REVIEW OF A NEW TECHNIQUE FOR CORRECTION OF CUBITUS VARUS DEFORMITY

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A dissertation submitted to the Tamil Nadu Dr.M.G.R. Medical University in partial fulfillment of the requirement for the award of M.S. Branch II (Orthopaedic Surgery) degree March 2006-2008

<u>CERTIFICATE</u>

This is to certify that this dissertation titled **"<u>REVIEW OF A NEW TECHNIQUE FOR CORRECTION OF CUBITUS VARUS DEFORMITY</u> "** is a bonafide work done by **Dr. VIVEK DUTT,** in the Department of Orthopaedic Surgery, Christian Medical College and Hospital, Vellore in partial fulfillment of the rules and regulations of the Tamil Nadu Dr. M.G.R. Medical University for the award of M.S. Degree (Branch-II) Orthopaedic Surgery under the supervision and guidance of **Prof. VRISHA MADHURI** during the period of his post-graduate study from March 2006 to February 2008.

This consolidated report presented herein is based on bonafide cases, studied by the candidate himself.

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INTRODUCTION

"The difficulties experienced by surgeons in making an accurate diagnosis; the facility with which serious blunders can be made in prognosis and treatment; and the fear shared by so many of the subsequent limitation of function, serve to render injuries in the neighborhood of the elbow less attractive than they might otherwise have proved."

These words of wisdom by Sir Robert Jones echoed the opinion of many others at the beginning of 20th century (1). These concerns are applicable even today. The presentation of a child with a swollen, injured elbow still brings some anxiety to the treating orthopaedic surgeon. Fractures in other regions of the body in children can often be managed with minimal intervention to obtain uniformly good results. In the region of the elbow, however, there are often more indications for aggressive treatment, including operative management than other parts of the body. Injuries around the elbow are very commonly sustained by children as they try to protect themselves while trying to avoid a fall . The upper extremity accounts for approximately around 65-75% of all fractures sustained in childhood amongst which one of the common ones are the supracondylar fractures of the humerus (ref) . Supracondylar fractures of the distal humerus account for 3% of fractures in children and may be associated with various acute and long-term problems (ref).

Cubitus varus (gunstock deformity) is one of the commonest complication of supracondylar fractures resulting from malunion of supracondylar fractures (ref).

This complication is associated more with conservative treatment of displaced supracondylar fractures. In India the prevalence traditional bone setters who widely practice nonoperative management consisting immobilization of these injuries using cloth, raw egg, bamboo sticks etc. Thus incidence of malunited supracondylar fractures seems to be a lot higher than compared to the western developed world. In the last century, many methods of treatment of this malunion have been described, the number indicating that each method has its own flaws and limitations. After our initial problems with the estabilished techniques, we developed a new technique for treatment of cubitus varus.

This study defines the surgical technique and presents its outcome over the last 6 years.

AIMS & OBJECTIVES

1) To describe a new technique for correction of cubitus varus deformity .

2) To dlinically and radiologically follow up the children who underwent correction of this deformity by this new technique .

3) To compare with the results of other surgical techniques published in the literature

SCOPE OF THE STUDY

This is a retrospective review , thus it has its limitations. A randomized control trial comparing this technique with other techniques of treatment might give us a better insight into which is the best techinique for correction of cubitus varus.

Also within the randomized trial it can be assessed whether a specific technique is better for different circumstances like larger corrections or different age groups, thus making each technique specific for different situations.

All the patients post-operatively are usually put on an above elbow cast. Within the cast the only deforming force is a varus force .Hence a study can be planned to test the resistance of various fixation devices used post-operatively against varus deforming forces and choose the best method of fixation for the osteotomy.

Most importantly more stress should be laid on prevention of this deformity rather than treating it. This requires proper reduction and maintainence of reduction of supracondylar fractures. Signs of instability should be identified pretty early and due attention has to be given to address the instability.

Altough there is some evidence in literature about the effect of cubitus varus on the elbow and shoulder biomechanics but none of the children present with any such problem (could be due to the fact that it takes a lot of time to become symptomatic).Probably some biomechanical studies can be undertaken to establish the fact that cubitus varus does alter shoulder and elbow biomechanics and a correction of that deformity restores normal biomechanics.

HISTORICAL REVIEW

The treatment of fractures is as old as human race itself. Old Indian texts (Ayurveda), Egyptian Papyrus etc have described in great detail the treatment of various kinds of fractures. Susrutha, father of Indian surgery, had studied fractures in detail and has given due consideration to the age factor in deciding the prognosis. He noted the difference in time to healing in the young. According to him, skeletal injuries take one month to heal in young patients, two months in middle-aged patients and three months in old people. Dealing with the principles of treatment, Susrutha gave four basic steps that is *Anchana* or traction; *Peedana* or manipulation by local pressure; *Samkshepa* or opposition and stabilisation and *Bandhana* or immobilisation. Detailed explanations on each of the above steps are given. He also stresses that the splinting should be proper. The splint should not be too loose or too tight. A loose splint will not serve the purpose while a tight one may causes pain and suppuration of the underlying tissues(33).

"There is no class of injuries so frequently productive of discontent, and perhaps so often the cause of litigation, as traumatic lesions of the elbow joint"

-Henry Jacob Bigelow, Massachusetts General Hospital,1868.(34)

In 1862, a papyrus was found in a tomb in Thebes and sold to an American Egyptologist, Edwin Smith. It is thought to be the work of Imhotep, an architect and chief minister to king Zoser (c. 2800 BC). It represents a collection of 48 clinical records including careful description of reduction and splinting of fractures around the elbow.

In 970 A.D., the Persian Abu Mansur Muwaffak suggested that fractures and other bony injuries should be coated with plaster. The Arabic physicians had discovered that the addition of water to a soft powder of anhydrous calcium sulfate produced the firm hydrated crystalline form. This was being used to treat elbow fractures.

The 19th century saw the use of splints, many custom made for the elbow joint and advocated with zeal by its developer. Some splints offered adjustable hinges which could be used to stretch out elbow contractures.
Of interest is perhaps the earliest turnbuckle splint, devised as early as 1517 by Hans von Gersdorff, who termed his splint the "appliance for the crooked arm."

The treatment of the elbow trauma during the nineteenth century was fraught with unfortunate outcomes not the least of which led to medical malpractice cases. Bigelow documented one such case:

"*Warren Co., Ky. A boy, ten years old, had broken his arm above the condyles, and his parents having employed a surgeon residing at some distance, the dressings* *were applied, and directions given to send for the surgeon whenever it became necessary. The parents saw the arm swell excessively, and knew that the boy was suffering very much, but did not notify the surgeon until the tenth day, when the hand was found to be in a condition of mortification, and at length amputation became necessary."*

"Long afterward, in the year 1851, when the boy became of age, he prosecuted his surgeon, but with no result to either party beyond the payment of their respective costs".

Most of the discussion during the 1700s and 1800s was directed toward the controversy regarding the correct position of immobilization.

Antisepsis, anesthesia, and the x-ray enabled ingenious surgeons bring us into the modern era of the management of elbow trauma. At the beginning of the 20th 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.

In 1919 Sirus IE in his follow up study of 330 children with Supracondylar fractures described loss of carrying angle in 26 with 8 having a glaring gunstock deformity. A cuneiform osteotomy was used to correct the deformity in 2 of them (ref Sirus et al). Following this there have been a number of reports detailing the outcome of corrective osteotomies for cubitus varus in the literature. Some of these which include the descriptions of osteotomies are listed below:

1) Siris et al 1939 - lateral closing wedge osteotomy fixed with lane plate .
2) King et al 1951 – medial closing wedge osteotomy with bone graft fixed with two Steinmann pins and Riedel clamp.
3) French 1959 – lateral closing wedge osteotomy fixed with two screws and wire loop.
4) Smith et al 1960- osteotomy fixed with overhead skeletal traction.
5) Amspacher et al 1964 – oblique osteotomy fixed with one screw.
6) Langenskiold et al 1967 – lateral closing wedge osteotomy fixed with plate
7) Nassar et al 1974 – lateral closing wedge osteotomy fixed with crossed K-wires.
8) Rang et al 1974 – lateral closing wedge osteotomy fixed with k- wires
9) Sweeney et al 1975 – lateral closing wedge osteotomy fixed with crossed K-wires.
10) Griffin et al1975- lateral closing wedge osteotomy held with a cast.

11) Laupattarakasem et al 1982 – Quadrilateral osteotomy

12) Bellemore et al 1984- lateral closing wedge osteotomy held with K- wires .

13) Laupattarakasem et al 1989 – Pentalateral osteotomy .

14) Paul De Rosa et al 1987- Step cut osteotomy

15) Matsushita et al 1995- Arc osteotomy.

16) Song et al 1997 - Osteotomy with Ilizarov fixation

17) Tien et al 1999 – Dome osteotomy .

18) Kim et al 2005- Step cut translational osteotomy fixed with posterior Y – plate.

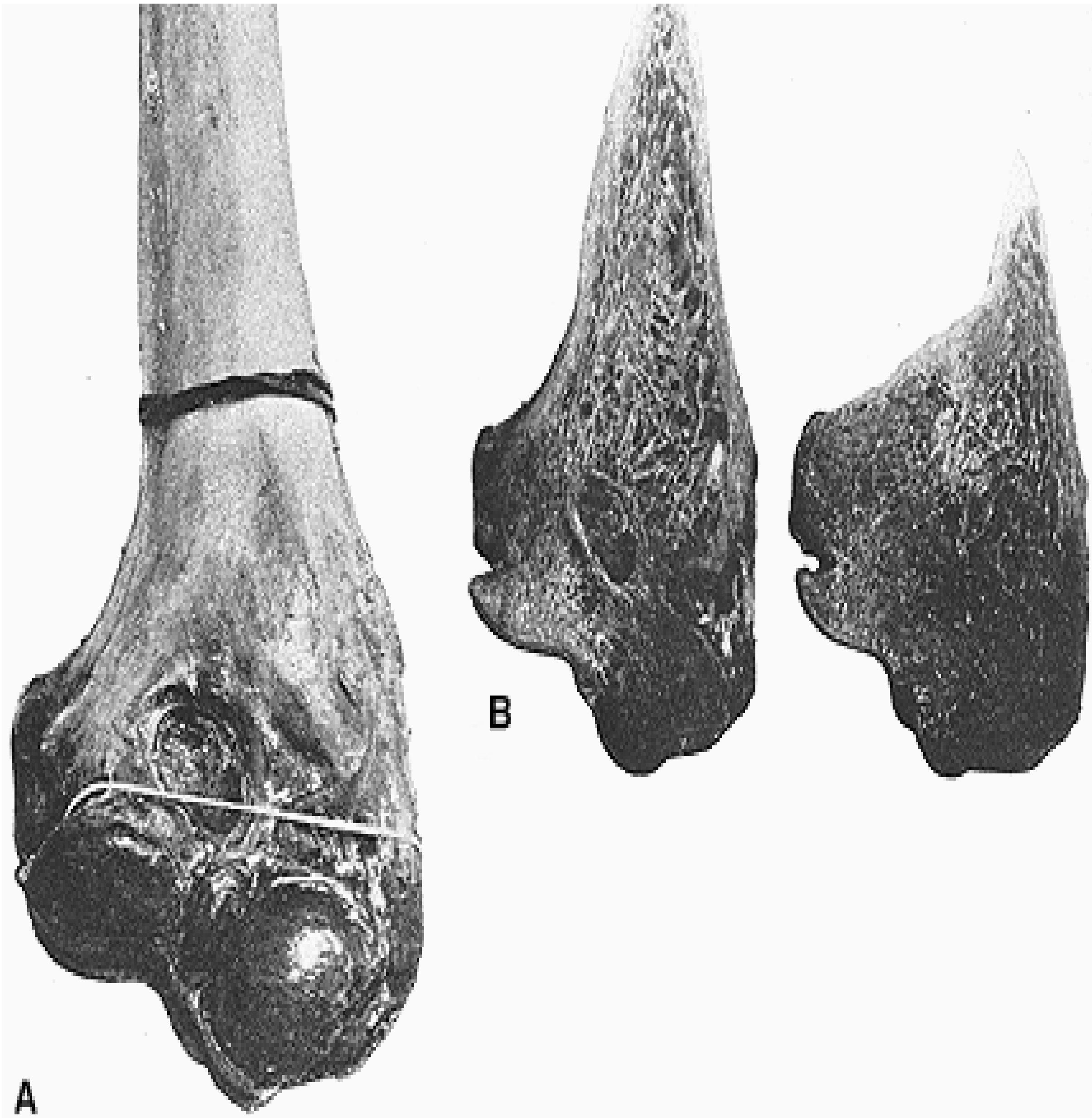
A plethora of these osteotomies indicate a lack of satisfaction with any technique. A lack of these deformities being corrected close to the joint line results in many of the deficiencies that have been listed. The present technique attempts to address this issue.

THE ELBOW

In the lower species, the elbow functions in the quadruped position with the humerus adducted and internally rotated. Thus, for the forearm to remain in a sagittal plane, the ulnohumeral articulation developed a spiral configuration that resulted in an angular relation in extension. In these species, the shallow trochlea provides a large surface area to withstand heavy loads.As humans developed into the erect position, there was more need for elbow stability for flexion and extension prehensile activities than for weight bearing in the extended position. Thus, the trochlea became deep and well defined and closely fits the trochlear notch of the ulna.(2)

THE OSSIFICATION PROCESS

It usually proceeds at a predictable rate around the elbow. In general the rate of ossification in girls exceeds that of boys . The girls had the following sequence of ossification: capitulum, radial head, medial epicondyle, olecranon, trochlea, and lateral epicondyle at age 1, 5, 5, 8.7, 9, and 10 years, respectively. For the boys, the



1) Fig-1 ANATOMICAL SPECIMEN OF CUBITUS VARUS (Wilkins KE: Fractures and Dislocations of the Elbow Region. In Rockwood CA, Wilkins KE, King RE (eds). Fractures in Children. Ed 4. Philadelphia, JB Lippincott Company 604–605, 1990).

sequence was similar. The time of ossification was significantly different i.e., at age 1, 6, 7.5, 10.5, 10.7, and 12 years, respectively.(34)

Just before completion of growth , the capitellum, lateral epicondyle and trochlea fuse to form one epiphyseal centre. Metaphyseal bone seperates the extraarticular medial epicondyle from this common humeral epiphyseal centre. The common epiphyseal centre ultimately fuses with the distal humeral metaphysic.The medial epicondyle may not fuse with the metaphysic until late teens.

<u>JOINT STRUCTURES</u>

The elbow is a compound paracondylar joint –articulates with both ulna and radius It is a hinge joint which consists of three articulations namely humeroulnar , humero-radial and proximal radio-ulnar joints. All three share the same joint capsule reinforced laterally by radial collateral ligament and medially by ulnar collateral ligament and annular ligament hold the head of the radius in place .

The distal aspect of the humerus divides into medial and lateral columns . Each of these columns is roughly triangular and is bound on its outer border by a supracondylar ridge.

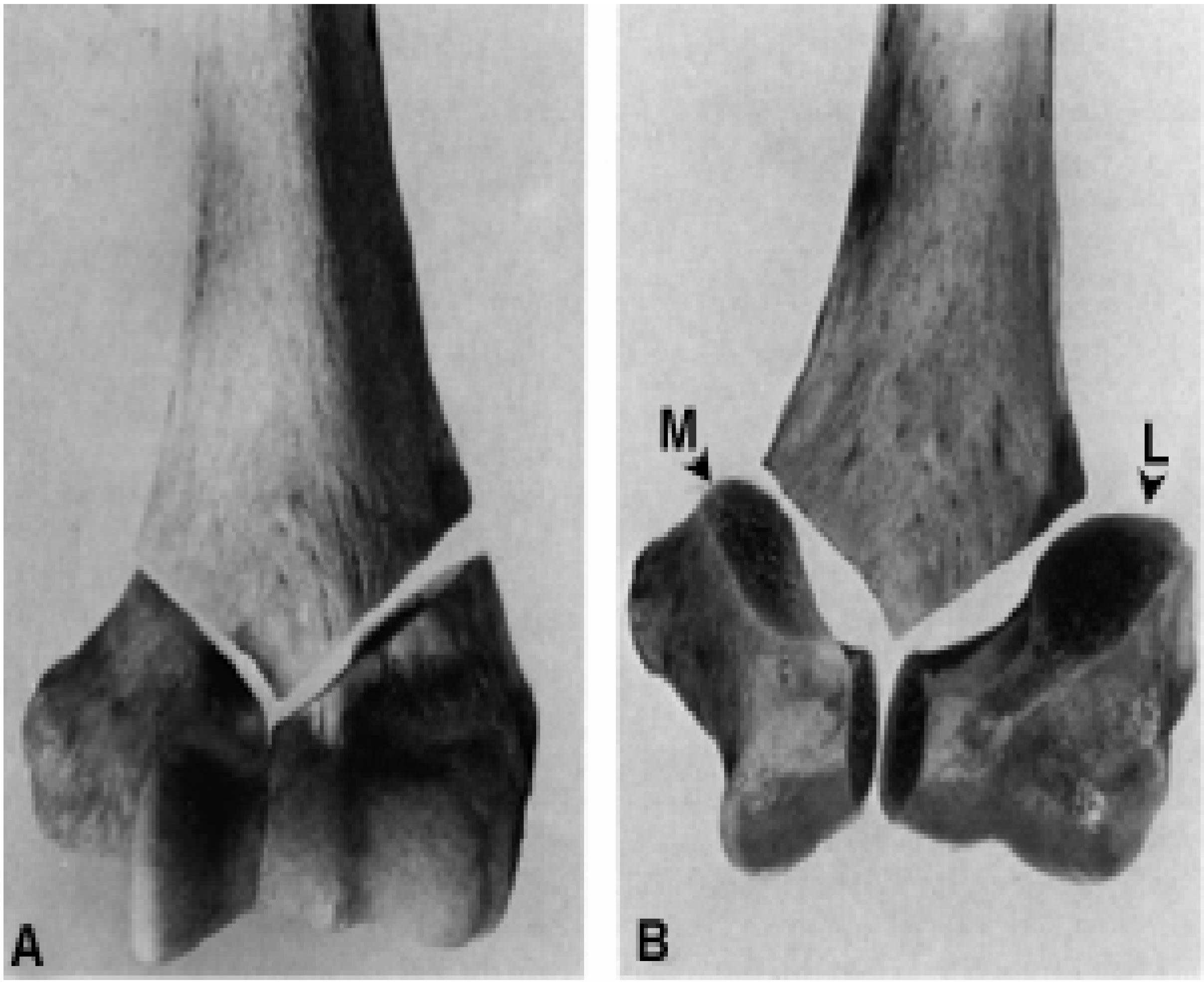


Fig 2 DISTAL HUMERUS- MEDIAL AND LATERAL COLUMNS

The divergence of these two columns increases the diameter of the distal humerus in the mediolateral plane. From structural and functional standpoints, the distal humerus is divided into separate medial and lateral components, called condyles, each containing an articulating portion and a nonarticulating portion. Included in the nonarticulating portions are the epicondyles, which are the terminal points of the supracondylar ridges. The lateral epicondyle contains a roughened anterolateral surface from which the superficial forearm extensor muscles arise. The medial epicondyle is larger than its lateral counterpart and serves as the origin of the forearm flexor muscles. The posterior distal portion of the medial epicondyle is smooth and in contact with the ulnar nerve as it crosses the elbow joint. When a condyle loses continuity from its supporting column, as in a fracture, displacement can occur, because no muscles are attached to the condyles to oppose those attached to the epicondyles.

The articulating surface of the lateral condyle is hemispherical and projects anteriorly; it is called the capitellum (capitulum), or "little head." The capitellum is much smaller than the trochlea, and its convex surface articulates with the reciprocally concave head of the radius. These surfaces are in contact throughout only a small portion of the full range of elbow motion.

The articular surface of the medial condyle, the trochlea, is more cylindrical or spool-like. It has very prominent medial and lateral ridges, which Milch believed are important in maintaining medial and lateral stability of the elbow. Between these ridges is a central groove that articulates with the greater sigmoid (semilunar) notch of the proximal ulna. The diameter of the trochlea at this groove is approximately half that of the medial ridge, and the groove occupies nearly the entire circumference of the trochlea. It originates anteriorly in the coronoid fossa and terminates posteriorly in the olecranon fossa. On the posterior surface of the trochlea the groove is directed slightly laterally. This obliquity of the trochlear groove produces the valgus carrying angle of the forearm when the elbow is extended. Between the lateral ridge of the trochlea and the hemispheric surface of the capitellum, a sulcus separates the medial and lateral condyles. This capitello-trochlear sulcus articulates with the peripheral ridge of the radial head.

Proximal to the condyles on the anterior surface of the humerus lie the coronoid and radial fossae. They receive the coronoid process and radial head, respectively, when the elbow is flexed. Posteriorly, the olecranon fossa is a deep hollow for the reception of the olecranon, making it possible for the elbow to go into full extension. The bone that separates these anterior and posterior fossae is extremely thin, usually translucent, and occasionally even absent. The presence of extraneous material in the olecranon fossa, such as fracture fragments or an internal fixation device, necessarily impedes full extension of the elbow.

The articular cartilage surface of the capitellum and trochlea projects downward and forward from the end of the humerus at an angle of approximately 30°. The centers of the arcs of rotation of the articular surfaces of each condyle lie on the same horizontal line through the distal humerus. Thus, malalignment of the relationship of one condyle to the other changes their arcs of rotation, limiting flexion and extension .

A bony spine, called the supracondylar process, occasionally projects downward from the anteromedial surface of the humerus. It arises approximately 5 cm superior to the medial epicondyle and is attached to the medial epicondyle by a fibrous band. The process, the shaft of the humerus, and the fibrous band form a foramen through which the median nerve and the brachial artery pass. The spur gives origin to a part of the pronator teres muscle and may receive a lower portion of the insertion of the coracobrachialis muscle.

CARRYING ANGLE

The spiral orientation of the trochlea or humeroulnar joint has resulted in an angular valgus alignment of the humerus with the forearm. The angle formed is termed the carrying angle. Because of this spiral orientation of the humeroulnar joint, the transverse axis of the elbow is not perpendicular to the long axis of the

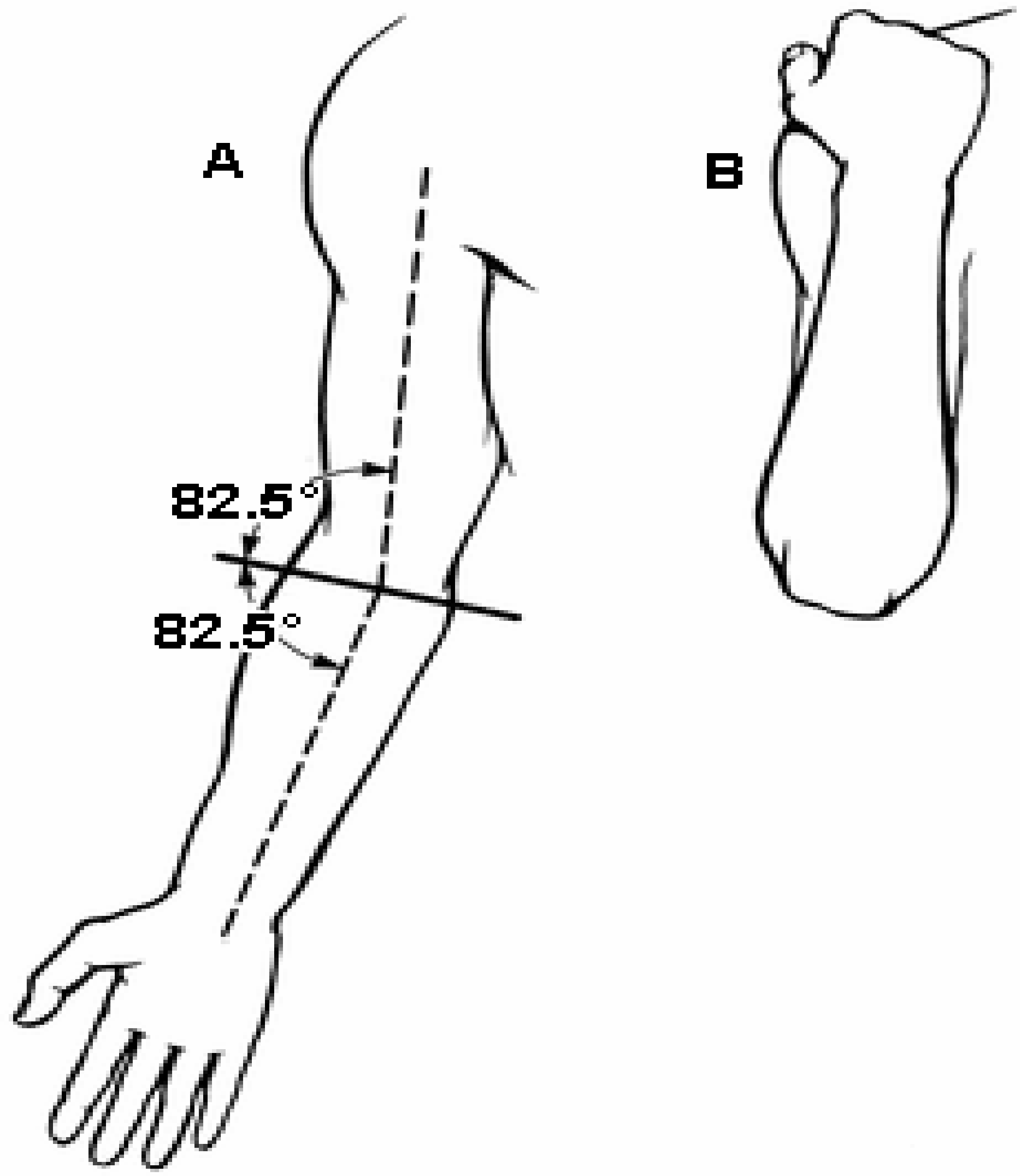


Fig 3 CARRYING ANGLE(due to obliquity of elbow axis with respect to humerus and forearm) (26)

humerus or even of the forearm but is slightly oblique to both. This obliquity of the axis of the elbow causes the long axes of the humerus and forearm to be parallel when they are superimposed in full flexion. (25) According to the normative data published for South India the carrying angles are as follows.(26)

Table 1 **Mean carrying angle and standard deviation by age and sex and *P* value for difference between them**

Age group (years)	Carrying angle (°) mean ± SD		*P* value
	Boys	Girls	
5–6	8.6 ± 4.2	10.0 ± 3.0	0.136
8–9	10.4 ± 2.9	11.8 ± 3.9	0.121
11–12	11.6 ± 3.2	13.6 ± 3.4	0.023
14–15	12.4 ± 2.5	15.4 ± 2.6	0.000
17–18	10.8 ± 3.6	13.6 ± 3.5	0.004
Overall	10.75	12.88	0.000

The carrying angle shows a progressive increase with age, followed by a slight fall after the age of 15 years. The *P* values indicate that sex differences gradually set in with age with a maximum around puberty (15 years).

The same study confirmed that the carrying angle is greater in girls than in boys by a mean of 1.311, in the south Indian population. Sex differences gradually increase with puberty, maximum values being attained at 15 years. The carrying angle correlates best with age. The rate of increase of the carrying angle with age is about 0.41 per year for boys and 0.61 per year for girls up to 15 years of age.(26)

SUPRACONDYLAR FRACTURES OF THE HUMERUS

There are two main types of supracondylar fractures:

1) Extension type.
2) Flexion type.

In 1959, Gartland (10) described three stages based on the degree of displacement: type I, nondisplaced; type II, minimally displaced; and type III, completely displaced. This classification system is still followed. While comparing this fracture to fracture neck of femur which is popularly known as the "***unsolved fracture***" he called it as ***"misunderstood fracture"***. The fracture line is transverse in the coronal plane and 80% of times transverse in the sagittal plane too(11). The fracture is extra-articular and is commonly proximal to the attachments of the collateral ligaments and distal to the insertion of the flexor and extensor group of muscles.

