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COMPARATIVE ANALYSIS OF CONSERVATIVE TREATMENT VERSUS PLATE FIXATION FOR DISPLACED MIDDLE THIRD CLAVICLE FRACTURES: AN AMBISPECTIVE STUDY

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ABSTRACT **Background:** Clavicle fractures account for 5–10% of all fractures presenting to emergency departments, and middle third fractures make up approximately 80% of clavicular injuries. The optimal management of displaced midshaft fractures remains debated. Conservative treatment, historically the standard of care, is associated with higher rates of nonunion, malunion and persistent functional deficit in displaced fractures. **Aim:** To compare the clinical, radiological and functional outcomes of conservative treatment versus plate fixation for displaced middle third clavicle fractures in adults.**Materials and Methods:** A single-centre, non-randomised, ambispective (combined prospective and retrospective) comparative study was conducted in the Department of Orthopaedics of a tertiary care hospital over three years. Thirty skeletally mature patients aged 18–60 years with displaced unilateral middle third clavicle fractures were included. Group A (n = 15) was managed with a figure-of-eight brace and arm-pouch sling; Group B (n = 15) underwent open reduction and internal fixation with a 3.5 mm pre-contoured plate. Patients were followed at 1, 2, 3, 6 and 12 months. Function was assessed with the Constant-Murley Score (CMS) and the Disabilities of the Arm, Shoulder and Hand (DASH) score. Data were analysed with SPSS 15.0 using the independent t-test and chi-square or Fisher's exact test, with Bonferroni correction for repeated time-point comparisons and 95% confidence intervals (CI). **Results:** Males predominated (80%). Mean age was 32.13 ± 5.93 years (conservative) and 36.93 ± 12.2 years (plating) ($p = 0.18$). Road traffic accidents were the commonest mechanism (63.33%). At 12 months, the plating group had a higher mean CMS (89.40 ± 5.7 vs 76.20 ± 4.0; mean difference 13.2, 95% CI 9.5 to 16.9; $p < 0.001$) and a lower DASH score (19.5 ± 2.1 vs 35.4 ± 3.7; mean difference −15.9, 95% CI −18.2 to −13.6; $p < 0.001$); both differences remained significant after Bonferroni correction. Union within 12 weeks was more frequent after plating (66.7% vs 46.7%), but time to union did not differ significantly ($p = 0.41$). Nonunion occurred in 0/15 plated and 2/15 conservatively treated patients ($p = 0.48$). Overall complications were less frequent after plating (6.7% vs 46.7%; risk difference −40.0%, 95% CI −63.9% to −8.2%; $p = 0.035$).**Conclusion:** In this small, non-randomised study, plate fixation of displaced middle third clavicle fractures was associated with better functional recovery and fewer overall complications than conservative management. The trend towards faster union was not statistically significant. These findings support selective operative fixation in fit, active adults rather than routine fixation of all displaced midshaft fractures, and require confirmation in adequately powered randomised trials.

KEYWORDS : Clavicle Fracture; Midshaft Clavicle; Plate Fixation; Conservative Treatment; Constant-murley Score; Dash Score; Functional Outcome; Nonunion

INTRODUCTION

The clavicle is the most frequently fractured bone in the human body, accounting for approximately 5–10% of all fractures presenting to hospital emergency departments.[1] Middle third fractures constitute approximately 80% of clavicular injuries, making them the most commonly encountered subtype in clinical practice.[2] These fractures predominantly affect young adult males and are typically caused by high-energy trauma such as road traffic accidents, sports injuries and falls onto the shoulder.[3–5]

The clavicle is the only bony strut connecting the upper limb to the axial skeleton. It maintains the width of the shoulder girdle, protects the subclavian vessels and brachial plexus, and serves as the attachment for the sternocleidomastoid, trapezius, deltoid and pectoralis major. The middle third is the thinnest part of the bone and lies at the junction of its two curvatures, without ligamentous or muscular reinforcement, which explains why most fractures occur here.[2,3] After fracture, the weight of the arm and the pull of pectoralis major depress and medialise the distal fragment, while sternocleidomastoid elevates the medial fragment. The result is displacement and shortening, which are the main predictors of nonunion and poor shoulder function.[3,6]

Several classification systems have been described. Allman divided clavicle fractures into medial, middle and lateral thirds.[2] The Robinson (Edinburgh) classification further grades diaphyseal (type 2) fractures by cortical apposition and comminution; type 2B fractures, with complete displacement, carry the highest risk of nonunion after non-operative treatment.[3]

