# *Open reduction and K-wiring of severely displaced supracondylar humerus fracture in children: Comparison between posterior triceps splitting approach and lateral approach*

*By*

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***Abstrak***

Ini adalah suatu analisa retrospektif terhadappesakit-pesakit yang dirawat secara reduksi terbukauntuk fraktur suprakondilar humerus beranjak teruk di kalangan kanak-kanak yang berusia kurang dari 12 tahun.

Fiksasi terbuka secara tusukan K-wire melintang adalah suatu cara rawatan yang dijayakan di merata-rata institut pembedahan dibenua ini. Malah terdapat berbagai jenis-cara untuk merawat fraktur yang sedemikian oleh pelbagai pihak.

Di-Hospital Ipoh,cara pembedahan “posterior triceps splitting approach” dan “lateral approach”adalah dua cara yang paling di-gemari.Kesemua pesakit di-rawat secara fiksasi trbuka dan tusukan K-wire melintang, antara Januari1997 hingga April 1998 telah di-panggil semula untuk rawatan susulan.Dikalangan pesakit-pesakit yang di bedah ,hanya 36 orang pesakit yang kembali untuk rawatan susulan.Mereka di-periksa untuk fungsi sendi siku dan komplikasi cosmetik.

Fungsi dan kesan kosmetik di-dapati sungguh memuaskan dikalangan pesakit yang di bedah secara “lateral approach”.Manakala pesakit yang di- bedah secara “posterior triceps splitting approach”didapati kurang memuaskan kesan komplikasi yang banyak.Ini juga merangkumi kecederaan saraf,parut yang tidak memuaskan dan kegagalan untuk mendapat reduksi yang memuaskan.

Oleh yang demikian,kami mencadangkan pembedahan dengan “lateral approach”untuk semua fraktur suprakondilar kerana kesan sampingan yang kurang dan keputusan yang lebih memuaskan dari segi reduksi dan komplikasi kosmetik.

*Abstract*

This is a retrospective study of patients treated with open reduction and internal fixation of a severely displaced supracondylar fracture humerus in children. Open reduction and internal fixation with k-wire for displaced supracondylar fracture of the humerus is practiced widely in many centers. Various approaches and techniques for open reduction of this type of fracture have been described by various authors.(Ramsey and Griz 1973,Carcassonne et al 1972)

In Hospital Ipoh, posterior or lateral approach is commonly used . All patients treated with open reduction and k-wiring in Hospital Ipoh from January 1997 till April 1998 were reviewed. Out of total patients operated during the study period, 36 returned for final follow-up. They were re-examined to assess the functional outcome,range af motion and incidence of cubitus varus of the affected elbow, as well as surgical and cosmetic complications.

. The posterior approach group was noted to have higher incidence of surgical complications eg cubitus varus deformity and reduced range of elbow motion. This also included nerve injury, failure to achieve good reduction at first attempt of open reduction and unsightly scar and painful scar.

Those patients who were operated by lateral approach had a better result and fewer complications.

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# 1.0 Introduction

Supracondylar fractures commonly occur in the first decade of life, with the peak occurance at age 6.6 years (Graph1) (Wilkins,1991). The high occurrence at this age is related to combination of the hyperlaxity of the ligaments and the relative weaker metaphyseal area. These fractures occur more often in boys and in the left arm (Minkowitz and Busch1994). as most of them fell on an outstretched left hand.

Supracondylar fractures are generally classified into two major types, depending on the position of the elbow at the time of the injury. The most common type is the extension type which comprise about 97% while the flexion type is rare. Gartland (1959) classified the extension supracondylar fractures on the basis of the degree of displacement and the existence of an intact cortex. Type I is the undisplaced or minimally displaced fractures while Type II is displaced fracture with intact posterior cortex. The severely displaced fractures, or Type III have no cortical contact and the distal fragment is usually angulated and displaced posteriorly. In addition, the distal fragment may either be posteromedial, posterolateral, or straight posterior in relation to the proximal fragment.

The treatment goal in displaced supracondylar humerus fractures in children is anatomic reduction and regaining good range of motion as well as an acceptable carrying angle (Wilkins.1991).

Type I and type II can usually be treated by closed methods while type III usually requires an open reduction and fixation with Kirschner wire. The major indications for primary open reduction include an open fracture, failure to achieve an adequate reduction during closed manipulation or vascular compromise that worsens especially with the manipulative technique.

Though closed maniplation reduction with percutaneous pinning is the preferred method of choice of most surgeons for Type III fractures, the choice of surgical approaches varies. Various approaches have been described,which includes lateral, medial, anterior and its variants, combined medial and lateral, and posterior.

In the Hospital Ipoh, open reduction and internal fixation,through the posterior approach with triceps splitting technique or the lateral approach are commonly used..

The objectives of this study is mainly to compare the functional (range of motion) and cosmetic (carrying angle) outcome between this two approaches. The surgical complications namely infection,hypertrophic scar and nerve injuries post operatively were also taken into consideration.

