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REVIEW ARTICLE

Is shortening of displaced midshaft clavicle fractures associated with inferior clinical outcomes following nonoperative management? A systematic review

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Background: Management of displaced midshaft clavicle fractures is controversial. Nonoperative treatment can lead to shortening, a risk factor for nonunion and poor functional outcomes. These inferior results have resulted in authors recommending surgical fixation for fractures with significant shortening. The aim of this systematic review was to analyze the effect of fracture shortening on shoulder function and nonunion rates in nonoperatively managed displaced midshaft clavicle fractures.
Methods: A review of the online databases MEDLINE and Embase was conducted on February 16, 2018, in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. The review was registered prospectively in the PROSPERO database. Clinical studies with midshaft clavicle fractures treated nonoperatively reporting an evaluation of the degree of clavicle shortening and either shoulder function or nonunion were included. The studies were appraised using the Methodological Index for Non-Randomized Studies (MINORS) tool.
Results: The search strategy identified 16 studies eligible for inclusion, comprising 4 randomized controlled trials and 12 nonrandomized retrospective comparative studies. Of the 12 case series, 11 failed to demonstrate any correlation between shortening and shoulder outcome scores. Of the 4 randomized controlled trials, 3 reported no significant association between fracture shortening and shoulder outcome scores. The studies also failed to demonstrate a significant association between nonunion and the presence of clavicle shortening.
Conclusion: There is no significant association between fracture shortening and nonunion rates or shoulder outcome scores in displaced midshaft clavicle fractures managed nonoperatively.

No institutional review board approval was required for this review article.

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Midshaft fractures account for approximately 75% of all clavicle fractures and are most common in the young active population.[26,29] Although nondisplaced fractures do not require surgical treatment, displaced midshaft clavicle fractures can be successfully treated both operatively[14,31] and nonsurgically.[9,13] Nonsurgical treatment has been associated with a nonunion rate of 15% to 21%,[8-10,30] with fracture shortening being reported as a risk factor for nonunion.[10,19,38]

The clinical relevance of fracture shortening remains a matter of debate, with some studies showing no correlation with functional outcomes[20] but others reporting poorer functional outcomes with shortening.[4,18,19] Biomechanical studies have demonstrated that shortening results in altered scapular kinematics,[16,17] and this has been linked to persistent pain.[4,10,11,30] Similarly, the extent of shortening required to affect clinical outcomes remains uncertain; previous studies have considered this to be 15 mm,[6,10,38] but more recent studies have suggested that shortening of 2 cm or more alters scapulohumeral movement and functional outcomes.[3,19] As such, some studies have advocated early operative management of shortened, completely displaced midshaft clavicle fractures, citing a decreased nonunion rate, a low complication rate, and better functional results.[3,21,39]

The aim of this systematic review was to analyze the effect of fracture shortening on shoulder function and nonunion rates in nonoperatively managed displaced midshaft clavicle fractures.

Methods

A systematic review of the literature was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines[22] using the online databases MEDLINE and Embase. The review was registered in the PROSPERO database on March 6, 2018 (reference No. CRD42018089799). The searches were performed independently by 2 authors on February 16, 2018, and repeated on March 5, 2018, to ensure accuracy. Any discrepancies were resolved through discussion between these 2 authors, with the senior author resolving any residual differences. The MEDLINE search strategy is illustrated in Table I.

The eligibility criteria were as follows: clinical studies published in the English language, study populations comprising adult patients (aged > 15 years) with midshaft clavicle fractures treated nonoperatively, and studies that reported an evaluation of the degree of clavicle shortening and either shoulder function or nonunion. Only primary research was considered for review, with any abstracts, comments, review articles, and technique articles excluded.

The clinical studies were appraised independently by 2 authors, and quality assessment of nonrandomized studies was completed using the Methodological Index for Non-Randomized Studies (MINORS) tool.[34] The MINORS tool is a validated scoring tool for nonrandomized studies. Each of the 12 items in the MINORS criteria was given a score of 0, 1, or 2, with maximum scores of 16 and 24 for noncomparative and comparative studies, respectively (Table II). The quality of randomized studies was measured against the Consolidated Standards of Reporting Trials (CONSORT) checklist[32] (Table III).

Results

The search strategy identified 128 studies, 16 of which were eligible for inclusion.[5-10,12,19,23,25,27,28,33,35-37] Of these studies, 4 were randomized controlled trials (RCTs) and 12 were nonrandomized retrospective comparative studies. A flowchart of the search strategy is shown in Figure 1. Study characteristics are summarized in Table IV. Tables V and VI detail the relation of clavicle shortening to shoulder function and the rate of nonunion, respectively.

