Minimally invasive approach for clavicular fractures

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ABSTRACT

Objectives: To describe the minimally invasive locking plate approach for midshaft clavicular fractures and report our radiographic and clinical results. **Methods:** We retrospectively evaluated fifteen patients (12 men and 3 women, mean age: 32.4 years [range 17-51]) with clavicular fractures who underwent minimally invasive superior locking plate osteosynthesis and reduction. According to the Allman classification of clavicular fractures, 12 patients had a type I fracture, while 3 had a type II fracture. **Results:** The average operating time was 53 minutes (range 51-65). Union was achieved in all patients in an average of 13.3 weeks (range 12-15). Patients were satisfied with cosmetic and functional results. **Conclusions:** This study shows that the minimally invasive superior locking plate approach for midshaft clavicular fractures can be a reproducible procedure and an alternative to conventional surgical approaches. Clinical and radiological results were achieved without major complications or wound dysesthesia.

Key words: Minimally invasive approach; fracture; clavicle.

Level of evidence: IV

Fractura de clavícula. Técnica mínimamente invasiva

RESUMEN

Objetivo: Describir la técnica quirúrgica mínimamente invasiva con placa regional bloqueada para fracturas mediodiafisarias de clavícula y mostrar nuestros resultados clínicos y radiográficos. **Materiales y Métodos:** Se evaluó, en forma retrospectiva, a 15 pacientes (12 hombres y 3 mujeres, media de la edad, 32.4 años [rango 17-51]) con fractura de clavícula, tratados con reducción y osteosíntesis con placa superior bloqueada anatómica mediante una técnica mínimamente invasiva. Según la clasificación de Allman, 12 pacientes tenían fractura de clavícula tipo I y tres, tipo II. **Resultados:** El tiempo promedio de cirugía fue de 53 minutos (rango 51-65). Se logró la consolidación de todas las fracturas en un promedio de 13.3 semanas (rango 12-15). No hubo seudoartrosis ni consolidaciones viciosas. El puntaje promedio de Constant fue de 98 (rango 95-100). Todos los pacientes se manifestaron satisfechos con los resultados estéticos y funcionales. **Conclusiones:** Este estudio demuestra que la técnica mínimamente invasiva para las fracturas mediodiafisarias de clavícula, utilizando placas regionales anatómicas bloqueadas superiores, puede ser un procedimiento reproducible y una alternativa a las técnicas quirúrgicas convencionales. Además, los resultados clínicos y radiográficos satisfactorios se obtuvieron sin complicaciones mayores y sin disestesias en la zona de la herida.

Palabras clave: Técnica mínimamente invasiva; fractura; clavícula.

Nivel de Evidencia: IV

INTRODUCTION

Clavicular fractures are common injuries in adults, representing up to 5% of all fractures and 44% of shoulder fractures[1-3]. Most of them are shaft fractures, more specifically midshaft fractures, due to the thinness of the bone at this site and their subcutaneous position[4, 5].

Several methods of treatment for midshaft clavicular fractures have been described, including conservative therapy, open reduction and internal fixation, and intramedullary fixation, all of them with good clinical results[6, 7].

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Open reduction and fixation with a locking plate is currently considered the preferred method for surgical treatment of these fractures[5, 8].

The MIPPO approach (Minimally Invasive Percutaneous Plate Osteosynthesis) has already been used with good results in other long bones. It consists in sliding a plate through small incisions made far from the fracture site, aiming at an indirect, non-anatomical reduction and avoiding the fracture site. The advantages are avoiding muscle and soft tissue damage, as well as injury to sensory nerves, resulting in less dysesthesia and better cosmetic results[11-14].

The same applies to the MIS approach (Minimally Invasive Surgery), in which small incisions and an anatomical reduction are combined at the fracture site. As far as we know, this approach has not yet been published in the literature.

