Clavicle Fracture: MIPO Superior Fixation Technique

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ABSTRACT

Introduction: Since Neer's foundational work, the superiority of surgical treatment over conservative management for displaced clavicle fractures has been established. However, open techniques carry risks such as sensory nerve injury, stretching, and painful scarring. The MIPO (minimally invasive plate osteosynthesis) technique may mitigate these complications. This retrospective series evaluates our experience with closed, displaced, midshaft clavicle fractures, describes the surgical technique with emphasis on the approach, and presents functional outcomes. **Material and Methods:** We retrospectively analyzed 32 patients (28 men [87.5%] and 4 women [12.5%]) with closed, simple, or comminuted fractures of the middle third of the clavicle treated surgically between January 2021 and March 2023. The average follow-up was 19 months (range 14–25), and the mean patient age was 32 years. Exclusion criteria included patients under 16 years old, associated injuries, and significant comorbidities. Functional outcomes were assessed using the ASES and the visual analog scale (VAS) for pain. **Results:** Surgery was performed within 3 days of injury, and radiological consolidation occurred at an average of 15.6 weeks. The mean modified Constant-Murley score was 88.34, the mean ASES score was 83.8, and the mean VAS pain score was 0.5. No cases of subclavicular hypesthesia or painful scarring were reported. **Conclusion:** This technique achieved fracture consolidation and full range of motion while minimizing complications. The MIPO approach, with its simple and reproducible parameters, can be considered a safe option.

Keywords: Fracture; clavicle; MIPO; nerve injury.
Level of Evidence: IV

Fractura de clavícula: técnica MIPO de fijación por la cara superior

RESUMEN

Introducción: A partir de los estudios clásicos propuestos por Neer, se ha establecido que los resultados de la cirugía abierta son superiores a los del tratamiento conservador en las fracturas desplazadas de clavícula. Sin embargo, la técnica abierta no está exenta de complicaciones (lesión nerviosa sensitiva, desperiostizaciones, cicatriz dolorosa). La aplicación de la técnica MIPO permitiría disminuir estos riesgos. **Objetivos:** Comunicar nuestra experiencia en fracturas cerradas, desplazadas y mediodiafisarias de clavícula; describir la técnica quirúrgica focalizando en el abordaje y mostrar los resultados funcionales. **Materiales y Métodos:** Serie retrospectiva de 32 pacientes (28 hombres [87,5%] y 4 mujeres [12,5%] con fracturas del tercio medio de la clavícula, cerradas, con trazos simples y conminutos, operados entre enero de 2021 y marzo de 2023. La edad promedio era de 32 años y el seguimiento promedio fue de 19 meses (rango 14-25). Se realizaron controles radiográficos y se evaluó la función mediante la escala de Constant-Murley modificada, la escala ASES y la escala analógica visual para dolor. **Resultados:** El tiempo hasta la cirugía fue de 3 días, se constató la consolidación radiológica en una media de 15.6 semanas. El puntaje promedio de Constant-Murley modificado fue de 88,34; el puntaje ASES, de 83,8 y el de la escala analógica visual, de 0,5. No se reportaron hipoestesias subclaviculares ni dolor en la cicatriz. **Conclusiones:** Se logró la consolidación y la movilidad completa, evitando morbilidades y complicaciones asociadas. La MIPO, a partir de parámetros técnicos simples y reproducibles, es una opción segura.

Palabras clave: Fractura de clavícula; MIPO; lesión nerviosa.
Nivel de Evidencia: IV

INTRODUCTION

Clavicle fractures are classified into medial, middle, and lateral thirds, with fractures of the middle third accounting for 80% of all clavicle fractures.[1] Surgical treatment of fractures in the middle third has demonstrated better outcomes in terms of healing time and reduced risk of pseudoarthrosis.[2,3]

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Open reduction and internal fixation with plates and screws for clavicle fractures is not without complications. These include pseudoarthrosis in areas with significant bone resorption, wound infections, implant intolerance, sensory loss in the infraclavicular region, cosmetic concerns, and painful scars.[4,5]

