Clavicle Fracture Management: An Updated Overview for Recent Options of Fixation

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Abstract

***Background:**Clavicle fractures are common fractures, comprising 5% to 10% of all fractures seen in emergency departments. Fractures of the middle third, or midshaft, are the most common, accounting for up to 80% of all clavicle fractures. They occur due to falls on the lateral aspect of the shoulder, the outstretched hand or due to high-energy direct impact over the bone. The incidence of clavicle fractures has increased in recent years and the operative treatment of these fractures has increased disproportionately. Clavicle fractures are most commonly classified according to the Allman classification and the Robinson classification. The location and type of fracture are important in decision-making as it influences management strategies. The clavicle acts as the only osseous link between the upper extremity skeleton and the thorax. In animals that do not bear weight on their forelimbs, it is absent. In such animals, the scapula is stabilized to the thorax by numerous powerful muscles. The absence of a clavicle improves running and agility on four limbs. In brachiating animals however, including man, it serves as a solid strut to position the upper limb away from the trunk and enhance more global positioning and use of the limb. Intramedullary fixation is often preferred over plate fixation because it is a simpler procedure. Intramedullary fixation has a smaller surgical incision, less invasive, easier hardware removal, and shorter hospital stay. Various devices can be used with this surgical option including Knowles pins, Hagie pins, Rockwood pins, and minimally invasive titanium nails. Devices need to be very flexible; the implant needs to be very stable, and it must be small enough to pass through the medullary space at its most narrow point in the midclavicle.*

***Keywords:**Midshaft Fracture Clavicle,Intra Medullary Fixation*

Anatomy of The Clavicle:

Gross Anatomy:

The clavicle is an elongated, S-shaped bone that rests horizontally at the sternum across the upper part of the ribcage, and the acromial end of the scapula[1].

It is made up of a medial two-thirds which is circular in section and convex anteriorly, and a lateral one third which is flattened in section and convex posteriorly, it has a role as main stability between the axial skeleton medially (through the sternoclavicular joint) and the upper limb laterally (through the acromioclavicular joint), in addition to its superficial location, explains why it is liable to injury[2].

This bone is an important part of the skeletal system since it plays an essential role in everyday functional movement, serving as the connection between the axial skeleton and the pectoral girdle[1] (Figure1).

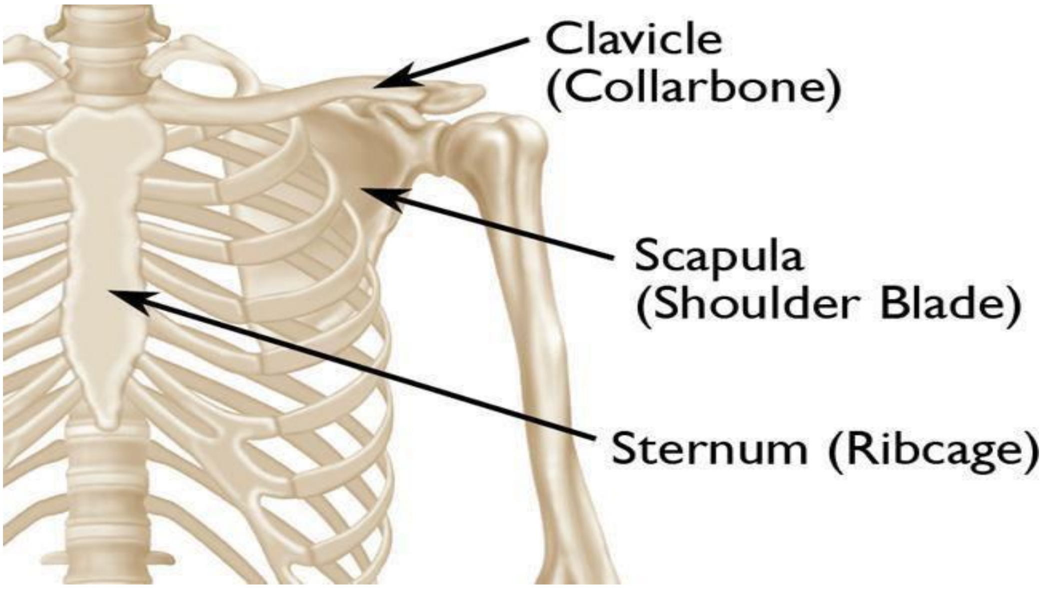

Figure (1): The clavicle and its location in the shoulder girdle [92]

As a result, the clavicle is able to act as a brace for the shoulder, allowing weight to be transferred from the upper limbs to the axial skeleton. Injuries of the clavicle seriously compromise everyday activities [1].

