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Original Article

Open reduction and plating for displaced mid third clavicle fractures – A prospective study

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ARTICLE INFO

Article history:

Received 26 August 2013

Accepted 3 September 2013

Available online 27 September 2013

Keywords:

Clavicle fracture

Middle third displaced

Open reduction

Locking plate

ABSTRACT

Introduction: Displaced middle third clavicle fractures were treated conservatively with figure of '8' harness in the past. Current management trend in treating displaced clavicle fractures with internal fixation provide rigid immobilization and pain relief avoiding non-union, shortening and deformity. This study prospectively evaluates the functional outcome of 25 patients with clavicle fractures treated surgically.

Materials and methods: 25 patients with displaced mid third clavicle fractures were included in the study. Open reduction and internal fixation with clavicular locking plate placed superiorly was done. Patients were followed up on 3, 6, 8, and 12 weeks. Functional outcome was assessed using DASH scores and Simple Shoulder Test (SST). Statistical analysis was done using One-way ANOVA.

Results: Out of the 26 clavicles operated (one patient had bilateral fracture), 6 were comminuted (23%) and the rest were 2 part displaced fractures. Interfragmentary screws were used in 3 cases with butterfly fragment. All fractures united (mean = 6.8 weeks). The DASH scores reduced to a significant negligible level by 8 weeks in all but 4 cases with comminution where it took longer than 8 weeks to reach negligible levels. The SST showed significant improvement in all cases by 8 weeks after surgery. All patients were satisfied with the outcome. 84% of patients returned to their work by 6 weeks.

Conclusion: Primary plating of displaced mid third clavicle fractures with superiorly placed locking plate avoids complications of non-operative management and leads to early return to pre injury activities.

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1. Introduction

For years, displaced mid shaft clavicle fractures were treated conservatively with figure of '8' harnesses and sling. In 1960,

Neer reported a non-union rate just 0.1% with non-operative treatment and discouraged operative fixation as it resulted in non union and infection.^{1,2} However, these earlier attempts at operative intervention were complicated by utilization of

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<http://dx.doi.org/10.1016/j.jcot.2013.09.002>

smooth pins with cataclysmic results from pin migration, infection and non-union.³ Recent randomised control studies show that the outcome of non-operatively treated mid shaft fractures is not as good as was once thought.^{4–6} Contemporary management of these fractures by open reduction and internal fixation avoids non-union, symptomatic malunion, shortening and deformity. Intra medullary fixation of clavicle though cosmetically acceptable is fraught with a complication rate as high as 75%.⁷ Plating provides immediate rigid immobilization, pain relief and early return to pre injury activities.^{4,8,9} This study prospectively evaluates the functional outcome of 25 patients with displaced mid shaft clavicle fractures treated by open reduction and plating.

2. Patients and methods

25 patients with clavicle fractures between June 2010 and July 2012, satisfying the inclusion criteria were included in the study. The inclusion criteria were: closed displaced (≥ 2 cm) mid third clavicle fracture within a week of trauma, fractures tenting the skin (impending open fracture), and comminuted fractures. Patients with open fractures, pathological fractures, skin abrasions over the fracture segment, fractures more than a week's duration were excluded from the study.

All patients were evaluated in the casualty with antero-posterior radiograph of the involved shoulder, after a thorough clinical examination (Fig. 1). We did a routine chest X ray to rule out associated rib and scapula fractures. Arm sling was applied and patients were worked up for surgery. Patients were explained the options of treatment including the non-operative management. All patients opted for surgical fixation. Informed consent was obtained from patients participating in the study. The terms of the Helsinki Agreement were strictly adhered to in the present study. All patients were operated within 3 days of admission.

2.1. Surgical technique

All 25 patients were operated under general anaesthesia. Surgery was performed with the patient in beach chair position with a bolster in the interscapular area. The affected extremity was

draped free for mobilization. Perioperative antibiotic prophylaxis was given with cefaperazone + sulbactam at the time of induction. A longitudinal skin incision was made along the axis of clavicle superiorly. The fracture was exposed after meticulous soft tissue dissection and minimal periosteal stripping. The subcutaneous tissue and the platysma muscle were taken as a single unit. Larger branches of supraclavicular nerve if encountered were preserved. The myofascial layer over the clavicle was elevated as a single flap. Reduction stabilized with 3.5 mm clavicular locking compression plate placed superiorly (Figs. 2 and 3). Length of the plate was determined by the fracture pattern with atleast 4 cortical purchases on either side of the fracture. Lag screw was used when necessary. Comminuted fractures were reduced and held with cerclage wires. Primary bone grafting was not found to be necessary in our cases. Incision was closed in layers. The myofascial flap and the subcutaneous tissue with platysma muscle were closed meticulously to cover the implant precluding implant prominence post-operatively. Subcuticular layer was secured with monocryl. The limb was supported in a pouch arm sling post-operatively.