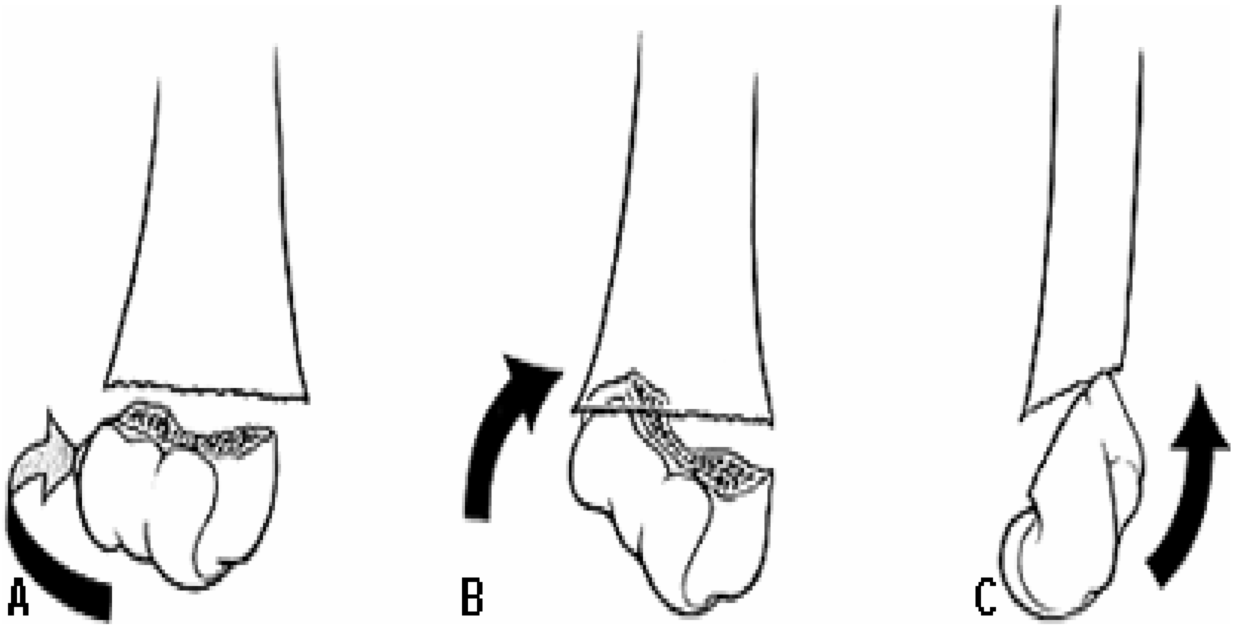


Fig 4 COMPONENTS OF VARUS (A) Internal rotation of distal fragment; (B) Varus angulation of distal fragment; (C) Hyperextension .

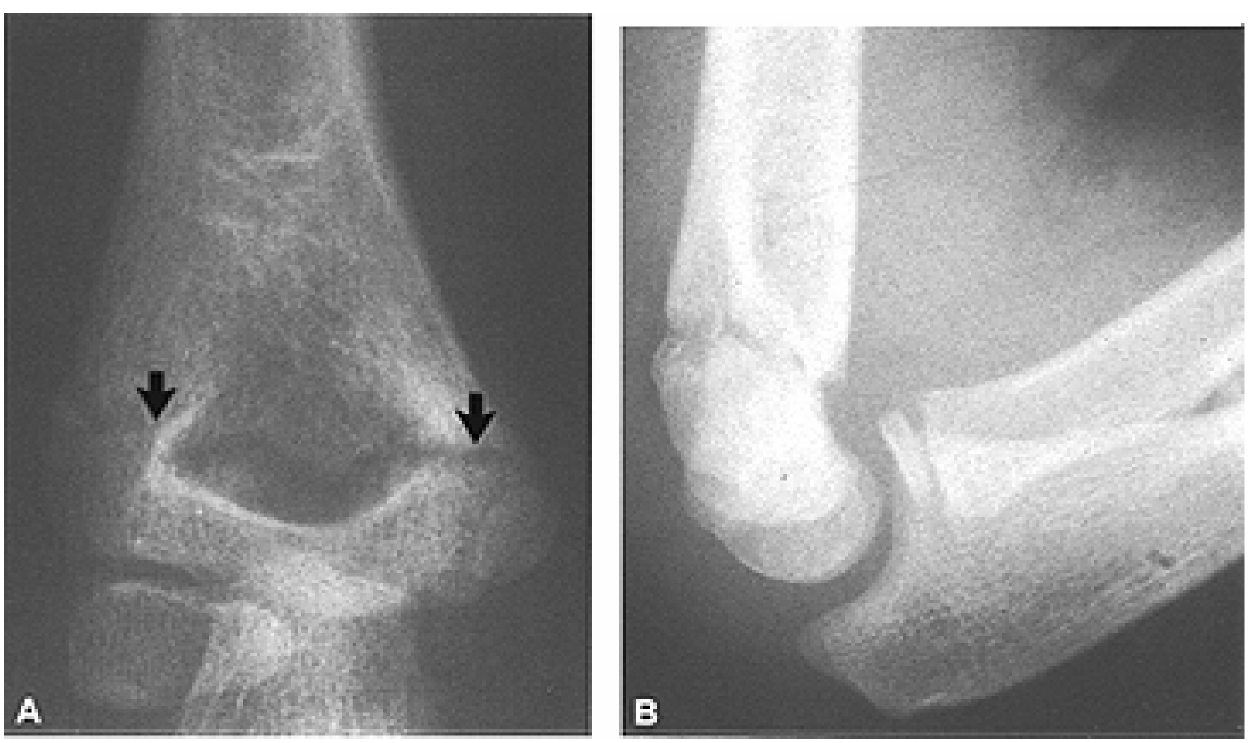


Fig 5 ORIENTATION OF FRACTURE LINE (mostly transverse in both planes

There are many complications associated with supracondylar fractures which include vascular injury, neurological injury, compartment syndrome ,angular deformities, elbow stiffness and myositis ossificans.

Cubitus varus is one of the commonest long term complication of supracondylar fractures .

CAUSES OF VARUS MALUNION:

Cubitus varus is one of the commonest late complication following a supracondylar fracture. The reported incidence ranges from 10–57% regardless of the method of treatment.(5) It consists of varus, hyperextension and internal rotation deformity of the distal bone fragment of the humerus.

The causes of varus malunion of a supracondylar humerus fracture are primarily due to the following in the presence of a malalignment:

1)failure to recognize (especially in minimally displaced fractures),

2)failure to reduce

3)failure to stabilize

Growth disturbance has less often been implicated as factor leading to varus deformity (3). Immobilisation with cast or traction have higher likelihood of leading to deformity than percutaneous pin fixation. Cadaver studies by Stimson in the late 1800s demonstrated that the deformity was in the metaphysis and that the joint surface was uninvolved. This concept—that the cubitus varus is a result of residual coronal angulation of the distal fragment—is still widely accepted.(12-19)

EFFECT OF ROTATION:

Attention has been given to the minimally angulated fracture with compression of the medial column and rotation of the distal fragment. If the compression and rotation are not addressed, there most likely will be a resultant varus malunion . The hourglass shape in the sagittal plane of the supracondylar humerus provides very little contact between the bony fragments, and thus the distal segment may slip medially to produce cubitus varus (4)

Displacement of the distal fragment is liable to occur in many directions, anterior or posterior, lateral or medial, rotation and angulation. Some fractures cannot be completely reduced because the small size of the antero-posterior diameter of the humerus makes reduction like an attempt to balance one knife edge on another

(Wainwright 1962)

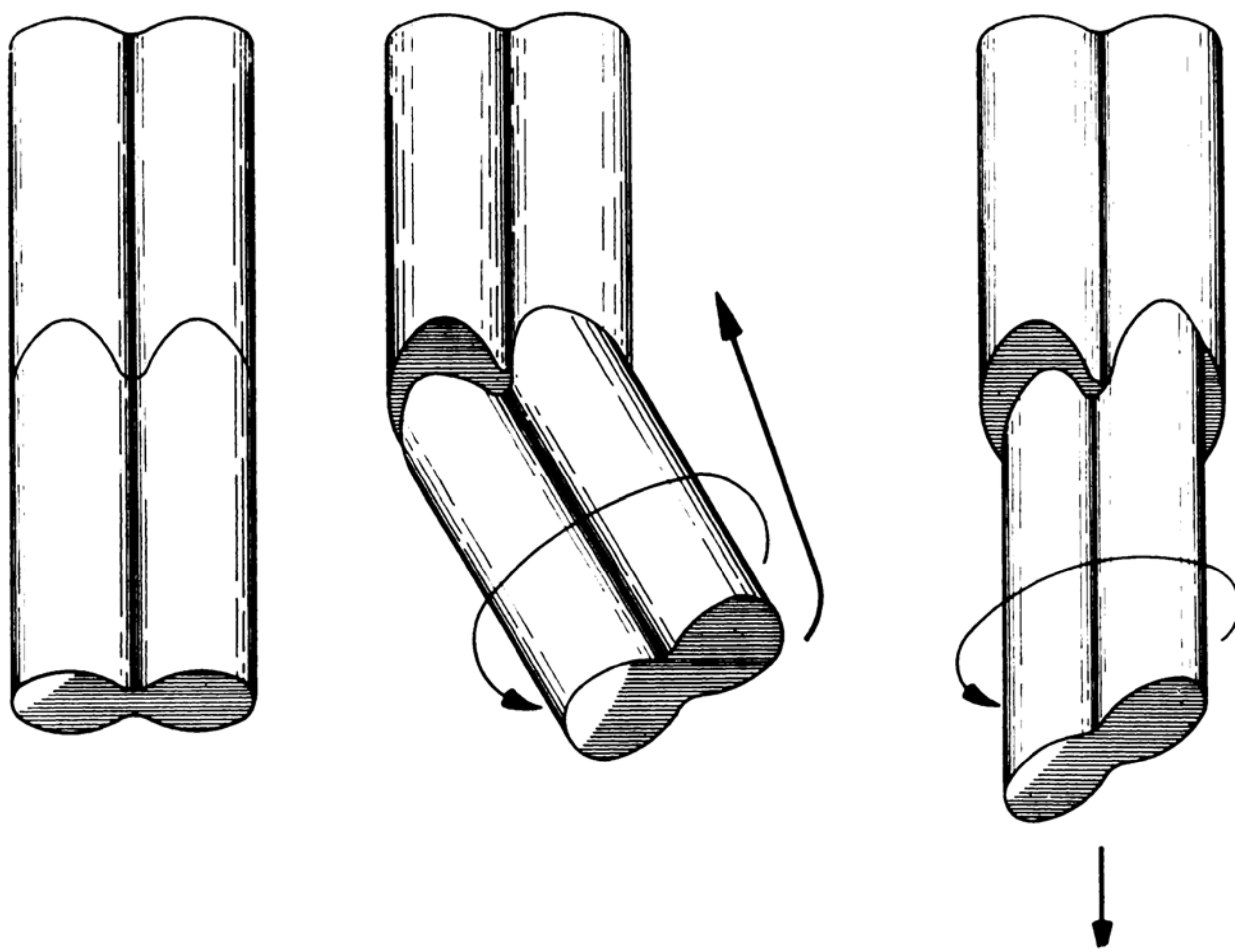


Fig 6 Mechanical drawing to illustrate the influence of rotation on the alignment of an oblique fracture. The plane of the fracture line is at 45 degrees to the long axis of the humerus. The central longitudinal constriction of the cylinder simulates the thin portion in the distal part of the humerus at the level of the olecranon and coronoid fossae. With rotation of the distal fragment and compression forces applied   angulation occurs. With traction applied, angulation is prevented. (36)

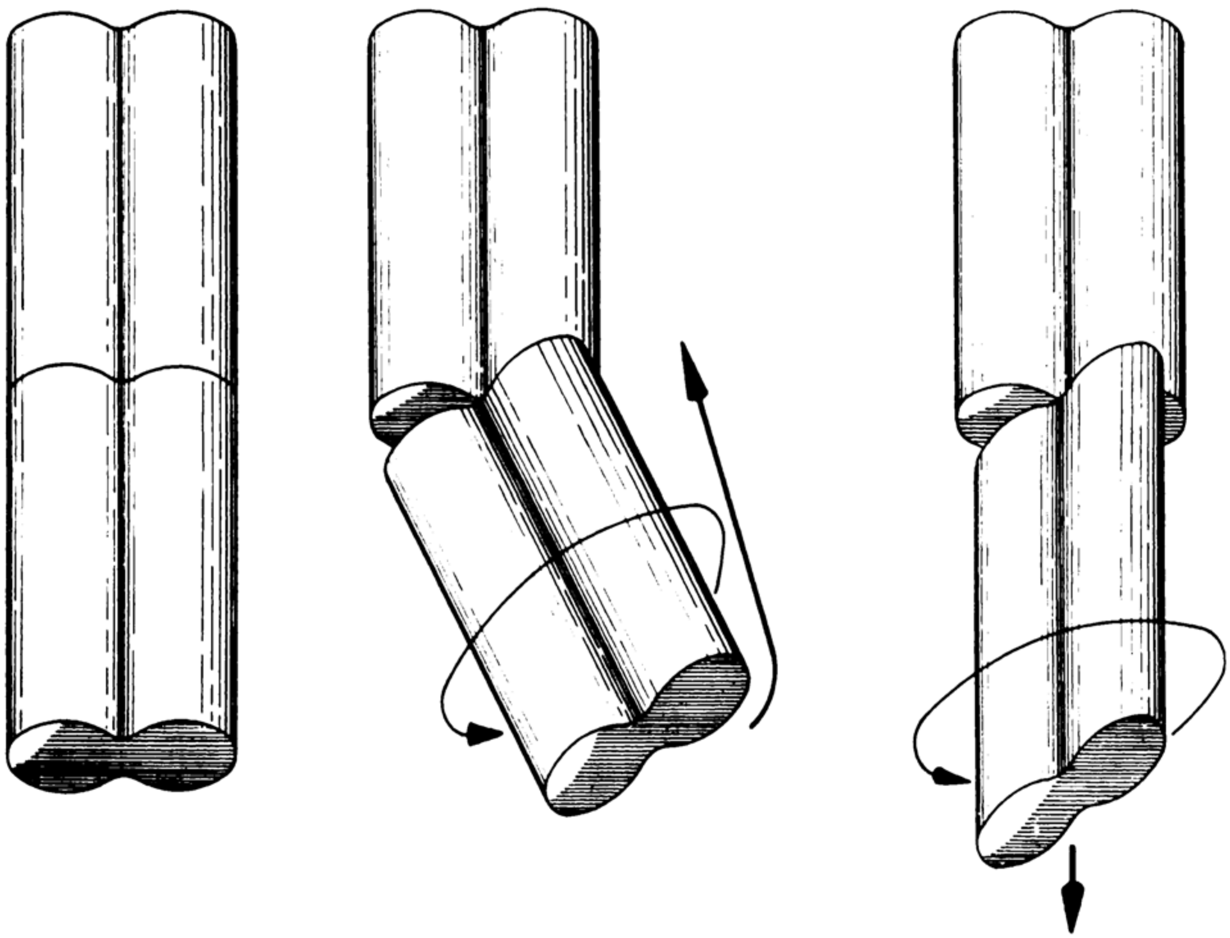


Fig 7 Mechanical drawing to illustrate the effects of rotation on the alignment of transverse supracondylar fracture. The bearing surfaces are reduced with minimal amounts of rotation;and, if a compressing force is acting, angulation is inevitable. Traction prevents angulation. (36)

There is often lack of control of the position of the fragments because of the tense haematoma which accompanies this fracture. There is also a tendency towards medial angulation when rotation persists after reduction; this is particularly so when oedema subsides and because of loose cast fixation is lost before the fracture achieves stability. This eventually leads to varus deformity. Medial rotation alone does not cause changes in the carrying angle. However, its presence predisposes to medial angulation of the distal fragment because of lack of contact between the medial cortex of the shaft of the humerus and the cortex of the distal fragment (Mann 1963). Medial angulation is the direct cause of varus deformity; it alters the relation between the axis of the humerus and the axis of the joint line of the elbow with subsequent deviation of the axis of the forearm (King and Secor 1951, Smith 1960, Mann 1963). It is a frequent residual displacement after reduction and can occur as a secondary displacement during fixation. Unfortunately, medial angulation is very difficult to detect after reduction once the elbow is flexed, because in the radiograph the distal end of the humerus is hidden by the shadow of the forearm bones and the plaster cast. When the elbow is flexed or the forearm pronated no measure of the carrying angle can be made. The carrying angle can be measured and controlled accurately when the elbow is fully extended and the forearm supinated.

The great power of remodeling(9) in children contributes a lot to improvement of the function of the elbow joint (Attenborough 1953) and largely corrects deformity caused by backward, medial or lateral displacement. But unfortunately medial angulation of the distal fragment, the cause of varus deformity, is not affected by the process of remodelling. In as many cases, acceptance of even minor angular displacement is the cause of many bad results related mainly to changes of the carrying angle (Mann 1963). The degree of remodelling diminishes in children over the age of ten years. Though many opinions are expressed in the literature regarding the remodeling of these fractures there is a no data which records the fate of cubitus varus deformity over a period of years after sustaining injury.

Varus malunion is much more clinically evident in the elbow with cubitus rectus (straight carrying angle). Examination of the patient with a supracondylar elbow fracture before treatment always should include an examination of the uninjured elbow. The tolerance for Incomplete reduction is much lower in the child with cubitus rectus.

In an eloquent laboratory study by Chess and coworkers(20) an anatomic model was devised in which 256 combinations of varus angulation, internal rotation, posterior angulation, and flexion contractures were produced and evaluated for the clinical appearance of cubitus varus. This study found that the major feature that created cubitus varus was true varus angulation in the coronal plane. Internal rotation did appear, however, to worsen the deformity. In a clinical study(21)measuring the true distal humeral rotation from wedges removed when performing osteotomies of the distal humerus, no correlation could be made between the degree of horizontal rotation of the distal humerus and the severity of the cubitus varus.

Thus, although horizontal rotation may accentuate the unsightly appearance of the clinical deformity, the degree of varus rotation in the coronal plane accounts primarily for the severity of the cubitus varus deformity. This is important to remember when planning a surgical correction of cubitus varus.

PATHOLOGY OF CUBITUS VARUS :

Three Distinct Patterns.- The development of coronal tilt can be seen in one of three patterns. In the first two, the deformity is essentially totally in the coronal plane. In the third type, the deformity is in one, two, or three planes.

1) GREENSTICK COLLAPSE. There can be a greenstick collapse of the medial supracondylar column that shifts the distal fragment into varus. This greenstick collapse can be unappreciated on the initial x-ray .

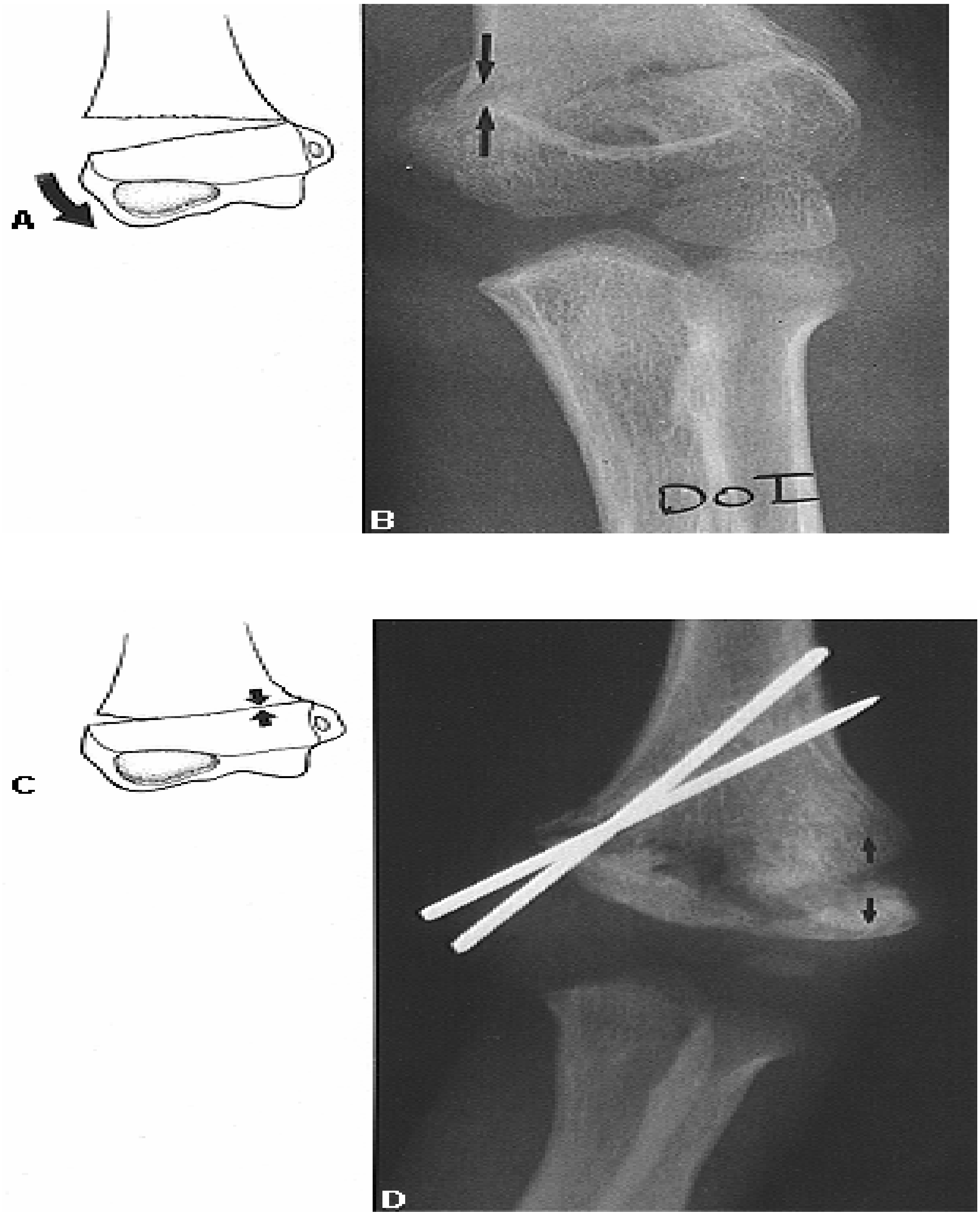


Fig 8 (A) &(D) - LATERAL OPENING ; (B)& (C)- MEDIAL

GREENSTICK COLLAPSE.

2) LATERAL OPENING. In the second deformity, the fracture site opens on the lateral side, again throwing the distal fragment into varus. This is probably the least common of the cubitus varus fracture patterns.

3) THREE-PLANE DEFORMITY. Most cubitus varus deformities are actually a combination of one, two, or three of the three-plane deformities . These secondary rotations can increase the grotesqueness of the coronal cubital angulation of the primary varus angulation. Medial horizontal rotation of the distal fragment can make the lateral condyle become more prominent clinically . Likewise, hyperextension can accentuate the varus angulation.

The burden of cubitus varus is more in the developing countries due to neglect caused by the strong faith of people in traditional bone setters and thereby more inadequate reduction and non-operative management.

DELETRIOUS EFFECTS OF VARUS MALUNION :

Varus malunion has been considered by several authors to be only a cosmetic deformity. More recent studies have suggested that there may be associated with additional morbidity.

Davids et al (22) have reported an increased incidence of lateral condyle fractures in the elbow in varus. The second fracture was an epiphyseal injury of the distal humerus associated with a fracture involving the lateral metaphysis below the supracondylar fracture. The diagnosis was either lateral condylar fracture or fracture-separation of the entire distal humeral epiphysis. These also involved the distal humeral physis. The physis and epiphysis tend to be more subject to injury than the metaphysis of the distal humerus in children after a supracondylar fracture. The involvement of the physis in the second fracture may depend on post-traumatic changes in the metaphysis of the distal humerus. It is thought that the healed injury leaves the metaphysis thickened thickened, which protects the area from further injury, but the growth plate becomes vulnerable. Davids et al studied the biomechanics of cubitus varus, and suggested that posttraumatic cubitus varus alignment could increase both the distraction and shear forces across the lateral condyle of the distal humerus generated by a routine fall on an outstretched upper arm . The fractures diagnosed as a lateral condylar fracture were classified as adduction avulsion fractures as described by Milch, which suggests that the cause had been predominantly a distraction rather than a compression force. When the elbow is re-injured, due to the cubitus varus, the main force is varus. The resultant injury pattern may be a total separation of the distal humeral growth plate or a fracture of the lateral condyle.

Spinner and Goldner(7) described the snapping or subluxing medial triceps over a malunited medial epicondyle from a supracondylar fracture malunion. This is secondary to changing the vector of the triceps. It can be painful and also can lead to ulnar nerve subluxation over the medial epicondyle, causing ulnar neuropathy. In addition , the internal rotation deformity associated with the elbow in varus has been recognized as a factor in the development of tardy ulnar neuropathy . Mitsunari and coworkers concluded that the internal rotation causes the medial epicondyle to rotate back , compressing the ulnar nerve , with concomitant increase in pressure from the medial aspect of the triceps . Finally , the varus deformity alters the biomechanics of the elbow which may lead to a posterolateral instability pattern. It has been suggested that this eventually can lead to degenerative changes in the elbow joint (S.W. O'Driscoll, MD, PhD, 1999). Cubitus varus malalignment secondary to a varus deformity of the distal part of the humerus produces two biomechanical disturbances that appear to act together to stretch out the lateral collateral ligament complex. First , with varus malalignment the mechanical axis (wrist to shoulder) displaces medial to the elbow. The repetitive varus torque caused by this malalignment increases tensile stress on the lateral collateral ligament , especially when an axial force is applied to the limb , such as occurs when

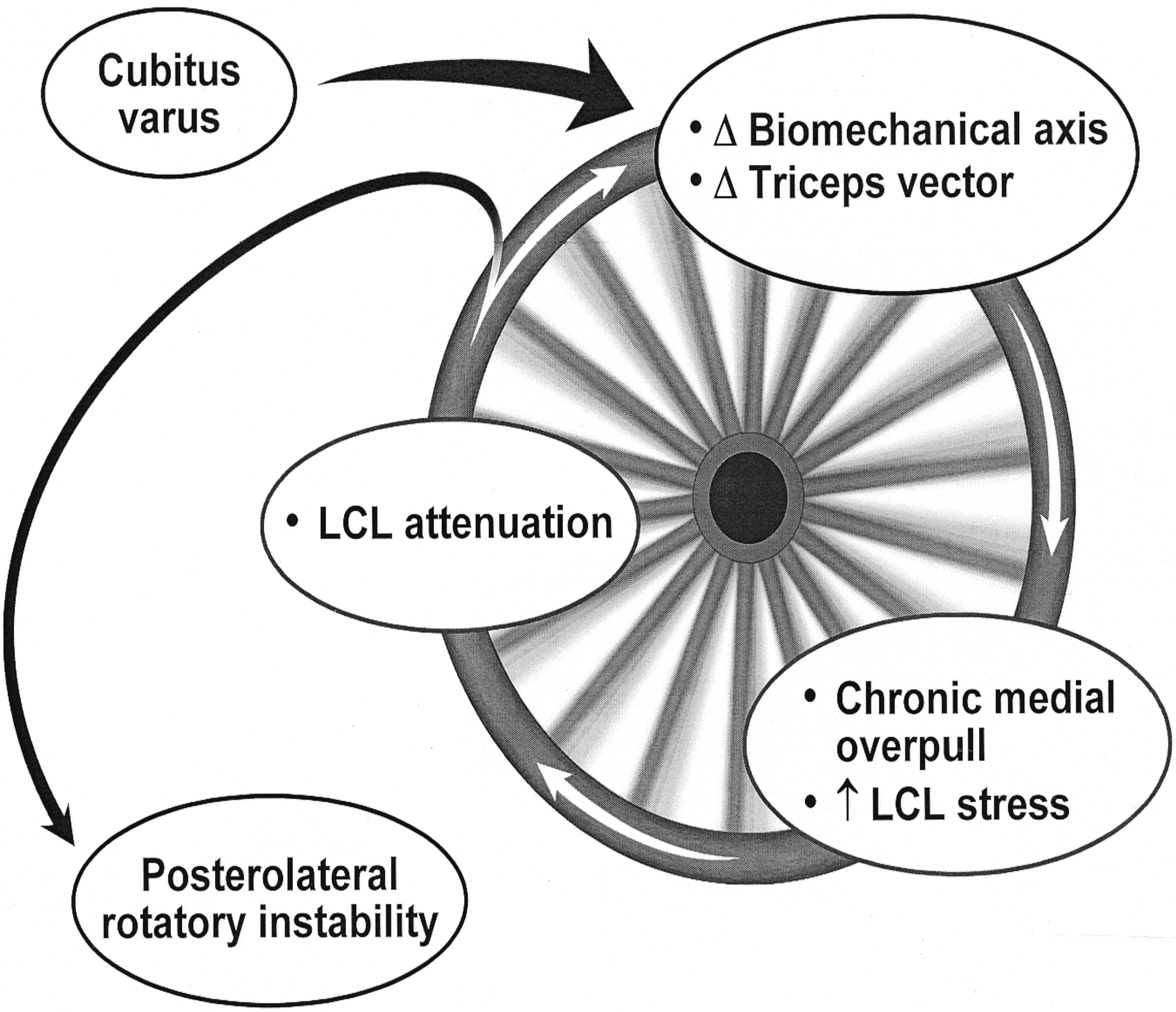


Fig 9 EFFECT OF CUBITUS VARUS ON ELBOW BIOMECHANICS

a person rises from a chair . This can further alter the mechanical axis. Second , varus malalignment also displaces the triceps force vector medially to create repetitive external rotatory torque on the ulna . With the elbow flexed to 90 ° and viewed from the posterior aspect , it is readily apparent that varus deformity of the distal part of the humerus causes medial displacement and external rotation of the ulna along its long axis . As a result of this , the triceps force vector , when resolved into two force vectors parallel and perpendicular to the joint surface , causes medial displacement . In addition , the triceps force vector is offset from the center of rotation of the deformity of the distal part of the humerus such that the moment arm creates external rotation torque on the ulna (that is, supination) . These repetitive abnormal torques cause chronic medial overpull of the triceps, which , during childhood growth , can cause medial elongation of the olecranon . Repetitive stress to such a malaligned elbow, as would occur when the person rises from a chair , can exacerbate and precipitate the biomechanical alterations.- It would seem that in addition to the benefit of improving cosmetic deformity , correction of severe malunions would lessen the risk of a lateral condyle fracture and improve elbow biomechanics . Cubitus varus has also recently been associated with joint ganglia and posterior dislocation of the radial head . Thus treatment of this deformity is important not only for cosmetic reasons but also to restore normal elbow biomechanics and to prevent any later associated complications .

