—Case Reports—

Clinical Results of Closed Reduction and Percutaneous Pinning for Gartland Type II Flexion-Type Supracondylar Humeral Fractures in Children: Report of Three Cases

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Supracondylar humerus fractures are the most common upper limb injury in children, but the incidence of flexion-type fractures is relatively low. Herein, we report the clinical results for three children with Gartland type II flexion-type supracondylar humeral fractures treated by closed reduction and percutaneous pinning. From April 2004 to March 2020, 102 children with supracondylar humeral fractures underwent surgery at our hospital and related institutions. Four had a flexion-type supracondylar humeral fracture (3.9%). Three patients (1 boy and 2 girls) with Gartland type II flexion-type supracondylar humeral fractures were followed for more than 12 months. The patients were treated by closed reduction and percutaneous pinning. Age was 7-13 years at the time of injury, and the duration of postoperative follow-up was 12-16 months. In one case, ulnar nerve paresis was observed as a preoperative complication. After performing closed reduction, percutaneous Kirschner wire cross-fixation was performed. Subsequently, long upper limb cast fixation was carried out for 4 weeks postoperatively. One patient developed preoperative nerve paralysis but recovered in approximately 3 months, without postoperative complications such as infection, nerve paralysis, or cubitus varus or valgus deformity. Flynn's criteria results were excellent for two patients and good for one patient. To maintain anatomical reduction of the fracture fragment, closed reduction using a traction table and percutaneous steel wire fixation are useful for treating flexion-type supracondylar humerus fractures in children with Gartland type II fractures. (J Nippon Med Sch 2023; 90: 294–300)

Key words: supracondylar humeral fractures, flexion-type fractures, closed reduction, percutaneous pinning, Gartland type II

Introduction

Supracondylar fracture of the humerus is the most common upper limb injury in children. However, the incidence of flexion-type fractures is relatively low (1%-10%)[1–7]. Flexion-type fractures are mainly caused by shearing force generated when the posterior surface of the distal humerus is directly impacted, with high energy, in the elbow joint flexion position[1,7]. Because of its rarity, optimal treatment of this fracture is unclear. We describe three pediatric cases of Gartland type II flexion-type supracondylar humeral fracture treated with closed reduction and percutaneous pinning (CRPP) using a traction table.

Patients

This study was performed in accordance with the principles of the Helsinki Declaration of 1983. Written informed consent for treatment and publication of data was obtained from all patients and their parents.

From April 2004 to March 2020, 102 children younger than age 15 years with supracondylar humeral fractures underwent surgery at our hospital and related institutions. Among them, four had flexion-type supracondylar humeral fractures (3.9%). One case was excluded because duration of follow-up was only 3 months. Three patients (1 boy and 2 girls) with flexion-type supracondylar hu-

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Table 1 Pre- and postoperative demographic data, complications, radiographic evaluations, range of motion in the injured elbow, and Flynn's criteria for three patients

Case	Age/ Sex	Side	Cause of trauma	Duration b/w trauma and surgery (day)	Follow-up period (months)	Complications	Post-BA (°)	Contra-BA (°)	Post-CA (°)	Contra-CA (°)	Flynn's criteria	Ext (°)	Flex (°)
1	7/F	Rt	Fall	1	12	-	66	65	14	14	E	0	140
2	8/F	Rt	Fall from a unicycle	0	12	-	79	69	22	27	E	10	145
3	13/M	Rt	Sports-related injury (Judo)	0	16	ulnar nerve disturbance	64	68	24	17	G	0	140

BA, Bauman's angle; b/w, between; CA, Carrying angle; Contra, contralateral; Ext, extension; Flex, flexion; Post, postoperative; Rt, right

Flynn's criteria: E, Excellent; G, Good

meral fractures were followed for longer than 12 months. The patients were treated by CRPP. The age of these three children ranged from 7 to 13 years at the time of injury, and the postoperative follow-up period was 12-16 months. On the basis of Gartland's classification[8], all patients had type II fractures. In addition, the interval from injury to surgery ranged from 0 to 1 day. In all patients, the injury occurred on the right side. The reason for the injury was fall from a height, in two patients, and sports-related trauma (from Judo practice), in one patient. One patient had preoperative ulnar nerve disturbance, ie, sensory disturbance of the ring and little fingers.