Historically, conservative management with a sling or figure-of-eight brace was the predominant strategy. This approach was largely shaped by the landmark series of Neer (1960) and Rowe (1968), which reported nonunion rates of only 0.13% and 0.8%, respectively.[7,8] These early series, however, included many children, in whom fracture healing is inherently more robust, and did not use patient-reported outcome measures. Subsequent studies in adults with displaced fractures treated non-operatively have reported nonunion rates of 7–15%, together with symptomatic malunion, shoulder dysfunction and persistent functional deficit.[3,9]

The multicentre randomised controlled trial of the Canadian Orthopaedic Trauma Society (COTS), comparing open reduction and internal fixation (ORIF) with sling treatment in 132 patients, showed significantly better Constant and DASH scores, faster union and fewer nonunions and symptomatic malunions after plate fixation.[10] This trial prompted a shift towards operative treatment of displaced midshaft fractures. Later randomised trials and meta-analyses confirmed that fixation reduces nonunion and symptomatic malunion and improves early function, but found that differences in long-term function are often modest and that many patients heal satisfactorily without surgery.[11–13] This supports selective rather than routine operative treatment.

Despite this evidence, practice varies considerably, and data from Indian tertiary care settings, where road traffic injury is the dominant mechanism and access to follow-up and rehabilitation differs, remain limited.[14–16] The present study was therefore designed to compare the clinical and functional outcomes of conservative management and plate fixation for displaced middle third clavicle fractures at a tertiary care centre, using the Constant-Murley Score and the DASH score as primary outcome measures.

Objectives

Primary objectives:

1. To compare conservative treatment with plate fixation for displaced middle third clavicle fractures.
2. To evaluate clinical and functional outcomes of the two treatment modalities using the Constant-Murley Score and the DASH score over 12 months.

Secondary objective: To analyse the advantages and disadvantages of each approach, including time to union and complications.

Materials and Methods

Study design and setting

A single-centre, non-randomised, ambispective (combined prospective and retrospective) comparative study was conducted in the Department of Orthopaedics of a tertiary care hospital, over a period of three years (academic year 2022–2023 onwards). Institutional Ethics Committee approval was obtained before commencement of the study (IEC No. MUHS/Medical/MUHS-053782/2019; approval date 07/02/2024). The study was conducted in accordance with the Declaration of Helsinki, and written informed consent was obtained from all participants before enrolment. The study is reported in line with the STROBE guidelines for observational studies.

Patients treated before the start of prospective enrolment were identified retrospectively from hospital records, and subsequent patients were enrolled and followed prospectively. The same case record form, outcome measures and definitions were applied to both cohorts. Differences in documentation between retrospectively and prospectively collected data cannot be excluded and are acknowledged as a limitation.

Study population and sample size

Thirty patients with displaced unilateral middle third clavicle fractures were included, 15 in each treatment arm (Figure 1). Allocation was not randomised; the treatment modality was decided in the course of routine clinical care through discussion between the treating surgeon and the patient, which introduces potential selection bias. The sample size was determined by the number of eligible patients available during the study period. No a priori power calculation was performed, and the study should therefore be regarded as exploratory.

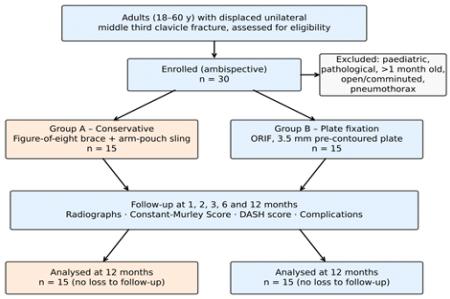


Figure 1. Study flow diagram showing eligibility, allocation to conservative (Group A) or plate fixation (Group B) treatment, follow-up schedule and analysis. All 30 patients completed 12-month follow-up.

Inclusion and exclusion criteria

Inclusion criteria: skeletally mature patients of either sex aged 18–60 years; a unilateral, displaced middle third clavicle fracture confirmed radiographically; fitness for surgery; and willingness to attend regular follow-up for 12 months.

Exclusion criteria: paediatric patients; pathological fractures; fractures older than one month; open or comminuted fractures; and associated pneumothorax.

Displacement was defined as loss of cortical contact between the main fragments on anteroposterior and 30° cephalic-tilt radiographs. Because multifragmentary (comminuted or segmental) fractures were excluded, all fractures corresponded to Robinson type 2B1 (displaced, simple or with a single wedge fragment).[3] The exact amount of shortening and the presence of wedge fragments were not quantified for each patient.

Pre-treatment evaluation

All patients underwent a detailed history and clinical examination, recording age, sex, hand dominance, side of injury, mechanism of injury and the interval between injury and treatment. Neurovascular status of the limb was documented and associated injuries were excluded. Radiographs of the affected clavicle were obtained in anteroposterior and 30° cephalic-tilt views. Baseline Constant-Murley and DASH scores were recorded at presentation.

