

## TO EVALUATE THE SURGICAL OUTCOME OF NON-UNION CLAVICLE USING PLATE AND SLIVERS OF AUTOLOGOUS ILIAC CREST CORTICOCANCELLOUS BONE GRAFT

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### ABSTRACT

#### INTRODUCTION

Clavicle fracture is one of the most common fracture presenting to the fracture clinic, accounting for about 5-10% of all the adult trauma reported but still the controversy exists with regards to the definitive management.

#### AIM

To evaluate the surgical outcome of nonunion clavicle in patients treated previously with surgical management or conservative management, using plate and slivers of autologous iliac crest corticocancellous bone.

#### DESIGN

Retrospective analysis of patients operated between May 2005 and February 2013 for nonunion of the clavicle.

#### METHODS AND MATERIALS

Twenty patients who were operated between May 2005 and February 2013 for nonunion of the clavicle at our hospital were recruited for our study and followup data was collected from our hospital records till their last outpatient visit. Inclusion criteria included patients with no evidence of radiological union, persistence of pain, cosmetic deformity, dysfunction or gross movement at the fracture site even after 16 weeks of conservative treatment or in cases of primary fixation failure.

#### STATISTICAL ANALYSIS

All Statistical analyses were made using Statistical Package Software for Social Sciences (SPSS) version 17.0 software (Chicago, IL, USA) for descriptive data. Chi2 test was used to compare the categorical data.

#### RESULTS

At the end of an average followup of 19 months, the average Visual Analogue Score for pain was  $1.9 \pm 2.2$  (range 0-6), the mean ASES score was  $81 \pm 18.5$  (51-100), and the mean Constant-Murley score was  $80 \pm 17$  (51-100). All the patients had a stable radiological union at the end of the followup period. There were no complications pertaining to the hardware or infection.

#### CONCLUSION

Treatment of nonunion of clavicle by using corticocancellous bone is well documented; however, use of iliac corticocancellous bone graft shaped in long slivers will give mechanical stability to the plate reconstruct in addition to providing a scaffold for new bone formation than just pieces of corticocancellous bone graft.

#### KEYWORDS

Clavicle, Nonunion, Mid shaft fractures, Corticocancellous bone graft, Iliac crest.

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**INTRODUCTION:** Clavicle fracture is one of the most common fracture presenting to the fracture clinic, accounting for about 5-10% of all the adult trauma reported.<sup>1</sup> The incidence of nonunion is variable according to different studies with a large meta-analysis study by

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Zlowodzki et al reporting it as 5.9% for undisplaced to 15.1% for displaced fractures.<sup>2</sup> Many causes such as fracture displacement, fracture comminution, female gender, advancing age,<sup>3-5</sup> shortening ( $>2$  cm)<sup>6</sup> and smoking have been ascribed to result in nonunion of clavicle fracture. In addition, poor implant choice and implant failure also contributes to a major extent to the problem.

Many surgical procedures with varying implants ranging from and intramedullary fixation with Steinmann pin<sup>7</sup> Knowles pin<sup>8,9</sup> modified Hagie pin,<sup>10,11</sup> Rush pins,<sup>12</sup> Kirschner wires,<sup>13</sup> external fixators,<sup>14,15</sup> plate and screws<sup>16-18</sup> and

screws<sup>19</sup> alone are used in the treatment of clavicle non-union, but still the controversy exists with regards to the definitive management. Some authors also advocate vascularized bone graft reconstruction.<sup>20,21</sup> Van Tongel et al suggested the augmentation of plate osteosynthesis with pectoralis major muscle<sup>22</sup> in recurrent cases.

A number of studies report open reduction and internal fixation with autologous bone grafting as an accepted technique for treatment of clavicle non-union in cases with atrophic fracture ends and or shortening of the fracture site to regain the necessary clavicle length.<sup>23-27</sup> Our aim is to evaluate the surgical outcome of nonunion clavicle in patients treated previously with surgical management or conservative management, using plate and slivers of autologous iliac crest corticocancellous bone.