Surgical Procedure

Surgery was performed with the patient in prone or lateral position under general anesthesia. The procedure for CRPP has been reported[9,10]. Briefly, closed reduction performed using a reduction bar was followed by percutaneous pinning with Kirschner wires. A surgeon applied traction on the limb with elbow flexion on a traction bar, while an assistant applied counter-traction on the distal humerus. After the surgeon confirmed the fracture was appropriately reduced, two or three crossed Kirschner wires were inserted from the distal humeral end to the proximal humeral end under visualization using an X-ray image intensifier. Under the image intensifier, the displaced fragment of the injured humerus was reduced and fixed with two or three crossed Kirschner wires that were adjusted to almost the same angle as Baumann's angle of the contralateral humerus, which was measured preoperatively on radiography. After CRPP, Baumann's angle (BA)[11] was remeasured on perioperative radiography, and the wires were bent back and left unburied on the skin when anatomical fracture reduction was confirmed.

Postoperatively, immobilization was performed using a long arm fiberglass cast with the elbow flexed at 90° in all patients. After confirmation of bone union of the fractures, the percutaneous Kirschner wires were removed at an outpatient clinic. The long arm cast was removed at the same time, and patients were encouraged to perform active range-of-motion exercises at home.

Radiographic findings, range of motion of the elbow joint, and postoperative complications (iatrogenic nerve injuries, infection, and cubitus valgus or varus deformity) were investigated. Cubitus varus deformity was evaluated by measuring internal rotation angle of the shoulder with the elbow at 90° flexion on the back and the shoulder held at the maximum extension by Yamamoto's method[12].

On the basis of findings from anteroposterior radiographs, the BA and carrying angle (CA) were calculated to evaluate deformity of the humerus[11]. Postoperative cosmetic and functional outcomes were assessed with Flynn's criteria[13], which involve evaluating the range motion of the elbow joint and CA. The cubitus varus deformity was classified as "poor," regardless of CA.

Results

Preoperative demographic data, complications, radiographic findings, range of motion in the injured elbow joint, and Flynn's criteria at the final evaluation are shown in **Table 1**. All patients achieved bone union within 4 weeks, without postoperative complications such as infection, nerve paralysis, or cubitus varus or valgus deformity. Although one patient had preoperative ulnar nerve paresthesia of the ulnar fingers, the sensory

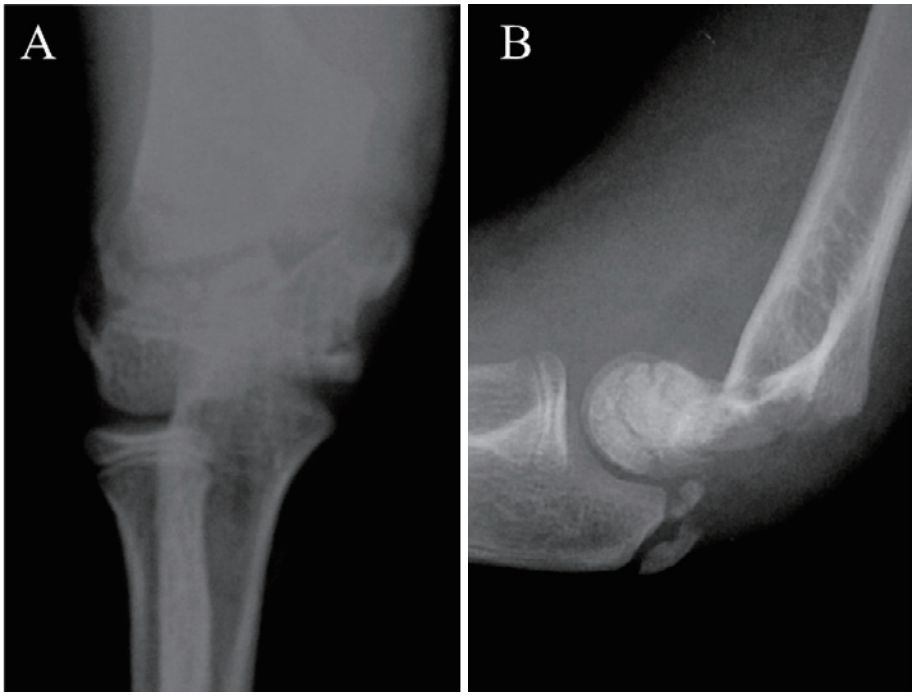

Fig. 1 Radiographs at the time of injury showing Gartland type II flexion-type supracondylar fracture of the right humerus in a 13-year-old male patient (case 3). (A) Anteroposterior view and (B) lateral view of the right humerus.

