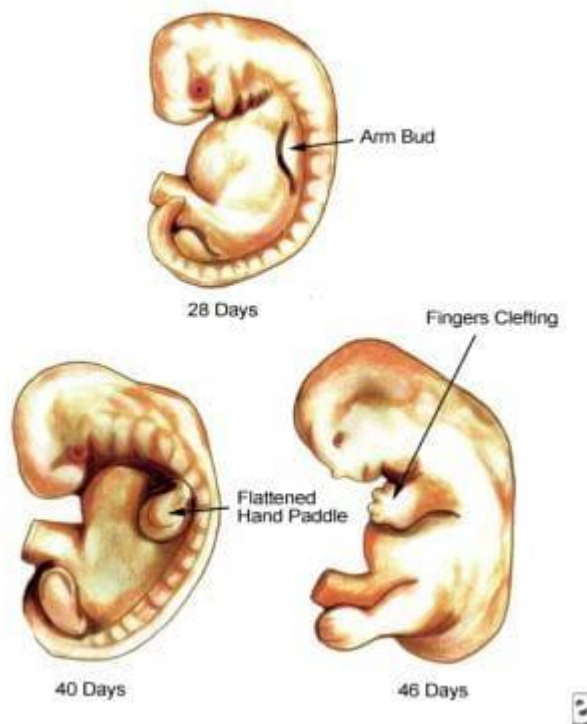


Clavicle Fractures

Maxime Coles MD

The clavicle is the first bone to ossify in a human embryo. It is believed that at around 5 weeks of gestation, the primary ossification centers of the clavicle are already present through a membranous ossification at two centers with no prior cartilaginous anlage (contiguous cells arranged in one plan but morphologically indistinct). These centers will fuse soon. The pectoral limb bud and the endochondral pectoral appendage are visible at 2-3 weeks of gestation, allowing the formation of the embryonic region of the clavicle and the neck.

