



## Displaced medial clavicle fractures: a systematic review of outcomes after nonoperative and operative management



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### ARTICLE INFO

#### Keywords:

Medial clavicle  
Fracture  
Operative  
Nonoperative  
Outcomes  
Systematic review

Level of evidence: Level IV; Systematic Review

**Background:** Fractures of the medial clavicle are uncommon. There is no consensus regarding the optimal treatment of displaced medial clavicle fractures.

**Methods:** A systematic review using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines was performed. PubMed, EMBASE, and the Cochrane Library were queried using the terms *medial clavicle* and *fracture* to identify all studies reporting on outcomes following either nonoperative or operative treatment of displaced medial clavicle fractures. Data extracted included patient demographics, fracture classification, surgical technique, patient-reported outcomes, physical, and radiographic findings. Study quality was evaluated using the Methodological Index for Non-Randomized Studies (MINORS) scoring system.

**Results:** The analysis included 15 studies (mean MINORS score,  $10 \pm 1.5$ ) with a total of 135 patients (85% male, mean age  $47 \pm 10.9$  years [range, 15–87 years]). Five studies (39 patients) reported outcomes following nonoperative treatment. At a mean follow-up of 27 months, there were 5 (13%) symptomatic nonunions, 2 (5%) malunions, and 2 (5%) delayed unions. Eleven studies (96 patients) reported outcomes following surgical treatment with a mean follow-up of 23 months. There were no reported nonunions. Complications included plate prominence/irritation (30%) and additional surgery was performed for plate removal (27%), fixation failure (3%), and wound débridement (1%).

**Conclusion:** There is limited, low-quality evidence in the literature to guide treatment of displaced medial clavicle fractures. The available data suggest that surgical treatment is associated with good functional outcomes and a lower risk of nonunion and malunion, compared to nonoperative treatment but plate irritation and further surgery to remove the plate was common.

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Fractures of the medial end of the clavicle are uncommon, accounting for only 2%–3% of all clavicle fractures.<sup>2,11,13,18,19,21,22</sup> They are associated with high energy trauma, multisystem injury, and death.<sup>1,2,13,19,24,33</sup> Traditionally, medial end clavicle fractures have been treated nonoperatively, even when significantly displaced.<sup>22,24,33</sup> However, nonoperative treatment of displaced fractures is often unsatisfactory, with reports up to half of all patients are still symptomatic more than a year after injury,<sup>17,33</sup> and a nonunion rate approaching 15%.<sup>23</sup>

In the last decade, there has been a trend toward operative intervention of displaced medial end clavicle fractures. There remain concerns about the close proximity of underlying vital mediastinal structures<sup>20,31</sup> and the potential for iatrogenic damage. However, excellent outcomes have been reported with various methods of plate fixation but hardware irritation and plate removal are common.<sup>1,7,27</sup>

Whilst there have been reports of outcome with management of undisplaced medial clavicle fractures with both operative and nonoperative methods, there remains no consensus on the optimal treatment of displaced medial clavicle fractures mainly due to the rarity of this injury. The purpose of this article was to review the literature regarding outcomes following nonoperative and operative treatment of displaced medial end clavicle fractures. Furthermore, this current review differs from two recently published

Institutional review board approval was not required for this systematic review.

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<https://doi.org/10.1016/j.jseint.2022.09.010>

