

Functional Outcome of Unstable Mid Shaft Clavicle Fractures Treated with Pre-Contoured Anatomical Locking Plate: A Prospective Clinical Study

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Abstract

Background: Unstable displaced midshaft clavicle fractures are common injuries in young and active adults. Although nonoperative treatment remains appropriate for many clavicle fractures, substantial displacement, shortening and comminution have been associated with nonunion, symptomatic malunion and persistent functional impairment. Modern pre-contoured anatomical locking plates are designed to restore clavicular alignment while providing stable fixation and permitting early shoulder rehabilitation. The present study evaluated the clinical, radiological and functional outcome of unstable clavicle fractures treated with open reduction and internal fixation using a pre-contoured anatomical locking plate. **Material and Methods:** A prospective clinical study was conducted in the Department of Orthopaedics, in a tertiary care teaching hospital for a period of 18 months. Twenty-five adult patients with closed unstable displaced midshaft clavicle fractures were treated with open reduction and internal fixation using a 3.5-mm pre-contoured superior anatomical locking plate. Patients were followed clinically and radiologically at regular intervals. Fracture union, complications and functional outcome were assessed. Functional assessment was performed using the Constant-Murley shoulder score, comprising pain, activities of daily living, strength and range of motion. **Results:** The study reported right-sided fractures in 15 patients and left-sided fractures in 10. Road-traffic accidents were the predominant mechanism (19 patients), followed by accidental falls (6 patients). Eight fractures were Robinson type 2B1 and 17 were type 2B2. The reported time to union ranged from 10 to more than 18 weeks, with a mean of 12.76 weeks; 2 patients united at 10 weeks, 14 at 12–14 weeks, 6 at 16 weeks, 2 at 18 weeks and 1 after 18 weeks. Twenty-four patients achieved a satisfactory Constant score and one was unsatisfactory. Overall functional grading was excellent in 19 patients (76%), good in 5 (20%) and poor in 1 (4%). Complications included hardware prominence (2), screw pullout (2), deep infection (1), nonunion (1) and paresthesia (1). The deep infection occurred in a patient with uncontrolled diabetes and was followed by implant removal and eventual nonunion. **Conclusion:** In this institutional cohort, fixation of unstable midshaft clavicle fractures with a pre-contoured anatomical locking plate was associated with a high rate of fracture union and predominantly excellent or good functional outcomes. Stable anatomical reduction, appropriate plate positioning and protection of the supraclavicular nerves are important for minimizing complications. The results support anatomical locking plate fixation as an effective option for appropriately selected unstable displaced midshaft clavicle fractures, while emphasizing careful patient selection and optimization of comorbidities such as diabetes.

Keywords: Clavicle Fracture, Midshaft Fracture, Unstable Fracture, Pre-Contoured Plate, Locking Plate, Open Reduction and Internal Fixation, Constant-Murley Score, Fracture Union, Hardware Prominence.

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INTRODUCTION

Clavicle fractures are among the common fractures encountered in orthopaedic trauma practice and occur particularly often in young, physically active adults. Epidemiological studies have shown a predominance of midshaft fractures, reflecting the characteristic geometry of the clavicle and the mechanical forces transmitted through the shoulder girdle.^[1,2] Robinson's epidemiological and classification work provided a reproducible framework for describing clavicular fractures and highlighted the prognostic relevance of displacement and fracture morphology.^[3]

Historically, most clavicle fractures were managed nonoperatively because the clavicle has considerable healing potential and many minimally displaced fractures unite uneventfully. However, the results of nonoperative management of markedly displaced midshaft fractures have been questioned. Patient-based studies have demonstrated

residual weakness, reduced endurance and disability after nonoperative treatment, while other investigations have documented symptomatic malunion and nonunion, particularly in substantially displaced or shortened fractures.^[4,5] These observations contributed to a gradual change in the management paradigm, particularly for young and active patients with complete displacement, substantial shortening or comminution.^[6,7]

