Overview of Cubitus Varus Deformity: Evaluation and Treatment

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Abstract

Background: Cubitus varus is the most common deformity following supracondylar fracture of the humerus. Although use of percutaneous techniques has reduced the incidence of cubitus varus deformity significantly, 5–10% of children with supracondylar humerus fractures still develop this deformity irrespective of the treatment. Cubitus varus deformity after supracondylar fracture of the humerus in children has two main causes are malunion and growth disturbance. Patients who have cubitus varus deformity have cosmetic problem and little functional disability (pain, decreased range of motion and epicondylitis). No functional differences between those who underwent corrective osteotomy and those who were simply observed so, the indications for osteotomy were merely cosmetic. Treatment of cubitus varus by reassurance if deformity mild, no functional disability or by corrective osteotomy mainly due to cosmetic problem. This article aimed to review the cubitus varus deformity and the different moadialites in the management of cubitus varus deformity.

Keywords: Cubitus Varus Deformity; Humerus ; Children ; Treatment

Introduction

The elbow joint is a highly congruous and stable joint. The passive stability is caused by both the highly congruent articulation between the humerus, ulna and the soft tissue constraints. The active stability results from joint compressive forces provided by the muscles **(1)**. The carrying angle of the elbow refers to the obliquity between the upper arm and the supinated forearm when the elbow is held in extension. The average carrying angle is 13° degree (a range 11°:14°) in valgus in both sexes at the age of one year **(2)**.

Although cubitus varus defined as a deformity in which the long axis of the forearm is deviated inward in relation to the long axis of the arm (the reverse of the carrying angle). Indeed it is a complex three dimensional deformity which consists of varus, hyperextension and internal rotation deformity of the distal bone fragment of the humerus **(3,4).**

The severity of a cubitus varus deformity is graded as follows: Grade I (loss of physiological valgus) ; Grade II (varus of 0-10 degrees) ; Grade III (varus of 11-20 degrees); and Grade IV (varus ＞20 degrees) **(5).**

The commonest aetiology of cubitus varus deformity is traumatic secondary to supracondylar fracture humerus; or medial humeral condyle fracture. These results from retardation of growth of the epiphysis due to vascular insult and/or ossification in the fracture line **(6)**. In case of lateral humeral condyle fracture; the cause of the deformity is believed to be secondary to a combination of lateral condyle physeal stimulation and inadequate reduction Biologic-related problems include lateral condylar spur formation results from overgrowth of the periosteal flap that is avulsed from the proximal fragment. The prominence may give the appearance of cubitus varus **(7).**

The second cause of physeal arrest secondary to trauma; or infection as osteomyelitis and septic arthritis; or tumors as Osteochondroma **(8).**

The varus was result of residual displacement of the distal fragment in the medial direction **(48)**. Despite higher power of remolding in children. No remolding could correct rotation and medial tilt of the distal humeral fragment. The medial rotation is the most important factor in the development of cubitus varus **(9)**.
In cases of cubitus varus following supracondylar humeral fracture the length of the outer part of the arm exceeds the inner one. This was due to overgrowth of the lateral condylar epiphysis as a result of stimulation by the fracture itself causing unequal growth of the distal humeral epiphysis **(10)**.
Cubitus varus produces an ugly deformity but rarely limitation of motion. Pure posterior displacement causes little deformity also pure horizontal rotation because rotation is adequately compensated for at the shoulder joint **(Fig. 1)**. Coronal tilting can occur with opening of the lateral aspect of the fracture site, causing angulation into a varus position, or with impaction of the medial side of the fracture site, again resulting in cubitus varus **(11).**
Horizontal rotation predisposes to coronal tilting, and a combination of horizontal rotation, coronal tilting, and posterior displacement can result in a three-dimensional deformity of cubitus varus **(Fig. 2) (11)** .

