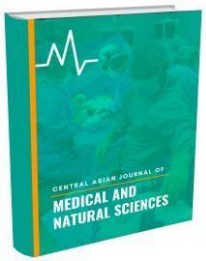

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Article

Outcomes of Supracondylar Humeral Fracture Fixation in Pediatric Patients: A Comprehensive Review

Ali A. H. AL-Shwilly*[1], Zina Saleam Huntush[2]

1,2 Assistant Department of Anatomy, College of Medicine, University of Sumer, Rifai Dhi Qar, Iraq
* Correspondence: zoznono730@gmail.com

Abstract: Supracondylar humeral fractures are common elbow fractures in children, a major concern in pediatric orthopedics. Management is crucial for maintaining function and preventing deformity. Various fixation techniques are used for optimal outcomes. To synthesize current knowledge on the various fixation techniques used for supracondylar humeral fractures in the pediatric population, focusing on outcomes, healing rates, and complication profiles associated with each method. This review explores literature on fixation of supracondylar humeral fractures in children, comparing pinning techniques, external fixation, and conservative management. It assesses the efficacy of different fixation methods in terms of anatomical and functional outcomes, healing time, and complications. Closed reduction and percutaneous pinning are widely accepted techniques for bone healing, elbow function, and low complication rates. Variations in pin configurations, such as crossed or lateral pinning, have their advantages and risks. External fixation and open reduction are less commonly required but are indicated in specific contexts, such as severely displaced fractures or when closed reduction is unsuccessful. Long-term outcomes generally show excellent functional recovery, with most children regaining full or near-full range of motion and strength. The management of supracondylar humeral fractures in pediatric patients is crucial for optimal healing and functional recovery. Closed reduction with percutaneous pinning is the cornerstone, with fixation techniques tailored to individual fracture characteristics and surgeon expertise. Further research is encouraged for better understanding.

Keywords: Supracondylar Humeral Fracture, Percutaneous Pinning, Open Reduction and Internal Fixation (ORIF), External Fixation, Healing Rate, Complications

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1. Introduction

Supracondylar fractures (SCF) of the humerus are the most prevalent fracture worldwide, in children with musculoskeletal traumas. Approximately 13% of pediatric fractures worldwide are caused by them. To improve treatment outcomes, Gartland described a therapy algorithm that allows for a range of management techniques. This approach was used to develop various therapy recommendations, all of which managed SCF of the humerus well. The type of fracture will determine how it is managed; non-displaced fractures have very good functional and radiological results after closed reduction and casting. There are contradictory methods for managing displaced fractures, especially type II fractures. However, most patients report a positive functional outcome and closed reduction and percutaneous pinning account for over 90% of radiological satisfaction. Due to a lack of resources and patients' delayed seeking of medical attention, fracture treatment delays in low-resource settings can last several hours, days, or even weeks. These delays raise the possibility of complications and unfavorable results [1].

Gartland type I fractures rarely result in unsatisfactory outcomes and typically yield satisfactory results. Patients are usually sufficiently recovered to be immobilized for two to four weeks with a cast. Conversely, operational control is necessary for various types of humeral SCF in order to have a good result; this is contingent upon the size of the stabilizing pins and the timing of the procedure. Because children's bones are malleable and have limitless growth potential, pediatric fractures receive particular care. Clinicians examining patients with humeral supracondylar fractures have noted a high degree of poor result, involving malunion and/or stiff elbow. Since damage to those structures constitutes an orthopedic emergency, neurovascular examination is carefully performed during the clinical evaluation of a patient with SCF of the humerus. Long-term disability resulting from neurovascular damage may incur costs up to five times higher than those associated with initial therapy [2].

