



Midshaft clavicle fractures: current concepts

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- Clavicle fractures are common fractures and the optimal treatment strategy remains debatable. The present paper reviews the available literature and current concepts in the management of displaced and/or shortened midshaft clavicle fractures.
- Operative treatment leads to improved short-term functional outcomes, increased patient satisfaction, an earlier return to sports and lower rates of non-union compared with conservative treatment. In terms of cost-effectiveness, operative treatment also seems to be advantageous.
- However, operative treatment is associated with an increased risk of complications and re-operations, while long-term shoulder functional outcomes are similar.
- The optimal treatment strategy should be one tailor-made to the patient and his/her specific needs and expectations by utilizing a shared decision-making model.

Keywords: clavicle; fracture; midshaft; treatment; operative; conservative; cost effectiveness; shared decision-making

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Introduction

Clavicle fractures are common fractures, comprising 5% to 10% of all fractures.¹ They occur due to falls on the lateral aspect of the shoulder, the outstretched hand or due to high-energy direct impact over the bone. The incidence of clavicle fractures has increased in recent years and the operative treatment of these fractures has increased disproportionately.^{2,3} Clavicle fractures are most commonly classified according to the Allman classification and/or the Robinson classification. The location and type of fracture is important in the decision-making as it influences management strategies. This paper focuses on the most common clavicle fractures, which are those in the mid-diaphyseal third (Allman 1 and Robinson 2).^{1,4-6} Described conservative treatment options for the clavicle fracture consist of pain reduction by

temporary immobilization using a sling or collar and cuff in combination with analgesics and/or kinesio tape. Operative treatment comprises open reduction and internal fixation (ORIF) using plates and screws or intramedullary fixation (IMF), of which the titanium elastic nail (TEN) is the most commonly used and described option.⁷⁻¹⁶ Classical operative treatment indications are open fractures, compromised skin, neurovascular complications or an additional fracture of the scapular neck (floating shoulder).^{17,18} Others have described relative indications for operative management, which are displaced midshaft clavicle fractures, a shortening of ≥ 2 cm, age, activity level and dominant side.^{17,19}

Even though the ancient Egyptians reported on the fractured clavicle and numerous studies have been conducted to fill the gaps in evidence, there is still no consensus regarding the management of these fractures. In this article, both conservative and operative treatment and the current concepts will be discussed, based on the available evidence.

Physical examination and radiological assessment

During physical examination, a dropped shoulder on the affected side, swelling and haematoma at the middle third of the clavicle are usually observed. Often the fracture elements are palpable. Assessment of possible skin compromise and neurovascular status is important. In addition to the physical assessment, radiological assessment is part of the diagnostic work-up.

Operative treatment

Current radiographic indicators for surgery are displacement and shortening. Displacement is a reproducible measure,^{20,21} but its implications for long-term results remain unclear. There is no clear cut-off point that discerns which patients will benefit from operative management. As for shortening, a decrease of $> 10\%$ in length is suggested to affect scapular kinematics in vivo.^{22,23} It is

reported that scapular upward rotation, posterior tilting and internal rotation increase.^{22,24,25} A shortening of > 2 cm or $> 10\%$ is presumed to be an indicator for poorer outcomes and a possible increased risk of gleno-humeral arthritis in those treated conservatively.^{19,26-34} Others report that the amount of shortening is not influential in the long-term functional outcomes.³⁵⁻³⁷ To the authors' knowledge, there is no universal standardized method of measuring and imaging the fracture reliably and accurately, which could account for these discrepancies. The direction and magnification of the divergent radiographs, as well as the patient's position, affect the imaging and subsequent measurements.³⁸⁻⁴⁰ A variety of imaging and measuring techniques are reported, ranging from a tape measure³¹ to anteroposterior (AP) panoramic radiograph views,^{19,29,35,37,41} tilted AP views (ranging from a 45° craniocaudal to 45° caudocranial views)^{27,30,33,42,43} or CT scans.³⁶ Measuring shortening by comparing the fractured side with the contralateral non-fractured side seems less reliable than expected, since 30% of the population has a physiological asymmetry of ≥ 6 mm.⁴⁴ Accurate and reproducible imaging and measurement methods should be developed if shortening is to be used as a radiographic indicator for surgery.