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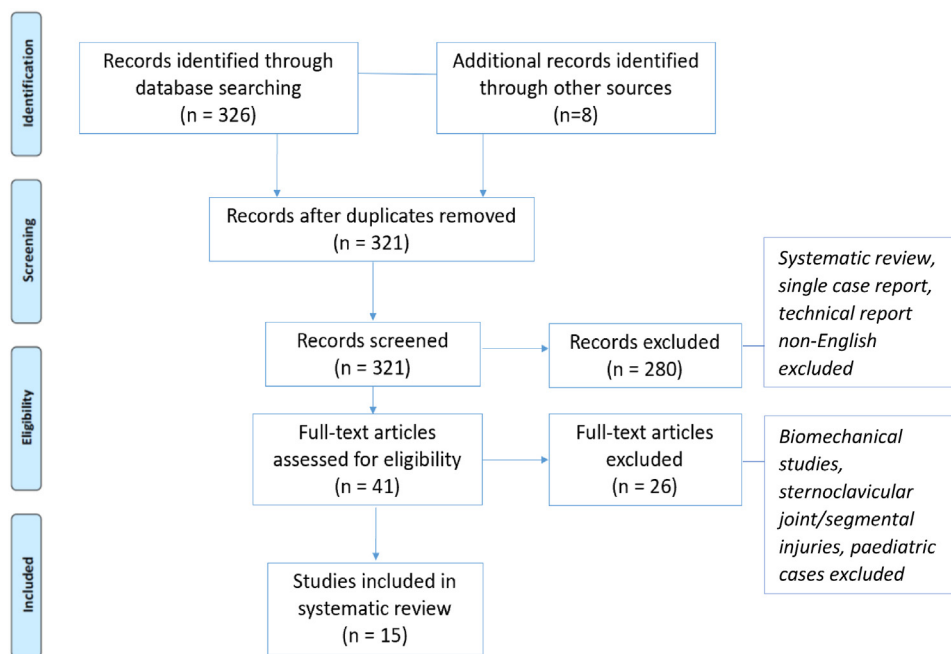


Figure 1 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram.

systematic reviews which have reported on all medial end clavicle fractures together without an attempt to stratify based on displacement.<sup>1,36</sup>

**Material and methods**

A systematic review was performed using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Two independent reviewers searched PubMed, EMBASE, and the Cochrane Library databases (up to April 15, 2021) using the terms *medial clavicle* and *fracture*. The authors sought to include all studies reporting outcomes after either nonoperative or operative treatment of *displaced* medial clavicle fractures. Additional articles were detected by searching through the reference lists of eligible studies. Articles not published in the English language were excluded, as were systematic reviews, technical and single patient case reports, biomechanical and animal studies, segmental clavicle fractures or injuries to the sternoclavicular joint, and studies involving only pediatric patients.

After duplicates were removed, titles and/or abstracts were reviewed, and full-text articles were further assessed for eligibility. Data were extracted and cross-checked for accuracy. Outcomes of interest included patient demographics, fracture classification, surgical technique, complications, patient-reported outcomes, physical, and radiographic findings.

Two reviewers independently assigned a Methodological Index for Non-Randomized Studies (MINORS) score<sup>29</sup> for each study to assess for quality and risk of bias. The maximum MINORS score is 16 for non-comparative studies and 24 for comparative studies, with higher scores indicating a lower risk of bias. Meta-analysis was not feasible due to the heterogeneity between articles with regard to patient populations, interventions, and outcome assessments.

**Results**

The literature search returned a total of 326 records. After exclusions, our review included 15 studies consisting of 135 patients

with a displaced medial clavicle fracture (Fig. 1). Outcomes following nonoperative treatment were reported for 39 patients<sup>3,22-24,35</sup> and after operative treatment for 96 patients.<sup>3,5,7,14-16,19,27,30,34,37</sup>

*General study characteristics*

The included studies were generally of low quality (mean MINORS score was 10 ± 1.5) consisting entirely of retrospective case series or observational cohorts. The mean age of patients across all studies was 47 ± 10.9 years (range, 15-87 years) with the majority male (85%). The most common mechanism of injury was a motor vehicle or motorbike accident (36%) followed by sports (25%) and bicycle (23%) injuries.<sup>3,5,7,15,16,19,28,30,34</sup> About 75% of patients had a computed tomography scan in conjunction with a plain radiograph.<sup>3,7,14,15,27,34,35</sup> All studies, except one,<sup>30</sup> defined the medial end of the clavicle to be either the medial 1/5 or 1/3 of the clavicle. Twelve studies<sup>3,5,7,14,15,19,22-24,27,35,37</sup> defined fracture displacement using either the Robinson (>100% translation of major fracture fragments),<sup>22</sup> Throckmorton (>10 mm displacement),<sup>33</sup> or AB (no contact between fracture ends)<sup>35</sup> classification systems (Table 1) with 3 studies having no definition.<sup>16,30,34</sup> The operative group, which included the treatment of 5 nonunions<sup>7,16,27</sup> and 8 physeal fractures,<sup>27,34</sup> had an overall mean follow-up of 23 months (range, 3-124 months). In 2 studies with nonoperatively treated patients,<sup>3,35</sup> the mean follow-up was 38 months (range, 6-67 months). In the remaining 3 nonoperative studies<sup>22-24</sup> which pooled together all clavicle fractures, including medial fractures, the mean period of follow-up was 5 months (range, 1-72) (Table 1). The Disabilities of the Arm, Shoulder and Hand (DASH) score was the most commonly reported functional outcome measure.<sup>3,5,15,16,19,27,37</sup> Shoulder range of motion,<sup>3,5,14-16,19,27,30,34</sup> return to work,<sup>14,15,24,27,30,34</sup> and complications<sup>3,5,7,14-16,19,23,24,27,34,35</sup> were also frequently reported.