Different surgical procedures and fixation strategies have been used over time to treat pediatric supracondylar humeral fractures. These consist of external fixation, percutaneous pinning, and open reduction and internal fixation (ORIF) with screws or plates. The patient's age, the concomitant neurovascular injury, the fracture displacement, the fracture pattern, and the surgeon's experience all influence the treatment approach that is used. With the exception of an acutely-exposed posture, many of these fractures remain unstable after reduction. Volkmann's ischemic contracture may be more likely to occur in a posture that compromises vascularity and has significant edema. When the pieces are immobilized in the safer right-angle position, they often slip and cause numerous abnormalities that lead to supracondylar problem. Internal fixation is conventionally advised even though SHFs with substantial displacement (types 3 and 4) can be handled non-operatively. Reduction combined with internal fixing yields good medium- and long-term results [3].

A wide range of fixation techniques have been reported for the management of SHFs. No one has been shown to be better than the others. Despite the fact that SHFs are frequent, no firm suggestions on the fixation method selection have been made thus far. The one area where there is almost universal consensus is that closed reduction and closed fixation should be the initial courses of treatment. One of the most hotly contested topics is the ideal arrangement for percutaneously implanted pins to stabilize SHFs. There are two primary configurations that stand out. One option is the X configuration, which involves inserting one or more medial pins from the medial condyle to the lateral cortex of the humeral shaft and lateral pins from the lateral condyle to the medial cortex. The alternative just uses pins that are inserted laterally. A medial pin may be added to increase resistance to torque, although doing so comes with a higher risk of iatrogenic ulnar nerve injury. On these two topics, there is contradicting data available. However, the risk of iatrogenic damage may be reduced by using a minimally invasive technique for medial pin insertion [4].

Examining the results of supracondylar humeral fracture repair in juvenile patients is the goal of this thorough analysis. We aim to provide a thorough understanding of the effectiveness, complications, and long-term results related with various surgical techniques and fixation methods by evaluating and integrating the current literature. Clinicians, orthopedic surgeons, and other healthcare professionals will find this review useful in making judgments about the best course of action for treating pediatric patients with supracondylar humeral fractures.

Objective of thif study is aimed to synthesize current knowledge on the various fixation techniques used for supracondylar humeral fractures in the pediatric population, focusing on outcomes, healing rates, and complication profiles associated with each method.

2. Materials and Methods

A systematic search was conducted using selected keywords, such as "Supracondylar humeral fractures," "Pediatric patients," Fixation methods," "Percutaneous pinning.", " External fixation", and "complications". Boolean operators (AND, OR) were utilized to combine these keywords to provide a targeted and thorough search. The publication date and language were included as additional parameters to help narrow down the search results. The databases Scopus, Web of Science, and PubMed were used for the literature search. These databases were picked because they provide a wide range of scientific literature coverage in different fields. The search was carried out through 2024 to include the most recent data that was accessible at the time of the investigation.

This review comprehensively examines the literature on the fixation of supracondylar humeral fractures in children, including studies that compare pinning techniques, the use of external fixation, and conservative management where applicable. Emphasis is placed on assessing the efficacy of different fixation methods in terms of anatomical and functional outcomes, time to healing, and incidence of complications such as nerve injury, infection, and malunion.

3. Results

3.1 Fixation Techniques for Supracondylar Humeral Fractures in Children

The Gartland classification is used to categorize supracondylar humeral fractures (SCHF) and acts as a therapeutic guidance. While kinds IIb and III of Gartland fractures require surgical treatment, types I and IIa may be addressed nonoperatively. The preferred surgical procedure is closed reduction and percutaneous (CRPP) fixation with Kirschner wires (K-wires) [5]. The non-surgical therapy for type I fractures involves immobilizing the elbow for three weeks using a posterior axillary-palmar splint in flexion from 60 to 80 degrees. It takes about seven days of radiographic control to recognize any displacement early. Initial treatment for stable fractures with displacement only in extension (type II A) may involve closed reduction, immobilization, and close monitoring to detect loss of reduction, according to certain studies [6]. Nonetheless, closed reduction and percutaneous fixation is the recommended course of action for treating misplaced SHF, under the guidelines published by the American Academy of Orthopedic Surgeons. Any fracture involving coronal translation, rotation, or angulation, or in which the anterior humeral line does not cross the capitellum, needs to be reduced and corrected. A physical examination aids in assessing the need for surgery. It is necessary to perform a thorough sensory, motor, and vascular assessment of the limb in question. Severity indicators include skin tension in the cubital area, volar ecchymosis, and significant edema, which point to enhanced soft tissue damage and a higher chance of concomitant neurovascular injury [7].