## MATERIALS AND METHODS:

**Patient Demographics:** Twenty patients who were operated between May 2005 and February 2013 for non-union of the clavicle at our hospital were recruited for our study and follow-up data was collected from our hospital records till their last outpatient visit. Inclusion criteria included patients with no evidence of radiological union, persistence of pain, cosmetic deformity, dysfunction or gross movement at the fracture site even after 16 weeks<sup>28</sup> of conservative treatment or in cases of primary fixation failure. Of the twenty, 15 were male and 5 were female patients with a mean age of 48 years at the time of surgery. Right clavicle was involved in 7 cases and left clavicle in 13 cases. 11 patients sustained the fracture following fall, 5 of them were involved in road traffic accident, 1 was a case of sports injury and 3 fell from bicycle. We used the Edinburgh classification<sup>1</sup> for the classification of clavicle fractures as it is the most accepted classification system. Majority of the fractures (eight) were of the type 2B1 (displaced with or without a single fragment), two were of type 2B2 (comminuted), two were extra-articular lateral end fractures which were displaced (3B1), one was a medial end displaced fracture (1B1). Five cases had fixation failure due to broken plates and two had nonunion with an intact plate. Out of the five cases of plate breakage, three had cerclage wires which were done elsewhere as a primary procedure for comminuted fracture and two were fixed with plate and lag screws for fragment fixation with one of these patient presenting to us with three failed operations elsewhere to treat the nonunion. Average duration from the onset of fracture to the surgery for nonunion was 36 weeks (range 16 to 80 weeks), all the patients were symptomatic either due to pain, restricted mobility, weakness or cosmetic deformity. Evaluation of plain x-ray film showed 3 cases as hypertrophic nonunion and 17 cases as atrophic nonunion. The mean duration for which followup done was 19 months (range 4 to 56 months). (Table 3)

**Surgical Procedure:** All operations were performed with the patient under general anaesthesia with the patient positioned in the beach-chair position with a folded towel placed beneath the ipsilateral scapula. The corticocancellous bone graft is harvested from usually the ipsilateral iliac crest and shaped into slivers measuring about 3-4 cm long. Skin incision was made over the superior surface along the

longitudinal axis of the bone centred over the site of the lesion. Careful subperiosteal dissection was performed and the non-union site was approached, the fibrous tissue was excised along with the sclerotic bone ends and the medullary canals of both fragments were opened up using a 4.5 mm drill bit. This was facilitated by holding the ends with a pointed reduction clamp. Once debrided the fracture ends are reduced and the plate is fixed. We used AO 3.5 mm reconstruction plate in 9 cases, AO 3.5 mm LCP in 10 cases and in one case which was type 1B1 we used a 3.5 mm semitubular plate for fixation. Using Ethibond no. 2, three or four stiches are passed around the fracture ends encircling the clavicle along with the plate, then the individual sticks of autogenous iliac crest graft harvested is placed longitudinally along the clavicle over fracture site and the sutures are tied firmly opposing the bone graft to the nonunion site thereby preventing the displacement of the grafted bone away from the nonunion site. Remaining cancellous bone is also placed at the nonunion site and the soft tissue and skin closed in layers. Immobilization was carried out with an arm sling for 2 to 8 weeks (average of 6 weeks).

**Clinical and Radiological Evaluation:** Patients were evaluated in the outpatient clinic at regular intervals and assessment was done using the PVAS, ASES<sup>29</sup> and Constant–Murley shoulder scoring system<sup>30</sup> at last followup. Union was defined as continuity of the bony cortices and remodelling on two radiographic views (Anteroposterior and 45°)

**STATISTICAL ANALYSIS:** All statistical analyses were made using Statistical Package Software for Social Sciences (SPSS) version 17.0 software (Chicago, IL, USA) for descriptive data. Chi<sup>2</sup> test was used to compare the categorical data.

**RESULTS:** At the end of an average followup of 19 months, the average Visual Analogue Score for pain was 1.9±2.2 (range 0-6), the mean ASES score was 81±18.5 (51-100), and the mean Constant–Murley score was 80±17 (51-100). All the patients had a stable radiological union at the end of the followup period. There were no complications pertaining to the hardware or infection.