2.2. Post operative protocol

Patients were started on shoulder pendulum exercises on day 1. Antibiotic prophylaxis was continued for 2 days post-operatively and stopped. Wound was inspected on day 4. Patients were discharged on day 4 with the advice of pendulum exercises and to continue arm sling. Review was done on the 3rd post-operative week and patients were examined clinically for fracture tenderness. Arm sling was discontinued and gentle shoulder range of motion exercises started (Fig. 4). Radiographs were ordered on the 6th post-operative week to assess fracture union and in the event of union, shoulder strengthening exercises begun. Subsequent follow up was done at 8 weeks and 3 months to determine the trabecular bridging at the fracture site. Contact sports were allowed at 3 months post-operatively.

2.3. Functional assessment and statistical analysis

Functional outcome was assessed using Quick Disability of the Arm Shoulder and Hand (DASH) scores and the Simple

Fig. 1 – Comminuted fracture of the right clavicle with a butterfly fragment.

Fig. 2 – Clavicle fracture fixed with interfragmentary screw and superiorly placed locking plate.

Fig. 3 – Intra operative picture showing clavicle fracture fixed with locking plate. The soft tissues around the clavicle are taken as a single unit and closed in layers precluding implant prominence.

Shoulder Test (SST). Statistical analysis was done using the One-way ANOVA test.

3. Results

Out of 25 patients operated for clavicle fractures, 20 were men (80%) and 5 women (20%), the mean age being 32.5 years (range 20–45 years). The right clavicle was fractured in 18 cases (72%) and the left in 6 cases (24%). One patient had bilateral clavicle fracture. 6 cases were comminuted (23%) and the rest were 2 part displaced fractures (77%). 2 patients had associated rib fractures, 1 patient had metacarpal fracture and 1 had a displaced distal radius fracture on the same side as the clavicle fracture.

No patient had any neurovascular impairment or pulmonary injury due to the operative procedure. All cases were fixed with superiorly placed clavicular locking plates.

Fig. 4 – Full active abduction of left shoulder at 3 weeks post-operative.

Interfragmentary screws were used in 3 cases with butterfly fragment (Fig. 2). Stainless steel wires were used in 4 cases with extensive comminution. None of the cases had post-operative infection. The average blood loss was <200 ml and the mean duration of surgery was 72.44 min. Patients were followed up at 3, 6, 8 and 12 weeks with clinical examination, assessment of DASH score, Simple Shoulder questionnaire and radiographs (Table 1). All fractures united. The mean time to radiographic union was 6.8 weeks. Implant removal was not scheduled in any case. The patient with bilateral fracture had his left side plate bent with hardware prominence, but he deferred removal (Fig. 5).

DASH score was assessed at 3, 6, 8, and 12 weeks. The mean DASH score at 3 weeks was 13.37 (range 2.5–50.83). Fractures with comminution and patients with associated injuries had higher scores at 3 weeks. The mean DASH score at 6 weeks was 7.02 (range 3.25–31.5). 21 cases had their scores dropped to 3.25 from their scores at 3 weeks. 4 cases who showed scores >3.25, nevertheless lower than their corresponding scores at 3 weeks. DASH score dropped to a mean 1.85 at 8 weeks (range 0–13.33) and 0 in all patients at 12 weeks (Table 2a). 21 patients gave a positive response of 8/12 at 3 weeks as assessed by the Simple Shoulder Test. 23 patients gave positive response of 12/12 at 8 weeks and all 25 patients gave a positive response of 12/12 by 12 weeks (Table 2b).

Except 2 patients, rest were able to lie on the affected side by 3 weeks. The subjective shoulder strength of all patients progressively improved from 3 weeks post-surgery. 21 patients returned to their work by 6 weeks; however 4 manual labourers required 8 weeks to return to their job. None of the patients had shoulder stiffness and none had complaints of shoulder droop post-operatively. All patients were able to wear shoulder straps without difficulty.

