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ORIGINAL ARTICLE

RETROSPECTIVE AND PROSPECTIVE STUDY OF PERCUTANEOUS FIXATION OF TYPE III SUPRACONDYLAR FRACTURES OF THE HUMERUS IN CHILDREN.

***[1]Dr.D. Karthikeyan and Prof. [2]Dr. B.Kanthimathi**

[1]Post Graduate, Department of Orthopaedics, Rajah Muthiah Medical College & Hospital, Annamalai University, Annamalainagar – 608 002, Tamil Nadu, India

[2]Professor, Department of Orthopaedics, Rajah Muthiah Medical College & Hospital, Annamalai University, Annamalainagar – 608 002, Tamil Nadu, India

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ABSTRACT

Humeral supracondylar fractures are the second most common fractures seen in children and young teenagers (16.6%). They represent 60-70% of all the elbow fractures. The maximum incidence is found between the fourth and ninth year of age, slightly more often in boys and on non-dominant hand. We performed a study from June 2012 to January,2014, children attending Rajah Muthiah Medical College & Hospital, India with Gartland Type III supracondylar fractures of the humerus. The included patients had closed supracondylar humerus fracture - type III.The mean age was 9.67 years (range 6 to 12years). Of 18 patients 16 belonged to the extension type (88.9%); only two (11.1%) patients had flexion type. There were no patients with any neurovascular injuries. All the patients were treated with crossed K-wire fixation under general anaesthesia. The mean day of surgery was 3.39 days. Closed reduction was performed in 11 patients and open reduction in 7 patients. Average postoperative follow up was 6.8 months. Bauman's angle, carrying angle and functional factor were measured postoperatively to analyse outcome.One patients had cubitus varus deformity and 3 patients had temporary limitation in extension; this makes 27.7% complication rate in our series. All the fractures healed in the expected period of 3–4 weeks. Results were scored using Flynn's Criteria and Mayo Elbow Performance Score. In our study we had excellent results in 83.3% of our patients. We suggest closed reduction and percutaneous crossed pinning for displaced supracondylar fracture of humerus. We also suggest treating these fractures as early as possible and conversion of closed into open reduction in case of lacking crepitation.

Keywords: Supracondylar, Humerus, Fracture, Percutaneous pinning, K-wire, Children, Flynn's criteria.

1.INTRODUCTION

Supracondylar fractures occur most often in immature skeletons and are usually seen in the first decade of life. It is the most common fractures about the elbow in children accounting for about 60% of the total[1].

The left or nondominant side is most frequently injured in almost all studies[2]. Supracondylar fractures of the distal end of the humerus may be produced by either a hyperextension or a flexion injury. An injury that results from a fall on the outstretched hand with the elbow hyperextended causes the more common extension type of fracture. If the injury occurs from a fall on the olecranon with the elbow flexed, the less common flexion type of supracondylar fracture results.

**Corresponding* author *Dr.D. Karthikeyan, Department of Orthopaedics*, Rajah Muthiah Medical College & Hospital, Annamalai University, Annamalainagar – 608 002, Tamilnadu, India

Supracondylar humeral fractures are usually initially classified as either extension or flexion injuries followed by classification according to the amount of radiographic displacement. This three-part classification system was first described by Gartland in 1959. Type I fractures are non-displaced or minimally displaced. Type II fractures have angulation of the distal fragment, posteriorly in extension injuries and anteriorly in flexion injuries, with one cortex remaining intact. Type III injuries are completely displaced, with both cortices fractured. Wilkins subdivided type III injuries according to the coronal plane displacement of the distal fragment eitherposteromedial or posterolateral. In type III (extension-type) supracondylar humeral fracture, the proximal fragment when displaced anteromedially, places the brachial artery and median nerve at risk and when displaced anterolaterally places the radial nerve at risk.

Treatment remained a subject of controversy, but numerous studies have led to a more acceptable protocol. Gartland type I and minimally displaced type II fractures are treated

conservatively with closed reduction followed by plaster immobilisation, while significantly displaced closed type II and all type III fractures are to be treated by closed or open reduction with percutaneous K-wire fixation. Open fractures and associations with neurovascular injuries require emergency surgical management addressing the fore mentioned complications.