A long persistent cubitus varus deformity has also been linked to shoulder instability. The most important restraints to posterior glenohumeral instability are the capsular ligamentous tissues and the dynamic integration of the shoulder girdle musculature, which was described as three layers acting as cones to stabilize the shoulder complex. The angular or rotational position of the arm has a further direct influence on the stability. In a cubitus varus deformity, there is often an internal rotation of the distal fragment, which means an external rotation of the humerus. Because there is a lack of support medially, coronal tilting of the distal fragment is the resulting deformity. This can cause anteromedial displacement of the triceps and ulnar nerve , whereas the long head of the biceps and the coracobrachialis displace anterolaterally. Shortening of the muscles on the posterior aspect of the proximal humerus and lengthening of those on the anterior aspect create a muscular imbalance that in the long term can increase the stress on capsular ligamentous restraints.

The alterations in the axial humeral muscles might be responsible for the varying degrees of flexion of the elbow while resting. The displaced long head of the biceps and triceps further decreases resistance to posterior subluxation, depending on shoulder rotation . These alterations in the direction and strength of the muscular contractions are helpful in understanding the mechanism of an involuntary (positional) posterior glenohumeral instability.

In view of all the reasons mentioned above it is important to correct this deformity. But in all published data till date most common reason for presentation of children to the orthopaedician is cosmetic deformity.

TREATMENT OF CUBITUS VARUS

The deformity does not improve with time . In correcting the deformity, only few authors(29,30)argue that the rotational components should be corrected. In two series(27, 28) good results were achieved by performing only a simple lateral closing osteotomy that corrected only the varus angulation. In another clinical evaluation of patients(31) in which only the varus angulation was corrected, there did not appear to be any clinical problem with a change in the rotation of the entire upper extremity at the shoulder from failure to correct the rotation of the distal fragment. Thus, in surgically correcting cubitus varus, the major focus should be on correcting the varus in the coronal plane.

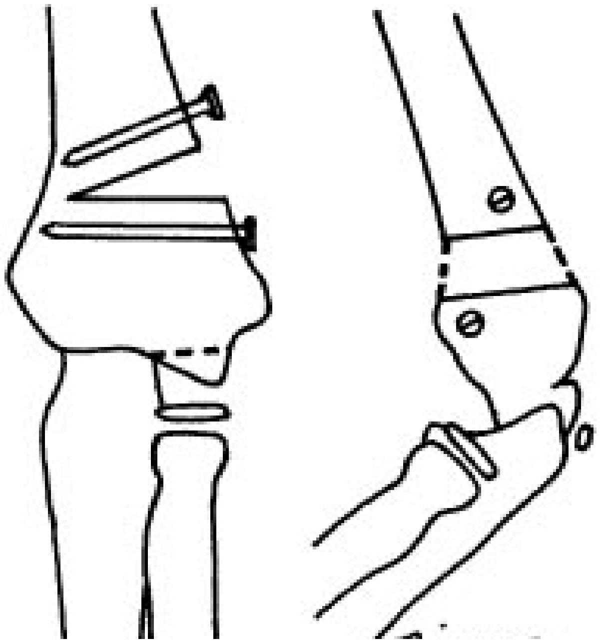
Three major types of osteotomy have been proposed to correct the deformity. Their primary aim is to correct the varus angulation. Correction of sagittal (hyperextension) angulation or medial horizontal rotation is secondary. The three most popular techniques are a simple lateral closing wedge osteotomy , a dome rotational osteotomy, and a step-cut lateral closing wedge osteotomy .

A list of various treatment techniques described in the literature is provided under the historical review.

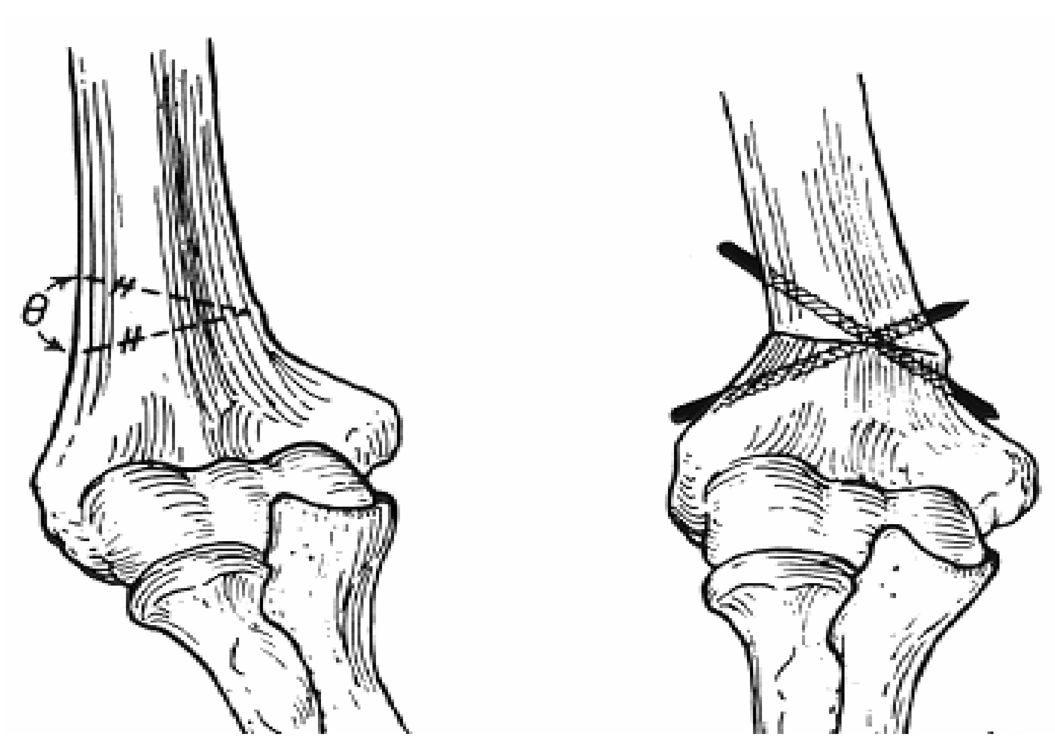
One of the initial corrective osteotomy was described by French who did a lateral closing wedge osteotomy by a posterior triceps splitting approach.The osteotomy site was fixed with two screws and then tightening a wire across the screws.

A lot of variations of this lateral closing edge osteotomy were described following this .The major problem with these osteotomies was inadequate fixation. To overcome these problems a step cut osteotomy was described wherein a lateral spike of bone remained on the distal fragment which provided additional stability at the osteotomy site. A reverse –V osteotomy was described where a inverted –V shaped wedge was removed from the distal humerus.

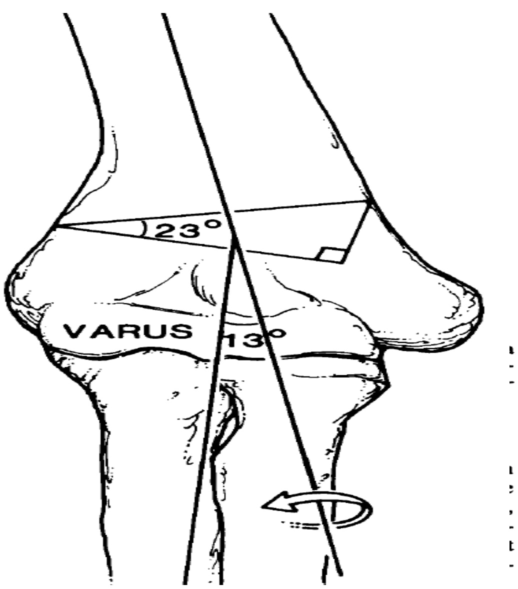
FRENCH OSTEOTOMY (Fig 10)



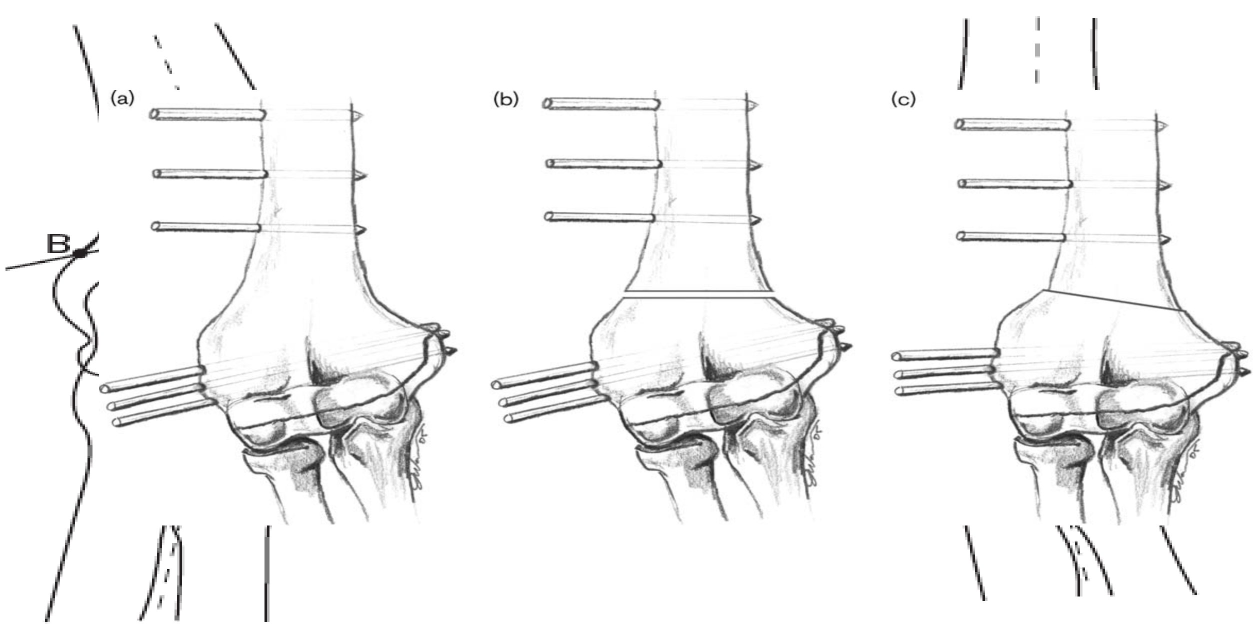
LATERAL CLOSING WEDGE OSTEOTOMY(Fig 11)



STEP CUT OSTEOTOMY (Fig 12)



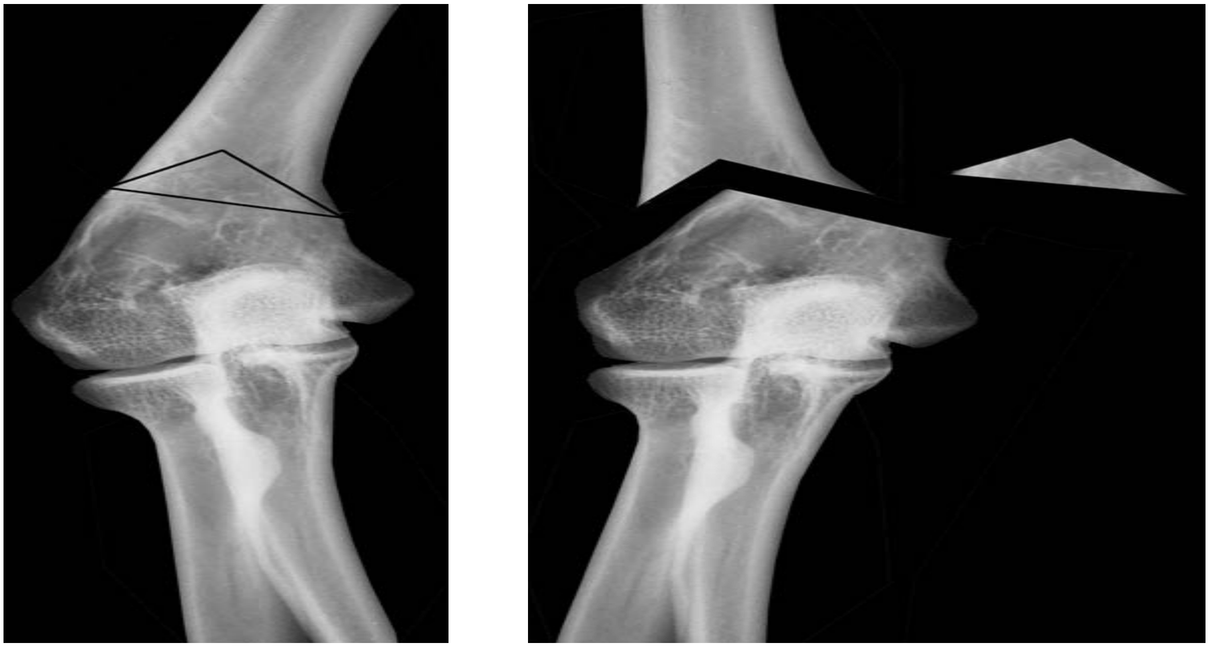
REVERSE V OSTEOTOMY (Fig 13)



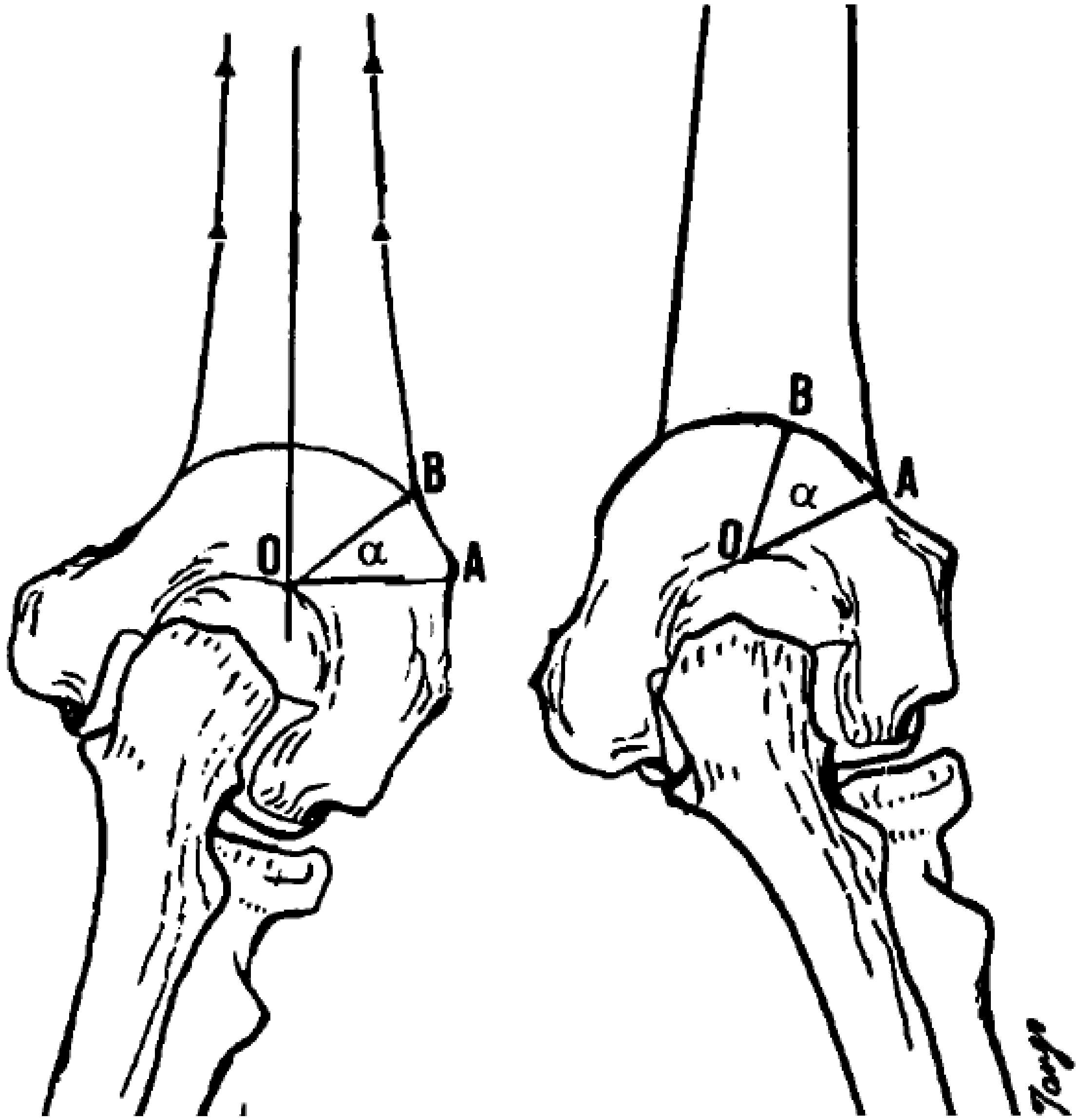
CORRECTIVE OSTEOTOMY USING AO EXTERNAL FIXATOR(Fig 15)

CORRECTION USING ILIZAROV TECHNIQUE(Fig 16)

CORRECTIVE OSTEOTOMY AS DESCRIBED BY HUI TAE KIM et al (Fig17)



DOME OSTEOTOMY   Higaki T, Ikuta Y(J Jpn Orthop 31:300–335, 1982)(Fig 14)



DOME OSTEOTOMY

The posterior cortex of distal humeral metaphysis is quite flat. Through a posterior approach, the domed osteotomy usually can be designed and finished easily. O the center of dome; A the junction between periosteum and perichondrium; B the starting point of the dome. The periosteum was detached to the junction with the perichondrium (Point A).The intersection of the midline and upper margin of the olecranon fossa (Point O) was designated as the center of the dome. With the OA line as the base, a second line was drawn from O to B to form an angle (alpha) that was equal to the planned correction angle. The arc of the domed osteotomy was defined based on these parameters After the domed osteotomy, the distal fragment was rotated along the dome until Point A reached the margin of the dome and thus the elbow was realigned as planned. Through the posterior approach, the realignment can be done precisely and the purchasing points

of the fixation pins can be selected easily.The elbow was realigned by rotating

the arc between A and B of the distal fragment into the dome.

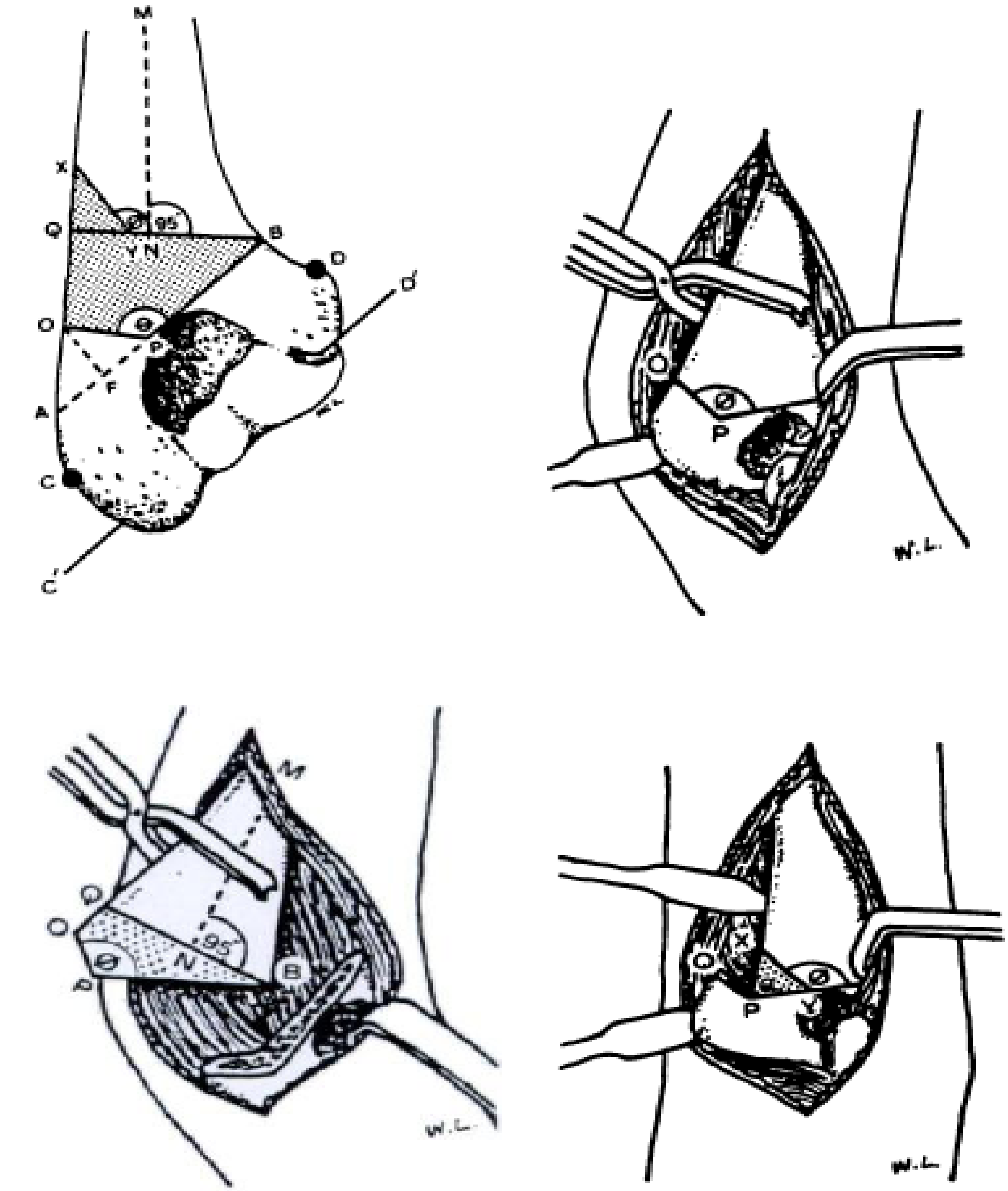


Fig 18   PENTALATERAL OSTEOTOMY

PENTALATERAL OSTEOTOMY

CD (Fig 18)is the line joining the epicondyles, practically parallel with the transverse axis of the elbow C'D'. AB is parallel to CD and just proximal to the olecranon fossa**.** AF is about half of the estimated shaft diameter and the angle OPB is about 120deg This angled line is marked and cut, and the proximal part mobilized. The proximal bone is then divided at QB, at about *95deg* to the longitudinal axis of the shaft MN. The line XY and the angle XYB can then be marked by temporarily reducing the cut surfaces. The cut surface of the proximal stump will show evidence of any medial rotation deformity. This is made apparent by a triangular zone of subperiosteal new bone posterior to the original posterior cortex. The degree of rotation can be directly measured from this. The cut XY is then made perpendicular to the coronal plane of the *old* bone ; this ensures that, after reduction, rotation will be corrected. When the osteotomies are complete, reduction is performed with the elbow extended. There may be minor discrepancy between YB and PB, but this makes little difference to the medial contour. The fragments are fixed, first by Kirschner wire and then by a lag screw, to provide compression .

COMPLICATIONS ASSOCIATED WITH CORRECTIVE OSTEOTOMIES

As evident by the large number of procedures described and the various modification for them, there doesn't seem to be a perfect answer to this problem .The more the number of procedures the more are the associated problems with them. The various complications were :

1) Local sepsis- pin track infections

2) Loss of fixation

3) Nerve injuries- Neurapraxia is a frequent postoperative complication of the lateral closing wedge osteotomy.(24,32) The nerve palsy is caused mainly by the pins used to stabilize the osteotomy. More frequently the ulnar nerve is involved.

4) Refracture.

5) Undercorrection/ overcorrection

6) Hypertrophic scar.

7) Elbow stiffness.

8) Lateral condylar prominence- seen in lateral closing wedge osteotomies where excision of wedge leaves two fragments of unequal width. Hinging on the medial cortex while closing the osteotomy effectively shifts the distal fragment laterally causing this unsightly deformity.

9) Lazy –S deformity – due to undercorrection of varus , rotational deformity and lateral condylar prominence with wasting of the flexor group of muscles.

In the study of Oppenheim et al,(32) with an average followup of 21⁄2 years, 24% of patients had complications of neurapraxia, sepsis, or cosmetically unacceptable scarring. In the study of Ippolito et al(24) with an average followup of 23 years, all but two of the 19 patients in whom the carrying angle had been measured preoperatively lost correction that had been obtained during surgery. Approximately 60% of the patients reported an unattractive postoperative scar.(24)

ASSESSMENT OF OUTCOME :

Most of the studies assess outcome using Oppenheim criteria (32)

Criteria	**EXCELLENT**	**GOOD**	**POOR**
HUMERUS – ELBOW WRIST ANGLE CORRECTIO	**Within 5 deg of normal**	**Within 10 deg of normal**	**Residual deformity > 10 deg**

N			
Loss of ROM at elbow	**Upto 5 deg**	**6- 10 deg**	➢ **10 deg**
COMPLICATIONS	**nil**	**Scarring/ lazy –S deformity**	**Any complication**

In various studies excellent results varied from 40% to 75 % of all operated patients.

TECHNICAL PITFALLS OF CORRECTIVE OSTEOTOMIES :

1)The osteotomy site is usually more proximal than the malunited metaphysis; therefore, it often is difficult to cross the fixation pins at the osteotomy site for rigid fixation.

2)The tightness of the medial soft tissue after the closing wedge osteotomy tends to produce a strong varus moment that can lead to recurrent deformity if the osteotomy site is not rigidly fixed.

3)Tendency to produce a prominent lateral condyle after the angulation is corrected.

This secondary deformity often compromises the cosmetic outcome

4)Wilkins et al reported difficulty in rotating in coronal plane in the dome osteotomy because of contractures of the soft tissue on the medial side, especially in the intermuscular septum.

In view of all the above a retrospective review of the current series of patients was done to evaluate whether this new technique of cubitus varus correction can overcome the pitfalls of the previous techniques.

MATERIALS AND METHODS

From January 2001 till July 2006 , thirty two corrective osteotomies for correction of cubitus varus were performed in the Paediatric Orthopaedics section of Christian Medical College Hospital, Vellore, South India under the supervision of a single surgeon by this newly described technique. Of these 21 were followed up for a period of 12 months or more. There were 14 boys and 7 girls with an average age of 10 years at surgery (range 3 to 17 years). 11 children were not seen after the first follow up . The average interval between injury and surgical correction of deformity was 29.8 months (range 3 to 72).The mechanism of injury was fall during playing in 17 children , fall at home for 3 children and vehicular accidents for 1 child. 1 child was treated surgically with a closed reduction and k –wire fixation after injury and 20 were treated conservatively with cast after injury. All patients presented with anxious parents with complaints of cosmetic deformity with no functional problem. The mean cubitus varus angle was 20.95 degrees (range 9 to 40 degrees) and the mean carrying angle in the normal limb was 7.86 degrees(range0 – 16 degrees).

CLINICAL EXAMINATION

The pre-operative examination consisted of measurement of carrying angle of both the elbows . The elbow was maintained at neutral, forearm in full supination and the wrist at neutral. An orthopaedic goniometer was placed with its hinge in the centre of the cubital crease (midway between the medial and lateral humeral condyles). The tips of the two axes of its arms were directed one toward the lateral edge of the acromion (easily palpable in children) and the other toward the midpoint of the radial and ulnar styloid. The angle was measured off the dial at the centre of the goniometer, to the nearest degree (as that was the lowest count of the goniometer). This angle corresponded to the acute angle between the axis of the arm and the axis of the fully supinated and extended forearm held neutral at the elbow(26). The range of movements at the elbow and shoulder joints were measured on both sides and noted. Special attention was given to presence of any elbow flexion contracture , elbow hyperextension and any difference in shoulder rotations. Also a thorough assessment of the neurovascular status of the upper limb was done . Post-operatively too the carrying angle on both the sides was measured by the above mentioned technique.Also range of motion at the elbow and shoulder were noted.At follow up the scar ,presence of any lazy –S deformity or any abnormal protuberance of the lateral condyle was noticed.