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Randomized trials have strengthened the evidence supporting operative fixation for selected displaced midshaft fractures. The Canadian Orthopaedic Trauma Society trial demonstrated better Constant and DASH scores, faster radiographic union, fewer nonunions and fewer symptomatic malunions with plate fixation compared with sling treatment.^[8] Subsequent multicentre randomized trials similarly demonstrated lower nonunion rates and improved early functional outcomes with plate fixation, although the magnitude of long-term functional benefit has been more modest.^[9,10] Meta-analyses have consistently shown that operative treatment reduces nonunion and malunion, while also emphasizing hardware-related complications and the possibility of secondary surgery.^[11,12] Among operative techniques, plate fixation and intramedullary fixation are the two principal methods. Plate fixation offers direct control of length, rotation and alignment and is particularly useful for comminuted patterns. Pre-contoured anatomical plates were developed to improve fit to the native clavicular contour and potentially reduce prominence and the need for intraoperative contouring.^[13,14] Biomechanical and clinical literature supports the mechanical suitability of pre-contoured clavicular plates, although implant-related symptoms remain clinically relevant.^[15]

The operative approach must also account for the nearby neurovascular structures. The supraclavicular nerves are vulnerable during exposure and can produce postoperative cutaneous numbness or dysesthesia. Anatomical studies have demonstrated important variations in the course of these nerves, reinforcing the need for careful soft-tissue handling.^[16] Likewise, the subclavian vessels lie immediately posterior and inferior to portions of the clavicle, making controlled drilling and appropriate screw length essential for safe fixation.^[17]

The present study was undertaken to evaluate the outcome of unstable displaced midshaft clavicle fractures treated with open reduction and internal fixation using a pre-contoured anatomical locking plate in a tertiary teaching hospital. The study specifically examined fracture union, time to union, complications and functional outcome using the Constant-Murley shoulder score.

The aim of the present study was to evaluate the clinical, radiological, and functional outcomes of unstable midshaft clavicle fractures treated by open reduction and internal fixation using a pre-contoured anatomical locking plate. The study specifically sought to determine the time required for achieving radiological and clinical fracture union following fixation with an anatomical locking plate and to assess postoperative shoulder function using the Constant-Murley shoulder score. In addition, the study aimed to document the occurrence of postoperative complications, including surgical-site infection, hardware prominence, screw pullout, delayed union, nonunion, malunion, implant failure, refracture, and postoperative paresthesia. The study also described the baseline characteristics of the fracture population, including the fracture pattern, side of clavicular involvement, and mechanism of injury

MATERIALS AND METHODS

This was a prospective clinical study conducted in the Department of Orthopaedics in a tertiary care teaching hospital for a period of 18 months during which patients presenting with closed unstable clavicular fractures and fulfilling the predefined eligibility criteria were evaluated for operative management. A total of 25 patients were included in the study. All eligible patients underwent open reduction and internal fixation using a pre-contoured 3.5-mm superior clavicular anatomical locking compression plate. The functional outcome was assessed clinically using the Constant-Murley shoulder score, while fracture healing was evaluated clinically and radiologically during follow-up.

The study population comprised adult patients with closed, displaced and unstable midshaft fractures of the clavicle who were considered suitable candidates for operative fixation. The original study protocol included fractures with more than 2 cm of displacement and more than 2 cm of shortening, with or without comminution, corresponding predominantly to Robinson type 2B1 and 2B2 fractures. The study also considered other unstable fracture configurations, while patients with conditions that could adversely influence operative treatment or follow-up were excluded according to the predefined criteria. All patients underwent clinical assessment and anteroposterior radiographic evaluation of the affected shoulder before surgery. A detailed history was obtained, with particular attention to the mechanism of injury and associated injuries, and routine investigations were performed as required for anaesthetic clearance. Written informed consent was obtained from all participants before inclusion in the study.

Inclusion Criteria: Patients were eligible for inclusion if they had a closed, unstable midshaft fracture of the clavicle with displacement greater than 2 cm and shortening greater than 2 cm, with or without associated comminution. Fractures corresponding to Robinson type 2B1 and 2B2 patterns were included because of their unstable nature and increased risk of symptomatic malunion or nonunion with conservative management. Patients had to be adults considered medically suitable for operative treatment and capable of providing informed consent.