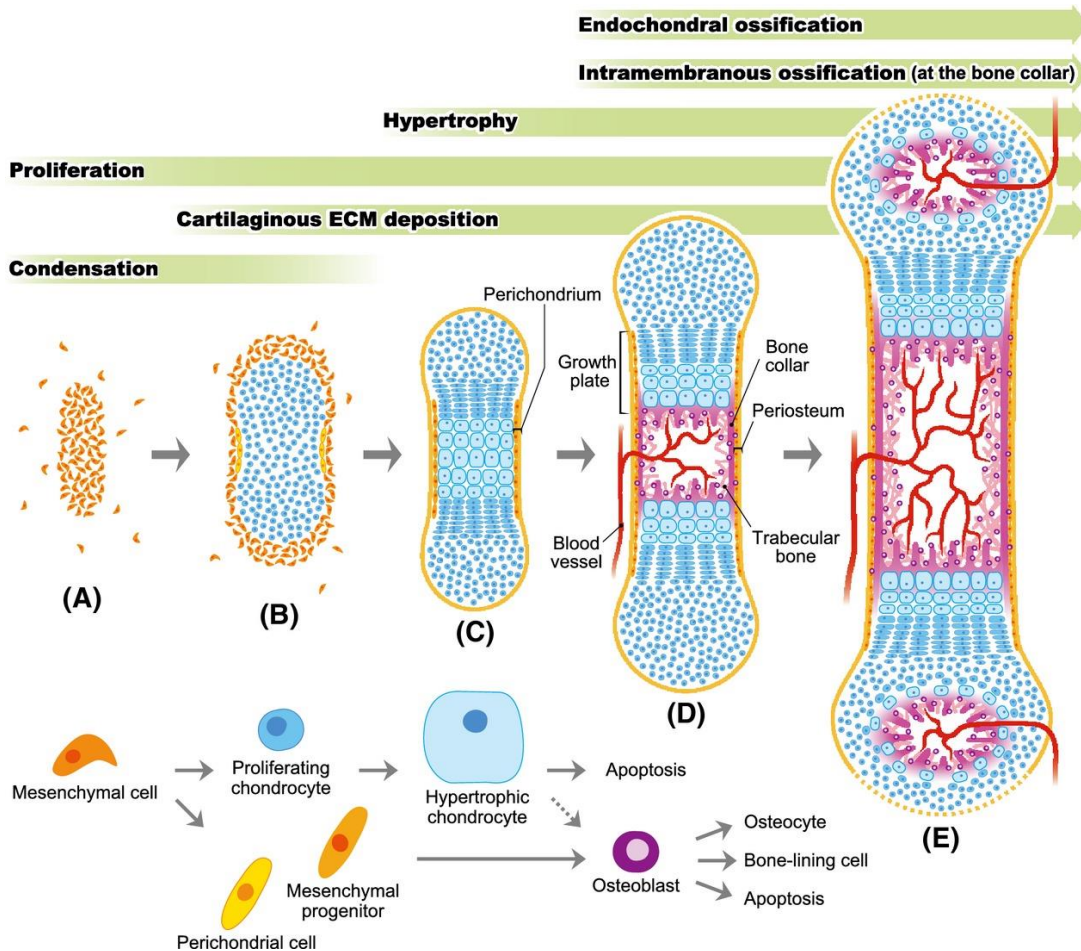


Embryo with an “arm bud” at 28 weeks of gestation

This is, in a way the reason why a clavicle is seen at birth, and it becomes the most common bone to break during delivery, in the birth canal. In the newborn, the growing individual or in the adult, the clavicle (collar bone) is commonly fractured and represent 5% of all adult fractures. Most clavicle fractures are seen after a fall

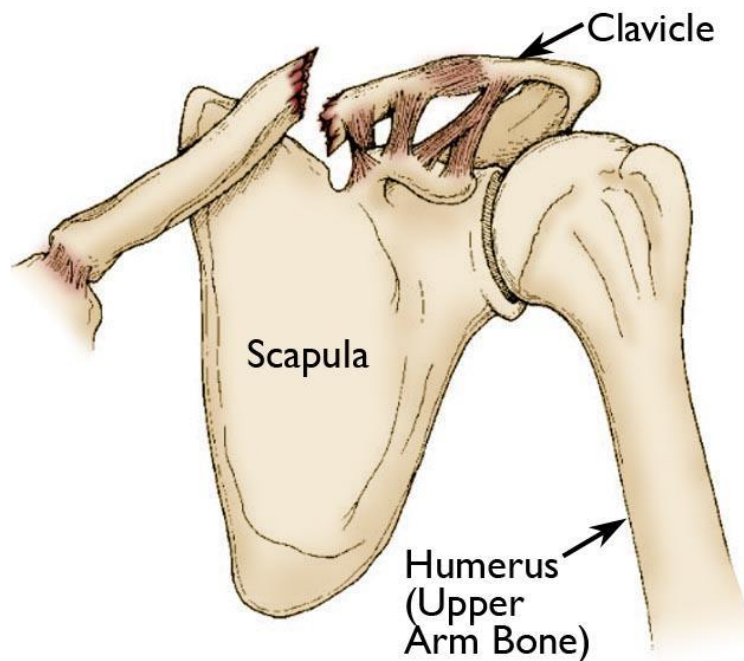
on the shoulder especially on an outstretched arm, creating a pressure on the bone which snaps or breaks. A broken clavicle can be painful at mobilization of the upper extremity.

The clavicle is formed by two membranous primary ossification centers appearing at 6 weeks of gestation and fusing approximately one week later allowing cartilage to develop at both ends. The medial cartilaginous mass will contribute more in length of the clavicle. Both masses will work to provide the shape of the bone. It may be possible that cartilaginous nests persist in the middle part of the clavicle.





The clavicle is located between the ribcage (sternum) and the shoulder blade (scapula). It is the bone that connects the arm to the body.



Many clavicle fractures can be treated by just wearing an arm sling to prevent the arm and shoulder from moving while the bone heals. Often a padded clavicular strap (Figure eight) may immobilize the clavicle better especially in children. Such fractures may be comminuted or angulated presenting a challenge to treatment. The fragments may show comminution or displacement placing at risk the vital structures in the area like the blood

vessels, the brachial plexus, the lungs etc. For the more complicated injuries, it is always better to approach such fractures surgically.