# 2.0 Literature Review

## Supracondylar fracture

### 2.1 Historical Background

Supracondylar fractures were described in the writings of Hippocrates during the third and fourth century A.D.,(Adams1939) but it was not until the 1700s that much was written about supracondylar fractures in the classic medical literature. Most of the discussion during the 1700s and 1800s was directed toward the controversy regarding the correct position of immobilization.(Wilkins1991)

At the beginning of the 20$^{th}$ century, treatment began to change from these simple passive methods to more aggressive and active methods. Scientific reason and study began to alter the methods of treatment. Traction methods, better methods of closed reduction, and even open reduction with internal fixation came into vogue. Newer imaging techniques and power equipment have greatly enhanced the ability to obtain and maintain an adequate reduction, with a marked decrease in the incidence of complications.

### 2.2 Incidence

#### First-Decade Injury

Age is the key factor in the incidence of supracondylar fractures. This is almost exclusively a fracture of the immature skeleton. This fracture occurs primarily in the first decade. The incidence increases during the first 5 years and peaks at 5 to 8 years of age. After this, there is a decrease in incidence until age 15, after which it is rare.

Fahey,(1960) observed that older children have a greater displacement with their supracondylar fractures. In fractures with marked displacement, a larger proportion of children were over 10 years of age.

Males sustain almost twice as many supracondylar fractures as females. In comparing the changes in incidence in the sexes from 1950 to 980,Landin(1983) found the overall incidence was unchanged in girls and decreased in boys. Landin found that girls had a bimodal incidence, with the first peak at 6 years of age and a second but lower peak at 11 years of age.

Cramer et al(1993) have noted that when a detailed neurologic examination is performed, the anterior interosseous nerve is the nerve most commonly injured.

**2.3 Kinematics**

The function of the elbow is to position and stabilize the hand in space for manual activities. The elbow allows primary motions in both flexion, extension, and pronation and supination. In view of the permitted motions in two degrees of freedom, the elbow has generally been described as a trochoginglymoid joint.

**Flexion-Extension**

The range of elbow motion in the flexion and extension plane varies from approximately 0 degrees to 145 degrees. According to Morrey.(1985), approximately 30 degrees to 130 degrees of this total arc were necessary to perform most activities of daily living. The motion pathway of elbow flexion-extension has been shown to approximate that of a loose hinge joint. The flexion-extension axis follows a line that can be drawn between the center of the capitellum and the center of curvature of the trochlear groove .External landmarks that are useful in defining this axis are the anteroinferior aspect of the medial epicondyle and the center of the arc of curvature of the capitellum. It has been demonstrated that the locus of instant centers of rotation is small, moving less than 4 mm throughout the arc of elbow flexion-extension. An understanding of the patterns of elbow motion has fostered the development of articulated external fixators and elbow distraction devices that are being increasingly used for reconstructive surgery and trauma, leading to the development and clinical application of loose hinge total elbow arthroplasty design. It is important to understand that the axis of rotation does not correspond to the so-called carrying angle described for the elbow. The axis of rotation is approximately 3 degrees to 5 degrees internally rotated relative to the plane of the medial and lateral epicondyles and in 4 degrees to 8 degrees of valgus with respect to the long axis of the humerus. For clinical purposes, the carrying angle is defined as the angle between the long axis of the humerus and the long axis of the ulna measured in the frontal plane with the elbow in the extended position. Considerable variation in the carrying angle exists between patients. Carrying angles are generally higher in women than in men. The average carrying angle for men has been reported to vary between 10 degrees to 15 degrees, and is about 5 degrees greater in women.(Dowd 1978) The clinical implication is that in patients with elbow flexion contractures, the true carrying angle of the elbow cannot be measured and varus deformities may not be apparent until a flexion contracture is corrected.

# 3.0 Anatomy

## 3.1 Remodeling Metaphysis

There is considerable difference in the bony architecture of the supracondylar area of the humerus between the child and the adult. At the age of peak incidence for supracondylar fractures, 6 years, the bone in the supracondylar area is undergoing remodeling with a decrease in both the anteroposterior and lateral diameters. It is less cylindrical than in the adult.(Mc Donnell,.and Wilson1948) The metaphysis of the 6-year-old extends just distal to the two fossae. Because this is newly formed bone, the trabeculae are less defined and thinner, and the cortex is very slender .In the lateral projection, the anterior cortices of the medial and lateral supracondylar columns do not project as far anteriorly, thus producing an anterior defect in the area of the coronoid fossa. As the humerus matures and the osseous epiphyseal centers fuse, the structure of the distal humerus widens both medially and laterally and in the anteroposterior projection to provide more resistance to stresses in this area . The cortices in the distal humerus and supracondylar area also thicken.

Ligamentous laxity with hyperextension of the joints is normal in younger children.Thus, as the younger child falls with the arm outstretched, the elbow is more likely to be hyperextended at the time of the fall.

Thus, the local anatomy is a major factor in producing supracondylar fractures during the first decade of life.

## 3.2 Mechanism of Injury

These mechanisms included hyperextension, abduction or adduction of the elbow, and a fall on the hand with it dorsiflexed and the elbow flexed (Fig 1). However, consistent patterns of supracondylar fractures are difficult to reproduce in adult cadaver extremities.