If untreated or treated by native means it can lead to malunion, commonly leading to cubitus varus deformity, compartment syndrome, and in late stages Volkmann's ischemic contractures. Neurovascular injuries may lead to disability and in serious case loss of the injured limb.

AIM

The aim of this study is to compare the functional and radiological outcome after crossed K-wire fixation of type III supracondylar humerus fractures and also initial management, appropriate time for surgery and length of hospital stay.

2.MATERIALS AND METHODS

We performed a retrospective and prospective study from June 2012 to July 2014, children attending Rajah Muthiah Medical College & Hospital, India with Type III supracondylar fractures of the humerus. The study included 18 patients. These children had closed supracondylar humerus fracture of type III (Gartland classification). The most common causes of injury include simple fall, fall from bicycle or height. The mean age of patients was 9.67 years (range 6 to 12-year). Out of 18 patients, 13 were boys (72.2%) and 5 were girls(27.8%). All the fractures were closed and 16 belonged to the extension type (88.9%); only two patients had flexion type(11.1%). Twelve patients (66.7%) had injury occurring to their left elbow, and 6 patients (33.3%) had injury to right elbow. None of the patients presented with an associated injury of the same arm. There were no patients with associated neurovascular damage. Initial management was with only one attempt of closed reduction for patients who presented within the first 12 hours of injury.Splinting slightly less than 90^{o} of flexion without any manipulation was done for patients who presented after 12 hours. Following reduction and splinting, towel sling limb elevation was given and hourly monitoring of radial pulse and stretch pain was done. None of the patients developed a pulseless hand or signs of compartment syndrome. Four patients had blisters, of which 3 patients (16.66%) were ones who visited the hospital after 12 hours and 1 patient developed blisters on second day after splinting. Two of those four patients had one episode of native treatment.All the four patients who developed blister were on an above elbow slab with flexion less than 90^{o}(Graph 1). Children who had blisters were given I.V. antibiotics.

Definitive treatment for all the patients was crossed K-wire fixation under general anaesthesia. The mean day of surgery was 3.39 days ranging from 1^{st} to 9^{th} day. During surgery the patient was placed supine with the injured upper arm at the side of the table. Image intensifier was placed along the table at the caudal end. The injured elbow was placed on the plate of the image intensifier. Since the paediatric elbow is relatively small, the plate of image intensifier usually sufficed to function as an arm support. Closed reduction was performed in 11 patients (61.1%), by longitudinal traction and counter traction with elbow in extension and supination.Medial or lateral displacement were corrected by valgus or varus force respectively. Posterior displacement and angulation was corrected by flexing the elbow and simultaneously applying posteriorly directed force from anterior aspect of proximal fragment and anteriorly directed force from posterior aspect of distal fragment. The adequacy of reduction was confirmed under image intensifier in two views – Jone's View and lateral view. Reduction was maintained by holding the elbow in a flexed position. And subsequently percutaneous pinning done with 1.8 or 2.0 mm K-wire depending on the size of the arm and age of the patient. When closed reduction failed, open reduction was done. In this series open reduction was done in 7 patients (38.9%). With patient in lateral position, through a posterior approach, ulnar nerve was isolated and a triceps splitting approach was done. Fracture exposed and reduced under direct visualisation. Pinning done with crossed K-wires in 17 patients (94.4%) and two lateral and one medial crossed pin configuration in 1 patient (5.6%). Reduction was checked under image intensifier. Post operatively 3 weeks of immobilisation with an above elbow slab was given for patients who had under gone closed reduction and 5 weeks of immobilisation for open reduction. Active finger and shoulder mobilization was encouraged 6 hours into post-operative period. Pin site and wound inspection from third day. Post-operative antero-posterior and lateral plain radiographs were taken and suture removal on 13^{th} day.

