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Corresponding Author
Takkallapalli Dushyanth Rao, Department of Orthopaedics, Mamata Medical College, Khammam, Telangana India
dush.neo93@gmail.com

Author Designation
[1]Senior Resident
[2,3,4]Assistant Professor,

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Prospective Study on the Surgical Management of Clavicle Fractures With Pre-Contoured Locking Compression Plate

[1]Rajesh Kolipaka, [2]G. Raviteja, [3]Cheekati Lalki Sai Kumar and [4]Takkallapalli Dushyanth Rao

[1,3,4]Department of Orthopaedics, Mamata Medical College, Khammam, Telangana India
[2]Department of Orthopaedics, Mahavir Institute of Medical Sciences, Vikarabad, Telangana India

Abstract
Clavicle fractures, particularly mid-shaft fractures, are common, especially in young, active men. Mid-shaft fractures account for 80% of all clavicle fractures. Recent literature indicates a 2% non-union rate with surgical treatment versus 15% with non-operative treatment. This study evaluates the efficacy of pre-contoured locking compression plates for treating middle third clavicle fractures. From October 2020 to September 2022, 20 patients with middle third clavicle fractures were treated with pre-contoured locking compression plates at Mamata Medical College and General Hospital, Khammam. Inclusion criteria were patients over 18 years with closed, displaced mid-shaft fractures (Robinson 2B1 and 2B2). Exclusion criteria included patients under 18 years, open fractures, fractures in other parts of the clavicle associated injuries. Of the 20 patients, 18 achieved union within 10-12 weeks, while 2 had delayed union, achieving it at 16 and 20 weeks. Complications included one case of implant prominence, one malunion with screw pullout one case of shoulder stiffness. Functional outcomes were excellent in 17 cases and good in 3 cases, based on the Constant Score. Pre-contoured locking compression plates provide effective and stable fixation for mid-shaft clavicle fractures, resulting in high patient compliance, early return to function minimal complications.

INTRODUCTION

The proper handling of dislocated mid-shaft clavicle fractures has been recognized since ancient times. The Edwin Smith Papyrus (circa 1600 BC) describes the treatment for a dislocated collarbone. If you treat a man for a dislocation in his collarbone, whose shoulders are found drooping while the head of his collarbone is facing toward his face, then you say about him: One who has a dislocation in his collarbone, an ailment I will handle. The ancient Egyptians treated clavicle fractures using bandages with stiff rolls of cloth, oil and honey. Despite this early knowledge, contemporary studies on clavicle fracture treatments have significant weaknesses due to their low quality and poor evidence, primarily consisting of retrospective case series reporting various treatment methods[1]. The main issue remains unclear: identifying which types of injuries require surgical intervention.

When viewed in the coronal plane, the clavicle is a slender bone that is wider at its medial sternal articulation and noticeably thinner at its lateral third. Axially, its three-dimensional structure reveals a gentle S-shape, with the medial end convex forward and the lateral end concave forward. This shape is likened to the musical symbol clavicula, from which it derives its name[2]. The clavicle acts as a bony link between the thorax and the shoulder girdle, contributing to shoulder movements. Due to its subcutaneous position, the clavicle is prone to fractures, either from high or low energy impacts[3]. Clavicle fractures account for 2.6% of all fractures and 44% of those involving the shoulder girdle. They represent approximately 2-5% of all fractures in adults and 10-15% in children. Middle third fractures are the most common, seen in 69.2% of patients, followed by lateral-end fractures in 28% medial-end fractures in 2.8% of patients[4].

Older studies suggested that even significantly displaced shaft fractures of the clavicle generally have a good prognosis when treated non-operatively. However, good outcomes are not universal for non-surgically treated fractures[5]. Plate fixation options, such as low-contact dynamic compression plates, are strong but can cause soft tissue irritation and are difficult to contour. Anatomically pre-contoured implants offer advantages such as not requiring further bending, having a lower profile, causing fewer soft tissue problems retaining mechanical strength[6]. The aim of the present study was to conduct a prospective analysis of the surgical management of clavicle fractures using pre-contoured locking compression plates and to evaluate the efficacy of this new fixation method through serial postoperative follow-ups.