disturbance resolved within 3 months after surgery. There was no restriction of more than 6° in range of motion, as compared with that of the contralateral side. According to Yamamoto's method of measuring internal rotation deformity[12], internal rotation angles for the shoulder were the same on the injured and contralateral sides. Radiographic evaluation revealed that the BA and CA were similar to those of the contralateral side. Thus, according to Flynn's criteria, clinical outcomes were excellent in two patients and good in one patient.

Representative Case

Case 3

A 13-year-old boy was injured during Judo practice. At his initial visit to our clinic, he reported numbness of the ring and little fingers. No motor nerve disturbance was observed. Radiographs and 3D-CT revealed Gartland type II flexion-type fracture of the distal humerus (**Fig. 1, 2**). On the day of the injury, CRPP was performed using a traction table with the patient in lateral position under general anesthesia (**Fig. 3**). After immobilization for 4 weeks, the Kirschner wires were removed, and the patient was encouraged to perform range-of-motion exercises. Paresthesia of the ring and little fingers had resolved at 3 months after surgery. At 16 months after surgery, extension and flexion angles of the elbow joint were 0° and 140°, respectively. Radiographs showed a BA of 64° and a CA of 24°. According to Flynn's criteria, the clinical outcome was good (**Fig. 4**).

Discussion

Cast fixation in the elbow flexion position is used to treat Gartland type II fractures with minimal displacement[14,15]. However, unstable Gartland type II fractures should be treated surgically[7,16]. Skaggs and Flynn reported that flexion-type fractures had comminution of the volar cortex of the distal humerus, which made it difficult to obtain anatomical reduction in the hyperflexion position, whereas this was not true for extension-type fractures[15]. Moreover, they reported that flexion-type supracondylar fractures tend to preserve the dorsal cortex of the humerus without comminution, which makes it stable during elbow extension[15]. On the basis of the characteristics of flexion-type fractures, Wilkins[1] and Williamson[3] suggested nonsurgical treatment using a cast in the elbow extension position for flexion-type supracondylar humerus fractures in children. However, immobilization with a long arm cast in the elbow extension position inevitably results in the loosening of the cast in children[7]. Therefore, surgical intervention is necessary for almost all flexion-type supracondylar humeral fractures in children[7,17].