The limb needs to be immobilized in a flexion range of 30 to 40° using a well-padded splint until it can get final treatment. A partial fracture reduction with an elbow flexion procedure up to 40° and gentle traction can enhance perfusion and ease the strain in the soft tissues in extreme situations, with significant deviation or without a perceptible pulse. Because of the danger of compartment syndrome, forced reduction attempts in the emergency room involving immobilization of the elbow in flexion more than 80° are not recommended. When a patient has a significant displacement, they need to be monitored in the hospital until they receive surgery. Regarding how long a closed fracture with a palpable pulse could wait, there is disagreement. Numerous studies demonstrate that delaying surgery for up to 24 hours in some series does not necessarily indicate an increased risk of problems, the requirement for an open reduction, or subpar outcomes. Nevertheless, because the most serious cases are typically treated first, selection bias affects these clinical trials. Treatment must begin as soon as possible after the decision is made

individually, paying close attention to the neurovascular condition and any indicators of severity [8].

The main fixation techniques include percutaneous pinning, open reduction and internal fixation (ORIF), and external fixation. Each technique has its advantages, considerations, and potential complications.

Table 1. Advantages and potential complications of Fixation Techniques for Supracondylar Humeral Fractures in Children.

Fixation Technique	Advantages	Potential complications
Percutaneous Pinning	- Less soft tissue dissection - less disruption of vascularity - Shorter operating room time - Shorter hospital stay - Quick recovery	- Less stable fixation - pin migration - initial limitation on motion, and stiffness - Malalignment or inadequate reduction - Infection at pin insertion sites - Neurovascular injury
Open Reduction and Internal Fixation (ORIF)	- help relieve pain - restore mobility - heal the bone in the correct position - Early mobilization and weight-bearing	- Malalignment or inadequate reduction - Infection - Bleeding - Penetration of screws into the articular surface of the humeral head - Avascular necrosis
External Fixation	- Minimally invasive - Early fracture stabilization - Adjustable and customizable - Allows for bone and soft tissue healing - Can be used in poly-trauma or contaminated cases	- Pin tract infection - nonunion, malunion, delayed union - hardware failure - neurovascular embarrassment

3.1.1 Percutaneous pinning

It is a widely used technique for the fixation of supracondylar humeral fractures in children. This technique involves the insertion of Kirschner wires (K-wires) across the fracture site to stabilize the fracture fragments. The wires are usually placed percutaneously, without the need for open surgical incisions. Percutaneous pinning offers advantages such as minimal soft tissue disruption, shorter operative time, and ease of removal. However, potential complications include pin site infection, neurovascular injury, and loss of reduction if the wires are not properly placed or maintained. The ideal K-wire pattern for fixing supracondylar fractures is a topic of discussion. The literature has provided two main configurations: two lateral pins and crossed pins (medial and lateral). Two ascending K-wires were placed, one through the lateral condyle and the other through the medial condyle, as part of the traditional medial-lateral cross-wire procedure. By using this method, the medial wire may cause damage to the ulnar nerve as it passes through the medial condyle. There have been reports of ulnar nerve damage rates as high as 6-8% [4]. As an alternative to placing K-wire medially for fixation, two parallel K-wires could be inserted through the lateral cortex to prevent damage to the ulnar nerve. Nevertheless, compared to the crosswire structure, this method is thought to be less biomechanically stable. A modified cross-wire approach called lateral crossed pin fixation

with ascending and descending K-wires Dorgan's lateral cross-wiring has been proposed as a way to establish stability and prevent injury to the ulnar nerve. In this method, cross-wire fixation is accomplished just from the lateral side [9].