*Surgical technique*

Three methods of fracture fixation were reported consisting of plating (88%), sutures (9%), and cerclage wires (3%). Suture fixation

**Table I**  
Study characteristics between operative and nonoperative cohort of medial clavicle fractures.

Operative									
Study	Number of patients	Mean age (range), y	Male/Female	Extra/Intra-articular fracture	Fracture classification system	Degree of displacement	Concurrent injuries (n)	Mean follow-up (range), mo	Study quality
Bartonicek et al (2010) <sup>3</sup>	3	26.3 (19-31)	3/0	3/0	Robinson Throckmorton	>10 mm or >100% translation	NR	18.0 (12-24)	9
Feng et al (2018) <sup>5</sup>	5	49.2 (39-67)	3/2	1/4	Robinson	>100% translation of major fragments	Thoracic injury with left radial/ulna fractures (1)	20.2 mo (12-42)	11
Frima et al (2020) <sup>7</sup>	15	52.0 (19-79)	15/0	11/3	Robinson	>1 shaft width or displaced intra-articular	Polytrauma (3)	39.0 (9-79)	11
Liu et al (2019) <sup>15</sup>	11	44.3 (28-66)	11/0	8/3	Robinson	>100% translation	Ipsilateral clavicle fracture (1)	16.0 (11-22)	9
Liu et al (2020) <sup>14</sup>	5	61.2 (44-72)	3/2	4/1	Robinson	>100% translation	NR	8.8 (6-12)	10
Low et al (2008) <sup>16</sup>	5	43.0 (25-52)	5/0	NR	NR	NR	Nil	39.6 (8-123.6)	9
Oe et al (2012) <sup>19</sup>	10	33.9 (15-73)	9/1	9/1	Robinson	>100% translation	Multisystem injury (6)	38.0 (14-52)	11
Sidhu et al (2015) <sup>27</sup>	27	Median 37 (interquartile range, 7-47)	26/1	20 Adult 7 Physeal injury	NR	>10 mm	NR	12.0	12
Sloan et al (2008) <sup>30</sup>	2	33.0 (25-41)	2/0	NR	NR	NR	Nil	3.0	7
Titchener et al (2019) <sup>34</sup>	8	31.3 (15-59)	7/1	4/3 1 Physeal	NR	NR	Nil	32.5 (24-45)	9
Xie et al (2018) <sup>37</sup>	6	46.3 (24-66)	5/1	3/3	Throckmorton	>10 mm	Nil	12.0 (10-14)	10
Nonoperative									
Bartonicek et al (2010) <sup>3</sup>	2	64.5 (63-66)	2/0	1/1	Robinson Throckmorton	>10 mm or >100% translation	NR	15.5 (13-18)	9
Robinson et al (1998) <sup>22</sup>	5	31.0 (13-87)	2/3	2/3	Robinson	>100% translation	NR	3.7 (1-34)	10
Robinson et al (2004) <sup>23</sup>	8	59.5 (26-87)	7/1	5/3	Robinson	>100% translation	NR	5.6	13
Salipas et al (2016) <sup>24</sup>	7	Median 53.5 (16-94)	NR	NR	Throckmorton	>10 mm (severe) 2-10 mm (moderate)	NR	36.0 (12-72)	9
Van Tongel et al (2018) <sup>35</sup>	17	57.2 (19-84)	10/7	NR	Anatomically based (AB)	No contact between fragments	NR	41.0 (6-67)	10

NR, not reported.