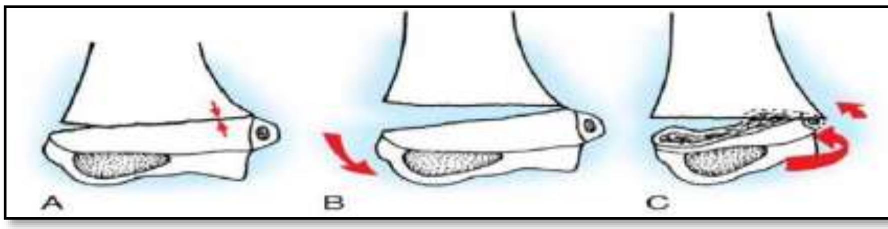

Fig. (1): Mechanism of coronal tilting: **(A)** Impaction of fracture medially; **(B)** Tilting of fragment medially; **(C)** Horizontal rotation **(11).**

Fig. (2): Three static components that combine to produce cubitus varus. (**A**) Horizontal rotation. (**B**) Coronal tilting. (**C**) Posterior displacement **(11).**

Assessment of cubitus varus:

The deformity needs to be characterized in three planes (coronal, sagittal and axial) as cubitus varus is a complex three dimensional deformity which consists of varus, hyperextension and internal rotation deformity of the humerus distal bone fragment **(5)**.

- Carrying angle (decreased or reversed):

The angle is determined by projecting the long axis of the arm and that of the forearm in a fully extended and supinated limb. 1st method done by marking four points; two are marked on the arm in the upper and middle third midway between the medial and lateral borders of the arm, the other two points one in the center of the wrist and the other at the center of the cubital fossa. A line connecting the upper two points marks the axis of the arm, another line joining the lower two points marks the axis of the forearm. The angle between the two axes indicates the carrying angle **(13).**
The second method measured by a manual goniometer with two drawing axes of the arm and forearm. The axis of the arm is defined by the lateral border of the cranial surface of the acromion to the midpoint of the medial and lateral epicondyles of the humerus. The axis of the forearm is defined by the midpoint of the lateral and medial epicondyles of the humerus to the midpoint of the distal radial and ulnar styloid processes **(14)**.

- Rotational deformity

It was estimated by having the patient bend forward slightly and setting the forearm behind the patient's back with the elbow flexed 90° and the shoulder hyperextended maximally. The examiner held the patient's elbow as a fulcrum and placed the humerus in maximal internal rotation by lifting the hand from the back.

Whereas the hand of a person with a normal upper extremity cannot be brought up from the back, the hand of a patient with an internal rotation deformity can be lifted, forming an angle between the horizontal plane of the midline of the forearm and the coronal plane of the back. This angle is considered to be the angle of internal rotation deformity of the humerus **(15)**.

Fig. (3): Method of measuring internal rotation deformity (cubitus varus). The patient bends forward and is viewed from behind **(15).**

- **Elbow stability evaluation**

1-Varus Stress Test: To properly assess collateral ligament integrity, the elbow should be flexed to about 15 degree. This relaxes the anterior capsule and removes the olecranon from the fossa. The examiner puts one hand above and one hand below the elbow. With the forearm in full supination, the elbow in extension and Varus stress is best applied with the humerus in full internal rotation. The examiner exerts varus force. Opening of the lateral compartment → lateral ligament laxity **(16).**

2- Valgus Stress Test: The examiner puts one hand above and one hand below the elbow. With the forearm in full supination and the elbow in slight flexion about 10 degree, the examiner exerts valgus force **(16).**

3-Lateral Pivot Shift Test: Insufficiency of the lateral collateral ligament is responsible for posterolateral instability of the elbow. Flexing the shoulder and elbow 90 degree, with the patient supine. The patient's forearm is fully supinated and the examiner grasps the wrist or forearm and slowly extends the elbow while applying valgus and supination movements and an axial compressive force. This produces a rotatory subluxation of the ulnohumeral joint; that is, the rotation dislocates the radiohumeral joint posterolaterally**.** Additional flexion results in a sudden reduction as radius and ulna visibly snap into place on the humerus **(17).**

- **Radiological assessment:** It includes anteroposterior and lateral radiographs of both elbow joints. Carrying angle (decreased). Different radiological methods to determine carrying angle using humerus-elbow-wrist angle; and Crescent sign that implies angulation and rotation, when it is seen on the lateral view **(Fig. 4) (18,19).**

Fig. (4): Crescent sign. (A) Normal lateral view of elbow. (B) In varus deformity, part of ulna overlies distal humeral epiphyses, producing crescent **(19).**

- **Anterior humeral line**: a line is drawn along the anterior border of the distal humeral shaft, it should pass through the middle third of the ossification center of the capitulum. This is referred to as the anterior humeral line**.** Passage of the anterior humeral line through the anterior portion of the lateral condylar ossification center or, anterior to it indicates the presence of posterior angulation of the distal humerus **(20).**
- **Tear drop sign of the elbow** : the anterior dense line represents the posterior margin of the coronoid fossa , the posterior dense line represents the anterior margin of olecranon fossa and the inferior margin of it is capitulum **(Fig. 5)**, this sign lost in cases of posterior angulation of distal humerus **(21)**.

