

Treatment of Distal Clavicle Fractures and Hook Plate Fixation Overview

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Abstract

There are several schemes for classification of lateral end clavicular fractures. Of these, the Neer classification is most widely used, Neer type I fractures are minimally displaced fractures that occur between or lateral to the intact coraco-clavicular ligaments. Neer type II fractures occur at the level of coraco-clavicular ligaments, with the trapezoid ligament remaining attached to the distal segment. Type II fractures can be further subdivided into type IIA, in which the conoid and trapezoid ligaments both remain attached to the distal fragment, and type IIB, in which the conoid ligament is torn. Type III injuries are intraarticular fractures that enter ACJ. Type IV fractures occur in children and they are considered physeal injuries. Type V fractures are multifragmentary fractures. The clavicle hook plate is designed to treat this problem by maintaining the acromio-clavicular joint biomechanics and this allows early mobilization and avoids the need for reconstruction of the coraco-clavicular ligament.

Keywords: Distal Clavicle Fractures, Hook Plate Fixation

Anatomy of the Clavicle

The radial nerve arises from the posterior cord of the brachial plexus. As all three trunks contribute The clavicle presents anteriorly in the shoulder girdle. It is a sigmoid shaped tubular bone with a double curvature, convex anteriorly in the medial part and concave anteriorly in the lateral part. (1)

It extends laterally and almost horizontally passing in front of the neck from the manubrium to the acromion being wholly subcutaneous. Its lateral third is flat while its medial two-thirds are rounded. (1)

Structure:

The clavicle consists of cancellous bone, enveloped by a compact bone, which is thicker in the intermediate part than at the periphery of the bone. Although the clavicle is classified as long bone, it has no medullary cavity like other long bones.

Gross features of the clavicle: (figure 1)

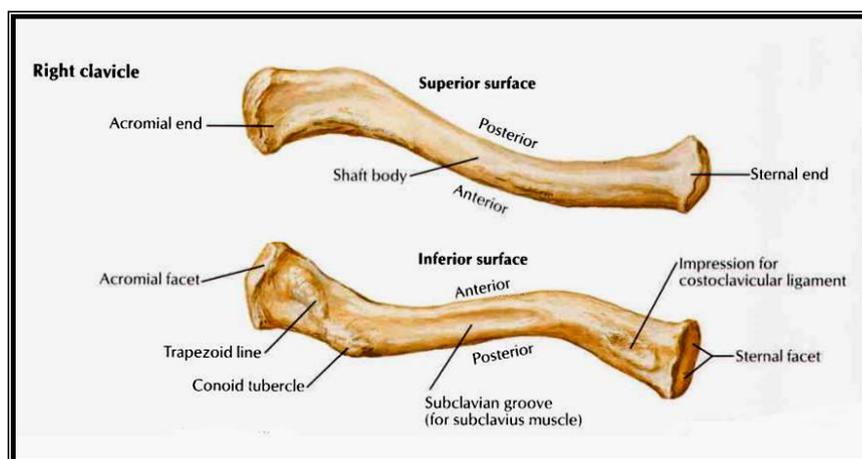


Figure (1): Superior and inferior surfaces of clavicle. (2)

◆ **The Shaft:**

The shaft is S-shaped being convex anteriorly in its medial two-thirds, and concave forwards in its lateral one third. The inferior aspect of its intermediate part has a groove in its long axis for subclavius muscle. (1) (3)

◆ **The lateral third:**

Is flat, it has a superior and inferior surface, posterior and anterior borders and a small oval articular surface which articulates with the medial aspect of the acromion, directed laterally and slightly downwards.

The anterior border is concave, rough and may show deltoid tubercle. The posterior border is convex, and its roughness made by muscular attachment. The palpable superior surface is smooth except near its margins. The inferior surface is roughened by the attachment of the two parts of coracoclavicular ligament, the conoid part which is attached near to the posterior border and the trapezoid part which is attached to narrow rough strip at the junction of lateral fourth to the rest of the shaft. (1),(3)

◆ **The medial two-thirds:**

It is roughly cylindrical or prismatic with four surfaces. superior and anterior surfaces are rough but laterally they are rounded and smooth above the infraclavicular fossa.