Exclusion Criteria: Patients were excluded if they were younger than 18 years or older than 60 years, had undisplaced or minimally displaced clavicular fractures, or had a medical contraindication to surgery such as significant cardiac disease, renal failure, or active chemotherapy. Patients with previous surgery involving the clavicle, pathological fractures other than those related to osteoporosis, and those receiving ongoing chemotherapy or radiotherapy for malignancy were also excluded. In addition, patients with open fractures, impending compound fractures with significant soft-tissue compromise, bilateral clavicular fractures, or those unable to provide informed consent were not included in the study. These criteria were applied to obtain a relatively homogeneous cohort of patients with closed unstable clavicular fractures undergoing primary operative fixation.

Preoperative assessment: A detailed history was obtained, including mechanism of injury and assessment for associated injuries. Standard anteroposterior shoulder radiographs were

obtained. Routine laboratory and pre-anaesthetic investigations were performed. Patients were counselled regarding operative and nonoperative alternatives and written informed consent was obtained.

Implant and operative technique: All patients underwent open reduction and internal fixation using a pre-contoured 3.5-mm superior clavicle anatomical locking compression plate. A 2.7-mm lag screw was kept available for fixation of unstable butterfly or comminuted fragments when required. Surgery was performed under regional or general anaesthesia. The patient was positioned supine with the head turned away from the operative side and a support beneath the scapula to facilitate reduction.

A skin incision was made inferior to the fracture, and the subcutaneous tissue and platysma were mobilized as a layer. The supraclavicular nerves were identified and preserved whenever feasible. The myofascial layer over the clavicle was elevated while maintaining soft-tissue attachments to comminuted fragments. Reduction was achieved with clamps and the pre-contoured plate was placed superiorly on the tension side. Screw insertion was performed cautiously because of the proximity of the subclavian vessels. The protocol aimed for at least two and preferably three bicortical screws on each side of the fracture, with lag screws used where necessary. The fascia was repaired over the plate and the wound was closed.

Postoperative rehabilitation and follow-up: The upper limb was supported in a sling postoperatively. Pendulum exercises and elbow, wrist and finger mobilization were started early, generally within 2–3 days. Sutures were removed on approximately the 12th postoperative day. Unrestricted shoulder range of motion was permitted after this stage according to clinical progress. Strengthening was commenced after approximately six weeks when radiographic evidence of union was present. Return to work and vigorous physical activity was generally permitted after approximately 12 weeks when adequate bony union was confirmed.

Patients were followed monthly during the first three postoperative months and subsequently at six and twelve months. Radiographs were obtained during follow-up. Clinical and radiological union were assessed. Delayed union was defined as failure to achieve expected union by four months, while nonunion was considered in the presence of persistent fracture lines, absent callus and/or sclerotic fracture margins at six months.

Functional outcome was assessed using the Constant-Murley shoulder score. The score incorporates pain (15 points), activities of daily living/activity level (20 points), strength of abduction (25 points) and range of motion (40 points), giving a maximum score of 100 points.^[18] The study classified the overall outcome as excellent, good or poor and separately reported satisfactory versus unsatisfactory results.

RESULTS

Patient characteristics

Table 1: Demographic and baseline characteristics

Parameter	Category	n	% of cohort
Sample size	Total	25	100.0
Age	Reported range 19–45 years	25	100.0
Sex	Male	16	64.0*
	Female	9	36.0*
Side	Right	15	60.0
	Left	10	40.0

The study included a total of 25 patients, representing 100% of the study cohort. The reported age range of the participants was 19–45 years. Regarding sex distribution, 16 patients (64.0%) were males, whereas 9 patients (36.0%) were females, demonstrating a male predominance among patients with unstable clavicular fractures included in the study. 5 -4-54-644

With respect to the side of fracture, the right clavicle was

involved in 15 patients (60.0%), while the left clavicle was involved in 10 patients (40.0%). Thus, right-sided fractures were more frequent than left-sided fractures, with a right-to-left distribution of 1.5:1. Overall, the baseline distribution indicates that the study population predominantly consisted of young adult males, with a slightly higher frequency of right-sided clavicular fractures.

