REVIEW ARTICLE

A REVIEW OF TREATMENT STRATEGIES OF SUPRA-CONDYLAR FRACTURE OF HUMERUS IN CHILDREN

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ABSTRACT

Pediatric supracondylar fracture of distal humerus frequently occurs within 10 years of age with peak at 6-7 years. There is higher incidence of complications such as neurovascular compromise and late cubitusvarus deformity if left untreated at initial stages. This often occur because of important neurovascular structures are crossing the elbow region which hold different anatomic characteristics as well. This article is based on appraisal of the classification, clinical evaluation, and with particular emphasis on the management of each type especially short term complications which may occur with fracture displacement.

Keywords: Pediatric; Classification; Compartment Syndrome; Fracture Fixation.

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INTRODUCTION

Fracture in distal end of humerus more specifically extra articular fracture which involve supracondylar region of distal humerus in school going age of children (7 years)[1]. Most commonly results after fall on outstretched hand, such fractures were managed with reduction and correction of deformity at elbow which usually require general anesthesia followed by application of plaster of paris (POP or Fiberglass) above elbow and maintain position of elbow with >100^0 flexion. However, it is difficult to keep >100^o elbow flexion as it may lead to vascular compromise so supracondylar fracture after correction of displacement, alignment and rotation need internal fixation with Kirschner wires (K- wires) either by closed technique or in rare circumstances open reduction and internal fixation. This is how we can avoid hyperflexion at elbow so minimize vascular complications. It is utmost important to reduce such fracture of any type except type 1 because these fractures will not heal without development of complications such as compartment syndrome or cubitusvasus deformity in neglected and maltreated cases[2]. The data was retrieved by searching the keywords Pediatric, Classification, Compartment syndrome, Fracture Fixation on search engines like Pubmed and Medline. This article reviews the classification system, reduction technique and management of vascular complications.

DISCUSSION

Pathoanatomy
Distal end of humerus, which represents supracondylar region in addition of both medial and lateral humeral condyle and represent 12-17% of children fracture[3]. Supracondylar fracture resulted most often in school going children (7-8 years) whose bones are still immature and distributed among boys and girls with 1.22:1.0 ratio[4]. This supracondylar region is undergoing remodeling and relatively thin cortex during this age therefore predisposes such fracture. Most of supracondylar fracture is resulted after fall onto an outstretched hand. Most common extension type injuries, which account 95% of supracondylar fracture that, exactly resulted when olecranon process of ulna pushes the distal fragment and thus displaced it posteriorly[5]. In comparison to extension injuries, flexion injuries account 2-5% of cases and is often the result of mechanism of fall opposite to pattern which leads to extension injuries, which is due to fallon bend Elbow of 900 or more.

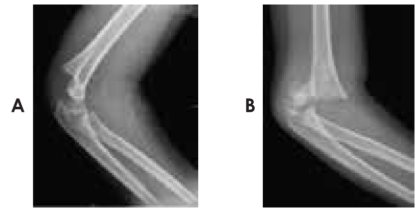


Figure 1: Depict a) Extension Type b) Flexion type.

Classification

Gartland has discribed the supracondylar fracture in 1959 and till date most of orthoapedic surgeon still applying this classification. Based on degree of displacement of fracture usually distal fragment, he divided extension injury into 3 types, these are type I non-displaced supracondylar fracture and type II displaced fracture with intact posterior cortex and type III completely displaced with no cortical contact between two fracture fragment left. Gartland considered flexion type injury separately[6]. However there are some limitation in his classification, since neurovascular status of limb which may be severed in such supracondylar injuries were not considered in his classification.

Figure 2: Showing Gartland's classification.

Wilkins[7] in 1984 modified Gartland's classification to create subdivision of Type- II and Type-III and he include Type-IV in his description. Type-IIA fracture being stable with no rotational abnormity and type-IIB fracture being unstable having some degree of rotation and angulation posteriorly. While Type-IIIA with posterior-medial and Type-IIIB posterior-lateral distal fracture fragment displacement. Type IV fracture, in which there is complete loss of periosteal hinge anteriorly and posteriorly and instability in both flexion and extension (Figure 1)[8].