Non-operative treatment

Conservative treatment consists of pain reduction by temporary immobilization using a sling or collar and cuff with or without analgesics. Although there are no clinical trials on its efficacy as yet, kinesiotape is also used. The use of a figure-of-eight bandage is not advised. Research from the 1980s and a recent study from 2015 compared conservative treatment with a sling and figure-of-eight bandage.^{45,46} They showed that both techniques have similar outcomes but that the patients in the latter group suffered more from pressure sores in the axillae. Range of motion exercises can be increased as tolerated to prevent adhesive capsulitis.

An important complication of conservative treatment is the development of a non-union, which occurs in 15% to 17% of conservatively treated patients.⁴⁷⁻⁴⁹ It appears that this risk is highest in patients with clavicular fractures displaced more than a shaft width or a shortening of > 2 cm.^{17,19} Approximately two-thirds of patients with a non-union undergo operative management because of persistent complaints.⁴⁹

Other risks of conservative management include mal-union and (temporary) neurological issues.^{19,30,50-52} Scapulothoracic kinematics in patients with shortened clavicles differ significantly from those in uninjured shoulders in the resting position and in movement.^{22,23} These changes do not seem to lead to decreased functional outcomes after four months,⁴³ but can be associated with an

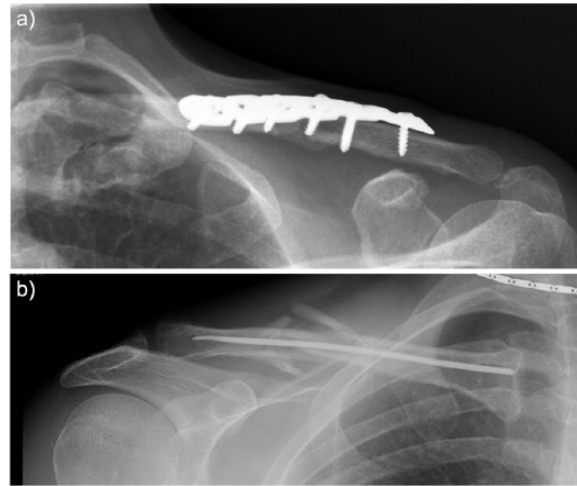


Fig. 1 a) Example of plate fixation of a clavicle fracture (patient treated in OLVG Amsterdam); b) example of intramedullary fixation of a clavicle fracture (patient treated in OLVG Amsterdam).

increased risk of gleno-humeral arthritis.³⁴ Several papers demonstrate that corrective surgery for mal-union is challenging but will lead to good results.^{26,51} Late reconstruction of mal-union results in restoration of objectively assessed muscle strength similar to those receiving immediate fixation; however, there are subtle decreases in endurance.⁵³ The aforementioned arguments may lean towards a predominantly conservative management and operative management only being indicated for symptomatic mal- and non-unions.

ORIF using plates and screws

ORIF using plates and screws is considered the current gold standard for the operative management of displaced and/or shortened midshaft clavicular fractures (Fig. 1a). The advantage of operative intervention is the restoration and preservation of the natural anatomy and length of the fractured clavicle. There are uniform reports of lower non-union rates of approximately 2%.^{49,54,55} An improved patient satisfaction and earlier return to work compared with conservative treatment is also reported.^{47,48,52}

As for all operative interventions, the risk of complications should not be ignored. Risks associated with operative management of the fractured clavicle include neuropathy of the supraclavicular nerve, infection, pneumothorax, implant failure and the need for hardware removal due to hardware-related complaints.³⁰ Nineteen per cent of patients have persistent loss of sensation around the scar and the anterior aspect of the chest wall due to neuropathy of the supraclavicular nerve.⁵⁴ A recent randomized clinical trial (RCT) of 160 patients reported 10.7% of patients undergoing a re-intervention because

of complications from ORIF within one year.⁵⁴ The most common reason for this was early implant failure, followed by deep infection, late implant failure and non-union. A database study involving 1350 patients found that one in four patients underwent re-operation (24.6%) within two years.⁵⁶ Primary implant removal was most common (77%); median time to implant removal was 12 months. A re-operation secondary to non-union, deep infection and mal-union occurred in 2.6%, 2.6% and 1.1% of the patients after a median of six, five and 14 months, respectively.

