



Displaced medial clavicle fractures: operative treatment with locking compression plate fixation

Herman Frima¹ · Roderick M. Houwert² · Christoph Sommer¹

Received: 13 March 2018 / Accepted: 4 October 2018 / Published online: 11 October 2018
© Springer-Verlag GmbH Germany, part of Springer Nature 2018

Abstract

Objectives Medial clavicle fractures are rare injuries and historically treated non-operatively. Displaced medial clavicle fractures, however, have a higher incidence of delayed- or non-union compared to non-displaced medial clavicle fractures and might benefit from operative treatment. We describe below a new technique for treating intra-articular fractures or extra-articular fractures with a small medial fragment using special locking plates and present the results of our operatively treated patients.

Methods First we describe our technique for treating very medial fractures with the radial (VA)-LCP™ Distal Humerus Plate (DePuy Synthes, Switzerland). Second, a retrospective cohort study was performed. All patients operated on for a displaced medial clavicle fracture between 2010 and 2017 were included. Primary outcome was the QuickDASH score and the Subjective Shoulder Value (SSV). Secondary outcomes were operative complications including mal- or non-union and implant removal.

Results All 15 patients were available for follow-up. Fourteen patients were included in our analysis. One patient was excluded due to severe concomitant injuries. Six patients were treated with the radial (VA)-LCP™ Distal Humerus Plate, eight patients with the LCP™ Superior Anterior Clavicle Plate with lateral extension (DePuy Synthes, Switzerland) and one with a LCP 3.5 plate. The mean follow-up was 39 months (range 9–79). The mean QuickDASH score was 0.81 (range 0–4.50, SD ± 1.44) and the mean SSV was 96 (range 80–100, SD ± 6.53). One patient had an early revision operation and developed an infection after 1.5 years. No mal- or non-unions occurred. Eight patients had their implants removed.

Conclusions Operative treatment of displaced medial clavicle fractures with well-fitting ‘small fragment’ locking plates provides an excellent long-term functional outcome. Intra-articular fractures or extra-articular fractures with a small medial fragment can be treated with the radial (VA)-LCP™ Distal Humerus Plate.

Keywords Medial clavicle · Fracture · Operative treatment · Osteosynthesis · Locking compression plate · Functional outcome

Introduction

Clavicle fractures account for 2–5% of all fractures in adults [1]. Of all clavicle fractures, midshaft clavicle fractures have the highest incidence at approximately 70–80% [2, 3]. The proportion of medial clavicle fractures ranges from 2.8 to

9.3% [2–5]. They are often a cause of high-energy trauma or as part of a multiple injured patient [3, 4, 6–8].

In literature, non-operative treatment has been advocated as the golden standard for medial clavicle fractures for a long time [1, 5]. Other studies, however, have shown a considerable risk of delayed- and non-union for displaced medial clavicle fractures. In literature, up to 14% non-unions for displaced medial clavicle fractures compared to 7% for non-displaced medial clavicle fractures are reported [3]. Therefore, a shift towards operative treatment for displaced medial clavicle fractures has been suggested in recent literature [1, 4, 9–11].

Several operative techniques have been described: fixation with inverted LCP™ Superior Anterior Clavicle Plate

✉ Herman Frima
herman.frima@ksggr.ch

¹ Department of Trauma Surgery, Kantonsspital Graubünden, Loëstrasse 170, 7000 Chur, Switzerland

² Utrecht Traumacenter, Universitair Medisch Centrum Utrecht, Heidelberglaan 100, 3584 CX Utrecht, The Netherlands

with lateral extension [10], distal radial plate [10], a small T-plate with tension band suturing [12], standard T-locking plate [4], a pilon plate crossing the sternoclavicular joint [4], cerclage [9] or transosseous sutures [10]. However, most studies are case reports and the fixation of comminuted and intra-articular displaced medial clavicle fractures remains a challenge, as no specific implant is available for these fractures. In our hospital, these fractures are treated with the radial (VA)-LCP™ Distal Humerus Plate (DePuy Synthes, Switzerland).