RADIOGRAPHIC EVALUATION

Standard long x-rays of the upper limb including the entire shoulder , elbow and wrist joints of both sides were taken preoperatively and post-operatively with the elbow fully extended and forearm in full supination to include the entire extent of the upper extremity.

The humerus-elbow-wrist angle was measured on anteroposterior radiographs of the upper extremities.To measure the humerus-elbow-wrist angle, we first drew two transverse lines (one proximal and one distal) across the humerus that connected the medial and lateral cortices and two lines (one proximal and one distal) across the forearm that connected the medial cortex of the ulna and the lateral cortex of the radius. We then drew a line connecting the midpoints of the two cross-humeral lines and another connecting the midpoints of the two lines across the forearm. These lines were extended until they intersected, and the angle of intersection was measured.This was the radiographic carrying angle.

The lateral condylar prominence index (LCPI) was calculated as ratio of the difference of medial and lateral widths from the longitudinal mid-humeral axis and the total width of distal humerus to avoid errors due to magnification and variations in the size of the humerus .

Fig 19 Humerus Elbow Wrist (HEW) angle

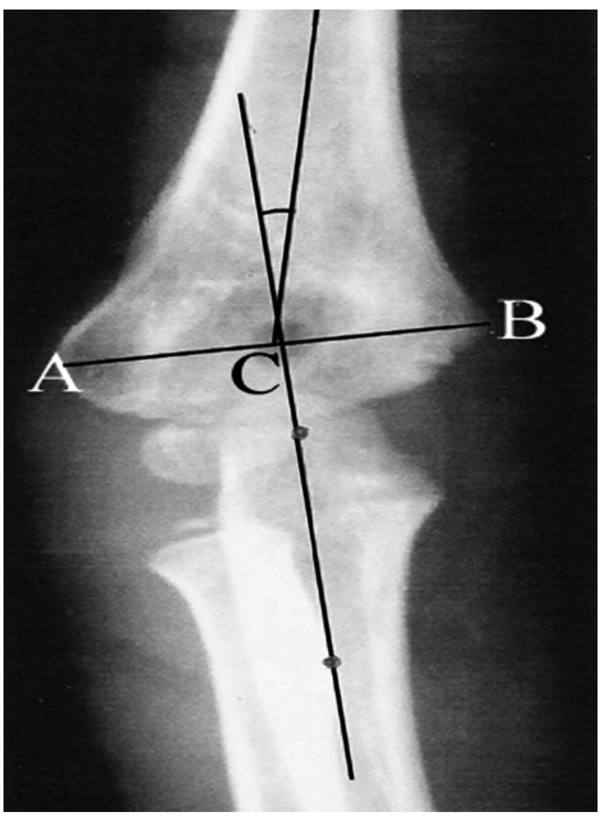


Fig 20 Lateral Condylar Prominence Index (LCPI) (AC-BC/AB X 100)

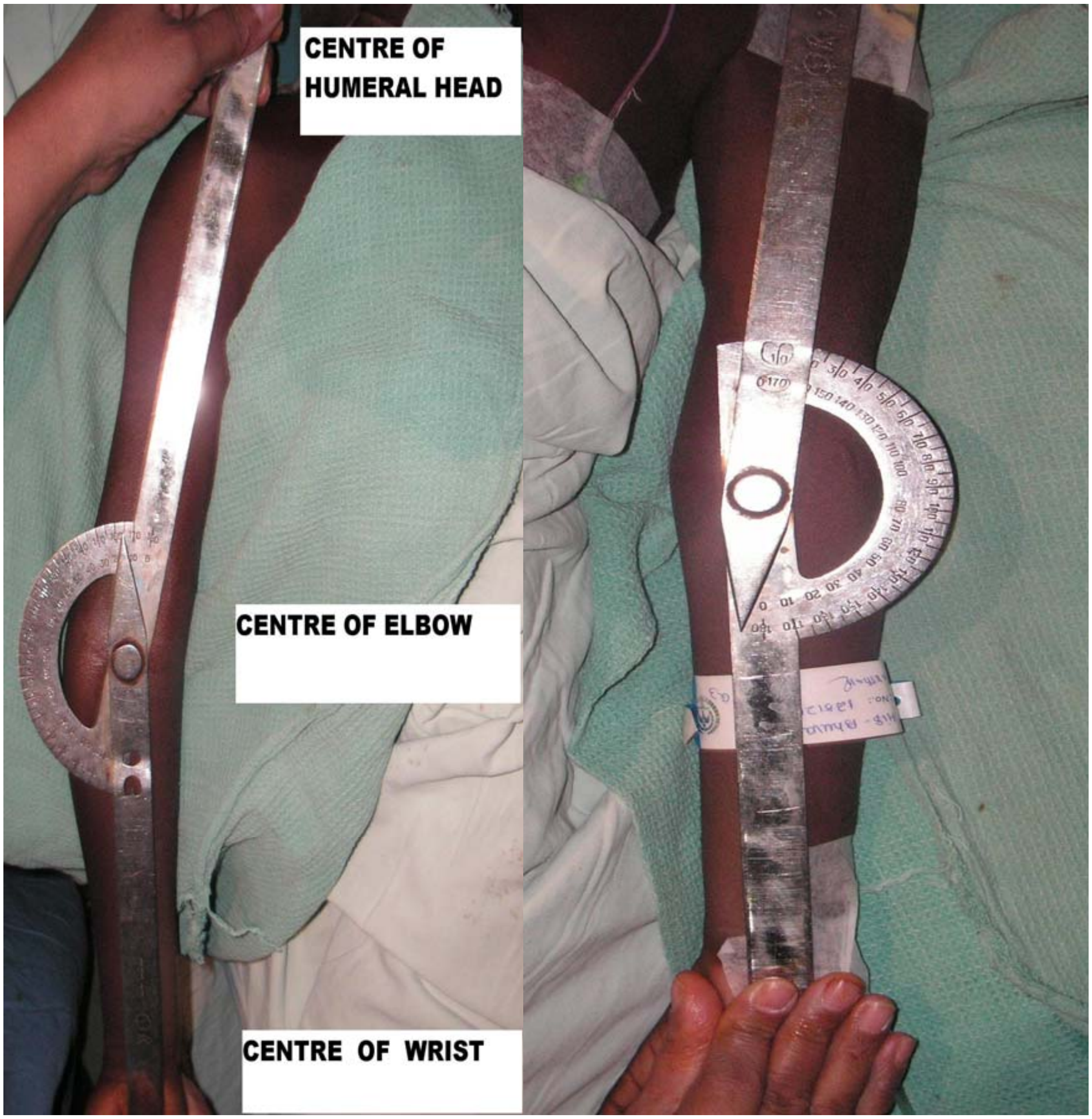
The LCPI measured pre-operatively and post-operatively and the difference was noted.On post –operative follow up any complications such as wound problems , loss of movement ,loss of power and implant related symptoms were noted.

SURGICAL TECHNIQUE

All patients were operated under general anaesthesia. The whole upper limb was cleaned and draped from the shoulder upto the fingertips. Pre-operative on table varus angle and contralateral normal carrying angle is measured.

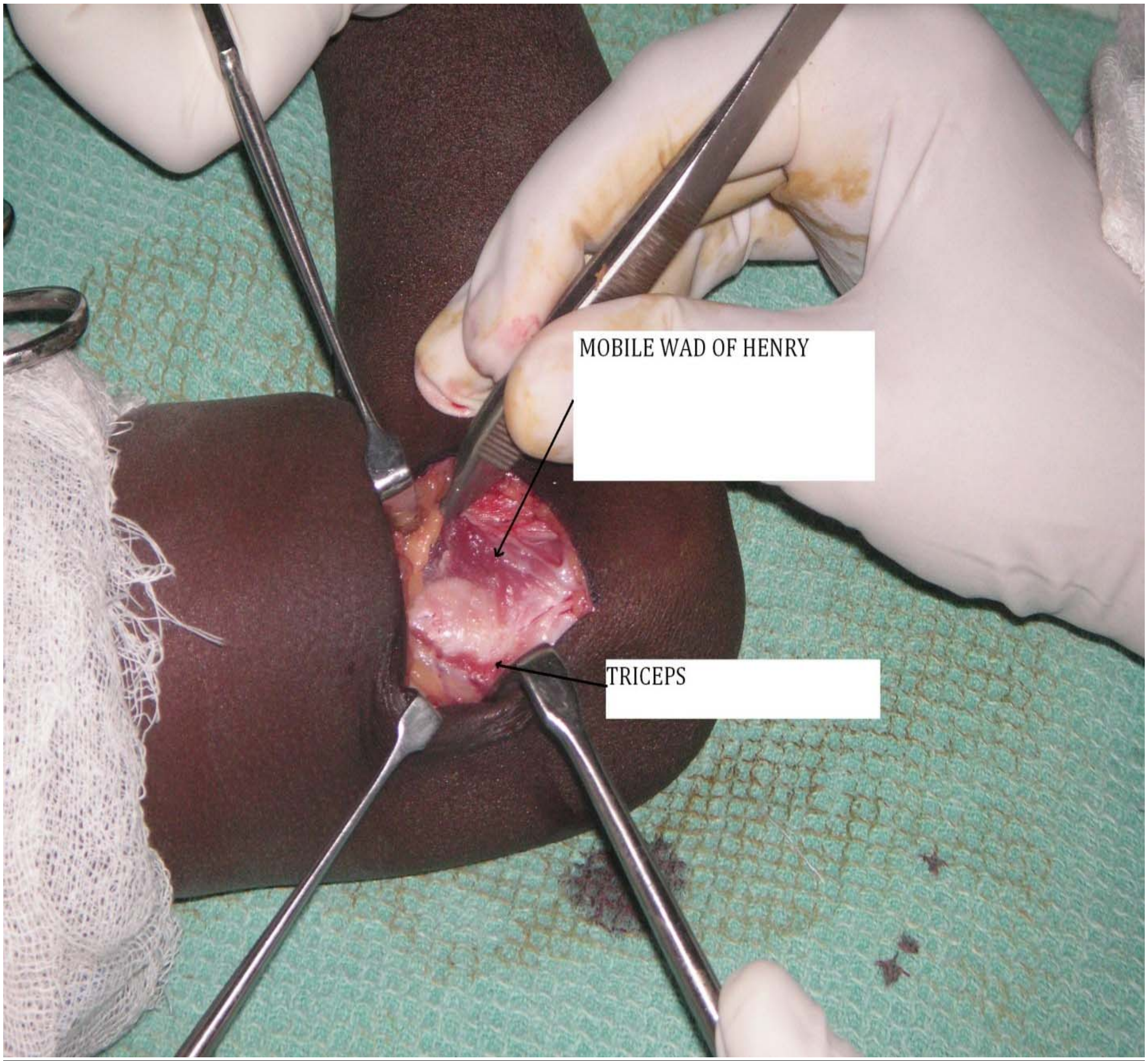
A sterile tourniquet is used.This is useful for assessing final on table correction. The skin incision is oblique along the Langers lines so as to get a cosmetic scar.

A lateral approach is used, taking the “mobile wad of Henry” anteriorly .Once the distal fourth of the humerus is exposed two James McDonald’s retractors are introduced .The first one is applied on the posterior aspect just proximal to the articulation of the olecranon with the distal humerus with the elbow in full extension.This helps to define the lower limit for the desired osteotomy. The second McDonald is applied anteriorly abutting the tip of the first one such that both are perpendicular to each other.This also serves as a protectionfor the ulnar nerve and is the guide for the osteotomy.

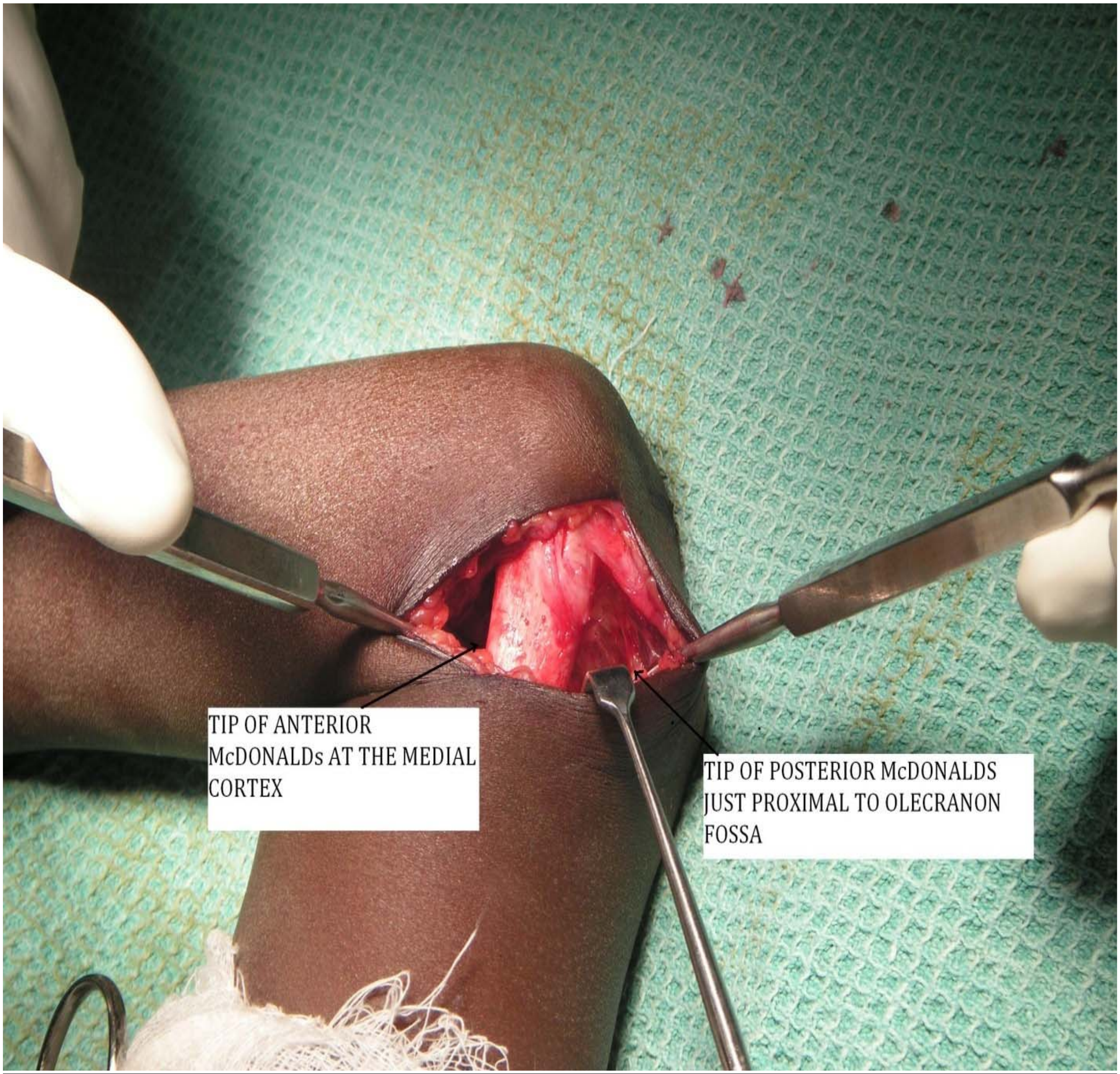


<u>MEASUREMENT OF CARRYING ANGLE ON THE AFFECTED SIDE AND CARRYING ANGLE ON OPPOSITE SIDE</u>

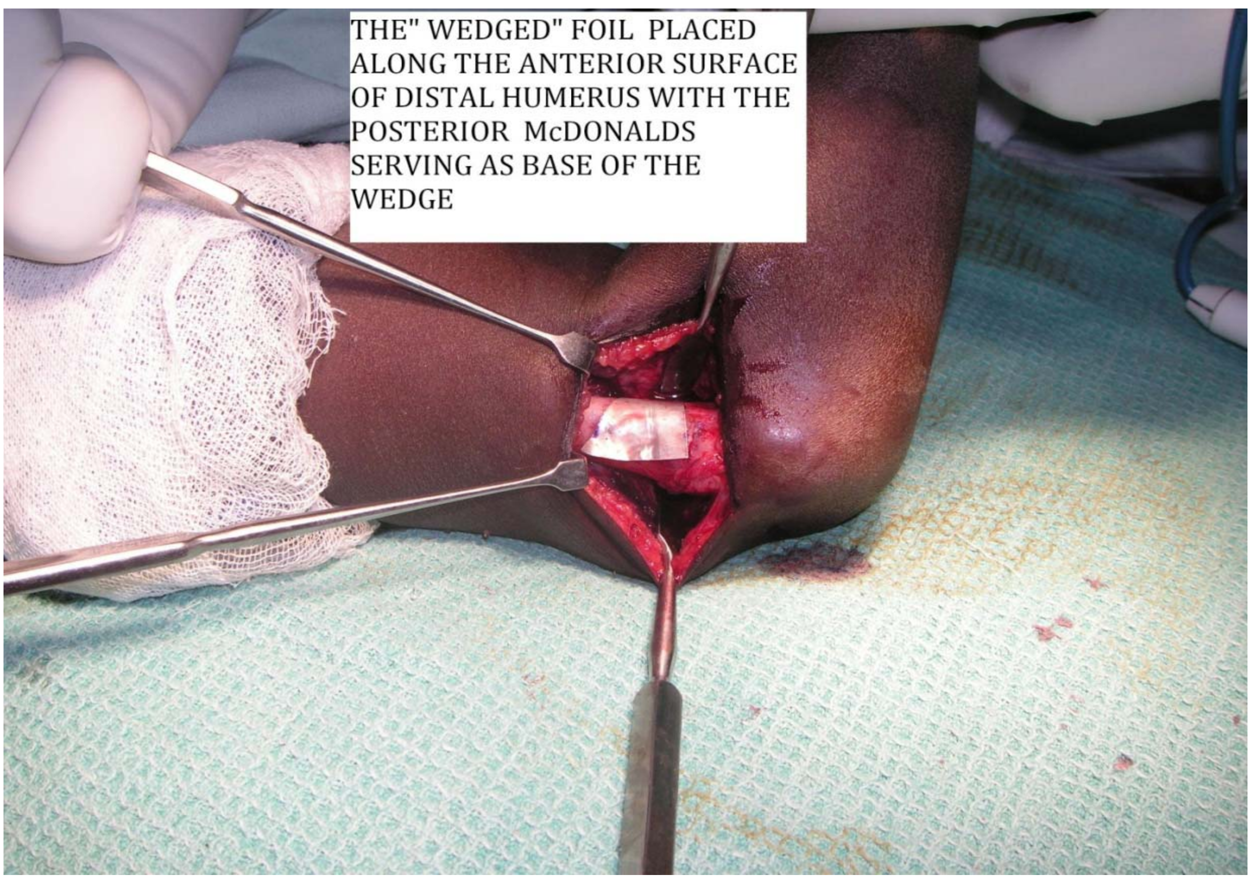
SKIN INCISION ALONG SKIN CREASE

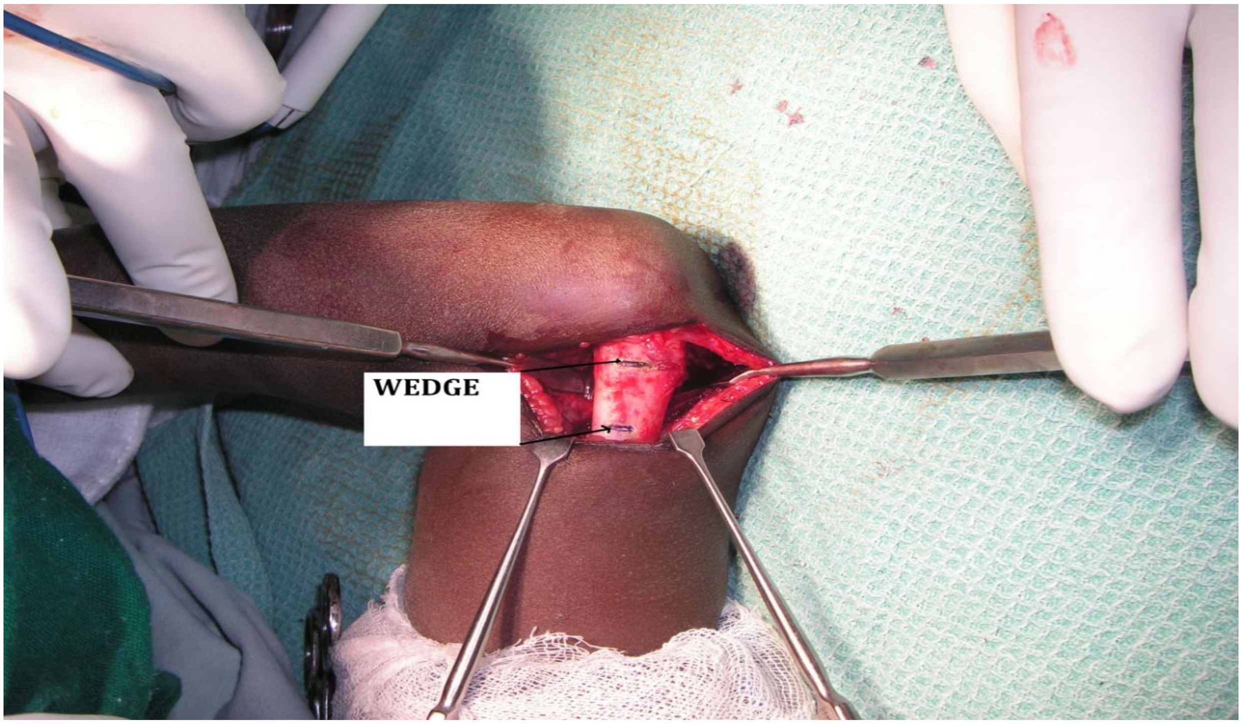


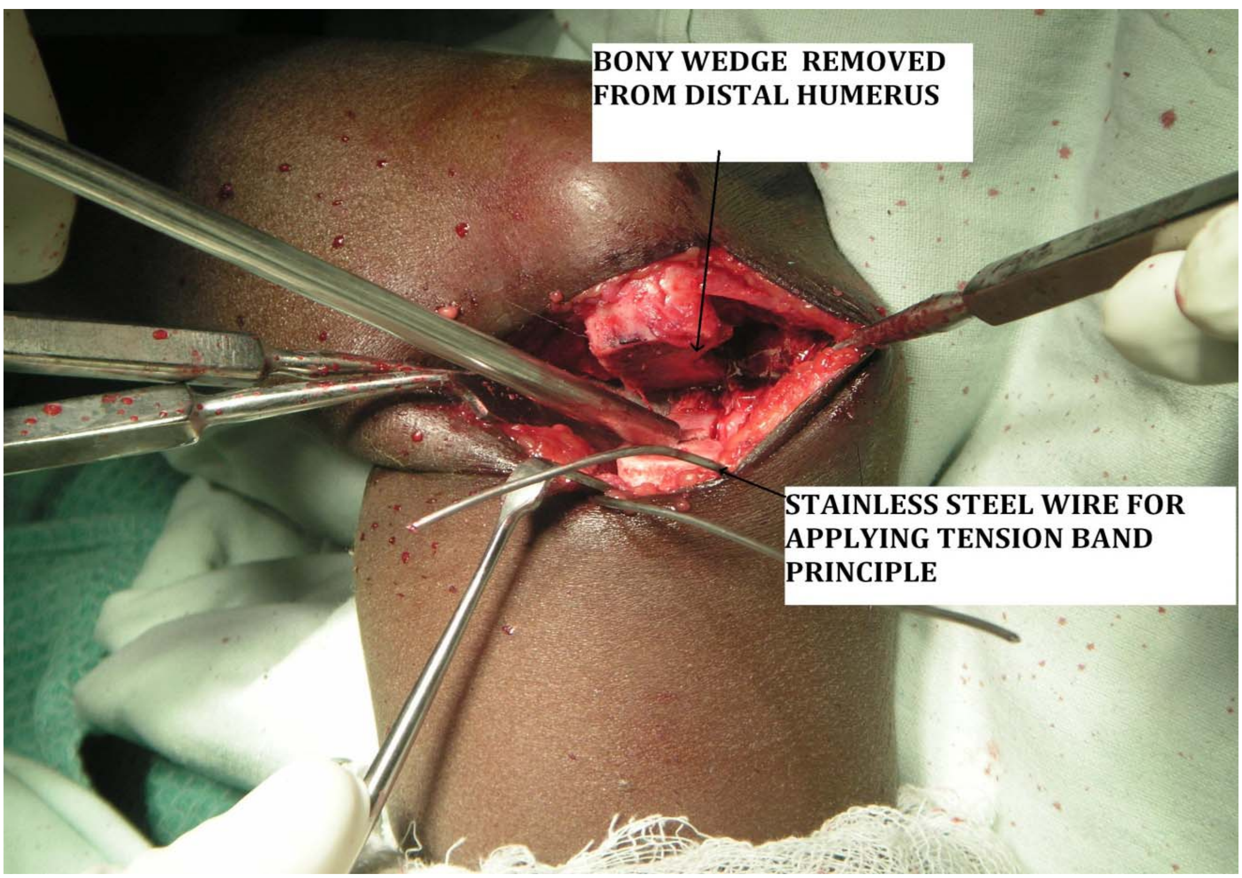
LATERAL APPROACH TO DISTAL HUMERUS


TIP OF ANTERIOR McDONALDs AT THE MEDIAL CORTEX
TIP OF POSTERIOR McDONALDS JUST PROXIMAL TO OLECRANON FOSSA

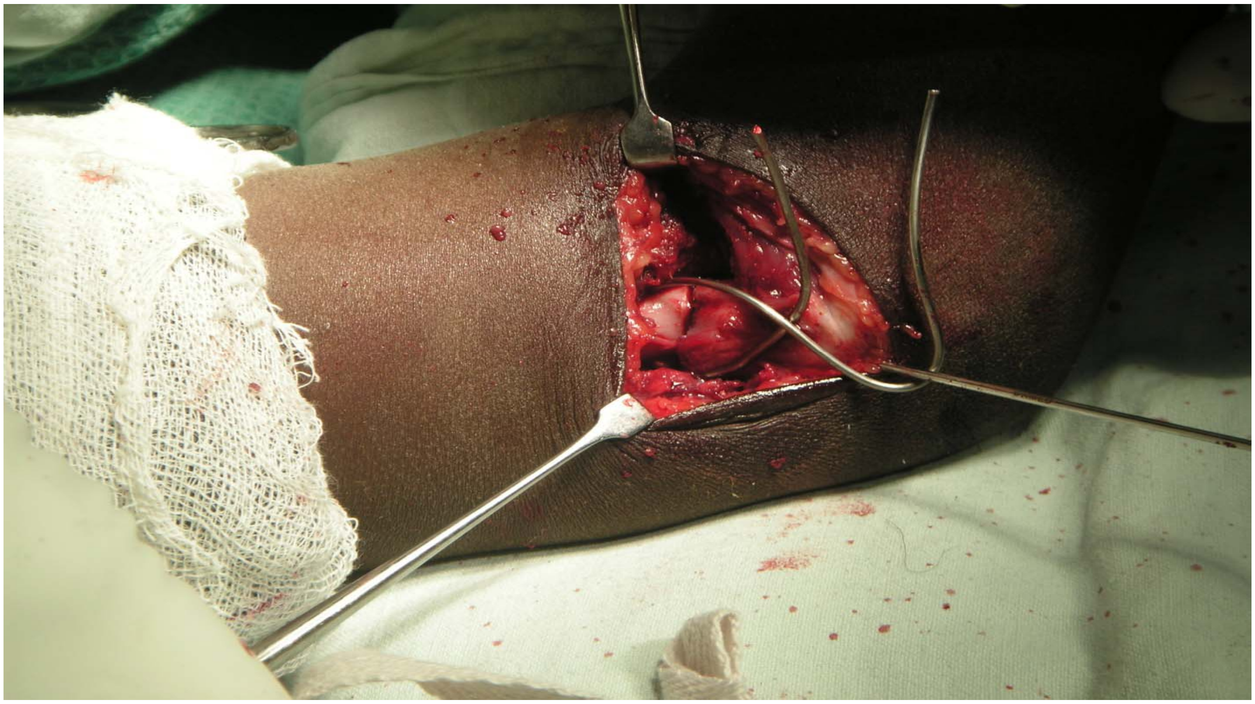

DESIRED WEDGE CUT OUT ON
FOIL FROM THE SUTURE
MATERIAL COVER


THE" WEDGED" FOIL PLACED
ALONG THE ANTERIOR SURFACE
OF DISTAL HUMERUS WITH THE
POSTERIOR McDONALDS
SERVING AS BASE OF THE
WEDGE

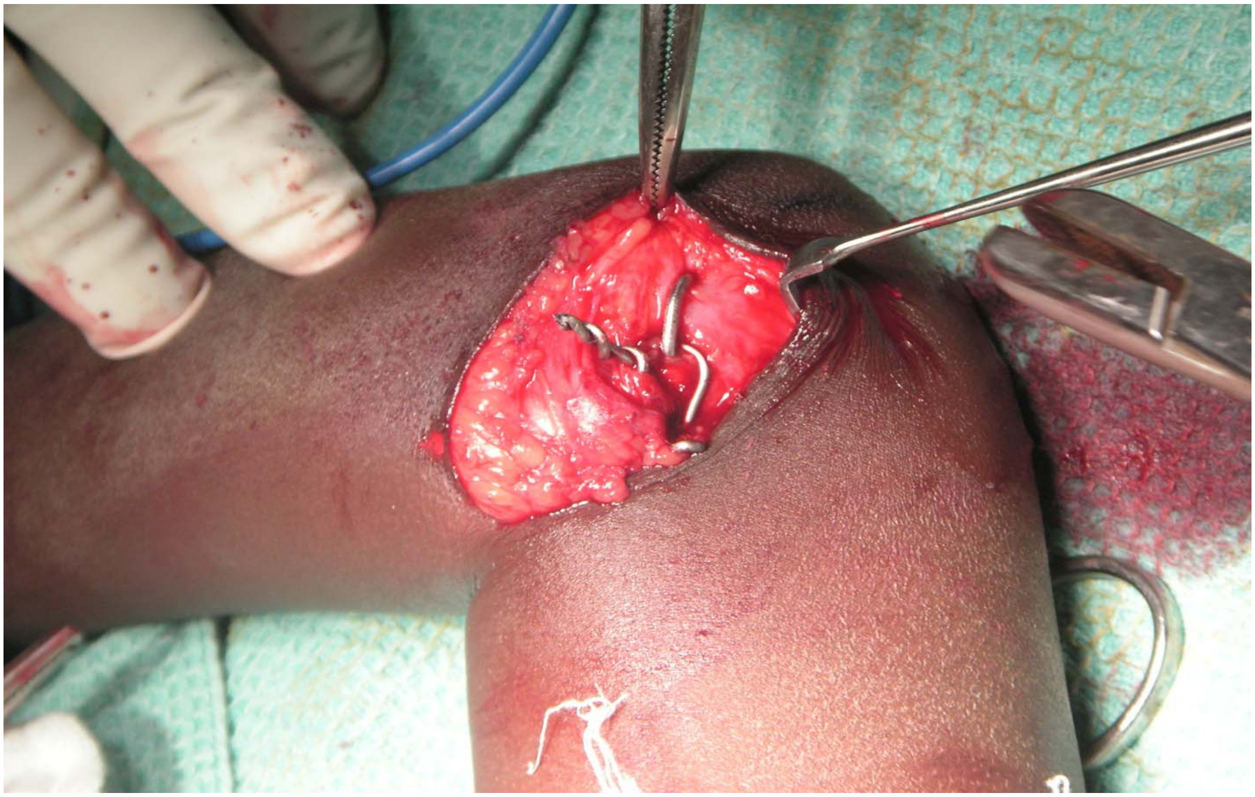

WEDGE


BONY WEDGE REMOVED
FROM DISTAL HUMERUS
STAINLESS STEEL WIRE FOR
APPLYING TENSION BAND
PRINCIPLE

CHECKING POST-OPERATIVE CORRECTION OF THE VARUS PRIOR TO TIGHTENING OF THE TENSION BAND(after removal of the wedge)



SS WIRE TIGHTENED , K-WIRE BURIED BEHIND LATERAL CONDYLE



Next the desired wedge of osteotomy is outlined and cut on a piece of foil paper (the aluminium foil cover of the suture material).