Concerning the type of incision, patients are reported to be cosmetically more satisfied when a necklace incision is used compared with a longitudinal incision.⁵⁷

Whether an operation leads to better shoulder function is debatable.^{47,48,54} Short-term data show that ORIF using plates and screws results in a more rapid return to normal function compared with conservative treatment.^{47,48} Shoulder function after six weeks may therefore play a role in choosing operative management.⁵⁵ Long-term results show no significant difference in functional outcomes according to a recent meta-analysis of 614 patients.⁴⁹

The type of plate can affect plate-related complications. A reconstruction plate is easily contoured to the morphology of the clavicle, but biomechanical studies show that it is a weaker construct than other plates such as the Low Contact Dynamic Compression Plate (LC-DCP) or an anatomically pre-contoured plate.^{58,59} A retrospective review of 111 patients reported that the use of reconstruction plates leads to 5% hardware failure.⁶⁰ Comparing the LC-DCP plate with the reconstruction plate, more plate-related complications are found in the latter, 1% *versus* 9%.⁶¹ Lower patient satisfaction and high rates of plate prominence have led to the use of lower profile and smaller plates. The position of the plate remains controversial. Superior plating is the most commonly used technique, but anterior-inferior plating, anterior plating or double plating with mini-fragment plates are described as well.⁶²⁻⁶⁴ A biomechanical study comparing anterior and superior plate placement showed that, for all fracture patterns, more construct stiffness was achieved in axial compression and with a superior plate, whereas more construct stiffness was achieved in cantilever bending with an anterior plate.⁶⁵ Antero-inferior plating of midshaft clavicle fractures results in lower hardware removal due to plate prominence.^{62,66} It was found that anterior-inferior plating reduces the time to union, but the location of the plate does not seem to influence functional outcomes or infection rates.⁶³

Dual mini fragment plating was investigated in a small retrospective study (17 patients).⁶⁴ Neither of these patients required a second operation to remove at least one of the plates within one year. No non-union was reported and functional outcomes were similar to other

studies.⁵² Compared with single plating, dual plating is biomechanically equivalent in axial loading and torsion.⁶⁴

Intramedullary fixation

Another option in the operative management of the displaced and/or shortened midshaft clavicle fracture is using an intramedullary device. Classically these comprise Rockwood Pins and Hagie Pins, but the current most used and described implant is the TEN (Fig. 1b).⁷⁻¹⁶ The use of TEN leads to equivalent results as the ORIF in terms of function and union rates.¹⁶ The advantage of this method is that the incision is smaller, causing less tissue damage and superior cosmetic results.⁶⁷ Besides these clinical outcomes, it has been reported in a finite element study that intramedullary treatment of the midshaft clavicle fracture with a TEN could be preferable to ORIF because it shows a stress distribution similar to the intact clavicle.⁶⁸

The disadvantages of the TEN are hardware migration, secondary shortening, telescoping and the need for routine removal.^{9,13,15,16,67,69,70} Most of these complications are attributed to the fact that the TEN aligns but does not fix itself in the fracture elements. The re-intervention ratio related to implant failures is reported to be in the range of 0% to 36%.^{7,10,71} In cases where the TEN is removed, this can be done under local anaesthesia, but is more commonly done under general anaesthesia. In general, up to 100% of TENs are removed.^{9,13,15,16,67,69,70}

A more recent development for intramedullary fixation is the Sonoma CRx. Although the body of evidence concerning this type of implant is small, it seems to lead to similar functional outcomes and reduced rates of implant removal. However, all papers report hardware failure of up to 5.7%.⁷²⁻⁷⁶

Cost-effectiveness

In a society in which health costs continue to increase, it is imperative to avoid unnecessary costs. Few data are available on the cost-effectiveness of operative management of the displaced and/or shortened midshaft clavicle fracture. A study published in 2010 reported that cost-effectiveness is not only defined by the actual cost of treatment but was also highly dependent on the duration and magnitude of functional benefit after operative management and the disability and increased time to union associated with non-operative treatment.⁷⁷ When functional benefits persisted for > 9 years, operative management using ORIF had a favourable value outcome. Another study with a follow-up of 2.5 years concluded that operatively managed patients cost more during their hospital stay but missed fewer days of work (8.4 days *versus* 35.2 days), required less assistance for care at home

(3 days *versus* 7 days) and incurred lower costs for physical therapy (\$971.76 *versus* \$1820).⁷⁸ An overall cost reduction of \$5091.33 in favour of the operatively managed patient was found.