Because supracondylar fractures have a peak incidence in the latter part of the first decade of life, there must be something unique about the anatomy of the elbow during this period that produces this type of fracture. The three major factors that seem to contribute to the unique predisposition of the juvenile humerus to supracondylar fractures are ligamentous laxity, the relation of the joint structures in hyperextension, and the bony architecture of the supracondylar area.

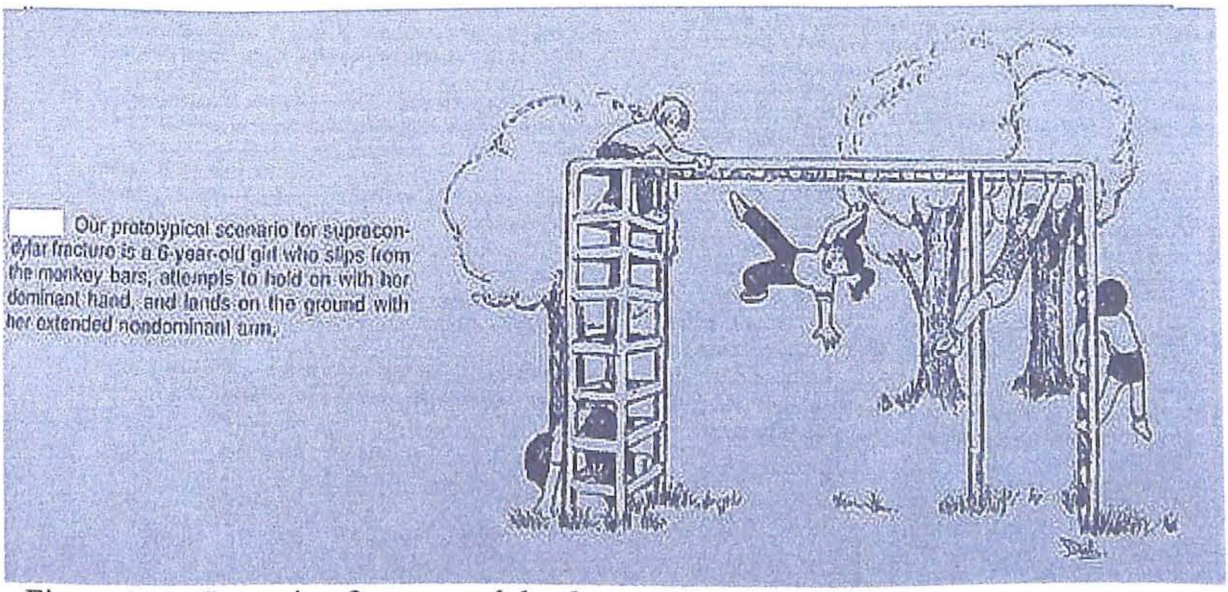


Figure 1 : Scenario of supracondylar fracture

### 3.3 Hyperextensibility

During the peak age for supracondylar fracture, the child's ligaments are especially lax. This ligamentous laxity allows for hyperextensibility of the major joints (see Fig.2). As the child matures, the ligaments tighten, decreasing the amount of extension of the joints. This is especially true in the elbow.

Figure 2 : Measurement of hyperextension of elbow

There is a significant increase in the incidence of supracondylar fractures in children who demonstrate hyperextension of the elbow.

**Relations of Joint Structures in Hyperextension**

Children often extend their elbows to break the force of a fall. Because of ligamentous laxity, the elbow hyperextends, allowing the linear force applied along the extended elbow to be converted to a bending force. This bending force is then concentrated by the olecranon into the anatomically weak supracondylar area. This interlocking of the tip of the olecranon into its fossa concentrates the bending forces in this area. When these forces exceed the strength of bone, a supracondylar fracture is produced.(Minkowitz and Busch,1994).

**Bony Architecture of the Supracondylar Area**

The bone in the supracondylar area is weaker during the last part of the first decade of life because it is undergoing metaphyseal remodeling. The thinnest portion occurs at the depth of the olecranon fossa, where the tip of the olecranon is forced during hyperextension. In addition, the large amount of elastic epiphyseal and articular cartilage in the distal portion can serve as a buffer to transfer the force of the hyperextension injury to the supracondylar area.(Gartland,1959).

Thus, overwhelming evidence has shown that extension-type supracondylar fractures are caused by a hyperextension mechanism of the elbow.

**4.0 Pathoanatomy**

To evaluate and treat extension-type supracondylar fractures, one must understand the pathology of the fracture and the associated soft-tissue findings.

**Coronal Plane**

In a minimally displaced fracture, the fracture line can be well delineated on the anteroposterior x-rays .The fracture is transverse, extending from just above the epicondyles and entering the thin area separating the coronoid and olecranon fossae. This fracture is just proximal to the widest anteroposterior diameter but is still distal to the termination of the cortex of the distal diaphysis. The fracture line may not be completely straight transversely; it may be somewhat oblique, usually from distal medial to posterior lateral on the anteroposterior x-ray. The fracture line may be slightly above the weak area of the fossa, or it may be somewhat below the central portion of the fossae. It is totally metaphyseal, lying usually at the anterior and posterior capsular origins.(Halls-Crags et al1985). In many cases, sharp protruding spikes involve the cortical portions of the respective supracondylar ridges. These sharp medial and lateral spikes of bone can damage the surrounding soft tissues and may be an impediment to the reduction of the fracture fragments.