Shortening

All studies determined clavicle shortening on plain radiographs, except for 1 study that used 3-dimensional computed tomography (CT) scans.[9] The most frequently used radiographic views for this calculation were anteroposterior (AP) views and cephalad tilted views ranging from 20° to 45° in addition to AP views.[3,7,8,19,23,25,27,36] Five studies relied on AP radiographs,[5,8,9,12,35] whereas 3 did not report on the type of radiographs used.[28,33,37] The mean amount of shortening in the studies ranged from 7.7 mm (SD, 3 mm)[5] to 25 mm (SD, 16 mm).[35]

Outcome scores

Shoulder outcomes were assessed objectively using either the Disabilities of the Arm, Shoulder and Hand (DASH) score or the Constant score (Table V). Three studies reported only the DASH score,[7,36,37] and 7 studies reported only the Constant score.[5,12,23,25,27,28,33] Five studies reported both the DASH and Constant scores.[3,8,9,19,35]

Table I Search strategy for Ovid MEDLINE

Search No.	Search term	Results
1	"Clavicle"[tw] OR "clavicular"[tw] OR "clavicula"[tw]	9255
2	"fractures, bone"[MeSH] OR "fractures"[tw] OR "fracture"[tw]	269,298
3	"midshaft"[tw] OR "mid-shaft"[tw] OR "mid shaft"[tw] OR "middle third"[tw] OR "middle-third"[tw]	5906
4	"Shortening"[tw] OR "Shortenings"[tw] OR "shortened"[tw]	84,405
5	"conservative"[tw] OR "conservatively"[tw] OR "nonoperative"[tw] OR "nonoperatively"[tw] OR "non-operative"[tw] OR "non-operatively"[tw] OR "nonsurgical"[tw] OR "nonsurgically"[tw] OR "non-surgical"[tw] OR "non-surgically"[tw]	142,964
6	"sling"[tw] OR "immobilisation"[tw] OR "immobilization"[MeSH Terms] OR "immobilization"[tw] OR "bandages"[MeSH] OR "bandages"[tw] OR "bandage"[tw]	93,110
7	1 AND 2 AND 3 AND 4 AND 5 AND 6	55
8	Limit 7 to "English" AND "Human"	51

The mean Constant score ranged from 78.28[33] to 96.75.[5] Three RCTs reported the Constant score.[3,5,9] Of these RCTs, 2 did not demonstrate any correlation between shortening and inferior outcome scores.[5,9] Goudie et al[9] found that shortening of 1 cm or less or shortening of 2 cm or greater had no effect on the Constant score. Ersen et al[5] reported on 11 patients with more than 15 mm of shortening and reported no association with shoulder outcome scores in their RCT. The third RCT showed a mean Constant score of approximately 91 but did not comment on any correlation with fracture shortening.[3]

There were 9 nonrandomized comparative studies reporting Constant scores.[8,12,19,23,25,27,28,33,35] Seven of these studies did not demonstrate any statistically significant correlation between shortening and the Constant score.[8,19,23,25,27,28,35] However, Lazarides and Zafiropoulos[12] reported that shortening of more than 18 mm in male patients or more than 14 mm in female patients was associated with significantly inferior patient satisfaction, and they found that a Constant score of less than 70 was significantly associated with a subjectively unsatisfactory result in both sexes ($P < .05$, χ^2 test). The final study did not comment on the correlation of shortening and shoulder function.[33]

The mean DASH score ranged from 2.3[37] to 24.6.[21] There were 3 RCTs that reported the DASH score.[3,9,36] Two RCTs showed that shortening did not affect outcome scores,[9,36] with Goudie et al[9] showing that shortening of 1 cm or less or shortening of 2 cm or greater had no effect on the DASH score. In contrast, the third RCT, from the Canadian Orthopaedic Trauma Society, showed that increased shortening was associated with higher DASH scores ($r = 0.326$, $P = .05$).[3]

There were 5 comparative studies reporting the DASH score; all 5 showed no correlation between shortening and the DASH score.[7,8,19,35,37] McKee et al[19] did report that a higher DASH score (>30 points) was recorded for patients with shortening of 2 cm or greater but this was not statistically significant ($P = .11$).

