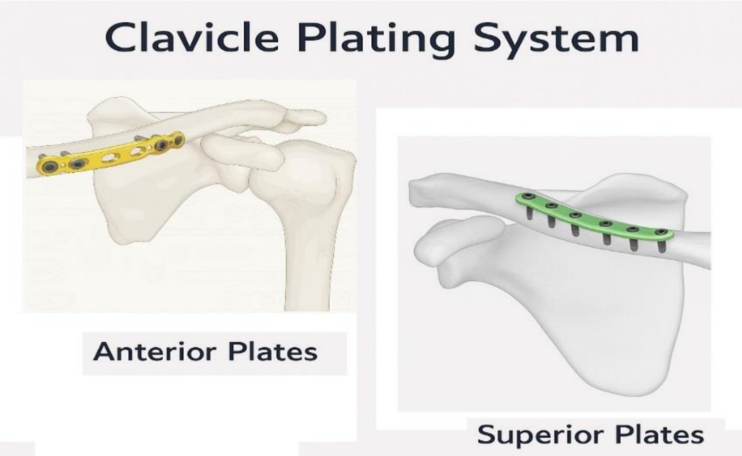

Figure 1.Anterior and Superior plates for clavicle fractures

Postoperative Protocols:

1- Pain and Postoperative Management: Patients were screened for immediate surgical complications, such as pneumothorax or infection, as well as late complications like neurovascular damage. Follow-up appointments were scheduled at two-week, six-week, and three-month intervals. Patients received a standardized regimen, starting with intravenous acetaminophen and NSAIDs, with limited short-term opioid use for severe pain. After 48 hours, oral medications were prescribed, with opioids being discouraged after five days to prevent dependency.

2- Immobilization: The affected arm was immobilized in a sling for two weeks to support initial healing, with strict activity restrictions during this period. Patients were instructed not to actively abduct or elevate the shoulder above 90 degrees and were advised against lifting weights over 1–2 kilograms. Pain-free passive range-of-motion exercises below shoulder level were permitted, but only under the supervision of physiotherapists.

3- Follow-Up Schedule: Patients attended follow-up visits at two, six, and twelve weeks post-surgery. These visits monitored healing through incision checks, radiographs, and mobility assessments, gradually transitioning patients from immobilization to more active use. The range of motion in the shoulder, as assessed by an orthopedic surgeon during physical examination, pain score (measured on a visual analog scale [VAS]), and complications, including malunion or non-union, were recorded at the two-week, six-week, and three-month intervals. Patients were asked to rate their overall satisfaction with the surgery on a scale of one to 100 after three months, and the need for revision surgery was also recorded. Return of function was defined as the patient resuming normal day-to-day activities without limitation due to the fracture.

4-Rehabilitation Program: Recovery involves three phases:

Weeks 2-6: Passive range-of-motion exercises to prevent stiffness.
Weeks 6-12: Active range-of-motion and light resistance training.
After 12 Weeks: Strengthening exercises and gradual return to complete activities after confirmed healing.

5-Patient Education: Patients were instructed on the proper use of the sling, safe movements, and how to recognize potential complications, with an emphasis on adhering to rehabilitation guidelines and activity restrictions for successful recovery.

Outcomes:

Primary Outcomes: Postoperative pain was assessed using the VAS scale at 2, 6, and 12 weeks, while fracture healing was evaluated through radiographs at 6 and 12 weeks, with outcomes categorized as complete, delayed, or nonunion.

Secondary Outcomes: Patient satisfaction (on a 0-100 scale), range of motion (measured with a goniometer), complication rates, and quality of life (assessed using the SF-36 questionnaire) were evaluated at various postoperative intervals, with a focus on functional recovery, complications, and overall well-being.

Statistical analysis

Statistical analysis was performed by a statistician who was blinded to the group assignments of the patients. Qualitative data are reported as frequencies with percentages, and quantitative data as means with standard deviations. Statistical analysis was conducted using SPSS version 25 (SPSS Inc., Chicago, IL, USA). Qualitative data were analyzed using chi-square tests, and quantitative data were analyzed using an independent t-test. The significance level was set at a p-value <0.05.