The objective of this study is to describe this new minimally invasive surgical approach of locking plate fixation for midshaft clavicular fractures and to discuss our clinical and radiological results.

MATERIALS AND METHODS

We retrospectively evaluated 46 patients (47 fractures) with a clavicular fracture who were treated by superior locking plate osteosynthesis and reduction between June 2012 and May 2014.

We included patients under 60 years of age, concerned about cosmetics, who suffered a clavicular fracture without joint involvement, and with indication of surgical treatment. The cases involved complete displaced fractures with a bone shortening >20 mm and a vertical third fragment. We excluded patients with pathological fractures, open fractures, fractures with associated neurovascular injury and nonunions, as well as patients with more than three fragments (due to the difficulty of reduction under the minimally invasive approach).

We evaluated 15 fractures in 15 patients (12 men and 3 women, mean age 32.4 years [range 17-51]) (Table 1). According to the Allman classification of clavicular fractures, 12 patients had type I fractures, and 3 had type II fractures (Table 1).

Table 1. Patient data

Patient	Gender	Age (years)	Type of fracture (Allman classification)	Follow-up (months)
1	M	27	I	14
2	F	17	I	16
3	M	45	II	14
4	M	51	I	17
5	M	23	II	21
6	M	31	I	18
7	M	28	I	14
8	F	23	I	24
9	M	34	I	19
10	M	42	I	13
11	M	49	I	22
12	M	37	II	15
13	M	27	I	17
14	F	22	I	20
15	M	30	I	15

F = female, M = male.

Surgeries of all the patients were in charge of the same surgeon (JMP) and the patients were evaluated post-operatively by other professionals of the same medical team.

The clinical evaluation included objective parameters, such as range of motion and shoulder strength compared to the contralateral healthy side, using the Constant score.

In the last follow-up, we evaluated the degree of patient satisfaction regarding cosmetic results in relation to the scar, measured by a subjective scale from 1 to 10, with 1 being a very bad result and 10, an excellent one.

Imaging studies included immediate pre-operative and post-operative AP and craniocaudal X-rays. X-rays were then taken every four weeks until consolidation of the fracture. The consolidation criterion was the absence of symptoms during clinical evaluation and a callus shown on X-rays using the anterior, axillary and Zanca views.

The average follow-up time was 17.2 months (range 13-24) (Table 1).

Surgical approach

Under general anesthesia, the patient is placed in a beach chair position on a radiolucent operating table. Lidocaine HCL 1% with epinephrine is infiltrated in the surgical site before making a longitudinal incision of approximately 3 cm along the superior border of the clavicle at the fracture site (Figure 1). Dissection is deepened to expose the bone, identifying the fracture line. The suprascapular nerve branch must be protected if identified. The main fragments are released, and a direct reduction is made with bone holding forceps. If necessary, the bone is fixed with an interfragmentary screw. If there is a third fragment, the fracture pattern is simplified with a cortical screw to subsequently achieve definitive reduction. Then, the dissection is deepened to the subpectoral plane, on the superior border of the clavicle, on both main fragments (Figure 2) in order to slide a 3.5 mm locking plate, both medially and laterally to the fracture site (Figure 3). The correct position of the plate is verified under fluoroscopy using AP and craniocaudal views[15] (Figure 4).

Figure 1. Longitudinal 3 cm incision along the superior border of the clavicle, over the fracture site. Dissection extends to the fracture site.