Nonunions

Eleven studies reported the rate of nonunion (Table VI),[3,7-10,23,25,27,33,36,37] which ranged from 0% to 17%.[9,23] The rate of nonunion in the nonoperative group was over 14% in all 3 RCTs reporting nonunion rates.[3,9,36] None of the RCTs provided an analysis of correlation between shortening and the nonunion rate.

Of the 8 nonrandomized comparative studies reporting nonunions,[7,8,10,23,25,27,33,37] only 3 commented on the nonunion rate and shortening.[7,8,10] Fuglesang et al[8] reported a nonunion rate of 15% (9 cases) but found no difference in initial shortening in patients who went on to have nonunion fractures vs. those who had united fractures. Figueiredo et al[7] reported a nonunion rate of 11.1% (6 cases), and all 6 nonunions had less than 1 cm of shortening. In contrast, Hill et al[10] reported 7 nonunions (15%), of which 6 had shortening of 2 cm or more. They concluded that initial shortening of 2 cm or more was significantly associated with the development of nonunion ($P < .0001$, Fisher exact test).

A funnel plot of all 11 studies reporting nonunion rates demonstrated a symmetrical spread of data points, suggesting no significant bias was present (Fig. 2).[3,7-10,23,25,27,33,36,37]

Discussion

The main finding of this systematic review was that there is no clear effect of fracture shortening on shoulder outcome scores.[5,7-9,13,19,23,25,27,28,33,35-37] Of the 4 RCTs reviewed, which provided the highest level of available evidence, 3 reported no significant association between fracture shortening and functional outcomes.[5,9,36] Although the Canadian Orthopaedic Trauma Society study did report increased shortening to be associated with significantly higher DASH scores,[3] the validity of these findings is questioned by the failure to reproduce these results either within the study using the Constant score or in any of the other more recent

Table II MINORS scores for clinical studies

	Clearly stated aim	Inclusion of consecutive patients	Prospective data collection	Endpoints appropriate to study aim	Unbiased assessment of study endpoint	Follow-up period appropriate to study aim	<5% lost to follow-up	Prospective calculation of study size	Adequate control group	Contemporary groups	Baseline equivalence of groups	Adequate statistical analyses	Total
Tutuhatunewa et al,[37] n = 94	2	2	1	1	1	1	1	0	2	2	1	2	16 of 24
Nordqvist et al,[23] n = 29	2	2	1	2	0	2	1	0	NA	NA	NA	NA	10 of 16
Stegeman et al,[35] n = 32	2	0	2	2	1	0	2	0	NA	NA	NA	NA	9 of 16
Hill et al,[10] n = 47	0	2	2	1	0	2	1	0	NA	NA	NA	NA	8 of 16
Fuglesang et al,[8] n = 59	2	2	2	2	1	2	1	0	NA	NA	NA	NA	12 of 16
Lazarides and Zafiropoulos,[12] n = 132	2	2	2	2	1	2	1	0	NA	NA	NA	NA	12 of 16
Oroko et al,[25] n = 28	2	0	2	2	0	1	2	0	NA	NA	NA	NA	9 of 16
McKee et al,[21] n = 30	2	2	2	2	2	2	2	0	NA	NA	NA	NA	14 of 16
Postacchini et al,[27] n = 68	2	2	2	2	2	2	1	0	NA	NA	NA	NA	13 of 16
Figueiredo et al,[7] n = 54	2	2	2	2	0	2	1	0	NA	NA	NA	NA	11 of 16
Shukla et al,[33] n = 25	2	2	2	2	0	1	2	0	2	2	1	1	17 of 24
Rasmussen et al,[28] n = 136	2	2	2	2	0	2	2	0	2	2	0	2	18 of 24

MINORS, Methodological Index for Non-Randomized Studies; *NA*, not applicable.
The items are scored as 0 (not reported), 1 (reported but inadequate), or 2 (reported and adequate), with the global ideal score being 16 for noncomparative studies and 24 for comparative studies.