Flierl et al[9] retrospective review showed that Type IIIB fractures were eventually leads to complications such as elbow stiffness and median or ulnar nerve injuries however, according to Heal et al[10] treatment based on fracture configuration. Table 1 shows Wilkins Modified Gartland's Classification. Lim et al[11] reported in his retrospective study a group of patients with fracture spike angle (<45°) had narrow fracture tip-skin distances, more surgical time and higher complications in comparison with control group. It is utmost important to determine such x-ray findings preoperatively that alert orthopedic surgeon to anticipate potential problems that one has to face while manipulation and reduction of fracture and may encounter trouble in open reduction.

Table 1: Wilkins Modified Gartland's Classification.

Type	Characteristics
I	Non -displaced
II -A	Angulated with intact posterior cortex and without rotation
II -B	Angulation with rotation
III -A	Posterior - medial displacement with intact Medial periosteal hinge
III -B	Posterior - lateral displacement with intact Lateral periosteal hinge
I -V	Unstable fracture in Flexion and Extension with completely disrupted Periosteum

Clinical Evaluation

Limb must be completely examined in children who sustained injury around elbow since ipsilateral forearm and wrist injuries are not uncommon. Such combine injuries may develop compartment syndrome. Elbow is being assessed for appearance of obvious deformity associated with swollen elbow and skin tethering or bruised / ecchymosed skin of cubital fossa pointed out proximal fragment of fracture which has buttoned out of torn brachialis muscle and also precede neurovascular injuries. Hence, it is important to examine vital structure simply to feel distal pulsation of radial and ulnar arteries and vascular perfusion assessment by color and temperature of hand must be recorded.

Clinical presentation of limb with pediatric supracondylar fracture of distal Humerus has different treatment approach, not only fracture configuration would alter treatment strategies but particular fracture types especially type III and IV when associated with neurovascular compromise. In these injuries, limb must be thoroughly evaluated for vascular injury clinically. Patient with apale, cold, hand with capillary refill time >2sec suggests that limb is poorly perfused, will eventually being managed differently than to a pink, warm hand with apalpable distal pulses. Secondly, common nerves that cross elbow are median nerve with anterior interosseous branch injury associated with extension type of fracture, radial nerve injury when fracture displaced posteriolaterally and ulnar nerve injury is associated commonly in flexion type fracture must be recorded if any of these abnormal findings resulting from neurovascular injurypresent that ultimately change treatment strategies.

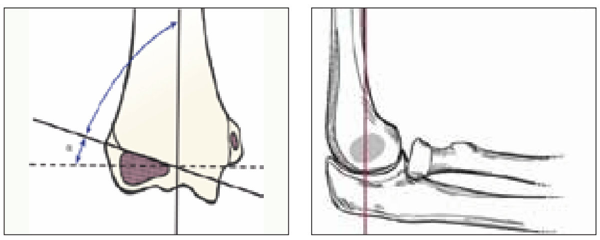
Compartment Syndrome

Compartment syndrome may be present during initial injury or afterwords so serial examinations are necessary that include patient'spain grades, response analgesics and posterior slab. Clinical features includeexcruciating pain which requires increasing doses of analgesics may be due to ischemia and eventually develop compartment syndrome[12]. Other symptoms of pallor, paralysis and paresthesia develop late and represent irreversible tissue damage. The muscle will be affected as soon as 4-6 hours after the onset of abnormally high compartmental pressures, which result in Volkmann contracture of limb secondary to development of compartment syndrome, such consequences, can be avoided by making early diagnosis.

A tense swollen forearm and positive stretch test are earlier signs that indicate development of compartment syndrome and warrant urgent release. In rare circumstances, when unable to assess compartment syndrome especially pediatric population then compartment pressure measurement should be obtained[13].

