

Surgical treatment of clavicle displaced midshaft fractures with pre-contoured plates using minimally invasive technique (MIPO)

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ABSTRACT

Introduction: Midshaft clavicle fractures represent up to 10% of the skeleton fractures. Conservative treatment provides patients with good results with low complication rates. However, in displaced fracture lines, multi-fragment fractures or significantly deformed fractures, surgery should be taken into account. The aim of this retrospective series is to show our experience in the treatment of midshaft displaced closed fractures of the clavicle with pre-contoured plates by the MIPO technique, to describe the technique and to report our preliminary functional results.

Materials and Methods: Retrospective series of 13 patients (11 males [84.6%] and 2 females [15.4%]), 31 years old on average, with displaced, closed shaft fracture of clavicle Robinson (Edinburgh) type 2B, treated by reduction and osteosynthesis with pre-contoured plates and MIPO between April 2010 and November 2013. Average follow-up: 13 months (11-25 range). X-ray and CT scan evaluation was carried out, assessing function with the modified Constant-Murley and the QuickDASH scores, and pain with the visual analogue scale.

Results: The average time until the surgery was of 8 days; surgery lasted 35 minutes and post-operative hospital staying, 1.28 days. Medical-radiological fracture healing was verified at week 15.5, on average. The average modified Constant-Murley score was 88; the QuickDASH score, 26.9, and the visual analogue scale showed 0.3. There were neither systemic nor esthetic complications.

Conclusion: Minimally invasive osteosynthesis in midshaft displaced closed fractures of clavicle was a reproducible technique with reduced surgical time and acceptable functional results, and no relevant complications.

Key words: Clavicle fracture; displaced; closed; MIPO.

Level of evidence: IV

TRATAMIENTO QUIRÚRGICO DE LAS FRACTURAS MEDIODIAFISARIAS DESPLAZADAS DE CLAVÍCULA MEDIANTE PLACAS PRECONTORNEADAS CON TÉCNICA MININVASIVA

Conflict of interests: The authors have reported none.

RESUMEN

Introducción: Las fracturas mediodiafisarias de clavícula representan hasta el 10% de las fracturas del esqueleto. El tratamiento conservador brinda buenos resultados con baja incidencia de complicaciones. Sin embargo, en trazos desplazados, multifragmentarios o con deformidad significativa, se debe considerar la cirugía. El propósito de esta serie retrospectiva es exponer nuestra experiencia en el tratamiento de fracturas cerradas, desplazadas y mediodiafisarias de clavícula con placas precontorneadas mediante la técnica MIPO, describir la técnica y los resultados funcionales preliminares.

Materiales y Métodos: Serie retrospectiva de 13 pacientes (11 varones [84,6%] y 2 mujeres [15,4%]), media de la edad: 31 años, con fracturas diafisarias cerradas desplazadas de clavícula de tipo 2B de Robinson (Edimburgo), tratadas mediante reducción y osteosíntesis con placas precontorneadas con MIPO, entre abril de 2010 y noviembre de 2013. Seguimiento promedio: 13 meses (rango 11-25). Se realizaron controles radiográficos y tomografías computarizadas, valorando la funcionalidad mediante las escalas de Constant-Murley modificada, QuickDASH y el dolor con la escala analógica visual.

Resultados: El tiempo promedio hasta la cirugía fue de 8 días; la cirugía duró 35 minutos y el tiempo de internación posoperatoria fue de 1.28 días. La consolidación clínico-radiológica se registró en una media de 15.2 semanas. El puntaje promedio de Constant-Murley modificado fue 88; el de QuickDASH, 26,9 y la escala analógica visual arrojó un valor de 0,3. No hubo complicaciones sistémicas ni cosméticas.

Conclusión: La osteosíntesis mínimamente invasiva en fracturas cerradas mediodiafisarias desplazadas de clavícula presentó una técnica reproducible con un tiempo quirúrgico reducido y puntajes funcionales aceptables, sin complicaciones de relevancia.

Palabras clave: Fracturas claviculares; desplazadas; cerradas; MIPO.

Nivel de Evidencia: IV

Introduction

Midshaft fractures of the clavicle are frequent and represent 2.6-10% of all skeleton fractures and up to 80% of clavicle fractures.^{1,2}

In general, conservative treatment for fractures with mild deformity and displacement is associated with good results and low complications rates.³ However, in the case of displaced fragments, multi-fragment fracture or significantly deformed fractures surgical treatment should be taken into account.^{4,5}

Over the last decades, the use of pre-contoured locked osteosynthesis plates and intramedullary nails showed good-to-excellent results, with low complications rates and rapid retaking of work and sport activities.^{4,6}

On the other hand, minimally-invasive techniques for the treatment of extra-articular fractures in long bones (femur, tibia and humerus) proved to be effective both in technique reproducibility and results.^{7,8} These techniques seek a relatively stable state of affairs at the level of the fracture line trying not to affect negatively the biological cascade of fracture healing, since absolute stability, although mechanically effective, is associated with high biological costs in terms of extensive approaching, soft tissues injuries and bone-implant contact.