Mechanism of injury

Table 2: Mechanism of injury

Mechanism	n	Percentage
Road-traffic accident	19	76.0%
Accidental fall	6	24.0%
Total	25	100.0%

Road-traffic accidents were the predominant mechanism, accounting for 19 of the 25 fractures (76.0%), while six patients (24.0%) sustained the injury following an

accidental fall. This distribution is consistent with the high-energy mechanism frequently associated with displaced and unstable clavicular injuries.

Fracture morphology

Table 3: Distribution according to Robinson fracture classification

Robinson classification	Description in study	n	%
Type 2B1	Displaced/unstable midshaft pattern	8	32.0
Type 2B2	Displaced/unstable comminuted pattern	17	68.0
Total		25	100.0

Type 2B2 fractures predominated, accounting for 17 patients (68.0%), whereas 8 patients (32.0%) had type 2B1 fractures. The predominance of the more complex 2B2

pattern indicates that the study population represented a clinically selected group of unstable fractures rather than the spectrum of all clavicle fractures.

Treatment timing and hospital course

Table 4: Operative and early postoperative parameters

Parameter	Reported finding
Time from injury to surgery	Within 10 days
Average hospital stay	12 days
Implant	3.5-mm pre-contoured superior anatomical locking plate
Additional fixation	2.7-mm lag screw when required
Initial mobilization	Pendulum and distal limb exercises within 2–3 days

All patients were taken for surgery within 10 days of injury. The average hospital stay was reported as 12 days. The protocol emphasized stable superior plate fixation with at

least two and preferably three bicortical screws on each side of the fracture and selective use of lag screws for comminuted fragments.

Fracture union

Table 5: Time to fracture union

Time to union	n	%
10 weeks	2	8.0
12–14 weeks	14	56.0
16 weeks	6	24.0
18 weeks	2	8.0
>18 weeks	1	4.0
Total	25	100.0

The time to union ranged from 10 weeks to more than 18 weeks. The largest proportion, 14 patients (56.0%), achieved union between 12 and 14 weeks. Six patients (24.0%) united by 16 weeks, two

(8.0%) by 18 weeks and two (8.0%) by 10 weeks. One patient (4.0%) required more than 18 weeks. The reported mean time to union was 12.76 weeks.

Clinical and radiological union status

Table 6: Overall fracture-healing outcome

Outcome parameter	n	%
Successful union	24	96.0
Nonunion	1	4.0
Delayed union	0	0.0
Malunion	0	0.0

Twenty-four of the 25 fractures (96.0%) achieved union with a satisfactory clinical and radiological result. One patient developed deep infection in the setting of uncontrolled diabetes; despite wound management,

antibiotics and subsequent implant removal, the fracture progressed to nonunion. No delayed union or malunion was reported in the study.

Postoperative complications

Table 7: Complications following anatomical locking plate fixation

Complication	n	% of 25
Hardware prominence	2	8.0
Screw pullout	2	8.0
Deep infection	1	4.0
Delayed union	0	0.0
Nonunion	1	4.0
Malunion	0	0.0
Hardware/implant failure	0	0.0
Refracture	0	0.0
Paresthesia	1	4.0

Hardware prominence and screw pullout were each reported in two patients (8.0%). The study indicates that the prominence was related to screw pullout and did not require urgent implant removal. One patient developed numbness below the clavicle, attributed to supraclavicular nerve involvement. One patient with uncontrolled diabetes

developed deep infection and subsequently nonunion. No implant breakage, malunion, refracture or delayed union was reported. Complication categories are not mutually exclusive; therefore, their frequencies should not be summed.

Functional outcome

Table 8: Functional outcome according to Constant-Murley score

Constant-Murley outcome category	n	%
Excellent	19	76.0
Good	5	20.0
Poor	1	4.0
Total	25	100.0

At final assessment, 19 patients (76.0%) had an excellent outcome, five (20.0%) had a good outcome and one (4.0%) had a poor outcome. Thus, 24 patients (96.0%) had an

excellent or good functional result. The poor outcome corresponded to the patient with infection and subsequent nonunion.