Availability of Data

The underlying, de-identified data used to support the conclusions of this study are available upon reasonable request to the corresponding author.

Results

In our study, we assessed 90 patients for eligibility. Two patients were excluded as they were above the age limit for our research, three declined to participate, and three opted out for other reasons. Patients were initially allocated using a 1:1 computer-generated randomization sequence. Superior plating was performed in more patients due to logistical issues, such as the temporary unavailability of anterior plates and the non-uniform distribution of the daily surgical load. Out of the 82 patients, 25 were assigned to anterior plating and 57 to superior plating. After seven superior plating patients were lost to follow-up, the analysis included 75 patients (25 anterior, 50 superior). Although the group sizes were imbalanced, baseline clinical and demographic characteristics were statistically similar between the groups [Figure 2].

In total, 63 (84%) patients were male and 12 (16%) were female. The most common mechanism of fracture was vehicular accidents (65.3%), followed by falls (30.6%). The average age was 41.33 (±11.77) years. Patients did not have any relevant comorbidities. [Table 1] shows that the two groups are well matched on demographic, clinical, and baseline outcome factors, including fracture type. Specifically, no statistically significant differences were observed between the groups in the rate of displaced fractures (anterior: 86.5%, superior: 83.8%) or comminuted fractures (anterior: 13.5%, superior: 16.2%), with p-values of 0.76 for both.

The lack of statistically significant differences ($p > 0.05$ for all characteristics) indicates that randomization effectively balanced the groups, supporting the validity of subsequent treatment comparisons [Table 1].

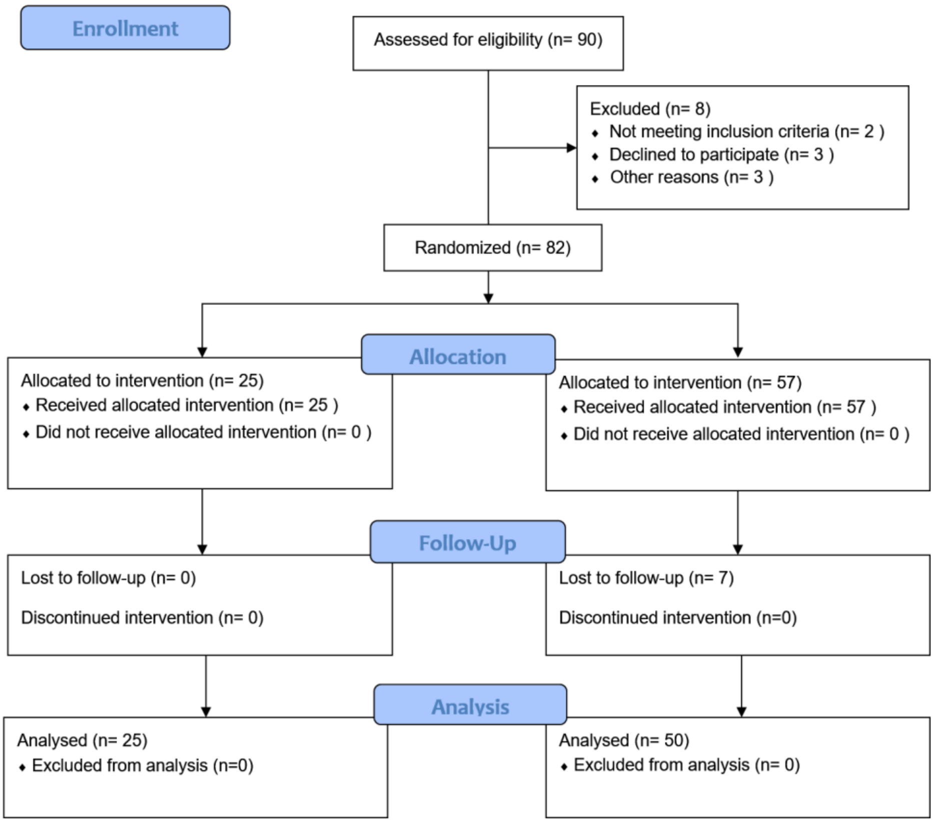

Figure 2. Inclusion criteria and analysis diagram of the patients

Table 1. Demographic characteristics of the patients

Group		Anterior	Superior	P-value
Gender, n (%)	*Male*	20 (80%)	43 (86%)	0.437
	Female	5 (20%)	7 (14%)	
Fracture mechanism, n (%)	*Vehicle accident*	16 (64%)	33 (66%)	0.598
	Falling	8 (32%)	15 (30%)	
	Others	1 (4%)	2 (4%)	
Age, years average (±SD)		42.32 (±12.67)	40.92 (±11.45)	0.619
BMI (kg/m^2)		24.6 ± 3.2	25.1 ± 3.4	0.54
Smokers (%)		48.6%	54.1%	0.68