This wedge of foil is then placed flush on the anterior surface of the distal humerus with the apex at the anterior medial most edge and the base at the lateral border The base is marked with either cautery or marker pen.

The desired angle of wedge is then cut out from the distal humerus cutting the medial cortex but retaining the medial cortex and periosteal hinge . Prior to this using a 2.5 mm drill, a hole is drilled on the proximal fragment about a cm above the marked osteotomy medial to the lateral edge of the humerus. A length of stainless steel wire is then passed through this. The medial cortex is also fractured and the wedge is removed .

The lateral border of the proximal and distal fragments of the humerus is then matched to correct any rotational deformity and the distal fragment is pushed medially till the lateral edges of the proximal and distal fragments coincide.This is to prevent abnormal protuberance of the lateral condyle. Finally a K- wire is passed from lateral condyle anterior portion of the distal fragment to medial portion of the proximal fragment so that it passes through the near as well as distant cortex correcting the internal rotation by matching the anterior cortices and the stainless steel wire is tightened around the K-wire in a figure of 8 pattern creating a tension band.

Before tightening the stainless steel wire, the elbow is fully extended and the amount of correction achieved is checked with a goniometer.

The K- wire is finally bent and buried behind the lateral condyle. The stainless steel wire is trimmed and rotated to come and lie under the anterior muscle mass.

The wound is closed over a drain which is kept long in length so as to be brought out proximal to the above elbow cast. An above elbow cast is applied in extension and full supination with moulding in cubitus valgus (medial in the forearm and lateral in the arm) from the axilla up to the distal palmar crease.

POST-OPERATIVE

Post-operative x-rays are taken on the immediate post op day and drain is removed after 48 hours during which time the limb is kept elevated and routinely assessed for any neurovascular compromise. The patient is usually discharged after 3rd day and advised to follow up as an outpatient. The cast is removed at 1 month and elbow is mobilized actively.

ASSESSMENT OF OUTCOME :

Oppenheims criteria (32)

Criteria	**EXCELLENT**	**GOOD**	**POOR**
HUMERUS – ELBOW WRIST ANGLE CORRECTION	**Within 5 deg of normal**	**Within 10 deg of normal**	**Residual deformity > 10 deg**
Loss of ROM at elbow	**Upto 5 deg**	**6- 10 deg**	**➢ 10 deg**
COMPLICATIONS	**nil**	**Scarring/ lazy –S deformity**	**Any complication**

REVIEW OF A NEW TECHNIQUE FOR CORRECTION OF CUBITUS VARUS DEFORMITY

Background : Many types of osteotomy have been proposed for the treatment of cubitus varus , but they have limitations, such as poor internal fixation, residual protrusion of the lateral or medial condyle, technical difficulty, the need for long-term immobilization, a risk of neurovascular injury, and patient discomfort. We reviewed the results of a simple lateral closing wedge osteotomy by a new technique that overcomes these limitations.

Methods : Between 2001 and 2006, we operated thirty two children with cubitus varus deformity with use of a new technique of lateral closing wedge osteotomy of the distal humerus. After surgery, twenty one children were observed closely for more than one year. We compared preoperative and postoperative clinical carrying angle and radiological humerus-elbow wrist angles, ranges of motion, and lateral condylar prominence indices for all patients. The results were evaluated according to the criteria of Oppenheim et al. The presence of tardy ulnar nerve palsy and its duration, and postoperative lazy-s deformity or unsightly scarring, were also noted.

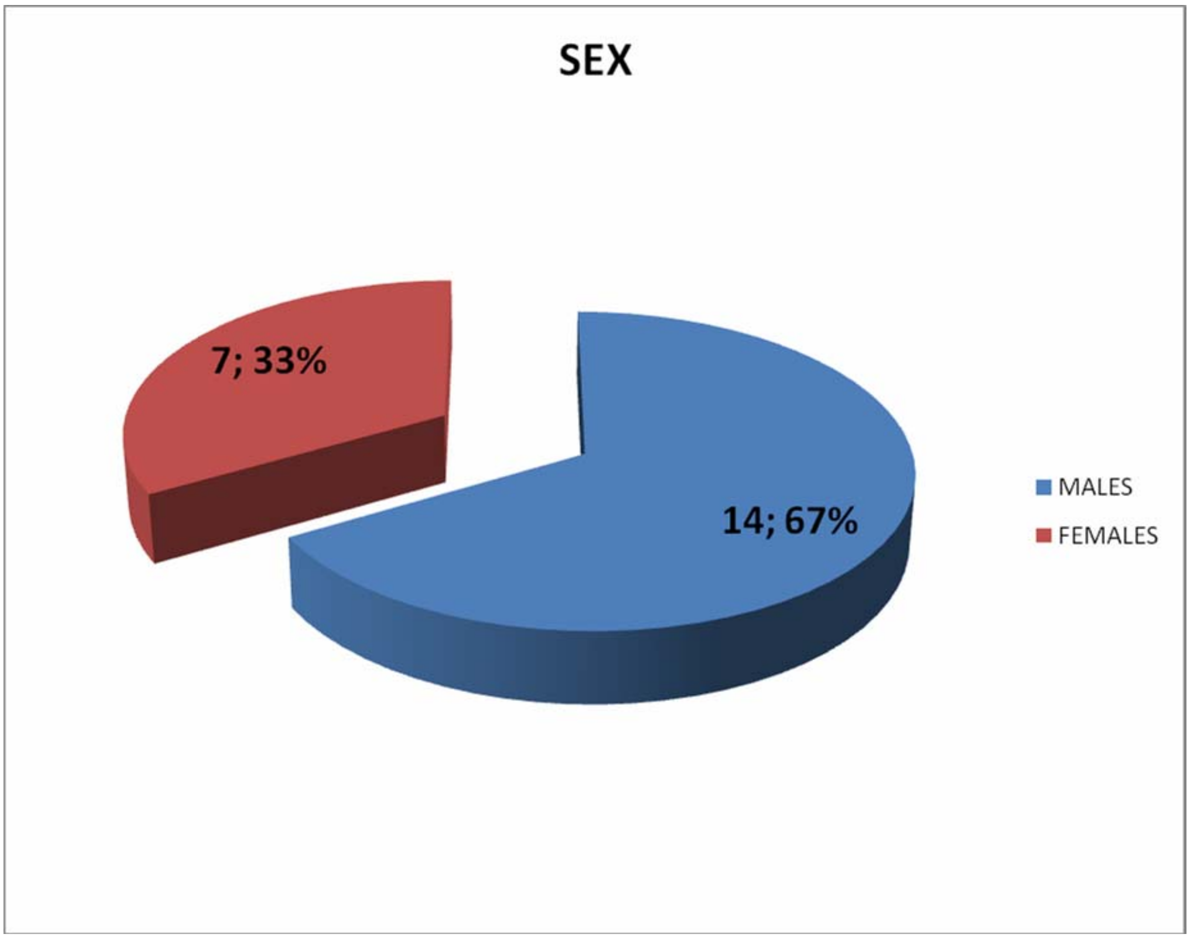
Results: There were fifteen excellent ,five good results and 1 poor result. In the twenty one children with cubitus varus, the mean correction of the carrying angle was 26.0°, to a mean postoperative angle of 6.1°.Only 4 children had a increase in

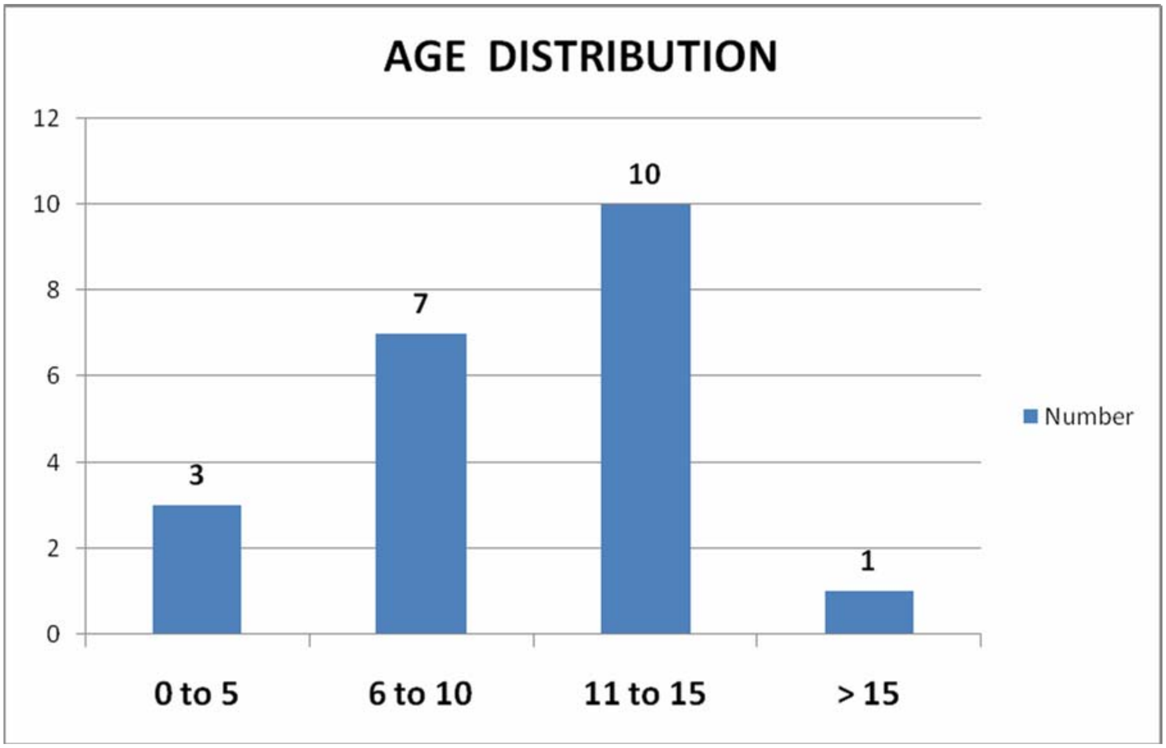
LCPI but there was no clinically apparent lateral condylar prominence. In all patients, the desired range of motion, good alignment, and complete union of the bone were achieved.Only three children had complications .

Conclusions: This new technique described by us is a relatively simple procedure resulting in very firm fixation that allows early movement of the joint with good clinical results.

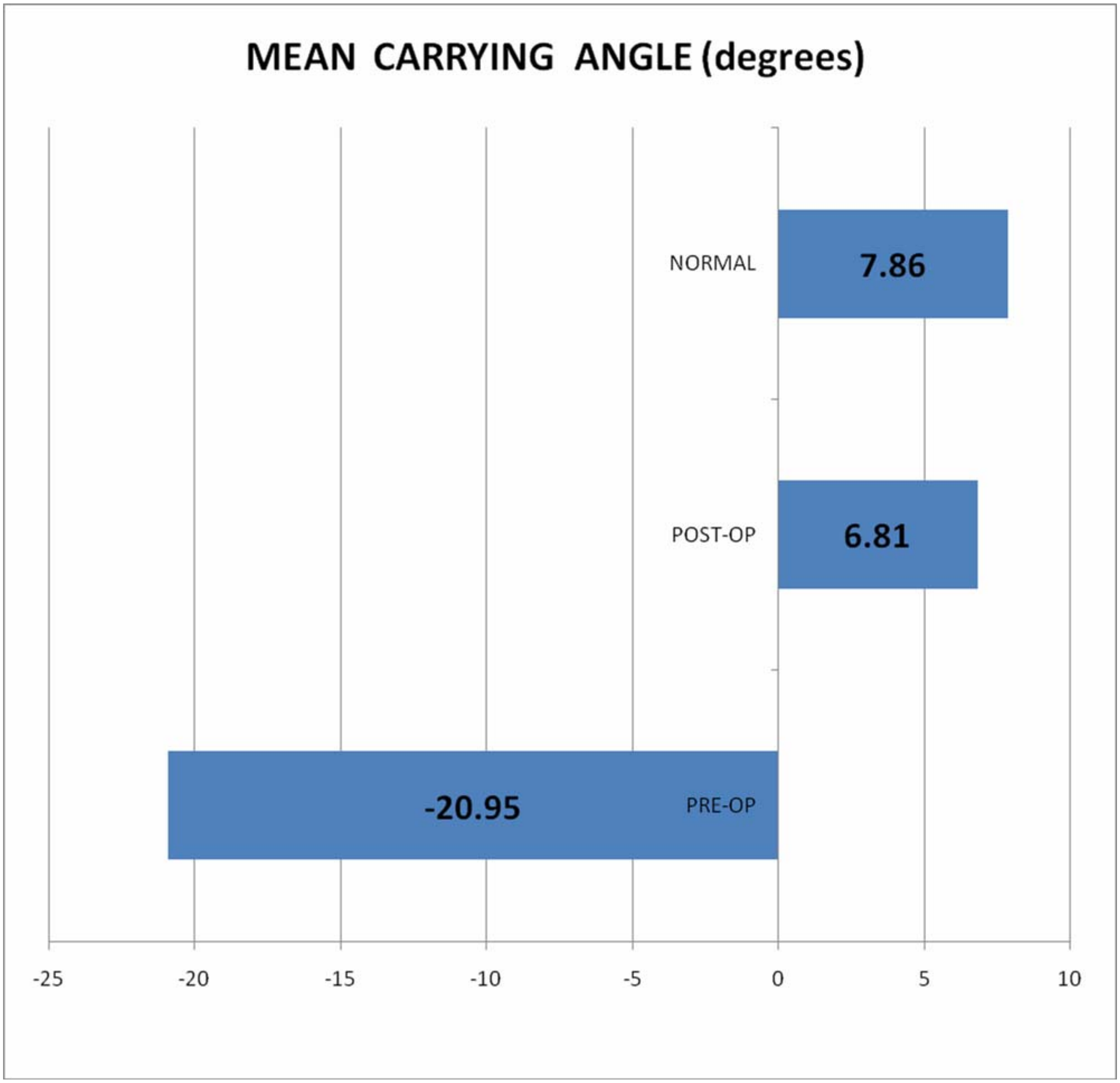
RESULTS

A total of **32 children** underwent correction of cubitus varus with our new technique**. 21 out of these 32 children** were followed for a period of **1 year** or more. Age and sex distribution is shown in the pie chart and bar diagram.

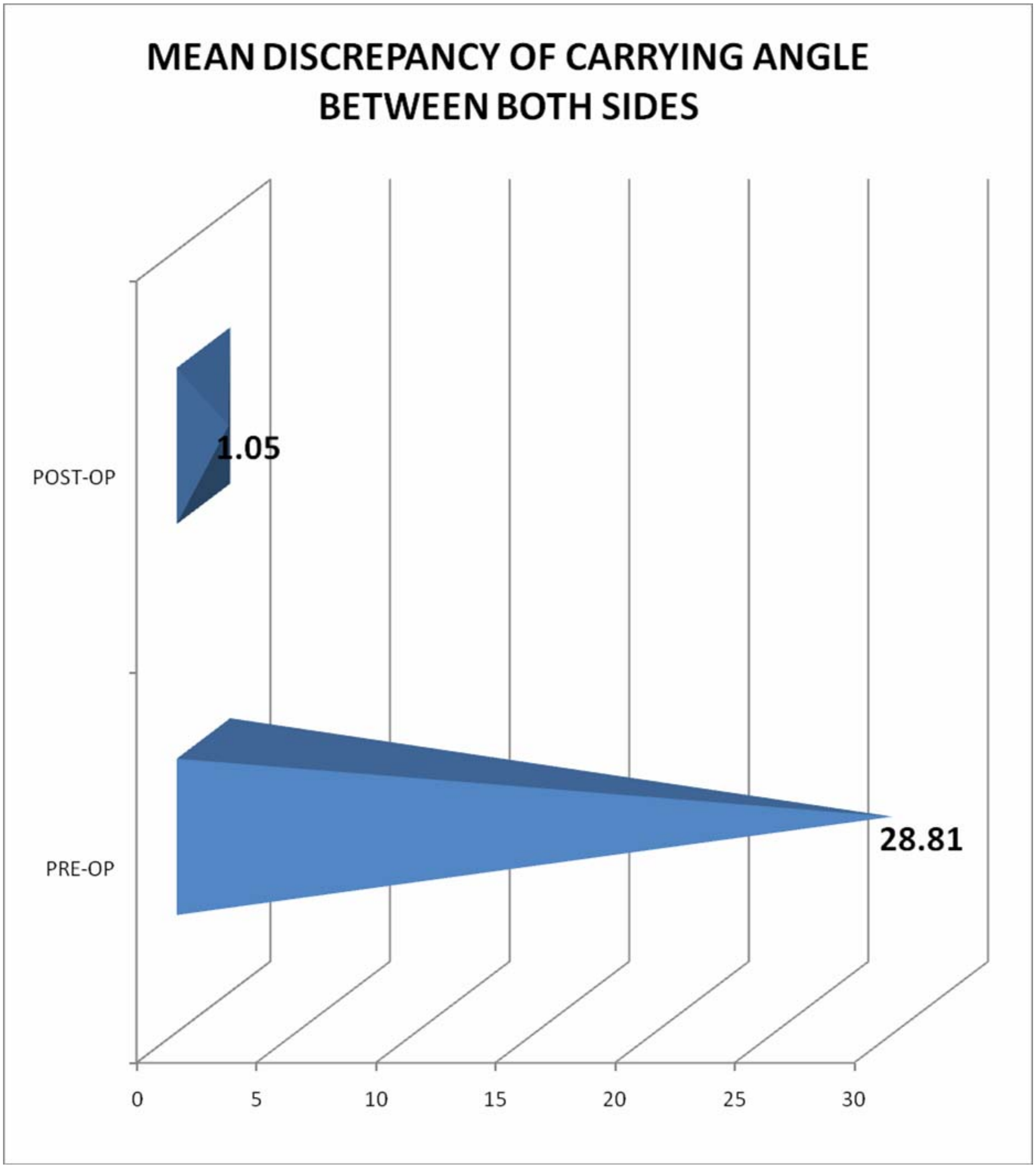


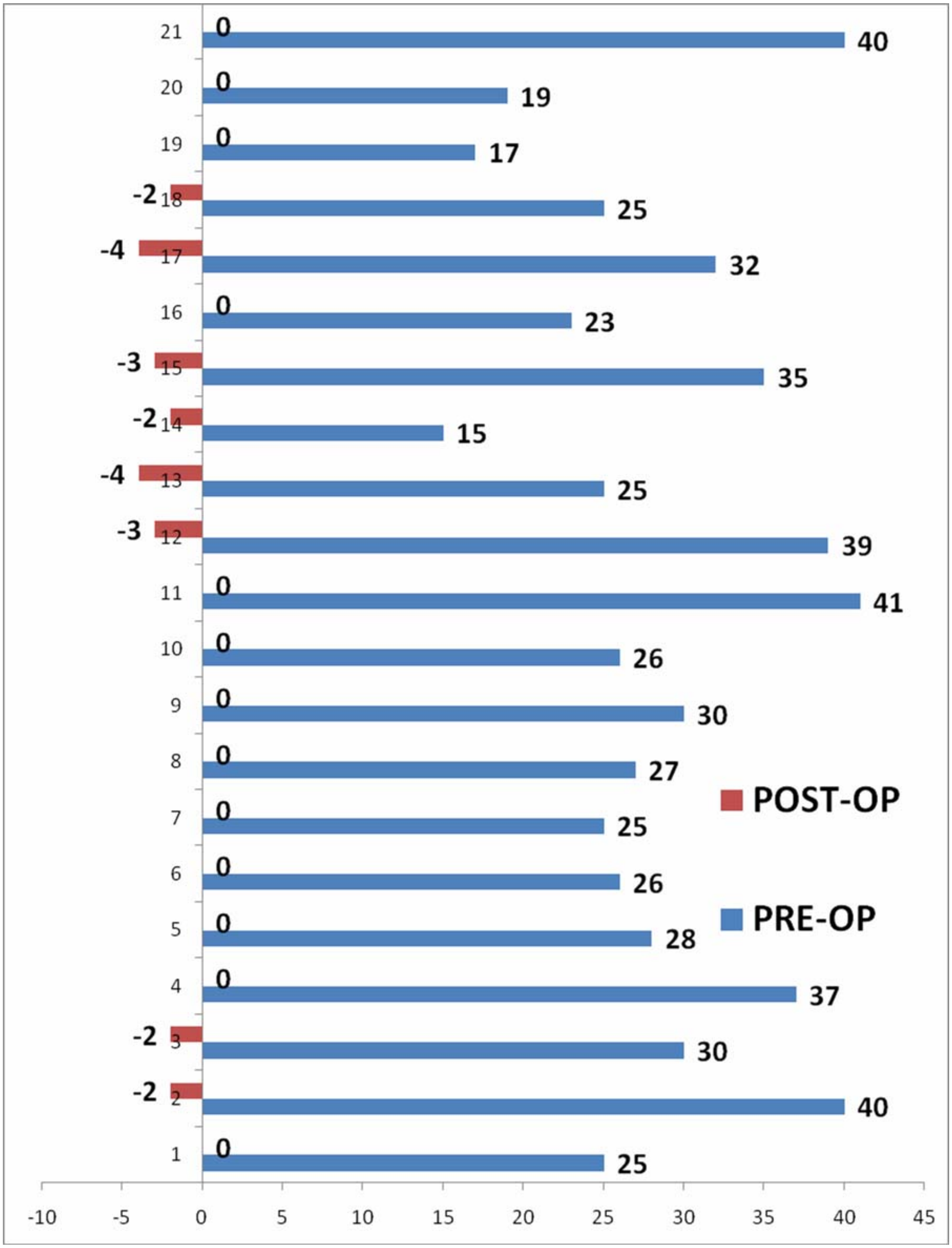


The mean **carrying angle** on the affected side **pre operatively was -20.95 (Range: -9 to -40 ; SD: 8.53)**. The mean carrying angle on the **normal side** was **7.86(Range:0 to 16 ; SD: 3.63).**The mean carrying angle on **the affected side post-operatively was 6.81(Range:0 to 16; SD:3.88**). The corrected carrying angles after surgery was within 4 degrees of the normal side in all children.

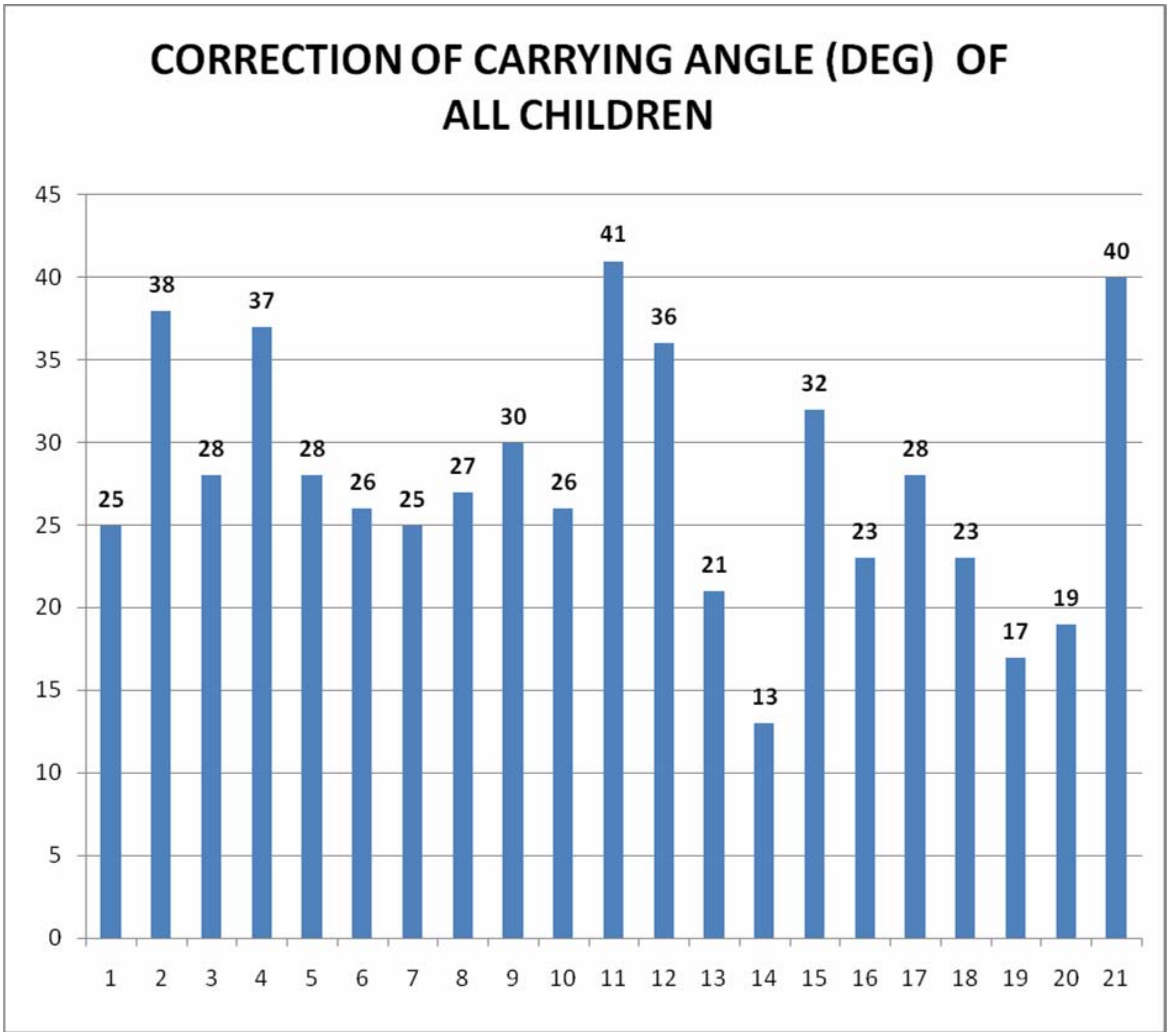


The mean discrepancy of carrying angle between the affected side and normal side pre-operatively was **28.81 degrees (Range:15 to 41; SD:7.613)** and post-operatively it was **1.05 degrees (Range:0 to 4 ; SD: 1.46).**All children had a correction of carrying angle from **13 to 41 degrees**.