Return to sport

For athletes and the active population, return rates and time to return to sport can be important factors in deciding the treatment modality. In case of non- or minimally displaced midshaft clavicle fractures, the return rate to sports was equal between the conservatively and operatively managed patients.⁷⁹ Time for return to sport was significantly longer in the conservatively managed patient when comparing the two treatment options for displaced midshaft clavicle fractures; 21.5 weeks (12 to 78) *versus* 10.6 weeks (10 to 13).⁷⁹

In this review, operative management using intramedullary fixation was included.⁷⁹ No statistically significant differences were identified between ORIF and IMF groups concerning return rates (98% *versus* 99%). In those treated with ORIF, mean return time was 9.4 weeks (2 to 24); in the IMF group, return time was 9.9 weeks (2 to 14). It was concluded that operative management of displaced midshaft fractures offers improved rates and times to return to sport compared with non-operative management.

Shared decision-making

Defining the most suitable treatment for patients with midshaft clavicle fractures is challenging. A frequently used model is shared decision-making (SDM). It is widely used in treatment strategies for diabetes mellitus, cardiovascular disease and cancer. SDM is on the more patient-centred side of the spectrum, between paternalistic decision-making and informed decision-making.

Joint decision-making is subject to several conditions:

- both the patient and the physician are involved in the decision-making;
- both the patient and the physician exchange information;
- both the patient and the physician indicate their preferences regarding diagnostic methods and treatments;
- both the patient and the physician agree with the final decision.⁸⁰

During a study in the Netherlands, the current daily practice of shared decisional behaviour in clavicle fracture treatment was evaluated.⁸¹ After the decision-making moment a questionnaire was filled in. The mean score for perceived degree of SDM was 74 out of 100. In 68% of patients, the preferred role matched the actual role in making the decision. Thirty-two per cent of patients would have

preferred either a less or a more active role. As a health provider it is meaningful to be aware of these nuances.

Conclusions

Operative treatment with either ORIF or IMF leads to improved short-term functional outcomes, increased patient satisfaction, an earlier return to sports and lower rates of non-union compared with conservative treatment. In terms of cost-effectiveness, operative treatment seems to be advantageous. However, operative treatment is associated with an increased risk of complications and re-operations, while long-term shoulder functional outcomes are similar.

Functional outcomes and union rates are similar between ORIF and IMF. Both ORIF and IMF are subject to implant-specific complications and should be evaluated with the patient before opting for operative management. The optimal treatment strategy should be one tailor-made to the patient and his/her specific needs and expectations by utilizing a shared decision-making model.

Further research on better discerning those who will benefit most from operative management remains necessary. A uniform method of imaging, measuring and reporting radiological parameters as possible indicators for operative management is a consideration for future studies.

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REFERENCES

1. **Robinson CM.** Fractures of the clavicle in the adult. Epidemiology and classification. *J Bone Joint Surg [Br]* 1998;80-B:476-484.
2. **Huttunen TT, Launonen AP, Berg HE, et al.** Trends in the incidence of clavicle fractures and surgical repair in Sweden: 2001-2012. *J Bone Joint Surg [Am]* 2016;98-A:1837-1842.

