

SYMPTOMATIC NONUNION AFTER FRACTURE CLAVICLE, WHAT IS THE FUNCTIONAL OUTCOME AFTER OPEN REDUCTION AND INTERNAL FIXATION WITH A CURVED RECONSTRUCTION PLATE?

Mohamed Mansour Elzohairy¹; MD

(1) Lecturer of Orthopaedic Surgery, Faculty of medicine, Zagazig University, Egypt.

ABSTRACT

Background: Although fracture mid shaft clavicle always united with a good functional outcome, nonunion of fracture clavicle always leads to impaired shoulder joint functions with a significant disability that can cause poor functional outcome and limitations of shoulder joint activities due to pain and stiffness. **Materials and Methods:** From July 2005 through October 2011, twenty (20) patients (13 males and 7 females) were suffering from symptomatic nonunion of the mid-shaft clavicle (no union for more than three months). They had treated operatively in 14 patients who had suffered from the atrophic nonunion by using a curved reconstruction plate and autologous iliac bone grafting and in six patients with hypertrophic nonunion of mid-shaft clavicle fracture by using a curved reconstruction plate and “local bone grafting” from local callus, bone chips. The American Academy of Orthopedic Surgeons (AAOS) disabilities of the arm, shoulder and hand (DASH) questionnaire was used for the outcome results evaluation. **Results:** The patients were followed-up for an average of 15 months (range from one year to four years). All fractures were united within three months. The preoperative DASH score was varied from 80 to 70, mean (75). The postoperative DASH score was varied from, 10 to 25, mean (12.7) in our series. Functionally, this was very much acceptable. **Conclusion:** Based on the results of our and other studies, we recommended open reduction and internal fixation with using a curved reconstruction plate and autologous iliac bone grafting in patients whom suffering from the atrophic nonunion. For treating patients whom suffering from hypertrophic nonunion of mid-shaft clavicle fracture we recommended using a curved reconstruction plate and local bone graft as a sufficient procedure to achieve necessary union, and autologous bone graft from other sites of the body appears to be unnecessary. This successful procedure had a good functional outcome and most of the patients had promising results, as regard to return to a near normal level of function.

Keywords: Fracture clavicle, nonunion, curved reconstruction plate.

INTRODUCTION

Clavicle fractures occur commonly; accounting for 5% to 10% of all fractures, more than 75% up to 80% are located in the mid-shaft, most of these fractures can be treated nonoperatively and will heal without surgical intervention⁵.

Mukhopadhaya⁷ and Rowe⁹ considers a delayed union of clavicle fractures to be defined as the absence of clinical and radiological signs of union at six weeks, and they considered the nonunion in patients to be defined as the absence of clinical and radiological signs of union after three months, double the time required for union. The reported incidence of nonunion of a fracture clavicle were varying from 1% to 15%².

The patients are thought to be susceptible to nonunion due to different factors as; age, gender, location, nature of the fracture and the

amount of displacement, soft-tissue interposition or damage, inadequate immobilization, and primary operative treatment are suggested as contributing factors^{3,6,8}.

Despite of the displaced fractures of the clavicle often cannot be reduced and maintained in perfect position, it always was united and the cosmetic appearance is acceptable usually without functional disability⁷. The patients with delayed union or nonunion of fracture clavicle always suffered from pain and impaired function of the shoulder girdle and upper limb with deformity that may be in sometimes lead to pressure on the subclavian vessels or brachial plexus causing pain and troublesome neuralgia in the upper limb. For all of these reasons that patients are always the ideal candidate for open reduction and internal fixation with or without bone grafting to correct the deformity and also to

alleviate the symptoms seeking to satisfy functional improvement¹¹.

AIM OF THE WORK

In this study, we evaluated the results of twenty patients, suffered from symptomatic nonunion after fracture clavicle managed by open reduction and internal fixation with a curved reconstruction plate and autogenous iliac and local bone grafting.