MATERIALS AND METHODS

The present study was conducted from October 2020-September 2022 in the Department of Orthopaedic Surgery and Traumatology at Mamtha Medical College and General Hospital in Khammam. During this period, 20 patients with clavicular fractures were surgically managed using pre-contoured locking compression plates.

Inclusion and Exclusion Criteria: Inclusion criteria included patients over 18 years of age with closed fractures, specifically Robinson classification 2B1 and 2B2 (displaced mid-shaft fractures) no medical contraindications to anesthesia. Exclusion criteria included patients under 18 years of age, open fractures, fractures in the medial and lateral third of the clavicle, pathological fractures, undisplaced fractures, associated head injury, neurovascular injury, established nonunion from previously treated fractures associated AC joint dislocation.

Patient Assessment: General information and detailed histories were recorded, noting the mode of injury, site of pain swelling. Past medical history and family history were also documented. Local examinations included inspection for deformities, bruises, swelling condition of the skin, as well as evaluation of the position of the shoulders and shoulder blades. Palpation was used to identify anatomical abnormalities and tenderness clavicular stability was tested both vertically and horizontally. Sensation, upper-limb function, pulse range of motion were assessed. Plain radiographs of the clavicle with the shoulder in anteroposterior view were taken to assess the site and type of fracture, classified according to Robinson's classification. The affected upper limb was immobilized in an arm pouch.

Preoperative Preparation: General investigations, including blood tests (Hb%, total count, differential count, ESR, blood urea, sugar, serum creatinine), ECG, HBsAg HIV tests, were performed. Patients were kept nil per orally for six hours before surgery written informed consent was obtained. The neck, chest, axilla, shoulders arm were thoroughly prepared. A systemic antibiotic (ceftriaxone 1gm intravenously) was administered half an hour before surgery. All patients underwent surgery under general anesthesia.

Surgical Procedure: Under general anesthesia, patients were placed in a supine position with a sponge pad under the affected shoulder. An incision was made along the superior border of the clavicle the fracture site was exposed and carefully dissected. In two cases, the supraclavicular nerve was encountered and

retracted to prevent injury. After reducing the fracture with bone clamps, an appropriate-sized (commonly 6, 7, or 8-holed) 3.5mm pre-contoured locking compression plate was fixed over the superior surface of the clavicle with plate-holding forceps and drill sleeves. A 2.7mm drill bit was used to drill pilot holes 3.5mm self-tapping locking screws were fixed to the plate on either side of the fracture. In cases of oblique fractures, an interfragmentary screw was used. The wound was closed in layers, sterile dressing applied the limb supported in an arm sling.

Postoperative Protocol: Postoperatively, all patients were immobilized in an arm pouch. Wounds were dressed on the 2nd, 5th 10th postoperative days, when sutures or staples were removed. Rehabilitation, including shoulder exercises, began two weeks postoperatively.

Evaluation and Scoring: Patients were evaluated using the Constant and Murley scoring system, which includes subjective assessments of pain and daily living activities objective measurements of range of motion, functional movements strength of abduction. The total score out of 100 points classified the results as Excellent (90-100), Good (80-89), Fair (70-79), or Poor (below 70).

Statistical Analysis: Statistical analysis was carried out using SPSS software (version 25.0). Descriptive statistics were used to summarize the demographic and clinical characteristics of the study population. A p-value of less than 0.05 was considered statistically significant.

RESULTS AND DISCUSSIONS

The present study consists of 20 patients of fresh displaced mid-shaft clavicle fractures which were treated with pre-contoured locking compression plate between October 2020-September 2022. Among them 20 patients were treated at Department of orthopedic surgery and traumatology, Mamtha Medical College and General hospital at Khammam. All the patients were followed at regular intervals. Results were analyzed both clinically and radiologically. Outcome was measured by Constant and Murley Score.