Table 1. Continued

Fracture Type - Displaced (%)	86.5%	83.8%	0.76
Fracture Type - Comminuted (%)	13.5%	16.2%	0.76
Dominant Side Fracture (%)	56.8%	51.4%	0.64
Baseline Pain (VAS)	6.8 ± 1.2	6.7 ± 1.3	0.89
Baseline ROM - Flexion (°)	110.5 ± 15.4	109.8 ± 16.2	0.84
Baseline ROM - Abduction (°)	102.3 ± 14.6	100.9 ± 15.3	0.72

On average, surgery took 58.12 (±3.12) minutes, with the anterior group requiring an average of 65.96 (±4.93) minutes, significantly longer than the 53.8 (±2.11) minutes in the superior group (p<0.001). Range of motion was similar in both groups after two weeks, with 100.04 (±10.52) and 92.93 (±22.93) degrees in the anterior and superior groups, respectively (p>0.05); however, at the six-week and three-month follow-ups, both groups demonstrated a full range of motion in the shoulder. The average pain score in the anterior group was 3.56 (±0.82), and 3.66 (±1.17) in the superior group (p>0.05), decreasing to 0.64 (±0.7) in the anterior group and 0.76 (±1.03) in the superior group after three months (p>0.05). The average time until the arm was fully functional was 5.82 (±1.66) weeks in the anterior group and 5.21 (±1.81) weeks in the superior group (p>0.05). Four patients (16%) in the anterior group and ten patients (20%) in the superior group reported irritation and the sensation of the plate after three months. Two patients in the superior group developed non-union and required re-surgery. There were no cases of infection or pneumothorax related to surgery. Out of the 75 patients included in this study, two patients in the superior group and one patient in the anterior group reported a loss of function even at the three-month follow-up [Table 2].

Table 2.Surgical outcome of the patients. p-value was calculated using an independent T-test with significance defined as p<0.05.

Group		Anterior	Superior	P-value
Surgery duration, average minutes (±SD)		65.96 (±4.93)	53.8 (±2.11)	<0.001
Shoulder abduction, average degrees (±SD)	*2 weeks*	90.04 (±10.52)	88.93 (±22.93)	0.142
	6 weeks	120	120	n/a
	3 months	120	120	n/a
Shoulder flexion, average degrees (±SD)	*2 weeks*	74.33 (±8.75)	73.25 (±8.88)	0.114
	6 weeks	90	90	n/a
	3 months	90	90	n/a
Shoulder extension, average degrees (±SD)	*2 weeks*	30.17 (±4.14)	29.87 (±4.33)	0.557
	6 weeks	60	60	n/a
	3 months	60	60	n/a
VAS pain score, average (±SD)	*2 weeks*	3.56 (±0.82)	3.66 (±1.17)	0.619
	6 weeks	2.66 (±0.94)	2.96 (±1.47)	0.68
	3 months	0.64 (±0.7)	0.76 (±1.03)	0.576
Surgical complications, n (%)	*Pneumothorax*	0	0	n/a
	Infection	0	0	
	Neurovascular damage	0	0	
Time until full function, average weeks (±SD)		5.82 (±1.66)	5.21 (±1.81)	0.432
Satisfaction, average (±SD)		96.68 (±1.13)	58.08 (±12.32)	<0.001
Irritation after three months, n (%)		4 (16%)	10 (20%)	0.024

Discussion

This was a randomized, double-blind clinical trial aimed at assessing the outcomes of anterior plate fixation versus superior plate fixation for clavicle fractures. We found that anterior plate fixation surgery took significantly longer. However, patients in the anterior plating group reported higher satisfaction scores after three months. This difference was primarily due to discomfort from feeling the superior plate, even though no pain was noted. Full functionality and complete range of motion were regained in a similar time frame between the groups. While we do not expect shoulder movement to be significantly affected in isolated clavicle fractures, patients typically refrain from movement in the first weeks after surgery due to pain in the clavicle and discomfort during shoulder movement. Surgical complications were also similar between the two groups. We did not observe any cases of neurovascular damage or infection, and the only cases of non-union were mainly due to personal factors, as these patients tended to be heavy smokers and used corticosteroids regularly.