was used almost exclusively for physeal fractures.<sup>16,27</sup> Only one author reported using cerclage wires as their mode of fracture fixation.<sup>3</sup> Half of all plates utilized consisted of an inverted, or reversed, distal clavicle locking plate.<sup>7,15,27,30,34,37</sup> Some authors used a variety of plates including distal radius,<sup>27</sup> distal humerus,<sup>7</sup> and pilon locking plates.<sup>19</sup> Hook plate fixation<sup>5</sup> and double-plating<sup>14</sup> were also reported. When plating, most authors placed the medial screws in a unicortical fashion<sup>15,27,30,34,37</sup> due to the close proximity of underlying mediastinal structures. One author reported using bicortical medial screws whenever possible<sup>7</sup> and the remaining authors did not specify whether they used or preferred unicortical or bicortical medial screws.<sup>5,14,16,19</sup>

*Range of motion*

Range of motion following surgery was assessed in 9 studies<sup>3,5,14-16,19,27,30,34</sup> which included 76 patients (79% of all operative cases). Full shoulder range of movement was achieved in 92% of patients at final follow-up (Table II). One study reported a patient with slight restriction in shoulder movement of less than 15 degrees following a reversed lateral locking clavicle plate.<sup>15</sup> In another study which included 5 patients with an isolated, displaced medial clavicle fracture fixed with a hook plate, the authors

reported the mean shoulder forward flexion as 164° (range, 160-170°).<sup>5</sup>

Only one study assessed range of motion following nonoperative treatment which consisted of only 2 patients (5% of all nonoperative cases).<sup>3</sup> One patient had 10° restriction of external rotation and the other a restriction in both forward flexion of 20° and external rotation of 15° (Table II).

*Patient-reported outcomes*

Disabilities of the Arm, Shoulder and Hand (DASH)<sup>3,5,15,16,19,27,37</sup> or QuickDASH<sup>7,34</sup> scores following surgery were included in 9 studies. After a minimum mean follow-up of 12 months, mean DASH and QuickDASH scores ranged from 0.4 to 25 and 0.6 to 0.8, respectively (Table II). Four studies reported visual analog scale (VAS) pain scores, at rest or with activity, after surgery with all mean scores ranging from 0 to 1.<sup>3,5,14,16</sup> Two studies utilized the Constant Score with mean scores of 94.2 and 94.4 reported after a mean follow-up of 8.8 months and 20.2 months, respectively, following surgery.<sup>5,14</sup> In addition to the QuickDASH score, one study also included a subjective shoulder value with a mean score of 96 after a mean follow-up of 39 months.<sup>7</sup> Another study also utilized American Shoulder and Elbow Surgeons score and Rowe Scores in