4. Discussion

Good results with excellent union and low complication rates were seen in numerous studies done on primary fixation of clavicle fractures negating the pessimism that surrounded prior studies where a poor understanding of soft tissue handling, selection bias of patients and inadequate implants combined to produce inferior results.^{10,11} Recent studies show increasing evidence that non-operative treatment of displaced, comminuted mid shaft fractures of clavicle was not as optimal as once thought. Non-union rates, strength and endurance deficits are common in cases treated conservatively.¹² Hill et al used patient oriented outcome measures to examine patients with clavicle fractures and found a non-union rate of 15% and an unsatisfactory outcome in 31%. Patients had pain requiring painkillers, pain with shoulder straps, pain sleeping on the affected side, local tenderness, and cosmetic abnormality.⁴ Zlowodzki in a meta-analysis of literature found that the non union rate of clavicles treated non-operatively was 15.1%, much higher than that was described earlier by Neer (0.1%).⁷ Stanley and Norris stated that 33% of patients treated conservatively had symptoms 3 months after fracture.¹³ Sankarankutty and Turner reported 15% of patients with deformity at the fracture site in 100 cases treated non-operatively.¹⁴

Table 1 – Patients and functional assessment data.

Pt. no.	Fracture pattern	Time taken for union	Associated injuries	DASH score				Simple shoulder test			
				3 Weeks	6 Weeks	8 Weeks	12 Weeks	3 Weeks	6 Weeks	8 Weeks	12 Weeks
1	Comminuted with single butterfly	6 Weeks	Nil	23.25	3.25	0	0	8 Yes	8 Yes	12 Yes	12 Yes
2	2 Part displaced	6 Weeks	Nil	5	3.25	0	0	8 Yes	10 Yes	12 Yes	12 Yes
3	2 Part displaced	6 Weeks	Nil	2.5	3.25	0	0	8 Yes	10 Yes	12 Yes	12 Yes
4	Comminuted	12 Weeks	Nil	23.25	3.25	3.25	0	8 Yes	8 Yes	12 Yes	12 Yes
5	2 Part displaced	6 Weeks	Nil	5	3.25	0	0	8 Yes	10 Yes	12 Yes	12 Yes
6	2 Part displaced	6 Weeks	7th rib fracture Rt	7.5	3.25	0	0	8 Yes	10 Yes	12 Yes	12 Yes
7	Comminuted with single butterfly	8 Weeks	Nil	23.25	3.25	0	0	8 Yes	8 Yes	12 Yes	12 Yes
8	2 Part displaced	6 Weeks	Nil	2.5	3.25	0	0	8 Yes	10 Yes	12 Yes	12 Yes
9	Comminuted	8 Weeks	Nil	23.25	3.25	3.25	0	8 Yes	8 Yes	12 Yes	12 Yes
10	2 part displaced	6 weeks	Nil	2.5	3.25	0	0	8 Yes	10 Yes	12 Yes	12 Yes
11	2 Part displaced	6 Weeks	Nil	2.5	3.25	0	0	8 Yes	10 Yes	12 Yes	12 Yes
12	2 Part displaced	6 Weeks	4th metacarpal fracture Rt	31.5	3.25	3.25	0	5 Yes	8 Yes	12 Yes	12 Yes
13	2 Part displaced	6 Weeks	Nil	5	3.25	0	0	8 Yes	10 Yes	12 Yes	12 Yes
14	2 Part displaced	6 Weeks	Nil	5	3.25	3.25	0	8 Yes	10 Yes	12 Yes	12 Yes
15	2 Part displaced	6 Weeks	Nil	2.5	3.25	0	0	8 Yes	10 Yes	12 Yes	12 Yes
16	2 Part displaced	6 Weeks	Nil	7.5	3.25	0	0	8 Yes	10 Yes	12 Yes	12 Yes
17	Comminuted	8 Weeks	3rd rib fracture Rt	23.25	3.25	3.25	0	8 Yes	8 Yes	12 Yes	12 Yes
18	2 Part displaced	6 Weeks	Nil	2.5	3.25	0	0	8 Yes	10 Yes	12 Yes	12 Yes
19	2 Part displaced	6 Weeks	Nil	5	3.25	0	0	8 Yes	10 Yes	12 Yes	12 Yes
20	2 Part displaced	6 Weeks	Nil	5	3.25	0	0	8 Yes	10 Yes	12 Yes	12 Yes
21	Comminuted with single butterfly	6 Weeks	Rt Distal radius displaced fracture	40	31.5	3.25	0	3 Yes	8 Yes	12 Yes	12 Yes
22	2 Part displaced	6 Weeks	Nil	7.5	3.25	0	0	8 Yes	10 Yes	12 Yes	12 Yes
23	2 Part displaced	8 Weeks	Nil	5	25	6.66	0	8 Yes	10 Yes	12 Yes	12 Yes
24	Comminuted	12 Weeks	Nil	50.83	32.5	13.33	0	5 Yes	5 Yes	7 Yes	12 Yes
25	Bilateral 2 part displaced	8 Weeks	Nil	23.25	18.33	6.66	0	5 Yes	5 Yes	7 Yes	12 Yes