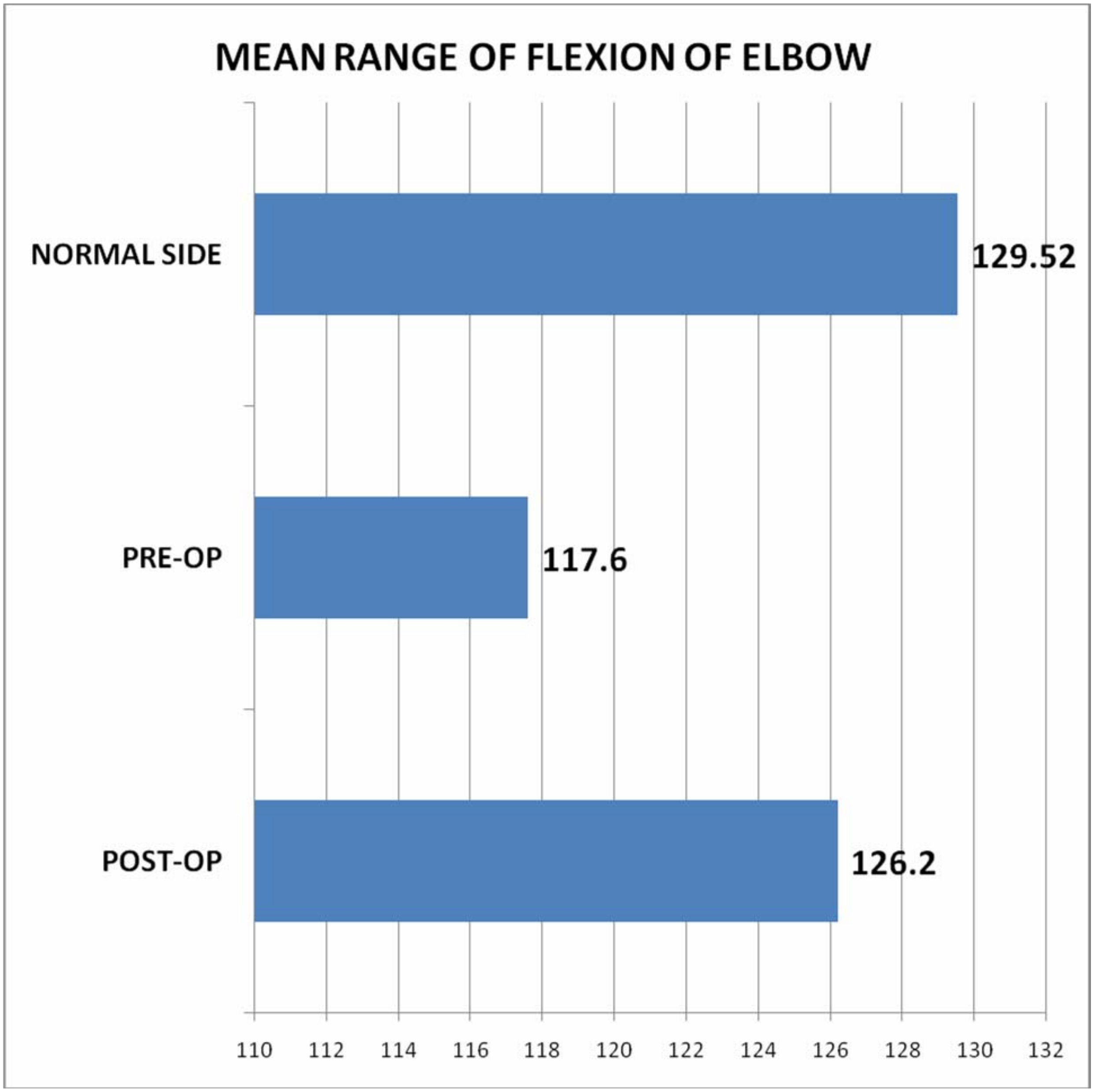

MEAN DISCREPANCY OF CARRYING ANGLE BETWEEN BOTH SIDES
POST-OP
1.05
PRE-OP
28.81
0
5
10
15
20
25
30



<u>PRE-OPERATIVE AND POST-OPERATIVE DISCREPANCY IN CARRYING ANGLE.</u>

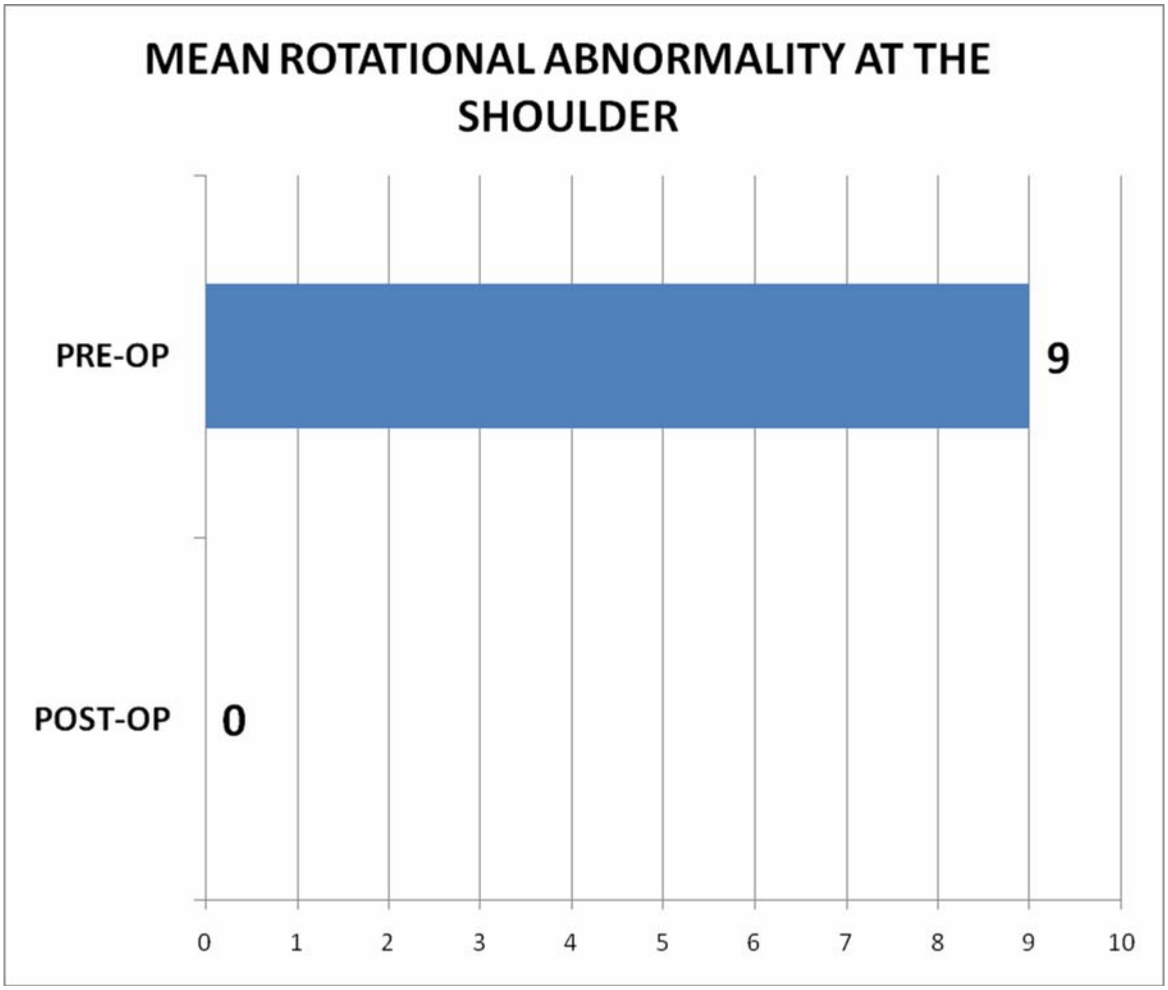


The mean range of flexion at the affected elbow was **117.62(Range:85 to 160; SD:17.72)** which improved post-operatively to **126.19(Range:110-140;SD:7.56).** The mean range of flexion on the normal side **was 129.52(Range:120 to 145;SD:6.87).** 6 patients had flexion deformity pre-operatively, out of which 4 had no deformity post-operatively.

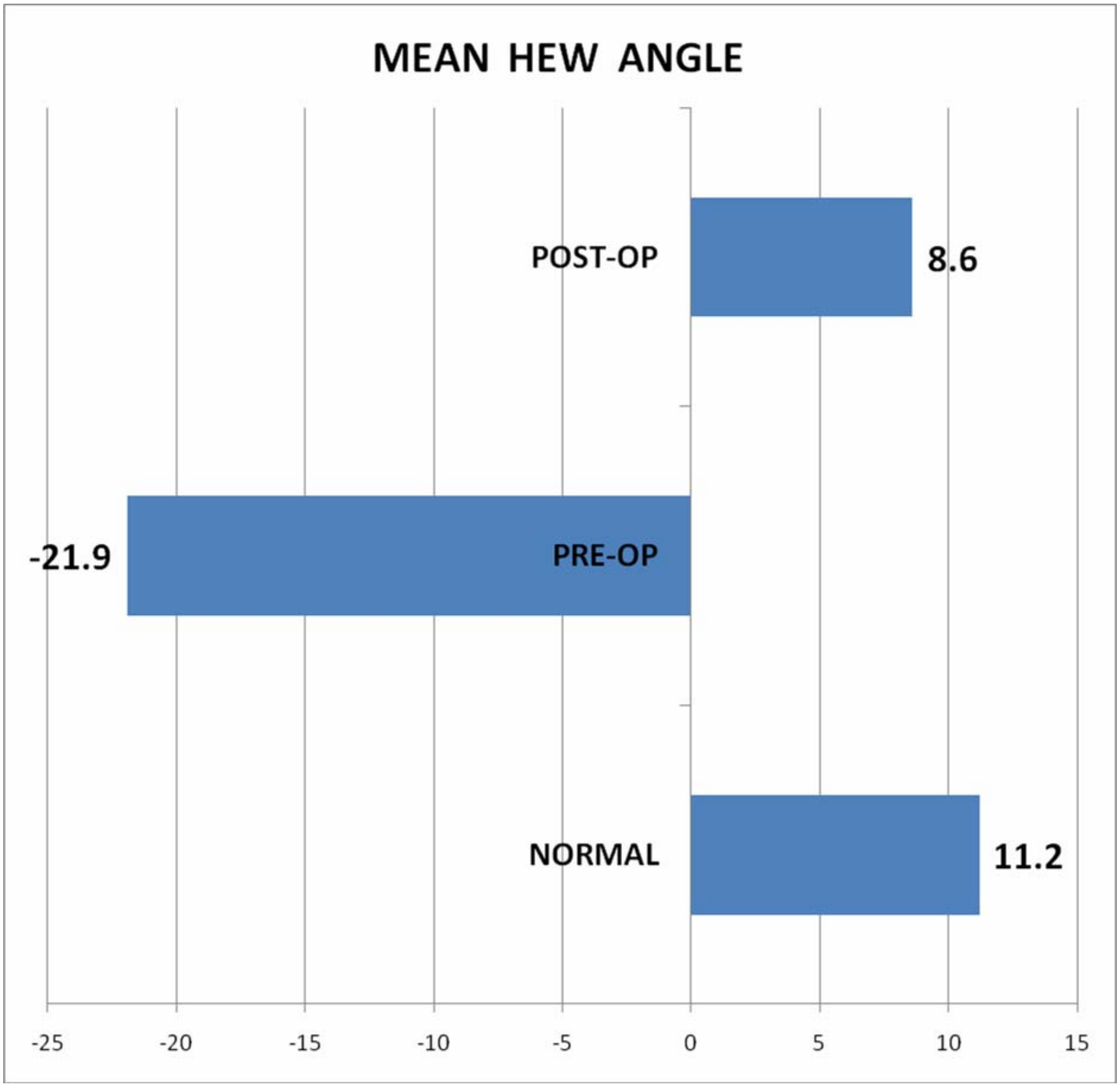


4 patients had hyperextension at the elbow pre-operatively out of which 3 had hyperextension at the normal elbow too. The last patient did not have any hyperextension post-operatively.

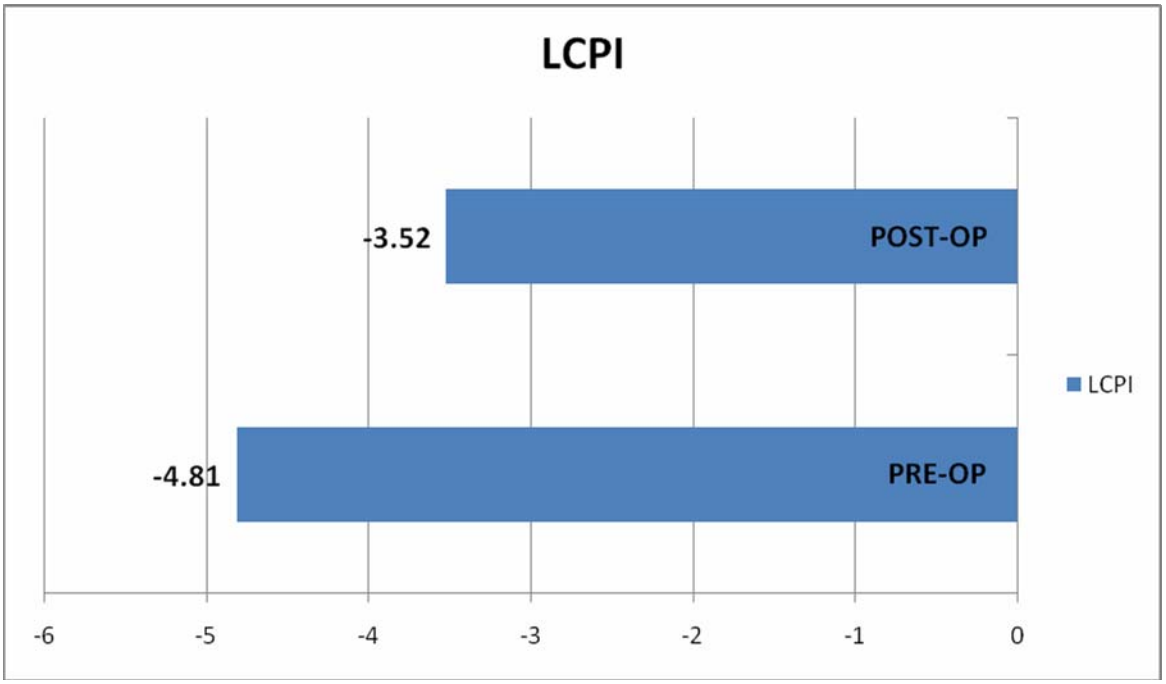
9 out of the 21 patients had rotational abnormalities in the shoulder, all of which were totally corrected post-operatively.The mean rotational deformity was 9 degrees(Range:0 to 40 degrees).



The mean radiological HEW (humerus-elbow-wrist) angle on the affected side pre-operatively was **-21.9 (Range:-12 to -34; SD:6.11)** and post-operatively was **8.6 (Range: 6 to 13; SD:2.028).** The mean HEW angle on the normal side was **11.21(Range:3 to 16;SD:3.12).**



The mean LCPI (Lateral condylar prominence index) on the affected side pre-operatively was **- 4.18% (Range:-25 to 19.2 %)** and post-operatively was **-3.51%(Range:-30 to 44%)**.The change in LCPI was not found to be significant (p=0.866)



3 out of 21 patients had complications.Two of them had pin track infections and one had a lazy -S deformity.

According to Oppenheims criteria the following were the results,

	NUMBER	PERCENTAGE
EXCELLENT	**15**	**71.4 %**
GOOD	**5**	**23.8 %**
POOR	**1**	**4.8 %**
TOTAL	21	100 %

ILLUSTRATIVE CASE EXAMPLE : 4 year old child with left cubitus varus of 25 degrees and normal side carrying angle of 7 degrees.

IMMEDIATE POST-OP- --

1 YEAR POST-OP - Carrying angle of 8 degrees.

POST-OPERATIVE PHOTOGRAPHS-

NO RESIDUAL VARUS

SHOULDER AND ELBOW ROM BILATERALLY EQUAL.

COSMETICALLY ACCEPTABLE SCAR.

DISCUSSION

In India, the treatment of closed skeletal injuries in rural areas is still quite commonly carried out by traditional bonesetters. Our relatively large series of patients was mainly the result of this practice. Many of our patients gave a history suggestive of a supracondylar fracture, and had been immobilised with the elbow extended in a traditional bamboo splint for some weeks.

Since Siris first described a lateral closing wedge osteotomy for the correction of cubitus varus deformity in 1939, various types of osteotomies have been proposed. The three major types are the simple lateral closing wedge, the step-cut lateral closing wedge which improves the stability of fixation, and the dome rotational osteotomy. The dome osteotomy has theoretically the advantage of correcting the rotational problem and avoiding shortening while at he same time allowing medial translation. There have been two different case reports describing a quadrilateral and a pentalateral osteotomy. However these have not been popular. Lateral closing wedge osteotomy is easy and safe, but it has several problems. It is hard to achieve strong internal fixation, so early mobilization and union is difficult. In addition, protrusion of the lateral condyle and/or a lazy-s deformity of the elbow may develop due to inability to translate the osteotomised fragments.

The problem with a simple step-cut osteotomy is that the step limits medial translation of the distal fragment. The distal fragment can be rotated only in the horizontal plane to correct the deformity. It is not very different from the lateral closing wedge osteotomy, except for the stabilization of the osteotomy site by the lateral step up and fixation with a single screw. However, its disadvantages are precarious fixation if the lateral cortex fractures and the longer period of immobilization recommended (8 weeks). The latter may partly due to the older mean age in their series . A dome osteotomy can reorient the distal fragment in both the coronal and the horizontal plane; thus, residual prominence of the medial and lateral condyles can be avoided. In the experience of Wilkins,(43) the domed osteotomy is often difficult to rotate in the coronal plane because of contractures of the soft tissue on the medial side, especially in the intermuscular septum. He modified the osteotomy by doing a combination of dome and lateral closing wedge osteotomies that involved two semicircular cuts.

Several other techniques for correction of cubitus varus also have been proposed. A pentalateral osteotomy corrects angular deformity, translating the distal fragment medially. Protrusion of the lateral condyle can be avoided with this approach, but the technique is complicated and difficult to perform consistently. The external fixation method decreases the protrusion of the lateral condyle, translating the distal fragment medially. However, there may be neurovascular injury, and the method causes discomfort to the patient. Correction of large deformities may result in relative prominence of the lateral condyle. This prominence is accentuated by the disuse atrophy of the musculature following surgery. As extremity function and strength return, the increase in muscle size helps to mask the lateral condyle. Periosteal new bone will also smooth the lateral contour of the humerus, diminishing the prominence of the lateral condyle. All the patients and parents were pleased with the overall cosmetic result achieved with valgus correction.

In our report we had a ratio of male to female of 2:1 which corresponds to the sex ratio of supracondylar fractures in various reports.This does not support the aasumption that the clinical deformity is more likely to be concealed in girls as the carrying angle is more in the girls.

The mean age of surgery was 10 years(3- 17 years). In other reports the mean age of surgery varied from 7 years (lateral closing wedge) upto almost 23 years(dome osteotomy) . The patients undergoing a lateral closing wedge kind of osteotomy were of a younger age group and all were skeletally immature as compared to those who underwent a dome or an arc osteotomy.

The mean cubitus varus angle on the affected side pre operatively was 20.95 (Range: -9 to -40 ; SD: 8.53). The mean carrying angle on the affected side post-operatively was 6.81(Range:0 to 16; SD:3.88). The corrected carrying angles after surgery was within 4 degrees of the normal side in all children.The mean pre-op cubitus varus angles in various studies was almost the same but what was striking was that 10 out of our 21 corrective osteotomies had a pre op cubitus varus of more than 25 degrees as compared to the other reports where there were only occasional values of more than 25 degrees . Since a much larger wedge is removed in those with more severe deformity we suggest that our technique which allows the distal cut to go very close to the physis just above the olecraonon fossa has a distinct advantage over the others.

No patient in our follow up had a residual varus deformity as compared to other studies of different closing wedge osteotomies where a few patients did have residual varus despite the fact that they had an overall smaller corrections to be made. Dome osteotomies and Arc osteotomies also did not have any residual varus in the literature. However the predictability of the correction in our series (comparison with carrying angle on the opposite side) was better than achieved in the published results of these studies.

None of our operated children had any loss of elbow ROM whereas all other studies had few patients with reduced ROM at the elbow.We attribute this to the lateral approach which results in less disturbance of the extensor mechanism.

9 out of our 21 children had a rotational abnormality at the shoulder which was completely corrected post operatively. No other study has actually looked at the degree of rotational abnormality before or its correction after surgery . The rotational correction is achieved by matching of the anterior margin of the lateral pillar during surgery ,a problem not addressed in many osteotomies(7,8,9,10,11,12,13,14).

Although we had an increase in the mean LCPI (lateral condylar prominence index) from -4 to -1. Since these values are negligible it means that there is no clinically significant change in the prominence of lateral condyle. This is quite similar to the dome osteotomy where there was no incidence of any abnormal lateral condylar prominence but far superior than the lateral closing wedge type of osteotomies where the incidence of lateral condylar prominence was almost up to 50 percent. The incidence of unduly prominent lateral condyle is decreased by the new technique and was very less as evident by the LCPI(lateral condyle prominence index) values pre- operatively and post-operatively. 17 out of 21 children had either a decrease or no change in the LCPI values which basically indicates the fact that there has been no unduly prominent lateral condyle.

Such a low incidence of unduly prominent lateral condyle is due to the fact that per-operatively care was taken to shift the distal fragment medially with respect to the proximal fragment after removing the desired wedge of bone and prior to fixing the osteotomy. The 4 children who had prominent lateral condyle were amongst the few who were operated by this technique; however, adequate translation was not done and as the technique has been progressively used we have not noticed any unduly prominent lateral condyle.

There were only two pin tract infections and no other post-operative complications which is almost same as the dome osteotomy group but much better than all other osteotomy groups where in complications like pin tract infections, loss of fixation, hypertrophic scar, nerve injuries were plenty.

Dror Paley states that if the correction of a deformity is done at the level of the apex of the deformity only angular correction is needed but if the correction is done elsewhere in addition to the angular correction , translation is also needed. There lies the first advantage of our new osteotomy i.e. the level of osteotomy , which is very close to the apex of the deformity i.e. very close to the physis in the metaphyseal region , thus maximal and the best possible correction is achieved. This is possible as the main fixation device is a tension band wire at the lateral border of the humerus and only a K-wire passes within the bone from the lateral to the medial cortex , crossing the physis. This was not achieved earlier with screws , plates or other fixation methods as they could not be applied so distally as they could not cross the physis. The cross K wires also would allow a distal osteotomy however the fixation is less optimal and more risky on the medial side.

An unacceptable postoperative scar is another complication that frequently compromises the cosmetic outcome of the lateral closing wedge osteotomy. This complication occurred in approximately 60% of patients in one follow up series (28). A tendency for formation of a hypertrophic scar on the skin could explain this complication because the standard lateral longitudinal incision that is used to approach the distal end of the humerus directly crosses the Langer lines in this area. Furthermore, the anterior location of the scar on the hanging arm at rest and upward location of the scar on the pronated arm on a desk cause the scar to be obvious and unacceptable. But in our series there was no child who had a post-operative hypertrophic , unacceptable scar. This was mainly due to the fact that the skin incision was an oblique one along the elbow crease which provided a cosmetic scar. Also extreme care was taken while closing the wound so as not to cause undue tension while skin closure.

One of the notable feature was the absence of any neurological injury in all the operated children inspite of large corrections. This is mainly due to absence of medial implant, or any strtch on the medial tissues as this is a closing wedge. The correct placement of McDonalds retractor anteriorly and posteriorly helped to protect both anterior and medial structures.Also contributing to this good result was the fact that wire insertion was under vision. Both , the K- wire and the stainless steel wire were applied under full vision both on the medial and the lateral side .

The excellent performance of this technique is in the backdrop of the simplicity of technique. A simple lateral approach, a simple wedge osteotomy, a tension band fixation similar to Lister's technique, no image intensifier guidance, and clinical assessment on the table are the high lights of the surgical technique. Lack of any residual varus, correction of all components of deformity, good range of motion in the absence of any significant complications and predictability of corrections make it an attractive option for the surgeon only occasionally dealing with this procedure.

CONCLUSION

This study conclusively proves that the simple new technique of lateral low closing wedge osteotomy of the distal humerus fixed with a tension band on the lateral aspect is very predictable, effective and successful in correcting all components of cubitus varus deformity and has a very low rate of complications.

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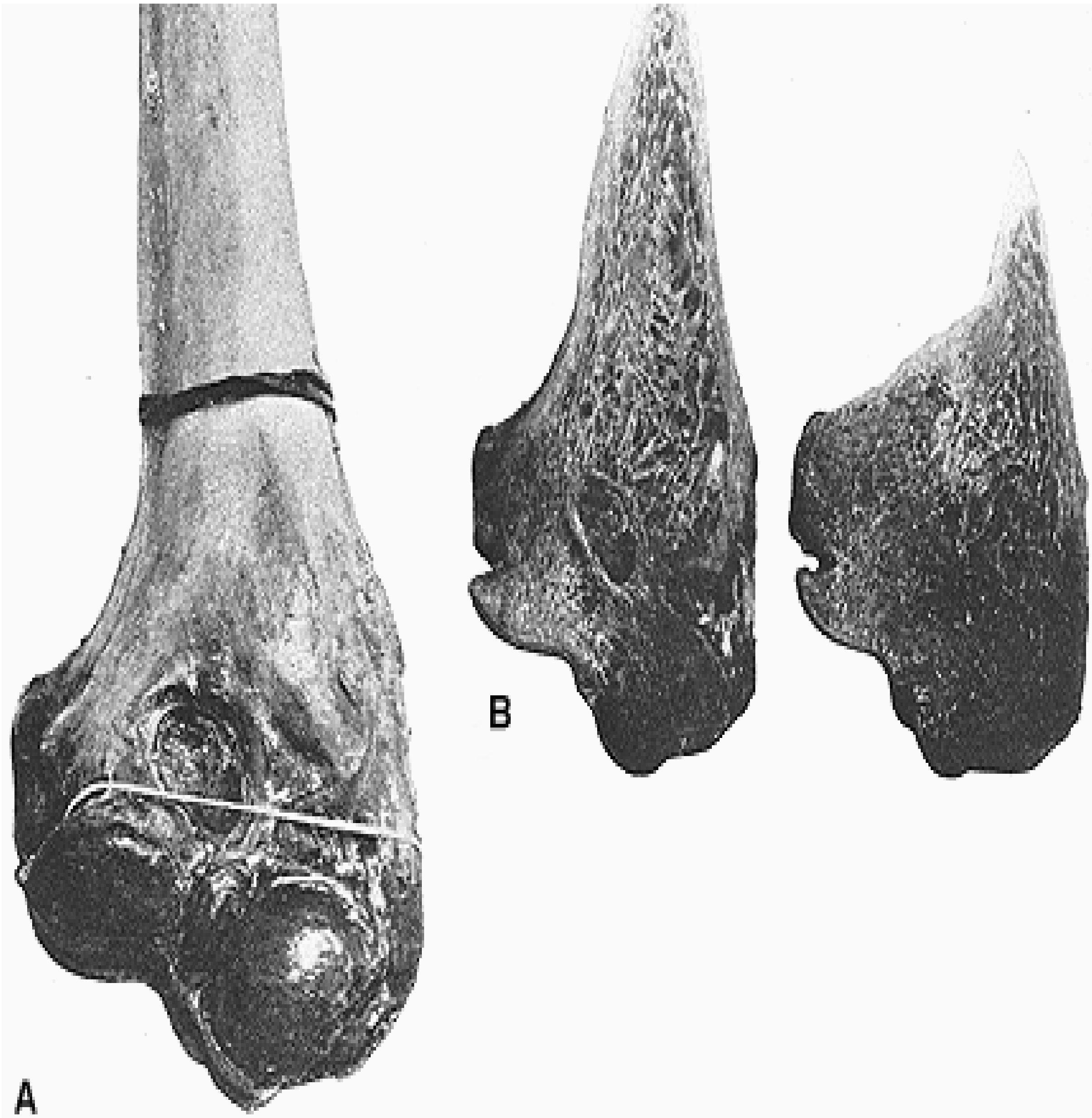


1) Fig-1 ANATOMICAL SPECIMEN OF CUBITUS VARUS (Wilkins KE: Fractures and Dislocations of the Elbow Region. In Rockwood CA, Wilkins KE, King RE (eds). Fractures in Children. Ed 4. Philadelphia, JB Lippincott Company 604–605, 1990).