Articulations:

Due to the clavicle's structure, there are only two planar diarthrosis articulations that can be found. This type of articulation is also known as a 'double plane joint' where two joint cavities are separated by a layer of articular cartilage [1].

Acromioclavicular joint:

Which is formed by the acromial end of the clavicle and the acromion of the scapula respectively. It enables slight gliding movement about the shoulder region. The synovial joint is surrounded by a capsule of articular cartilage filled with intra-articular synovium [1].

From infancy, the articular cartilage starts as hyaline cartilage but soon develops into fibrocartilage (at the scapula acromion and the clavicle acromial end at ages 17 and 24, respectively). The acromioclavicular ligament forms a strong connection between the clavicle and the scapula acromion, which restricts movement about the clavicle at its acromial end [1].

The coracoclavicular (conoid and trapezoid) ligaments pass from the inferior surface of the clavicle to the base of the coracoid process of the scapula, these strong ligaments provide vertical stability to the acromioclavicular joint, they constitute the primary support by which the scapula is suspended from the clavicle; complete division of these ligaments is necessary for a complete superior dislocation to occur [1] (Fig 2).

Sternoclavicular joint:

Which is formed by the sternal end of the clavicle and the manubrium of the sternum. This synovial joint is important as it anchors the clavicle and scapula to the axial skeleton. However, the joint enables a variety of limited movements of the arm, including:

- Protraction and retraction.
- Depression and elevation.
- Slight rotation.

Like the acromioclavicular joint, the sternoclavicular joint is surrounded by an articular cartilage capsule, but with a fibrocartilage articular disk inside that creates a clavicular and a sternal synovial cavity. Sternoclavicular joint ligaments stabilize the joint on its anterior and posterior surfaces [1].

The joint is also reinforced by two accessory ligaments:

- The anterior interclavicular ligament, which covers the superior surface of the joint. This ligament is responsible for preventing dislocation of the clavicle upon shoulder depression [1].
- The posterior costoclavicular ligament, which runs from the clavicle costal tuberosity to the superior and medial surface of the first rib. In contrast, this ligament prevents clavicle dislocation upon shoulder elevation [1] (Fig 2).

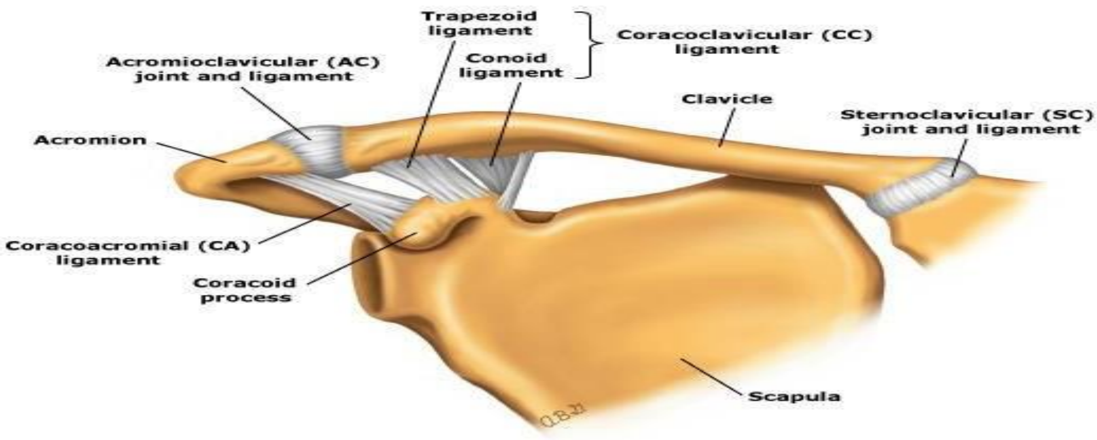

Figure (2): Articulation of the clavicle; acromioclavicular(ac)joint, sternoclavicular (sc) joint, with related ligaments [3].