Alternative techniques, such as intramedullary nailing, cause less surgical trauma but carry risks of fragment rotation and significant challenges during reoperations for implant removal. Pin osteosynthesis alone has been associated with inadequate fixation and implant migration.[6,7]

The MIPO (minimally invasive plate osteosynthesis) technique has yielded favorable outcomes in diaphyseal fractures of the upper and lower limbs.[8,9] This method achieves relative stability while preserving the biological benefits of the fracture hematoma, as it avoids direct invasion of the fracture site and minimizes extensive soft tissue dissection.[5-9]

However, the clavicle presents unique technical challenges for reduction and implant placement, along with increased neurovascular risks.[10]

The objectives of this study are to present our experience with closed, displaced, mid-diaphyseal clavicle fractures; to describe the surgical technique with an emphasis on reducing sensory nerve injury and optimizing surgical times; and to report the functional outcomes.

MATERIALS AND METHODS

This retrospective study included a series of 32 patients (28 men [87.5%] and 4 women [12.5%]) with closed, simple, or comminuted fractures of the middle third of the clavicle, treated surgically between January 2021 and March 2023. The mean follow-up period was 19 months (range: 14–25 months). Patients were aged between 18 and 72 years (mean: 32 years); 21 fractures were on the right clavicle and 11 on the left.

Anatomically contoured locking plates specifically designed for the clavicle were used in all patients. Radiographic follow-up was performed, and functional outcomes were assessed using the modified Constant-Murley score, the ASES (American Shoulder and Elbow Surgeons) score, and a visual analog scale (VAS) for pain.

Inclusion criteria were: acute fractures, with a maximum of 72 h, fractures in the middle third, closed, displaced with more than 2 cm of shortening or overriding, without fragment contact, simple or comminuted traces; age >16 years.

Exclusion criteria were: associated neurovascular injuries, open fractures, associated fractures, clavicle fractures outside the middle third; comorbidities (diabetes, smoking, alcoholism, etc.), age <16 years.

Radiological follow-up was conducted at 1 week and 4 weeks postoperatively, and then biweekly until complete callus formation was observed.

Surgical Technique

The patient is placed in a beach chair position on a radiolucent table. An interscapular bolster is placed to facilitate fracture reduction (Figures 1 and 2). The affected upper limb is left free to allow manipulation during the operation. The C-arm is positioned at the bedside, ensuring the surgeon has unrestricted mobility. Before the surgery, the fracture line and clavicle boundaries are identified with radiological guidance, and the incision is marked using a guide implant identical to the one to be used.