3. **Schairer WW, Nwachukwu BU, Warren RF, Dines DM, Gulotta LV.** Operative fixation for clavicle fractures—socioeconomic differences persist despite overall population increases in utilization. *J Orthop Trauma* 2017;31:e167–e172.
4. **Nordqvist A, Petersson C.** The incidence of fractures of the clavicle. *Clin Orthop Relat Res* 1994;(300):127–132.
5. **Postacchini F, Gumina S, De Santis P, Albo F.** Epidemiology of clavicle fractures. *J Shoulder Elbow Surg* 2002;11:452–456.
6. **Khan LAK, Bradnock TJ, Scott C, Robinson CM.** Fractures of the clavicle. *J Bone Joint Surg [Am]* 2009;91:447–460.
7. **Assobhi JEH.** Reconstruction plate versus minimal invasive retrograde titanium elastic nail fixation for displaced midclavicular fractures. *J Orthop Traumatol* 2011;12:185–192.
8. **Braun KF, Siebenlist S, Sandmann GH, et al.** Functional results following titanium elastic-stable intramedullary nailing (ESIN) of mid-shaft clavicle fractures. *Acta Chir Orthop Traumatol Cech* 2014;81:118–121.
9. **Chen Q-Y, Kou DQ, Cheng XJ, et al.** Intramedullary nailing of clavicular midshaft fractures in adults using titanium elastic nail. *Chin J Traumatol* 2011;14:269–276.
10. **Frigg A, Rillmann P, Perren T, Gerber M, Ryf C.** Intramedullary nailing of clavicular midshaft fractures with the titanium elastic nail: problems and complications. *Am J Sports Med* 2009;37:352–359.
11. **Jubel A, Andermahr J, Schiffer G, Tsironis K, Rehm KE.** Elastic stable intramedullary nailing of midclavicular fractures with a titanium nail. *Clin Orthop Relat Res* 2003;408:279–285.
12. **Kadokia AP, Rambani R, Qamar F, et al.** Titanium elastic stable intramedullary nailing of displaced midshaft clavicle fractures: A review of 38 cases. *Int J Shoulder Surg* 2012;6:82–85.
13. **Langenhan R, Reimers N, Probst A.** [Intramedullary stabilisation of displaced midshaft clavicular fractures: does the fracture pattern (simple vs. complex) influence the anatomic and functional result?]. *Z Orthop Unfall* 2014;152:588–595.
14. **Mueller M, Rangger C, Striepens N, Burger C.** Minimally invasive intramedullary nailing of midshaft clavicular fractures using titanium elastic nails. *J Trauma* 2008;64:1528–1534.
15. **Saha P, Datta P, Ayan S, et al.** Plate versus titanium elastic nail in treatment of displaced midshaft clavicle fractures: A comparative study. *Indian J Orthop* 2014;48:587–593.
16. **van der Meijden OA, Houwert RM, Hulsmans M, et al.** Operative treatment of dislocated midshaft clavicular fractures: plate or intramedullary nail fixation? A randomized controlled trial. *J Bone Joint Surg [Am]* 2015;97-A:613–619.
17. **AO Foundation.** AO/OTA fracture and dislocation classification: Clavicle diagnosis. <https://www2.aofoundation.org/wps/portal/surgery?showPage=diagnosis&bone=Clavicle&segment=Nonsegmented> (date last accessed 18 December 2017).
18. **AO Foundation.** AO/OTA fracture and dislocation classification: Clavicle reduction and fixation. https://www2.aofoundation.org/wps/portal/!ut/p/a1/04_Sj9CPykssyoxPLMnMzovMAfGjz0KN_AoM3D2DDBz9_UMMDRyDXQ3dw9wMDAwCTYEKlvEocDQnTr8BDuBoQEh_QW5oKABaevup/dl5/d5/L2dJQSEvUUt3QS8oSmlFL102XzJPMDBSHVMwS09PVDEwQVNFMDWRjAwMFE1/?showPage=redfix&bone=Clavicle&segment=Nonsegmented&classification=15-Special%20considerations&treatment=&method=Special%20considerations&implantstype=hidden&approach=&redfix_url=1429710546336 (date last accessed 18 December 2017).
19. **Hill JM, McGuire MH, Crosby LA.** Closed treatment of displaced middle-third fractures of the clavicle gives poor results. *J Bone Joint Surg [Br]* 1997;79-B:537–539.
20. **Jones GL, Bishop JY, Lewis B, et al; MOON Shoulder Group.** Intraobserver and interobserver agreement in the classification and treatment of midshaft clavicle fractures. *Am J Sports Med* 2014;42:1176–1181.
21. **Stegeman SA, Fernandes NC, Krijnen P, Schipper IB.** Reliability of the Robinson classification for displaced comminuted midshaft clavicular fractures. *Clin Imaging* 2015;39:293–296.
22. **Hillen RJ, Burger BJ, Pöhl RG, van Dijk CN, Veeger DHEJ.** The effect of experimental shortening of the clavicle on shoulder kinematics. *Clin Biomech (Bristol, Avon)* 2012;27:777–781.
23. **Matsumura N, Ikegami H, Nakamichi N, et al.** Effect of shortening deformity of the clavicle on scapular kinematics: a cadaveric study. *Am J Sports Med* 2010;38:1000–1006.
24. **Andermahr J, Jubel A, Elsner A, et al.** Malunion of the clavicle causes significant glenoid malposition: a quantitative anatomic investigation. *Surg Radiol Anat* 2006;28:447–456.
25. **Kim D, Lee D, Jang Y, Yeom J, Banks SA.** Effects of short malunion of the clavicle on in vivo scapular kinematics. *J Shoulder Elbow Surg* 2017;26:e286–e292.
26. **Hillen RJ, Burger BJ, Pöhl RG, de Gast A, Robinson CM.** Malunion after midshaft clavicle fractures in adults. *Acta Orthop* 2010;81:273–279.
27. **De Giorgi S, Notarnicola A, Tafuri S, et al.** Conservative treatment of fractures of the clavicle. *BMC Res Notes* 2011;4:333.
28. **Eskola A, Vainionpää S, Myllynen P, Pätäälä H, Rokkanen P.** Outcome of clavicular fracture in 89 patients. *Arch Orthop Trauma Surg* 1986;105:337–338.
29. **Jubel A, Schiffer G, Andermahr J, Ries C, Faymonville C.** [Shortening deformities of the clavicle after diaphyseal clavicular fractures: influence on patient-oriented assessment of shoulder function]. *Unfallchirurg* 2016;119:508–516.
30. **Ledger M, Leeks N, Ackland T, Wang A.** Short malunions of the clavicle: an anatomic and functional study. *J Shoulder Elbow Surg* 2005;14:349–354.
31. **McKee MD, Pedersen EM, Jones C, et al.** Deficits following nonoperative treatment of displaced midshaft clavicular fractures. *J Bone Joint Surg [Am]* 2006;88-A:35–40.
32. **Postacchini R, Gumina S, Farsetti P, Postacchini F.** Long-term results of conservative management of midshaft clavicle fracture. *Int Orthop* 2010;34:731–736.
33. **Thormodsgard TM, Stone K, Ciraulo DL, Camuso MR, Desjardins S.** An assessment of patient satisfaction with nonoperative management of clavicular fractures using the disabilities of the arm, shoulder and hand outcome measure. *J Trauma* 2011;71:1126–1129.
34. **Weinberg DS, Vallier HA, Gaumer GA, Cooperman DR, Liu RW.** Clavicle fractures are associated with arthritis of the glenohumeral joint in a large osteological collection. *J Orthop Trauma* 2016;30:605–611.
35. **Figueiredo GS, Tamaoki MJ, Dragone B, et al.** Correlation of the degree of clavicle shortening after non-surgical treatment of midshaft fractures with upper limb function. *BMC Musculoskelet Disord* 2015;16:151.
36. **Goudie EB, Clement ND, Murray IR, et al.** The influence of shortening on clinical outcome in healed displaced midshaft clavicular fractures after nonoperative treatment. *J Bone Joint Surg [Am]* 2017;99:1166–1172.
37. **Rasmussen JV, Jensen SL, Petersen JB, et al.** A retrospective study of the association between shortening of the clavicle after fracture and the clinical outcome in 136 patients. *Injury* 2011;42:414–417.