The inferior surface has a small oval rough depression near its sternal end and it's for the attachment of costoclavicular ligament. Rarely, this area is smooth or even elevated and may make a synovial joint for articulation with the first rib. Its lateral half is grooved for the attachment of the subclavius muscle. The posterior surface is smooth. (1) (3).

◆ **The sternal end: (figure 2)**

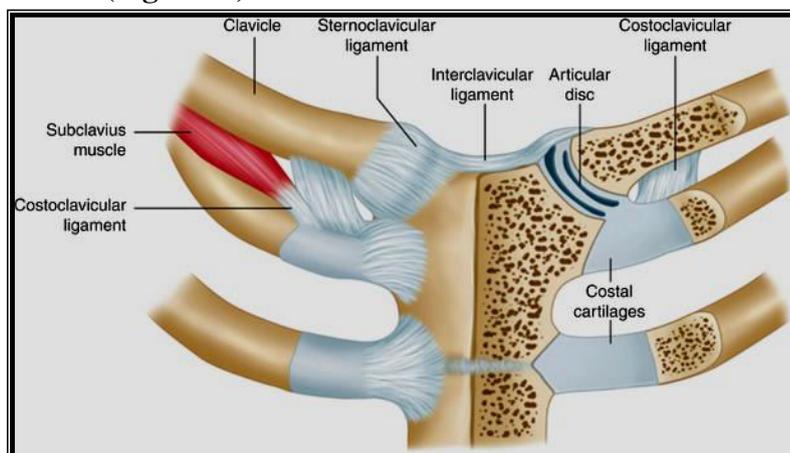


Figure (2): Anatomy of the ligaments surrounding the SCJ. (4)

Directed medially, forwards and slightly downwards, it articulates with the manubrium at the clavicular notch on its superolateral edge, Its sternal surface usually irregular, quadrangular (sometimes triangular) and somewhat rough above for attachment of sternoclavicular capsule, articular disc and the interclavicular ligament, The articular surface is smooth and extends on to the lower surface to articulate with the first costal cartilage. (1, 3)

The sternal end projects above the manubrium sterni and can be felt (Prominent clinical landmark)

◆ **The acromial end: (figure3)**

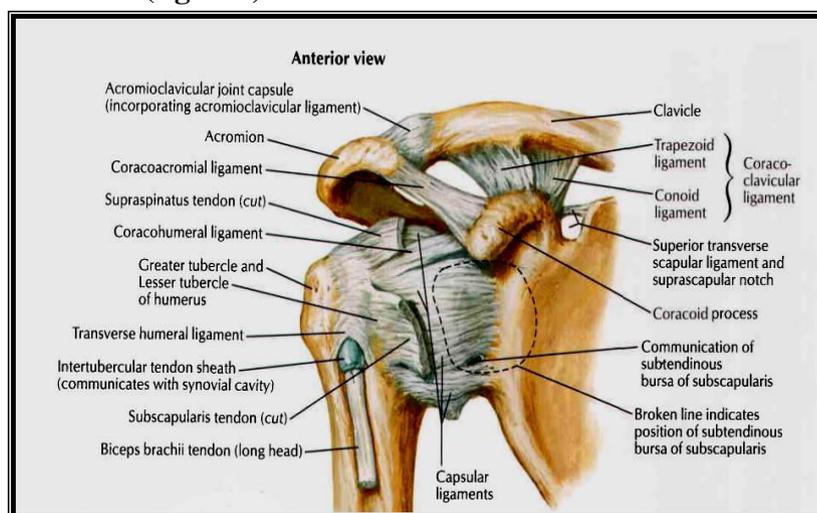


Figure (3): The acromial end of the clavicle. (2)

The acromial extremity has a small, oval flattened surface directed laterally and obliquely downward, to articulate with the acromion of the scapula. The circumference of the articular facet is rough, especially above, for attaching the acromioclavicular ligaments (1, 3)

Treatment of Distal Clavicle Fractures

Fractures of the distal third of the clavicle may heal with non-operative treatment. However, many authors recommend primary open reduction and internal fixation due to the deforming forces of the fracture and high incidence of nonunion, using either intramedullary fixation or some method of dynamic fixation to bring the medial clavicular segment to the lateral segment. Others have used a coraco-clavicular screw. Complications can occur with each of these methods, including wire migration. Plate fixation is often not practical because of the small distal segment (5)

◆ **Nonoperative:**

Neer recognized and classified fractures of distal clavicle as an entity different from other clavicle fractures because of their unique behavior.