Follow up AP and lateral x-ray was done on third week and callus formation assessed. K-wires were removed and gentle mobilisation of the elbow was started at 3-4 weeks. For patients who had under gone open reduction, immobilisation was continued until the 5^{th} week. Average postoperative follow up was 6.8 months.Assessment of Baumann's angle (Figure. 1), carrying angle (Figure. 2) and range of motion were done at each visit. The reduction and functional outcome were evaluated using the Flynn criteria (Table.1)and Mayo Elbow Performance Score respectively (Table.2). All data was compiled and analyzed with IBM SPSS version 20.

3.RESULTS

None of the patients had a deep tissue infection. One patient had superficial infection, which was resolved with I.V. antibiotics. One patient (open reduction) had cubitus varus deformity, none of the patients had elbow contracture, 3 patients (closed reduction) had temporary limitation in extension, and none of the patient had iatrogenic ulnar nervelesion, this makes 27.7% complication rate in our series. All the fractures healed in the expected period (3–4 weeks).

Postoperative average of Bauman's angle was $17.61^{o} \pm 4.50^{o}$ SD for the injured elbow.

We also measured the carrying angle of both elbows (the injured and the healthy one) on the last clinical examination. Sixteen patients (88.9%) had loss of carrying angle between 0° and 5°, one patient (5.6%) had loss between 6° and 10°, one patient (5.6%) had loss between 11° and 15°, none of them had loss above 15°.

Table 1. Flynn's Criteria

Results	Cosmetic factor – loss of carrying angle (degrees)	Functional factor – loss of motion (degrees)
Excellent	0-5	0-5
Good	6-10	6-10
Fair	11-15	11-15
Poor	>15	>15

Table 2. Mayo Elbow Performance Score

Function	Definition (Points)	
Pain	None (45)	/45
	Mild (30)	/30
	Moderate (15)	/15
	Severe (0)	/0
Motion	Arc >100 degrees (20)	/20
	Arc 50–100 degrees (15)	/15
	Arc <50 degrees (5)	/5
Stability	Stable (10)	/10
	Moderate instability (5)	/5
	Gross instability (0)	/0
Function	Comb Hair (5)	/5
	Feed (5)	/5
	Perform hygiene (5)	/5
	Perform hygiene (5)	/5
	Don Shoe (5)	/5
Total		/100
Classification: Excellent >90 Good 75–89 Fair 60–74 Poor<60.		

Table 3. Cross tabulation of Day of Surgery with Conversion to open reduction

Day of Surgery	CONVERSIONCRTO OR		Total
	NO	YES	
	1 16.7%		16.7%
	2 16.7%		16.7%
	3 16.7%	11.1%	27.8%
	4 16.7%	5.6%	22.2%
	5	5.6%	5.6%
	7	5.6%	5.6%
	9 5.6%		5.6%
Total	72.2%	27.8%	100.0%

We also measured the range of motion (flexion and extension) in the elbow; 15 patients (83.3%) had less than 5° loss, 3 patients (16.8%) had loss of flexion/extension above 16°

Mayo's elbow performance score was also assessed,in which 15 patients (83.3%) had excellent score, 2 patients (11.1%) had good score and 1 patient (5.6%) had fair score.

Table 4. Flynn's Criteria Result

Table 2. Flynn's Criteria Result

	Frequency	Percent	Valid Percent	Cumulative Percent
EXCEL	8	44.4	44.4	44.4
GOOD	7	38.9	38.9	83.3
POOR	3	16.7	16.7	100.0
Total	18	100.0	100.0	

Table 3. Mayo Elbow Performance Score Results

		Frequency	Percent	Valid Percent	Cumulative Percent
	EXCEL	15	83.3	83.3	83.3
	GOOD	2	11.1	11.1	94.4
	FAIR	1	5.6	5.6	100.0
	Total	18	100.0	100.0	