Midshaft clavicle fractures in adults are treated in a variety of ways. Historically, non-surgical treatment was preferred for midshaft clavicle fractures, even in cases of apparent displacement, due to its extremely low nonunion rate.[28] However, more recent data suggest that fractures with significant displacement (>2 cm shortening or >100% displacement) and/or comminution have better short-term outcomes and lower rates of nonunion with surgical management.[29] Several studies have compared the two surgical methods for clavicle fractures. One randomized controlled trial in Korea demonstrated similar surgical properties between the two methods, but anterior plating provided better clinical outcomes.[30] A large-scale review and meta-analysis by Nourian et al. reported similar functional outcomes between the two methods, which is consistent with our findings. They also reported identical union rates, although patients in the superior group had a higher probability of experiencing symptomatic hardware.[31] All of these findings are consistent with our study. However, another large-scale review by Hulsmans et al. reported a higher rate of asymptomatic patients in the anterior plating group, although implant removal rates were similar in both groups. They concluded that no correlation exists between the surgical approach to plating and implant-related irritation.[32] While studies focusing on outcomes and patient experiences exist, some have also examined the biomechanical features of each plate. Studies have shown that superior plating performs better under axial compression and anterior cantilever bending.[33] A review study with meta-analysis by Nourian et al. demonstrated that plating along the superior and anterior aspects of the clavicle led to similar operative outcomes in terms of union, nonunion, malunion, and implant failure, as well as similar functional outcome scores. Plates applied to the superior aspect of the clavicle are associated with higher rates of symptomatic hardware and more frequent implant removal,[34] a finding that is consistent with our study. Additionally, Serrano et al. reported less irritation and fewer symptomatic patients in those with anterior clavicle plating.[35]

Studies focused on complications secondary to plate implantation have noted that plate fixation is a safe method with low rates of surgical complications. Cho et al. reported a nonunion and malunion rate of less than 10% in their study, with the most common complication being hypertrophic scarring in 18%, followed by limitation of shoulder movement in 9%.[36] In our study, we reported limitation of movement in only 4% of cases, which is significantly lower. Formaini et al. also reported a nonunion rate of about 5%,[37] while we observed no cases of nonunion. This discrepancy could be attributed to the larger sample size in their study compared to ours. Wound and deep infections were also rare in most studies on this topic. For instance, Ferran et al. reported an infection rate of about 7%, all of which were superficial wound infections,[38] while the Canadian Orthopaedic Trauma Society reported an infection rate of 3%.[39] Although we reported no cases of infection, this may be due to our smaller sample size and the more rigorous antibiotic therapy regimen used in our study.

This research has several limitations. Firstly, the study was conducted at a single institution, which may limit the generalizability of the findings to other hospitals or cohorts. Secondly, although we used a computer-generated randomization sequence, practical considerations led to unequal group sizes. Thirdly, while double-blinding was attempted, the palpability of the implant and variations in incision sites may have compromised both patient and assessor blinding, potentially affecting subjective outcomes such as satisfaction and pain. Fourth, fractures were not systematically categorized according to the AO/OTA classification, preventing subgroup analysis of fracture complexity. Additionally, seven patients (12.3%) in the superior group were lost to follow-up and did not meet the inclusion criteria for analysis. This exceeds the acceptable loss rate and may have introduced attrition bias. Although demographic information showed no statistically significant differences between included and lost patients, this limitation affects the internal validity of the results. Future multicenter trials with standardized classification and larger, more diverse patient populations are advisable.