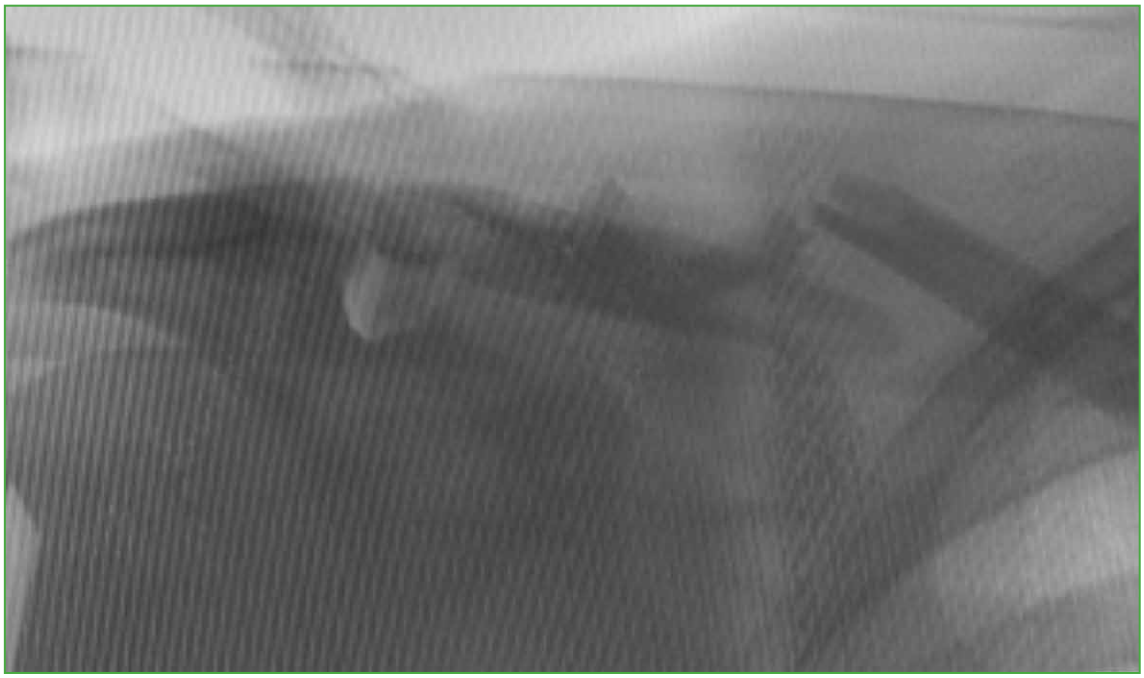

Figure 1. Image intensifier, AP view. Displaced segmental middle third fracture.

Figure 2. Preoperative oblique clavicle radiograph.

To protect the sensory branches of the supraclavicular nerve, specific anatomical landmarks are utilized. A medial point is marked 2.5–4 cm from the acromioclavicular joint, and a lateral point is marked 4–6 cm from the sternoclavicular joint. This creates a 9 cm margin where three terminal branches of the medial trunk of the supraclavicular nerve can typically be found (Figure 3). The lateral trunk, which provides sensory innervation to the shoulder above the circumflex, lies outside the surgical field.[11]

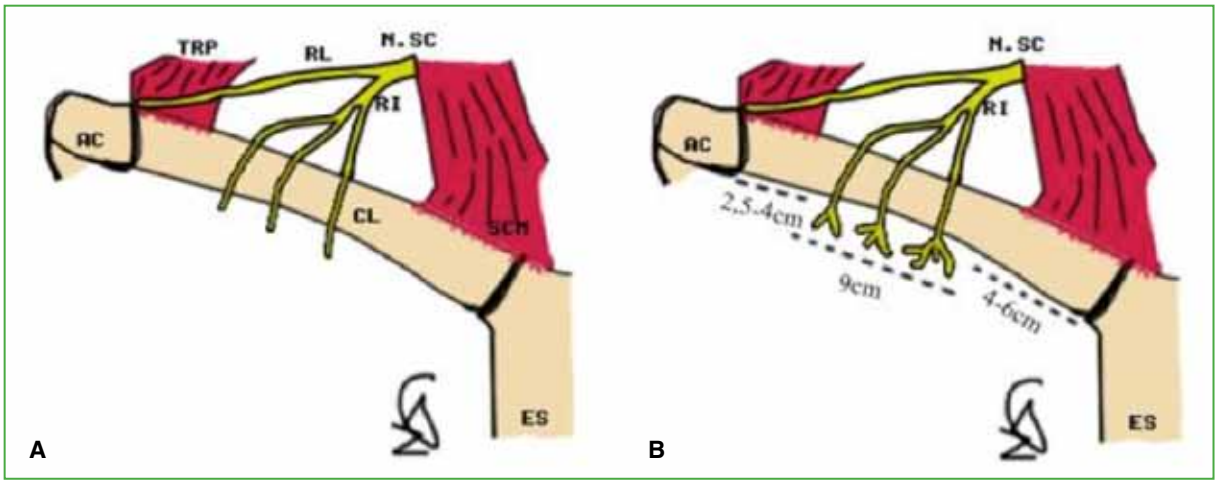

Figure 3. Representation of the innervation of the supraclavicular sensory branches.

The superior aspect of the clavicle is approached by making a skin incision 1 cm lateral and medial to the fracture (Figure 4), extending through the skin and exposing the platysma. Subcutaneous blunt dissection is performed between the periosteal plane and the platysma to avoid injury to sensory branches. If proper fracture reduction is not achieved using the beach chair position and interscapular bolster, indirect maneuvers such as shoulder mobilization (elevation and retraction) or digital compression at the fracture site can be employed. In cases where these methods are insufficient, direct maneuvers may involve placing K-wires (Figure 5) into both fragments to facilitate reduction.

Figure 4. Radiologcally demarcated approaches.