The aim of this study is to describe our treatment algorithm, surgical technique and results of the operative treatment of displaced medial clavicle fractures.

Methods

Study design

A retrospective cohort study was performed at a level 1 trauma centre. All patients who were operated on for a medial clavicle fracture between 2010 and 2017 were eligible for inclusion. Patients under 18 years of age and patients with a physeal fracture were excluded from this analysis. Follow-up was done during regular outpatient department visits and by telephone for assessment of long-term functional outcome. This assessment was done by one of the treating trauma surgeons. Informed consent was obtained from all individual participants included in the study. This study was approved by the Cantonal Ethic Committee Zürich (KEK-ZH-Nr. 2017-00192).

Operative indications

Patients who were clinically suspected of having a medial clavicle fracture were analysed with plain X-ray and/or CT scan (Fig. 1). Indications for operative treatment in our hospital include (1) displacement > 1 shaft width, (2) open fractures, (3) intra-articular displaced fractures and (4) symptomatic mal- or non-union (referred patients). Fractures were classified using the AO Classification and the Robinson Classification [2, 13].

Operative procedure

Two different plate types were preferred for fracture fixation depending on the fracture type. If the fracture was extra-articular and if there was enough bone stock to achieve a stable fixation medially, we used the inverted LCP™ Superior Anterior Clavicle Plate with lateral extension (DePuy Synthes, Switzerland). This fixation method has been described before [10, 11]. For intra-articular fractures or fractures, where this aforementioned plate would not provide enough



Fig. 1 Pre-operative CT scan of a very medial and displaced intra-articular clavicle fracture

stability, we used the radial (VA)-LCP™ Distal Humerus Plate (DePuy Synthes, Switzerland). The advantage of this plate is that it is possible to insert angular stable screws in two different planes. With the development of Variable Angle (VA) systems, even more fixation directions are possible.

Patients were placed in a supine position on a radiolucent operation table. An incision was made on the lower edge of the medial clavicle and parallel to it. After dissecting the subcutis, the fracture was exposed. The periosteum was preserved as much as possible. Direct reduction and temporary fixation was done using reduction forceps and small Kirschner-wires (K-wires). If the LCP™ Superior Anterior Clavicle Plate with lateral extension was used, it was inverted and positioned antero-cranially. If definitive fixation was done with the radial (VA)-LCP™ Distal Humerus Plate, it was positioned with the 'lateral support' of the plate at the caudal side of the clavicle. The length of the plate should allow the insertion of at least three conventional or two angular stable screws in the lateral (diaphyseal) part of the clavicle. The angular stable screws in the medial (comminuted) fragments were inserted bicortically if possible. If necessary, plate-independent (lag)-screws were additionally inserted (Fig. 2). Reduction, plate positioning and screw length were intra-operatively verified with X-ray in cranio-caudal and caudo-cranial direction (Figs. 3, 4). After irrigation, the wound was closed in layers.

Post-operative treatment

Patients were treated functionally without weight bearing for 6 weeks. They were allowed free functional movement of the shoulder with abduction limited to 90° for 6 weeks supported by physiotherapy. Standard post-operative follow-up