**Role of the Periosteum**

In experimentally produced supracondylar fractures, there appears to be a reproducible pattern of periosteal failure. This was demonstrated in a study by Abraham et al(1982). The failure of the periosteum progresses in three stages (see Fig. 3): First, there is the minimally displaced fracture with a type I periosteal change (see Fig. 3A). The periosteum, while intact, stretches across the anterior fracture site and is detached from the anterior surface of the humerus for a considerable distance proximally. In the second stage, as the fracture becomes more displaced, the detached periosteum is torn as it is pulled distally across the sharp edge of the proximal fragment (see Fig.3B). This stretched periosteum may not produce new bone, leaving a gap anteriorly. The final stage represents complete displacement (see Fig. 3C). At this point, the periosteum is completely torn anteriorly. The periosteum remains intact posteriorly and to some degree medially and laterally. The distal portion of the proximal fragment is circumferentially stripped of its periosteum. The distal fragment then becomes displaced not only posteriorly but also proximally. A portion of periosteum remains attached to the distal fragment. This tag of variable length can become interposed between the edges of the fracture fragments to prevent complete reduction.

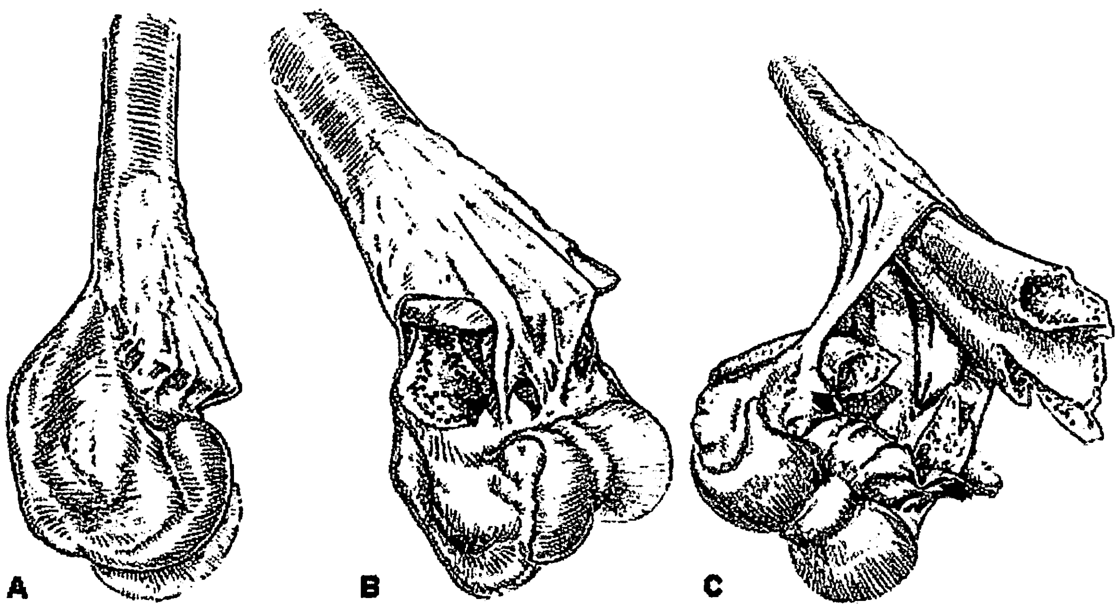

Figure 3 : Periosteum failure in stages

**Anterior Periosteum**

This tag of periosteum has considerable clinical significance in the management of supracondylar fractures. It may be interposed between the anterior edges of the fragments to prevent complete reduction. It may produce a persistent gap in the fracture surface anteriorly. Because the periosteum is broken and torn from the anterior surface of the proximal fragment, there is usually little periosteal new bone anteriorly. In contrast, the periosteum is usually intact posteriorly to produce abundant new bone.

**Periosteal Hinge**

Kekomaki et al(1984)had reported that medial and lateral periosteal hinges at the fracture site that could be used to secure a closed reduction.

**Posteromedial Most Common**

Extension-type supracondylar fractures with total displacement are often described as being posteromedial or posterolateral, depending on whether the distal fragment is medial or lateral to the proximal fragment (Fig. 4). In series in which this displacement of the distal fragment has been specifically noted, 75% of the time the fragmentwasdisplacedposteromedially.(Arnoldetal1977,Aronson,.andPrager,1987,Pirone et al 1988.) The posteromedial displacement is probably secondary to the pull of the triceps, which originates more medially (Fig. 5).