The (table 1) presents a comprehensive overview of the demographic and clinical characteristics of 20 patients who were treated for middle third clavicle fractures using pre-contoured locking compression plates. All fractures were located in the middle third of the clavicle, with no cases involving the lateral or medial thirds. The age distribution of the patients varied, with the majority falling within the 30-39 year age group (30%) the overall average age being 38.2 years. The youngest patient was 18 years old, while the oldest was 65 years old.

In terms of gender, a significant majority of the patients did male (70%), with females constitute 30% of the cases. The most common cause of injury was road traffic accidents, accounting for 60% of the cases, followed by falls directly on the shoulder (30%) and falls on an outstretched hand (10%). The right clavicle was more frequently affected than the left, with 80% of the fractures occurring on the right side and 20% on the left. This data highlights the predominant demographic factors and injury mechanisms associated with middle third clavicle fractures in this patient cohort.

The majority of the middle third fractures were comminuted (Robinson 2B2), accounting for 65% of the cases (13 out of 20). Non-comminuted fractures (Robinson 2B1) were seen in 35% of the cases (7 out of 20). For Robinson 2B1 fractures, 6-holed plates were used in 4 cases (57.14%) 7-holed plates in 3 cases (42.85%). None of the Robinson 2B1 fractures required 8-holed plates. For Robinson 2B2 fractures, 6-holed plates were used in 9 cases (69.23%), 7-holed plates in 2 cases (15.38%) 8-holed plates in 2 cases (15.38%).

The (table 3) presents an overview of the clinical outcomes and complications in 20 patients treated for middle third clavicle fractures using pre-contoured locking compression plates. Most patients (90%)

Fig. 1: Demonstration of External Rotation Movements Post Clavicle Fracture Surgery

Table1: Demographic and Clinical Characteristics of Patients with Middle Third Clavicle Fractures

Characteristic	Number of Cases	Percentage (%)
Site of Clavicle Fracture		
Middle Third	20	100
Lateral Third	0	0
Medial Third	0	0
Age Incidence (Years)		
18-29	4	20
30-39	6	30
40-49	5	25
50-59	4	20
60-69	1	5
Sex Incidence		
Male	14	70
Female	6	30
Mode of Injury		
Road Traffic Accident	12	60
Fall on Shoulder	6	30
Fall on Outstretched Hand	2	10
Side Affected		
Right	16	80
Left	4	20

Table 2: Classification and Plate Usage in Middle Third Clavicle Fractures

Characteristic	Number of Cases	Percentage (%)
Type of Fracture		
Robinson 2B1	7	35
Robinson 2B2	13	65
Fracture Type and Plate Used	**6 Holes**	**7 Holes**
Robinson 2B1	4 (57.14%)	3 (42.85)
Robinson 2B2	9 (69.23%)	2 (15.38)

Table 3: Clinical Outcomes and Complications in Middle Third Clavicle Fractures

Characteristic	Number of Cases	Percentage (%)
Duration of Union		
10-12 weeks	18	90
>12 weeks	2	10
Complications		
Superficial infection	0	0
Hypertrophic scar	0	0
Plate prominence	1	5
Delayed union	2	10
Screw pullout	1	5
Malunion	1	5
Implant failure	0	0
Non-union	0	0
Shoulder stiffness	1	5
Functional Outcome		
Excellent (90-100)	17	85
Good (80-89)	3	15
Fair (70-79)	0	0
Poor (0-70)	0	0

achieved bone union within 10-12 weeks, with an average union time of 11.7 weeks. Two patients experienced delayed union due to comminution, achieving union at 16 and 20 weeks postoperatively. Complications were minimal, with no cases of superficial infection, hypertrophic scar, implant failure, or non-union. There was one case each of plate prominence, screw pullout, malunion shoulder stiffness, each representing 5% of the cases. An 18-year-old female with plate prominence underwent implant removal for cosmetic reasons, resulting in good functional recovery. A 40-year-old male with screw pullout experienced malunion but maintained a good range of motion and excellent functional outcome. Two patients had delayed union due to severely comminuted fractures but eventually achieved union. A 50-year-old female with shoulder stiffness improved with physiotherapy.