The limb development at itself can be the topic of an extensive discussion. Early in limb outgrowth, a thickening develops along the ventromedial border of the limb bud forming the “apical ectodermal ridge (AER)”, to provide an axis of orientation and digitation. This is an oblong marginal structure thickness at the limb apex: 2-5 cells in thickness covering a layer of undifferentiated mesenchymal cells, essential in limb outgrowth (PZ). Those 2 zones contain a large marginal blood supply, which branches at the base of the limb bud to join the cardinal vein. They convey messenger proteins to integrate the process.

The limb continues to grow outward from the ventral wall but, reaching day 32, a flattened and paddle-shaped hand plate is formed. On the fifth week, the mesenchymal cells condense to form a blastema which eventually will develop into cartilaginous models of the upper extremity bones. Nerve ingrowth followed also occurs from the rami of the spinal cord. By the sixth week, hyaline cartilage models of the proximal bones of the extremity are formed.

At seven week, the upper extremity rotates 90 degrees and the elbow project posteriorly, then the development of the hands lying in the thorax while the cartilaginous models of the bones are undergoing ossification through their respective ossification centers within their diaphysis. Mesenchymal cells deriving from the dermatome condense within the connective tissue scaffolds to form 2 common muscle masses. They are soon penetrated by the spinal nerves and the masses of muscles split to form a group of extensors and a group of flexors respectively.

The development of fingers continues as the AER begin to fragment to form the rays (fingers) until day 46. At day 50, the fingers are webbed and will separate at day 52 through an “apoptosis” (cell death) of the interdigital webspace. The end of eighth week correspond to the end of the embryonic period and the beginning of the fetal period in which vascular penetration of the bone will follow (humerus). Ossification and growth will proceed through the fetal period. The most critical period for development of anomalies is during the 24th through the 36 days of life. The common muscle mass will continue to separate for individual muscles while the joints cavitate and become functional. At birth, the limb is fully formed but

eventual ossification of the epiphysis and the carpal bone and the myelinization of the nerve will follow.

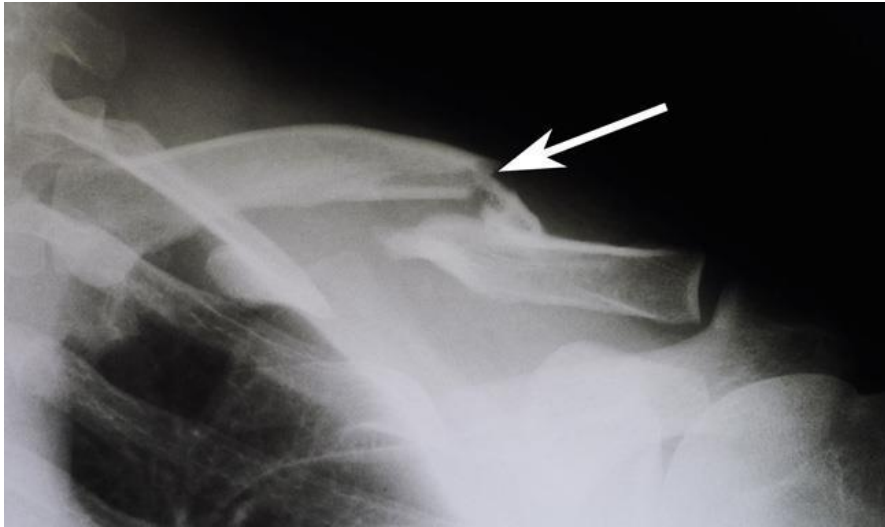
Now that we know about the embryology of the upper extremity, we will discuss fractures of the clavicle. I have already stated the reason why such fracture is so common at birth and represents 5% of all fracture occurring in people at any age. The middle portion (shaft) is more often broken, it may also happen at either end involving the sternoclavicular or the acromioclavicular joints. The fracture can be simple or in many pieces (comminuted) or can remain aligned or be displaced. In any way, the mechanism of injury is important to determine the extension of the traumatism.