Graph 1.Cross Tabulation Initial Management And Blisters

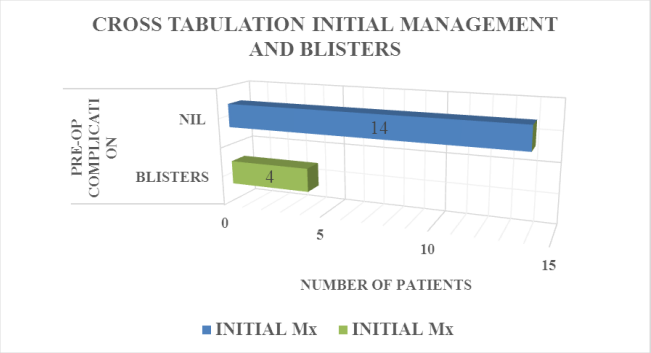


Figure1. Baumann's Angle

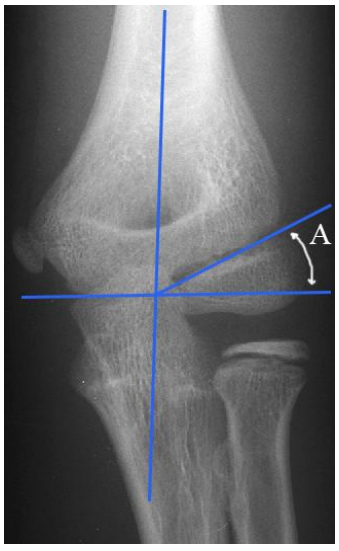
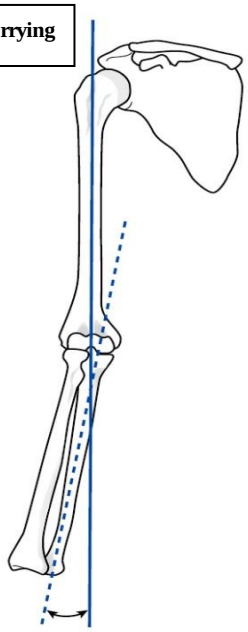
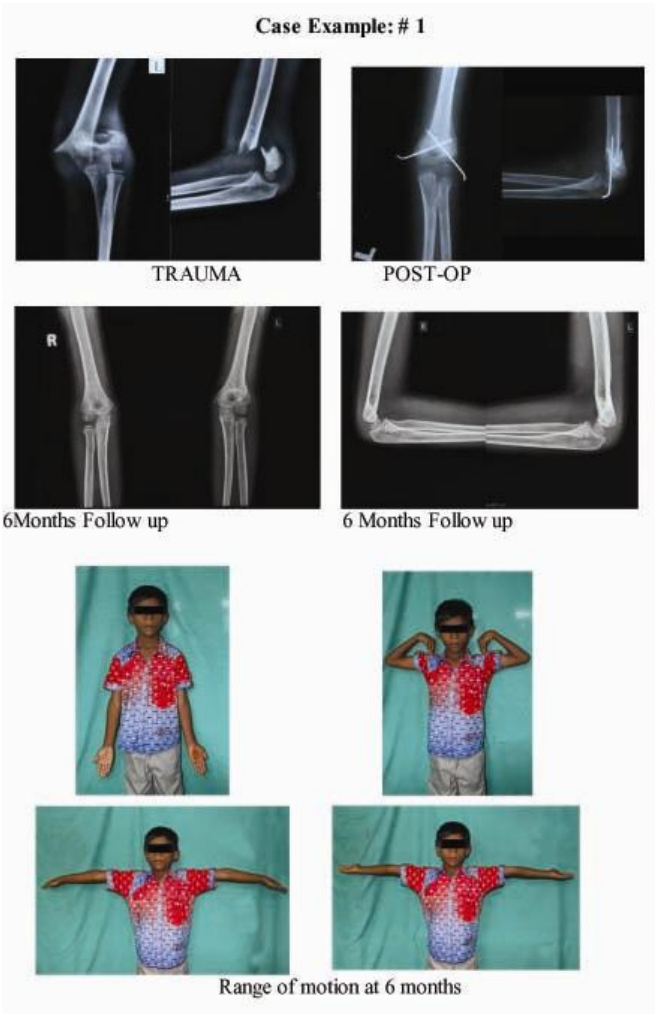
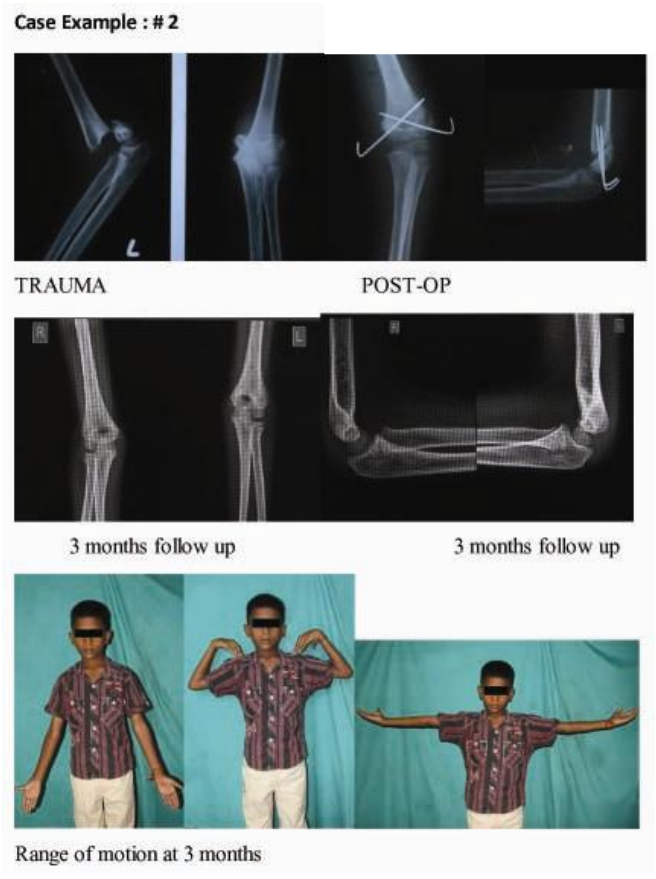