Treatment protocol

Group A (conservative, n = 15): Patients were managed with a figure-of-eight clavicle brace combined with an arm-pouch sling. The brace was checked and tightened at each early visit. Passive range-of-motion exercises limited to forward flexion below 90° were started at 4 weeks. The brace was discontinued at 6 weeks, followed by gradual resumption of activities.

Group B (plate fixation, n = 15): Patients underwent open reduction and internal fixation under appropriate anaesthesia, in the supine position with a bolster between the scapulae. A skin incision was centred over the fracture along the superior border of the clavicle. Supraclavicular nerves were identified and preserved where possible. The fracture was reduced and held with bone-holding clamps, and a 3.5 mm pre-contoured plate (limited contact dynamic compression or third-tubular plate) was applied to the superior or anteroinferior surface. A minimum of three bicortical screws was placed in each of the proximal and distal fragments. Lag screws were added for long oblique fractures or those with a wedge (butterfly) fragment where feasible. Prophylactic antibiotics were given preoperatively, and the wound was closed in layers. Codman's pendulum exercises began on the third postoperative day.

Rehabilitation: Both groups were rehabilitated by the departmental physiotherapy team. After initial pendulum exercises, plated patients progressed to active-assisted range-of-motion and then strengthening exercises as pain and healing allowed; conservatively treated patients followed the protocol above. Heavy manual work and contact sports were deferred until clinical and radiological union in both groups. Brace compliance, physiotherapy attendance and time to return to work were not systematically quantified.

Outcome assessment and follow-up

All patients were reviewed at 1, 2, 3, 6 and 12 months. Radiological evaluation and functional scoring were performed at each visit.

Constant-Murley Score (CMS): a 100-point composite score comprising pain (15 points), activities of daily living (20 points), range of motion (40 points) and strength (25 points). Higher scores indicate better shoulder function.

Disabilities of the Arm, Shoulder and Hand (DASH) score: a 30-item patient-reported questionnaire on upper-limb symptoms and function, scaled from 0 (no disability) to 100 (maximum disability). Lower scores indicate better function. A difference of approximately 10.8 points is considered the minimal clinically important difference (MCID).[17]

Radiological union was defined as bridging callus or trabeculae across at least three of four cortices on anteroposterior and 30° cephalic-tilt radiographs, with absence of tenderness and pain on movement at the fracture site. **Delayed union** was defined as union after 18 weeks, and **nonunion** as absence of radiological union at 6 months without progression on subsequent radiographs. Blinded radiological assessment was not feasible because the implant is visible on radiographs.

Complications recorded included nonunion, delayed union, shoulder stiffness, infection, implant failure and the need for implant removal. Plate-specific complications such as hardware prominence, symptomatic implant irritation, supraclavicular numbness and cosmetic satisfaction were not systematically recorded.

Statistical analysis

Data were analysed with SPSS version 15.0 (SPSS Inc., Chicago, IL, USA). Continuous variables are presented as mean ± standard deviation (SD) and categorical variables as frequency and percentage. Between-group comparisons of age and of CMS and DASH scores at each time point used the independent samples t-test, reported as mean difference with 95% CI and effect size (Hedges' g). Because each score was compared at six time points, a Bonferroni correction was applied (threshold 0.05/6 = 0.0083 per score) and adjusted p-values are reported.

Categorical variables were compared using the chi-square test, or Fisher's exact test when any expected cell count was below 5. Proportions are reported with Wilson 95% CIs and between-group risk differences with Newcombe 95% CIs. Given the sample size and small number of events, multivariable adjustment for confounders was not considered statistically robust; baseline characteristics were therefore compared between groups. A p-value below 0.05 was considered statistically significant for single comparisons.

RESULTS

All 30 patients completed the 12-month follow-up and were included in the analysis (Figure 1).

Demographic and baseline characteristics

Of the 30 patients, 24 (80%) were male and 6 (20%) female. Mean age was 32.13 ± 5.93 years (range 25–46) in the conservative group and 36.93 ± 12.2 years (range 20–56) in the plating group (mean difference 4.8 years, 95% CI −2.4 to 12.0; p = 0.18). Twenty-two patients (73.33%) were right-hand dominant and 8 (26.67%) left-hand dominant; the dominant limb was involved in 18 patients (60%). Road traffic accidents were the commonest mechanism (n = 19, 63.33%), followed by sports injuries (n = 6, 20%) and falls (n = 5, 16.67%). The left clavicle was injured more often (n = 21, 70%) than the right (n = 9, 30%). The mean interval from injury to treatment was 3.21 ± 1.76 days in Group A and 4.4 ± 2.82 days in Group B (t = −1.37, p = 0.185) (Table 1; Figure 2).