A direct blow to the shoulder can fracture the clavicle. Motor vehicle accidents, Sport injuries are other common mechanisms especially when one falls on an outstretched upper extremity. Any clavicle fracture is painful although some pathological fracture may not be too apparent or symptomatologic. Deformity and mild swelling can be apparent while it becomes painful to move the involved extremity. Deformation of the clavicle with sagging of the shoulder downward and forward. Inability to raise the involved extremity. A grinding sensation at mobilization of the extremity, discomfort, and inability to raise the arm, bony crepitation and an obvious deformity or a deformation over the broken area. Bruising and swelling as well as pain are striking signs.

What are the symptoms? The examination of the shoulder needs to be meticulous. An obvious deformation at birth or following an injury in the older child or adult may certainly be suspicious of such injury. Gentle pressure or percussion over the area may illicit pain and discomfort, or possibly a bony crepitation. Is the fracture a closed or an open injury with fragments protruding through the skin, creating an open fracture? It is of a rare occurrence but more often the skin can be tented with a possibility of the fragments protruding through the skin.

It is imperative to request a radiological study to help pinpoint the location of the fracture on the S shaped clavicle, as well as to evaluate the severity and the comminution of the break. Standard X-Rays or even a CT scan may be necessary to evaluate a clavicle fracture. A CT-Scan may provide substantial details especially when either end is involved in a fracture or a dislocation. If there is displacement or comminution, further studies may

also be like an arteriogram may be needed to evaluate the vascular tree to the upper extremity.



X-ray shows a displaced fracture in the middle of the clavicle.

Clavicle fractures fracture can be treated conservatively according to the age of the patient. If the broken parts have not shifted substantially, no surgical treatment is needed. A simple arm sling is sufficient for any adult above 75 years old. As far as the newborn, I have learned during the time of my orthopedic residency that the application of a simple band-aid on the extremity, may be sufficient to bring special attention to the broken extremity and offer a reminder to handle the child with care. Arm support under the form of an arm sling to keep the extremity supported while the injury heals.

Padded clavicular strap maybe popular in treating adolescents until competent callus formation is appreciated. Additional medication like acetaminophen or light pain medication can also be used to relieve the symptoms. Physical therapy added to the pendulum exercises and range of motion will prevent stiffness because you may lose some strength during the conservative treatment. Strenuous exercises will gradually restore the functions of the extremity involved. Subsequent radiological studies will appreciate the healing process. If the fracture fails to heal (non-union) or is misaligned (mal-union) or even foreshortens the clavicle or is deformed, it may become a permanent source of pain which may require surgical treatment.



A Padded clavicular strap of Figure of eight splint

The first thing a physician will ask is an X-Ray to determine the site of the fracture and evaluate the comminution. Generally, there are three types based on their location near the sternum Medial end (5 %), near the Acromio-clavicular joint but the most common location is in the middle shaft of the bone. Immobilization with an arm sling or a padded clavicular strap also called figured-of-eight splint is often preferred and recommended in most of the fractures. The adolescent often will find the bandage uncomfortable and irritating for the arm-pit.

Arm support under the form of an arm sling to keep the extremity supported while the injury heals. Padded clavicular strap maybe popular in treating adolescents until competent callus formation is appreciated. Additional medication like acetaminophen or light pain medication can also be used to relieve the symptoms. Physical therapy added to the pendulum exercises and range of motion will prevent stiffness because you may lose some strength during the conservative treatment. Strenuous exercises will gradually restore the functions of the extremity involved. Subsequent radiological studies will appreciate the healing process.

If the fracture fails to heal (non-union) or is misaligned (mal-union) or even foreshortens the clavicle or is deformed, it may become a permanent source of pain which may require surgical treatment. Occasionally, we may be dealing with a cosmetic issue on a healed fracture presenting a protuberant callus in which case, surgical treatment may be required especially if we are dealing with a young woman. Finally, it may be a pathological fracture from a primary bony lesion or a metastatic lesion

which can become problematic to treat. Let us review a little the different options an orthopedist may enjoy to treat such fracture.