Figure 2. Carrying Angle







4.DISCUSSION

Supracondylar humerus fractures are a frequent injury in childhood with an age peak between 4 and 9 years[3,4,5,6]. The distal end of the humerus is unique in design, it has strong medial and lateral columns which are connected by a thin wafer of bone[7]. This distinct anatomy is the reason a supracondylar fracture to be so unstable. Dameroncompared this circumstance to attempting to balance the blades of two knives on each other. Because this feat is impossible, the two fragments invariably rotate and then tilt to produce an angular deformity. Hence, becomes one of the most difficult fractures to treat. Mercer Rang quoted, the goal of treatment of supracondylar humeral fractures is to "avoid catastrophes" (vascular compromise, compartment syndrome) and "minimize embarrassments" (cubitus varus, iatrogenic nerve palsies)[8].Type I Fracture (Nondisplaced), the periosteum is intact with significant inherent stability of the fracture. Simple immobilization with a posterior splint applied at 60 to 90 degrees of elbow flexion with for 3-4 weeks is preferred by some[9] The correct management of type II supracondylar fractures remain elusive because of the lack of appropriate studies. Luis Moraleda et al. conducted a retrospective study in 46 patients treated conservatively for type II fractures, of which 36.9% had unsatisfactory results. Suggesting the need for closed reduction and percutaneous pinning[10]. Closed reduction with immobilization, either by casting or Blount's technique, is indicated in type-II fractures but is usually considered to be unreliable for type III displaced fractures[11]. Parikh and associates provided an analysis of 25 angulated type II supracondylar humerus fractures that were treated with initial reduction and casting in the emergency department and concluded that reduction and casting may be a viable treatment option for type II fractures, while avoiding a hyperflexion cast and inherent risks. Since 28% of their patients lost reduction and required late reduction and pinning,this treatment was not recommended[12].