Table 9: Satisfactory versus unsatisfactory functional outcome

Constant-Murley overall interpretation	n	%
Satisfactory	24	96.0
Unsatisfactory	1	4.0
Total	25	100.0

The study separately classified the Constant-Murley result as satisfactory in 24 patients (96.0%) and unsatisfactory in one patient (4.0%). The four domains of the Constant score

were pain (15 points), activity level (20 points), strength of abduction (25 points) and range of motion (40 points).

Integrated outcome summary

Table 10: Overall clinical and radiological outcome

Outcome domain	Favorable result	Unfavorable result
Fracture union	24/25 (96.0%)	1/25 nonunion (4.0%)
Excellent/good Constant outcome	24/25 (96.0%)	1/25 poor (4.0%)
Delayed union	0	None reported
Malunion	0	None reported
Implant failure	0	None reported
Refracture	0	None reported

Taken together, the cohort demonstrated a high rate of union and predominantly favorable shoulder function. The principal adverse outcome occurred in the patient with uncontrolled diabetes who developed deep infection and subsequently nonunion. The relationship between the infection and poor functional outcome highlights the importance of perioperative optimization and postoperative surveillance.

DISCUSSION

The principal finding of this study is that pre-contoured anatomical locking plate fixation of unstable midshaft clavicle fractures was associated with a 96.0% union rate and a 96.0% rate of satisfactory functional outcome in the 25-patient cohort. Three quarters of the patients achieved an excellent Constant-Murley outcome, and the mean time to union was 12.76 weeks. Although the study is limited by its small sample size and lack of a comparison group, the observed results are broadly consistent with the direction of evidence from randomized trials and systematic reviews supporting fixation for appropriately selected displaced

midshaft fractures.^[8-12]

The predominance of young adults and high-energy road-traffic injuries in the present cohort is clinically plausible. Clavicle fractures occur frequently in younger active populations, and midshaft injuries constitute the majority of clavicle fractures.^[1,2] Robinson's classification remains useful because it incorporates fracture location and displacement and allows recognition of patterns at increased risk of healing complications.^[3] In the current cohort, 68% of fractures were Robinson type 2B2, indicating that most patients had a displaced and comminuted pattern. Such morphology provides a reasonable rationale for choosing a fixation method that can restore length and alignment while controlling intermediate fragments.

The observed 12.76-week mean time to union compares favorably with the longer union times reported in some nonoperative cohorts. In the Canadian Orthopaedic Trauma Society randomized trial, the mean radiographic time to union was 16.4 weeks following plate fixation compared with 28.4 weeks after nonoperative treatment.^[8] Other randomized evidence has similarly shown lower nonunion rates with operative fixation.^[9,10] A network meta-analysis of 22 randomized trials reported union in 96.7% of operatively treated

fractures compared with 88.9% of nonoperatively managed fractures, with plate constructs demonstrating particularly high union rates.^[12] The 96% union rate in the present cohort therefore falls within the range reported for contemporary operative management.

The functional findings are also favorable. Twenty-four patients had excellent or good Constant-Murley outcomes. The Constant-Murley score is a multidimensional instrument incorporating pain, activity, strength and range of motion and is widely used in shoulder outcome research.^[18] Earlier randomized trials demonstrated statistically better Constant and DASH scores following plate fixation, especially during early follow-up.^[8-10] However, more recent evidence suggests that the long-term functional difference between operative and nonoperative treatment may be smaller than the difference in union rate.^[12] Therefore, the favorable functional results in the present study should be interpreted as evidence of good outcome after fixation rather than proof that fixation is superior to nonoperative treatment for every displaced fracture.

The predominance of pre-contoured plate use is important. The clavicle has a complex three-dimensional contour, and conventional straight plates may require intraoperative bending. Pre-contoured designs are intended to improve anatomical fit and reduce prominence. Van Tongel and colleagues demonstrated the relevance of plate-to-bone alignment, while other clinical studies have reported lower hardware prominence or lower hardware-removal rates with pre-contoured implants.^[14,19] Reisch et al., in a series of the first 100 patients treated with a new anatomical pre-contoured locking plate, reported generally favorable clinical and radiographic results, although 30% underwent plate removal for subjective discomfort and several required revision surgery.^[13] These observations emphasize that even well-designed implants do not eliminate hardware-related symptoms.