The aim of this retrospective series of cases is to show our experience in the treatment of midshaft, displaced, closed fractures of clavicle with pre-contoured plates by the MIPO (minimally invasive plate osteosynthesis) technique, to describe the technique and to report our preliminary functional results.

Materials and Methods

This is a retrospective series of 13 patients (11 males [84.6%] and two females [15.4%]) who averaged 31 years old (ranging from 17 to 47) and were operated on between April 2010 and November 2013. Average follow-up was 13 months (ranging from 11 to 25).

The inclusion criteria were: closed, displaced shaft fracture of clavicle Robinson (Edinburgh) type 2B. Eleven cases were sub-type 2B1 (displaced simple fracture or butterfly-wing-fragment fracture), and two cases, type 2B2 (comminute fracture or segmental fracture). Exclusion criteria were: open fracture, pathologic fracture, scapular girdle associated injury, and <13-month follow-up.

The causes of fracture were traffic collision, domestic accidents and contact sports. In 11 cases the clavicle fracture was isolated, whereas in two cases it was associated to radius fracture, all unilateral. In all the patients we used diverse pre-contoured locked plates (provided by the patient's Union in all cases) for surgical stabilization.

Surgical technique

Anesthesia was combined with regional blocks and general anesthesia, the patient in beach-chair position (30°-inclination) with inter-scapular bulge to lengthen the clavicle and facilitate reduction. We included the upper limb affected in the surgical field.

We used systematically two openings. The first one was a lateral opening upon the distal end of the clavicle, of approximately 3 cm in length, which allowed the surgeon to expose the upper aspect of the clavicle by dissection.

The second surgical opening, of 3 cm in length too, was carried out in the medial end of the clavicle checking the sternocleidomastoid attachment, which was not affected (Figures 1 and 2).

While trying fracture reduction by simple traction by the affected upper limb, and if reduction is acceptable, it is necessary to carry out soft extra-periosteal divulsion right by the bone since the lateral opening and upon the upper aspect of the clavicle lateral fragment towards the fracture line, repeating such maneuver since the medial opening. The aim of this surgical gesture is to create a wide tissue pocket to advance the implant, avoiding the sensitive branches of the supraclavicular nerve, which pass normally to the clavicle shaft. In the case of simple

fracture lines, it is possible to manipulate reduction by two 3.0-mm Kirschner pins fixed to both fracture ends. When it is difficult to reduce the fracture, it is worth resorting to a per-cutaneous reduction clamp making by soft manipulation the main fragments come into contact.

The pre-contoured osteosynthesis plates that we used were fixed taking at least six cortexes in both fracture fragments, all on the upper aspect of the clavicle and under fluoroscopic control. At the level of the medial opening, it is essential to protect the pass of the drill through the posterior cortex to avoid injuring vascular structures and the brachial plexus, especially the inferior proximate subclavian vein.



▲ **Figure 1.** Midshaft clavicle fracture Robinson (Edinburgh) type 2B1.



▲ **Figure 2.** Lateral and medial openings with osteosynthesis already inserted.

We administered the patients antibiotic prophylaxis with *e.v.* first generation cephalosporins—2-g cefazolin 30 minutes before the surgery and, then, 1-g cephalothin every 6 hours on the first post-operative day.

Post-operative follow-up

We used immobilization with Vietnam sling anchored to the patient's thorax during two weeks and, afterwards, we started progressive passive and active mobilization as tolerated by the patient. We carried out radiologic follow-up with clavicle vertex off-focused AP and oblique projections immediately after the surgery, once a month until the sixth post-operative month and finally at post-operative month 12. We added CT scan with reconstruction in all cases if we suspected some radiologic fracture healing so as to verify the resolution of the fracture line and allow the patient to do sports, especially contact sports.

We used the modified Constant-Murley scale⁹ and the QuickDASH questionnaire to assess function, and the visual analogue scale (VAS) to assess pain.

Results

The Table shows the 13 patients' data. The average time since the injury until the surgery was of 8 days (ranging from 5 to 20). Average surgical time was 35 minutes (ranging from 20 to 45), and post-operative hospital staying was 1.28 days on average. In all cases we verified fracture healing in 15.2 weeks (ranging from 9 to 23) by X-ray and CT scan follow-up (Figures 3 and 4). There was no conversion into open surgery, and esthetic results were favorable (Figure 5).

In the modified Constant-Murley scale, the average score was of 88 marks (ranging from 65 to 100). Average QuickDASH score was 26.9 (ranging from 22.7 to 38.5). Pain score evaluated with the VAS was, on average, 0.3 (ranging from 0 to 2).