Table III CONSORT items for randomized controlled trials

	Item No.	Goudie et al,[9] n = 48	Tamaoki et al,[36] n = 47	Ersen et al,[5] n = 51	COTS,[3] n = 49
Title and abstract	1a, 1b	Yes	Yes	Yes	Yes
Introduction					
Background and objectives	2a, 2b	Yes	Yes	Yes	Yes
Methods					
Trial design	3a, 3b	Yes	Yes	Yes	Yes
Participants	4a, 4b	Yes	Yes	Yes	Yes
Interventions	5	Yes	Yes	Yes	Yes
Outcomes	6a, 6b	Yes	Yes	Yes	Yes
Sample size	7a, 7b	Yes	Yes	Yes	Yes
Randomization					
Sequence generation	8a, 8b	Yes	Yes	Yes	Yes
Allocation concealment mechanism	9	No	Yes	Yes	Yes
Implementation	10	No	Yes	Yes	No
Blinding	11a, 11b	No	Yes	No	No
Statistical methods	12a, 12b	Yes	Yes	Yes	Yes
Results					
Participant flow (diagram is strongly recommended)	13a, 13b	Yes	Yes	Yes	Yes
Recruitment	14a, 14b	Yes	Yes	Yes	Yes
Baseline data	15	Yes	Yes	Yes	Yes
Numbers analyzed	16	Yes	Yes	Yes	Yes
Outcomes and estimation	17a, 17b	Yes	Yes	Yes	Yes
Ancillary analyses	18	Yes	Yes	Yes	Yes
Harms	19	Yes	Yes	Yes	Yes
Discussion					
Limitations	20	Yes	Yes	Yes	Yes
Generalizability	21	Yes	Yes	Yes	Yes
Interpretation	22	Yes	Yes	Yes	Yes
Other information					
Registration	23	Yes	Yes	Yes	Yes
Protocol	24	Yes	Yes	No	No
Funding	25	Yes	Yes	Yes	Yes
Total	25	22 of 25	25 of 25	23 of 25	22 of 25

CONSORT, Consolidated Standards of Reporting Trials; *COTS*, Canadian Orthopaedic Trauma Society.

RCTs reviewed.[5,9,36] This main finding is further supported by the failure to demonstrate any correlation between shortening and shoulder function in 11 of the 12 case series.[7,8,12,19,23,25,27,28,33,35,37]

Neither of the 2 studies reporting inferior shoulder function with clavicle shortening was able to define an absolute value of shortening that was acceptable for good shoulder function.[3,10] In addition, these 2 studies had limitations that may explain this discrepancy in results. These included heterogeneity in the way shortening was measured, as well as the method of immobilization of the fractured clavicle, which varied in different studies. Hill et al[10] reported that final shortening of 2 cm or more was associated with unsatisfactory results ($P < .0001$). However, this study had significant limitations as demonstrated by the MINORS score of 8, which is the lowest score attributed to any of the clinical studies included in our systematic review. The main weakness was the failure to provide an objective way to assess shoulder function to validate these conclusions.

Although 11 studies reported nonunion rates (with the mean ranging from 0% to 17%), only 3 specifically analyzed whether there was a correlation between fracture shortening and the union rate.[7,8,10] These 3 studies were all case series, thus providing a lower level of evidence for review. Fuglesang et al[8] performed multivariate logistic regression analysis and reported that the odds ratio for the risk of nonunion more than doubled for every 10-year increase in patient age ($P = .04$) and was 5 times higher in female patients, but no correlation with fracture shortening was demonstrated. The other 2 studies did not perform a multivariate analysis to account for other known