Displaced fractures of clavicle can never be treated the same way as undisplaced or minimally displaced fractures for the deforming pull of sternocleidomastoid is too great and that the deformity recurs shortly after figure of eight bandage.^{15,16} It has been shown that mid third clavicle

Fig. 5 – Implant failure and malunion in a patient with bilateral clavicle fracture.

fractures with >2 cm displacement/15 mm of shortening are at increased risk of non-union.⁴ Thompson reviewed 100 mid third clavicular non-unions and found that 90% of the original fractures had displacement >100%, over riding >1 cm or had severe comminution, thus necessitating surgical stabilization.^{17,18} Plate fixation provides immediate stabilization of the fracture with pain relief, facilitates early mobilization and early return to pre injury activities. A multicenter trial conducted by Canadian Orthopaedic Trauma Society on 111 patients showed good overall shoulder function, rapid decrease in pain with lower malunion and non-union rates, and a shorter overall time to union in clavicle fractures treated with plating.¹¹ Kaisa et al in a study comparing sling with plate osteosynthesis for displaced mid shaft clavicle fractures found operative stabilization to be a reliable method with low complication rate and high union rate. He also noted that non-operative treatment resulted in a higher non union rate of 24%.¹⁹

Reconstruction plates used for clavicle fixation are low profile and can be contoured to fit the anatomical curves of the clavicle. Though they are successful in speeding the healing by increasing the load sharing across the fracture site, antero-inferior plating is insufficient for fracture fixation as they plastically deformed at a load that could be seen in routine activity. Superiorly placed locked compression plate was

Table 2 – a: One-way ANOVA for DASH score. b: One-way ANOVA for SST.

a: Fracture type	N	DASH score after the duration of surgery				F-value		CD (0.05)
		3 Weeks	6 Weeks	8 Weeks	12 Weeks	Value	df	
2-Part displaced	18	7.07 ^a	5.30 ^a	1.10 ^b	0.0 ^b	8.01**	3.68	3.360
Comminuted	4	30.15	10.56 ^a	5.77 ^a	0.0 ^a	6.38**	3.12	15.965
Comminuted with butterfly fragment	3	28.83 ^a	12.67 ^{ab}	1.08 ^b	0.0 ^b	5.95*	3.18	17.938

b: Fracture type	N	SST score after the duration of surgery				F-value		CD (0.05)
		3 Weeks	6 Weeks	8 Weeks	12 Weeks	Value	df	
2-Part displaced	18	7.83	9.33	12 ^a	12 ^a	213.14**	3.68	0.4
Comminuted	4	6.75	9.5	12 ^a	12 ^a	13.83**	3.12	2.074
Comminuted with butterfly fragment	3	6 ^a	6.67 ^a	8.67 ^{ab}	12 ^b	4.43*	3.8	4.175

Note: 1. Means with the same superscripted alphabet are on a par with each other, when compared with the respective CD_(.05) values.

2. ** – $p < 0.01$, * – $P < 0.05$.

found to be biomechanically stable especially in cantilever bending where the plate is loaded in tension and the fracture fragments are compressed.^{20,21}

All 25 patients in our study were treated with superiorly placed clavicular locking plates within 3 days of trauma. Most of the fractures in our series were 2 part fractures (76%). No neurovascular injury was encountered during the procedure or in the post-operative period. None of our cases got infected. The union rate was 100% in our study and 76% of the fractures united by 6 weeks. Prominence of plate was seen in one patient due to implant failure. The fracture united with slight malunion in this case. Implant removal was advised but the patient refused. Statistical analysis (One-way ANOVA) showed that there was a significant improvement in the functional outcome of patients treated surgically. The DASH scores reduced to a significant negligible level by 8 weeks in all but 4 cases with comminution where it took longer than 8 weeks to reach negligible levels. The SST showed significant improvement in all cases by 8 weeks after surgery. Cosmetically none had complaints about the scar probably owing to the subcuticular sutures we had used in every case. All patients were satisfied with the outcome. No patient had difficulty carrying back packs and 84% of patients returned to their work by 6 weeks.

While there is increased enthusiasm in treating clavicle fractures operatively, it is imperative to remember that most fractures can be treated non-operatively and the paradigm of clavicle fracture management should be individualized to the patient. The functional expectations of each patient and the fracture characteristics should be taken into account for a pragmatic approach to clavicle fracture management. Operative treatment is beneficial to a subset of patients where surgery rapidly restores anatomy and provides stable fixation facilitating early mobilization. Adequate counselling regarding the risks, benefits and results of operative intervention should be discussed with the patient prior to the surgery to help patients make an optimal decision.

Conflicts of interest

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

Acknowledgement

Nil.

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