Percutaneous pinning is an alternative treatment for

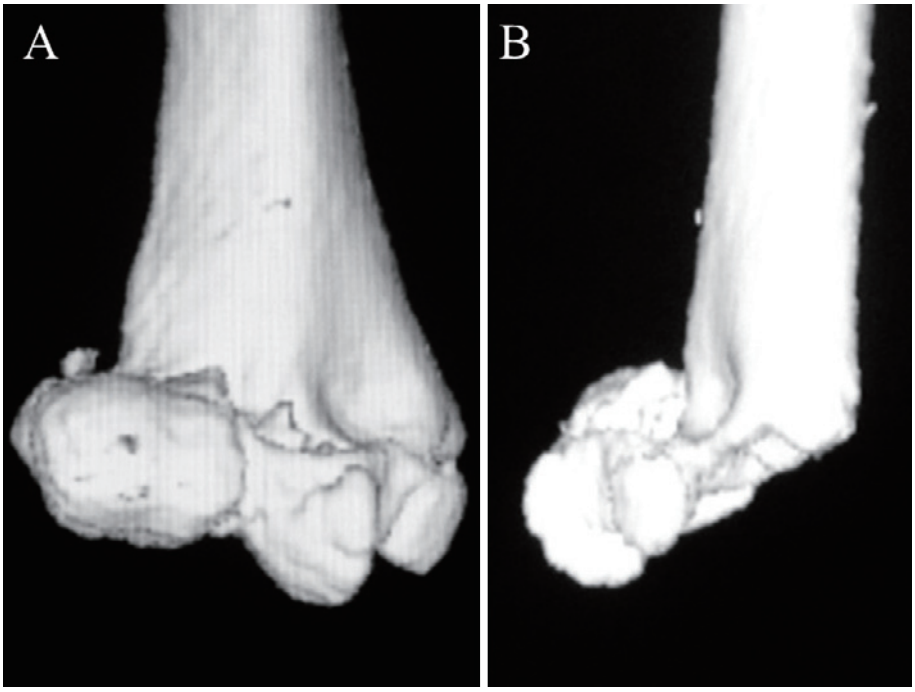

Fig. 2 Three-dimensional computed tomography images at the time of injury, showing severe comminution of the anterior cortex of the distal humerus. (A) Anteroposterior view and (B) lateral view of the right humerus.

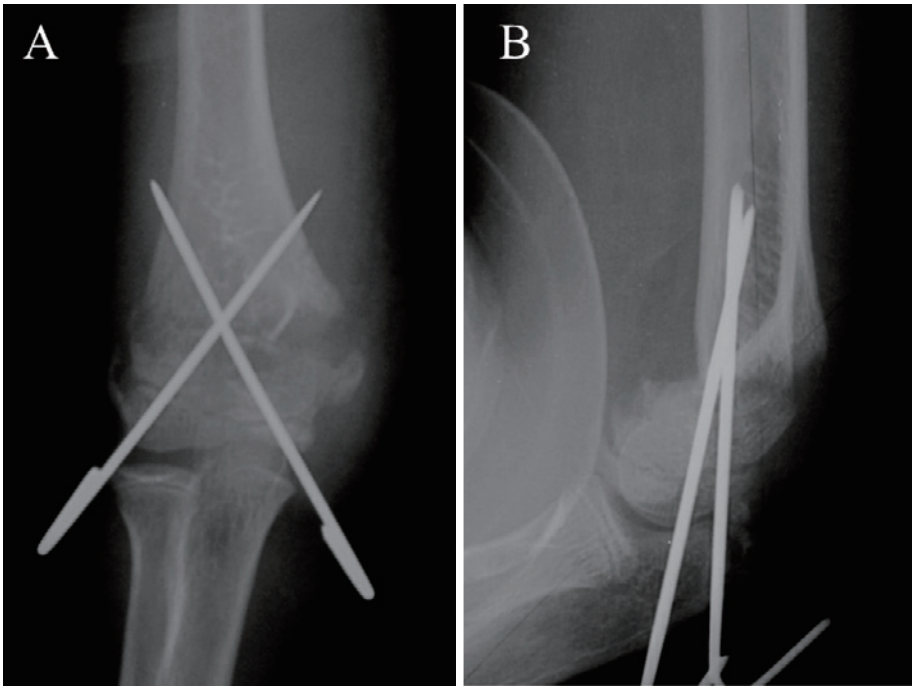

Fig. 3 Postoperative radiographs of the right humerus after percutaneous pinning for the right humerus confirm achievement of anatomical reduction. (A) Anteroposterior view and (B) lateral view of the right humerus.

flexion-type supracondylar humeral fractures in children[7,17], and Skaggs and Flynn suggested that it should be performed in elbow extension[15]. However, it is difficult to perform percutaneous pinning while maintaining anatomical reduction of the distal humerus in elbow extension[7,17]. On the other hand, when factors that inhibit