Radiographs

Images of the anterior-posterior elbow (AP) and a lateral view are taken. The Baumann angle is measured on elbow x-ray AP view (Figure 3), which is the angle between the longintramedullary axis of the humerus and the line along growth plate of lateral humerus condyle. A normal angle ranges between 850 and 890. An increase in angle suggests the varusangulation of the fracture. In the lateral view the anterior humeral line should pass through the capitellum, in addition to that posterior fat pad sign become sometimes evident on lateral view of elbow x-ray, such sign is the result of hamatoma of fracture when displacesto posterior olecranon fat pad. Occasionally an oblique view of the elbow is obtained to visualize the occult fracture, which is not evident in the standard AP and lateral views.[14]



A B

Figure 3: Showing AP View (a) Baumann's angle (b) Anterior humeral line.

MANAGEMENT

Closed Reduction

First phase of restoration, followed by realignment of the distal fragment to the humeral shaft, traction is applied to the arm to free the proximal fracture fragment from the brachialis muscle, longitudinal traction is applied with surgeon and assistant provide countertraction with elbow in extension and supination in an attempt to counteract the edges of both fragments. Therefore, the assistant maintains the stabilization, and then next step is to correct displacement in either direction.

Correction of medial displacement is accomplished by pronating the forearm so that medial periosteal hinge become tightened simultaneously apply valgus force and translation with one hand. Similarly, lateral displacement of fracture is corrected with the forearm supination in order to tighten lateral periosteal hinge and apply varus stress and translation with one hand.

Khare, et al. who noted that forearm pronation was more effective than supination in reducing the posterolaterally displaced supracondylar fracture[15].

Then direct the angulation and displacement of the fracture with extension type fracture, the elbow is flexed at 1200. While pushing the distal fragment to reduce it, it can be done by positioning the thumb on the olecranon and levering on theforearm while the elbow is flexed, a posterior direct force is applied to the proximal fragment, the flexion is maintained to contain the reduction and the K-wires are then insertedlaterally under C- arm images.

Open Reduction

Open reduction and fixation with k-wires indicated when there is open fracture, pale ischemic limb that does not revascularize with reduction of closed fracture, failure of reduction with closed treatment[16] and if there is neurovascular damage and requires exploration of both arteries and nerve[17]. Open reduction is also indicated when pucker's sign present clinically, such finding should be considered and helps in making decision to proceed for open reduction.

Gartland Type I

Gartland type I fractures can be treated effectively with above elbow cast at 900 flexion and cast remain for three to four weeks[18]. Be aware pressure effect of cast on neurovascular structure at anterior cubital fossa which can be avoided by altering method of application of cast. According to Thomson et al. upper plaster layer is applied in a figure of eight over anterior of elbow, followed by application of second layer in conventional pattern[19].

Gartland Type II

Angulated fractures but the intact posterior cortex requires reduction. Closed reduction and casting for type II supracondylar fractures is a feasible treatment option, but some patients will not maintain the initial reduction in plaster[20].

This study sought to identify predictive factors such as failure of closed reduction and casting for these fractures. The degree of extension of fracture based on the anterior humeral line on lateral radiography was significantly related to treatment failure. Another risk factor predicted in the study was the width of the soft tissue shadow of the upper arm on x-ray film after reduction and when an elbow flexion is required greater than 900 to maintain the reduction of the fracture, then percutaneous pins must be inserted. Most authors agreed for closed manipulation and reduction followed by fixation of K-wires percutaneously[21]. While hyperflexion at the elbow may be associated with vascular compromise[22,23].

Gartland Type III

This fracture is particularly prone to neurovascular compromise. Closed reduction and percutaneous fixation are the preferred treatment option for displaced fractures. Fractures with conservatively managed displacement have a higher incidence of residual deformity than those treated with reduction and fixation with k-wire[24]. Optimal management consists of a percutaneous wire fixation in an urgent manner and at least within 24 hours. Certainly, a child with a probableoperative treatment must be admitted for close observation of the distal neurovascular status while awaiting surgical treatment. Occasionally an open reduction is required approached from front or side of elbow. The elbow may be assessed anteriorly which get direct exposure of neurovascular structures (brachial artery and median nerve) in addition, this minimize elbow contracture as well.