Treatment options and recommendations for this fracture, therefore, are different of those of midshaft fractures and the literature is more controversial for this fracture type than for the mid clavicular fractures. In Neer's original series of clavicle nonunion, he discovered that, distal clavicle fractures accounted for one-half of the nonunions although they were uncommon. (6)

Most distal clavicle fractures with intact CC ligaments will heal eventually with non-operative management. Initial management usually requires temporary immobilization for comfort followed by gradual increase in activity.

Sling immobilization should be provided until the patient is comfortable to begin shoulder use, or the fracture shows early evidence of healing radiographically. Once this has been achieved, rehabilitative exercises can begin to restore strength, function, and range of motion.

The phases of non-operative treatment include:

- ◆ Temporary immobilization

- ◆ Passive range of motion
- ◆ Active range of motion
- ◆ Progressive resistance exercises

➤ **Phase (I): Day one to three weeks after injury**

Usually, immobilization is maintained for 3-4 weeks, After distal clavicular injury, it is important to maintain full motion of the unaffected joints to preserve joint motion and to reduce arm swelling.

These exercises are recommended:

- ◆ Open and closure of the hand.
- ◆ Squeezing of a soft ball.
- ◆ Flexion and extension of the elbow.

➤ **Phase (II): Three to six weeks after injury**

When pain starts to subside pendular exercises can be started. Assisted range of motion exercises of the shoulders are started with:

- ◆ External rotation
- ◆ Internal rotation
- ◆ Flexion with arms on table
- ◆ Flexion with ball on wall.

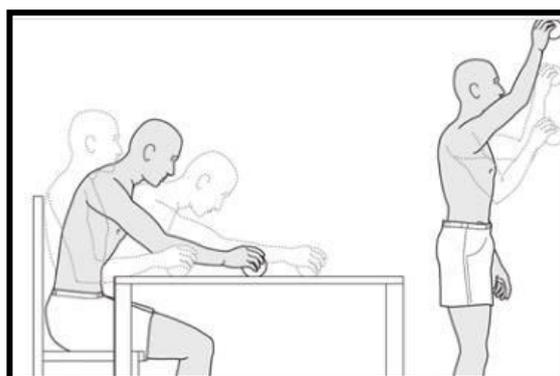


Figure (4): flexion with arms on table and flexion with ball on wall. (7)

Phase (III): Six to twelve weeks after injury:

Radiographic union of lateral clavicle fractures is often delayed compared to midshaft fractures. This should not delay the progression of rehabilitation, as most of these patients will obtain minimal pain nearly full function and despite radiographic evidence of delayed union.

Typically, return to contact sports or full activities is permitted beyond 6 months after full healing of the fracture, however, this may be sooner or later depending on progress of fracture healing and response to rehabilitation. (7)

◆ **Operative:**

Several authors have recommended initial surgical treatment for the unstable distal clavicle fractures (8,9,10,11)

Neer recommended trans-acromial k-wire fixation. In his original article (8) and reported that seven fractures treated with this technique healed at an average of 6 weeks.

In another study, good results were achieved with treatment with a trans-acromial Knowles pin.

(12) Kona et al however, reported high complication rate including deep infection and nonunion

with trans-acromial fixation and recommended against this technique (13). Neviasser recommended internal fixation using a cerclage wire. (14) Yamaguchi and colleagues used a temporary coraco-

clavicular screw to reduce the fracture. (15) Ballmer and Gerber reviewed their technique of indirect reduction of the fracture and placement of a coraco-clavicular screw. (16)

Kao et al also treated 12 patients with unstable distal clavicle fracture with k-wires and tension band with good results. (17)

Goldberg et al reported their technique of reduction of the fracture using Dacron tape passed around the medial clavicular segment and the base of the coracoid combined with suture fixation of the proximal clavicular fragment to the distal. (55)