- 38. Malik A, Jazini E, Song X, et al.** Positional change in displacement of midshaft clavicle fractures: an aid to initial evaluation. *J Orthop Trauma* 2017;31:e9-e12.
- 39. Backus JD, Merriman DJ, McAndrew CM, Gardner MJ, Ricci WM.** Upright versus supine radiographs of clavicle fractures: does positioning matter? *J Orthop Trauma* 2014;28:636-641.
- 40. Axelrod D, Lubovsky O, Safran O, Axelrod T, Whyne C.** Fractures of the clavicle; which x-ray projection provides the greatest accuracy in determining displacement of the fragments? *Journal of Orthopaedics and Trauma*, 2013;3: art235627.
- 41. Lazarides S, Zafropoulos G.** Conservative treatment of fractures at the middle third of the clavicle: the relevance of shortening and clinical outcome. *J Shoulder Elbow Surg* 2006;15:191-194.
- 42. Fuglesang HFS, Flugsrud GB, Randsborg P-H, Stavem K, Utvåg SE.** Radiological and functional outcomes 2.7 years following conservatively treated completely displaced midshaft clavicle fractures. *Arch Orthop Trauma Surg* 2016;136:17-25.
- 43. Stegeman SA, de Witte PB, Boonstra S, et al.** Posttraumatic midshaft clavicular shortening does not result in relevant functional outcome changes. *Acta Orthop* 2015;86:545-552.
- 44. Cunningham BP, McLaren A, Richardson M, McLemore R.** Clavicular length: the assumption of symmetry. *Orthopedics* 2013;36:e343-e347.
- 45. Andersen K, Jensen PO, Lauritzen J.** Treatment of clavicular fractures. Figure-of-eight bandage versus a simple sling. *Acta Orthop Scand* 1987;58:71-74.
- 46. Ersen A, Atalar AC, Birisik F, Saglam Y, Demirhan M.** Comparison of simple arm sling and figure of eight clavicular bandage for midshaft clavicular fractures: a randomised controlled study. *Bone Joint J* 2015;97-B:1562-1565.
- 47. Zlowodzki M, Zelle BA, Cole PA, Jeray K, McKee MD; Evidence-Based Orthopaedic Trauma Working Group.** Treatment of acute midshaft clavicle fractures: systematic review of 2144 fractures: on behalf of the Evidence-Based Orthopaedic Trauma Working Group. *J Orthop Trauma* 2005;19:504-507.
- 48. McKee RC, Whelan DB, Schemitsch EH, McKee MD.** Operative versus nonoperative care of displaced midshaft clavicular fractures: a meta-analysis of randomized clinical trials. *J Bone Joint Surg [Am]* 2012;94-A:675-684.
- 49. Woltz S, Krijnen P, Schipper IB.** Plate fixation versus nonoperative treatment for displaced midshaft clavicular fractures: a meta-analysis of randomized controlled trials. *J Bone Joint Surg [Am]* 2017;99-A:1051-1057.
- 50. Nowak J, Holgersson M, Larsson S.** Sequelae from clavicular fractures are common: a prospective study of 222 patients. *Acta Orthop* 2005;76:496-502.
- 51. Chan KY, Jupiter JB, Leffert RD, Marti R.** Clavicle malunion. *J Shoulder Elbow Surg* 1999;8:287-290.
- 52. Canadian Orthopaedic Trauma Society.** Nonoperative treatment compared with plate fixation of displaced midshaft clavicular fractures. A multicenter, randomized clinical trial. *J Bone Joint Surg [Am]* 2007;89-A:1-10.
- 53. Potter JM, Jones C, Wild LM, Schemitsch EH, McKee MD.** Does delay matter? The restoration of objectively measured shoulder strength and patient-oriented outcome after immediate fixation versus delayed reconstruction of displaced midshaft fractures of the clavicle. *J Shoulder Elbow Surg* 2007;16:514-518.
- 54. Woltz S, Stegeman SA, Krijnen P, et al.** Plate fixation compared with nonoperative treatment for displaced midshaft clavicular fractures: a multicenter randomized controlled trial. *J Bone Joint Surg [Am]* 2017;99:106-112.