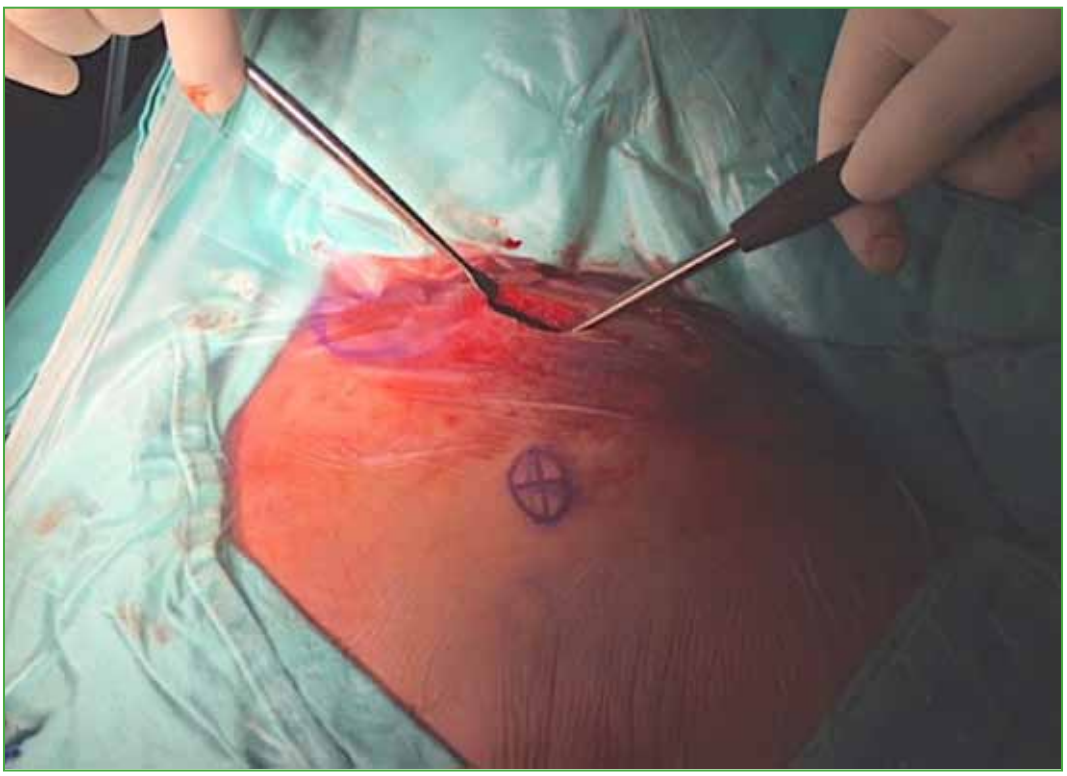

Figure 2. Subpectoral dissection on the superior border of the clavicle on both main fragments.