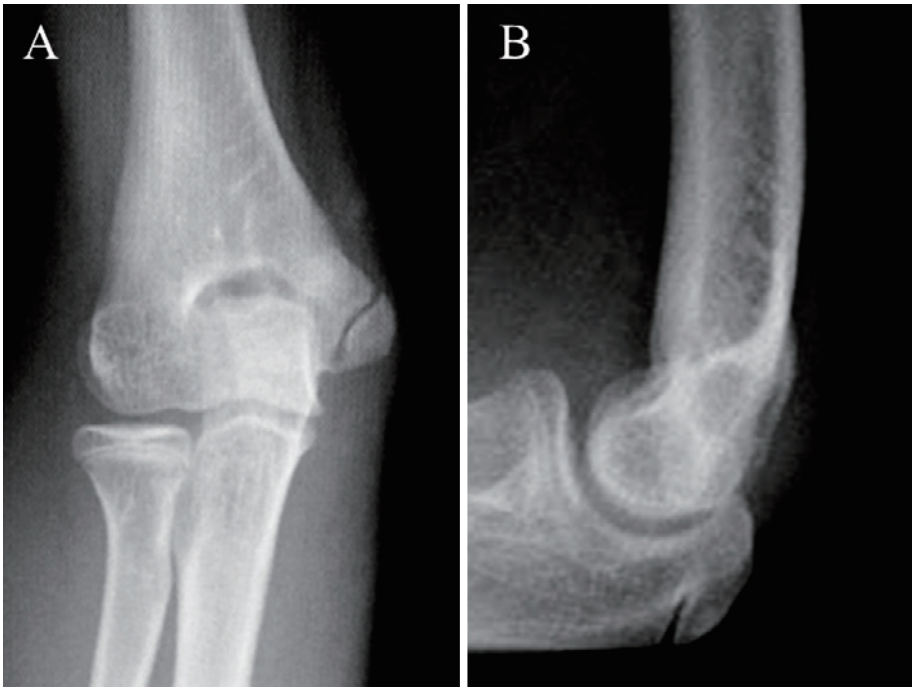

Fig. 4 Radiographs 16 months after surgery. The BA and CA were 64° and 24°, respectively. (A) Anteroposterior view and (B) lateral view of the right humerus.

fracture reduction are absent, closed reduction using a traction table enables reduction of the displacement of the fracture and maintains anatomical reduction by pulling down the injured upper arm[9,10]. Volar cortical bone of the distal humerus is compressed in Gartland type II flexion-type supracondylar fracture; however, dorsal cortical bone is preserved (**Fig. 5A**). A volar cortical bone defect occurs when closed reduction is performed (**Fig. 5 B**). In CRPP using a traction table, the surgeon applies traction to the injured arm with elbow flexion on the traction bar while the assistant applies counter-traction to the distal humerus. The compressed volar cortical bone is reduced by closed reduction. After closed reduction, a two or three percutaneous pinning procedure enables the reduction position to be maintained with an intact dorsal cortical hinge (**Fig. 5C**). In our patients, CRPP using a traction table enabled anatomical reduction and led to satisfactory clinical outcomes.

Ulnar nerve disturbance is a known complication of flexion-type fractures of the distal humerus[1,4–7,17,18]. Ulnar nerve disturbance occasionally occurs when the ulnar nerve is entrapped between the proximal and distal fracture fragments, especially in cases of volar and radial displacement of the fracture fragment of the distal humerus[7,18]. According to previous reports[5,6,18], Gartland type III flexion-type fractures resulted in entrapment of the ulnar nerve between fracture fragments, which had no contact with proximal and distal fracture fragments and hindered anatomical reduction by closed reduction. In contrast, because continuity of the periosteum is preserved in Gartland type II fracture, Gartland type II flexion-type supracondylar humeral fractures can be reduced effectively by closed reduction using a traction table, in the same manner as Gartland type II extension-type fractures[9,10]. Although preoperative ulnar nerve disturbance was observed in one of the present patients, Gartland type II flexion-type fracture is easily anatomically reduced without neurolysis of the ulnar nerve. However, unsuccessful anatomical reduction of the fracture fragment might lead to entrapment of inhibitory soft tissues, such as muscle and neurovascular bundles[4,6,7,18,19], between fracture fragments. In that case, open reduction and neurolysis are required.

In our patients, CRPP was performed with a traction table. Closed reduction with a traction table resulted in anatomical reduction of the displaced fracture, and percutaneous pinning was carried out while maintaining anatomical reduction of the distal humerus. The traction table enabled us to maintain anatomical reduction of the fracture fragment and subsequent percutaneous pinning; thus, CRPP using a traction table is useful for treating Gartland type II flexion-type supracondylar humerus fractures.