Group-wise data on smoking, diabetes mellitus, occupation, fracture shortening and wedge fragments were not available; potential confounding from these variables is acknowledged.

Table 1. Demographic and baseline characteristics of the study population (n = 30)

Characteristic	Category	Value	p-value
Sex, n (%)	Male	24 (80.0)	—
	Female	6 (20.0)	
Age (years), mean ± SD	Conservative (n = 15)	32.13 ± 5.93	0.18
	Plating (n = 15)	36.93 ±12.2	
Hand dominance, n (%)	Right	22 (73.33)	—
	Left	8 (26.67)	
Limb involved, n (%)	Dominant	18 (60.0)	—
	Non-dominant	12 (40.0)	
Side of fracture, n (%)	Left	21 (70.0)	—
	Right	9 (30.0)	
Mechanism of injury, n (%)	Road traffic accident	19 (63.33)	—
	Sports injury	6 (20.0)	
	Fall	5 (16.67)	
Injury-to-treatment interval (days), mean ± SD	Conservative	3.21 ± 1.76	0.185
	Plating	4.4 ± 2.82	

SD, standard deviation. p-values from the independent t-test.

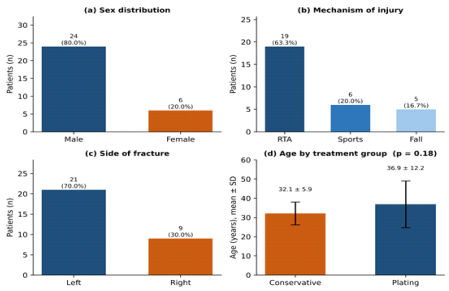


Figure 2. Baseline characteristics. (a) Sex distribution; (b) mechanism of injury (RTA, road traffic accident); (c) side of fracture; (d) mean age by treatment group with error bars showing ± 1 SD. Bar labels give number and percentage of the 30 patients.

Functional outcome: Constant-Murley Score

At presentation, mean CMS was slightly higher in the plating group (29.80 ± 2.5) than in the conservative group (27.90 ± 1.9; mean difference 1.9 points, unadjusted p = 0.026). This difference was not significant after Bonferroni correction (adjusted p = 0.16) and was small compared with later between-group differences. From 1 month onwards, the plating group had significantly higher scores at every time point (all Bonferroni-adjusted p < 0.001). At 12 months, mean CMS was 89.40 ± 5.7 after plating and 76.20 ± 4.0 after conservative treatment (mean difference 13.2 points, 95% CI 9.5 to 16.9; Hedges' g = 2.61) (Table 2; Figure 3).

Table 2. Constant-Murley Score in the two groups at each time point

Time point	Plating, mean ± SD	Conservative, mean ± SD	t-value	p-value
At injury	29.80 ± 2.5	27.90 ± 1.9	2.34	0.026
1 month	64.15 ± 5.1	48.50 ± 3.5	9.80	< 0.001*
2 months	60.30 ± 4.9	45.20 ± 4.1	9.15	< 0.001*
3 months	75.60 ± 5.3	66.80 ± 4.2	5.04	< 0.001*
6 months	84.90 ± 6.1	72.00 ± 4.8	6.44	< 0.001*
12 months	89.40 ± 5.7	76.20 ± 4.0	7.34	< 0.001*

Independent t-test, df = 28. *Significant after Bonferroni correction for six comparisons (adjusted p < 0.001). The baseline difference was not significant after correction (adjusted p = 0.16). Higher scores indicate better function.

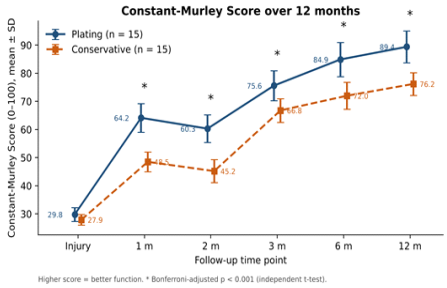


Figure 3. Mean Constant-Murley Score (± SD) at each follow-up visit in the plating and conservative groups. The plating group scored higher from 1 month onwards. *Bonferroni-adjusted p < 0.001.

Functional outcome: DASH score

At baseline, DASH scores were similar in both groups (plating 62.4 ± 3.2; conservative 63.1 ± 3.5; p = 0.57). By 1 month the plating group had a significantly lower mean DASH score (48.7 ± 4.1 vs 56.3 ± 4.7; p < 0.001), indicating faster early recovery, and this advantage persisted throughout follow-up (all Bonferroni-adjusted p < 0.001). At 12 months, mean DASH was 19.5 ± 2.1 after plating and 35.4 ± 3.7 after conservative treatment (mean difference −15.9, 95% CI −18.2 to −13.6; p < 0.001) (Table 3; Figure 4). From 2 months onwards, the between-group difference exceeded the MCID of 10.8 points.