Figure 4A:anterior posterior view


Figure 4B:lateral view

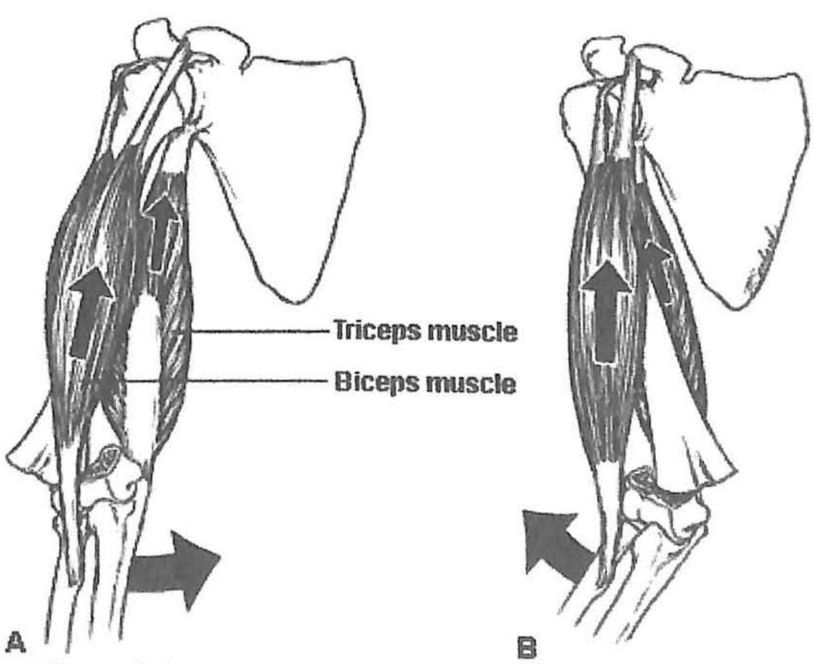


Figure 5 :Posteriormedial displacement due to triceps pull

**Clinical Significance**

The differentiation between posteromedial and posterolateral position of the distal fragment may be of clinical significance in one or more ways. First, if the distal fragment is displaced posterolaterally, there is a greater chance of vascular insufficiency. In this fracture pattern, the medial spike of the proximal fragment is more likely to impinge on the brachial artery.

Second, the displacement of the distal fragment may have a bearing on the treatment method. In treating these fractures by closed reduction and cast application,and using the location of the distal fragment to determine the position of the forearm to lock against the so-called intact periosteal hinge.

Third, if percutaneous fixation is used after a closed reduction, the displacement of the distal fragment has a bearing on which pin is placed first. If an open reduction is necessary, the position of the distal fragment may enter into the decision as to which surgical approach to use.

Fourth, the position of the fragment may affect the development of a residual deformity. Posteromedial fractures have a higher incidence of varus angulation, whereas posterolateral fractures tend to develop valgus angulation.(Arnold et al 1977). Posteromedial fractures have a tendency for the distal fragment to rotate internally, whereas posterolateral fractures tend to rotate externally. Thus, this difference in the displacement of the distal fragment is important in all phases of the management of displaced supracondylar fractures.

**Effects of Obliquity**

Most fractures are straight transverse on both anteroposterior and lateral x-rays. Occasionally, the fracture line is the classic oblique anterior distal to posterior proximal. Obliquity can predispose to increasing the degree of angular deformity if there is rotation of the distal fragment (Fig.6). If the fracture line is transverse, horizontal rotation in itself does not produce angulation. If, however, the fracture line is oblique, rotation of the distal fragment produces a secondary distal angulation. In posteromedial fractures, the rotation tends to be internal rotation, producing cubitus varus. In posterolateral fractures, the external rotation of the distal fragment tends to produce a valgus angulation.

**Elbow Flexion**

Once the distal fragment becomes separated from the main portion of the humerus, there is no counterforce to the effects of the forearm muscles that originate from the epicondyles. Thus, these unopposed forearm muscles tend to flex the distal fragment at the elbow joint (Fig. 7).