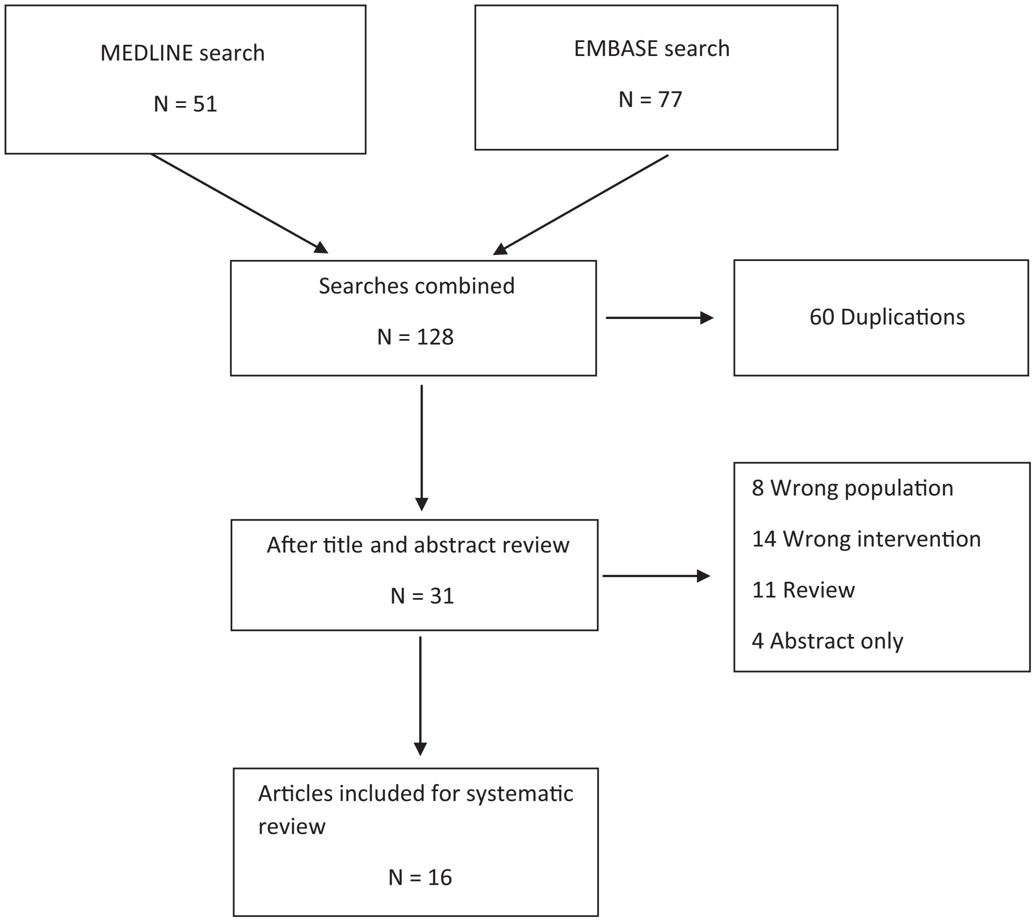

Figure 1 Flow diagram of review process.

risk factors predisposing to nonunion.[7,10] Results varied, with Hill et al[10] demonstrating a significant association between shortening and nonunion ($P < .0001$) and Figueiredo et al[7] reporting a higher nonunion rate in patients with shortening of less than 1 cm. Therefore, the studies reviewed provide limited data and contrasting results on the association between nonunion and clavicle shortening in nonoperatively managed fractures.

Clavicle shortening was calculated using radiographs (AP radiographs in most cases) in all but 1 study in this systematic review. Shortening measurements taken on radiographs depend on the views taken and can be subject to error depending on the estimates made if the film is not calibrated. Malik et al[15] demonstrated significant changes ($P < .001$) in fracture shortening measurements by altering patient position; in the supine position, shortening was −0.41 mm (95% confidence interval, −2.53 to 1.70 mm), whereas in the upright position, it was 4.86 mm (95% confidence interval, 1.66-8.06 mm). Only 1 included study measured shortening using CT scans, which has been demonstrated to be a more accurate method of assessing fracture shortening than plain radiographs.[1,24] The increased radiation dose associated with CT imaging would be a concern if introducing CT as the routine imaging modality to measure fracture shortening for midshaft clavicle fractures. The radiation dose of a CT scan of the shoulder (2.06 mSv)[2] is higher than that of a plain chest radiograph (0.1 mSv). As this systematic review has failed to demonstrate any correlation between fracture shortening and either outcome scores or nonunion, routine CT imaging to enable accurate measurement with the subsequent risk of radiation exposure cannot be recommended at this time. It is a limitation of this review that there was considerable variability among studies with respect to the methods used to calculate shortening and that none of the included studies attempted to evaluate malrotation at the fracture site. It is plausible that malrotation may be of greater clinical importance than shortening because it more profoundly affects scapula position. Further study of this aspect is required.

Appraisal of the randomized studies showed them to be Consolidated Standards of Reporting Trials (CONSORT) compliant (Table III), with scores ranging between 22 and 25 (maximum possible score, 25). Appraisal of the nonrandomized clinical studies using the MINORS tool demonstrated a variety of limitations, which are summarized in Table II. The MINORS scores ranged from 8 to 14 for noncomparative studies (maximum possible score, 16)