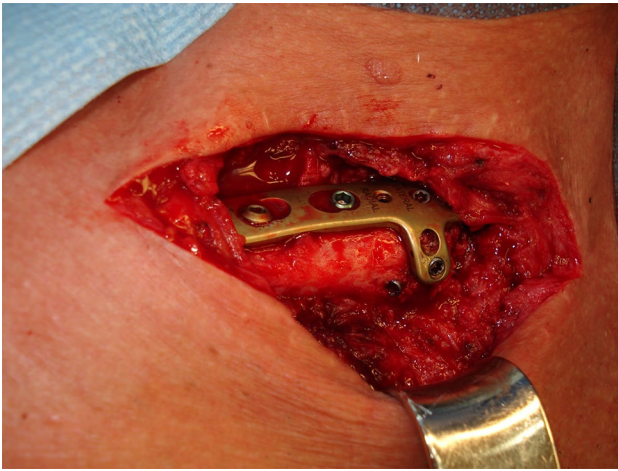


Fig. 2 Intra-operative image of radial LCP™ Distal Humerus Plate

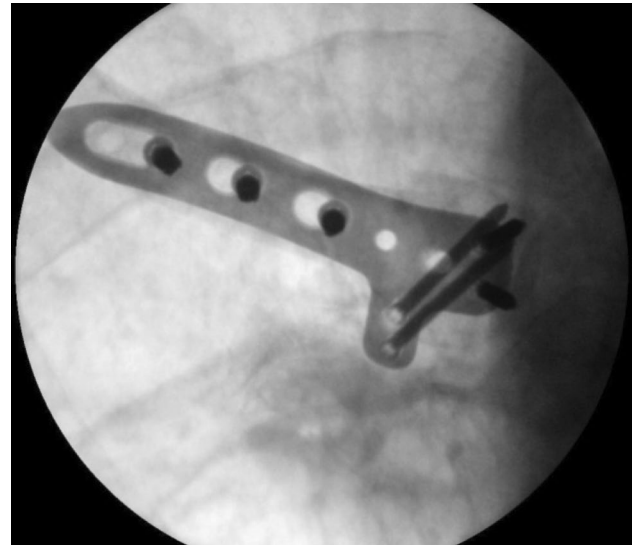


Fig. 4 Intra-operative X-ray cranio-caudal



Fig. 3 Intra-operative X-ray caudo-cranial

including X-rays was done at 6, 12 and 24 weeks in the outpatient department. If patients had persistent complaints or fractures had not healed clinically or radiologically, follow-up was extended with visits at 1 year. Implant removal was not routinely performed. It was carried out on clear indication, for instance with implant related irritation.

Primary outcome

Primary outcome was the shoulder function measured using the QuickDASH score and the Subjective Shoulder Value (SSV) [14–17]. The QuickDASH provides a summative score on a 100-point scale, with 100 indicating the most disability. A QuickDASH score of less than 10 is considered an excellent result, a score of > 40 indicates a poor shoulder

function. The SSV is a single measure score from 0 to 100 developed by Jost et al. with 100 indicating the best function [16]. The SSV has shown a reliable agreement with the Constant Score [15].

Secondary outcome

Secondary outcome parameters were complications, including implant failure, infection (superficial or deep), non-union, mal-union, revision surgery, refracture after implant removal and implant related irritation.

The definition of implant failure was implant loosening, bending or breakage not bridging the fracture anymore resulting in a revision operation. Superficial infection was defined as redness, swelling and/or purulent discharge from the wound that could be treated with antibiotics. If surgical drainage was required, it was considered a deep infection. A lack of radiographic evidence of healing combined with clinical evidence of pain and motion at the fracture site 6 months after surgery was considered a non-union. Fracture union in a shortened, angulated, or displaced position on radiographs was considered a mal-union. Interventions needed to treat these complications were also noted. Re-interventions performed before routine implant removal was indicated, were considered complications of treatment.

Implant removal was analysed using the algorithm Hulsmans et al. developed to investigate the presence of implant related irritation [18].

Statistical analysis

Data were presented as mean \pm standard deviation (SD) for continuous variables or as absolute numbers (percentage)

for categorical variables. The analyses were performed with SPSS, version 22.0 (IBM Corp., Armonk, NY) for Windows.

Results

Between 2010 and 2017, 15 patients were treated with an open reduction and internal fixation (ORIF) for a medial clavicle fracture. Baseline characteristics are presented in Table 1. Fourteen patients were operated for a primary displaced medial clavicle fracture. Eleven fractures were extra-articular and three intra-articular fractures. One patient with a Robinson 1A1 fracture was referred to our hospital with a non-union 8 months after his accident. He was initially operated in another hospital with a bridging sternoclavicular plate. After 1 month, the plate was removed due to an infection. The soft tissues recovered uneventfully but a symptomatic non-union developed. One patient was treated with a standard 3.5 LCP™ Plate, 8 patients with an inverted LCP™ Superior Anterior Clavicle Plate with lateral extension and 6 patients with a radial (VA)-LCP™ Distal Humerus Plate. The mean age at time of injury was 52 years (range 19–79). All patients were male. Twelve patients suffered a single injury, and three patients were polytrauma patients. The most common mechanism of injury was (winter) sports related (10/15) with traffic accident as the second most common mechanism (3/15).