- 55. Kong L, Zhang Y, Shen Y.** Operative versus nonoperative treatment for displaced midshaft clavicular fractures: a meta-analysis of randomized clinical trials. *Arch Orthop Trauma Surg* 2014;134:1493-1500.
- 56. Leroux T, Wasserstein D, Henry P, et al.** Rate of and risk factors for reoperations after open reduction and internal fixation of midshaft clavicle fractures: a population-based study in Ontario, Canada. *J Bone Joint Surg [Am]* 2014;96-A:1119-1125.
- 57. Shukla DR, Rubenstein WJ, Barnes LA, et al.** The influence of incision type on patient satisfaction after plate fixation of clavicle fractures. *Orthop J Sports Med* 2017;5:232596711712235.
- 58. Eden L, Dohrt S, Frey SP, et al.** Biomechanical comparison of the Locking Compression superior anterior clavicle plate with seven and ten hole reconstruction plates in midshaft clavicle fracture stabilisation. *Int Orthop* 2012;36:2537-2543.
- 59. Iannotti MR, Crosby LA, Stafford P, Grayson G, Goulet R.** Effects of plate location and selection on the stability of midshaft clavicle osteotomies: a biomechanical study. *J Shoulder Elbow Surg* 2002;11:457-462.
- 60. Woltz S, Duijff JW, Hoogendoorn JM, et al.** Reconstruction plates for midshaft clavicular fractures: A retrospective cohort study. *Orthop Traumatol Surg Res* 2016;102:25-29.
- 61. Gilde AK, Jones CB, Sietsema DL, Hoffmann MF.** Does plate type influence the clinical outcomes and implant removal in midclavicular fractures fixed with 2.7-mm anteroinferior plates? A retrospective cohort study. *J Orthop Surg Res* 2014;9:55.
- 62. Baltés TPA, Donders JCE, Kloen P.** What is the hardware removal rate after anteroinferior plating of the clavicle? A retrospective cohort study. *J Shoulder Elbow Surg* 2017;26:1838-1843.
- 63. Ai J, Kan SL, Li HL, et al.** Anterior inferior plating versus superior plating for clavicle fracture: a meta-analysis. *BMC Musculoskelet Disord* 2017;18:159.
- 64. Prasarn ML, Meyers KN, Wilkin G, et al.** Dual mini-fragment plating for midshaft clavicle fractures: a clinical and biomechanical investigation. *Arch Orthop Trauma Surg* 2015;135:1655-1662.
- 65. Toogood P, Coughlin D, Rodriguez D, Lotz J, Feeley B.** A biomechanical comparison of superior and anterior positioning of precontoured plates for midshaft clavicle fractures. *Am J Orthop (Belle Mead NJ)* 2014;43:E226-E231.
- 66. Chen C-E, Juhn R-J, Ko J-Y.** Anterior-inferior plating of middle-third fractures of the clavicle. *Arch Orthop Trauma Surg* 2010;130:507-511.
- 67. Wijdicks F-JG, Houwert RM, Millett PJ, Verleisdonk EJJM, Van der Meijden OAJ.** Systematic review of complications after intramedullary fixation for displaced midshaft clavicle fractures. *Can J Surg* 2013;56:58-64.
- 68. Zeng L, Wei H, Liu Y, et al.** Titanium elastic nail (TEN) versus reconstruction plate repair of midshaft clavicular fractures: a finite element study. *PLoS One* 2015;10:e0126131.
- 69. Andrade-Silva FB, Kojima KE, Joeris A, Santos Silva J, Mattar R Jr.** Single, superiorly placed reconstruction plate compared with flexible intramedullary nailing for midshaft clavicular fractures: a prospective, randomized controlled trial. *J Bone Joint Surg [Am]* 2015;97-A:620-626.
- 70. Smekal V, Irenberger A, Struve P, et al.** Elastic stable intramedullary nailing versus nonoperative treatment of displaced midshaft clavicular fractures-a randomized, controlled, clinical trial. *J Orthop Trauma* 2009;23:106-112.
- 71. Houwert RM, Smeeing DP, Ahmed Ali U, et al.** Plate fixation or intramedullary fixation for midshaft clavicle fractures: a systematic review and meta-analysis of randomized controlled trials and observational studies. *J Shoulder Elbow Surg* 2016;25:1195-1203.