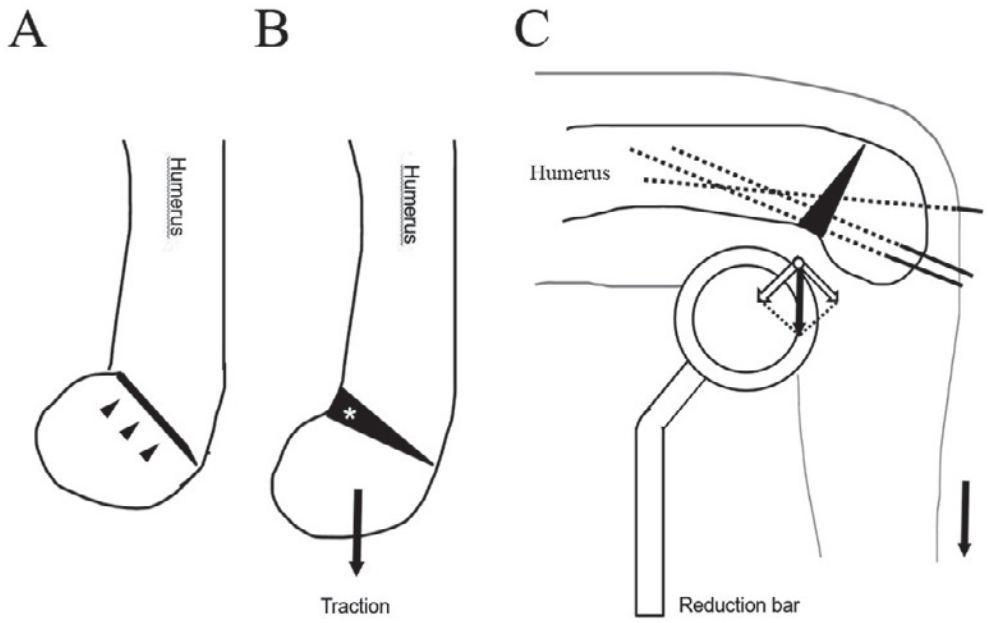

Fig. 5 Illustrations of treatment for Gartland type II flexion-type supracondylar fracture of the humerus in pediatric patients. (A) Volar cortical bone of the distal humerus is compressed in Gartland type II flexion-type supracondylar fracture, while dorsal cortical bone is preserved. Black arrowheads indicate compression of anterior cortical bone. (B) A volar cortical bone defect after closed reduction. The white asterisk indicates anterior cortical bone defect. (C) Closed reduction is performed with a reduction bar, followed by percutaneous pinning, with the patient in prone or lateral position. In CRPP using a traction table, the surgeon applies traction to the injured arm with elbow flexion on the traction bar while the assistant applies counter-traction to the distal humerus. The compressed volar cortical bone is reduced by closed reduction. After closed reduction, a two or three percutaneous pinning procedure enables maintenance of the reduction position with an intact dorsal cortical hinge.

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Conflict of Interest: None declared