**Table II**  
Comparison of outcomes between operative and nonoperative cohort of medial clavicle fractures.

Operative					
Study	Surgical treatment	Subjective outcomes*	Objective outcomes	Return to activity	Complications
Bartonicek et al (2010) <sup>3</sup>	Cerclage wires (3)	DASH: 25.0 (24.2-25.8) Pain VAS at rest: 0 Pain VAS with normal activity: 0 Pain VAS with heavy activity: 0	Full ROM in all patients	NR	Removal of cerclage wires (3, 100%)
Feng et al (2018) <sup>5</sup>	Basler Hook plate (5)	DASH: 4.2 (0-8.3) Pain VAS: 0.6 (0-2) CMS: 94.4 (87-100), All patients satisfied	FF 1674 degrees (160-170)	NR	Wound hematoma day 3 postoperative (healed after débridement)
Frima et al (2020) <sup>7</sup>	Inverted LCP superior anterior clavicle plate (8), radial VA-LCP distal humerus plate (6), LCP 3.5 plate (1)	QuickDASH: 0.81 (0-4.5) SSV: 96 (80-100)	15-degree ROM restriction in 1 patient, otherwise full ROM	100% return to activity, 82% return to work	Plate removal (7, 47%), plate irrigation (1, 7%), implant failure (1, 7%)
Liu et al (2019) <sup>15</sup>	Reverse lateral locking plate (with unicortical medial screws)	DASH: 8 (0-13) All patients satisfied 9 excellent, 2 good	Full ROM in all patients	100% return to activity	Plate removal (2, 18%), mild SCJ pain on movement (1, 9%)
Liu et al (2020) <sup>14</sup>	Double LCP plates 2.4/2.7 mm	Pain VAS at rest: 0 Pain VAS with overhead work: 0.4 (0-2) Satisfaction VAS: 9.6 (8-10) ASES: 94.8 (89-100) CMS: 94.2 (87-100) Rowe: 95.8 (91-100)	Full ROM in all patients	NR	Plate breakage and removal (1, 20%)
Low et al (2008) <sup>16</sup>	Plate (4), screws and sutures (1)	DASH: 9 (0-17) Pain VAS at rest: 0.75 (0-2) Pain VAS with normal activity: 0.75 (0-2) Pain VAS with heavy activity: 1 (0-2) Satisfaction VAS: 10	Full ROM in all patients	100% return to activity and work	Plate removal (1, 20%)
Oe et al (2012) <sup>19</sup>	T-locking plate (5), Pilon locking plate (2), reconstruction locking plate (1), dynamic compression plate (1), BOS plate (Stryker Corp, Kalamazoo, MI) (1)	DASH: 13.5 (0-66.7) 4 excellent, 2 good	Full ROM in 9 out of 10 patients	NR	Plate removal (7, 70%), implant failure (1, 10%)
Sidhu et al (2015) <sup>27</sup>	Reverse lateral clavicle plate (15), distal radius locking plate (2), standard locking compression plate (2), transosseus sutures (8)	DASH: median 0.4 (IQR 0-5) All patients satisfied	Full ROM in all patients	100% return to work, 96% return to sport	Plate removal (3, 13%), mild plate irritation (17, 71%), wound dysesthesia >6 mo (5, 19%)
Sloan et al (2008) <sup>30</sup>	Inverted distal clavicle locking plate (with unicortical medial screws)	NR	Full ROM in all patients	100% return to activity and work	Nil
Titchener et al (2019) <sup>34</sup>	Inverted distal clavicle locking plate (with unicortical medial screws)	QuickDASH: 0.6 (0-2.3) All patients satisfied	NR	NR	Plate prominence (2, 25%)
Xie et al (2018) <sup>37</sup>	Inverted distal clavicle locking plate (with unicortical medial screws)	DASH: 8.6 (7-9) 5 excellent, 1 good	NR	NR	Plate removal necessary
Nonoperative Bartonicek et al (2010) <sup>3</sup>	Nil	DASH: 30.2 (27.1-33.3) Pain VAS at rest: 0 Pain VAS with normal activity: 1.5 (1-2) Pain VAS with heavy activity: 3 (2-4)	ROM restriction of 10-degrees ER (1), 25-degrees ER and 20-degrees FF (1)	NR	Symptomatic malunion (1, 50%)

Table II (continued)

Operative					
Study	Surgical treatment	Subjective outcomes <sup>a</sup>	Objective outcomes	Return to activity	Complications
Robinson et al (1998) <sup>22</sup>	Nil	NR	NR	NR	NR
Robinson et al (2004) <sup>23</sup>	Nil	NR	NR	NR	Nonunion (14%)
Salipas et al (2016) <sup>24</sup>	Nil	ASES: 96.3 (83-100) SSV: 8.4 (5-10) Pain VAS: 0.6 (0-3)	NR	NR	Painful atrophic delayed union (2, 29%), intraoperative vascular complication during subsequent surgery (1, 14%) Symptomatic nonunion (4, 24%), malunion (1, 6%)
Van Tongel et al (2018) <sup>35</sup>	Nil	CMS: 72 OSS: 39	NR	NR	

DASH, disabilities of arm, shoulder and hand score; VAS, visual analog scale; ASES, American Shoulder and Elbow Surgeons shoulder score; CMS, Constant-Murley Score; SSV, subjective shoulder value score; ROM, range of movement; SCJ, sternoclavicular joint; OSS, Oxford Shoulder Score; ER, external rotation; FF, forward flexion; NR, not reported; LCP, locking compression plate.

<sup>a</sup>Numerical outcomes expressed as mean (range).

addition to VAS pain and Constant Scores.<sup>14</sup> Two studies reported mean VAS satisfaction scores of 9.6 and 10 after a mean follow-up of 8.8 months and 39.6 months, respectively.<sup>14,16</sup> In 4 studies, all patients were either happy to undergo the same procedure again<sup>27,34</sup> or were satisfied with the outcome of surgery.<sup>5,15</sup> Five studies reported 100% return to pre-injury activities and 96% return to previous occupation following surgery.<sup>14,16,19,27,34</sup>