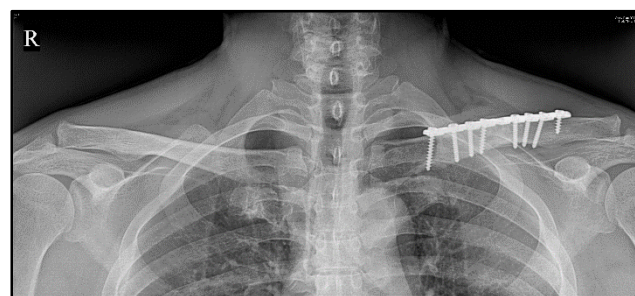
| Studies            | n= | graft | complications                   | Type of plate        | union |
|--------------------|----|-------|---------------------------------|----------------------|-------|
| Olsen et al.       | 16 | Iliac | –                               | Compression plate    | 100%  |
| Nikiforidis et al. | 11 | Iliac | –                               | Compression plate    | 100%  |
| Wentz et al.       | 22 | Iliac | Mechanical - 1                  | Reconstruction plate | 100%  |
| Stufkens et al.    | 21 | Iliac | Infection - 1<br>Mechanical - 1 | Antero inferior LCP  | 100%  |
| O'Connor et al.    | 24 | Iliac | Infection-1<br>RSD-1            | Recon-7<br>DCP-17    | 91%   |

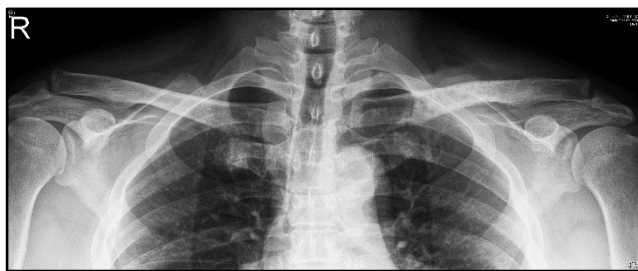
**Table 1**

| Studies         | n= | graft                                            | complications                | Type of plate    | union |
|-----------------|----|--------------------------------------------------|------------------------------|------------------|-------|
| Khan et al      | 11 | Insitu-5<br>Iliac -6                             | Mechanical-1                 | LCP              | 100%  |
| Ebraheim et al. | 16 | Iliac -15<br>Substitute - 1                      | Mechanical-3                 |                  | 94%   |
| Endrizzi et al. | 47 | In situ - 30<br>Substitute - 14<br>Autograft - 3 | Mechanical-3                 | RCP-43<br>DCP-4  | 93%   |
| Huang et al.    | 21 | Iliac/in situ                                    | Infection-1                  | RCP-21           | 100%  |
| Bradbury et al  | 32 | Iliac/in situ                                    | Mechanical<br>DCP-6<br>RCP-7 | DCP-15<br>RCP-17 | 96%   |

**Table 2**

| Serial No. | SEX    | AGE | SITE  | Delay in Surgery | CAUSE OF INJURY  | PVAS | Constant Score | ASES Score | CLASSIFICATION             | Follow up duration (Months) |
|------------|--------|-----|-------|------------------|------------------|------|----------------|------------|----------------------------|-----------------------------|
| 1.         | MALE   | 65  | LEFT  | 16               | SOCCER           | 4    |                |            | 2B1                        | 12                          |
| 2.         | MALE   | 53  | LEFT  | 28               | SUPDOWN          | 2    |                | 100        | 2B2                        | 12.5                        |
| 3.         | FEMALE | 58  | LEFT  | 17               | TRAFFIC ACCIDENT | 6    | 51             |            | 2B2                        | 4                           |
| 4.         | MALE   | 38  | LEFT  | 48               | SUPDOWN          | 0    | 82             |            | PLATE FAILURE              | 3                           |
| 5.         | MALE   | 57  | LEFT  | 20               | TRAFFIC ACCIDENT | 0    | 92             | 100        | 2B1                        | 21                          |
| 6.         | MALE   | 34  | LEFT  | 29               | FALLDOWN         | 0    | 52             | 62         | FAILURE-PLATE N WIRE       | 19                          |
| 7.         | FEMALE | 36  | RIGHT | 62               | TRAFFIC ACCIDENT | 1    | 79             | 85         | INTACT PLATE AND WIRES     | 56                          |
| 8.         | MALE   | 62  | RIGHT | 20               | FALLDOWN         | 0    | 100            | 100        | 2B1                        | 11.5                        |
| 9.         | MALE   | 60  | LEFT  | 36               | FALLDOWN         | 0    | 98             | 100        | 2B1                        | 24                          |
| 10.        | FEMALE | 62  | RIGHT | 41               | BICYCLE FALL     | 3    | 88             | 95         | 2B1                        | 38                          |
| 11.        | MALE   | 48  | LEFT  | 13               | TRAFFIC ACCIDENT | 1    | 68             | 68         | 2B1                        | 47                          |
| 12.        | MALE   | 57  | RIGHT | 80               | SUPDOWN          | 5    | 92             | 70         | 2B1                        | 2                           |
| 13.        | MALE   | 42  | LEFT  | 20               | MOTORCYCLE TA    | 0    | 97             | 60         | INTACT PLATE AND LAG SCREW | 16.5                        |
| 14.        | MALE   | 38  | LEFT  | 38               | SUPDOWN          | 5    | 55             | 51         | 1B1                        | 24                          |
| 15.        | MALE   | 47  | RIGHT | 56               | BICYCLE FALL     | 0    | 100            | 100        | PLATE FAILURE              | 26                          |
| 16.        | MALE   | 32  | LEFT  | 27               | SNOW BOARD       | 5    | 71             | 63         | PLATE FAILURE              | 15                          |
| 17.        | FEMALE | 51  | RIGHT | 43               | FALLDOWN         | 1    | 87             | 85         | FAILURE-PLATE N WIRE       | 12.6                        |
| 18.        | FEMALE | 42  | RIGHT | 18               | FALLDOWN         | 5    | 56             | 56         | 3B1                        | 10.5                        |
| 19.        | MALE   | 24  | LEFT  | 52               | FALLDOWN         | 0    | 85             | 93         | 2B1                        | 13                          |
| 20.        | MALE   | 52  | LEFT  | 54               | FALLDOWN         | 0    | 86             | 100        | 3B1                        | 12                          |