Treatment of Fractures Clavicle

Traditionally, midshaft clavicular fractures have been managed non-operatively, even when substantially displaced [4,5] with good to excellent results [6,7]. Recent evidence, however, reveals that the final result of non-surgically midshaft clavicular fractures, particularly those with quite large displacements or shortening, is not like that which was previously thought, demonstrating higher rates of delayed union, non-union, shoulder weakness and residual pain [8,9].

Conservative (Non-operative) treatment:

Non-operative treatment is warranted for fractures in children, simple fractures with minimal displacement, and fractures in patients with low compliance without indication for surgical treatment [10].

Figure (3): Simple midshaft fracture with minimal displacement.[11]

Non-operative treatment is focused on pain management and either a sling or figure-of-eight bandage. The figure-of-eight bandage allows for an extension by pulling the shoulders back in an attempt to prevent clavicular shortening and malunion. For the figure-of-eight bandage to work appropriately, it must maintain its tension and often needs to be tightened daily.

The use of a sling has also shown to be beneficial and is often more comfortable for the patient than the figure-of-eight bandage [11].

The sling assists in immobilization of the affected arm as well as allows for comfort by supporting the weight of the arm.

Figure (4): Arm sling (above), and Figure-of-eight bandage (below) as a conservative treatment of fracture clavicle.[77]

Adults who sustain a midshaft clavicle fracture do heal non-operatively. When treating non-operative, the initial treatment is immobilization (sling or figure-of-eight bandage) until the pain is resolved, usually 2 to 4 weeks. At the time of pain resolution, patients are allowed to work on a range of motion and then light resistance to be added at six weeks. Athletic could be returned to play after non-operative treatment is on the average three months.

The limits associated with non-operative treatment are, in fact, the risk of nonunion, malunion, altered biomechanics of the upper girdle, deformity with unsatisfactory cosmetic results, and upper extremity weakness [13,14].

Surgical (operative) treatment:

Absolute indications are the presence of open fractures, high commination and/or displacement of the fragments, high risk for in–out skin wounds, a shortening superior to 20 mm, floating shoulder and neurovascular lesions. Relative indications are polytraumas, painful malunions or nonunions[14,15]

Operative treatment of displaced MSCFs can be achieved successfully using plates or intramedullary (IM) implants like Rush pins, Kirschner wires, or titanium elastic nails [14].

Plate fixation:

Operative measures of internal fixation have included dynamic compression plates, tubular plates, or reconstruction plates. Plate fixation is commonly used to surgically treat displaced midshaft clavicle fractures. 3.5mm Plate fixation was been a procedure of choice since it allows for immediate stability and rapid postoperative mobilization [15,16]

There have been many reports of successful plate implants, however, complications have also been reported. 3.5mm Plate fixation is also associated with higher neurovascular risks [65]. Due to the local anatomical structures, it is recommended option the plate be removed because of undue pain or discomfort. Plate fixation complications have included implant failure, nonunion,

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infection, and refracture after plate removal, hypertrophic or dysesthetic scars, implant loosening, intraoperative vascular injury [65,69,71]. Reconstruction plates are prone to leading to deformation at the site of the fracture, decreasing the chance of union [16].