In the present study, hardware prominence and screw pullout were each reported in two patients. The study attributes the prominence to screw pullout and notes that two patients returned to work very early, before fracture union. This observation is clinically important because locking constructs provide stability but do not make the fracture immediately biologically united. Premature high-load activity may jeopardize fixation. Patient education concerning restrictions until radiographic union is therefore an integral component of postoperative care.

Infection was the most consequential complication in this series. One patient with uncontrolled diabetes developed deep infection and subsequently nonunion despite implant removal, wound care and antibiotics. The overall infection rate was 4%. Infection following clavicle fixation is uncommon but clinically significant because infection can compromise union and may necessitate debridement and implant removal. The association in this cohort with uncontrolled diabetes should be regarded as a clinical signal rather than a statistically established risk factor because the study was not powered for risk-factor analysis.

Cutaneous paresthesia is another recognized complication

of clavicle surgery. The supraclavicular nerves are vulnerable during the skin and fascial exposure. Ou et al. reported postoperative cutaneous paresthesia in 19.3% of 135 patients following internal fixation, although persistent troublesome numbness was uncommon at later follow-up.^[16] The single case of paresthesia in the present cohort illustrates the same anatomical concern. Meticulous identification and preservation of the supraclavicular nerve branches, when feasible, may reduce postoperative sensory symptoms.

Safe screw placement is particularly important because of the close relationship between the clavicle and subclavian vessels. Sinha et al. demonstrated that the relationship between the clavicle and underlying vascular structures varies along its length and defined regions in which drilling requires particular caution.^[17] The operative technique used in this study emphasized controlled drilling and appropriate bicortical screw placement. This technical principle remains essential regardless of the plate design.

The current evidence base does not support routine operative fixation of every clavicle fracture. Contemporary reviews emphasize that nondisplaced and minimally displaced fractures can generally be treated nonoperatively, while surgery should be discussed for markedly displaced, shortened or comminuted fractures, particularly in active adults.^[6,7] Network meta-analyses indicate that surgery improves the probability of union but that the average long-term functional benefit may be modest.^[11,12] The present study therefore supports anatomical locking plate fixation as an effective option for selected unstable fractures rather than as a universal treatment strategy.

