International Journal of
Science Inventions Today
www.ijsit.com
ISSN 2319-5436
Review Article

ANTEROINFERIOR VERSUS SUPERIOR PLATING OF DISPLACED MIDSHAFT CLAVICLE FRACTURES

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ABSTRACT

The clavicle is large doubly curved long bone that connects the arm to the trunk of the body. It is 'S' shaped and is also known as a collarbone. It is the first bone in the body to be ossified and the last bone to complete ossification. Clavicle fracture (broken collarbone) has seen in all ages, but the midshaft clavicle fracture is the most common in adults. The traditional treatment of displaced midshaft clavicle fracture is nonoperative management. However, recently it has been reported that nonoperative management of displaced midshaft clavicle fracture has increased rate of complications. To reduce the complications, operative management results in better functional outcome and patient satisfaction. When a midshaft clavicle fracture requires surgical fixation, the commonly performed procedure involves either insertion of an intramedullary device or fixation with a plate and screws. A fixation with the screw and plate is considered the standard fixation technique (gold standard surgical option). Anteroinferior plating and superior plating are the two popular techniques for the fixation of displaced midshaft clavicular fracture.

Key words: Clavicle fracture; Displaced; Midshaft; Superior plating; Anteroinferior (AI) plating

INTRODUCTION

The large doubly curved clavicle_lies horizontally just above the first rib on the either side of the anterior chest wall. Its medial end articulates with the clavicular notch of the manubrium of the sternum and its lateral end articulates with the acromion process of the scapula. It is one of the most fractured bones in the body, accounting for 3%–12% of all fractures and as high as 66% of fractures around the shoulder [1]. The fracture of the middle third (midshaft) is the most common, accounting upto 80% of all clavicle fractures [2, 3]. When the midshaft clavicular fractures displaces, the proximal fragment generally is pulled superiorly by the sternocleidomastoid muscle while the distal fragment is pulled laterally by the weight of the arm [4].

A displaced midshaft clavicle fracture can be managed nonoperatively or operatively, but the outcomes following nonoperative treatments are being increasingly doubted [5]. However, literatures have shown increased rates of nonunion, symptomatic malunion, and unsatisfactory patient outcomes with nonoperative management of displaced midshaft clavicular fractures (DMCF) [6-8]. Various studies have demonstrated improved outcomes with surgical intervention for displaced, comminuted or shortened clavicle fractures in active individuals when compared to nonoperative management [6, 8-12]. It is still doubted whether all adult displaced mid-shaft clavicle fractures should be treated by operative fixation [13, 14].

The parameters to be evaluated favoring operation are displacement, shortening or comminution of the fracture, gender and age [7, 8, 15]. In addition to fracture characteristics (comminution, shortening and displacement), patient-specific factors such as demographics, baseline activity level or employment status must be considered when discussing treatment options [16]. A shift toward surgical treatment has been seen in recent decades. Surgical treatment of DMCF is most commonly done using plates and intramedullary devices. Studies have reported significant advantages using these surgical methods compared with nonoperative treatment [17]. Open reduction and internal fixation with a plate and screw has been considered a gold-standard treatment option for DMCF. Anteroinferior plating and superior plating are the two popular techniques for the fixation of DMCF. However, there is still controversy about the choice of the approach and implants during surgery [18]. The purpose of the review was to study the optimal plate position for DMCF.

Classifications of Clavicle Fractures:

Allman's classification [19]: The classification proposed on the base of anatomical location of fractures in 1967 is divided into three groups:

i. Group 1: Middle third clavicle fracture
ii. Group 2: Lateral third clavicle fracture
iii. Group 3: Medial third clavicle fracture

Neer's classification [20, 21]: Neer's classification is specific for the distal end fractures. Basically, these classifications are based on the location of the fracture in relation to the coracoclavicular ligament and their intactness.