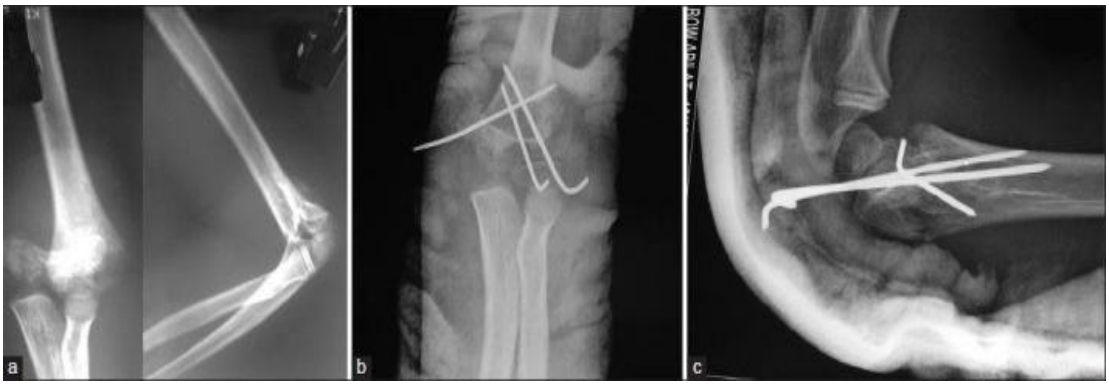

Figure 1. (a) Pre-operative A-P and Lateral radiographs showing Supracondylar fracture of humerus of 4-year-old child, (b) Post-operative anteroposterior radiographs of Supracondylar fracture of humerus showing with Crossed K-wire fixation, (c) Post-operative Lateral radiographs of Supracondylar fracture of humerus showing with crossed K-wire fixation (Sahu, 2013).

Percutaneous pinning is a widely used fixation technique for supracondylar humeral fractures in children. The literature review reveals that this technique is safe and efficient, with a low infection rate. [10] `s study aimed to assess the effectiveness of percutaneous pinning methods in the treatment of displaced supracondylar humeral fractures (Gartland types II and III). Techniques: An investigation conducted prospectively on thirty patients hospitalized to Zagazig University Hospital's Orthopedic Department between January and July of 2019. All patients were randomized into two groups: lateral pin fixation (n = 22) and medial-lateral pin fixation (n = 8), with type II affecting 24 patients and type III affecting 6 patients. For loss of reduction, vascular, and iatrogenic ulnar nerve injury, primary examination was accomplished. Following surgery, the patients' clinical status was evaluated using Flynn criteria. In terms of the Flynn criteria, 13% had unsatisfactory (fair and poor) and 86.7 percent had satisfactory (outstanding and good). Complications included Ulnar nerve injury (3.3%), pin tract infection (13.3%), and neither vascular injury nor Cubits Varus case. The unsatisfactory group showed a substantial correlation with related injuries as well as with ulnar nerve injury, loss of reduction, and pin tract infection. A safe, quick, minimally invasive, and reliable procedure for treating unstable type II and III Gartland supracondylar fractures in children with few to no complications is closed reduction and percutaneous K-wire fixation.

[11] examined the efficacy of SCHF fixation and the problems associated with the two percutaneous Kwire pinning configurations that are currently most popular from a clinical and radiological standpoint. Thirty-five children were included in the study between May 2005 and December 2012. Patients were treated with two distinct pin modules: lateral (Group 2) and crossing (Group 1) modules. Assessment Following the procedure, radiography and clinical testing were conducted. The clinical evaluation conducted after the procedure showed that the elbow's joint function had been restored. Group 1 included two patients with short paresthesia, while Group 2 included two patients with local infections, one patient with modest hyperextension, and one patient with slight varus, mild asymmetry, and decreased humeral extension. They stated that there was no discernible difference between the lateral K-wire and cross-wire techniques; both groups achieved satisfactory outcomes; both approaches were comparable in terms of clinical and radiographic outcomes; however, the cross-wired configuration carries a higher risk of neurovascular injuries than the lateral K-wire configuration.