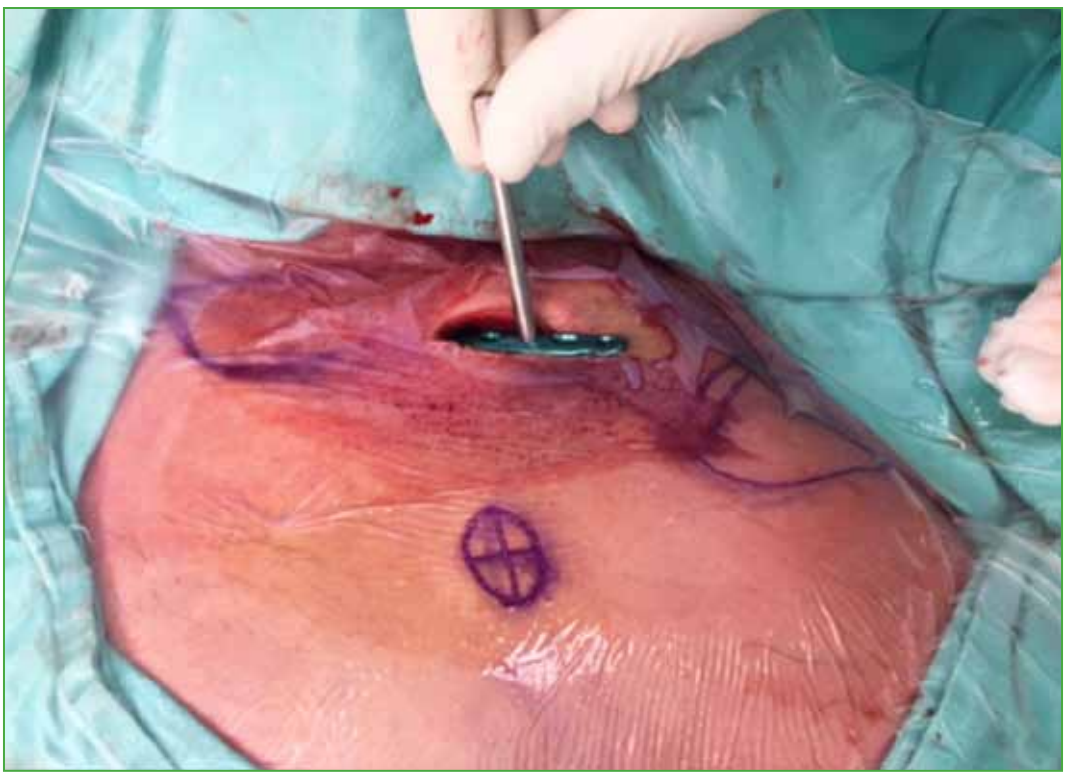

Figure 3. A 3.5 mm anatomical locking plate is slid through the incision, medially and laterally to the fracture site.

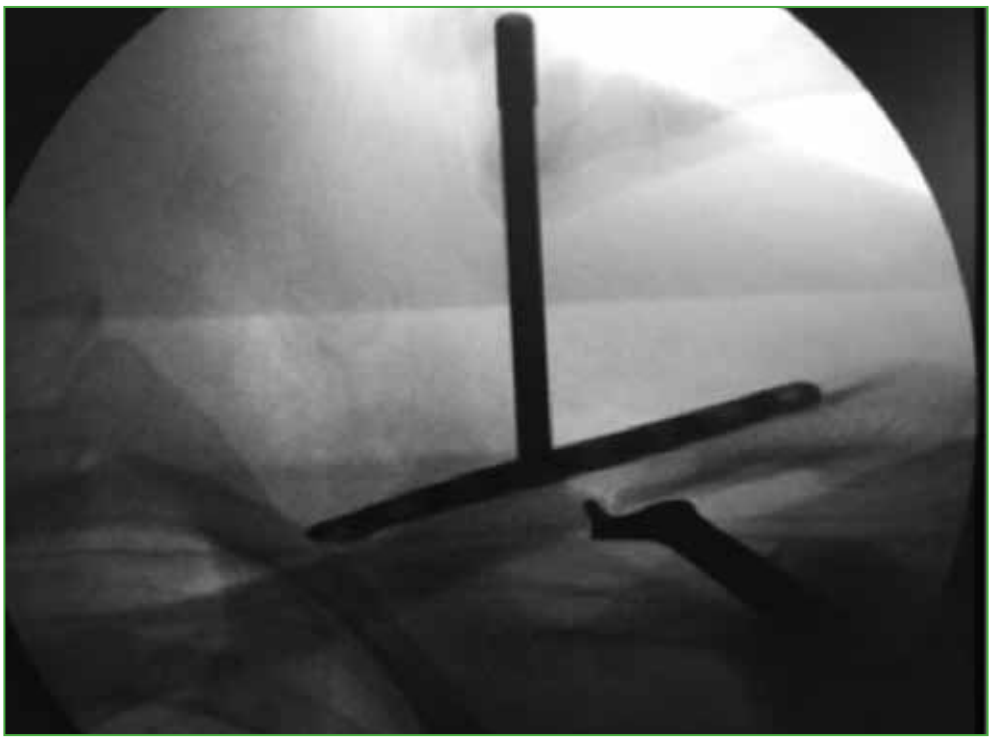

Figure 4. Verification of correct plate position under fluoroscopy.