i. Type 1: Fracture lateral to the coracoclavicular ligament attachment, which has very minimal displacement
ii. Type 2: Fracture medial to the ligament attachment. It is subsequently modified by Rockwood into 2A and 2B [22]
    - 2A (Rockwood) -both the conoid and the trapezoid ligaments are attached to the distal fragment
    - 2B (Rockwood) -conoid is detached from the proximal fragment while the trapezoid is attached to the distal fragment.
iii. Type 3: Fracture with intra-articular extension
iv. Type 4: Occurs in children where a periosteal sleeve gets avulsed from the inferior cortex with the attached coracoclavicular ligament and the medial fragment gets displaced upwards
v. Type 5: Is similar to Type 2, which involves an avulsion fracture leaving behind an inferior cortical fragment attached to the coracoclavicular ligament

Craig classification [23]**:** On the base of Allman's classification, Craig introduced in 1990 a more detailed classification of clavicular fractures that was based on the variable fracture patterns seen within the three board groups of Allman's clavicle fracture classification.

i. Type I: Fracture of the middle third
ii. Type II: Fracture of the distal third
    A. Minimal displacement (interligamentous)
    B. Displaced fractures, fracture medial to the coracoclavicular ligaments
        a) Conoid and trapezoid attached
        b) Conoid torn, trapezoid attached
    C. Fractures into articular surface
    D. Fractures in children, intact coracoclavicular ligaments attached to periosteal sleeve, proximal fragment displaced
    E. Comminuted fractures
iii. Type III: Fracture of the proximal third
    A. Minimal displacement
    B. Displaced
    C. Intra-articular
    D. Epiphyseal separation

E. Comminuted

Nordqvist & Petersson classification [24]: Nordqvist and Petersson classified Allman's classification based on displacement and comminution.

i. Group I: Middle third fracture
   A. Undisplaced
   B. Displaced comminuted
ii. Group II: lateral third fracture
   A. Undisplaced
   B. Displaced
iii. Group III: medial third fracture
   A. Undisplaced
   B. Displaced

Edinburgh classification [25]:

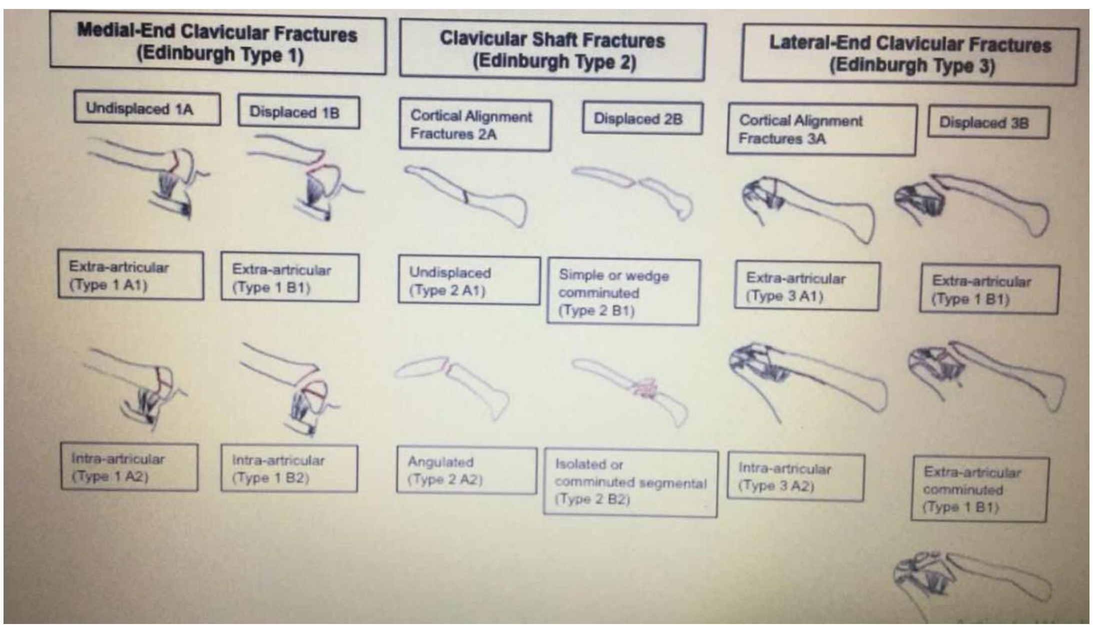

Figure 1: Illustration of Edinburgh classification [26].