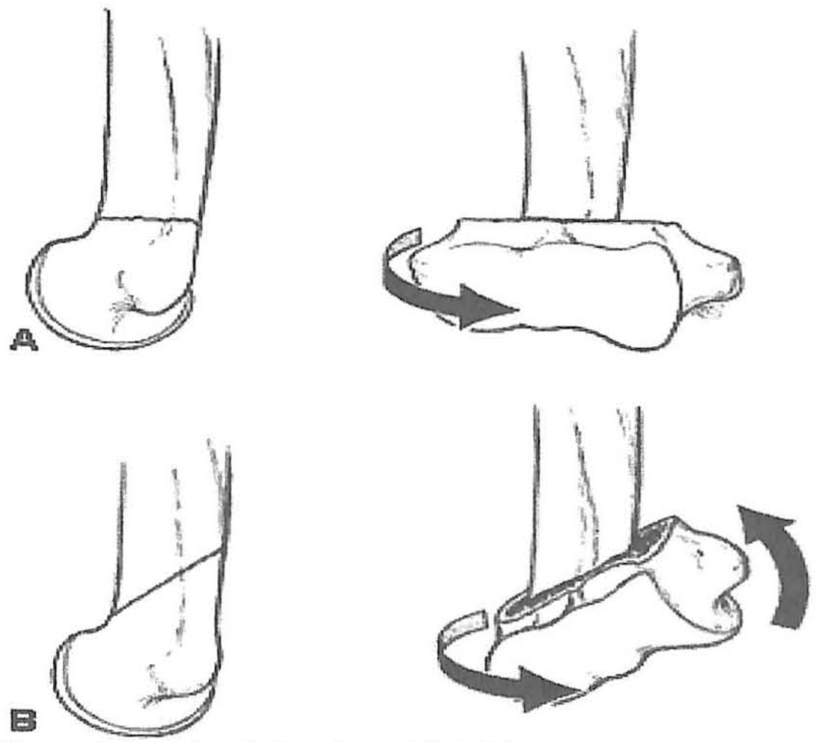

Figure 6:Angular deformity of distal fragment

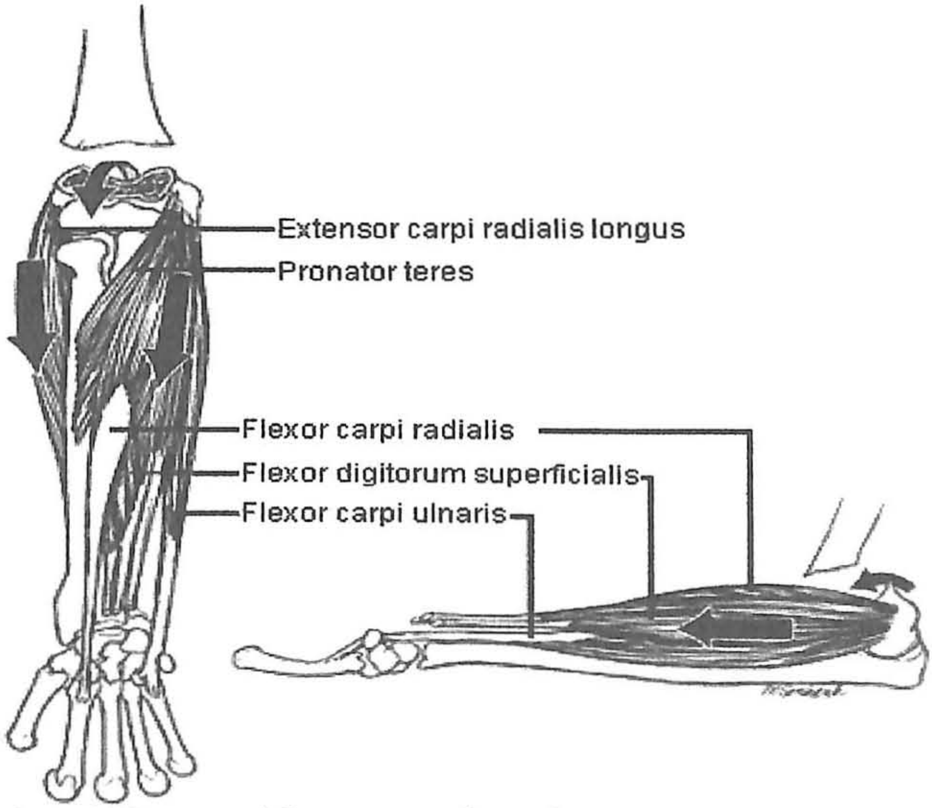

Figure 7:Unopposed forearm muscle tends to flex distal fragment

## 4.1 Soft-Tissue Pathology

In most supracondylar fractures, the brachialis muscle protects the anterior neurovascular structures from injury. In severe displacement, either the medial or lateral spike may completely penetrate the brachialis muscle and its fascia and lie in the subcutaneous tissue. In these cases, this spike can be palpated under the skin. The spike may even impale the dermis to create a puckering of the overlying epidermis. The position of the distal fragment has a bearing on the neurovascular structures that may be injured.

### Posterolateral Pathology

With posterolateral displacement of the distal fragment, the medial spike penetrates the subcutaneous tissue and there may be tethering of the median nerve or brachial artery over this anterior spike.Rowell(1974) has shown that in many cases the supratrochlear artery tends to bind the brachial artery across the spike, producing a complete occlusion (Fig. 8). The median nerve is usually tethered across this same spike. Rarely, the brachial artery and median nerve can become displaced posteriorly to the proximal fragment and become interposed between the fracture fragments (Fig.9) (Staples 1965.)

### Posteromedial Pathology

If the distal fragment is displaced posteromedially,the lateral spike often penetrates the the brachialis muscle and the radial nerve may be tethered .