Table IV Summary of 16 clinical studies

Study	Study design	Age and sex of population	Intervention	Comparator	Follow-up	Outcome measure	Results
Goudie et al,[9] n = 48	RCT	33 yr (SD, 12.5 yr)	Collar and cuff		12 mo	DASH score Constant score SF-12 score	Mean shortening, 11.3 mm (SD, 7.6 mm)
Tamaoki et al,[36] n = 47	RCT	34.6 yr (SD, 12.6 yr); 81% male patients	Figure of 8		12 mo	DASH score VAS score for pain	Mean shortening, 9.3 mm (SD, 6.6 mm) Mean VAS score for pain, 0.38 No restriction in range of shoulder movement
Ersen et al,[5] n = 51	RCT	31.6 yr (range 15-75 yr)	Figure of 8 vs. sling		8.3 mo (6-12 mo)	Constant score ASES score VAS score for pain	Mean shortening, 9mm (SD 3.8 mm) for figure 8 and 7.7 mm (SD 3 mm) for broad arm sling. p = 0.30; 95% CI -2.2 to 5.3. Maximum shortening, 24 mm for broad arm sling VAS score on day 21, 0.6 for figure of 8 and 0.5 for sling; *P* = .9
COTS,[3] n = 49	RCT	33.5 yr	Sling		52 weeks	DASH score Constant score	Mean shortening, 14.3 mm
Tutuhatunewa et al,[37] n = 94	Retrospective observational study	42.4 yr (range 25.6-55.8 yr); 78% male patients	Sling or collar and cuff		50 d (25.8-106.8 d)*	QuickDASH score VAS score for pain Health-related quality of life (Eq-5D-5L)	Average shortening, 24.7 mm (SD, 15.6 mm) Median VAS score, 0 (10.0-1.4)
Nordqvist et al,[23] n = 29	Retrospective case series	>15 yr	Not stated		5 yr	Constant score Nonunion ROM	Shortening, 11.1 mm (CI, 8.2-14.0 mm) No statistically significant difference in active ROM (*P* value not given)
Stegeman et al,[35] n = 32	Retrospective observational study	31 yr (range 21-62 yr); 84% male patients	Not stated		Not stated	Constant score DASH score	Mean shortening, 25 mm (SD, 16 mm)

Hill et al,[10] n = 47	Retrospective case series	34 yr (range 18-59 yr); 71.1% male patients	Figure of 8 vs. sling vs. no treatment	38 mo (15-68 mo)	Nonunion Pain Paresthesia	Mean shortening, 11.8 mm (0-22 mm) Final shortening ≥ 2 cm associated with unsatisfactory results
Fuglesang et al,[8] n = 59	Retrospective case series	39.1 yr (SD, 12.3 yr); 83% male patients	Sling for 2 weeks	2.7 yr	Constant score DASH score VAS score Nonunion	Mean initial shortening, 15 mm (12-20 mm) Mean shortening in united fractures, 15 mm (7.8-18.3 mm) Median VAS score for pain, 1.3
Lazarides and Zafiropoulos,[12] n = 132	Retrospective	Male patients, 25.4 yr (range 16-72 yr) Female patients, 34.2 yr (range 15-77 yr)	Broad arm sling	30 mo (12-43 mo)	Constant score Pain ROM	Shortening in male patients, 14.4 mm (SD, 8.5 mm) Shortening in female patients, 11.2 mm (SD, 7.3 mm) ROM impairment, 18 (13.6%) Pain, 40 (30.3%)
Oroko et al,[25] n = 28	Retrospective case series	40 yr (range 13-83 yr); 76% male patients	Broad arm sling, poly-sling, or collar and cuff	38 weeks (16 weeks to 3 yr)	Constant score Nonunion	Median shortening, 10 mm (range, 0-30 mm)
McKee et al,[21] n = 30	Retrospective	37 yr (range 19-67 yr)	Sling	55 mo (12-72 mo)	DASH score Constant score ROM	Mean shortening, 14.1 mm (SD, 8.9 mm)
Postacchini et al,[27] n = 68	Retrospective case series	36.9 yr	Figure of 8 or sling	8.7 yr	Constant score Nonunion	Shortening in male patients, 14.1 mm (SD, 8.9 mm) Shortening in female patients, 10.9 mm (SD, 7.8 mm) Overall, mean OV and DS of 12% and 1.6 cm, respectively

(*continued on next page*)

Table IV Summary of 16 clinical studies (*continued*)