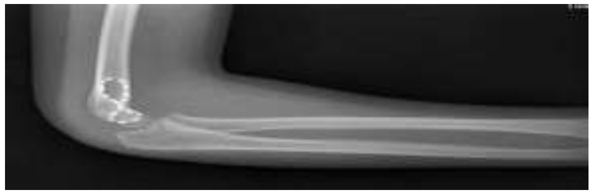

Fig. (5): Teardrop sign of the elbow joint **(21).**

Treatment of cubitus varus

Controversy exists in the treatment of angular malalignment after supracondylar fractures. Options include observation, hemiepiphysiodesis and osteotomy.

➢ **Reassurance and observation with expected remodeling**:

The angular deformities in long bone fractures can undergo spontaneous correction to some degree especially if the angulation is in the plane of motion (i.e., hyperextension deformity), while angulation in other directions corrects less easily. Also, the younger the child and the nearer the fracture to the end of the bone, the more is the remodeling of the fracture **(23).** But, there is no effective method for treating these deformities nonoperatively. Once the patient achieves full extension and the deformity is clinically apparent, the only method of correcting the deformity is surgical **(24).**

➢ **Hemiepiphysiodesis:**

It may be of benefit in the setting of medial growth arrest or trochlear avascular necrosis. Without treatment medial growth arrest leads to progressive worsening varus deformity secondary to lateral overgrowth. Hemiepiphysiodesis, however, is not indicated in the much more common setting of varus malreduction with a normal physis **(7).**

➢ **Supracondylar corrective osteotomy**:

When cosmetic issues and functional implications associated with significant cubitus varus underscore the importance of restoring anatomy and maintaining alignment when supracondylar fractures are initially treated and also support correction of residual deformity when it occurs **(25).**

Corrective osteotomy is best staged after the fracture has had a chance to heal and remodel and elbow motion has plateaued. The correction is deteriorated with continued growth in young patients after osteotomy so, waiting until children were closer to skeletal maturity **(26).**

Disruption of medial growth occurred in 11% of patients with cubitus varus and was a potential cause of progressive deformity so, waiting at least 1 year after injury before performing corrective osteotomy for proper assessment of this potential problem **(5).**

➢ **Lateral closing wedge osteotomy (LCWO)**

The osteotomy performed most is the lateral closing wedge osteotomy. There have been several modifications to the original procedure. The amount of wedge taken should equal the number of degrees of cubitus varus plus the number of degrees of carrying angle on the opposite uninjured side **(25).**

Advantages of LCWO is technically a safe and simple procedure. Disadvantages include the lateral scar oftentimes can become hypertrophic, inadequate secure fixation. Furthermore there is a tendency toward a prominence of the lateral condyle, which may compromise final cosmetic outcome **(25).**

- **Osteotomy with screws fixation**

French's and Modified French's osteotomy used two screws are applied parallel to the edges of the designed wedge. The lower screw is put more anterior than the upper one. After excision of the pre-determined wedge, the osteotomy is fixed by tightening the screws by stainless steel wire in a figure of "8" manner **(27).**

The fixation of the osteotomy by the two screw and figure of eight wire is unstable to maintain the correction achieved during surgery so, additional fixation by Kirschner's (K-) wires from the lateral condyle engaging the proximal medial cortex through the osteotomy site for good fixation **(27).**

- **Osteotomy with plate fixation**

Fixation of the osteotomy with a two-hole lateral plate and a percutaneous medial pin to increase stability **(28).**

- **Osteotomy with threaded pins fixation**

Uniplanar supracondylar closing wedge humeral osteotomy with preset Kirschner wires for correction of post-traumatic cubitus varus deformity **(29).**

Lateral closed wedge osteotomy with fixation with two crisscrossing Schanz screws ith equal limbs **(30)**.