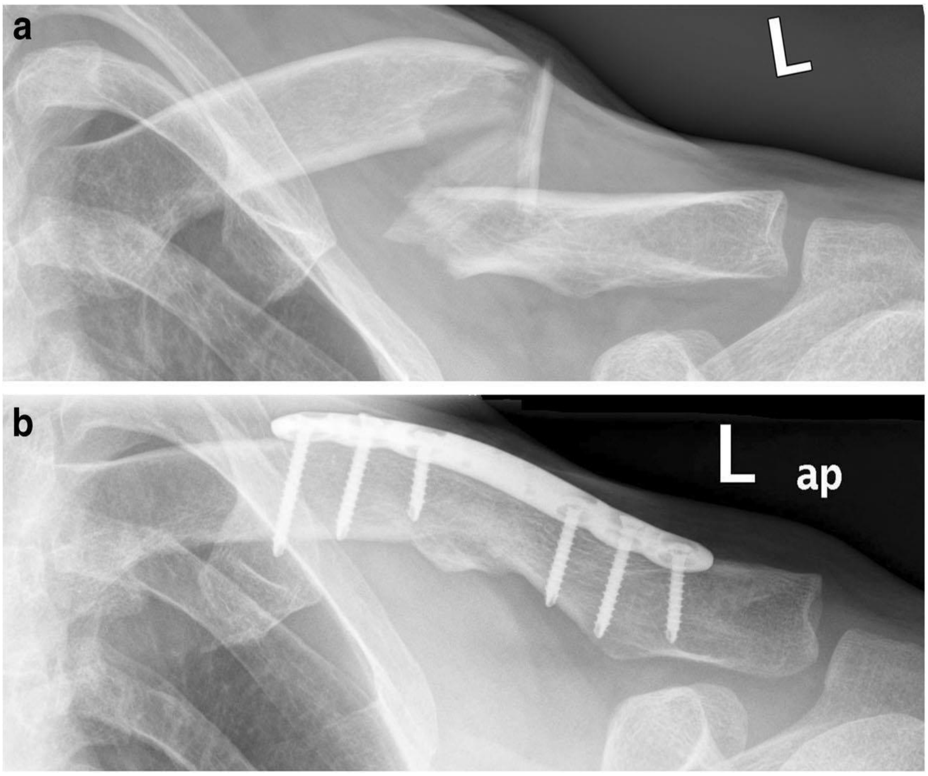

Figure (5): Fracture midshaft clavicle with plate fixation; pre & post operation x-ray.[16]

A majority of the infections reported from plate fixations were found to be wound infections that were treated successfully with oral antibiotics. furthermore, 3.5mm plates and screws require significant soft tissue stripping, which may compromise the blood supply to the clavicle and interfere with subsequent healing. The bicortical screws on the clavicle may act as multiple stress raisers leading to fractures [17]

Figure (6): Fracture clavicle with broken plate fixation due to stress.[20]

Intramedullary fixation:

Intramedullary fixation is often preferred over plate fixation because it is a simpler procedure. Intramedullary fixation has a smaller surgical incision, less invasive, easier hardware removal, and shorter hospital stay [17]**.** Various devices can be used with this surgical option including Knowles pins, Hagie pins, Rockwood pins, and minimally invasive titanium nails [16]

Devices need to be very flexible, the implant needs to be very stable, and it must be small enough to pass through the medullary space at its most narrow point in the midclavicle[7]**.**

Additionally, the implant must be stable enough to neutralize the potentially disruptive forces. Though intramedullary fixation is often preferred, it does not allow for as much rotational stability as plate fixation [18].

Figure (7): Fracture clavicle with different devices of intramedullary fixation; at Lt Titanium nail, at Rt Rockwood pin.[19]

In addition, pin migration has also been reported as a concern. Intramedullary fixations was concluded the procedure was minimally invasive with excellent functional and cosmetic results.

It has been suggested intramedullary fixation should not be the treatment of choice if plate fixation will maintain the clavicular length [20].

In addition, complications include implant shortening, implant breakage, temporary brachial plexus palsy, and skin break down where the hardware is inserted [65].

However, besides the great response in healing rates, intramedullary fixation has been associated with complications.

The majority of reported complications have been superficial infections, however, delayed union, non-union and refractures have also been reported [20].

Biomechanically, intramedullary bracing using elastic titanium nails allows the optimal position of the implant to maintain tension adequate position under loaded stress [20]. It is minimally invasive and provides pain relief. Intramedullary nailing allows for a stable fixation for early function and restitution of clavicle symmetry. The disadvantages are the cost of the implant and the need for implant removal after the union.

All hardware was removed once the union was complete on an average of 6 months postoperative [21]**.**

Surgical procedures of intramedullary fixation:

Intramedullary fixation (Elastic nailing) was done using the technique described first by Jubel et al[22]. A small skin incision was made approximately 1 cm opened using an awl pointed laterally and angled at about 30 degrees to the coronal plane in line with the clavicle. Care was taken not to perforate the dorsal cortex in order to avoid major complications. Single elastic nails of different diameters varying from 2 to 3.5 mm, were used, depending on the width of the bone. To obtain the exact position of the titanium elastic nail (TEN), fluoroscopy with true perpendicular views was used. Closed reduction was done under an image intensifier and provisionally fixed with two percutaneously pointed reduction clamps. In some cases, close reduction of the fracture site could not be done, so an additional small incision was made above the fracture site for direct manipulation of the main fragments before the nail was introduced into the lateral fragment and the fracture was compressed. Care was taken to avoid perforation of the dorsolateral cortex of the lateral clavicle. The TEN was cut as short as possible at the medial end[22]