All patients were available for follow-up. The mean follow-up was 39 months (range 9–79). Twelve patients had at least one follow-up visit in our hospital resulting in a mean radiological follow-up of 35 weeks (range 5–105). The mean QuickDASH score was 0.81 (range 0–4.50, SD ± 1.44) and the mean SSV was 96 (range 80–100, SD ± 6.53), both indicating a very good functional outcome. These results are presented in Table 2.

One 75-year-old patient suffered a polytrauma with an Injury Severity Score of 29. He was discharged to a rehabilitation clinic with an incomplete tetraplegia. He had a Robinson 1B1 medial clavicle fracture treated with a radial (VA)-LCP™ Distal Humerus Plate. Currently, 3.5-year post-injury, he is in a nursing home. He has no complaints of his left clavicle. The plate is not causing any irritation. His overall condition with a lack of strength, however, results in a QuickDASH of 65 and a SSV of 40. As this is clearly the result of his concomitant injuries and not of his medial clavicle fracture, this patient is not included in our functional analysis.

We did not register any non- or mal-union. We had one patient with an implant failure. This patient with an AO 15-A3.3 and Robinson 1B2 fracture (Fig. 5) was treated with a radial (VA)-LCP™ Distal Humerus Plate. After 2 days, there was a cut-out of the medial screws, clearly caused by a non-optimal initial plate position (too medially) with

Table 1 Baseline characteristics

	Patients (<i>n</i> = 15)
Age (years), mean (range)	52 (19–79)
Sex	
Male	15
Female	0
Side	
Right	7
Left	8
Polytrauma (ISS > 16)	
Yes	3
No	12
Trauma mechanism	
Traffic	3
Sports	10
Ski	4
Snowboard	1
Cross-country skiing	1
Bike	4
Fall from stairs	1
Other	1
Pre-operative imaging	
X-ray	10
CT	10
Both	5
Classification	
AO	
15.1-A	12
15.1-B	0
15.1-C	3
Robinson	
1A1	1
1A2	0
1B1	11
1B2	3
Follow-up (months), mean (range)	39 (9–79)
Size of medial fragment (mm), mean (range)	17.8 (0–45)
Implant	
LCP™ 3.5 plate	1
LCP™ Superior Anterior Clavicle Plate with lateral extension (2.7/3.5)	8
Radial (VA)-LCP™ Distal Humerus Plate (2.7/3.5)	6

insufficient primary stability (Fig. 6). He underwent revision surgery with another radial (VA)-LCP™ Distal Humerus Plate in a better position (Fig. 7). The fracture consolidated. Unfortunately after 1.5 years, a skin perforation with subsequent infection occurred due to a broken and displaced screw. The plate was removed and the infection was treated with antibiotics in his regional hospital. In the end he had a

Table 2 Results

	<i>n</i> = 14
QuickDASH, mean (range, \pm SD)	0.81 (0–4.50, \pm 1.44)
SSV, mean (range, \pm SD)	96 (80–100, \pm 6.53)
Implant irritation	
Implant not removed, no irritation	5 (36%)
Implant not removed, irritation but implant removal not necessary	0
Implant not removed, irritation, no request for removal due to fear of surgery	0
Implant not removed, irritation, considering removal	1 (7%)
Implant removed routinely or on patients request without irritation	2 (14%)
Implant removed due to implant irritation	7 (50%)
Complications	
Non-union	0
Mal-union	0
Implant failure	1 (7%)
Superficial infection	0
Deep infection	1 (7%)
Revision surgery	1 (7%)
Refracture after implant removal	0

**Fig. 5** Pre-operative CT of intra-articular displaced medial clavicle fracture of patient with implant failure and early revision

good recovery resulting in a QuickDASH of 2.3 and a SSV of 100. Two other patients had one or more broken angular stable 2.7 mm screws discovered at 7 weeks and 11 month follow-up without any clinical consequences.