Then, the plate is fixed with two cortical screws, one medial and one lateral, to preserve the reduction and fix the plate to the bone. These screws can be placed through the same incision or percutaneously (Figure 5A). The rest of the locking medial and lateral screws are then placed percutaneously with the help of the locking plate system (Figure 5B).

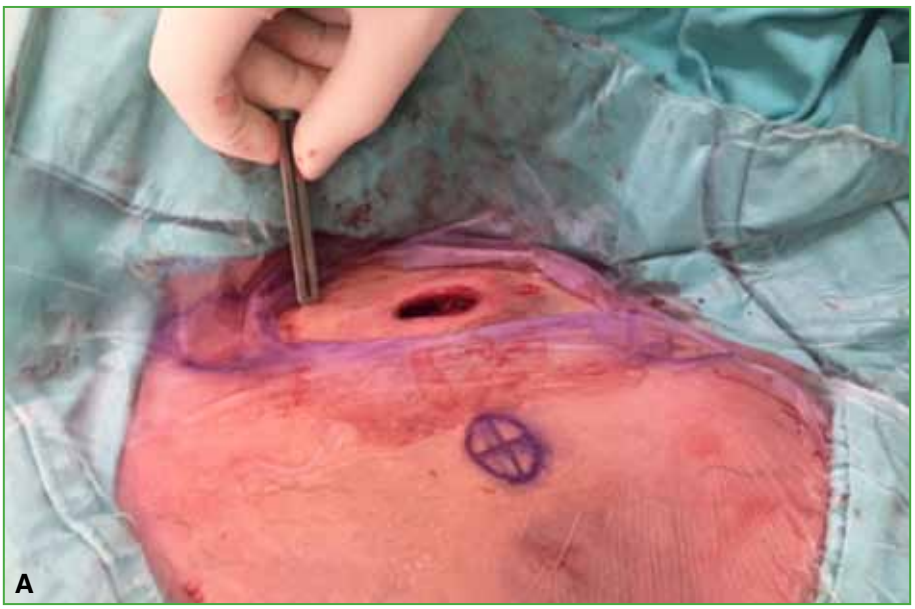

Figure 5. A. Placement of locking screws, percutaneously, at midshaft of the clavicle.

Figura 5. B. Intra-operative fluoroscopic view of the placement of the percutaneous screws.

Stability, adequate reduction and correct length of the screws are verified under fluoroscopy. Finally, the wound is closed following the planes of dissection (Figure 6).

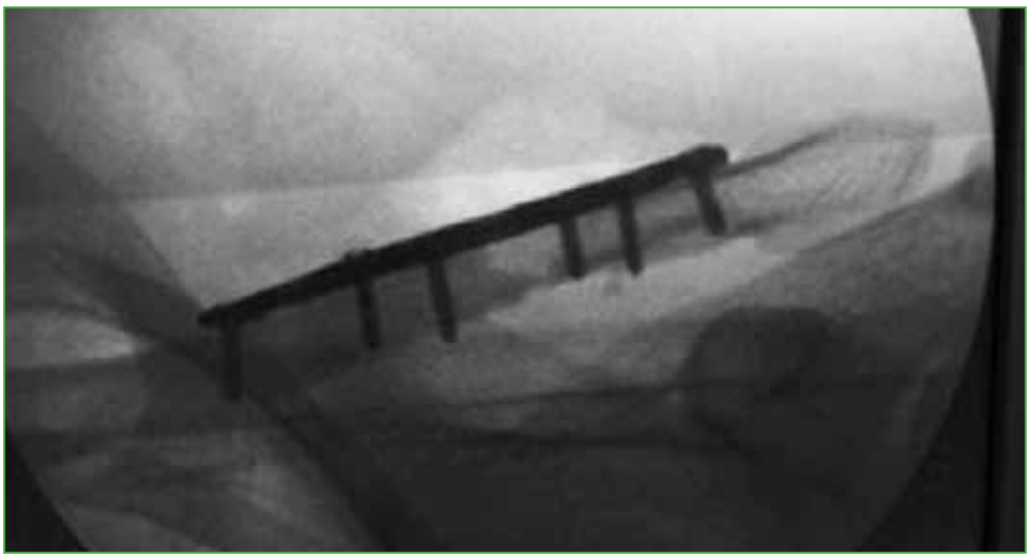

Figure 6. Intra-operative craniocaudal and AP views under fluoroscopy to verify correct plate position and screw length.