Study	Study design	Age and sex of population	Intervention	Comparator	Follow-up	Outcome measure	Results
Rasmussen et al,[28] n = 136	Retrospective case series	35 yr (range 15-70 yr); 79% male patients	Figure of 8, sling, or collar and cuff		55 mo (24-83 mo)	Constant score	Average shortening, 11.6 mm (SD, 8.2 mm) Shortening for sling, 10.9 mm (SD, 7.3 mm) Shortening for figure of 8, 12 mm (SD, 7.3 mm) Mean difference in shortening, 1.2 mm (95% CI, −1.9 to 4.2 mm); $P = .45$
Shukla et al,[33] n = 25	Case-control series	32.6 yr (SD, 6.43 yr)	Clavicle brace		6 mo	Constant score Union time	Mean shortening, 19.36 mm Mean radiographic union time, 23.45 ± 1.40 weeks
Figueiredo et al,[7] n = 54	Prospective cohort study	34 yr (range 17-64 yr); SD, 12.73 yr; 81.4% male patients	Figure of 8		1 yr	DASH score VAS score for pain	Mean shortening, 9.2 mm (0-30 mm); SD, 6.4 mm VAS score, 0.34 (0-5); SD, 0.98

RCT, randomized controlled trial; *SD*, standard deviation; *DASH*, Disabilities of the Arm, Shoulder and Hand; *SF-12*, Short Form 12; *VAS*, visual analog scale; *ASES*, American Shoulder and Elbow Surgeons; *COTS*, Canadian Orthopaedic Trauma Society; *QuickDASH*, short version of Disabilities of the Arm, Shoulder and Hand questionnaire; *ROM*, range of motion; *CI*, confidence interval; *OV*, overlapping of fracture fragments; *DS*, mean distance between craniocaudally displaced fragments; *Eq-5D-5L*, Health-related quality of life measured using the EuroQol group 5D tool.

* Data are presented as median (first quartile to third quartile).

Table V Summary of clinical studies and functional outcomes in relation to shortening

Study	Mean shortening	Mean Constant score	Mean DASH score	Correlation between shortening and function
Goudie et al,[9] n = 48	11.3 mm (SD, 7.6 mm)	88.7 (SD, 12.3)	4.9 (SD, 10.5)	Shortening ≤ 1 cm or ≥ 2 cm had no effect on the DASH or Constant score.
Tamaoki et al,[36] n = 47	9.3 mm (SD, 6.6 mm)	—	3 (SD, 9.4)	Shortening did not have an effect on shoulder function.
Ersen et al,[5] n = 51	9 mm (SD, 3 mm) for figure of 8 7.7 mm (SD, 3 mm) for broad arm sling	96 (range 80-100) for figure of 8 96.75 (range 75-100) for sling	—	Shortening was not associated with lower functional results.
COTS,[3] n = 49	14.3 mm	91[*]	14[*]	Increased shortening led to higher DASH scores (r = 0.326, P = .05).
Tutuhatunewa et al,[37] n = 94	24.7 mm (SD, 15.6 mm)	—	2.3 (range 0-14.2)[†]	Shortening showed no disadvantage regarding overall shoulder function.
Nordqvist et al,[23] n = 29	11.1 mm	93 for injured shoulder vs. 93 for contralateral shoulder	—	There was no statistically significant difference between shortening and the Constant score (stepwise regression analysis).
Stegeman et al,[35] n = 32	25 mm (SD, 16 mm)	96 (SD, 5.3)	5.2 (SD, 6.3)	The Constant score and DASH score were not affected by clavicle shortening.
Fuglesang et al,[8] n = 59	15 mm	81 (range 69-90)	6.7 (range 0.8-19)	No correlation was demonstrated, with P = .1 for DASH score and P = .5 for Constant score.
Lazarides and Zafiropoulos,[12] n = 132	14.4 mm in male patients 11.2 mm in female patients	84 (range 62-100)	—	A Constant score < 70 was significantly associated with a subjectively unsatisfactory result in both sexes (P < .05, χ^2 test). Patient dissatisfaction was noted for shortening > 18 mm in male patients (P < .001, χ^2 test) and > 14 mm in female patients (P < .001, Fisher exact test).
Oroko et al,[25] n = 28	10 mm (range, 0-30 mm)	90 (range 44-100) for injured shoulder vs. 100 (range 66-100) for contralateral shoulder	—	No correlation was found between shortening and the Constant score.