Treatment of mid-shaft clavicle fracture [27]:

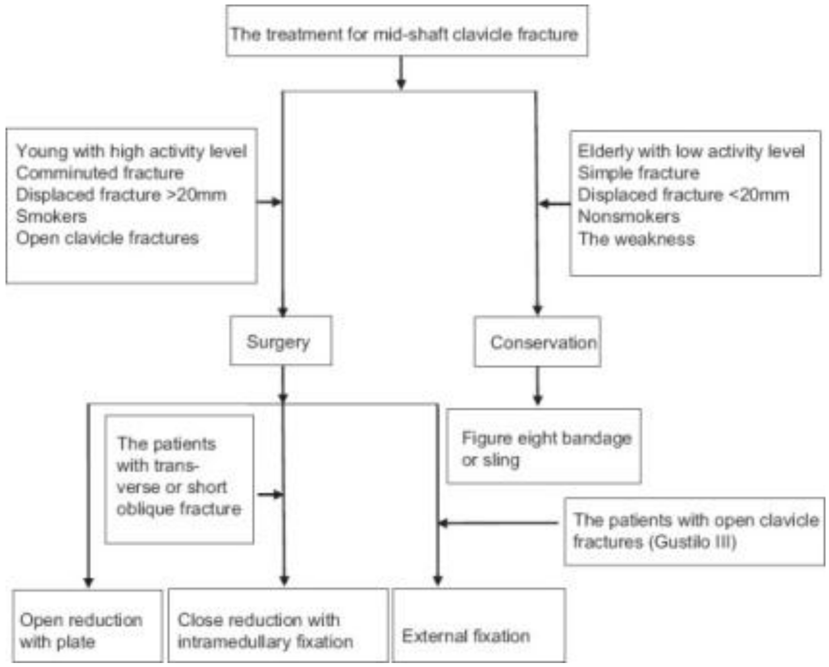

Figure 2: Algorithm for the treatment of mid-shaft clavicular fracture.

Surgical indications for displaced mid-shaft clavicle fractures:

a) Athletes [16]
b) Seizure disorder [16]
c) Cosmesis/patient discontentment [16]
d) Comminuted fractures [16, 28]
e) Fractures with >2 cm shortening or 100% displacement fractures [16, 28]
f) Open fractures or skin tenting [16, 28]
g) Floating shoulder [16, 28]
h) Neurovascular involvement [16, 28]
i) Prolonged or painful nonunion/malunion [16, 28]
j) Polytrauma [16, 29]
k) Vertical fragment [28]
l) Soft tissue interposition [8, 12, 30, 31]
m) An inability to tolerate closed treatment

Complications of plate fixation:

a) Neurovascular injury [32]
b) peri-incisional numbness or dysthesias [32]
c) Infection (deep or superficial) [32-34]
d) Implant prominence [32, 34]
e) Irritation [33]
f) Poor cosmesis [34]
g) Nonunions [32, 33]
h) Malunion [32]
i) Implant failure (breakage, screw pullout) [32-34]
j) Refracture as a result of removal of the plate [33, 34]
k) Scar or neuroma related pain [34]
l) Symptomatic acromioclavicular arthrosis [32]