CONCLUSION

In this prospective institutional cohort of 25 unstable displaced midshaft clavicle fractures, open reduction and internal fixation with a pre-contoured anatomical locking plate produced a high rate of fracture union and predominantly favorable functional results. The mean reported time to union was 12.76 weeks, 96.0% of patients achieved union, and 96.0% achieved a satisfactory Constant-Murley outcome. The main complications were hardware prominence/screw pullout, deep infection, nonunion and paresthesia. The findings support the use of pre-contoured anatomical locking plates in carefully selected unstable clavicle fractures, particularly when substantial displacement, shortening or comminution is present. Nevertheless, the small uncontrolled sample means that the results should be interpreted as supportive observational evidence rather than proof of superiority over nonoperative treatment. Careful surgical technique, protection of the supraclavicular nerves, safe drilling, adequate screw fixation and optimization of comorbidities are important to maximize outcome.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Postacchini F, Gumina S, De Santis P, Albo F. Epidemiology of clavicle fractures. *J Shoulder Elbow Surg.* 2002;11(5):452-456. doi:10.1067/mse.2002.126613.
2. Moverley R, Little N, Gulihar A, Singh B. Current concepts in the management of clavicle fractures. *J Clin Orthop Trauma.* 2020;11(Suppl 1):S25-S30. doi:10.1016/j.jcot.2019.07.016.
3. Robinson CM. Fractures of the clavicle in the adult. Epidemiology and classification. *J Bone Joint Surg Br.* 1998;80(3):476-484. doi:10.1302/0301-620X.80B3.8079.
4. McKee MD, Pedersen EM, Jones C, Stephen DJG, Kreder HJ, Schemitsch EH, et al. Deficits following nonoperative treatment of displaced midshaft clavicular fractures. *J Bone Joint Surg Am.* 2006;88(1):35-40. doi:10.2106/JBJS.D.02795.
5. McKee MD, Wild LM, Schemitsch EH. Midshaft malunions of the clavicle. *J Bone Joint Surg Am.* 2003;85(5):790-797. doi:10.2106/00004623-200305000-00003.
6. Wiesel B, Nagda S, Mehta S, Churchill R. Management of midshaft clavicle fractures in adults. *J Am Acad Orthop Surg.* 2018;26(22):e468-e476. doi:10.5435/JAAOS-D-17-00442.
7. Song HS, Kim H. Current concepts in the treatment of midshaft clavicle fractures in adults. *Clin Shoulder Elb.* 2021;24(3):189-198. doi:10.5397/cise.2021.00388.
8. 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(1):1-10. doi:10.2106/JBJS.F.00020.
9. Robinson CM, Goudie EB, Murray IR, Jenkins PJ, Ahktar MA, Read EO, et al. Open reduction and plate fixation versus nonoperative treatment for displaced midshaft clavicular fractures: a multicenter, randomized, controlled trial. *J Bone Joint Surg Am.* 2013;95(17):1576-1584. doi:10.2106/JBJS.L.00307.
10. Qvist AH, Vaesel MT, Jensen CM, Jensen SL. Plate fixation compared with nonoperative treatment of displaced midshaft clavicular fractures: a randomized clinical trial. *Bone Joint J.* 2018;100-B(10):1385-1391.
11. Woltz S, Krijnen P, Schipper IB. Plate fixation compared with nonoperative treatment for displaced midshaft clavicular fractures: a meta-analysis of randomized controlled trials. *J Bone Joint Surg Am.* 2017;99(12):1051-1057. doi:10.2106/JBJS.16.01068.
12. Axelrod DE, Ekhtiari S, Bozzo A, Bhandari M, Johal H. What is the best evidence for management of displaced midshaft clavicle fractures? A systematic review and network meta-analysis of 22 randomized controlled trials. *Clin Orthop Relat Res.* 2020;478(2):392-402. doi:10.1097/CORR.0000000000000986.
13. Reisch T, Camenzind RS, Fuhrer R, Riede U, Helmy N. The first 100 patients treated with a new anatomical pre-contoured locking plate for clavicular midshaft fractures. *BMC Musculoskelet Disord.* 2019;20:4. doi:10.1186/s12891-018-2396-9.
14. VanBeek C, Boselli KJ, Cadet ER, Ahmad CS, Levine WN. Precontoured plating of clavicle fractures: decreased hardware-related complications? *Clin Orthop Relat Res.* 2011;469:3337-3343.
15. Goswami T, Markert RJ, Anderson CG, Sundaram SS, Crosby LA. Biomechanical evaluation of a pre-contoured clavicle plate. *J Shoulder Elbow Surg.* 2008;17(5):815-818. doi:10.1016/j.jse.2008.02.017.
16. Ou L, Yang L, Zhao J, Su W. Cutaneous paresthesia after internal plate fixation of clavicle fractures and underlying anatomical observations. *Medicine (Baltimore).* 2018;97(41):e12729. doi:10.1097/MD.00000000000012729.
17. Sinha A, Edwin J, Sreeharsha B, Bhalai V, Brownson P. A radiological study to define safe zones for drilling during plating of clavicle fractures. *J Bone Joint Surg Br.* 2011;93(9):1247-1252. doi:10.1302/0301-620X.93B9.25739.
18. Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. *Clin Orthop Relat Res.* 1987;(214):160-164.
19. Van Tongel A, Huysmans T, Amit B, Sijbers J, Vanglabbeek F, De Wilde L. Evaluation of prominence of straight plates and precontoured clavicle plates using automated plate-to-bone alignment. *Acta Orthop Belg.* 2014;80(3):301-308.
20. Narsaria N, Singh AK, Arun GR, Seth RRS. Surgical fixation of displaced midshaft clavicle fractures: elastic intramedullary nailing versus precontoured plating. *J Orthop Traumatol.* 2014;15(3):165-171. doi:10.1007/s10195-014-0298-7.