For a satisfactory result a displaced supracondylar fracture should be reduced accurately and stabilised[13,14.] Of the common methods of treatment, a cast with the elbow in acute flexion is the most dangerous because of the risk of ischemia and its irrevocable sequelae. If the elbow is not flexed sufficiently, however, the fracture is likely to redisplace. Traction is still one of the electoral methods for the treatment, but the length of treatment and high incidence of cubitus varus are certainly pushing this method behind. In our experience we observed the development of blisters around elbow in 2 patients (11.6%) on the second to third day .The blisters were probably due to a higher degree of flexion (above 90^{o}) in order to maintain the reduction.

An alternative to standard technique has been the more recent use of ESIN (elastic stable intramedullary nailing) for

fracture stabilization[15]. Further studies of the ESIN method need to be completed before sound recommendations can be given[16]. Closed reduction followed by percutaneous pinning is considered to be the golden standard for type 2 and 3 fractures[17].

Of the various techniques discussed in the literature, the closed reduction and crossed percutaneous pin technique, where one pin is placed laterally and the other medially, and the two lateral percutaneous pin techniqueare discussed with inordinate controversies. Crossed percutaneous pin technique places the ulnar nerve at high risk of being damage which is often described in the literature as up to 20%[18]. Injury to the ulnar nerve results from penetration, contusion or kinking of the nerve by a misdirected medial pin. Iatrogenic constriction of the cubital tunnel by an apparently incorrectly placed medial pin, and damage to a hypermobile ulnar nerve that can subluxate anteriorly when the elbow is held in a hyperflexed position, are other mechanisms that have been recently reported[19,20] Measures taken to avoid iatrogenic ulnar nerve damage while inserting a medial pin include relative extension of the elbow with a maximum of 60^{o} flexion, after inserting the lateral pin. This should reduce possible ulnar nerve subluxation before inserting the medial pin. In very unstable fractures, a second lateral pin may be needed to provide more stability before partially extending the elbow for safe medial pin placement. If the ulnar nerve and groove cannot be identified with confidence, we suggest a small incision over the pin insertion site and blunt dissection down to the bone, and place the pin under direct vision. In our study no ulnar nerve injury was encountered in any patients.

Given the high risk of ulnar nerve damage described in the past, several authors investigated lateral K-wire fixation[21,22,23]. Skaggs et al. recorded displacement in 7% of cases for fixation with two lateral pins compared to only 1% for crossed technique[5]. Weinberg et al. concluded that crossed K-wires showed the highest stability and lowest loss of reduction under cyclic loading[i]. In another study Zionts et al. compared crossed K-wire technique with lateral K-wire fixation alone. Greater stability was achieved with the crossed technique[24]. Given these biomechanical findings and the results of our own study we emphasise on using crossed K-wires.

Often, intraoperative closed reduction attempts do not yield satisfactory alignment of the fracture[25]. Inadequate reduction in the coronal plane can produce deformities such as cubitus varus, sagittal plane malrotation leading to valgus deformity, angulation or translation, which can cause functional losses[26,27].Traditionally Open reduction has been reserved for cases with primary vascular or neural disruption, open fractures, signs of Volkmann's ischemia, failure of closed reduction and severe swelling not allowing acceptable reduction[28-31].This means that a certain portion of the displaced fractures cannot be reduced with the closed method, with the conversion rate to open reduction being between 3 and 46%[32]. In our study we had a conversion rate of 27.8%. The day of trauma to the day of surgery had influence on the conversion from closed reduction to open reduction. We observed a tendency for open reduction if surgery is delayed beyond 3 days (Table 3). Also in 2 other patients were closed reduction was difficult due to communition and a highly unstable fracture.

Our studyhadbetter results in crossed pin technique like other previous studies. The range of motion in terms of extension and flexion seen in our series with satisfactory outcomes at final follow up was 83.3% (Table 4). The value in our series lie in between 82.6% to 100% for bilaterally equal range of motion. The most discussed axial deviation is valgus deformity. The reported incidence of this deformity varies widely, from 0% to 60%[33]. In our series we had 11.2% of patients with cubitus varus of $6^{o}$to $15^{o}$and no valgus deformity after eight months of follow up. According to Mayo Elbow PerformanceScore we had 83.3% (Table. 5) satisfactory results.We suggest having an absolute intra operative anatomical reduction can foresee and prevent these deformities.