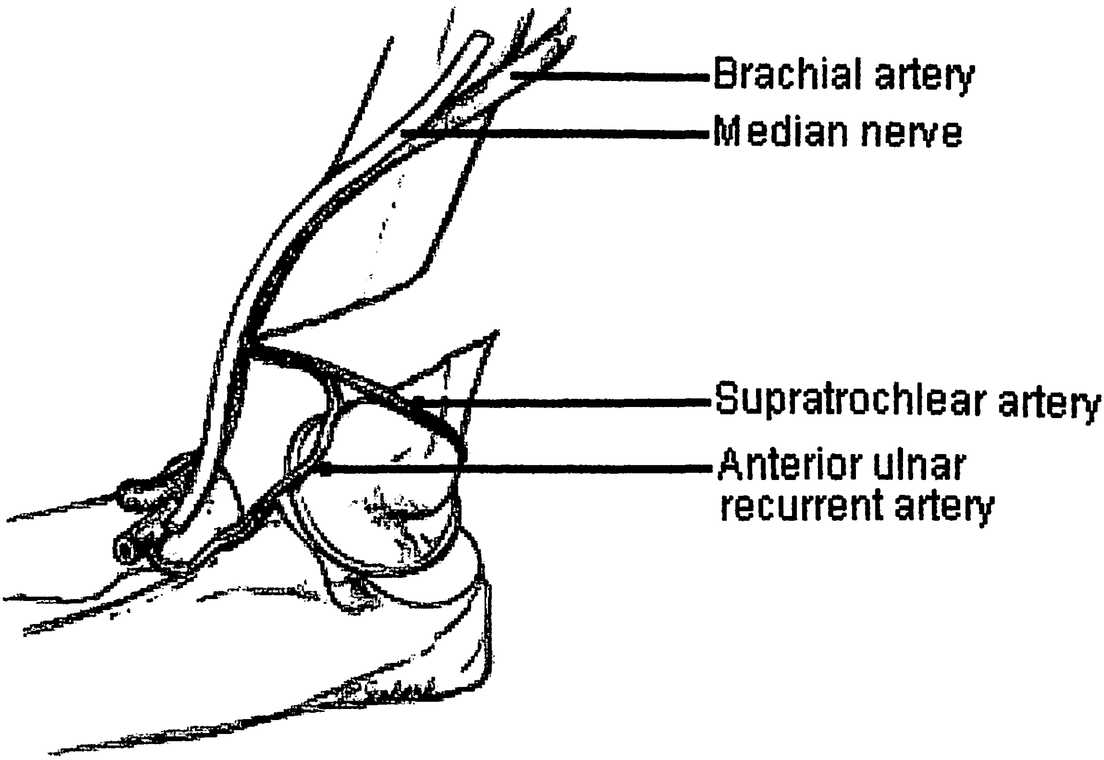


Figure 8: The supratrochlear A tends to bind brachial A across the spike

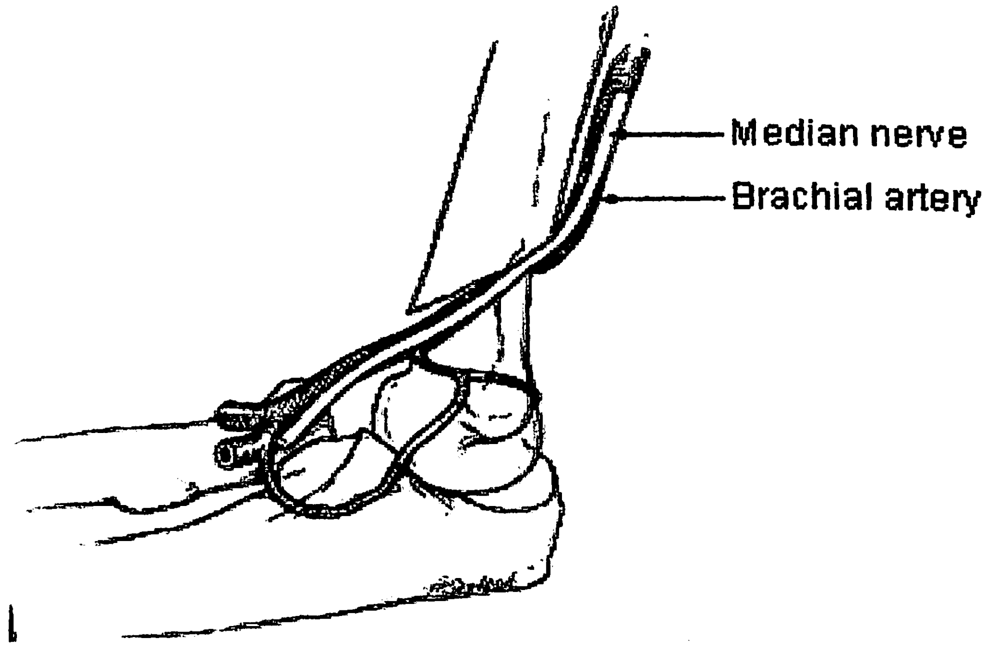


Figure 9 : The brachial A and median N interposed between fracture end

## Supracondylar Fractures

### 5.0 Previous Classifications

Numerous attempts have been made to classify extension-type supracondylar fractures. These classifications have been based on two factors: the degree of displacement and the type and location of the fracture line. Knowing the amount of displacement is useful in determining whether manipulation is required. Supposedly, the location and type of fracture line will dictate the postmanipulative stability and give some prognosis for the development of late deformities.

Later classification separated the fracture types into combinations of the degree and direction of displacement.(Dodge,1972,Pirone et al1989.) These extensive classifications, while helpful, often are cumbersome and impractical.