PATIENTS AND METHODS

From July 2005 through October 2011, twenty (20) patients (13 males and 7 females) were suffered from of symptomatic nonunion of mid-shaft clavicle (no union for more than three months) they had treated operatively in, 14 patients who had suffered from atrophic non union by using a curved reconstruction plate and autologous iliac bone grafting and in six patients with hypertrophic nonunion (of mid-shaft clavicle fracture) by using a curved reconstruction plate and "local bone grafting" from local callus, bone chips and reaming dust. All the patients gave the informed consent prior to being included in this study. They were (13 males and 7 females), (12 right clavicle and 8 left). The average age at the time of injury was 33 years (range 23-44 years). The time elapsed since they had fractured was ranging from 3 months to 9 months (average 5 months) after trauma. The causes of the fractures were varied from a motorcycle accident in 12 patients, falling from a height in 6 patients or sliding on the floor in 2 patients. The mechanism of injury, where falls onto the affected shoulder with direct impact were in 17 patients, and falling onto an outstretched hand with an indirect impact were in 3 patients, table (1),(2). We included only the symptomatic patients with nonunion, who characterized by, mobility at the fracture site on clinical examination and fracture gap with inadequate callus formation on radiographic examination and there were a significant disability due to pain and inability to use their limbs to normal function.

Surgical technique:

Under general anesthesia the patient positioned in the beach chair position with their head turned to the opposing side.

A prophylactic antibiotic with intravenous 1gm Cefotaxime 1g preoperatively was administered to all patients. Over the clavicle a curvilinear incision was made to expose the fracture. The fracture ends, which were freshened and mobilized with careful sharp dissection, and then the fracture were reduced with extreme caution not to damage the adjacent structures. Then after the fracture reduction it was stabilized by contoured 3.5 mm reconstruction plate placed superiorly with at least 6 cortical purchases on either side. As necessary cancellous screws were used at the lateral end of the clavicle for better purchase in cancellous bone and the interfragmentary screw was used when needed.

Preoperative, intravenous antibiotics are given to removal of the drain (Cefotaxime 1g, two times a day for three days, then followed by ciprofloxacin orally 750 mg two times a day till the suture removal). Cancellous autologous iliac bone chips graft was used in ten cases with atrophic non union gap less than 1.6 cm. In four patients with atrophic non union gap more than 1.6 cm we used iliac crest strut tricortical autologous bone grafting because of a significant defect at the site of nonunion after the bone ends freshened. In six cases with hypertrophic nonunion local bone grafting from local callus, bone chips was used, table (3).

Post operative protocol:

The sutures were removed after two weeks; the patients were started with gentle pendulum exercise, then the patient flow an instructive physiotherapy program till the full range of motion of the shoulder joint was allowed once the pain subsided and the fracture united. The union was considered if clinically the fracture site was non tender; no abnormal movement and radiologically when there was a visible callous. The patients were followed-up for an average of 15 months (range from one year to four years). American Academy of Orthopedic Surgeons (AAOS) disabilities of the

arm, shoulder and hand (DASH) questionnaire^{1,4} was used for the outcome results evaluation. The American Academy of Orthopedic Surgeons (AAOS) developed The **DASH** (**D**isabilities of the **A**rm, **S**houlder and **H**and) outcome measure which is a self-report questionnaire consisted of (30) -items designed to measure physical functions and symptoms in patients with any or several musculoskeletal disorders of the upper limb. It gives clinicians and researchers the advantages of having a single, reliable instrument that can be used to assess any or all joints in the upper extremity. More severely disabled individuals have a higher score on a scale of 0 to 100.

RESULTS

The patients were assisted by both clinical and radiological assessments. We evaluated the shoulder joint performance, including incision site numbness, redness and swelling, and obviousness of scars.

In addition, we evaluated complications, including refracture, plate fracture and loss of fixation, nonunion, malunion, or deep wound infection, symptomatic malunion. As regards the radiological assessment, all the fractures

Case presentation

Figure (1), Male patient, 44 years old, the X-Ray showed non union 9 months after fracture clavicle. Figures (2), (3) showed the defect and fracture mobility. Figures (4), (5) and (6) exposure and reduction with strut autogenous iliac graft and reconstruction plate application. Figure (7) postoperative X-ray showed complete union within three months and the iliac crest strut grafting also showed satisfactory incorporation. Figure (8) preoperative range of shoulder movement with a great limitation movement. Figures (9) and (10) postoperative range of movement with great improvement, of shoulder movement.

were united within three months with incorporation of the all bone grafts including the iliac strut bone grafts which used in four patients. As regards the clinical assessment, no major complications occurred in our cases. The complication was mainly, Hypertrophic scar or keloid formation which was developed in two patients. All the patients were able to achieve full range of motion except two patients who had difficulty in abduction over 100° we advised them to make arthroscopic arthrolysis to the shoulder but they refused. Though it is important to preserve supraclavicular nerve during operation, none of our patients had any complaints, even if it was sacrificed during operation. Hardware prominence reported by two patients, but they were satisfied and refused further surgery to remove the plate.