With regard to the constant demand for cost reduction in the health sector in developing nations like India, the duration of hospital stay plays a major in higher cost of treatment. In our study we observed an average of 10.09 days for closed pinning and 18.25 days for open reduction and pinning. We have inferred that earlier the surgery,chances for open reduction can be avoided and duration of hospital stay can be minimised.

5.CONCLUSION

Closed reduction and percutaneous crossed pinning under fluoroscopic guidance for displaced supracondylar fracture of humerus is a stable, least time consuming, and cost effective method with relatively lower rate of complications. We also suggest treating these fractures as early as possible and conversion of closed into open reduction in case of lacking crepitation (possibility of interposition of soft tissues between fracture fragments).

6.REFERENCES

1. Green & Swiontkowski: Skeletal Trauma in Children, 4th Ed.
2. Beaty, James H.; Kasser, James R. Title: Rockwood and Wilkins Fractures in Children, 7th Edition
3. Mangwani, J., Nadarajah, R., Paterson, J. M.: Supracondylar humeral fractures in children: ten

years' experience in a teaching hospital. J. Bone Jt Surg., 88-B: 362–365, 2006

4. Ramachandran,M., Birch, R., Eastwood, D. M.: Clinical outcome of nerve injuries associated with supracondylar fractures of the humerus in children: the experience of a specialist referral centre. J. Bone Jt Surg., 88-B: 90–94, 2006.
5. Skaggs, D. L., Cluck, M.W., Mostofi, A., et al.: Lateral entry pin fixation in the management of supracondylar fractures in children. J. Bone Jt Surg., 86-A: 702–707, 2004.
6. Weinberg, A. M., Marzi, I., Gunter, S. M., et al.: (Supracondylar humerus fracture in childhood—an efficacy study. Results of a multicenter study by the Pediatric Traumatology Section of the German Society of Trauma Surgery—I: Epidemiology, effectiveness evaluation and classification). Unfallchirurg, 105:208–216, 2002
7. Holda M.E., Manoli 2nd A.: LaMont, R.I. Epiphyseal separation of the distal end of the humerus with medial displacement. *J Bone Joint Surg [Am]* 1980; 62(1):52-57.
8. Yusof A, Razak M, Lim A (1998) Displaced supracondylar fracture of humerus in children–comparative study of the result of closed and open reduction. Med J Malaysia 53 (Suppl A):52–58
9. Charnley J. Closed Treatment of Common Fractures. Edinburgh: Churchill Livingstone, 1961:105-115.
10. Luis Moraleda, MD, Marı´a Valencia, MD, Ra ´ ul Barco, MD, PhD, and Gaspar Gonz´alez-Moran, MD. Natural History of Unreduced Gartland Type-IISupracondylar Fractures of the Humerus in Children. Bone Joint Surg Am. 2013;95:28-34
11. Kasser JR, Beaty JH. Supracondylar fractures of the distal humerus. In: Beaty JH, Kasser JR, Wilkins KE, Rockwood CE, editors. Rockwood and Wilkins'fractures in children. 6th ed. Philadelphia: Lippincott Williams and Wilkins; 2006. 543-89.
12. Parikh SN, Wall EJ, Foad S, Wiersema B, Nolte B. Displaced type II extensionsupracondylar humerus fractures: do they all need pinning? J Pediatr Orthop. 2004Jul-Aug;24(4):380-4.
13. Attenborough C. G. (1953): Remodelling of the humerus after supracondylar fractures in childhood. Journal Of Bone and Joint Surgery, 35-B, 386-395.
14. Gruber and Hudson O, C, (1964): Supracondylar frnclules of the humerus in childhood. Journal Of Bone and Joint Surgery, 46-A, 1245-1252.
15. Schaffer, K., Bohm, R., Dietz, H. G.: (Elastic stable intramedullary nailing (ESIN) of supracondylar fractures of the humerus in children). Unfallchirurg, 110: 852–858, 2007.