Rehabilitation

After surgery, the shoulder is protected with a sling for two weeks, but immediate mobilization of the elbow and the wrist is allowed. The stitches are removed 15 days after surgery. AP and craniocaudal X-rays are taken immediately after surgery, after a week, after a month, and then at four-week intervals until consolidation of the fracture.

After two weeks, the patient can take up passive range of motion exercises of the shoulder. Active range of motion up to 90° is allowed after four weeks. After four weeks, the patient regains full active range of motion, but weight lifting is not allowed until the sixth week. Contact sports are not allowed until six months after surgery.

RESULTS

The average operating time was 53 minutes (range 51-65). There was no need to convert to conventional open surgery in any of the cases.

Consolidation of all fractures was achieved in an average of 13.3 weeks (range 12-15). There were no nonunions or malunions.

During the final follow-up, the average Constant score was 98.4 (range 94-100). All patients were satisfied with the cosmetic (Figure 7) and functional (scale 1-10) results (Table 2).

Figure 7. Cosmetic results four months after surgery.

Table 2. Surgery results

Patient	Operating time (minutes)	Consolidation (months)	Follow-up (months)	Satisfaction (scale 1 to 10)	Constant score
1	53	13	14	9	100
2	58	13	16	8	98
3	51	15	14	9	100
4	53	13	17	8	98
5	52	12	21	9	98
6	50	15	18	9	100
7	65	12	14	8	94
8	53	14	24	9	100
9	51	12	19	10	100
10	51	13	13	10	100
11	55	14	22	9	96
12	52	15	15	9	100
13	53	13	17	9	100
14	51	14	20	8	100
15	54	12	15	8	94

At final follow-up, there were no patients with wound dysesthesias. One patient (case 8) had a hypertrophic scar, but had a history of this type of scarring, so she was very satisfied with the cosmetic result (Figure 8).

Figure 8. Patient with a history of hypertrophic scarring.

DISCUSSION

For many years, midshaft clavicular fractures were treated with conservative therapy[16,17].

The available literature based on comparative studies between conservative and surgical treatments shows that, compared to conservative therapy, surgery reduces the range of complications, such as nonunions and clinical malunions, and yields better functional results and a quicker return to daily personal and professional activities[18,19].

Several methods of treatment for midshaft clavicular fractures have been described over the years, including conservative therapy, open reduction and internal fixation, and intramedullary fixation, all of them with good clinical results[6,7].

With the development of fixed-angle locking plates, clinical results in patients treated with open reduction and internal fixation improved, thus, currently, this treatment is considered the golden standard[5, 8]. However, it increased the incidence of certain complications, such as nonunions, refractures after the removal of the osteosynthesis material and deep infection, which could be related to excessive periosteal stripping at the fracture site[20-23].

In order to reduce the incidence of these complications, the minimally invasive percutaneous plate osteosynthesis (MIPPO) approach has been described for midshaft clavicular fractures in order to preserve the soft tissues and periosteal blood supply at the fracture site[24-29].

Al-Sadek *et al.*[25] treated 12 patients with the MIPPO approach and achieved good clinical and radiological results in all cases. No new incisions had to be made in any of the cases. However, one of the patients had a delayed consolidation.

Zhang *et al.*[26] treated 15 patients using the MIPPO approach. Operating time was between 40 and 80 minutes. All fractures consolidated within three months after surgery without major complications. Clinical results were outstanding, with an average Constant score of 99 and a DASH score of 3.8. Only two patients reported numbness or loss of local sensitivity at the scar site.