There were no complications such as non-union, infection, osteosynthesis loosening, hypertrophic scars at the level of the surgical openings, hypo/anesthesia in the surgical area or vascular injuries.

In one patient we removed the osteosynthesis material 14 months after the surgery because of material intolerance, although there was no esthetic deformity.

Three out of four patients who practiced contact sports returned to the level of competence previous to the surgery. One of them did not return to competence even though individual assessment scales were favorable.

Discussion

Traditionally, contemporary bibliography has considered that the vast majority of midshaft clavicle fractures progress inexorably to healing without sequela if treated with conservative treatment, whereas only 3-5% of them suffer delayed union, non-union or whatever complications.^{1,2}

However, current prospective studies with extensive follow-ups have shown that up to 46% of the patients suffer some degree of sequela such as post-effort persistent pain, nocturnal pain, disorders in the mechanics of the scapular girdle, and unacceptable esthetic deformities.

Table. Date from the retrospective series

Patient	Age	Sex	Constant-Murley	QuickDASH	Visual analogue scale	Associated injury
1	47	Female	65	38.5	2	Yes (wrist)
2	21	Male	100	23	0	No
3	25	Male	85	28.2	1	No
4	28	Male	92	25.1	0	No
5	19	Male	88	26	0	No
6	31	Male	81	28.5	1	No
7	33	Male	70	34	1	Yes (wrist)
8	35	Male	100	23.4	0	No
9	41	Male	96	24.2	0	No
10	44	Male	82	28.1	0	No
11	39	Male	96	24	0	No
12	32	Male	100	23.5	0	No
13	17	Female	100	22.7	0	No



▲ **Figure 3.** X-ray. Fracture healing at post-operative week 15.



▲ **Figure 4.** CT scan. Fracture healing at post-operative week 15.



▲ **Figure 5.** Esthetic looks at post-operative week 15.

Lack of contact between fracture fragments, multi-fragment fractures, and >12-mm shortening are initial radiologic factors that increase the risk of sequela.^{2,4,10}

Improvement in biomechanics concepts and the subsequent use of pre-contoured blocked plates have been effective for the treatment of clavicle midshaft fractures. Diverse reports suggest high percentages of fracture healing with a low number of complications and rapid retaking of daily-life activities.⁵⁻⁷

Moreover, there has been considerable progress with elastic intra-medullary nails with varied models and entrance openings (lateral, medial, etc.), and they represent another valid option with high percentages of healing and a low number of complications, mainly in one-line fractures. As for multi-fragment or complex fractures, this method is associated with greater limitations and is backed by fewer.¹⁰

The use of MIPO techniques with pre-contoured locked plates in the treatment of long-bone fractures (femur, tibia, and humerus) has been proved, even in the case of complex fractures.^{11,12} The philosophy of this procedure is based on the possibility to get reasonable reduction and contact at the level of the fracture line with relative mechanical stability, trying not to affect negatively the natural biological cascade of fracture healing and without the absolute stability that characterizes open reparation with plates, because, although these procedures are very effective in mechanical terms, they are associated with high biological costs in terms of extensive approaches, periosteal harm, soft tissues mobilization with potential injury, and negative effects on the implant-bone inter-phase.

Reports on minimally invasive surgery for clavicle fractures are scarce and recent, although Sohn et al.'s¹³ and Yang et al.'s¹⁴ results and other published series, which show mainly fracture healing and low complication rates, make us foresee an increasing incorporation of this technique into the therapeutic arsenal for clavicle fracture.

The insertion of the plate in the clavicle comes as another debatable issue. Insertion on the clavicle upper aspect is widely accepted by most surgeons, while there are others who prefer anterior insertion.¹⁵ In comparative biomechanics studies, there are reports on contradictions when it comes to the advantages provided by anterior vs. upper insertion of the osteosynthesis at the time of flexion, axial compression and torsion, and the choice is based on the surgeon's common sense and their technical expertise.¹⁴⁻¹⁶

In the development of this technique, two openings (the lateral one and the medial one) have been enough to get reasonable reduction and stabilization; however, in the case of difficulties or the impossibility to carry out reduction, this procedure shows as additional advantage the possibility to change to open techniques or carry out rescue or revision of osteosynthesis.

In our series of patients treated with this method, the average time of bone healing did not differ from that reported in other series of patients treated with locked plates and open surgery. It is worth highlighting the short surgical time and the positive esthetic results associated with the MIPO technique.

The limitations of this study are its small series of patients and its retrospective design, the heterogeneous use of pre-contoured plates (provided by the patients' Unions), the short follow-up and the lack of a control group to make the necessary comparisons.

Conclusions

On the grounds of our initial results, we believe that our experience with the MIPO technique in clavicle midshaft displaced fractures is encouraging in terms of reproducibility, reduced surgical time and efficiency. However, in spite of these results, conclusions are not definite and they invite to plan studies with more statistically significant samples and long-term follow-ups.

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