- 72. Calbiyik M, Ipek D, Taskoparan M.** Prospective randomized study comparing results of fixation for clavicular shaft fractures with intramedullary nail or locking compression plate. *Int Orthop* 2017;41:173-179.
- 73. Calbiyik M, Zehir S, Ipek D.** Minimally invasive implantation of a novel flexible intramedullary nail in patients with displaced midshaft clavicle fractures. *Eur J Trauma Emerg Surg* 2016;42:711-717.
- 74. King PR, Ikram A, Lamberts RP.** The treatment of clavicular shaft fractures with an innovative locked intramedullary device. *J Shoulder Elbow Surg* 2015;24:e1-e6.
- 75. Zehir S, Akgül T, Zehir R.** Results of midshaft clavicle fractures treated with expandable, elastic and locking intramedullary nails. *Acta Orthop Traumatol Turc* 2015;49:13-17.
- 76. Zehir S, Zehir R, Şahin E, Çalbiyik M.** Comparison of novel intramedullary nailing with mini-invasive plating in surgical fixation of displaced midshaft clavicle fractures. *Arch Orthop Trauma Surg* 2015;135:339-344.
- 77. Pearson AM, Tosteson AN, Koval KJ, et al.** Is surgery for displaced, midshaft clavicle fractures in adults cost-effective? Results based on a multicenter randomized, controlled trial. *J Orthop Trauma* 2010;24:426-433.
- 78. Althausen PL, Shannon S, Lu M, O'Mara TJ, Bray TJ.** Clinical and financial comparison of operative and nonoperative treatment of displaced clavicle fractures. *J Shoulder Elbow Surg* 2013;22:608-611.
- 79. Robertson GA, Wood AM.** Return to sport following clavicle fractures: a systematic review. *Br Med Bull* 2016;119:111-128.
- 80. Stiggelbout AM, Van der Weijden T, De Wit MP, et al.** Shared decision making: really putting patients at the centre of healthcare. *BMJ* 2012;344:e256.
- 81. Woltz S, Krijnen P, Meylaerts SAG, Pieterse AH, Schipper IB.** Shared decision making in the management of midshaft clavicular fractures: nonoperative treatment or plate fixation. *Injury* 2017;48:920-924.