Eight patients (8/14) experienced implant related irritation. In 7 patients, this resulted in implant removal. One patient is still considering implant removal. In total, eight patients had their implant removed after a mean of 16 months (range 8–44, $SD \pm 11.8$).

Discussion

Successful operative treatment of displaced medial clavicle fractures provides excellent long-term functional results. Locking plates are generally ideal implants to stabilise juxta-articular fractures in any location. Both ends of the clavicle, a small bone with small diameter, are

**Fig. 6** Post-operative CT with implant failure. Plate positioning was too medially with screws being intra-articular

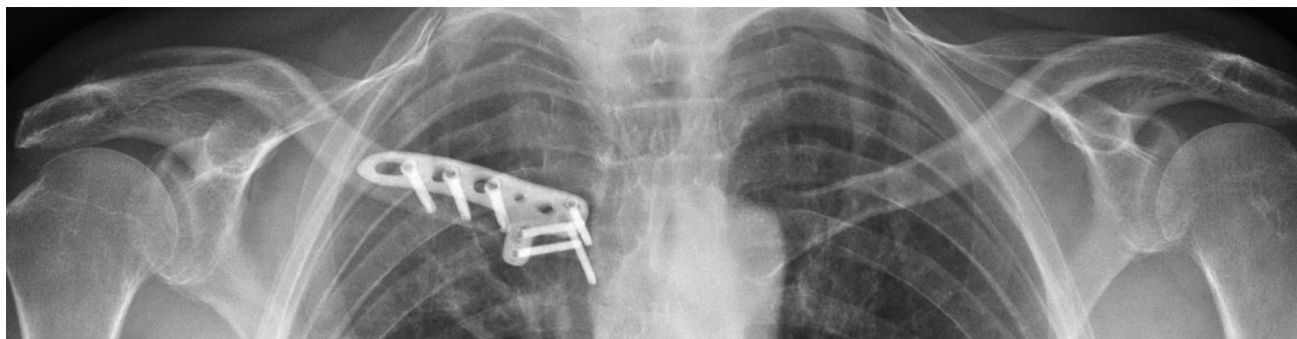


Fig. 7 Follow-up X-ray 6 week post-operative

predisposed for small, pre-contoured locking plates. For the more common lateral fractures, such plates exist and are extremely helpful to achieve a stable fixation. As the medial end of the clavicle has a rather similar surface and angulation as the lateral one, the inverted LCP™ Superior Anterior Clavicle Plate with lateral extension is an almost ideal implant for fracture fixation, if the medial bone stock is long enough (> 2 cm). For intra-articular fractures or extra-articular fractures with a small medial fragment, the aforementioned implant is not suitable. We found, that for these rare and very special situations, the radial (VA)-LCP™ Distal Humerus Plate can be successfully used for stable fixation. Due to its design for the distal humerus with extra ‘lateral support’, it is possible to position this ‘lateral support’ as ‘caudal support’ for medial clavicle fractures. This gives the surgeon the possibility to insert the medial locking screws at an almost perpendicular angle to each other resulting in a more stable fixation. The ‘Variable Angle’ version of the plate facilitates an even greater range of screw positioning. Sidhu et al. suggested the development of an anatomical medial clavicle plate, but to our knowledge, no such plate has been designed yet [10].

The natural course of medial clavicle fractures has been described in three studies. Non-union rates of 6.7% for non-displaced and 14.3% for displaced medial clavicle fractures have been reported [3]. Salipas et al. found a delayed-union rate of 10% for medial clavicle fractures in general. When distinguishing between displaced and non-displaced medial clavicle fractures, the delayed-union rate was 20% for displaced medial clavicle fractures [7]. The overall functional outcome of non-operative treatment for displaced and non-displaced fractures was good with a reported SSV of 77. Unfortunately no differentiation between displaced and non-displaced fractures was made. Throckmorton et al. reported moderate to severe pain in up to 28% of the patients after non-operative treatment [5]. Taking these results into account, operative treatment of displaced medial clavicle fractures should be considered and discussed with any patient who has this injury.

