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Dr. Mukesh S Dwivedi
Assistant Professor, GMERS,
Gotri Medical College, Gotri,
Vadodara, Gujarat, India

Dr. Jitendra Rathva
Senior Resident, GMERS, Gotri
Medical College, Gotri,
Vadodara, Gujarat, India

Dr. Vikas Patel
Senior Resident, GMERS, Gotri
Medical College, Gotri,
Vadodara, Gujarat, India

Open reduction and internal fixation in close middle third fracture clavicle by pre-contoured anatomical clavicle plate: A study of 125 cases

Dr. Mukesh S Dwivedi, Dr. Jitendra Rathva and Dr. Vikas Patel

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Abstract

Introduction: The concept of treating displaced, middle third fractures of clavicle by open reduction and stable fixation thereby restoring the clavicular length is gaining more and more acceptance amongst trauma surgeons. The aim of our study was to analyze the clinical outcome of internal fixation of middle third clavicle fracture by anatomical pre-contoured plate.

Method: 125 patients with isolated displaced middle third clavicle fractures were treated by open reduction and anatomical pre-contoured locking compression plate and followed prospectively till six months after union. All patients were assessed radiologically, clinically and according to disability of arm, shoulder and hand scoring system (DASH).

Results: Average time of union was 8 weeks. Union rate in our study was 97.6%. Most of the patients returned to pre-injury working status by the end of 10 weeks. Average DASH score at the end of 6 months was 12.

Conclusion: Superiorly placed anatomical pre-contoured locking plate for operative treatment of displaced middle third fractures is a safe and effective option with early return to pre injury working level and at the same time avoiding potential complications of delayed union, non-union and mal-union.

Keywords: clavicle fracture, non-union, mal-union, anatomical clavicle plate

Introduction

Clavicle fractures are common due to indirect mechanism being fall on an out-stretched hand, accounting for upto 2.6% to 10% of all fractures and upto 44.1% of the fractures involving upper girdle^[1]. Fractures of middle third account for approximately 80% of all clavicular injuries. Traditionally, these fractures have been managed non-operatively, even when substantially displaced^[2], with good to excellent results^[3,4]. The limitations of conservatively treated fractures are increased risk of non-union and mal-union resulting in altered bio-mechanics of upper girdle, cosmetic dissatisfaction and upper extremity weakness^[5-8]. These factors have caused a gradual shift towards surgical treatment of this fracture^[7,9]. Many devices have been described for treatment by internal fixation that included circlage wires, Steinmann pins, Kirschner wires, Knowel's pins, Rush rods, Recon plates etc^[10-12]. The proponents who favor ORIF in these fractures emphasize on early and accurate reduction achieving clavicular length resulting in quicker pain relief and early functional recovery. As the consensus for operative treatment picks-up, recent studies show lower incidence of non-union and mal-union rates and early return to work compared to conservative treatment^[13-18]. With the advent of more advanced anatomically contoured plates, the discussion is shifting from indications for operation to choice of implant for mid shaft clavicle fracture^[19-23]. This study prospectively evaluates the functional outcome of infra-clavicular approach and superior anatomical clavicle plating for close fractures of middle third clavicle, their advantages and complications in 125 patients.

Materials and Methods

A prospective study of 125 patients from Jan-2014 to Jan-2017 of close fracture middle third clavicle treated by open reduction and anatomical clavicle plating at GMERS, Gotri medical

Correspondence
Dr. Mukesh S Dwivedi
Assistant Professor, GMERS,
Gotri Medical College, Gotri,
Vadodara, Gujarat, India

college, Vadodara, a tertiary care centre was undertaken. The study was approved by Ethics committee of our college. Written informed consent of patients was taken before including them in the study.

Inclusion Criteria: Close, displaced middle third clavicle fracture between age group 18yrs to 60yrs. Medically fit patient.

Exclusion Criteria: Fracture associated with neuro-vascular injury, other associated fracture or systemic injury, medically unfit patient, and those patients who refused operative intervention.

Procedure: All patients were evaluated primarily on outdoor basis and other systemic injuries were ruled out. Radiological evaluation included x-ray of both clavicle to assess the extent of shortening on affected side and extent of comminution of fracture. Pre-anaesthetic evaluation and assessment was done and once patients were fit to undergo surgery they were posted for surgery. Beach chair position was given and a bolster in inter-scapular region was placed. Depending on patient's medical condition either regional or general anaesthesia was given. A curved incision was placed inferior to clavicle fracture. Supra-clavicular nerve was carefully identified and protected. Periosteal stripping was avoided as far as possible. Depending upon the extent of comminution one or two inter-fragmentary screws of 2.7 mm were used to fix them. Once reduction was achieved anatomical clavicle plate of adequate size was applied over the superior surface (Figure -1) and fixed with 3.5 mm screws. Infra-clavicular vital structures were protected throughout the procedure. Final reduction was assessed using fluoroscopy. Wound was closed in layers, subcuticular suture was taken and sterile dressing was applied. The limb was supported in an arm-sling pouch during the post-operative period. Pendulum exercises were started as pain tolerance of the patient improved. Patient was discharged after first dressing and stitch removal was done on 10th post-operative day. Subsequent follow-ups were at four weeks, eight weeks and six months. At each visit patients were evaluated clinically and radiologically and assessed using DASH scoring system.