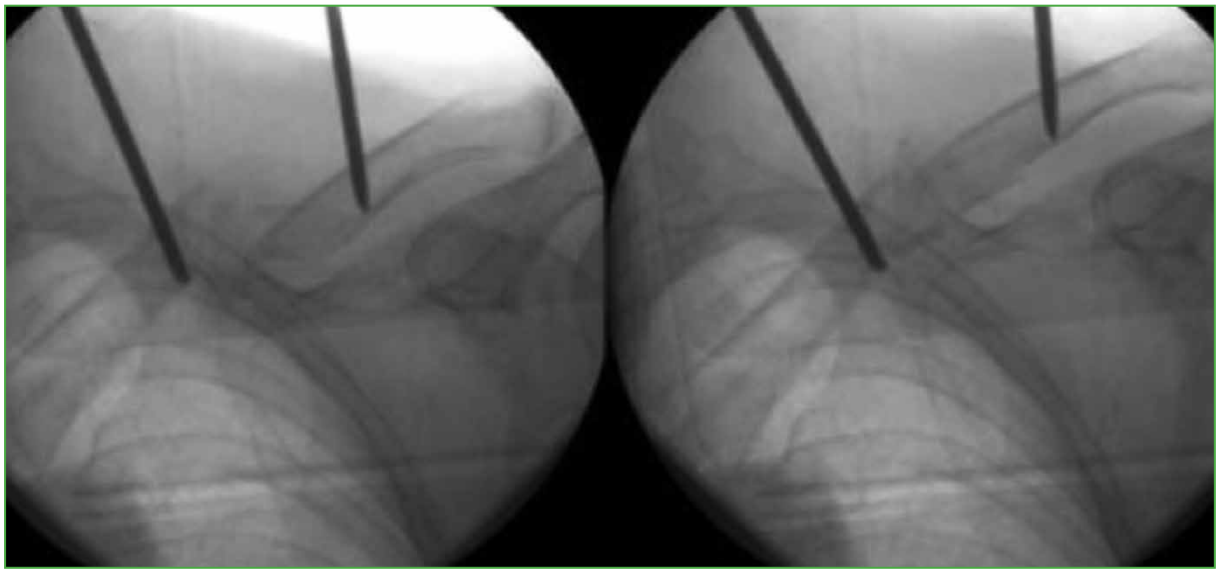

Figure 5. Fracture reduction using *joystick* pins.

Timely surgical intervention is crucial to prevent soft callus formation, which can hinder effective fracture reduction.

Once the fracture is reduced and confirmed using the C-arm, the implant (Figure 6) is slid along the superior aspect of the clavicle. It is initially fixed with one screw on each side (medially and laterally) to restore clavicular length. The remaining screws are then placed to ensure stable fixation, maintaining contact between the main fragments. Bicortical locking screws are preferred, especially medially, where care must be taken to avoid injury to neurovascular structures due to drill penetration or screw length. Alternatively, cortical screws may be used initially to minimize implant prominence, which can cause patient discomfort. Locking screws can then be added for enhanced stability. For challenging reductions, joystick-like pins (minimum diameter 2.5 mm) can be used to restore clavicular length (Figure 5). The reduction is completed by adjusting plate interference (Figure 7), pulling the displaced fragments toward the plate using cortical screws before completing fixation with locking screws.

After implant fixation, the platysma, subcutaneous tissue, and skin are sutured to provide optimal implant coverage.

Figure 6. Blunt passage of the implant under the platysma.

Figure 7. Approximation of the implant to the bone with cortical screw.

Intraoperative fluoroscopic control with the C-arm (Figure 8) is essential to verify fracture reduction, implant positioning, and screw length. Positioning the C-arm at the patient's head helps ensure free movement for the surgical team.