**Table 3****Fig. 1: X-ray non-union of clavicle****Fig. 2: Post-operative X-ray of non-union of clavicle with locking compression plate and screws with bone graft**



**Fig. 3: X-ray showing complete union of the fracture 24 months later after removal of the plate and screws**

**DISCUSSION:** Non-union is defined as no radiological or clinical signs of healing even after 16 weeks following injury.<sup>28</sup> Most middle-third clavicle fractures treated conservatively has been found to be associated with higher rates of non-union and patient dissatisfaction with the final result.<sup>31</sup> Even with the surgical treatment the optimal method of fixation is controversial.<sup>2</sup> Many studies have reported open reduction and internal fixation with plate and autologous bone grafting as an accepted technique for treatment of clavicle non-union.<sup>23-27</sup> In conformity with many other studies<sup>1</sup> majority of the fractures which were managed conservatively earlier were of type 2B1. However, classification could not be done on x-ray for the non-union cases which were treated earlier and a result of fixation failure. We had two cases of lateral 1/3<sup>rd</sup> fracture non-union of the clavicle and one medial 1/3<sup>rd</sup> in our study. Lateral 1/3<sup>rd</sup> fractures of the clavicle are difficult to treat due to their small size and about 45% of these end in delayed union and 30% may end up being non-union,<sup>32</sup> there was complete union in our cases and we used 3.5 mm AO LCP supplemented with bone graft. Seven out of 20 of our cases were either due to fixation failure or due to intact plate with non-union, three of them had cerclage wire along with the plate, the use of cerclage wire along with the plate is controversial with some studies showing increased risk of non-union<sup>33,34</sup> and others showing no risk of non-union if performed carefully with minimal soft tissue dissection.<sup>35</sup>

Our study showed 100% results in 20 cases of non-union treated with open reduction and internal fixation with plate and bone grafting using the corticocancellous bone grafts from the iliac crest; (Fig. 1 and Fig. 2) however, the modification was in the shape of the iliac crest graft where we shaped the iliac crest in the form of long slivers. Our results (Fig. 3) were comparable with other studies which also reported 100% union with autologous bone grafting and plate fixation (Table 1). O'Connor et al showed relatively lower union rates with only autologous iliac crest bone grafting.<sup>25</sup> However, many studies have reported good union rates when either autologous iliac crest bone graft, bone graft substitutes or in situ bone graft obtained from the ends of the hypertrophic non-union (Table 2). In all our cases, we used the superior approach as it is presumed to have greater biomechanical stability and tension band principle.<sup>36,37</sup> A study done by Collinge et al had ASES score of 93 in 58 patients treated with both midshaft clavicular fracture and non-union clavicle using plate fixation through anteroinferior approach.<sup>18</sup> We had an average Constant–Murley score of  $80 \pm 17$  (51-100) and ASES score of  $81 \pm 18.5$  (51-100), but the

low score in our case is probably because of the highly variable follow-up period (4-56) months.

Drawbacks of the study were that unfortunately we were not able to collect the preoperative ASES and constant scores, this would have shown us the actual improvement of disability, we could not get any similar study for non-union with which we could compare our scores.

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