The purpose of [12] study was to evaluate and contrast the results of operating on pediatric displaced supracondylar humerus fractures using crossing versus lateral pinning methods. Materials and procedures: This is a prospective observational study that was carried out from January 2014 to December 2016 at the orthopedic department of a tertiary care facility. 110 patients between the ages of 2 and 12 who had displaced supracondylar fractures of the humerus were registered in this study. All children with displaced supracondylar humeral fractures who arrived at the emergency room or outpatient clinic were examined physically and radiologically. Patients with Gartland types II and III were incorporated in the study, while those who had an open fracture, vascular damage, or neurological deficit at the time of display were not. Based on the percutaneous pinning technique, children were split into two groups: (A) Lateral pinning (n = 52) versus (B) Crossed pinning (n = 58). The gender distribution, mean age, kind of fracture, and interval between injury and surgery were compared between the two groups. Range mobility was the clinical endpoint assessed at the 6-month follow-up, and fracture relocation, union, and a shift in Baumann's angle at union were the radiological outcomes. Evaluations were also conducted on the consequences (pin tract infection and ulnar nerve neuropraxia or damage). Findings: A total of 110 patients—52 for lateral pinning and 58 for crossover pinning—were incorporated into the study. When comparing the radiological results of fractures undergoing lateral pinning to those managed with crossing pinning, the variation in ulnar nerve neuropraxia between the two configurations was statistically not significant. In the context of above study, it was found that fixation with crossed pins are better for repairing displaced supracondylar humeral fractures. When inserting medial pins, care should be exercised to prevent iatrogenic ulnar nerve injury.

3.1.2 Open reduction and internal fixation (ORIF)

Open reduction and internal fixation (ORIF) involves open surgical exposure of the fracture site and the use of screws, plates, or both to stabilize the fracture fragments. ORIF provides direct visualization of the fracture anatomy, allowing for accurate reduction and fixation. This technique is especially useful for complex or severely displaced fractures. ORIF offers the advantage of stable fixation, which promotes early mobilization and potentially better functional outcomes. However, it carries the risk of infection, implant-related complications, and prolonged operative time [13].

Numerous studies and papers addressing the application of open reduction and internal fixation (ORIF) for this kind of fracture are found in the literature review. According to a study on the long-term outcomes of open reduction and internal fixation surgery for children with displaced supracondylar humeral fractures, this method works well most of the time [14]. The purpose of this study was to assess the long-term outcomes of open reduction and internal fixation surgery for pediatric patients with displaced supracondylar humerus fractures. 21 patients who received open reduction and internal fixation for the treatment of displaced, supracondylar humerus fractures that were intractable by closed methods—as per the Gartland classification—were included in the descriptive retrospective analysis, which took place between 1996 and 2003. The Flynn criteria (functional and cosmetic) were used for the clinical evaluation of the patients. In addition, a questionnaire about how pleased patients were with treatment was given, as well as data on range of motion, postoperative radiological assessment, and the existence of postoperative problems. The patients' average age was 5.8 years. Follow-up averaged 11.52 years. 17.6° was the average post-operative Baumann angle. 90% of patients showed elbow range of motion within normal limits. Final loss of flexion was 5.1° (range: 0–20°), while loss of extension averaged 0.71° (range: 0–10°). In 85.5% of cases, the functional and cosmetic outcomes fulfilled the Flynn criterion. The two most frequent post-operative problems were migration of metal work and superficial wound infection. All patients, with the exception of two, were extremely pleased with the outcome at the last follow-up, and none of them reported having trouble engaging in their favorite sports or everyday activities. Open reduction and internal fixation show comparable outcomes to closed

procedures in situations where there is an inadequate reduction or when a stable closed reduction is not maintained.