No patient had a refracture, plate fracture, loss of fixation, nonunion, malunion, or deep wound infection. The preoperative DASH score was varied from 80 to 70, the mean was (75), the postoperative DASH score was varied from 10 to 25, the mean DASH score of the patients in our series was (12.7). Figures (1 to 10), (table 4).





Tables

Table (1) the causes of fracture clavicle

Causes of trauma	numbers
Motorcycle accident	12
Falling from a height	6
Sliding on the floor	2

Table (2) the mechanism of injury of fracture clavicle

mechanism of injury	numbers
Falls onto the affected shoulder with direct impact	17
Falls onto an outstretched hand with indirect impact	3

Table (3) the type of the graft used and the numbers of the cases

Type	Numbers	Type of graft used
Atrophic nonunion with gap less than 1.6 cm	10	Cancellous autologous iliac bone chips graft
Atrophic nonunion with gap more than 1.6 cm	4	iliac crest strut tricortical autologous bone graft
Hypertrophic	6	local bone grafting from local callus, bone chips

Table(4) Results and the complications

Hypertrophic scar or keloid	Two cases	
Difficulty in abduction over 100°	Two cases	
DASH scores	Perioperative	Postoperative
	80 to 70. Mean (75)	10 to 25. Mean (12.7)

DISCUSSION

Nonunion is a relatively common complication after clavicle fractures. The recent studies suggested a higher incidence than previously thought. Traditionally, mid-shaft clavicle fractures have been managed conservatively, even when substantially displaced. Recent literature has highlighted the high non-union rate of displaced mid-shaft clavicle fractures, with a nonunion rate up to 15%^{2,7,10}. Nonunion of midclavicular fractures usually leads to shoulder pain, weakness and asymmetry, thus compromising function and cosmetic appearance. In the literatures the symptomatic nonunion of midshaft clavicle fractures is usually managed surgically with different techniques either an intramedullary device or plate fixation, and this often combined with iliac crest bone graft. The success results in achieving union were varying from 89% to 100%. Those methods, including the intramedullary fixation with Key wire, Knowle's pins, Haige pins, Rockwood pins and titanium nails and the extramedullary including semitubular plates, reconstruction plates, Dynamic Compression Plate (DCP), Limited Contact Dynamic Compression⁵. Despite of the intramedullary fixation of the clavicle can be placed with smaller incisions, removing these devices also can be easier, with smaller surgical incisions which is more cosmetic. These devices may not offer as much initial stability, especially in more complex fractures, but also technically more demanding owing to lack of clear cut medullary canal and higher complication rates up to 75%.

Comparing with Plate fixation which has many advantages including, Superior placement of the plate which is biomechanically more stable especially in presence of inferior cortical

comminution the plates and screws will give immediate rigid stabilization, pain relief, facilitates early mobilization and return to pre injury activities. The disadvantages of plate fixation including, it requires larger incisions and also in thin patients with low body fat, the plate will be palpable under the skin but this is not a problem for most patients. The plates may also require removal in the future^{2, 6}. In the series by Manske et al⁶, Mukhopadhaya et al⁷ and Dhoju et al², the authors suggests that, the plate fixation on the superior surface of the clavicle is a reliable and predictable method of repair and management of clavicle fracture nonunion. Plate fixation has the theoretic advantage of rotational control compared with intramedullary fixation and can be used to regain length when significant shortening has occurred. Because the three-dimensional morphology of the clavicle is complex, plate placement should be carefully considered.

The superior surface was the most common place for plate fixation, where benefits include an uncomplicated approach, minimal opening of the periosteal sheath, and easy plate placement. The plate will be prominent in thin patients and can be sensitive to pressure, which often leads to a second surgery for hardware removal and this minimized by the use of a contoured, curved reconstruction plate, which has a lower profile and more rounded edges than a dynamic compression plate. Manske et al⁶, Mukhopadhaya et al⁷ and Dhoju et al², concluded that, the curved pelvic reconstruction plate has become the plate of choice for repair of clavicular fracture nonunion, because, it is substantially thicker and significantly more rigid than the straight pelvic reconstruction plate or pelvic locking plates (3.6 mm vs. 2.8 mm). It is narrower and easily contoured

compared with the straight limited contact, dynamic compression (LC-DC) or locking compression (LC) plates. The role of locking plate fixation for these nonunion had been not well defined in these studies, but in their opinion, they found that the, current locking pelvic reconstruction plates may be too thin for use in all but except with the slightest patients and they concluded that plate fixation applied superiorly is an effective treatment for clavicle nonunion. The autogenous bone graft is not routinely necessary, except when clavicle atrophic nonunion or shortening cannot be corrected without intercalary grafting 2,3,5,6,7,8,10,11