Plate fixation is insecure, because the distal fragment is usually small and soft. Therefore, a hooked plate with an extension under the acromion has been developed to give more stable fixation, AO clavicle hook-plate was introduced in Europe in 1997 and in Asia in 2002. The design of this plate was upgraded to prevent fracture of acromion and other complications. (4)

Surgical technique of hook plate fixation:

- **Anaesthesia:** General Anaesthesia or regional block.
- **Position:** Beach-chair position, with head tilted away from the operated site and places it on a round support, A sandbag under the spine allows the arm to fall backwards, this aids reduction of the fracture.
- **Approach:**
 - Superior approach is usually used for this procedure.
 - Superficial dissection includes Deepening the skin incision through the platysma muscle to reach the subcutaneous surface of the clavicle. branches of the supraclavicular nerve should be preserved as possible (18), the safe zones lie within 2.7 cm of the sternoclavicular joint and 1.9 cm of the acromio-clavicular joint. (19)
 - Deep dissection includes stripping of soft tissue off the clavicle gently with preserving as much as soft tissue attachment as possible. (18)

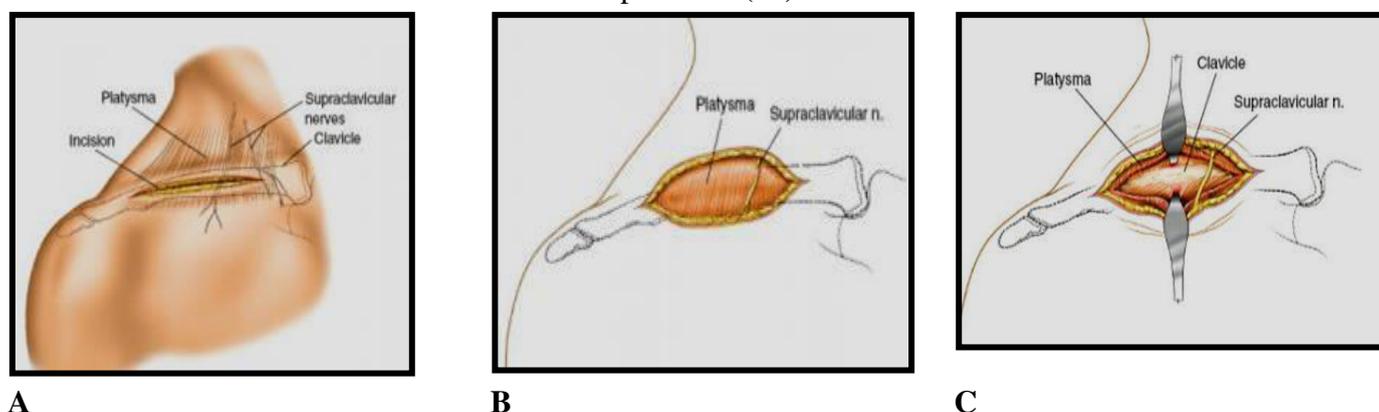


Figure (5): A. skin incision B. superficial dissection C. deep dissection (25)

• Surgical Procedure:

The surgical technique consisted of application of basic reduction and plating methods, following the operative procedure as advised by the AO. (26)

- After reflection of deltoid from distal clavicle, identification of acromio-clavicular joint by a sterile gauge needle.
- Reduction can be performed with different methods, depending on surgeon's preference and fracture configuration; direct reduction can be done using fracture clamps on the proximal and distal fragments. The hook plate can be also used to provide an indirect reduction of a distal clavicle fracture. (Figure 18)

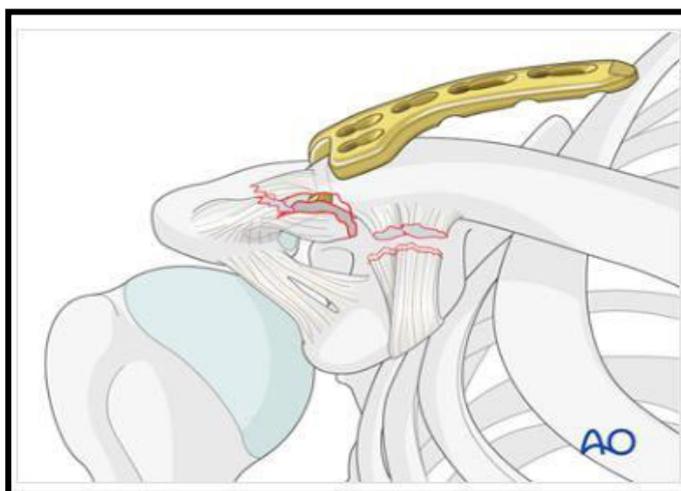


Figure (6): indirect reduction with the plate. (26)