Closed manipulation and reduction followed by insertion of percutaneous insertion of k–wire are indicated for unstable but reducible fractures and usually those supracondylar fractures, which require maintaining a 90-degree of elbow flexion.

The most common wire configurations include a two or three-wire or a medial and lateral crossover wires[25,26]. Previous studies have suggested that the laterally inserted K–wires were not get better results than crossed K-wire placement.[27, 28] Zhao et al.[29] compared the risk of iatrogenic injury to ulnar nerve when medial k-wire was being inserted. More cases of iatrogenic ulnar nerve injury were associated with crossed K–wire placement when compare to lateral k-wire insertion. Karim et al.[30] compared the results of cross-wire and lateral wire configurations in the management of supracondylar humeral fractures found significant difference in stability between the group of crossed k-wires and the lateral k-wires. Lateral k-wire resulted in less stable fixation. The crossed pins fixations were associated with neuropraxia secondary to iatrogenic ulnar injury. This study showed that stability of fracture with stable fixation methods are utmost important and usually C–arm is required to guide correct placement of K–wire. If a medial wire is to be used then elbow must be in extension in order to avoid injury to ulnar nerve[31].

However, Jaeblon et al.[32] in his work, he concluded that the configurations of the lateral placed k-wire provide enough stability to the such fracture and maintaining the reduction of in different planes (transverse, sagittal, oblique and transverse elevated fractures) without any iatrogenic nerve injury.

Frequently increase in the risk of iatrogenic nerve injury in the crossed-wire group was observed in one study[33]. The fixations with K-wires in supracondylar fracture humerus is not free from unwanted complications, in fact lead to greater incidence of iatrogenic nerve injury particularly associated with medial placed wire hence, K-wire configuration remains a controversial, it is utmost important to avoid injury to ulnar nerve if crossed wires method of fixation are being used. A 2mm k-wire is inserted in diverging position to each other in order to improve fracture stability.

Management of Supracondylar Fracture with Neurovascular Compromise

Mangat et al. [34] found association between median nerve branch (AIN) injury with sharp spike of fracture. Such injury requires early surgery to address anterior interosseous nerve injury (AIN). The arterial injury in a fracture may result in different ways. Hence, the brachial artery can be tense, bruising or divided. Neurovascular injury to limb with no pulse palpable should raise suspicious of an brachial artery injury. Pediatric Supracondylar humerus fractures with a pulseless and poorly-perfused hand should be operated emergently. If the limb still remains pulseless after the closed manipulation under anesthesia and reduction with k-wires fixation, prompt vascular exploration, and repair (if required) should bedone. While pulseless limb but well-perfused hand should be operated urgently with closed reduction and fracture fixation. If the limb still remains pulseless after the surgery, vascular status should subsequently be reassessed[35].

For vascular exploration, a standard anterior approach was performed through a "lazy S" incision at the centre of the cubital fossa. Scannell et al[34] presented cases of pulseless limb but well perfusion noticed in fractures that were treated with closed manipulation and K wire insertion followed by postoperative neurovascular status assessment.

Gartland type-III, supracondylar humerus fracture accounts majority of cases and ¼th of the patients' cohort had successfully returned distal vessels flow after the successful closed reduction of the fracture detected clinically with palpable pulse. However, Welleret[35] who presented a series of 20 patients of type III fracture with pink pulseless hand, after closed reduction and fixation, patients' limb was monitored for vascular status, 19 of patients had return of radial pulse with absence of any consequences. Therefore, it is stated that after optimal treatment of such injuries, limb should be monitored for 24 hours to 48 hours.

CONCLUSION

Supracondylar fracture of distal humerus is common injury in children and can be associated with neurovascular complication. To avoid potential consequences such as deformity and neurovascular compromise, one must perform through assessment of limb of child who has sustained supracondylar fracture of distal humerus. However, closed manipulation and reduction is preferred treatment option, but occasionally require open reduction and fixation with K–wire in order to limit morbidity associated with this injury.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS CONTRIBUTION

All authors equally contributed to this study.

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