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Table V Summary of clinical studies and functional outcomes in relation to shortening (*continued*)

Study	Mean shortening	Mean Constant score	Mean DASH score	Correlation between shortening and function
McKee et al,[21] n = 30	14.5 mm (SD, 8.6 mm) <20 mm in 19 (63%) ≥20 mm in 11 (37%)	71	24.6	No correlation was found between shortening and the DASH score (r = 0.315, P = .11) or Constant score (r = −0.196, P = .44).
Postacchini et al,[27] n = 68	14.1 mm (SD, 8.9 mm) in male patients 10.9 mm (SD, 7.8 mm) in female patients	87.1% 1b and 85.6% 1c Constant score ≥ 90% (n = 55) with OV of 7.7% and Constant score ≤ 80% (n = 9) with OV of 13.2% for 1b and 1c	—	If overlap was 7.7% (11.6 mm), the Constant score was ≥90%. If overlap was 12%, the Constant score was between 81% and 89%.
Rasmussen et al,[28] n = 136	11.6 mm (SD, 8.2 mm) ≥20 mm, n = 20	86.3 (range 29-100) 93.7 (range 81-100) for contralateral shoulder	—	No correlation was found between shortening of the clavicle and the clinical outcome (r = 0.14, P > .05).
Shukla et al,[33] n = 25	19.36 mm	78.28	—	—
Figueiredo et al,[7] n = 54	9.2 mm (range 0-30 mm); SD, 0.64 mm	—	3.38 (range 0-58); SD, 9.21	No correlation was found between shortening and the DASH score at 6 weeks or 1 yr (P = .073 and P = .706, respectively). Setting a minimum threshold for shortening of 2 cm did not improve the correlation.

DASH, Disabilities of the Arm, Shoulder and Hand; *SD*, standard deviation; *COTS*, Canadian Orthopaedic Trauma Society; *OV*, overlapping of fracture fragments.

* Figures were taken from the illustrations because they were not mentioned in the text.

† Data are presented as median (first quartile to third quartile).

Table VI Summary of clinical studies and nonunions

Study	No. of patients	No. of nonunions	Correlation between shortening and nonunion (when recorded)
Goudie et al[9]	48	16 (17%)	Nonunions were excluded from the results to avoid skewness.
Tamaoki et al[36]	47	7 (14.9%)	Five patients remained asymptomatic.
COTS[3]	49	7 (14.3%)	—
Tutuhatunewa et al[37]	94	20 (13.2%)	Delayed union and nonunion were grouped.
Nordqvist et al[23]	29	0	—
Hill et al[10]	47	7 (15%)	Six patients had shortening > 20 mm. Shortening > 20 mm was significantly associated with nonunion (P < .0001, Fisher exact test).
Fuglesang et al[8]	59	9 (15.3%)	No difference was found in initial shortening between nonunions and fractures that united.
Oroko et al[25]	28	0	—
Postacchini et al[26]	68	5 (5.5%)	—
Shukla et al[33]	25	2 (8%)	—
Figueiredo et al[7]	54	6 (11.1%)	All 6 nonunions had <1 cm of shortening.

COTS, Canadian Orthopaedic Trauma Society.

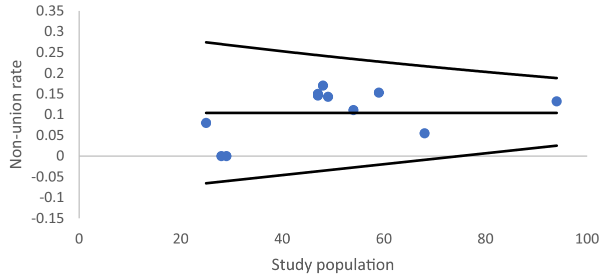

Figure 2 Funnel plot showing nonunion rates in included studies.

and from 16 to 18 for comparative studies (maximum possible score, 24). Common limitations of the non-comparative studies occurred in the categories of assessment of endpoints, an acceptable rate of patients lost to follow-up (<5%), and prospective sample size calculation. Common weaknesses of the comparative studies were failure to demonstrate baseline equivalence between groups, as well as how shortening was measured on radiographs depending on the type of radiographic views taken. Furthermore, not all studies looked at a cutoff point of shortening affecting shoulder function, and those that did consider 15 mm or 2 cm had very small numbers of patients within these groups, potentially skewing the results. Another weakness is the length of follow-up in these studies, which varied from 50 days to 8.7 years.

This systemic review has analyzed clinical studies including RCTs that evaluated displaced midshaft clavicle fractures and the effect of shortening on shoulder outcome scores. It overall shows that shortening in midshaft displaced clavicle fractures managed nonoperatively does not have an effect on outcome scores. We therefore recommend that shortening should not be routinely used to predict outcomes after nonoperative management of displaced midshaft clavicle fractures.

Conclusion

There is no significant association between fracture shortening and nonunion rates or shoulder outcome scores in displaced midshaft clavicle fractures managed nonoperatively.

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