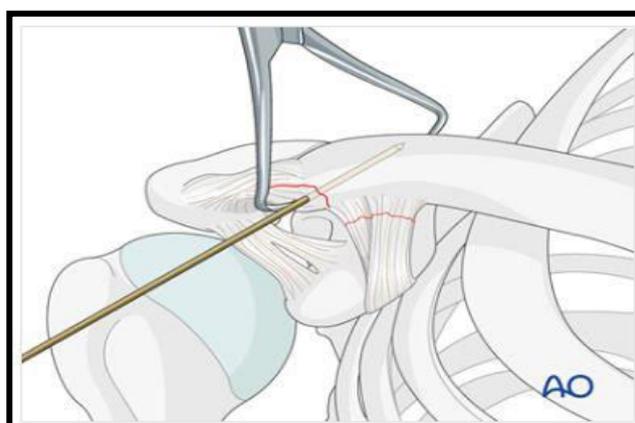


Figure (7): temporary fixation by k-wire.(26)

- A small incision is made at the posterior aspect of the acromio-clavicular joint to allow placement of the hook under the acromion.

AO Clavicular hook plate

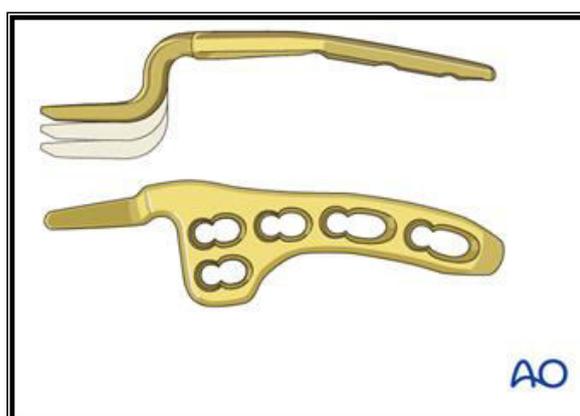


Figure (8): AO clavicular hook plate

Features:

- ◆ The 3.5 mm LCP (locking compression plate) clavicle hook plate provides fixation for lateral clavicular fractures and acromio-clavicular dislocations.
- ◆ Anatomically precontoured to facilitate optimal plate placement to improve outcome.
- ◆ Optimized implant selection
- Right and left plates

- Different sizes of plate with 4, 5, 6, 7 and 8 holes (figure 22)
- 3 hook depth 12 mm, 15 mm, and 18 mm. (figure 21)
- Stainless steel and titanium.

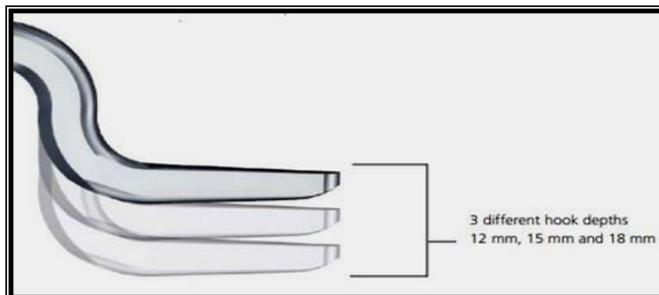


Figure (9): Different hook depth of clavicular hook plate.

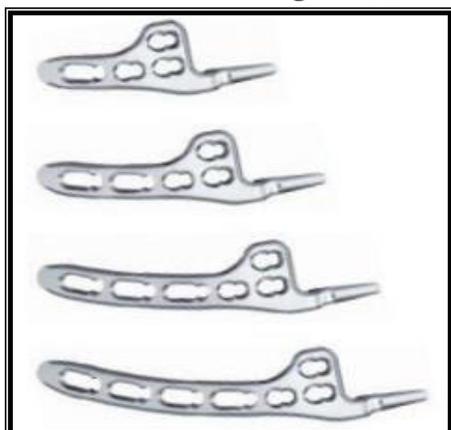


Figure (10): Different plate sizes.