Fig 1: Superior plate placement.

Results

A total of 125 patients were enrolled in the study from Jan-2014 to Jan-2017 as per the inclusion criteria and underwent open reduction and anatomical clavicle plating. 107 were male and 18 were female. 52 fractures were right sided and 73 were left sided. All the patients had indirect mode of trauma that is fall on an outstretched hand. Average age was 33.7 yrs with range from 18 to 60 years. Average admission- operation

interval was 3.8 days (range 2 to 7 days). Average duration of post-operative stay was 3.68 days. 5 patients (4%) had superficial infection which resolved subsequently with regular dressings and antibiotics. 3 patients (2.4%) developed delayed deep infection which did not resolve by antibiotics and dressings and necessitated removal of implant. 8 patients had cosmetically unacceptable scar appearance. There was no case of any neuro-vascular complication during intra-op or post-operative phase. All fractures united at an average duration of 8 weeks except 3 cases which went in for non-union. (union rate 97.6%). 5 patients had complaint of peri-incisional numbness at 6 months follow-up. 3 patients had implant failure at three months follow-up and required second surgery in form of plating plus bone grafting and subsequently the fracture united at three month follow-up. No patient was advised implant removal at the end of two years. However 8 patients underwent voluntary removal due to cosmetic reasons or due to prominently palpable subcutaneous plate. Most of the patients returned to work by the end of 10 weeks. Average DASH score was 25 at 4 weeks, 20 at 8 weeks, 12 at 6 months. 8 patients had DASH score of more than 20 even after 6 months.

Discussion

Simple, minimally displaced fractures which have been treated conservatively have consistently given satisfactory results. [3] It is the comminuted, displaced fractures in young healthy active individuals with shortening of clavicle compared to opposite side, who were more prone to non-union and mal-union and became most frequent indications for surgical treatment. [24-28] The concept of accepting mal-union and non-union of clavicle which was earlier thought to be of radiological and academic interest only, not requiring any form of intervention has gradually evolved over to accepting the fact that clavicular mal-union is a distinct clinical identity with radiographic, orthopaedic, neurologic, and cosmetic implications, requiring intervention in some cases. Recent studies have shown increasing evidence that non-operative treatment of displaced mid-shaft fractures of clavicle is not optimal and acceptable as once thought of earlier [5, 29, 30, 25].

Different authors have reported the incidence of non-union and mal-union in conservatively treated fractures. Hill *et al* reported incidence of 15% non-union and poor outcome in 31% cases [5]. Nowak *et al* reported 7% non-union rate with un-satisfactory outcome in 46% of their patients [30]. Zlowodzki *et al* in a meta-analysis of literature found non-union rate of 15.1% [28]. Sankarenkutty and Turner reported 15% patients with deformity [31].

Two distinct methods have evolved over years for treatment involving operative intervention in mid shaft fractures. One is IM nailing using flexible nails like rush pins, Kirschner wires, TENS nail etc [11, 32]. Other method is ORIF using recon plates, DCP, etc. Different authors have compared ORIF using plates and IM nailing and come to varying inferences with one better over the other and some suggesting that there is no significant difference after 12 months in functional outcome [33-37, 16]. Open reduction and plate fixation is superior to IM nailing as it better resists bending and torsional forces that occur during overhead abduction of shoulder [38].

Lazarides and Zafiroopoulos in their study have suggested that clavicle shortening of more than 18 mm in males and 14 mm in females is significantly associated with unsatisfactory results [24]. Eskola [39] and associates reported that patients

with shortening of clavicle segments of more than 15 mm at follow-up had statistically significantly more pain than those without these findings. Care should be taken to avoid acceptance of shortened clavicle. Restoration of clavicular length is believed to be the pretext for ORIF of clavicle, especially in active younger age group [8, 18].

The concept of open reduction and plating in displaced, comminuted, mid-shaft fractures of clavicle is gaining wider acceptance as a preferred method of treatment over intramedullary nailing. Two different plate placements have been studied widely by different authors. Superiorly placed locked compression plate was found to be more biomechanically stable especially in cantilever bending where plate is loaded in tension and fracture fragments are compressed [38]. Study by Nathan *et al* found no difference in union rates while comparing antero-inferior plating and superior plating [40]. There was no difference in peri-operative complication in either groups of their series. Placement of plate in either position carries the risk of iatrogenic neuro-vascular injury and neither position had significantly decreased risk [41].