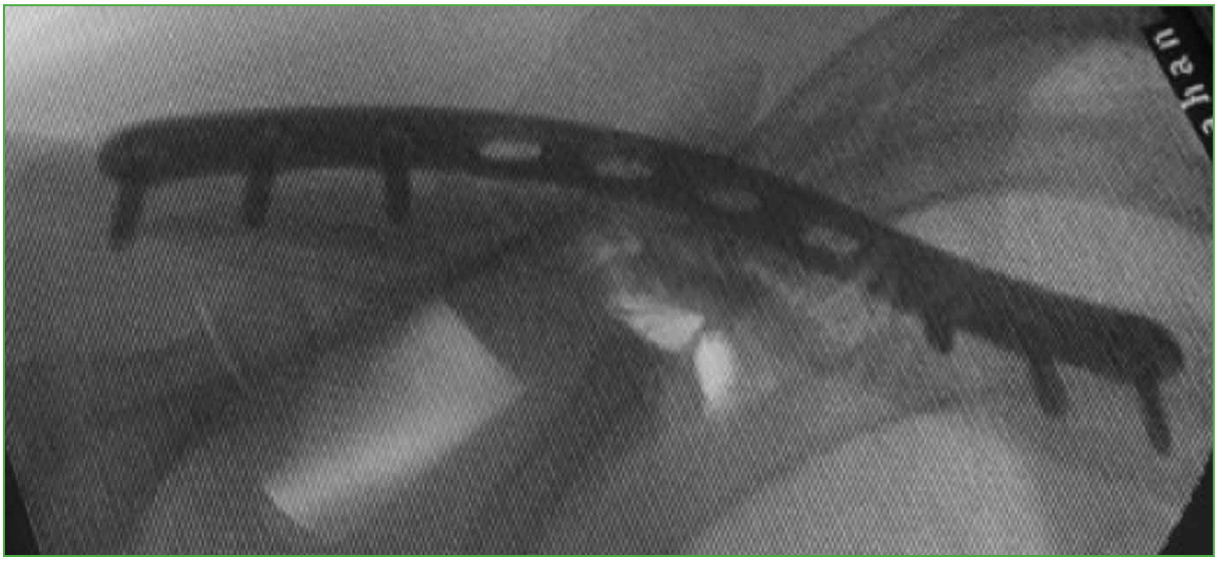

Figure 8. Postoperative radiological control. Anatomical plate acting as a bridge.

RESULTS

The duration of surgery ranged from 32 to 95 minutes (mean: 42 minutes). Consolidation was achieved in all patients within 13 to 21 weeks (mean: 15 weeks) (Figure 9).

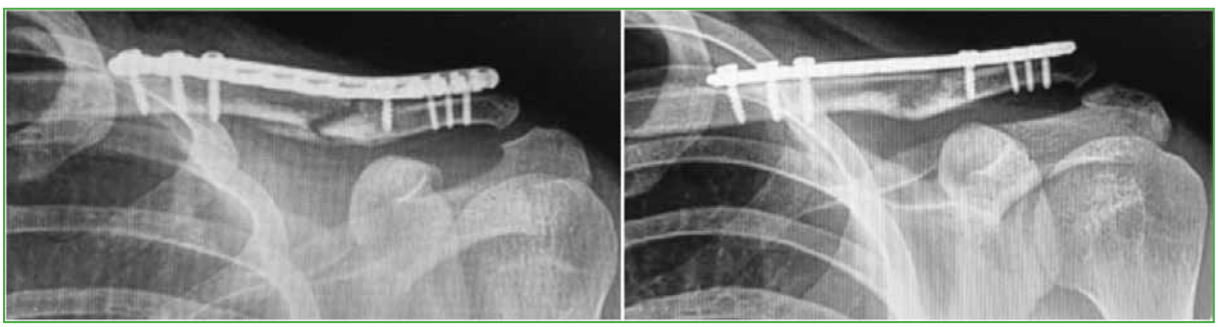

Figure 9. Postoperative radiological control. Anatomic plate acting as a bridge.

Range of motion (ROM) was assessed using a goniometer. All patients regained ROM comparable to the non-operated side. Average measurements were as follows: flexion 178°, extension 35° and abduction 85° (Figure 10).

No implants required removal. There were no cases of wound infection, vascular injury, or hypoesthesia in the infraclavicular region (Figure 11).

Figure 10. Mobility one month after surgery. **A.** Shoulder at rest. **B.** Shoulder in maximum abduction.

Figure 11. Remote evolution of the surgical wound.