Current literature has clearly shown that the indications for surgical treatment of clavicle fractures in adults are expanding. Although clavicle fractures in children and adolescents have traditionally been treated nonoperatively, surgical treatment of displaced clavicle fractures may be indicated for adolescent athlete and rapid return to competition can be achieved with surgical treatment. One has also to expect complications like screw loosening, infection, pins migration even re-fracture or local discomfort like loss of sensibility and numbness because of cutaneous nerve injury.

A displaced and foreshortened or comminuted clavicle can present a dilemma for the orthopedic surgeon even if length and alignment can be obtained, but the risk of losing the blood supply to the fragment may force the surgeon to deal with a non-union or a mal-union with poor outcomes. The clavicle remains the most commonly fractured bone in children and adults accounting for almost 15% of all fractures but almost 45% of all shoulder fractures. During my years of residency, the tendency was to try to stay away from surgically treating a clavicle fracture unless a comminution or an open fracture was suspected jeopardizing the neurovascular status of the extremity (subclavian Neurovascular bundle). Advances in trauma has pushed the limits of the orthopedic surgeon to such an aggressivity that more clavicle fractures are now treated surgically. We will have to wait for and review this new trend in term of complications and disabilities in all age group to accept the proper indications.


There is no doubt that a faster return to competitive sport can be achieved via surgical treatment but the complications remain an obstacle. The middle-third is certainly the most common area involved but any such fracture of that level can injure the growth potential of the bone before maturity is achieved at twelve years of life. This can jeopardize potentially the remodeling process. Less than 2 centimeters of shortening can be well accepted.

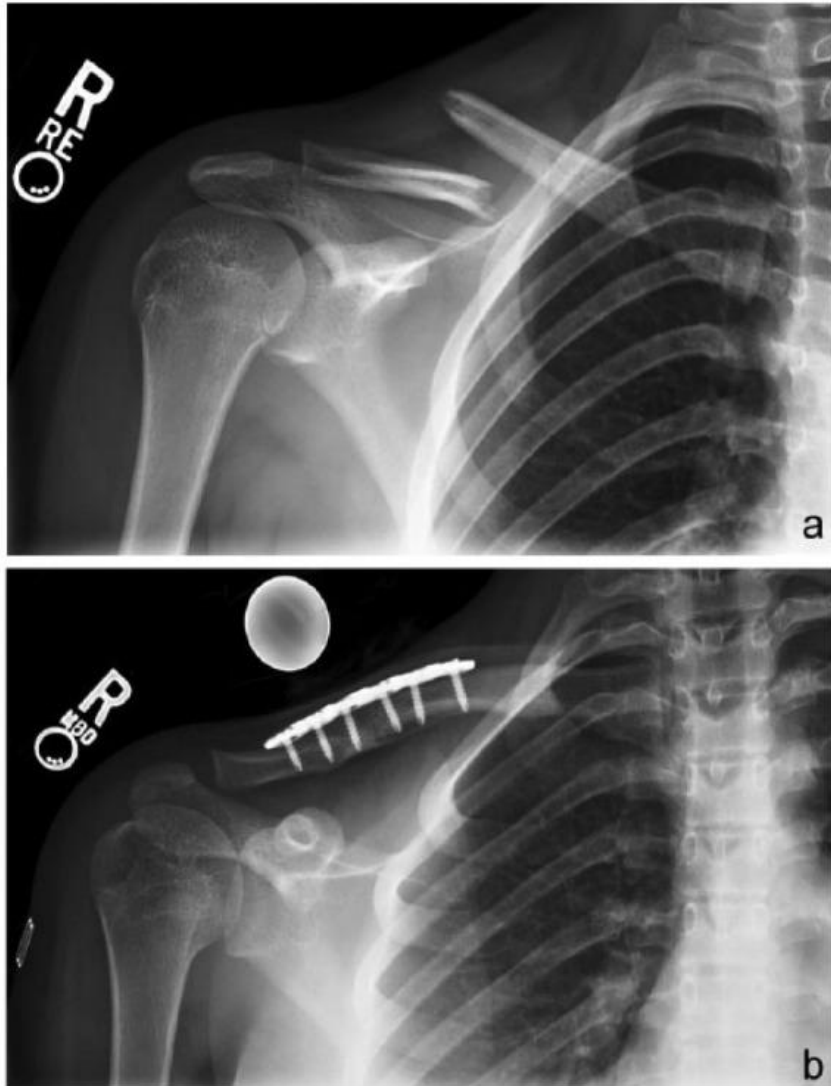
The treatment of a comminuted clavicle appears to favor surgical treatment unless we are dealing with a pathological fracture. With the