In our study of 125 patients, all were treated by open reduction and superior placement of anatomical pre-contoured locking plate. The average admission-operation interval was 3.8 days. There was no incidence of peri-operative damage to neuro-vascular structures in our study. Average union time in study by D. Gaughriou *et al* was 12.8 weeks. [42] Study by Campochiaro *et al* and K.R. Reddy [43] showed healing time of 2.3 months and 2.4 months respectively. Average healing time in our study was 8 weeks with a range from 7 weeks to 11 weeks.

Reports of infection in literature range from 0% to 18% in different studies [25] Campochiaro *et al* [22] and Balaji *et al* [44] reported no case of superficial or deep infection in their study which could possibly be due to their smaller sample size. In our study there were 5 cases of superficial infection (4%) which resolved with dressing and antibiotics. 3 patients (2.4%) had deep infection in our study.

Dauraiyaswami *et al* [44] and S. Venkatachalam *et al* [45] reported 100% union in their studies which may be due to their small sample size. There was 97.6% union rate in our study which is similar to Campochiaro *et al* who reported union rate of 97.1%. [22]

Chen *et al* reported incidence of implant failure rate of 7.1% in their study [32]. We had 3 patients of implant failure (incidence of 2.4%) at three months follow-up who required second surgery in form of re-plating plus bone grafting and subsequently the fracture united at further follow-up of three months.

Gherghiu *et al* had 4 patients with hypersensitivity at the scar site [42]. In our study 5 patients had peri-incisional numbness at six months follow-up which is comparable to other studies.

Campochiaro *et al* [22] had 4 cases of hypertrophic scar in their study. We had 8 patients (6.4%) having cosmetically unacceptable scar hypertrophy.

Canadian orthopaedic trauma society reported 11 cases out of 62 with hardware irritation or prominence which could possibly be because of use of DCP or recon plate in large number of their patients. [25] We had 8 patients (incidence 6.4%) who underwent implant removal once fracture healed either due to prominently palpable subcutaneous plate or due to cosmetic reasons.

Multicenter trial conducted by Canadian ortho trauma society on 111 patients showed good shoulder function, rapid decrease in pain in post-operative phase, lower incidence of

non-union and mal-union rates and overall shorter union time in clavicle fractures treated by open reduction and plating [25]. Vander *et al* found that patients who had surgical intervention had quicker radiological union and returned to work earlier [17]. Most of our patients returned to pre-injury work level by the end of 10 weeks.

Gheorghiu *et al* reported DASH score of 13.4 at 11 months follow-up. [42] Campochiaro *et al* reported score of 4.8 at the end of 24 months follow-up. [22] Average DASH score in our study was 25 at 4 weeks, 20 at 8 weeks, and 12 at six months follow-up. This shows that DASH score kept on decreasing with time.

Limitations of Study: We had small data base of patients. No comparison has been done with IM nailing and its outcome or conservative treatment and its outcome. Large and randomized controlled trials are needed to further evaluate the outcome of ORIF with plating. Long term complications need to be evaluated.

Conclusion

Anatomical pre-contoured locking clavicle plating is a safe procedure with excellent post-operative rehabilitation and early return to pre-injury working status. Stable operative fixation is an effective method to restore shoulder function. ORIF decreases the incidence of delayed union, mal-union and non-union while treating displaced, comminuted fractures of middle third clavicle with more than 20 mm of shortening. Technique of superior plate placement is safe and can be easily replicated by all orthopaedic surgeons. Subcuticular stitches probably improved the cosmetic appearance and acceptance of scar in most of the patients.

Recommendation: Based on our study we recommend treatment of all comminuted, displaced, middle third shaft fractures of clavicle by open reduction and internal fixation using anatomical pre-contoured locking compression plate.

Conflict Of Interest: The authors have no conflict of interest to declare.

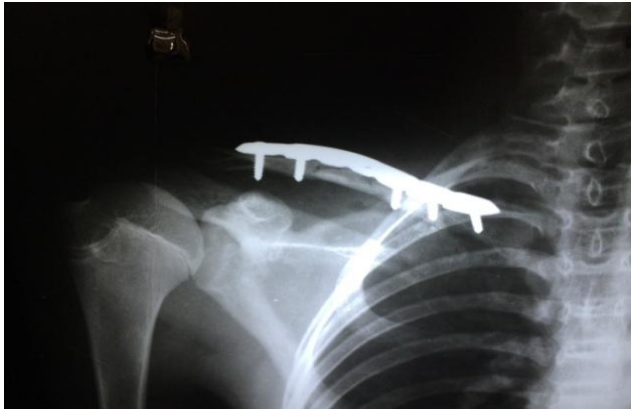
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Pre- operative x-ray. (case no21)



Post- operative x-ray.



8 weeks post-op x-ray showing union.



Pre-operative x-ray. (case no 67)



Post-operative x-ray.



9 weeks post-op x-ray showing union

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