- **Osteotomy with staple fixation**

The lateral closing wedge osteotomy, hinged medially, and held with a barbed staple, after green sticking the medial cortex, with predrilling the lateral supracondylar ridge, prior to placement of the staples **(31).**

➢ **Step cut lateral closing wedge osteotomy**

Step-cut osteotomy technique fixed with a single cortical screw **(Fig. 6)**. The osteotomy reported with some advantages no ulnar or radial nerve injuries, infections, nonunion, or hypertrophic scars, and all patients retained preoperative ranges of motion. They concluded that this osteotomy with single-screw fixation is a safe procedure that can correct multiple planes of deformity **(32).**

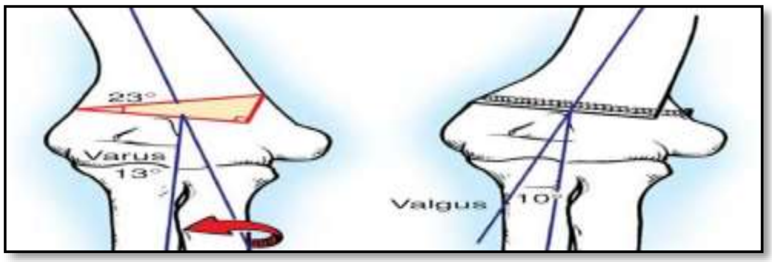

Fig. (6): The osteotomy is designed to correct a cubitus varus deformity of 13°. The distal fragment may be rotated to correct additional deformity **(33).**

If a more extensive osteotomy is needed, step-cut translation osteotomy and fixation with a Y-shaped humeral plate for firm fixation that allows early movement of the joint. They treated cubitus varus or valgus secondary to supracondylar or lateral condylar fractures in older children and young adults with good clinical results **(33).**

➢ **Supracondylar Dome shaped Osteotomy**

The dome rotational osteotomy was popularized in Japan. Advantages of the dome osteotomy are that it can reorient the distal fragment in the coronal and horizontal planes. So, considered a simple, safe and technically sound procedure with less residual prominence of the lateral condyle. Rotation in the coronal plane may be limited or difficult to achieve, secondary to medial soft tissue contracture **(34).**

The center of the osteotomy is about 3-5 mm, from the tip of olecranon. From this point, 2-3 cm, distance was measured to determine the line of osteotomy. Fixation was done by the use of two or more Kirschner wires **(35).**

➢ **Medial opening wedge osteotomy (MOWO)**

Medial opening wedge osteotomy (MOWO) has the advantages of maintaining humeral length and better cosmesis through a medially-based incision. In addition, the osteotomy does not produce a secondary translational deformity. The disadvantage stems from lengthening the medial structures, which may result in an ulnar neuropraxia. Moreover, MOWOs take longer to heal and therefore require long-term cast immobilization, which is not desirable in adolescents and adults **(36).**

- **Medial opening wedge osteotomy with external fixation.**

Under image intensifier control, insertion of four Schanz screws is performed from medial to lateral. In between, an incomplete medial osteotomy is performed obliquely, leaving a small part of the radial humeral cortex intact. The osteotomy is opened until varus and, if present, hyperextension deformation is corrected. Then, the fixator system is applied **(37).**

- **Medial opening wedge osteotomy with Ilizarov technique of distraction osteogenesis.**

Distraction was started after seven days and took place four times each day.

Advantages of treatment of deformities of the elbow by distraction osteogenesis with an Ilizarov method appears to be an efficient, safe, stable and versatile method which avoids unsightly scar formation and loss of range of movement that elbow and shoulder exercises were started on the first postoperative day. It offers some advantages such as the possibility of further correction during the distraction period and it allows the early resumption of daily activities. Disadvantages of this method are pain, heaviness of metal frame and cosmotic problem of the frame **(38).**

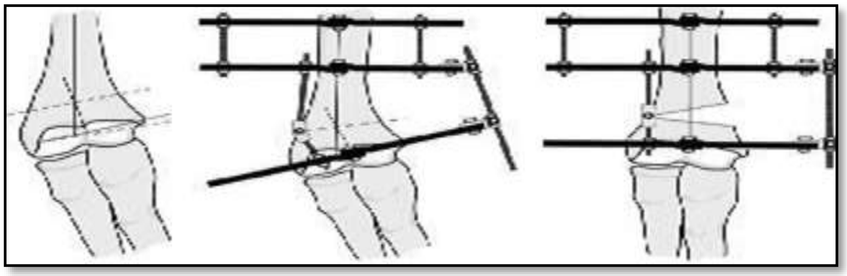

Fig. (7): Diagrams showing the Ilizarov method of fixation for cubitus varus (38).