According to [15], 43 patients with Gartland type II/III fractures, ages 4 to 12, who visited the orthopedics department within two weeks of the injury were included in the current institution-based, longitudinal, prospective study. All patients had two unsuccessful efforts at closed reduction following manipulation. K-wire internal fixation and open reduction were carried out using the anterior cubital technique. The functional outcome was evaluated at three months, six months, and three weeks using the Mayo Elbow Performance Score. At the 6-month follow-up, 41.9% of patients had a good outcome and 55.8% of patients had an excellent functional outcome. Therefore, the anterior technique is a good substitute that should be investigated further in pediatric patients with delayed presentation and unsuccessful reduction of supracondylar fractures.

[16] conducted a retrospective study on pediatric patients who underwent open reduction and internal fixation for humeral supracondylar fractures. The study included 24 patients who underwent these procedures, adjusted by the closed method. The patients were evaluated based on Gartland's classification, postoperative radiological assessment, range of motion, and postoperative complications. The results showed that the majority of patients were satisfied with their treatment, with conservative treatment recommended for Gartland type I and nondisplaced type II fractures. Open reduction with two or three pins was the preferred treatment option for most supracondylar fractures. The study concluded that conservative treatment is recommended for most fractures.

3.1.3 External fixation

External fixation is another fixation technique used for supracondylar humeral fractures in children, although it is less commonly employed compared to percutaneous pinning and ORIF. External fixation involves the use of pins or wires inserted into the bone above and below the fracture, which are then connected externally using a frame. This technique allows for dynamic fixation and can be particularly beneficial in cases where soft tissue swelling or open fractures complicate the use of other fixation methods. However, external fixation has its limitations and potential complications, including pin tract infection, joint stiffness, and prolonged immobilization [17]. The choice of fixation technique for supracondylar humeral fractures in children depends on various factors, including fracture type, displacement, patient age, surgeon experience, and preferences. The decision is often made based on individual patient characteristics and the surgeon's judgment. It is crucial to consider the advantages, limitations, and potential complications associated with each fixation technique to select the most appropriate approach for each case.

The application of external fixation techniques, like lateral entry pins and Slongo's external fixation, has been compared to standard treatments such as closed reduction and percutaneous pinning for supracondylar humeral fractures in children. These studies highlight the diversity of approaches available for managing these fractures and emphasize the importance of selecting the most appropriate technique based on the specific characteristics of the fracture and the patient [18]. [19] `s study compared the effectiveness of Slongo's external fixation with lateral entry pins in treating supracondylar humeral fractures in older children. The study involved 8-year-old children who received surgery for supracondylar humeral fractures between January 2016 and December 2020. The study analyzes two groups' demographic information, length of operation, number of fluoroscopies, and fracture healing time. Six months following surgery, postoperative assessments of the elbow joint's function, healing time, lifting angle, range of motion, and Flynn score will be carried out.

The findings showed that, with regard to the demographic data, there was no discernible difference between the two patient groups. Kirschner wire surgery needed less time and fluoroscopies than external fixation surgery ($P < 0.05$). However, compared to the

Kirschner wire fixation group, the elbow range of motion and Flynn scores were higher in the external fixator group, and the fracture healing period was significantly shorter ($P < 0.05$). In the Kirschner wire group, there was one incidence of secondary fracture displacement, and in the external fixator group, there was one case of pin tract infection. There were no additional iatrogenic injuries or side effects noted. Given that Slongo's external fixator can produce superior fixation strength and early recovery of elbow joint movement with a decreased risk of joint stiffness, it may be an appropriate alternative treatment choice for children older than 8 years old who have supracondylar humeral fractures.