Table 3. DASH score in the two groups over 12 months

Time point	Plating, mean ± SD	Conservative, mean ± SD	Difference	p-value
At injury	62.4 ± 3.2	63.1 ± 3.5	0.7	0.572
1 month	48.7 ± 4.1	56.3 ± 4.7	7.6	< 0.001*
2 months	36.2 ± 3.8	48.9 ± 4.2	12.7	< 0.001*
3 months	28.4 ± 3.2	43.7 ± 3.9	15.3	< 0.001*
6 months	22.7 ± 2.6	39.1 ± 4.1	16.4	< 0.001*
12 months	19.5 ± 2.1	35.4 ± 3.7	15.9	< 0.001*

Significant after Bonferroni correction (adjusted p < 0.001). Lower scores indicate better function

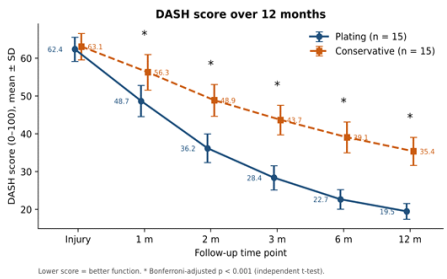


Figure 4. Mean DASH score (± SD) at each follow-up visit. Disability fell faster and further after plate fixation. *Bonferroni-adjusted p < 0.001.

Effect sizes and adjustment for multiple comparisons

Mean differences with 95% CIs, effect sizes and Bonferroni-adjusted p-values for all CMS and DASH comparisons are shown in Table 4 and Figure 5. From 1 month onwards, effect sizes were large for both scores (Hedges' g 1.79–3.48 for CMS; −1.68 to −5.14 for DASH).

Table 4. Mean differences, effect sizes and Bonferroni-adjusted p-values for CMS and DASH

Score	Time point	Mean difference, plating − conservative (95% CI)	Hedges' g	Unadjusted p	Adjusted p
CMS	At injury	1.9 (0.2 to 3.6)	0.83	0.026	0.159
CMS	1 month	15.7 (12.4 to 18.9)	3.48	< 0.001	< 0.001
CMS	2 months	15.1 (11.7 to 18.5)	3.25	< 0.001	< 0.001
CMS	3 months	8.8 (5.2 to 12.4)	1.79	< 0.001	< 0.001
CMS	6 months	12.9 (8.8 to 17.0)	2.29	< 0.001	< 0.001
CMS	12 months	13.2 (9.5 to 16.9)	2.61	< 0.001	< 0.001
DASH	At injury	−0.7 (−3.2 to 1.8)	−0.20	0.572	1.000
DASH	1 month	−7.6 (−10.9 to −4.3)	−1.68	< 0.001	< 0.001
DASH	2 months	−12.7 (−15.7 to −9.7)	−3.09	< 0.001	< 0.001
DASH	3 months	−15.3 (−18.0 to −12.6)	−4.17	< 0.001	< 0.001
DASH	6 months	−16.4 (−19.0 to −13.8)	−4.65	< 0.001	< 0.001
DASH	12 months	−15.9 (−18.2 to −13.6)	−5.14	< 0.001	< 0.001

Positive CMS and negative DASH differences favour plating. Bonferroni adjustment for six time points per score.

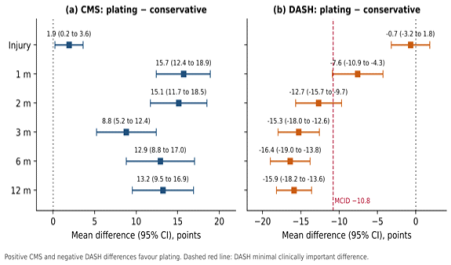


Figure 5. Forest plot of between-group mean differences (95% CI) in (a) Constant-Murley Score and (b) DASH score at each time point. The dotted line marks no difference; the dashed red line marks the DASH minimal clinically important difference (−10.8 points).

Complications

Fourteen of 15 plated patients (93.33%) had no complication; one (6.67%) had delayed union. In the conservative group, 8 patients (53.33%) had no complication, 3 (20.0%) developed shoulder stiffness, 2 (13.3%) had delayed union and 2 (13.3%) progressed to nonunion (Table 5; Figure 6). The overall complication rate was significantly lower after plating (1/15 vs 7/15; risk difference −40.0%, 95% CI −63.9% to −8.2%; Fisher's exact p = 0.035). Individually, differences in nonunion (0 vs 2; p = 0.48), shoulder stiffness (0 vs 3; p = 0.22) and delayed union (1 vs 2; p = 1.00) were not statistically significant (Table 7). There were no infections, implant failures or neurovascular injuries, and no implant removal was required within 12 months.