General complications after supracondylar corrective osteotomies were inadequate angular correction , little functional improvement , infection , scar hypertrophy and ulnar & radial nerve palsy **(39).**

Summary & Conclusion

Cubitus varus deformity is composed of horizontal rotation, coronal tilt and posterior displacement. Carrying angle in cubitus varus is decreased or reversed.

Different methods of corrective osteotomy in treatment of cubitus varus e.g. lateral closing wedge osteotomy, step cut lateral closing wedge osteotomy, supracondylar dome shaped osteotomy and medial opening wedge osteotomy.

Prevention of varus deformity after supracondylar fractures of the humerus by putting the elbow in extension and the forearm in supination and immobilization in posterior plaster slab. This method is easy, simple and prevents medial and lateral angulation of the distal fragment but, varus deformity occurs in (14%) this may be attributed to loosening of the slab after subsidence of oedema.

The best method to avoid this deformity is to achieve anatomical reduction of the supracondylar fractures from the start because neither rotational nor angular deformities can be corrected by remolding**.**

Cubitus varus can be prevented by making certain that the Baumann's angle is intact at the time of reduction of the supracondylar fractures and remains so during healing, which generally the best is assured with pin fixation.

No Conflict of interest.

References

1. Hasegawa M, Suzuki T, Kuroiwa T, Oka Y, Maeda A, Takeda H, et al. Reliability and validity of radiographic measurement of the humerus-elbow-wrist angle in healthy children. JBJS Open Access. 2017;2(1).
2. quilina AL, Grazette AJ. Suppl-8, M2: Clinical Anatomy and Assessment of the Elbow. The Open Orthopaedics Journal. 2017;11:1347.

3. Tomak Y, Desteli EE. Upper limb deformities. Basic Techniques for Extremity Reconstruction: External Fixator Applications According to Ilizarov Principles. 2018:461-92.

4. Tang X, Wang J, Slongo T, Wang S, Ze R, Zhou R, et al. Comparison of internal fixation vs. external fixation after corrective osteotomy in children with cubitus varus. Journal of shoulder and elbow surgery. 2020;29(4):845-52.

5. Vashisht S, Banerjee S. Cubitus Varus. 2020.

6. Misaghi A, Schoenecker JG, Arkader A. Physeal Injuries. Green's Skeletal Trauma in Children E-Book. 2019:18.

7. Marongiu MC, Luppi V, Rovesta C. Sequels of Treatment in Children's Traumatic Lesions. The Elbow: Principles of Surgical Treatment and Rehabilitation. 2018:287-96.

8. Gauger EM, Casnovsky LL, Gauger EJ, Bohn DC, Van Heest AE. Acquired upper extremity growth arrest. Orthopedics. 2017;40(1):e95-e103.

9. Lahoti O, Akilapa O. Not Kidding! Sequalae of elbow trauma in children. Journal of clinical orthopaedics and trauma. 2021;20:101471.

10. Weinberg A-M, Amerstorfer EE, Amerstorfer F. Pediatric Orthopedic Trauma. Pediatric Surgery: General Pediatric Surgery, Tumors, Trauma and Transplantation. 2021:693-733.

11. Gracy JA. The Elbow and Forearm. Orthopedics for Physician Assistant and Nurse Practitioner Students: An Introductory Guide: Springer; 2022. p. 53-80.

12. Ho CA. Cubitus varus—it's more than just a crooked Arm! Journal of Pediatric Orthopaedics. 2017;37:S37-S41.

13. Verma V, Singh A, Kushwaha NS, Sharma Y, Singh A, Kushwaha Sr NS. Correlation between morphometric measurements and carrying angle of human elbow. Cureus. 2022;14(7).

14. Chouhan DK, Arjun R, Behera P. Examination of elbow. Handbook of Clinical Examination in Orthopedics: An Illustrated Guide. 2019:133-46.

15. Laskowski ER, Johnson SE, Shelerud RA, Lee JA, Rabatin AE, Driscoll SW, et al., editors. The telemedicine musculoskeletal examination. Mayo Clinic Proceedings; 2020: Elsevier.

16. Karbach LE, Elfar J. Elbow instability: anatomy, biomechanics, diagnostic maneuvers, and testing. The Journal of Hand Surgery. 2017;42(2):118-26.

17. Smith MV, Lamplot JD, Wright RW, Brophy RH. Comprehensive review of the elbow physical examination. JAAOS-Journal of the American Academy of Orthopaedic Surgeons. 2018;26(19):678-87.