Three studies included patient-reported outcomes following nonoperative treatment.<sup>3,24,35</sup> Two studies reported VAS pain scores, at rest or with activity, with all mean scores ranging from 0 to 3.<sup>3,24</sup> In addition to VAS pain scores, one study reported a mean DASH score of 30.23<sup>3</sup> and in another study, a mean subjective shoulder value of 8.4 and American Shoulder and Elbow Surgeons of 96.<sup>24</sup> The final study reported a mean Constant Score of 72 and Oxford score of 39 after a mean follow-up period of 41 months.<sup>35</sup>

### Complications and additional surgery

Fracture healing complications were only reported after nonoperative treatment of displaced medial end clavicle fractures.<sup>3,23,24,35</sup> At a mean follow-up of 27 months, there were 5 (13%) symptomatic nonunions and 2 (5%) malunions.<sup>3,23,35</sup> There were 2 (5%) painful atrophic delayed unions which proceeded to plate fixation and iliac crest bone graft after an average of 4 months post injury.<sup>24</sup> One patient had metalware removed at 9 months and there was one intraoperative vascular complication with no long-term adverse outcome.<sup>24</sup>

All operatively treated displaced medial end clavicle fractures united successfully with no reported nonunions (Table II). Plate prominence or irritation was reported in 4 studies, affecting 7%–71% of patients.<sup>7,19,27,34</sup> Altogether 30% of all operative patients in this review experienced plate prominence/irritation and 27% of patients had additional surgery for implant removal. Rates of plate removal in individual studies ranged from 0% to 80%.<sup>3,7,14-16,19,27,34,37</sup> One author after utilizing an inverted distal clavicle locking plate as fixation, stated that it was necessary to remove the plate as soon as possible following fracture healing.<sup>37</sup> All 3 patients who underwent cerclage wire fixation subsequently had their wires removed.<sup>3</sup> In a study of 5 patients, at a mean of 20.2 months following Hook plate fixation, no patient required implant removal but one patient developed a wound hematoma 3 days post-operatively which healed after a débridement.<sup>5</sup>

Implant or fixation failure occurred in 3 patients (3%).<sup>7,14,19</sup> After a double-plating technique using 2.4 mm/2.7 mm locking compression plates,<sup>14</sup> one patient at 3 months was noted on x-ray to have a broken plate with the fracture well-healed. The plate was removed at 12 months after surgery without complication. In another study,<sup>19</sup> one patient was observed to have plate loosening (Pilon plate, non-locking screws) and superficial wound infection 5 days after surgery. The plate was removed and the wound débrided. The patient then received additional treatment for recurrent infection 7 months later and underwent resection of the medial two-thirds of the clavicle. In the final study,<sup>7</sup> a patient treated with a radial (VA)-locking compression plate distal humeral plate placed in a suboptimal position experienced cutout of the medial screws after 2 days, then underwent revision fixation with the same implant and the fracture united. Eighteen months later, a skin perforation with subsequent infection occurred due to a broken and displaced screw. The plate was removed and the infection successfully treated with antibiotics.

### Discussion

This systematic review exposed a paucity of studies, all of low quality, reporting on the outcomes following nonoperative or operative treatment of displaced medial clavicle fractures. There are very few cases of nonoperatively treated patients in the literature to guide recommendations for surgical treatment. With the available outcome data, the principle findings of this review suggest that when compared to nonoperative treatment, surgical treatment of displaced medial end clavicle fractures in experienced hands, is a safe procedure which is associated with good functional outcomes and a lower risk of nonunion.

Traditional radiographic-based studies have reported medial end clavicle fractures to be uncommon, accounting for only 2%–3% of all clavicle fractures.<sup>2,11,13,18,19,21,22</sup> Displacement of medial end clavicle fractures is most commonly defined in the literature using either the Robinson (>100% translation of major fracture fragments)<sup>22</sup> or Throckmorton (>10 mm displacement)<sup>33</sup> classification systems. By this definition, up to a third of all medial end clavicle fractures are considered displaced.<sup>23,24,33</sup> Nonoperative treatment of medial end clavicle fractures, especially of displaced fractures, may not be as benign as previously believed. At a mean of 15.5 months, Throckmorton et al<sup>33</sup> reported that 28% of surviving patients still had moderate or severe pain following nonoperative



treatment, and 9% had undergone surgery for their medial end clavicle fracture. Robinson et al<sup>23</sup> found a nonunion rate of 6.3% for non-displaced fractures and 14.3% for displaced fractures at 24 weeks after nonoperative treatment.