learning curve in dealing with trauma, the time for the Figure-of-eight immobilization or the arm sling may become absolute leaving place to a more aggressive treatment.

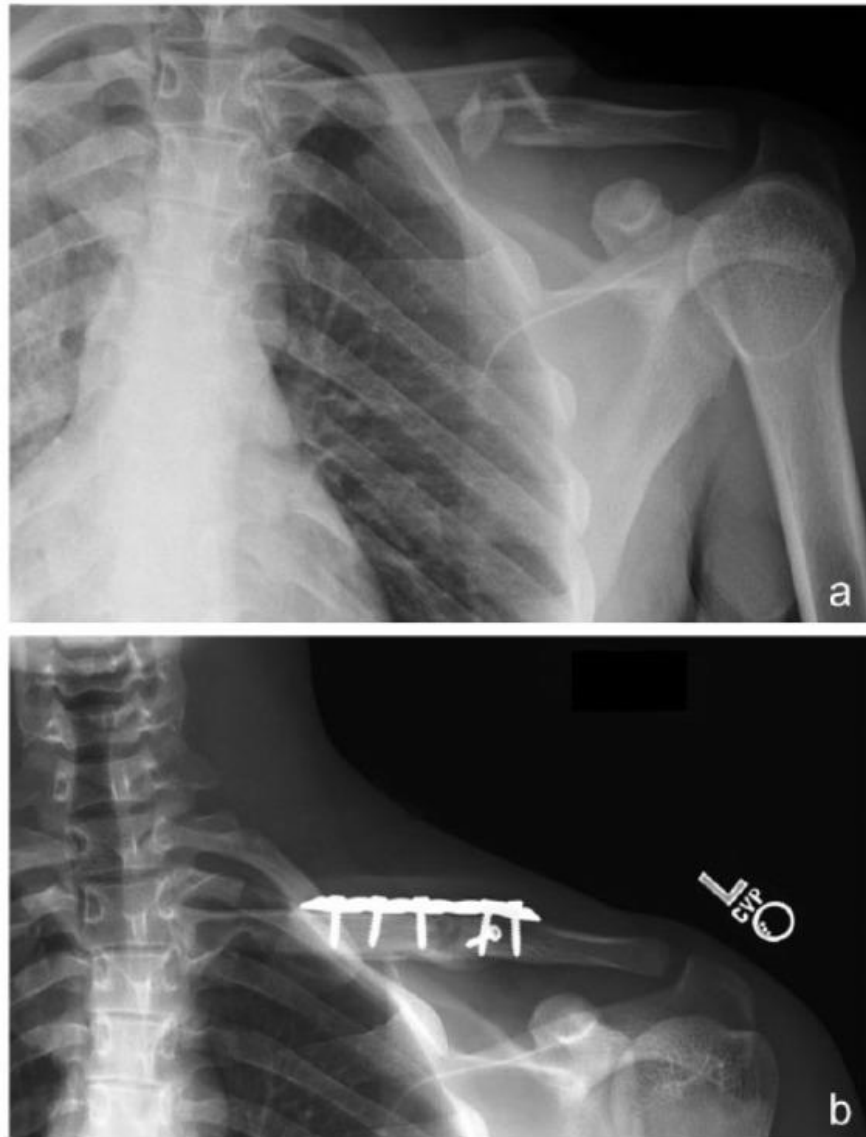
Several studies are already compared surgical vs non-surgical treatments among adult athletes with significant advantages in post operative strength and recovery for a faster return to competition in the operated groups. A decrease in the abduction strength especially in the throwing athletes was observed in the operated group while in the non-operated group almost half of the non-operated patients has demonstrated a persistent lack of strength with occasionally discomfort at rest.