In this study of twenty (20) patients were treated of symptomatic nonunion (nonunion more than three months) by using the technique of autologous bone grafting for the cases of atrophic nonunion, not only by this technique restored the length of the clavicle, but also helped to shield the stresses on the internal fixation. In our study, autologous bone grafting was not used, in six cases of hypertrophic nonunion of mid-shaft clavicle fracture, but “local bone grafting” from local callus, bone chips was performed.

All of the nonunion healed uneventfully, so this might mean that a “local bone graft” with refreshing the fracture, good bony contact, less periosteal stripping and good preservation of periosteal sleeve is sufficient to overcome the problem of inadequate osteogenesis in a nonunited mid-shaft clavicle fracture. These, together with rigid internal fixation, make the problems of nonunion (either poor fixation or inadequate osteogenesis) possible to overcome and union could be achieved smoothly. The postoperative DASH scores of the patients in our series were varying from 10 to 25; the mean was (12.7). Functionally, this was very much acceptable.

CONCLUSION

Based on the results of our and other studies, we recommended open reduction and internal fixation with using a curved reconstruction plate and autologous iliac bone grafting in patients whom suffering from the

atrophic non union. For treating patients whom suffering from hypertrophic nonunion of mid-shaft clavicle fracture we recommended using a curved reconstruction plate and local bone graft as a sufficient procedure to achieve necessary union, and autologous bone graft from other sites of the body appears to be unnecessary. This successful procedure had a good functional outcome and most of the patients had promising results, as regard to return to a near normal level of function.

Conflicts of Interest: None.

REFERENCES

1. Atroshi I, Gummesson C, Andersson B, Dahlgren E and Johansson A: The disabilities of the arm, shoulder and hand (DASH) outcome questionnaire: reliability and validity of the Swedish version evaluated in 176 patients *ActaOrthopScand*, 2000; 71:613-618.
2. Dhoju D, Shrestha D, Parajuli N, Shrestha R, Sharma V: Operative Fixation of Displaced Middle Third Clavicle (Edinburg Type 2) Fracture with Superior Reconstruction Plate Osteosynthesis. *Kathmandu Univ Med J* .2011; 36(4):286-91.
3. Eskola A, Vaianionpaa.S, and Myllynen P: Surgery for ununited clavicular fracture. *ActaOrthop Scand*. 1986; 57:366-7.
4. Hudak PL, Amadio PC, Bombardier C and The Upper Extremity Col-laborative Group (UECG): Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) *Am J Ind Med*.1986; 29:602-608.
5. Jupiter JP, Leffert RD: Non-union of the clavicle. Associated complications and surgical management. *J Bone Joint Surg Am*. 1987; 69: 753-60.
6. Manske DJ, Szabo RM: The operative treatment of mid-shaft clavicular non-unions. *J Bone Joint Surg*. 1985: 67-A: 1367–1371.
7. Mukhopadhaya.John, Shivapuri.Swastik: Functional outcome after open reduction and internal fixation for symptomatic delayed union and nonunion after fracture clavicle: A series of 31 cases. *Indian J Orthop*. Jul-Sep.2007; 41(3): 209–213.
8. Robinson CM, Court-Brown CM, McQueen MM, Wakefield AE: Estimating the risk of nonunion following nonoperative treatment of

-
- a clavicular fracture. J Bone Joint Surg Am. 2004; 86:1359-65.
9. Rowe CR: An atlas of anatomy and treatment of midclavicular fractures. ClinOrthopRelat Res.1968; 58:29-42.
 10. SEijAS .R, ROMEnY. S. SuáREz, M. G. BAIIEtBó, X. CuSCó, O. ARES, R. CuGAt: Delayed union of the clavicle treated with plasma rich in growth factors. ActaOrthop. Belg. 2010; 76, 689-693.
 11. Wilkins RM, Johnston RM: Ununited fractures of the clavicle. J Bone Joint Surg Am.1968; 65:773-8.