Sohn *et al*.[27] compared the results between two different approaches, open osteosynthesis using anterior-inferior plating and MIPPO, for the treatment of displaced acute midshaft clavicular fractures. The average operating time was 87.5 minutes in the group treated with open osteosynthesis and 77.2 minutes for those treated with the MIPPO approach. All fractures were consolidated. The average time of consolidation was similar in both groups (15.7 and 16.8 weeks, respectively), as well as the clinical results, as measured by the Constant score (94.74 and 95.75, respectively).

The proportional difference in clavicular length with respect to the healthy side at the end of the follow-up period was smaller in the open osteosynthesis group, but it was not significant. There were 15% more complications related to the incision, such as numbness, loss of sensitivity or irritation at the scar site, in the group treated with open osteosynthesis, which could be related to the wide incision necessary for this procedure.

Although there are no significant differences between the results of our series and those of the studies described above[25-27] regarding time of consolidation (13 weeks), the operating time (average of 53 minutes) and the functional results (Constant score, average of 98), the approaches are not comparable: the MIPPO approach uses indirect reduction and allows for stabilization of the clavicle, preserving the blood supply to the surrounding soft tissues and supraclavicular nerves; the fracture site is not exposed; and, in case of comminution or a third fragment, they are not reduced or fixed. Therefore, if the fracture site is opened, a direct reduction is made and a third fragment is fixed, it is not really a MIPPO approach, but a MIS.

As far as we know, there is only one published study that compares a minimally invasive approach for plate and screw osteosynthesis by opening the fracture site for a direct reduction with an open reduction and internal fixation using a conventional locking plate for midshaft clavicular fractures. In said study, Jian and Qu[28] treated 32 patients with a minimally invasive approach and 32 patients with conventional open reduction and internal fixation. Consolidation time was comparable in both groups (12 and 13 weeks, respectively), and there were no statistically significant differences in functional results (DASH and Constant scores). There were no cases of nonunions or malunions, but certain complications were observed, such as wound dysesthesias and hypertrophic scars, with a higher incidence in patients undergoing conventional open reduction and internal fixation. Patients treated by the minimally invasive approach were more satisfied with the look of the shoulder. In our series, all patients were satisfied with the cosmetic and functional results.

We must also consider restoring the length of the injured clavicle, since a malunion can result in functional deficits, such as scapular dyskinesias and pain while moving the shoulder girdle[29]. Our surgical approach allows for an anatomical reduction of the clavicle with consequent restoration of its length, avoiding this type of complications. In our series, there were no cases of malunion.

Our work has several limitations. The sample of patients is small, and the follow-up period is short to evaluate late onset complications. Another weakness is the lack of evaluation to determine the comparison of the length and angle to the contralateral side.

As for the strengths, we can mention the homogeneity of the sample of patients and the use of the same osteosynthesis material in all cases: a 3.5 mm clavicular locking plate.

The primary objective of our study was to show this new surgical approach, presented in a series of cases by Jiang and Qu[28], in which they combine the MIPPO approach with the fixation of fragments for comminuted fractures at the fracture site.

The secondary objective was to discuss our clinical and radiological results. We believe that a randomized controlled study with a longer follow-up period and a larger sample of patients is necessary to shed light on the difference and effectiveness of both surgical approaches.

CONCLUSIONS

This study shows that the minimally invasive approach for midshaft clavicular fractures using superior locking plates can be a reproducible procedure and an alternative to the conventional surgical approach. Furthermore, adequate clinical and radiological results were obtained, without major complications or wound dysesthesia.

Therefore, we believe that this surgical approach is a good alternative for patients concerned about their cosmetic appearance or in those with the need to preserve sensitivity at the scar site for professional or recreational purposes.

Conflict of interest: Authors claim they do not have any conflict of interest.

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