The current review identified only 5 studies, consisting of 39 patients, in the literature which reported outcomes following nonoperative treatment of displaced medial end clavicle fractures.<sup>3,22–24,35</sup> In total, there were 5 (13%) symptomatic nonunions, 2 (5%) malunions, and 2 (5%) delayed unions. Treatment of established nonunion of the medial end clavicle has rarely been reported but some studies suggest that successful union can be achieved with surgical plate fixation and bone grafting.<sup>7,16,24,25,27</sup> However, when symptomatic nonunion occurs after plate fixation, case reports have shown that partial medial clavicle resection with,<sup>4</sup> or without,<sup>32</sup> reconstruction can lead to satisfactory outcomes.

In the last decade, there has been a trend toward operative intervention of displaced medial end clavicle fractures with perceived advantages of quicker return of function, increased patient satisfaction and fewer healing complications. The current review identified 11 studies, consisting of 96 patients, in the literature which reported outcomes following surgical treatment of displaced medial end clavicle fractures.<sup>3,5,7,14–16,19,27,30,34,37</sup> Subjective outcomes and satisfaction rates were high,<sup>3,5,7,14–16,19,27,30,34,37</sup> shoulder movement mostly restored<sup>3,5,14–16,19,27,30,34</sup> and there were no reported nonunions. However, complications were relatively common including plate prominence or irritation (30%)<sup>7,19,27,34</sup> and additional surgery was performed for plate removal (27%)<sup>7,14–16,19,27,37</sup> and fixation failure (3%).<sup>7,14,19</sup> Authors mostly utilized anatomically contoured locking plates originally designed for other sites such as the lateral clavicle,<sup>7,15,27,30,34,37</sup> distal radius,<sup>27</sup> pilon<sup>19</sup> and distal humerus,<sup>7</sup> placed superiorly on the clavicle. Titchener et al<sup>34</sup> used an inverted distal clavicle locking plate which was twisted such that the medial part of the plate was positioned anteriorly and the lateral part superiorly over the clavicle. The advantages of an anterior plate are that the anterior surface of the medial clavicle is wider,<sup>9</sup> damage to the clavicular head of sternocleidomastoid can be avoided and that the patient's head does not interfere with accessing correct drill and screw trajectories.<sup>34</sup>

When the medial clavicle fragment is small or very comminuted and fixation is of concern, hook plates,<sup>5,8,38</sup> bridging plates to the sternum<sup>12,26,39</sup> and double-plating techniques<sup>9,15,40</sup> have been utilized to minimize the risk of fixation failure in multiple studies. However, despite high satisfaction and union rates, such fixation modalities typically require later removal. Distant migration of K-wires to other parts of the body has been documented in case studies as a cause of concern<sup>6</sup> as well as migration of medial locking screws into the chest.<sup>4</sup> Fortunately, the most serious potential complication, vascular injury, has been very rarely reported.<sup>10,24</sup> The closest underlying vital vascular structures have been reported to be only a few millimeters away from the sternoclavicular joint.<sup>20,31</sup> Unicortical medial screws<sup>15,27,30,34,37</sup> have been shown to minimize risk but due to the concerns about potential iatrogenic vascular damage, surgery for displaced medial end clavicle fractures is safest performed by surgeons experienced in operating around the sternoclavicular region with cardiothoracic support available if necessary.

### Limitations

The main limitation is the small number of studies which were included, all of which had relatively poor level of evidence. This is further reflected in the lower low MINOR scores (10 ± 1.5). Some studies did not provide sufficient detail regarding fracture displacement, outcomes, complications, and postoperative

protocol. Last, the small number of patients and heterogeneity of patient populations, interventions, protocols, and outcome assessments did not allow for a meta-analysis for treatment comparison.

### Conclusion

Medial end clavicle fractures may be more common than previously reported. There is a strong association with high energy trauma, multisystem injury, and death. The available data suggest that surgical treatment is associated with good functional outcomes and a lower risk of nonunion and malunion compared to nonoperative treatment but plate irritation and further surgery to remove the plate was common.

### Disclaimers:

Funding: No funding was disclosed by the authors.

Conflicts of interest: The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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