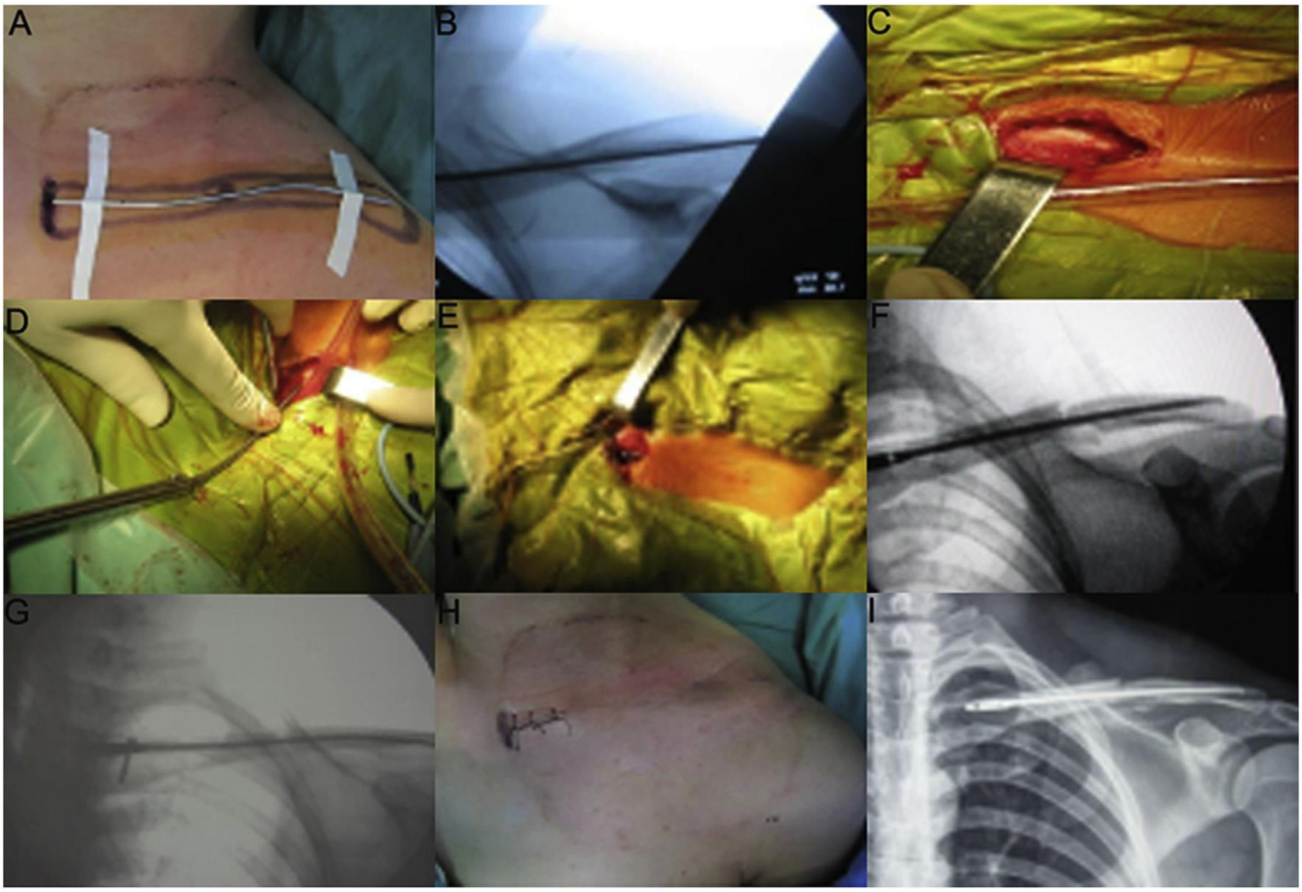

Figure (8): Surgical procedures of intramedullary nailing using TEN. (A) external location with Kirschner wire; (B) the length of TEN measured under the fluoroscopic control of C-arm machine; (C) the medullary cavity opening with a small size incision in the inner end of clavicle; (D) the insertion of TEN from the inner end of clavicle; (E) the outlook after TEN is completely inserted into the medullary cavity; (F) a good position of TEN is seen using C-arm machine; (G) locking the screw at the tail part of TEN; (H) the postoperative outlook of small size incision; (I) a radiograph obtained just after surgery shows a good position of TEN and satisfactory reduction of fracture.[24]

ConflictofInterest: Noconflictofinterest.

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