This study incorporates several methodological strengths aimed at addressing limitations observed in previous research on clavicle fracture treatment. First, by implementing a randomized, controlled trial design, this study minimizes selection bias and enhances the reliability of its findings, ensuring that any differences in outcomes can be more confidently attributed to the plating technique itself. The trial employed an independent, computer-generated 1:1 randomization list, with group allocation concealed in sealed opaque envelopes that were opened solely immediately before surgery by non-clinical staff. This ensured that allocation was independent of surgeon or patient variables. Although unequal group sizes arose due to logistical factors, the randomization process was unbiased, and the study thus qualifies as a randomized trial. Additionally, unlike many prior studies, this research included a double-blind assessment for postoperative evaluations, where both patients and assessors were unaware of the treatment group. This blinding approach helps reduce observer and response bias, particularly when assessing subjective outcomes such as pain and satisfaction.

Moreover, this study uniquely includes patient-reported outcome measures (PROMs), providing insights into patients' perspectives on comfort and quality of life, an area often overlooked in previous research. By capturing both objective and subjective data, the study offers a comprehensive view of the effectiveness of each plating technique. Finally, a standardized postoperative care protocol was applied to all participants, minimizing variability in recovery practices that could otherwise confound the results. Together, these design choices enhance the study's validity and provide valuable evidence to inform surgical decision-making.

Generalizability is also a concern. Anterior plating may be technically more challenging than superior plating, as it requires finer contouring and careful avoidance of neurovascular structures. The favorable outcomes observed in this study may be attributed to the expertise of high-volume orthopedic trauma surgeons specialized in these procedures. Institutions with less experience in anterior plating techniques may face a steeper learning curve, which should be considered when applying the findings to general practice.

Beyond the statistical differences, our results also have clinical implications. The improved satisfaction ratings and decreased irritation in the anterior plating group indicate a significant subjective improvement in patient comfort, particularly for thinner patients who are more prone to hardware prominence. Although anterior plating did result in a modest increase in operative time, this may be an acceptable trade-off for better patient-reported outcomes.

It should be noted that functional results must be considered with some qualifications. Although statistically significant, the 5.4-point difference in the mean DASH score between groups is smaller than the commonly cited Minimally Clinically Important Difference (MCID) for shoulder disorders, which ranges from 10 to 15 points. This suggests that, while a difference exists, its impact on patients' self-assessed function may be modest. However, when combined with higher satisfaction and a lower demand for hardware removal, anterior plating may still offer an improved overall recovery experience in well-selected patients.

While irritation was more frequently noted in the superior plating cohort (20% compared to 16%), no patient in either group required implant removal up to the three-month follow-up. This suggests that while irritation may affect patient satisfaction, it did not progress to the point of necessitating surgery during the initial postoperative period. Longer-term follow-up would be required to determine the actual rate of secondary surgery for pain related to hardware.

Conclusion

In conclusion, this study supports and extends prior research by demonstrating that anterior plating not only achieves similar fracture healing rates but also offers significant advantages in early pain reduction, improved range of motion, and reduced hardware prominence. These findings are consistent with biomechanical studies indicating that anterior plating provides a better distribution of mechanical stress, particularly against cantilever bending forces, potentially reducing hardware irritation [23, 33]. While both anterior and superior plating are effective for treating clavicle fractures, each technique presents considerations that warrant further investigation. Anterior plating may be more acceptable to patients due to its less symptomatic nature, whereas superior plating is easier to implant. Biomechanical differences also exist; however, this was not the focus of our study. We suggest that future research include different types of clavicle fractures with larger sample sizes to better clarify which plating technique is most suitable for specific situations. One factor to consider is that anterior plating is a newer method, and orthopedic surgeons may not yet be as familiar with it. Although anterior plating offers distinct advantages, it may require a higher level of technical skill due to the differences in surgical approach. This can result in longer surgical times; however, due to its significantly lower complication rate and higher patient satisfaction, it appears to be the preferred method overall. While anterior plating shows promise as a favorable option for treating midshaft clavicle fractures in carefully selected patients, individualized treatment decisions should consider patient-specific factors such as BMI, fracture type, and comorbidities. The findings of this study provide valuable evidence to guide surgical decision-making and underscore the need for further research to expand these conclusions to broader populations.

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