### 5.1 Gartland's Classification

In 1959, Gartland described three stages based on the degree of displacement: type I, nondisplaced; type II, minimally displaced; and type III, completely displaced. This three-stage classification with modifications is the one used most commonly in pediatric fracture texts.(Flynn,,and Zink1993).

It is prefered to use a simple classification of extension-type supracondylar fractures similar to one proposed by Gartland,(1969) based primarily on the degree of displacement. The direction of displacement can be added to the amount of displacement if needed. This classification is divided into three categories .Using this simple classification and modifying it in some cases (as to the intrinsic stability of the fracture or the direction of displacement), it is useful in determining the appropriate treatment.

**Type I**

In the first type, the fracture is undisplaced or minimally displaced such that the anterior humeral line still passes through the ossification center of the lateral condyle .If there is difficulty visualizing the fracture line, the diagnosis can be confirmed by taking oblique views, measuring the angulation of the distal humeral condyles, or assessing the displacement of the fat pads. Sometimes the original suspicion of a supracondylar fracture is made only in the follow-up x-ray, in which there is periosteal new bone formation .

**Type II**

In the second type, there is an obvious fracture line with displacement of the distal fragment, but there is still an intact cortex posteriorly .The amount of displacement may be minimal or great. The direction of displacement may be straight posteriorly or angulated medially or laterally. There may be a rotary component. An important aspect regarding treatment of this type is that the posterior cortex is intact enough so that the fracture is stable to external rotation when the elbow is flexed to 120°.

**Type III**

If, when the elbow is flexed to 120° and rotated, there is not enough intact cortex to provide intrinsic stability or if the fragments are completely displaced, this automatically is a type III fracture. Usually this occurs when there is no contact between the fragments. It is useful to classify type III fractures into posteromedial and posterolateral because this helps dictate the treatment modality and possible sequela

## 5.2 WILKINS CLASSIFICATION

Wilkins(1984)proposed a modification to the Gartland system in 1984. He recognised that a displaced supracondylar humeral fracture may be greenstick in nature with an intact posterio cortex. He noted that this greenstick injury may also have a rotary component. A fracture with an intact posterior cortex and angulation only was termed type IIA and that with a rotary component type IIB. Gartland made no reference to the greenstick injury in his system,merely classifying it in regard to the severity of displacement: non-displaced,minimal to moderate and severely displaced. In his original article there is a radiograph of a fracture which is completely displaced with no cortical contact and this is classified as moderately displaced. Wilkins termed the completely displaced supracondylar fracture with no cortical contact as type III. A type-IIIA fracture has posteromedial And type IIIB posterolateral displacement. These subtypes determine which neurovascular structures are most likely to be injured and which pin should be placed first. This subclassification, however, does not affect the ultimate management of these injuries, as both the type-IIIA and the type-IIIB fractures require closed/open reduction and stabilisation with Kirschner (K-) wires.(Wilkins1991).

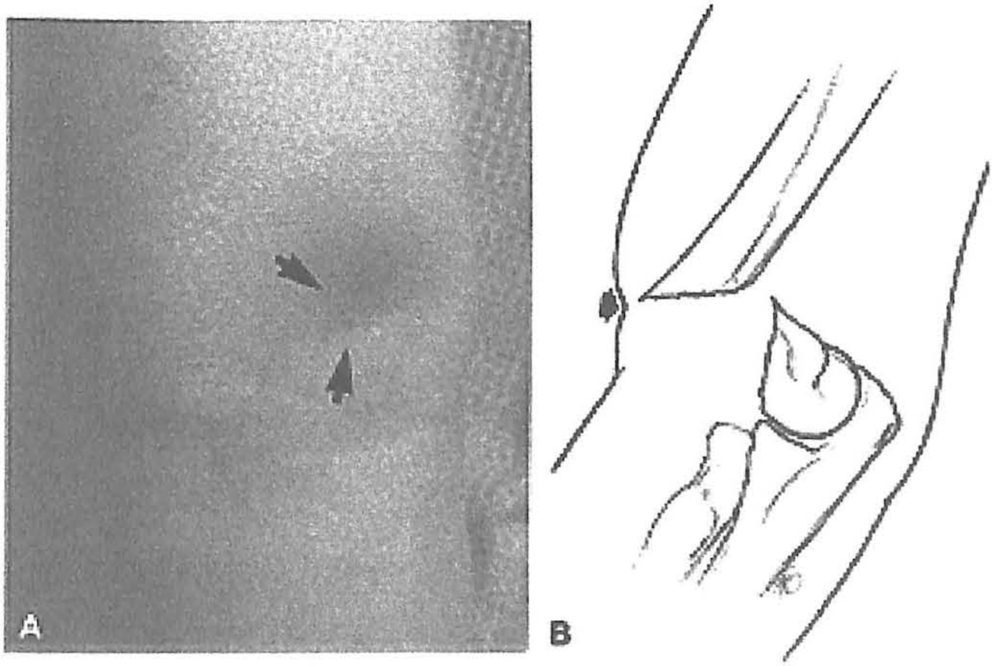


Figure 10 : Puckering of the skin-"pucker sign"