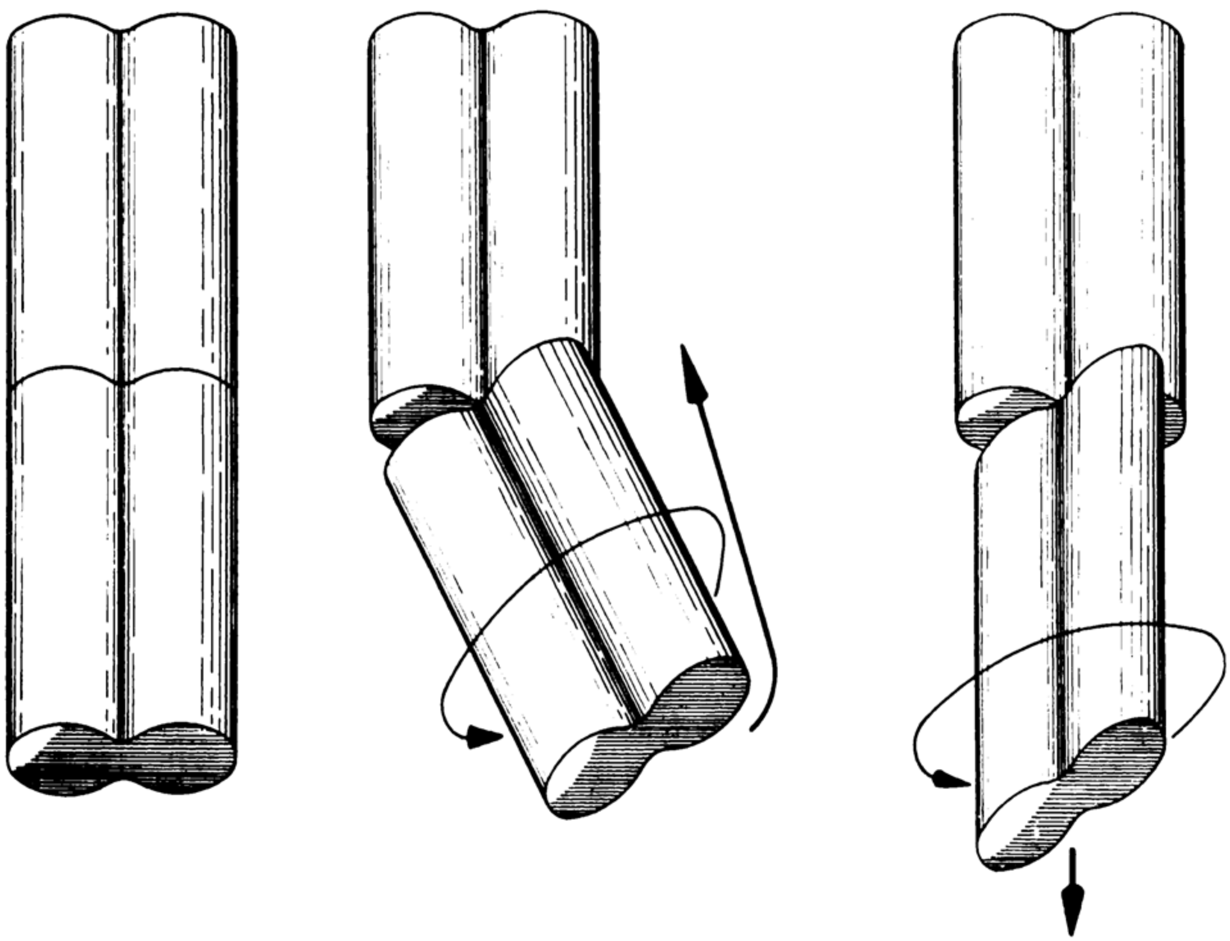


Fig 7 Mechanical drawing to illustrate the effects of rotation on the alignment of

transverse supracondylar fracture. The bearing surfaces are reduced with minimal amounts of rotation;and, if a compressing force is acting, angulation is inevitable. Traction prevents angulation. (36)

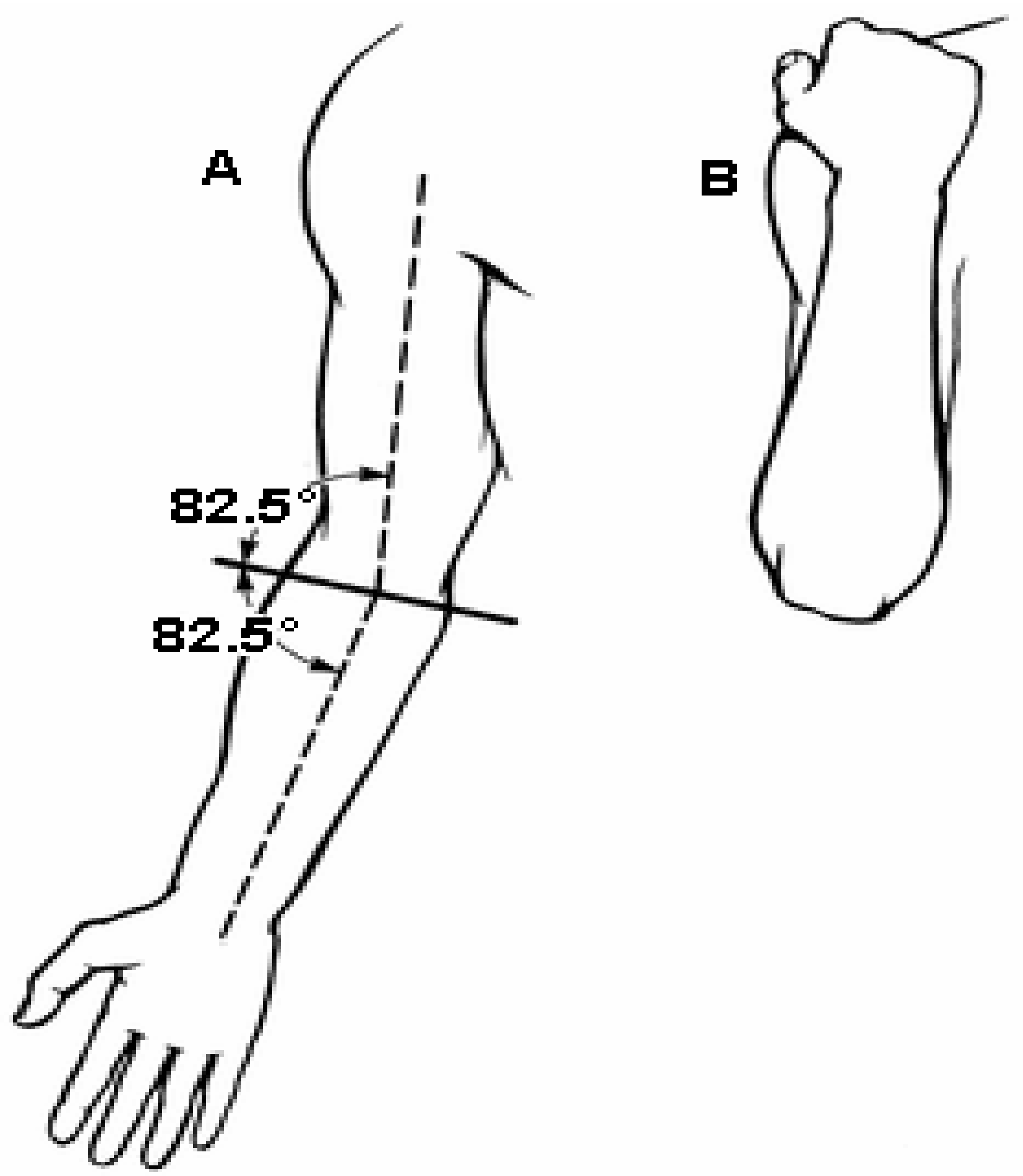


Fig 3 CARRYING ANGLE(due to obliquity of elbow axis with respect to humerus and forearm) (26)

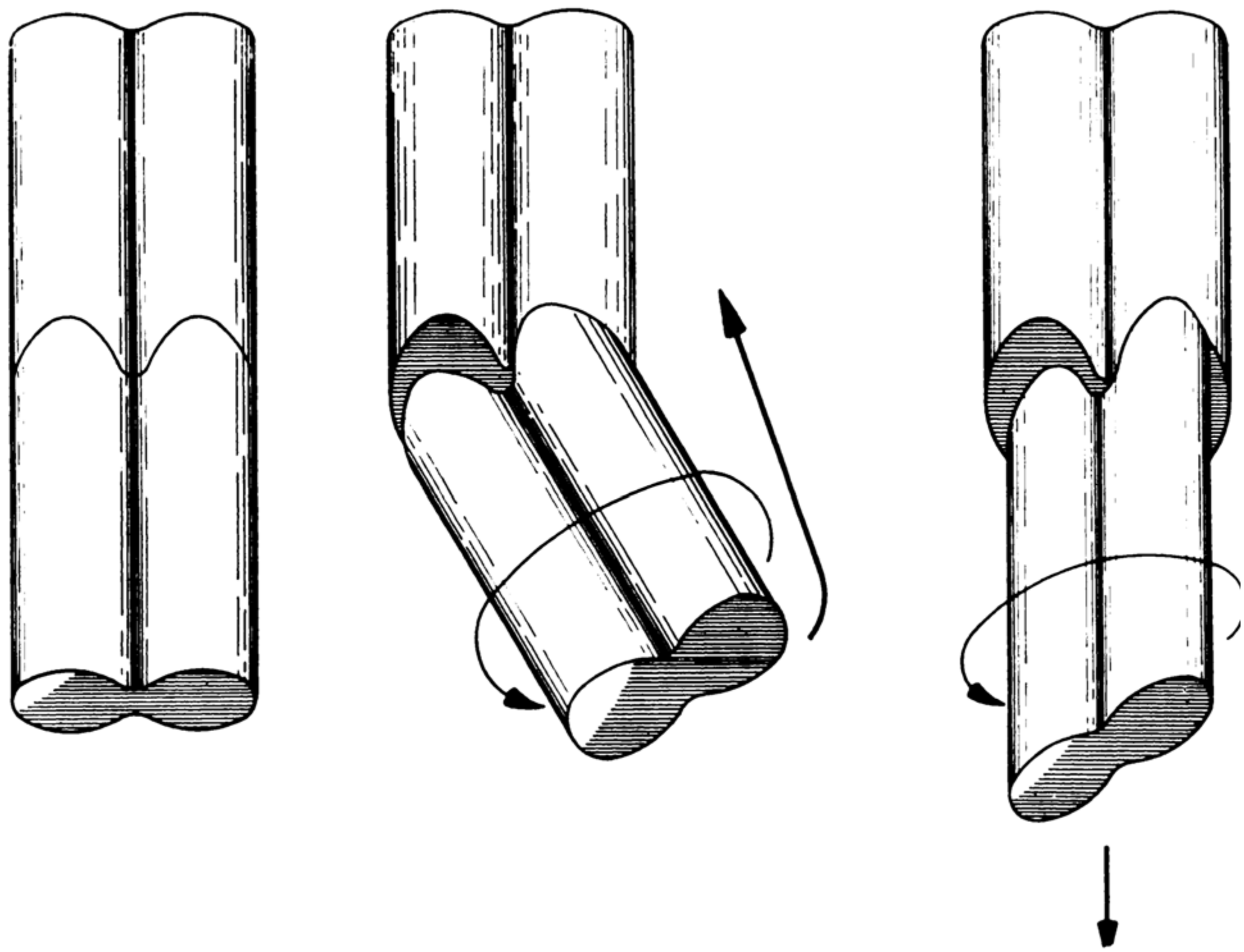


Fig 6 Mechanical drawing to illustrate the influence of rotation on the alignment of an oblique fracture. The plane of the fracture line is at 45 degrees to the long axis of the humerus. The central longitudinal constriction of the cylinder simulates the thin portion in the distal part of the humerus at the level of the olecranon and coronoid fossae. With rotation of the distal fragment and compression forces applied angulation occurs. With traction applied, angulation is prevented. (36)

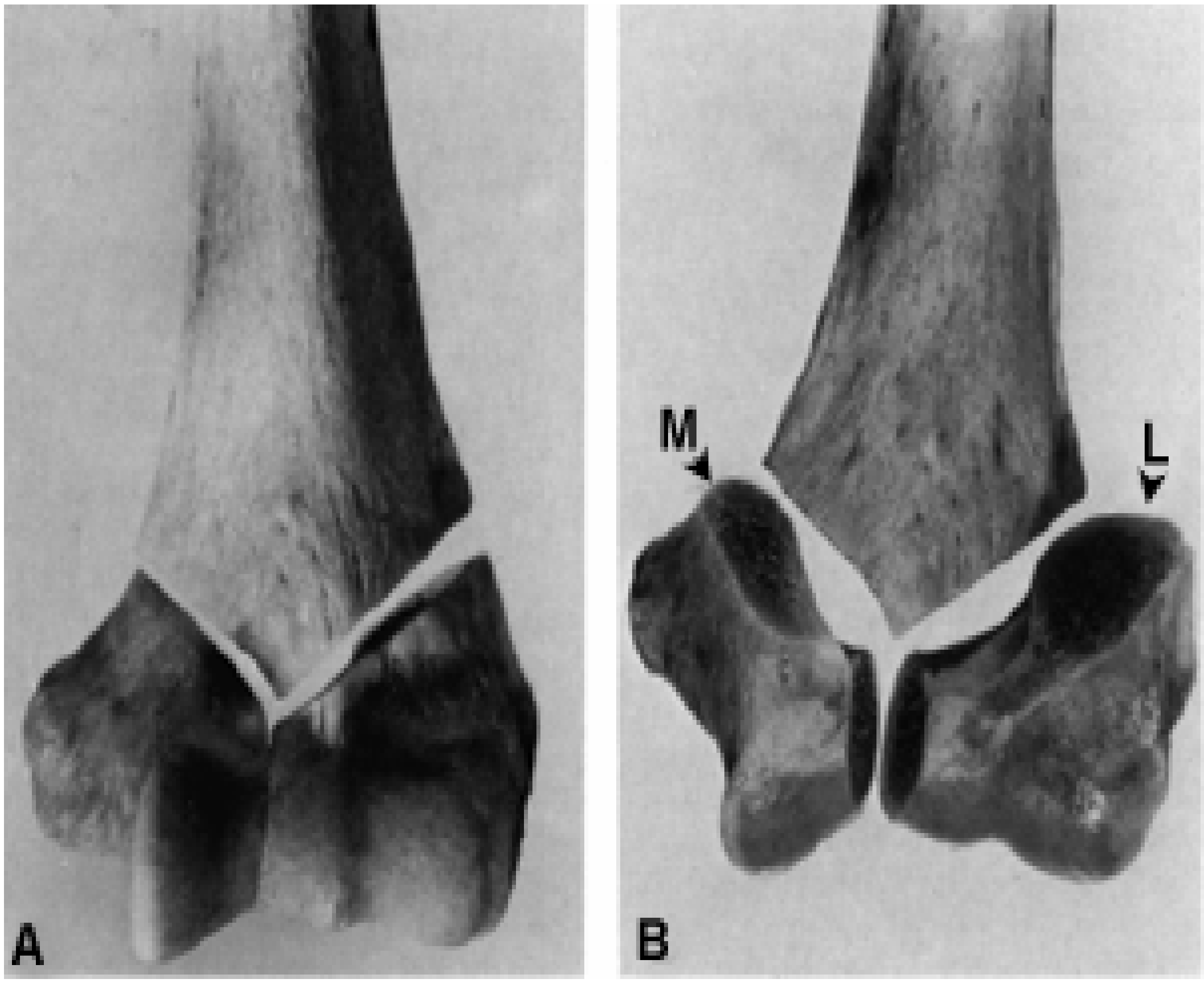


Fig 2 DISTAL HUMERUS- MEDIAL AND LATERAL COLUMNS

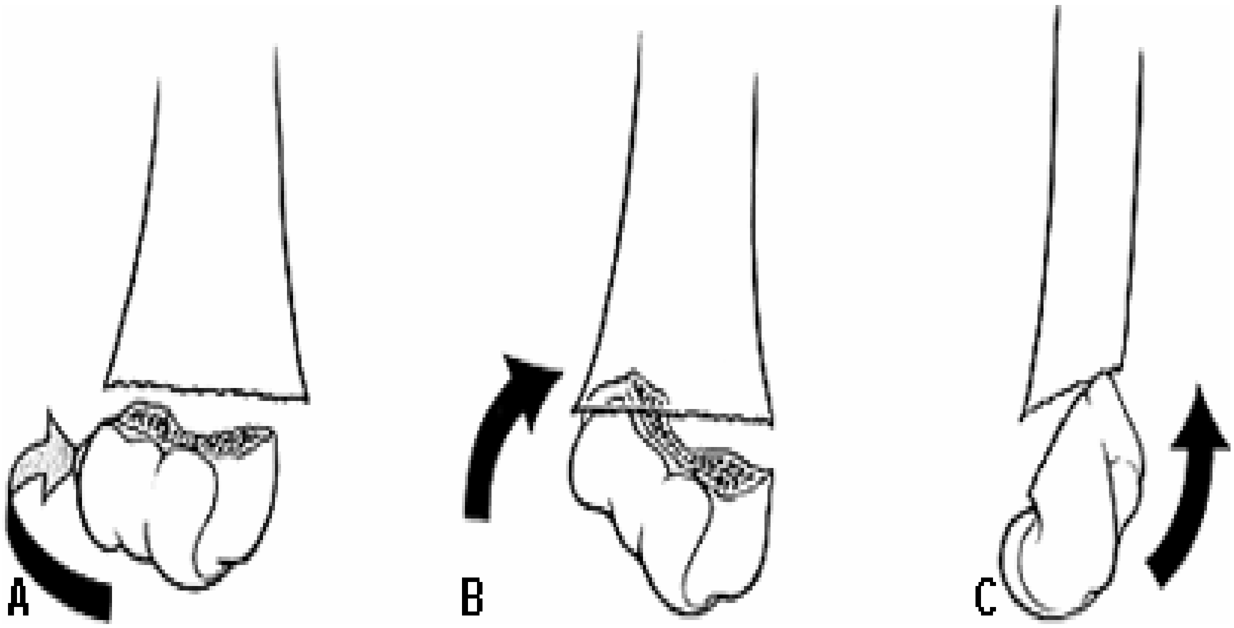


Fig 4 COMPONENTS OF VARUS (A) Internal rotation of distal fragment; (B) Varus angulation of distal fragment; (C) Hyperextension .

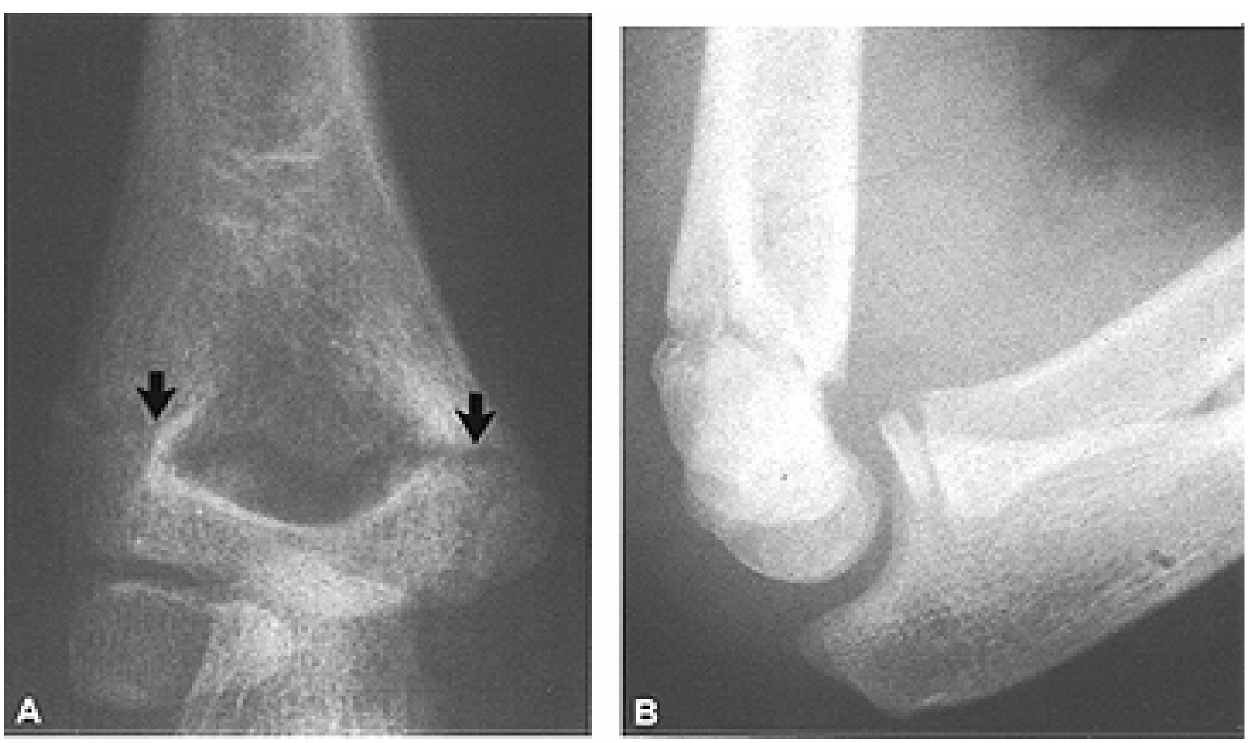


Fig 5 ORIENTATION OF FRACTURE LINE (mostly transverse in both planes

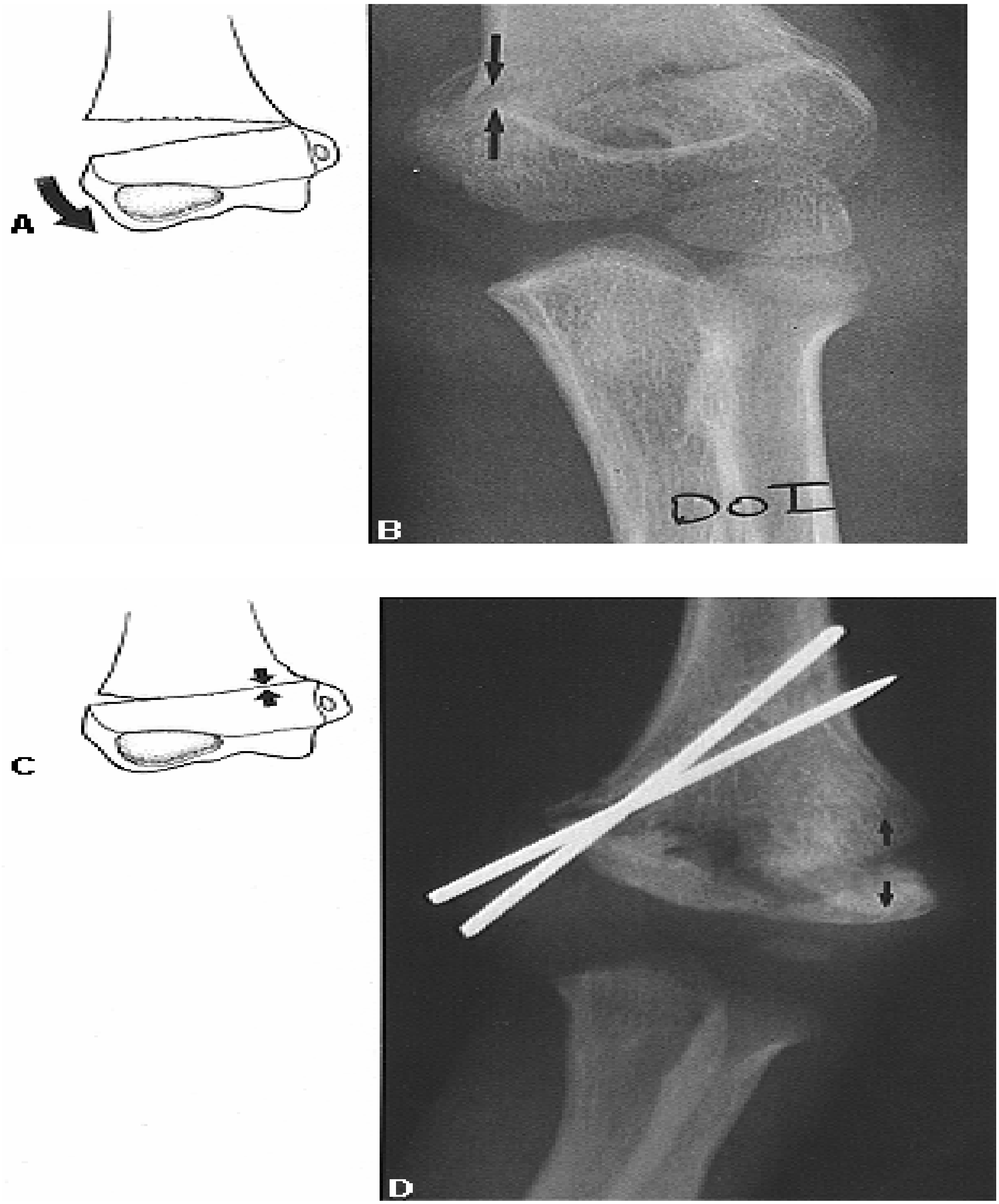
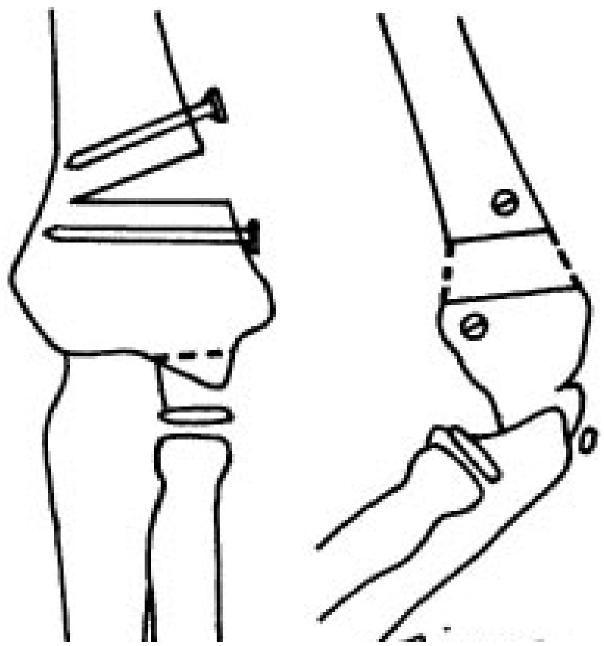
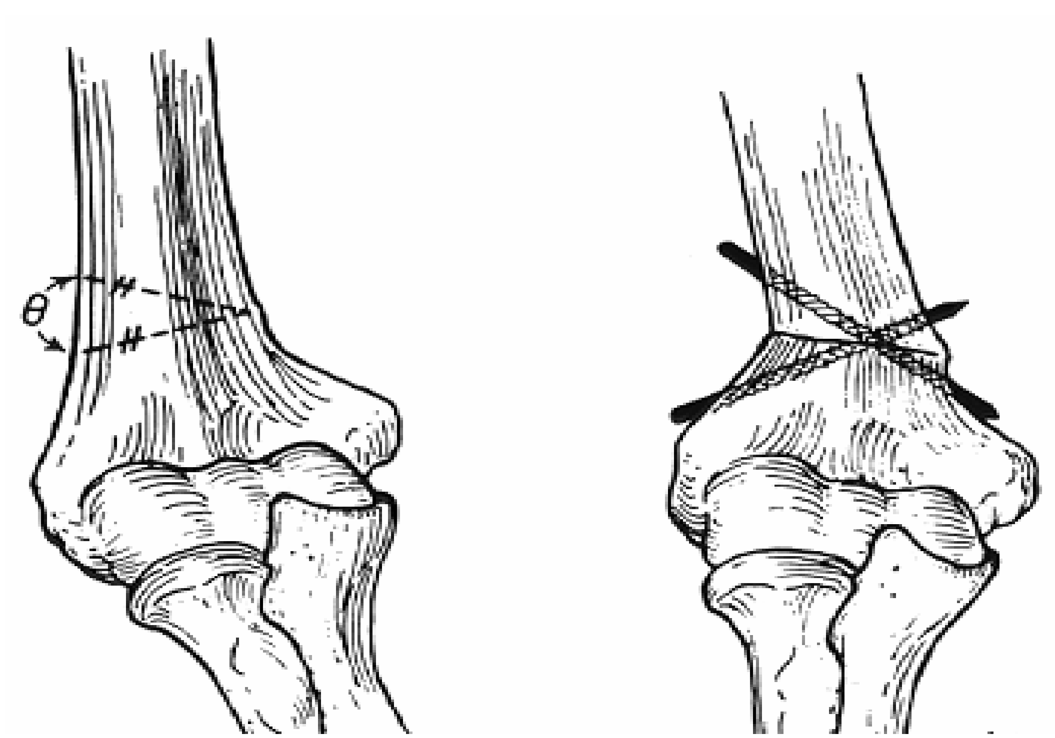


Fig 8 (A) &(D) - LATERAL OPENING ; (B)& (C)- MEDIAL GREENSTICK COLLAPSE.