The following treatment algorithm for medial clavicle fractures is determined by our hospital: non-operative treatment for non-displaced fractures with bony contact of the fragments. Our indications for operative treatment are (1) displacement > 1 shaft width, (2) open fractures, (3) displaced intra-articular fractures and (4) symptomatic mal- or non-union. In literature, displacement of > 10 mm is considered severe [2, 5, 7]. As the shaft medially is at least 10 mm thick, displacement of more than one shaft width, as used in our hospital, should be considered severe. A pre-operative CT scan provides a good understanding of the fracture that can be important for the implant choice in case of operative treatment.

Only two other studies describe a larger series of results of surgical treatment of displaced medial clavicle fractures. Sidhu et al. published results of 20 patients with different implants including the inverted LCP™ Superior Anterior Clavicle Plate (15 cases). They found a DASH score after 12 months of 0.9 that represents an excellent result [10]. Oe et al. presented results of 10 patients operated on with different implants like Pilon locking plate, T-oblique locking plate, reconstruction locking plate, Stryker BOS plate and DCP plate. Four patients showed an excellent DASH score (0–0.9), three a good DASH score (10–16) and 1 patient a very poor DASH score (67). This last patient had a complicated course and ended up with a medial clavicle resection. Two patients were not analysed due to tetraplegia/paraplegia [4].

Implants were not routinely removed in our cohort. Implant related irritation, analysed with the algorithm of Hulsman et al. [18], showed that after a mean of 16 months eight patients had their plate removed, 6 due to irritation, and 2 on request. The combination of the lack of soft tissue at the medial side of the clavicle and the bulky implants might result in irritation. Oe et al. recommend plate removal no earlier than 18 months after surgery because of the lack of weight bearing that might result in a prolonged healing process [4]. We only recommend implant removal in case of implant related irritation or on patients’ request.

Several limitations need to be addressed. First, the retrospective character of this study has its obvious drawbacks. Second, our cohort with 15 patients is relatively small although the largest other published studies describe 10 and 20 patients, respectively [4, 10]. Third, most patients were not available for long-term clinical follow-up. However, our protocol to obtain information and questionnaires by telephone resulted in a 100% follow-up rate; even from patients living further away or with a foreign residency. This is an obvious positive aspect of this study. Another strength of this study is the generalizability of our results as the 15 patients were operated on by 6 different surgeons.

Conclusions

Operative treatment of displaced medial clavicle fractures provides an excellent long-term functional outcome. Fractures with substantial medial bone stock can successfully be treated with the inverted LCP™ Superior Anterior Clavicle Plate with lateral extension. Intra-articular fractures or extra-articular fractures with a small medial fragment can be treated with the radial (VA)-LCP™ Distal Humerus Plate.

Acknowledgements The authors thank Michelle Reynolds for the excellent copy-editing of this manuscript.

Funding There was no external source of funding for this study.

Compliance with ethical standards

Conflict of interest Herman Frima, Roderick M. Houwert and Christoph Sommer declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study was approved by the Kantonale Ethikkommission Zürich.