Table 5. Complications in the two treatment groups

Complication	Plating, n (%)	Conservative, n (%)	Total, n (%)
No complication	14 (93.33)	8 (53.33)	22 (73.3)
Shoulder stiffness	0 (0)	3 (20.0)	3 (10.0)
Delayed union	1 (6.67)	2 (13.3)	3 (10.0)
Nonunion	0 (0)	2 (13.3)	2 (6.7)
Total	15 (100)	15 (100)	30 (100)

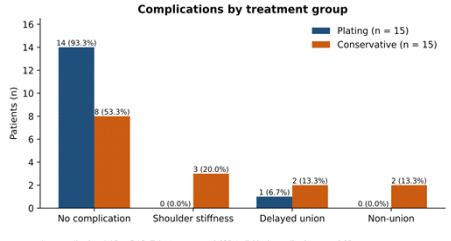


Figure 6. Distribution of complications by treatment group. Bar labels give number and percentage within each group.

Time to fracture union

In the plating group, 10 patients (66.7%) united within 12 weeks, 4 (26.7%) between 12 and 18 weeks and 1 (6.7%) after 18 weeks, with no nonunion. In the conservative group, 7 (46.67%) united within 12 weeks, 4 (26.67%) between 12 and 18 weeks, 2 (13.33%) after 18 weeks, and 2 (13.33%) went on to nonunion (Table 6; Figure 7). Although union was numerically faster after plating, the difference was not statistically significant (p = 0.41). Union within 12 weeks also did not differ significantly (10/15 vs 7/15; risk difference 20.0%, 95% CI −14.1% to 48.4%; Fisher's exact p = 0.46). The present data therefore do not demonstrate faster union with plate fixation.

Table 6. Time to radiological union by treatment group

Time to union	Plating, n (%)	Conservative, n (%)	p-value
< 12 weeks	10 (66.7)	7 (46.67)	0.41
12–18 weeks	4 (26.7)	4 (26.67)	
> 18 weeks (delayed union)	1 (6.7)	2 (13.33)	
Nonunion	0 (0)	2 (13.33)	
Total	15 (100)	15 (100)	

Chi-square test across the four categories.

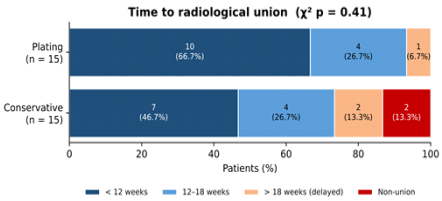


Figure vn as a percentage of patients. Labels give number and percentage.

Table 7. Complications and union: proportions with 95% CI and risk differences

Study	Design / sample	Key functional finding	Union / complications
COTS, 200710	Multicentre RCT; 132 patients	Higher Constant and lower DASH scores after plating	Fewer nonunions and symptomatic malunions after plating; faster union
Zlowodzki et al., 200520	Systematic review; 2144 fractures	—	Nonunion 15.1% after non-operative treatment of displaced fractures
van der Ven et al., 201518	Comparative cohort; mean 5-year follow-up	Constant score 90 (operative) vs 78 (conservative)	—
Daniilidis et al., 201319	Comparative series; 151 cases	Constant score 91.7 (operative) vs 88.1 (conservative)	—
Woltz et al., 201712	Meta-analysis of RCTs	Early functional benefit with plating; long-term differences modest	Lower nonunion after plating; implant-related reoperations
Present study	Ambispective, non-randomised; 30 patients	CMS 89.4 vs 76.2; DASH 19.5 vs 35.4 at 12 months	Complications 6.7% vs 46.7%; nonunion 0% vs 13.3%

Wilson 95% CIs for proportions; Newcombe 95% CIs for risk differences (plating − conservative).

DISCUSSION

This single-centre, non-randomised ambispective study of 30 patients with displaced middle third clavicle fractures found that plate fixation was associated with significantly better functional recovery and fewer overall complications than conservative management. Union was numerically faster after plating, but this difference was not statistically

significant. These findings are consistent with the growing evidence supporting operative treatment in selected patients with displaced midshaft fractures; given the non-randomised design, however, they should be interpreted as associations rather than proof of causation.