Absolute indication for surgical treatment in adult and adolescent remains in open fractures with severe angulation or displacement with neuro vascular compromised but relative indication, deals with shortening above 1.5cm, with a floating shoulder and most of displaced fracture-dislocation at either end of the clavicle. Cosmesis can rarely play a role.





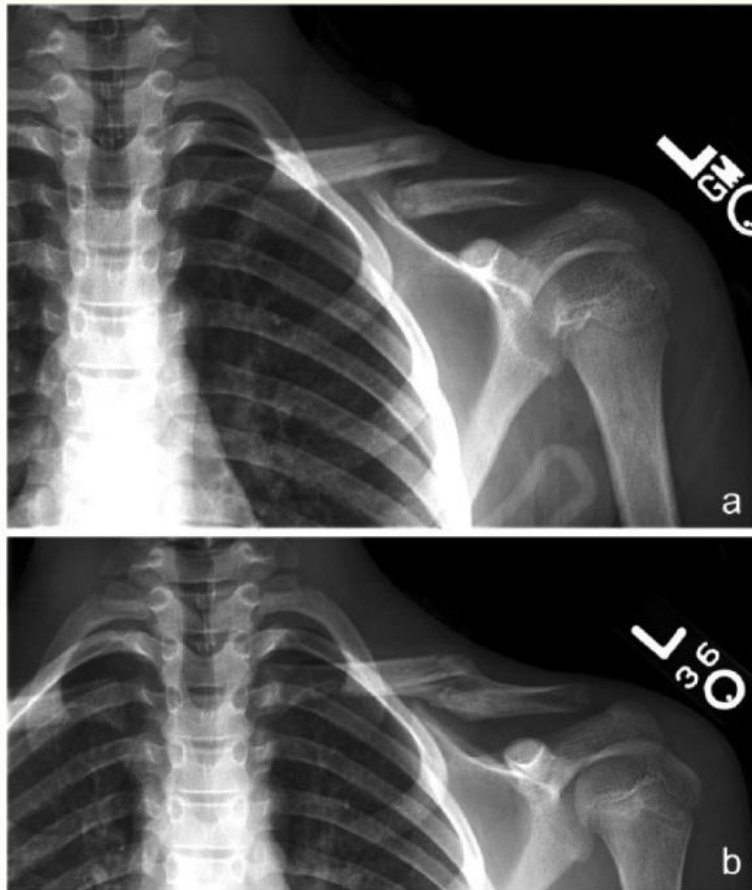
A middle third clavicle fracture with shortening and perhaps vascular compromise in an adolescent treated with a plate placed superiorly. These plates can also be placed inferiorly or anteriorly.



Another case with a mild comminution (Z-shape fragment) and possibly vascular compromised, with an open reduction and internal fixation and an interfragmentary screw.

Nonunion of adolescent clavicle fractures is rare but malunion can be seen especially if there is little possibility for remodeling because of the skeletal age. Such adolescent may become unable to consolidate a broken clavicle. A malunion, may follow and can become either symptomatic or asymptomatic.