Functional outcomes were highly positive, with 85% of patients achieving excellent scores (90-100) and 15% achieving good scores (80-89). No patients had fair or poor functional outcomes, indicating the effectiveness of the surgical intervention.

Previous literature from the 1960s, notably by Neer and Rowe, reported a very low incidence of non-union in clavicle fractures treated conservatively. However, more recent meta-analyses, such as the one by Zlowodzki *et al.,* have shown a 4% non-union rate overall[7]. Specifically, non-operative treatment resulted in a 6% non-union rate for all fractures and 15% for displaced fractures. Factors associated with non-union included fracture displacement, fracture comminution, female gender aging. Plating has been found to be more effective in achieving fracture

consolidation compared to non-operative treatment. Irritation from prominent metalwork has been a significant issue with dynamic compression plating, often necessitating plate removal. However, in this study, routine plate removal was not necessary as the low-profile pre-contoured locking compression plates caused minimal irritation. These plates provide more rigid fixation, better angular stability are suitable for elderly patients.

Our study is consistent with findings from Babu *et al.,* who studied 20 cases of mid-third clavicle fractures treated with pre-contoured locking compression plates[8] Daniel Gheorghiu *et al.,* who treated 29 cases with anatomically congruent locking compression plates[9].

In our study, most patients were in the 30-39 age groups, with an average age of 38.2 years. This aligns with Daniel Gheorghiu et al. (mean age 41.5 years) and Babu *et al.,* (mean age 32.1 years). These present observations are in accordance with earlier studies which reported similar age distributions[10,11]. In our study, 70% of the patients were male and 30% were female. This is comparable to Babu B. Hundekar's study (80% male, 20% female) and Panse *et al.* (90% male, 10% female).

Direct injury was the most common mode of injury, with road traffic accidents accounting for 60% and falls on the shoulder for 30%. This is consistent with Nayak A.J[12] Bostman[13] and studies by Maheshwari[14] also reported high incidences of injuries due to road traffic accidents and falls.

In our study, 80% of fractures occurred on the right side and 20% on the left. This distribution is similar to Babu Hundekar (55% right, 45% left) and Jain R.K (55% right, 45% left).

The average time from trauma to surgery in our study was 2.9 days, which is similar to Babu B. Hundekar (3 days) and shorter than Gheorghiu *et al.* showed 7.8 days[15].

Our study showed a mean union time of 11.7 weeks, with most patients achieving union between 10-12 weeks. This is in line with Gheorghiu *et al.* (12.8 weeks), BaHundekar (13 weeks), Jain R.K (12 weeks), Nayak A.J (12 weeks) Panse *et al.* (12 weeks).

One 18-year-old female developed implant prominence and underwent implant removal due to cosmetic reasons. Two cases of delayed union occurred due to severely comminuted fractures, with union achieved at 16 and 20 weeks. A 40-year-old male experienced screw pullout, resulting in malunion but maintained good functional outcomes. A 50-year-old female developed shoulder stiffness, which resolved with physiotherapy.

Comparatively, Daniel Gheorghiu *et al.* reported similar issues with plate prominence and mild hypersensitivity. Babu B. Hundekar reported dysesthesia, periarthritis brachial plexopathy, but no hardware issues.

In our study, 85% of patients achieved excellent functional scores 15% achieved good scores. This is comparable to Babu B. Hundekar's study, where 95% had excellent outcomes and 5% had good outcomes. Daniel Gheorghiu *et al.* reported a mean DASH score of 13.4, ASES score of 82.1 VAS score of 1.7, with all patients regaining full range of motion.

CONCLUSION

In conclusion, Mid-shaft clavicle fractures, commonly caused by road traffic accidents, are prevalent in younger age groups. While older studies showed good outcomes with conservative treatment, recent meta-analyses and our study indicate that surgical treatment with pre-contoured locking compression plates provides better stability, fewer complications excellent functional outcomes. Despite the small sample size and lack of a control group, our findings support the use of pre-contoured locking compression plates as a safe and effective treatment option for displaced mid-shaft clavicle fractures.

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