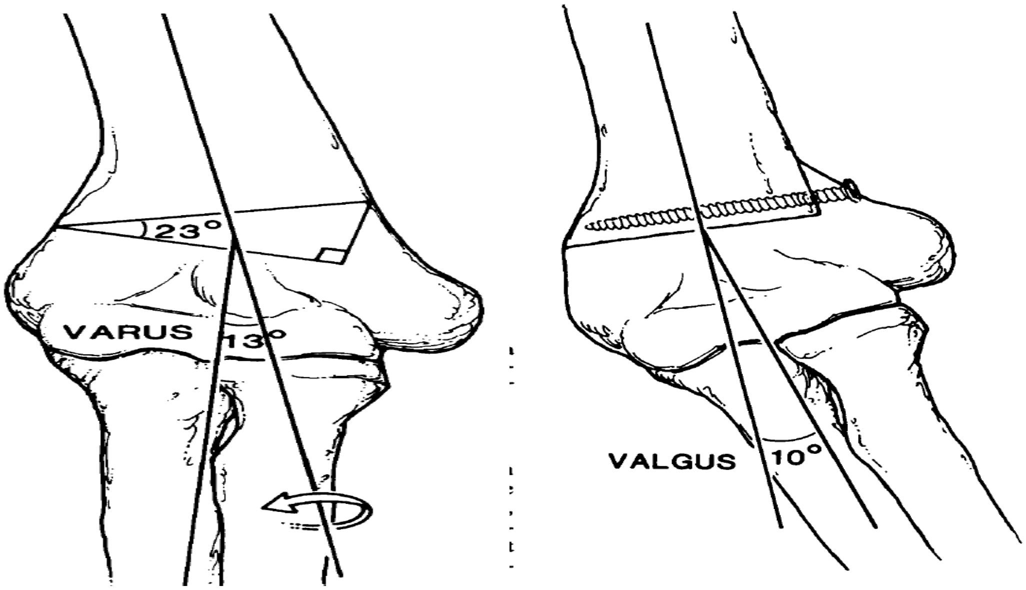
FRENCH OSTEOTOMY (Fig 10)



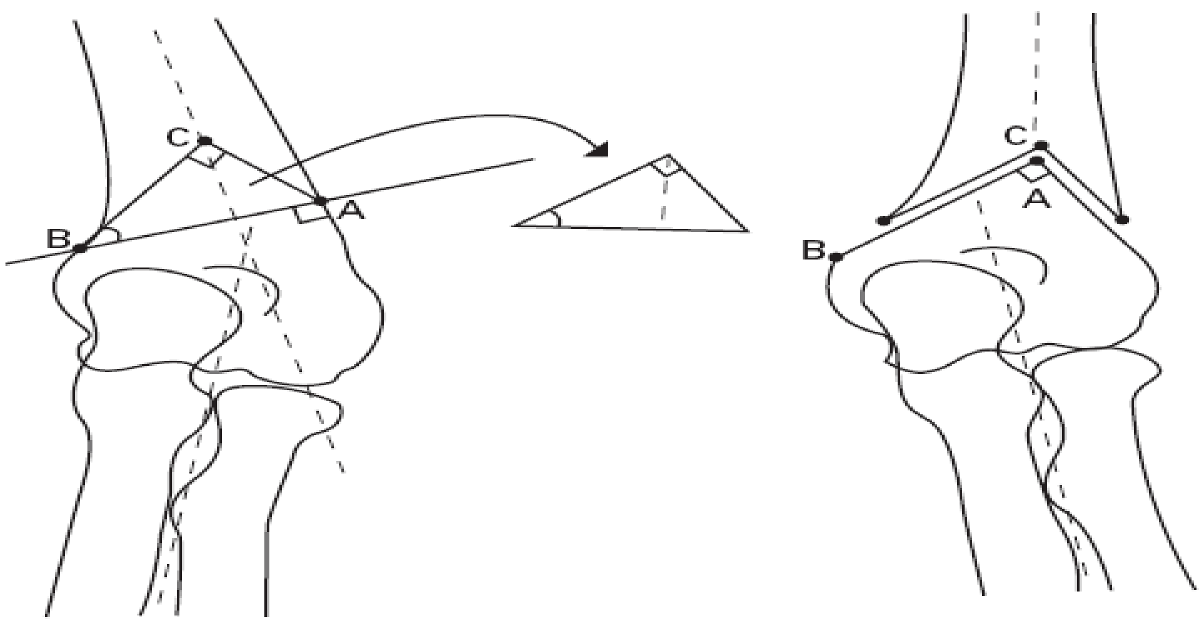
LATERAL CLOSING WEDGE OSTEOTOMY(Fig 11)



STEP CUT OSTEOTOMY (Fig 12)



REVERSE V OSTEOTOMY (Fig 13)



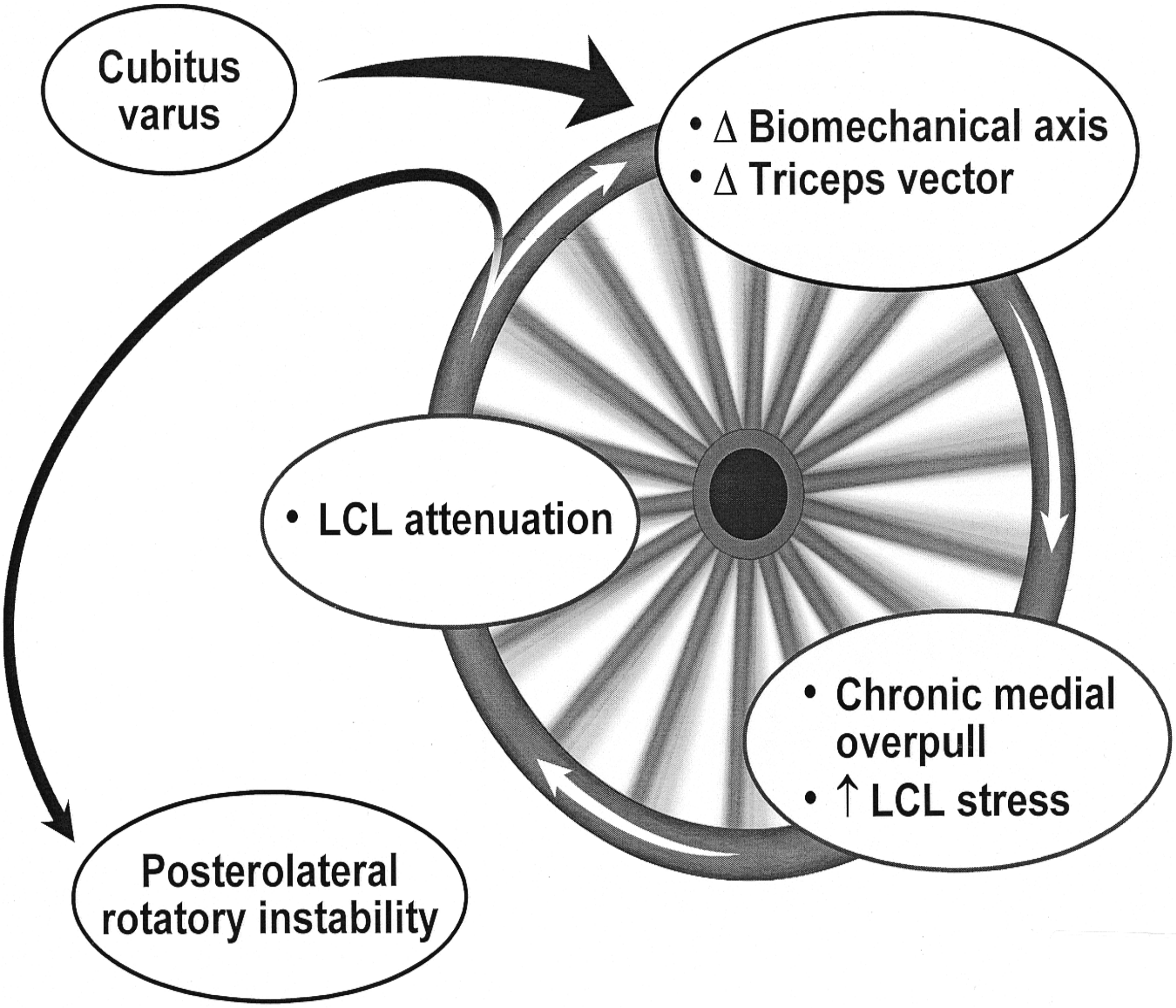
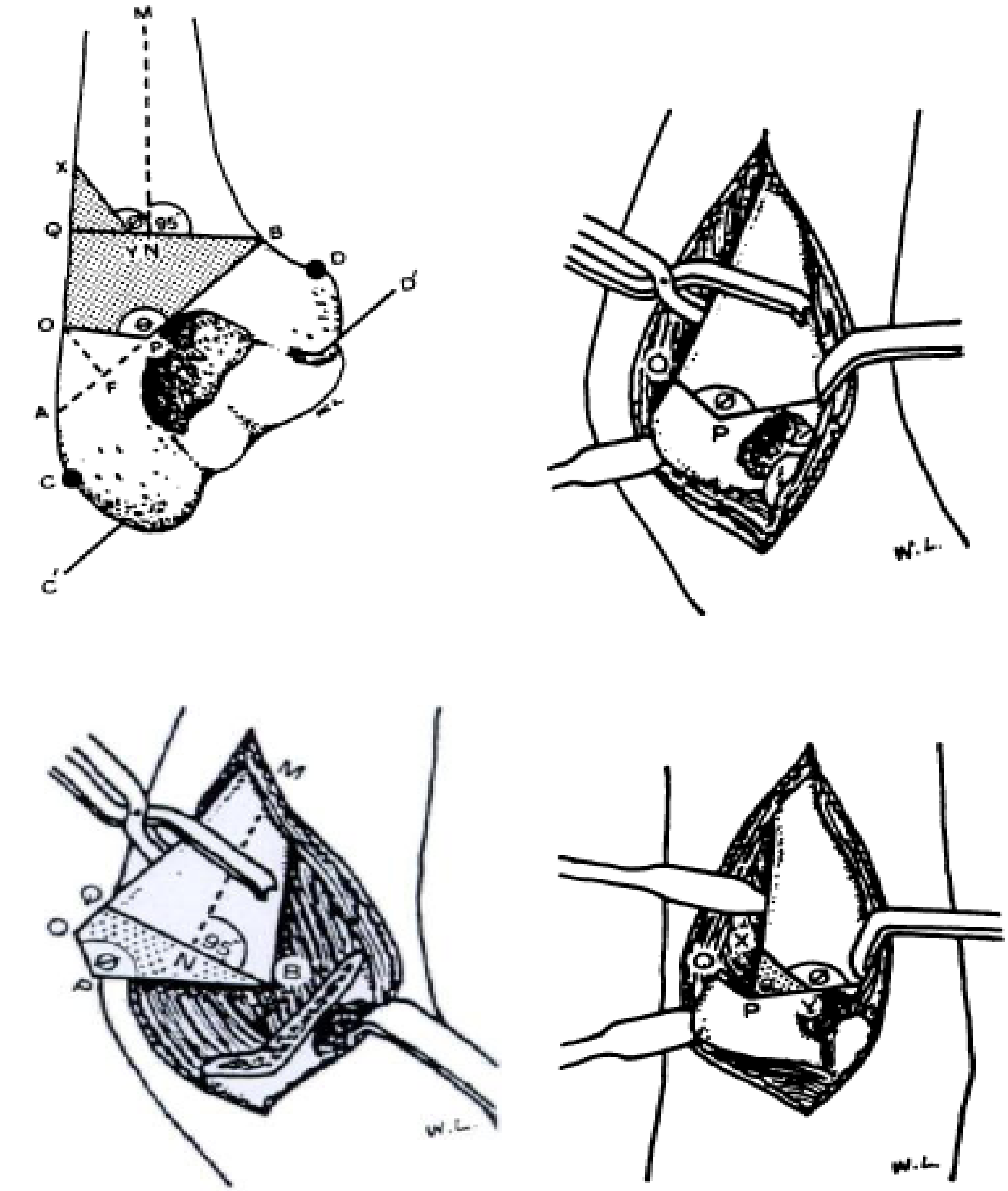
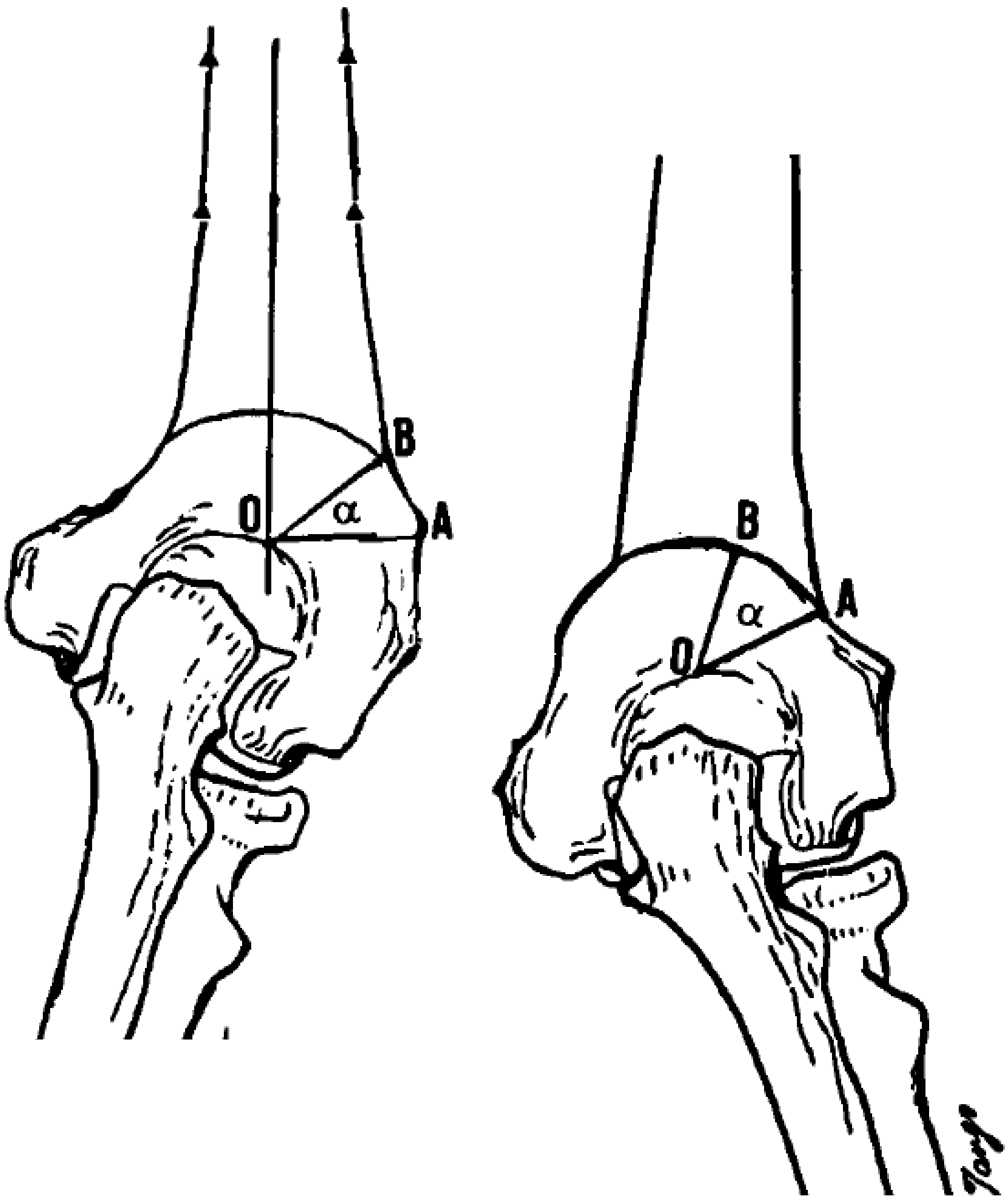


Fig 9   EFFECT OF CUBITUS VARUS ON ELBOW BIOMECHANICS

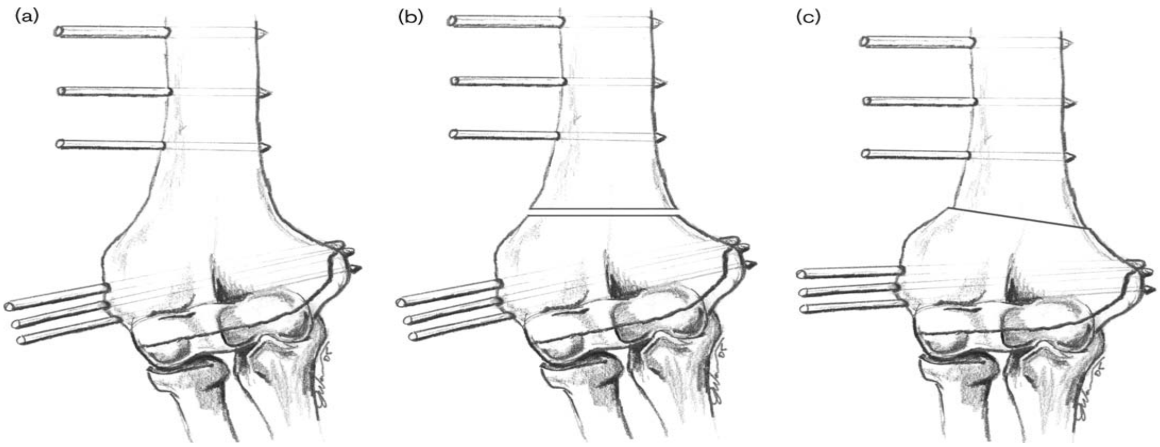


<u>Fig 18   PENTALATERAL OSTEOTOMY</u>

DOME OSTEOTOMY   Higaki T, Ikuta Y(J Jpn Orthop 31:300–335, 1982)(Fig 14)

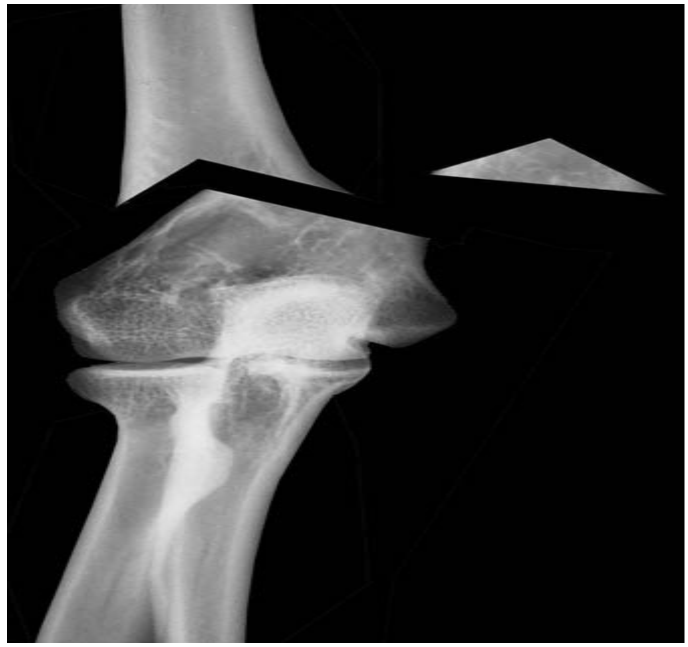


CORRECTIVE OSTEOTOMY USING AO EXTERNAL FIXATOR(Fig 15)



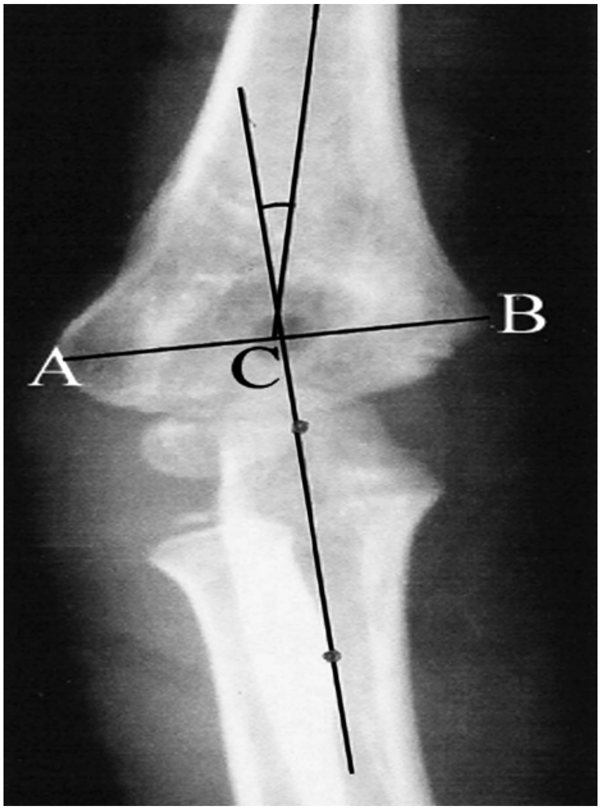
CORRECTION USING ILIZAROV TECHNIQUE(Fig 16)

CORRECTIVE OSTEOTOMY AS DESCRIBED BY HUI TAE KIM et



al (Fig17)

Fig 19 Humerus Elbow Wrist (HEW) angle



<u>Fig 20 Lateral Condylar Prominence Index (LCPI) (AC-BC/AB X 100)</u>

Name	Hospno	Age	were they treated by native bone setters	Sex	Duration from injury to surgery	Duration of follow up	Treatment given after injury	Mechanism of injury	Carrying angle pre op	Carrying angle post op	Cararying angle normal side	Discrepancy in carrying angle pre op	Discrepancy in carrying angle post op
MADHUMANT	864037-C	11	2	2	28	15	2	FOOH	-15	6	6	25	0
SOURAB CH	917069-C	10	2	1	48	13	1	FOOH	-40	2	0	40	2
ABHIJIT	694977-C	10	2	1	48	25	2	FOOH	-26	4	6	30	2
SALEHA	522033-C	3	2	2	12	24	2	FOOH	-25	12	12	37	0
YUVARAJ	696620-C	13	1	1	48	24	2	FOOH	-24	0	4	28	0
MAGI	453781-C	8	1	1	6	36	2	FOOH	-20	6	6	26	0
SAYANTAN	332237-C	13	2	1	14	48	2	FOOH	-17	8	8	25	0
TANMOY SA	488491-C	13	2	1	72	36	2	FOOH	-20	7	7	27	0
SAHANA	673561-C	9	2	2	26	48	2	FOOH	-14	16	16	30	0
ROHAN PAT	897821-C	5	2	1	4	15	2	FOOH	-20	6	6	26	0
SAYAN MAI	893272-C	4	2	1	48	15	2	FOOH	-35	6	6	41	0
SREEJA	784617-C	7	2	2	24	16	2	FOOH	-32	4	7	39	3
AYYAPPAN	021635-C	17	1	1	12	60	2	FOOH	-15	6	10	25	4
SATISH	092116-C	11	1	1	3	12	2	FOOH	-10	5	7	15	2
PRIYA G	161509-C	12	1	2	18	12	2	FOOH	-20	12	15	35	3
NAVEEN.M	036295-C	11	1	1	12	12	2	FOOH	-15	8	8	23	0
DILLY BAB	633875-C	10	1	1	24	25	2	FOOH	-28	0	4	32	4
RAM KUMAR	301617-C	13	1	1	24	36	2	FOOH	-15	8	10	25	2
YAMUNA	141445-B	10	1	2	60	24	2	FOOH	-10	7	7	17	0
SIVARANJI	141019-C	11	1	2	24	24	2	FOOH	-9	10	10	19	0
KOUSHIK N	411628-C	13	2	1	72	12	2	FOOH	-30	10	10	40	0

Name	Elbow ROM flexion affected side pre op	Elbow ROM flexion affected side post op	Elbow ROM extension normal side	Elbow ROM affected side pre op	Elbow Rom Affecteed side post op	Shoulder ROM Interal Rotation normal side	Shouler ROM Internal Rotation Affegted side Pre op	Shouler ROM Interal Rotation Affected side Post op	Shoulder ROM external rotation normal	Shouler ROM external rotation affected side pre op	Shoulder ROM external rotation affected side post o	HEW angle normal side	HEW angle affected side pre op
MADHUMANT	120	120	15	15	15	110	130	110	80	60	80	9	-14
SOURAB CH	100	130	0	-20	0	120	140	120	90	80	90	3	-25
ABHIJIT	85	110	0	-15	0	110	120	110	90	70	80	12	-25
SALEHA	120	120	0	0	0	110	130	110	90	80	90	10	-30
YUVARAJ	130	130	0	0	0	100	140	100	90	60	90	10	-26
MAGI	130	130	5	-5	-5	110	120	110	90	80	90	12	-24
SAYANTAN	100	125	0	-10	-10	110	120	110	90	80	90	14	-24
TANMOY SA	160	130	0	-20	0	100	110	100	80	70	80	8	-14
SAHANA	95	120	0	0	0	100	110	100	90	70	90	16	-14
ROHAN PAT	100	120	0	0	0	100	100	100	80	80	80	8	-23
SAYAN MAI	110	130	0	-10	0	100	110	100	80	70	80	12	-34
SREEJA	120	140	10	10	10	110	110	110	90	90	90	7	-24
AYYAPPAN	115	135	0	0	0	100	100	100	80	80	80	14	-22
SATISH	125	130	0	5	0	100	100	100	90	90	90	9	-16
PRIYA G	130	130	0	0	0	100	100	100	90	90	90	16	-25
NAVEEN.M	90	110	0	0	0	100	100	100	90	90	90	14	-16
DILLY BAB	130	130	5	5	5	100	100	100	80	80	80	14	-22
RAM KUMAR	130	130	0	0	0	100	100	100	90	90	90	12	-19
YAMUNA	130	130	0	0	0	100	100	100	90	90	90	12	-18
SIVARANJI	120	120	0	0	0	100	90	100	90	80	90	12	-12
KOUSHIK N	130	130	0	0	0	100	100	100	90	90	90	12	-32

Name	LCPI pre op	LCPI post op	LCPI diff	Compications	Outcome
MADHUMANT	19.2	13.6	-6	NIL	1

SOURAB CH	-24	44	68	LAZ	3
ABHIJIT	5	2.5	-2.5	NIL	2
SALEHA	3	0	-3	NIL	1
YUVARAJ	-25	-9	16	NIL	2
MAGI	0	-4	-4	PIN	2
SAYANTAN	-7	-10	-3	NIL	1
TANMOY SA	-9	-10	-1	NIL	1
SAHANA	4	-8	-12	NIL	1
ROHAN PAT	0	-10	-10	NIL	1
SAYAN MAI	8	0	-8	NIL	1
SREEJA	6	-9	-15	NIL	1
AYYAPPAN	-9	-14	-5	NIL	1
SATISH	-25	-30	-5	NIL	1
PRIYA G	-7	-7	0	NIL	1
NAVEEN.M	-23	0	23	NIL	2
DILLY BAB	-2	-5	-3	NIL	1
RAM KUMAR	2	5	3	PIN	2
YAMUNA	0	-4	-4	NIL	1
SIVARANJI	-10	-12	-2	NIL	1
KOUSHIK N	6	-7	-13	NIL	1

Elbow rom flexion on normal side
120
145
120
120
130
130
130
140
130
120
130
140
135
130
130
120
130
130
130
130
130

HEW angle affected side post op
6
6
10
9
9
6
12
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6
8
7
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13
11
9