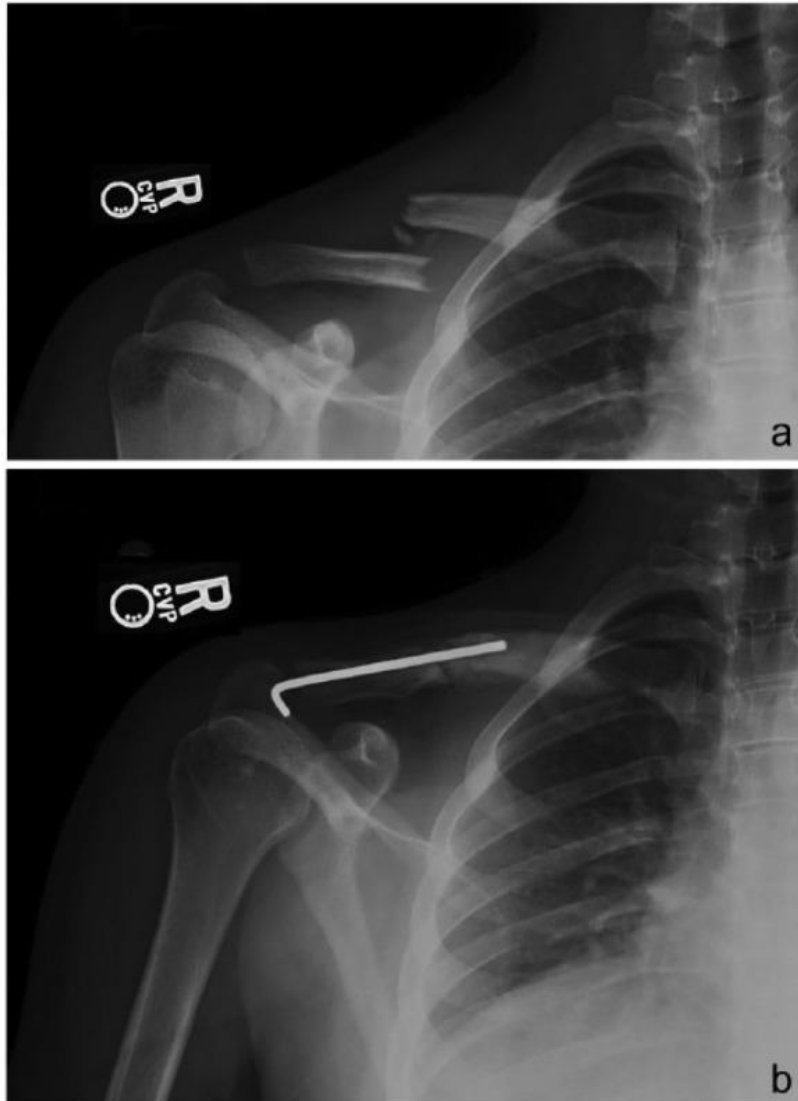
Any shortening of the clavicle greater than 2cms may become symptomatic especially among adolescents with >2 cm of shortening. They can become so symptomatic, that they may require surgical treatment in which case, a corrective osteotomy can be offered especially when overhead activities can generate fatiguability.



Non-Union mid-shaft left clavicle fracture and a non-union 4 months after with shortening.

In such case of non-union of a clavicle, studies have shown that an increase in the sternoclavicular joint angulation affect the scapulothoracic joint of the shoulder in abduction, velocity and weakness as well as in external rotation and internal rotation. The ulnar nerve was also found traumatized in 3 pilot-cases. Other cases were first treated conservatively but underwent further surgical treatment with a plate

fixation and returned to sport activity. Others have benefited from an intramedullary procedure and returned to full competition. Surgical treatment has been associated with infection (14%), Neurovascular injury (5%), non-union (15%), Adhesive capsulitis (&%), Re-fracture after removal of hardware (8%). Paresthesia at the surgical site is fairly common following the injury to the superficial supraclavicular nerve.



A comminuted mid-shaft clavicle fracture treated with an intra-medullary K-wire in an adolescent

In conclusion, the athlete age and the remaining growth in the clavicle must be taken in consideration when one is expected to treat a young patient surgically and count on remodeling for the healing of a displaced or comminuted clavicle fracture. I tried to expose the actual considerations that any orthopedist should have in mind when treating such injury. One certainly will find cases which can present other challenges or require other considerations like a pathological fracture or a “floating clavicle” with dislocation at both end of the clavicle with life threatening situation. Obviously, attempt at a conservative treatment is always mandatory.

I hope that I exposed the essential of what any orthopedic resident must carry in their armamentarium when approaching such injury and always I will encourage them to consider the simplest form of treatment unless there are circumstances which require undeniably a most sophisticated approach.

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