One patient developed medial and lateral keloids. A scar revision was performed using a lozenge excision, followed by the application of Steri-Strip® tapes to reduce tension in the surgical area, resulting in satisfactory healing.

The results of the series are summarized in the Table. In the Constant-Murley scale, Spanish version for Argentina,[12] the average score was 88.34 (range 78-100). The average score of the ASES scale was 83.8 (range 76-89).[13] The pain score according to the visual analog scale was, on average, 0.5 (range 0-2).

Table. Data from the retrospective series.

Pacient	Age	Sex	ASES Score	Constant-Murley Score	Visual analog scale for pain
1	30	Male	83	80	1
2	25	Female	89	96	0
3	16	Male	85	92	0
4	69	Male	85	100	0
5	31	Male	77	60	3
6	17	Male	85	88	1
7	26	Female	76	83	2
8	27	Male	82	100	0
9	16	Male	84	100	0
10	55	Male	85	78	1
11	55	Male	85	79	1
12	50	Male	81	80	2
13	41	Male	85	84	1
14	44	Female	85	88	1
15	19	Male	82	69	2
16	31	Male	81	70	1
17	67	Male	79	86	2
18	48	Male	88	88	1
19	50	Male	78	75	2
20	72	Male	84	86	1
21	29	Female	88	89	0
22	18	Male	86	90	0
23	35	Male	80	89	1
24	40	Male	82	88	1
25	41	Male	86	100	0
26	18	Male	89	86	0
27	31	Male	86	94	0
28	30	Male	87	85	0
29	25	Male	86	98	0
30	25	Male	86	100	0
31	27	Male	87	100	0
32	44	Male	80	91	2

ASES = *American Shoulder and Elbow Surgeons*.

DISCUSSION

The application of the MIPO principle minimizes disruption to the biological processes involved in fracture healing, providing relative stability that ensures adequate mechanical support for bone consolidation. This technique has been successfully applied across various bone segments with excellent outcomes.[8,9,10,14] We were able to replicate these positive results in our series of patients.

The debate over anterior versus superior placement of the implant remains ongoing. Kang et al.,[14] Iannotti et al,.[15] and Celestre et al.[16] advocate for anterior placement due to its reduced likelihood of causing patient discomfort and its biomechanical advantages, including lower risks of implant breakage and pull-out. In our series, a superior plate placement was used, yielding comparable results without implant breakage. Additionally, superior placement avoided injury to the deltoid at its insertion on the lateral third and the anterior edge of the clavicle. Superior fixation also simplifies the procedure, as it eliminates the need for extensive plate pre-molding to fit individual anatomy. When applied to comminuted fractures, a plate on the superior aspect functions as a bridge. In transverse fractures subjected to high stress under load, it acts as a tension band, generating compression at the fracture site. These biomechanical principles underpin the favorable outcomes achieved in this study.[14,17-19]

The length of screws, particularly on the medial side, poses a potential risk of vascular injury. Sohn et al. recommend anterior implant placement to mitigate this risk.[10] In our series, we used locking screws, which can even be monocortical, to capitalize on the enhanced cortical stability. By locking the screw to the plate, the risk of contralateral injury is eliminated. To further reduce risk during drilling, we used short drill bits with guides serving as depth stops. This approach provided sufficient fixation without any cases of screw pull-out or implant breakage.

Subclavicular nerve injury, a frequent complication reported by various authors,[11,20] often results in subcutaneous implant discomfort and scar pain. However, this complication was avoided in our patients by identifying the locations of the sensory branches and carefully preserving them during the surgical approach. The implant was also carefully slid under the platysma to further reduce the risk of nerve injury.

Six of our patients had tattoos in the surgical area; however, these did not interfere with the use of the anatomical landmarks essential for the MIPO technique.

The limitations of this study include the short follow-up period and the absence of a control group treated with open reduction, which would allow for more meaningful comparisons.

CONCLUSIONS

This study demonstrated successful fracture consolidation and full recovery of range of motion while avoiding morbidities and complications such as neurovascular injury, implant rupture, and implant removal. Based on straightforward and reproducible technical parameters, the MIPO technique represents a safe and effective surgical option.

Conflict of interest: The authors declare no conflicts of interest.

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