References

1. Wilkins KE. The operative management of supracondylar fractures. Orthop Clin North Am [Internet]. 1990 Apr;21(2):269–89. Available from: https://www.ncbi.nlm.nih.gov/pubmed/2183131
2. Cheng JC, Lam TP, Maffulli N. Epidemiological features of supracondylar fractures of the humerus in Chinese children. J Pediatr Orthop B [Internet]. 2001 Jan;10(1):63–7. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11269814
3. Williamson DM, Cole WG. Flexion supracondylar fractures of the humerus in children: Treatment by manipulation and extension cast. Injury [Internet]. 1991 Nov;22(6):451–5. Available from: https://www.ncbi.nlm.nih.gov/pubmed/1757135
4. Kuoppala E, Parviainen R, Pokka T, Sirviö M, Serlo W, Sinikumpu JJ. Low incidence of flexion-type supracondylar humerus fractures but high rate of complications. Acta Orthop [Internet]. 2016 Aug;87(4):406–11. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27168001
5. Fowles JV, Kassab MT. Displaced supracondylar fractures of the elbow in children. A report on the fixation of extension and flexion fractures by two lateral percutaneous pins. J Bone Joint Surg Br [Internet]. 1974 Aug;56B(3):490–500. Available from: https://www.ncbi.nlm.nih.gov/pubmed/4421700
6. Mahan ST, May CD, Kocher MS. Operative management of displaced flexion supracondylar humerus fractures in children. J Pediatr Orthop [Internet]. 2007 Jul-Aug;27(5):551–6. Available from: https://www.ncbi.nlm.nih.gov/pubmed/17585266
7. Sharma A. The flexion-type supracondylar humeral fracture in children: A review. JBJS Rev [Internet]. 2019 Apr;(4):e6. Available from: https://www.ncbi.nlm.nih.gov/pubmed/31048627
8. Howard A, Mulpuri K, Abel MF, et al. The treatment of pediatric supracondylar humerus fractures. J Am Acad Orthop Surg [Internet]. 2012 May;20(5):320–7. Available from: https://www.ncbi.nlm.nih.gov/pubmed/22553104
9. Tomori Y, Nanno M, Takai S. Clinical results of closed versus mini-open reduction with percutaneous pinning for supracondylar fractures of the humerus in children: A retrospective case-control study. Medicine (Baltimore) [Internet]. 2018 Nov;97(45):e13162. Available from: https://www.ncbi.nlm.nih.gov/pubmed/30407346
10. Sawaizumi T, Takayama A, Ito H. Surgical technique for supracondylar fracture of the humerus with percutaneous leverage pinning. J Shoulder Elbow Surg [Internet]. 2003 Nov-Dec;12(6):603–6. Available from: https://www.ncbi.n

lm.nih.gov/pubmed/14671527
11. Goldfarb CA, Patterson JM, Sutter M, Krauss M, Steffen JA, Galatz L. Elbow radiographic anatomy: Measurement techniques and normative data. J Shoulder Elbow Surg [Internet]. 2012 Sep;21(9):1236–46. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22329911
12. Yamamoto I, Ishii S, Usui M, Ogino T, Kaneda K. Cubitus varus deformity following supracondylar fracture of the humerus. A method for measuring rotational deformity. Clin Orthop Relat Res [Internet]. 1985 Dec;(201):179–85. Available from: https://www.ncbi.nlm.nih.gov/pubmed/4064403
13. Flynn JC, Matthews JG, Benoit RL. Blind pinning of displaced supracondylar fractures of the humerus in children. Sixteen years' experience with long-term follow-up. J Bone Joint Surg Am. [Internet]. 1974 Mar;56(2):263–72. Available from: https://www.ncbi.nlm.nih.gov/pubmed/4375679
14. Omid R, Choi PD, Skaggs DL. Supracondylar humeral fractures in children. J Bone Joint Surg Am [Internet]. 2008 May;90(5):1121–32. Available from: https://www.ncbi.nlm.nih.gov/pubmed/18451407
15. Rockwood CA, Beaty JH, Kasser JR. Rockwood and Wilkins' fractures in children. Philadelphia: Lippincott, Williams & Wilkins; 2010. p. 1.
16. Moraleda L, Valencia M, Barco R, González-Moran G. Natural history of unreduced Gartland type-II supracondylar fractures of the humerus in children: A two to thirteen-year follow-up study. J Bone Joint Surg Am [Internet]. 2013 Jan;95(1):28–34. Available from: https://www.ncbi.nlm.nih.gov/pubmed/23405411
17. De Boeck H. Flexion-type supracondylar elbow fractures in children. J Pediatr Orthop [Internet]. 2001 Jul-Aug;21(4):460–3. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11433157
18. Steinman S, Bastrom TP, Newton PO, Mubarak SJ. Beware of ulnar nerve entrapment in flexion-type supracondylar humerus fractures. J Child Orthop [Internet]. 2007 Sep;1(3):177–80. Available from: https://www.ncbi.nlm.nih.gov/pubmed/19308492
19. Delniotis I, Dionellis P, Gekas CC, et al. Flexion-type supracondylar humeral fracture with ulnar nerve Injury in children: Two case reports and review of the literature. Am J Case Rep [Internet]. 2020 Feb;21:e921293. Available from: https://www.ncbi.nlm.nih.gov/pubmed/32080162

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