Demographic profile

The demographic distribution in our study is comparable with the existing literature. Male predominance (80%) matches the series of Laishram et al. (86% male)[14] and the epidemiological data of Postacchini et al., who attributed male preponderance to greater participation in high-energy activities.[4] Road traffic accidents were the commonest mechanism (63.33%), reflecting the high burden of road traffic injury in India, whereas sport is a more frequent cause in Western series.[5] The mean ages in both groups (32.13 and 36.93 years) fall within the young working-age peak described for this injury.[3,4]

The plating group was older on average, although not significantly so. Because advancing age is an established risk factor for impaired healing and nonunion after clavicle fracture,[3,6] any residual age imbalance would be expected to bias results against, rather than in favour of, plating. With 30 patients, however, formal adjustment for age and other baseline differences was not feasible.

Functional outcome

Constant-Murley scores were significantly higher in the plating group from 1 month onwards and at every subsequent visit. This is consistent with randomised trials and comparative series. The COTS trial reported superior Constant and DASH scores after operative treatment,[10] van der Ven et al. reported mean Constant scores of 90 (operative) versus 78 (conservative) at a mean follow-up of 5 years,[18] and Daniilidis et al. found mean scores of 91.7 versus 88.1.[19] Naveen et al. also documented significantly better Constant scores in operatively treated patients in an Indian cohort.[15] Our 12-month CMS of 89.40 after plating versus 76.20 after conservative treatment is in keeping with these findings (Table 8). The between-group differences from 1 month onwards corresponded to large effect sizes and remained significant after correction for multiple comparisons.

Both groups showed a small dip in mean CMS between 1 and 2 months before rising again. This most likely reflects the transition from immobilisation to active mobilisation and loading, when pain and stiffness may transiently limit the range-of-motion and strength components of the score.

DASH findings reinforce the functional advantage of surgery. The 15.9-point difference at 12 months (95% CI 13.6 to 18.2) exceeds the DASH MCID of approximately 10.8 points;[17] as even the lower limit of the confidence interval exceeds this threshold, the difference is clinically as well as statistically meaningful. The early divergence of the curves (Figures 3 and 4) suggests that the main benefit of fixation is faster return of function, which is particularly relevant for manual workers and self-employed patients for whom prolonged disability carries economic cost.

Union and complications

The overall complication rate after conservative treatment (46.67%, including nonunion in 13.3%) is consistent with published data. A systematic review by Zlowodzki et al. reported a nonunion rate of 15.1% for displaced midshaft fractures treated non-operatively,[20] and Robinson et al. showed that the risk rises with displacement, comminution and advancing age.[3] All fractures in our conservative group were completely displaced, which explains the relatively high nonunion rate. No nonunion occurred after plating, consistent with published nonunion rates of 0–2.8% after plate fixation.[20,21]

With only 15 patients per group, however, the absence of nonunion after plating versus two nonunions after conservative treatment was not statistically significant ($p = 0.48$), and the wide confidence intervals (0–20.4% vs 3.7–37.9%) are compatible with both small and large true differences. Known risk factors for nonunion after non-operative treatment, such as smoking, comminution and complete displacement,[6] were not balanced by design and could not be adjusted for.

Union within 12 weeks was more frequent after plating (66.7% vs 46.67%), but this did not reach significance ($p = 0.41$), probably because of the limited sample size. Singh et al. and Vander Have et al. also reported faster union after operative management.[16,22] Our data do not confirm faster union with plating, and this observation should be regarded as hypothesis-generating only.

Surgical complications were minimal. One plated patient (6.67%) had delayed union, and there were no infections, implant failures or neurovascular injuries, in line with the findings of Micheloni et al.[23] No implant removal was required within 12 months. Plate-related problems, including hardware prominence and irritation, supraclavicular numbness, infection, implant removal and refracture after removal, nonetheless remain the principal disadvantages of fixation, and reported implant removal rates vary widely.[12,24] Many of these problems, particularly elective implant removal and refracture, occur after the first year; our 12-month follow-up is therefore insufficient to capture them, and the complication burden of plating is likely underestimated.

Comparison with published studies

Table 8 summarises our principal results alongside representative published studies.

Table 8. Comparison of the present study with published studies

Outcome	Plating, n (%) [95% CI]	Conservative, n (%) [95% CI]	Risk difference, % (95% CI)	Fisher's exact p
Any complication	1 (6.7) [1.2–29.8]	7 (46.7) [24.8–69.9]	−40.0 (−63.9 to −8.2)	0.035
Nonunion	0 (0.0) [0.0–20.4]	2 (13.3) [3.7–37.9]	−13.3 (−37.9 to 9.2)	0.483
Delayed union	1 (6.7) [1.2–29.8]	2 (13.3) [3.7–37.9]	−6.7 (−31.8 to 18.4)	1.000
Shoulder stiffness	0 (0.0) [0.0–20.4]	3 (20.0) [7.0–45.2]	−20.0 (−45.2 to 4.2)	0.224
Union < 12 weeks	10 (66.7) [41.7–84.8]	7 (46.7) [24.8–69.9]	20.0 (−14.1 to 48.4)	0.462

RCT, randomised controlled trial; CMS, Constant-Murley Score; DASH, Disabilities of the Arm, Shoulder and Hand.