References

- van der Meijden OA, Gaskill TR, Millett PJ. Treatment of clavicle fractures: current concepts review. *J Shoulder Elbow Surg.* 2012;21(3):423–9. <https://doi.org/10.1016/j.jse.2011.08.053>.
- Robinson CM. Fractures of the clavicle in the adult. Epidemiology and classification. *J Bone Joint Surg Br.* 1998;80(3):476–84.
- Robinson CM, Court-Brown CM, McQueen MM, Wakefield AE. (2004) Estimating the risk of nonunion following nonoperative treatment of a clavicular fracture. *J Bone Joint Surg Am* 86-a(7):1359–1365.
- Oe K, Gaul L, Hierholzer C, Woltmann A, Miwa M, Kurosaka M, Buehren V. Operative management of periarticular medial clavicle fractures-report of 10 cases. *J Trauma.* 2011. <https://doi.org/10.1097/TA.0b013e31820d1354>.
- Throckmorton T, Kuhn JE. Fractures of the medial end of the clavicle. *J Shoulder Elbow Surg.* 2007;16(1):49–54. <https://doi.org/10.1016/j.jse.2006.05.010>.
- Ferree S, van Laarhoven JJ, Houwert RM, Hietbrink F, Verleisdonk EJ, Leenen LP. Distribution and treatment of clavicular fractures in monotrauma and polytrauma patients. *J Trauma Manag Outcome.* 2014;8:17. <https://doi.org/10.1186/1752-2897-8-17>.
- Salipas A, Kimmel LA, Edwards ER, Rakhra S, Moaveni AK. Natural history of medial clavicle fractures. *Injury.* 2016;47(10):2235–9. <https://doi.org/10.1016/j.injury.2016.06.011>.
- van Laarhoven JJ, Ferree S, Houwert RM, Hietbrink F, Verleisdonk EM, Leenen LP. Demographics of the injury pattern in severely injured patients with an associated clavicle fracture: a retrospective observational cohort study. *World J Emerg Surg WJES.* 2013;8(1):36. <https://doi.org/10.1186/1749-7922-8-36>.
- Bartonicek J, Fric V, Pacovsky V. Displaced fractures of the medial end of the clavicle: report of five cases. *J Orthop Trauma.* 2010;24(4):e31–5. <https://doi.org/10.1097/BOT.0b013e3181aa5505>.
- Sidhu VS, Hermans D, Duckworth DG. The operative outcomes of displaced medial-end clavicle fractures. *J Shoulder Elbow Surg.* 2015;24(11):1728–34. <https://doi.org/10.1016/j.jse.2015.04.011>.
- Wang Y, Jiang J, Dou B, Zhang P. Inverted distal clavicle anatomic locking plate for displaced medial clavicle fracture. *Arch Orthop Trauma Surg.* 2015;135(9):1241–5. <https://doi.org/10.1007/s00402-015-2259-x>.
- Kim KC, Shin HD, Cha SM. Surgical treatment of displaced medial clavicle fractures using a small T-shaped plate and tension band sutures. *Arch Orthop Trauma Surg.* 2011;131(12):1673–6. <https://doi.org/10.1007/s00402-011-1367-5>.
- Marsh JL, Slongo TF, Agel J, Broderick JS, Creevey W, DeCoster TA, Prokuski L, Sirkin MS, Ziran B, Henley B, Audige L. Fracture and dislocation classification compendium – 2007: Orthopaedic Trauma Association classification, database and outcomes committee. *J Orthop Trauma.* 2007;21(10 Suppl):1–133.
- Beaton DE, Wright JG, Katz JN. Development of the Quick-DASH: comparison of three item-reduction approaches. *J Bone Joint Surg Am.* 2005;87(5):1038–46. <https://doi.org/10.2106/jbjs.d.02060>.
- Gilbart MK, Gerber C. Comparison of the subjective shoulder value and the Constant score. *J Shoulder Elbow Surg.* 2007;16(6):717–21. <https://doi.org/10.1016/j.jse.2007.02.123>.
- Jost B, Pfirrmann CW, Gerber C, Switzerland Z. Clinical outcome after structural failure of rotator cuff repairs. *J Bone Joint Surg Am.* 2000;82(3):304–14.
- Wright RW, Baumgarten KM. Shoulder outcomes measures. *J Am Acad Orthop Surg.* 2010;18(7):436–44.
- Hulsmans MH, van Heijl M, Houwert RM, Hammacher ER, Meylaerts SA, Verhofstad MH, Dijkgraaf MG, Verleisdonk EJ. High irritation and removal rates after plate or nail fixation in patients with displaced midshaft clavicle fractures. *Clin Orthop Relat Res.* 2017;475(2):532–9. <https://doi.org/10.1007/s11999-016-5113-8>.