16. K. Reising, H. Schmal, M. Kohr, K. Kuminack, N. P. Südkamp, P. C. Strohm Surgical Treatment of Supracondylar Humerus Fractures in Children ACTA Chirurgiae OrthopaedicaeEt Traumatologiae Čechosl, 78, 2011, p. 519–523
17. Jiang X, Tang X, Wang D, Peng M, Cheng X, Liu L. [Operative treatment of Gartland type III humeral supracondylar fractures in children with minimally invasive incision and percutaneous pinning]. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2010 Jun; 24(6): 677-9. In Chinese
18. Lyons, J. P., Ashley, E., Hoffer, M. M.: Ulnar nerve palsies after percutaneous cross-pinning of supracondylar fractures in children's elbows. J. Pediatr. Orthop., 18: 43–45, 1998
19. Gordon JE, Patton CM, Luhmann SJ, et al. Fracture stability after pinning of displaced supracondylar distal humerus fractures in children. J Pediatr Orthop 2001;21:313–8.
20. Ozc¸elik A, Tekcan A, Omerog˘lu H. Correlation between iatrogenic ulnar nerve injury and angular insertion of the medial pin in supracondylar humerus fractures. J Pediatr Orthop B 2006;15:58–61.
21. Davis, R. T., Gorczyca, J. T., Pugh, K.: Supracondylar humerus fractures in children. Comparison of operative treatment methods. Clin. Orthop. Relat. Res., 376: 49–55, 2000.
22. Gordon, J. E., Patton, C. M., Luhmann, S. J., et al.: Fracture stability after pinning of displaced supracondylar distal humerus fractures in children. J. Pediatr. Orthop., 21: 313–318, 2001.
23. Kallio, P. E., Foster, B. K., Paterson, D. C.: Difficult supracondylar elbow fractures in children: analysis of percutaneous pinning technique. J. Pediatr. Orthop., 1992, 12: 11–15, 1992
24. Weinberg, A. M., Castellani, C., Arzdorf, M., et al.:Osteosynthesis of supracondylar humerus fractures in children: a biomechanical comparison of four techniques. Clin. Biomech. (Bristol, Avon), 22: 502–509, 2007.
25. Aktekin CN, Toprak A, Ozturk AM, Altay M, Ozkurt B, TabakAY (2008) Open reduction via posterior triceps sparing approach in comparison with closed treatment of posteromedial displaced Gartland type III supracondylar humerus fractures. J Pediatr Orthop B 17(4):171–178
26. Sadiq MZ, Syed T, Travlos J (2007) Management of grade III supracondylar fracture of the humerus by straight–arm lateral traction. Int Orthop 31:155–158
27. Turhan E, Aksoy C, Ege A, Bayar A, Keser S, Alpaslan M (2008) Sagittal plane analysis of the open and closed methods in children with displaced supracondylar fractures of the humerus (a radiological study). Arch Orthop Trauma Surg 128

28. Ozkoc G, Gonc U, Kayaalp A, Teker K, Peker TT (2004) Displaced supracondylar humeral fractures in children: open reduction vs. closed reduction and pinning. Arch Orthop Trauma Surg 124(8):547–551
29. Mulhall KJ, Abuzakuk T, Curtin W, O'Sullivan M (2000) Displaced supracondylar fractures of the humerus in children. IntOrthop 24(4):221–223
30. Ababneh M, Shannak A, Agabi S, Hadidi S (1998) The treatment of displaced supracondylar fractures of the humerus in children. A comparison of three methods. Int Orthop 22(4):263–265
31. Oh CW, Park BC, Kim PT, Park IH, Kyung HS, Ihn JC (2003) Completely displaced supracondylar humerus fractures in children: results of open reduction versus closed reduction. J Orthop Sci 8(2):137–141
32. Alonso LM (1972) Bilaterotricipital approach to the elbow. Its application in the osteosynthesis of supracondylar fracture of the humerus in children. ActaOrthop Scand 43:479–490
33. Sadiq MZ, Syed T, Travlos J (2007) Management of grade III supracondylar fracture of the humerus by straight–arm lateral traction. Int Orthop 31:155–158

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