Advantages and disadvantages of each approach

Plate fixation offers anatomical restoration of length and alignment, stable fixation that allows early mobilisation, faster functional recovery and a lower risk of nonunion and symptomatic malunion. Its disadvantages are the risks of anaesthesia and surgery, wound infection, a visible scar, supraclavicular numbness, hardware prominence and the possible need for a second operation for implant removal.

Conservative treatment avoids surgical risks and implant-related problems and is inexpensive. Its disadvantages are a longer period of discomfort and disability, brace-related problems, a higher risk of nonunion, symptomatic malunion with shortening, and shoulder stiffness, as seen in 20% of our conservative group.

Limitations

- **Small sample:** 15 patients per group with no a priori power calculation; the study was underpowered for union and complication outcomes. Approximately 60 patients per group would be needed to detect a reduction in nonunion from 15% to 1% with 80% power at a two-sided α of 0.05.
- **Ambispective design:** combining retrospective and prospective data may introduce inconsistencies in documentation despite a common case record form and identical definitions.
- **Non-random allocation:** selection bias related to surgeon or patient preference, fracture characteristics or socioeconomic factors cannot be excluded.
- **Single centre:** generalisability to other hospitals and populations is limited.
- **Unmeasured confounders:** shortening, wedge fragments, smoking, diabetes, nutrition, occupation and activity level were not recorded in enough detail for comparison or multivariable analysis.
- **Analytical approach:** scores were compared at individual time points with Bonferroni correction rather than with a repeated-measures or mixed-effects model.
- **Unblinded assessment:** radiological union could not be assessed blind to treatment.

- **Unrecorded variables:** rehabilitation adherence, brace compliance, return to work, plate-specific symptoms and cosmetic satisfaction were not quantified.

- **Follow-up:** 12 months is insufficient to capture late plate-related complications, implant removal and refracture.

CONCLUSION

In this small, non-randomised ambispective study of skeletally mature adults with displaced middle third clavicle fractures, plate fixation was associated with significantly better functional outcomes, measured by the Constant-Murley and DASH scores, and fewer overall complications than conservative treatment with a figure-of-eight brace. The numerically faster union and lower nonunion rate after plating were not statistically significant.

These findings support selective operative fixation, particularly for fit, active patients with completely displaced or shortened fractures who prioritise early functional recovery, following shared decision-making. Routine fixation of all displaced midshaft fractures is not supported, because many patients achieve satisfactory results without surgery. Conservative treatment remains appropriate for patients with lower functional demands, those unfit for surgery and those who prefer to avoid operative risks. Adequately powered randomised trials with longer follow-up are required to confirm these results.

Clinical Message

Displaced middle third clavicle fractures in active adults may be considered for open reduction and internal fixation with pre-contoured plates, which in this study was associated with better functional recovery and fewer overall complications than conservative treatment. Because faster union was not statistically confirmed and many patients heal satisfactorily without surgery, treatment should be individualised through shared decision-making, balancing functional demands and fracture characteristics against plate-related risks.

Declarations

Ethics approval: Institutional Ethics Committee, IEC No. MUHS/Medical/MUHS-053782/2019, approved 07/02/2024.

Consent: Written informed consent was obtained from all patients before data collection and treatment. Consent for publication of anonymised data was obtained in accordance with institutional ethics guidelines.

Competing interests: The authors declare that they have no competing interests.

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Author contributions: NPD: conception, data collection, literature review, analysis and drafting. PB: supervision, surgical procedures and critical revision. All authors read and approved the final manuscript, its title and the order of authorship: Dr Nikhil Pramod Duthade (first and corresponding author) and Dr Prashant Bhandari (second author).

Data availability: Data are available from the corresponding author on reasonable request.

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List of Abbreviations

AP, anteroposterior; CI, confidence interval; CMS, Constant-Murley Score; COTS, Canadian Orthopaedic Trauma Society; DASH, Disabilities of the Arm, Shoulder and Hand; IEC, Institutional Ethics Committee; MCID, minimal clinically important difference; ORIF, open reduction and internal fixation; RCT, randomised controlled trial; RTA, road traffic accident; SD, standard deviation; SPSS, Statistical Package for the Social Sciences; STROBE, Strengthening the Reporting of Observational Studies in Epidemiology.

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