18. Inaba N, Suzuki T, Iwamoto T, Matsumura N, Oki S, Nishiwaki M, et al. Normal value and range of the humerus–elbow–wrist angle in a sample of healthy children with even distributions of age, sex, and laterality. Journal of Pediatric Orthopaedics B. 2019;28(1):57-61.

19. Singh J, Elvey MH, Hamoodi Z, Watts AC. Current perspectives on elbow dislocation and instability. Annals of Joint. 2021;6.

20. Sato K, Mimata Y, Takahashi G, Murakami K, Ouchi S, Shiraishi H, et al. Validity of the distance between the anterior humeral line and capitellum as a quantitative measure of supracondylar humeral fracture in children. Injury. 2020;51(6):1321-5.

21. Iyer KM. Examination of the Elbow. Introduction to Limb Arthrology: Jenny Stanford Publishing; 2023. p. 141-64.

22. Vaquero-Picado A, González-Morán G, Moraleda L. Management of supracondylar fractures of the humerus in children. EFORT open reviews. 2018;3(10):526-40.

23. Binder H, Tiefenboeck TM, Payr S, Schurz M, Aldrian S, Sarahrudi K. Treatment of proximal humerus fractures in children and young adolescents. Wiener klinische Wochenschrift. 2016;128:120-4.

24. Kumar S, Jashanpreet J, Singh R. A clinical study of outcomes of supracondylar osteotomy in correcting cubitus varus deformities.

25. Bauer AS, Pham B, Lattanza LL. Surgical correction of cubitus varus. The Journal of hand surgery. 2016;41(3):447-52.

26. Raux S, Madelaine A. Sequelae of childhood elbow fracture. Orthopaedics & Traumatology: Surgery & Research. 2022:103454.

27. Srivastava AK, Srivastava D, Gaur S. Lateral closed wedge osteotomy for cubitus varus deformity. Indian journal of orthopaedics. 2008;42(4):466.

28. Hernandez III MA, Roach JW. Corrective osteotomy for cubitus varus deformity. Journal of Pediatric Orthopaedics. 1994;14(4):487-91.

29. Voss FR, Kasser JR, Trepman E, Simmons Jr E, Hall JE. Uniplanar supracondylar humeral osteotomy with preset Kirschner wires for posttraumatic cubitus varus. Journal of Pediatric Orthopaedics. 1994;14(4):471-8.

30. Oppenheim WL, Clader TJ, Smith C, Bayer M. Supracondylar humeral osteotomy for traumatic childhood cubitus varus deformity. Clinical Orthopaedics and Related Research®. 1984;188:34-9.

31. Carlson Jr SC, Rosman MA. Cubitus varus: a new and simple technique for correction. Journal of Pediatric Orthopaedics. 1982;2(2):199-201.

32. DEROSA GP, GRAZIANO GP. A new osteotomy for cubitus varus. Clinical Orthopaedics and Related Research (1976-2007). 1988;236:160-5.

33. Kim HT, Lee JS, Yoo CI. Management of cubitus varus and valgus. JBJS. 2005;87(4):771-80.

34. Tien Y-C, Chen J-C, Fu Y-C, Chih T-T, Hunag P-J, Wang G-J. Supracondylar dome osteotomy for cubitus valgus deformity associated with a lateral condylar nonunion in children. JBJS. 2005;87(7):1456-63.

35. Kanaujia RR, Ikuta Y, Muneshige H, Higaki T, Shimogaki K. Dome osteotomy for cubitus varus in children. Acta Orthopaedica Scandinavica. 1988;59(3):314-7.

36. Storm SW, Williams DP, Khoury J, Lubahn JD. Elbow deformities after fracture. Hand Clinics. 2006;22(1):121-9.

37. Koch PP, Exner GU. Supracondylar medial open wedge osteotomy with external fixation for cubitus varus deformity. Journal of Pediatric Orthopaedics B. 2003;12(2):116-22.

38. Piskin A, Tomak Y, Sen C, Tomak L. The management of cubitus varus and valgus using the Ilizarov method. The Journal of Bone & Joint Surgery British Volume. 2007;89(12):1615-9.

39. Vallila N, Sommarhem A, Paavola M, Nietosvaara Y. Pediatric distal humeral fractures and complications of treatment in Finland: a review of compensation claims from 1990 through 2010. JBJS. 2015;97(6):494-9.