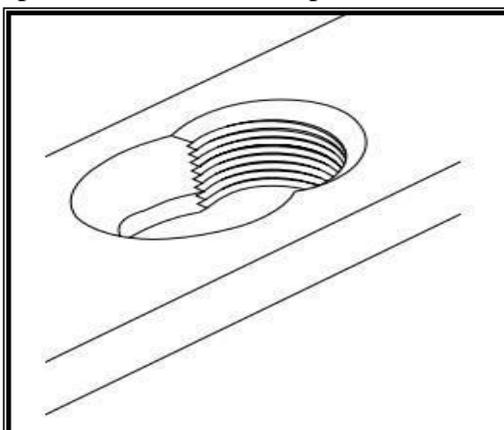


Figure (11) combi hole.

- Locking screws provide ability to create fixed angle construct.
- Fixed angle construct provides advantages in osteopenic bone and comminuted fractures.
- **Combi hole:** Intraoperative choice between compression and locking screws. (figure 23)
 - A. With standard screws for intra-fragmentary or dynamic compression.
 - B. Locking screws for stable plate screw connection.

Complications of clavicle fractures

Complications of nonoperative treatment

(A) : Nonunion:

Clavicle fractures are common, more than 75% - 80% present in the mid-shaft, and most of these fractures can be treated non-operatively and will unite without surgical intervention. (20)

Mukhopadhya and Rowe defined delayed union of clavicle fractures as the absence of clinical and radiological signs of union at six weeks, and they defined the nonunion of clavicular fractures as the absence of clinical and radiological signs of union at three months. They found that the incidence of nonunion of a fracture clavicle were varying from 1% to 15%. (21, 22)

Risk factors for clavicular non-union: (23)

1. Inadequate immobilization
2. Distal third clavicle > middle third clavicle
3. Comminution.
4. Displacement.
5. Z deformity
6. Female.
7. Old age.

8. Smoking.**➤ Inadequate immobilization:**

Although it may be difficult to determine time of union with certainty immobilization, by any method, should be continued until union is complete. Rowe suggested that the middle third of the clavicle healing periods usually as following: two weeks for infants, three weeks for children, four to six weeks for young adults, and six weeks or more for older adults. Moreover, it has been recognized that radiographic union may be delayed, with x-ray evidence of union not appearing for 12 weeks or more. When union is uncertain, immobilization should probably be continued. It has been suggested that a gradual increase in activity can be allowed safely when a fracture is clinically united, with no tenderness at the fracture site, even if radiographic union is incomplete. (24)

➤ Distal-Third Fracture.

About 85% of nonunion of the mid shaft. Despite this, it appears that the rate of nonunion is more in the distal third, Neer noted in his series on clavicular nonunions that distal clavicular fractures accounted for more than half of clavicular nonunion after nonoperative treatment. There are many reasons for this:

- ◆ Distal clavicular fractures are unstable, and weight of the arm and the muscle forces tend to displace the fracture fragments.
- ◆ Distal clavicular fractures frequently result from severe trauma, and this may affect fracture healing.
- ◆ Distal fractures are difficult to secure adequately with external immobilization.(6)

Treatment of nonunion:

- ◆ **If no symptoms:** no treatment necessary
- ◆ **If symptomatic,** ORIF with plate and bone graft (especially atrophic nonunion) (23)

(B) Post-traumatic Arthritis: (acromioclavicular arthritis) :**Risk factors**

Neer type I and III

Treatment:

Distal clavicle resection. (23)

Complications of operative treatment:

- A. Hardware problems.** About 30 %of patient request plate removal
- B. Infection (4.8%)**
- C. Neurovascular injury (3%):** Superior plates associated with increased risk of subclavian artery or vein penetration.
- D. Subclavian thrombosis.**
- E. Nonunion (1-5%).**
- F. Mechanical failure (~1.4%)**
- G. Adhesive capsulitis:** 4% in surgical group develop adhesive capsulitis that required surgical treatment.
- H. Pneumothorax. (23)**

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