DISCUSSION

The fracture of the midshaft clavicle fracture is the most common. Though the appropriate management of DMCF is still being debated, a shift towards surgical treatment has been seen in recent decades. The two popular plating methods (superior plating and anteroinferior plating) are considered safe and effective [32, 35] but there are some studies which reported advantage of anteroinferior plating over superior plating. The advantage of anteroinferior plating over superior plating are, safer screw trajectory [32]; reduced operation [36], blood loss and union time [35, 37], provides more rigid fixation in osteopenic bone, which will minimize fixation failure [35]; lower risk of neurovascular injury [38]; reduced implant irritation [39-41]; significantly lower rate of implant prominence at long-term follow-up [32]; better clinical outcome with higher fracture healing rate and lower fixation removal, especially using 2.7 mm dynamic compression plates [42]; significantly decreases the rate of secondary intervention, thus reducing the costs and risk of an additional surgery [32, 43, 44]; provides stronger bending stiffness [36, 38] and results in better appearance [36]. The advantages of superior plating are, allows fixation on the tension side of the fracture [28]; Provides higher biomechanical stability [39, 45, 46]; less soft tissue injury [39, 45, 46] and easier surgical technique [39, 45, 46]. There are also some literatures which reported good results after the plate fixation on the superior aspect of the clavicle [47-50]. But the main disadvantages of the superior plating are, little soft tissue coverage [51]; screw trajectories aimed towards neurovascular structures (greater risk of subclavian artery and nerve injury-neurovascular injury) [32, 51]; more implant related irritation [33]; higher rates of symptomatic hardware and more frequent implant removal than anteroinferior [9, 32, 52].

Hulsmans et al.[33] study found that an anteroinferior and superior surgical approach showed no significant difference in rates of implant-related irritation after a follow-up of at least one year. In a subgroup of patients in whom the plate was still in place, an anteroinferior position of the plate resulted in a higher proportion of patients without any complaints of irritation. In the study the patients requested for implant removal were mostly young (age <40 years). Wang et al. [53] reported that clinical symptoms (irritation) were particularly seen in younger patients. This may be explained by the fact that younger people are more often exposed to (athletic) activities that cause them to be more aware of their constraints. Nourian A. et al. [54] in meta-analysis concluded that plating along the superior and anteroinferior aspects of the clavicle lead to similar operative outcomes with respect to union, nonunion, malunion, and implant failure, as well as similar functional outcomes scores, but the plates applied to the superior aspect of the clavicle are associated with higher rates of symptomatic hardware and more frequent implant removal. Ai et al [37] in meta-analysis, the anteroinferior plating may reduce the blood loss, the operation and union time, but no differences were observed in constant score, and the rate of infection, nonunion, and complications between the two groups.

Partal et al. [38] concluded that the plate placing anteroinferiorly on the clavicle provides a more stable construct in terms of bending rigidity with no difference in axial and torsional stiffness compared with placing the plate superiorly. Author also believed that anteroinferior plating is preferred as a result of the increase in bending rigidity together with other advantages, including avoidance of neurovascular compromise, the use of longer screws and decreased hardware prominence. Other studies also have shown that anteroinferior plate placement leads to greater resistance to cantilever bending [55, 56]. Chen et al.[36] study demonstrated that anteroinferior plating has the best biomechanical properties and this surgical method can reduce the operation time, can avoid neurovascular complications, postoperative complications and have a better appearance. Author study also demonstrated that the plates placed at the anteroinferior position had a similar anti-torsion effect to the plates placed at the superior position. Iannoti et al [46]. thought that the plate placed at the superior position could provide better fracture rigidity, construct stiffness and strength in torsional and axial loading than one placed at the anterior position. More construct stiffness was achieved in axial compression and torsion (except for the oblique fracture pattern in clockwise torsion) with a superior plate [56]. Other studies have also reported greater biomechanical stability after superior plating and favor this treatment in load to failure as well as bending failure stiffness, which is a measure for deformation loads [45, 46]. Superior placement of the reconstruction plate may be recommended for a patient with a high risk of shoulder impacts (axial compression) [55]. Because of these contradictory results on biomechanical outcome and differences in testing mode, concluding whether anteroinferior or superior plating should be the optimal plating technique for clavicular fractures from a biomechanical point of view is difficult.

CONCLUSION

Clinically, most surgeons choose the fixation technique according to their preference and the development of materials. Recently anteroinferior plate application has drawn more interest because it potentially avoids neurovascular complications, is associated with less frequent implant irritation, less need for implant removal and have better appearance as compared to superior plate application. The biomechanical outcome is contradictory. Because of the contradictory results on biomechanical outcome, it is difficult to conclude whether anteroinferior plating or superior plating would be the optimal plating technique.

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