4. Discussion

4.1 Comparative Analysis of Fixation Techniques for Supracondylar Humeral Fractures in Children: A Review of Outcomes, Healing Rates, and Complications

The search results provide evidence for the best fixation technique for the treatment of supracondylar humeral fractures in children. Childhood humeral supracondylar fractures are a common injury. Fractures that have moved are by nature unstable. A conservative approach leads to disunion. Recovery after open reduction and internal fixation (ORIF) is longer and involves more intrusive procedures. Between September 2004 and September 2005, close reduction and percutaneous Kirschner (K) wire fixation under c-arm fluoroscopy were used to treat 102 displaced supracondylar fractures of the humerus in patients ranging in age from one and a half to thirteen years. Cross K-wires were used to treat 79 patients, and lateral two K-wires were inserted in 23 cases. In every instance, the Paris back slab's above elbow plaster was administered for a minimum of four weeks. After four weeks, the back slab and K-wires were taken out, and elbow range-of-motion exercises were initiated. Flynn's criteria were used to the results analysis. Every patient was monitored until the fourteenth week following surgery. At the eight-week follow-up, the cross K-wire group (N=79) had 70.8% excellent, 22.7% good, 3.8% fair, and 2.5% poor results. At the fourteen-week follow-up, the numbers improved to 91.1% excellent, 6.3 good, 1.2% fair, and 1.26% poor results. In the lateral K-wire group (N=23), after eight weeks, the results increased to 91.3% excellent, 4.3% good, 4.3% fair, and no poor result at the 14-week follow-up from 70% excellent, 21.7% good, 4.3% fair, and 4.3% poor. Seven patients experienced ulnar nerve damage after surgery, and eight patients experienced superficial pin tract infections. This treatment was suggested for children with displaced supracondylar fractures because it is a safe, economical method with manageable rates of complications [20].

Closed reduction and pinning (CRPP) is a procedure that typically yields excellent results, although it requires leaving the pins outside the skin. Pins on the outside may serve as an infection nidus. It was described that the ten-year history of infection problems following SCHF treatment at a tertiary children's hospital that is a single center. To date, this is the biggest described series on infectious complications following CRPP of SCHF. [21] `s study aimed to identify any early postoperative infections following closed reduction and percutaneous pinning for pediatric supracondylar humerus fractures of types II and III. From 2011 to 2021, pediatric patients with postsurgical infections within 90 days who were undergoing CRPP for a type II or type III SCHF had been identified. From medical files, demographic and clinical data were obtained. Determined descriptive statistics were presented as counts with percentages or as means or medians with range values. Eight individuals with type III SCHF and ten patients with type II SCHF met the inclusion criteria altogether. The fracture was diagnosed at an average age of 4.7 (2 to 9) years. For the index procedure, the average operating duration was 29 minutes (12 to 42). The average number of days following surgery before the pin was removed was 29.8 (18 to 52), and the average number of days following surgery before a readmission or symptom-related visit was 38.9 (18 to 77). Six patients (33%) had a record of wet casts that was reported. The majority of positive cultures (9, 50%) showed methicillin-sensitive

Staphylococcus aureus in the ten (56%) individuals who had fever. Thirteen patients, or 72% of the total, went back to the operating room for drainage and incision. Following the initial infection, no individuals had persistent problems during a median follow-up of 63 days (8 to 559). An uncommon adverse effect is infection following CRPP of SCHF. It was most frequently connected to common infections and wet casts in our study. Depending on the presentation, it may not always be necessary to return to the operating room; nevertheless, if oral antibiotics are taken effectively afterwards, there is a little risk of problems or recurrence. Patients should be given thorough instructions on how to take care of their casts, show that they understand the dangers and difficulties involved, and call their orthopaedist if they think their cast isn't holding up as it should.

[22] `s study study consisted of thirty displaced supracondylar fractures of the humerus in children. From May 2015 to October 2017, every patient treated at the orthopaedics department of Government Medical College, Jammu, was under the age of thirteen. All displaced fractures were treated by closed reduction and percutaneous pinning under a c-arm, with fractures being categorized based on the Gartlands classification system. The age range was 4.5 years old to 11 years old. In every age group, there were more men than women. Flynn's criterion showed that 23 cases (76.7%) had excellent results, 4 cases (13.3%) had good results, 2 cases (6.7%) had acceptable results, and 1 case (3.3%) had poor results. There was radiological evidence of union for around three to five weeks. Returning to a normal range of motion took an average of nine weeks. This study demonstrates that the best course of treatment for children with severely displaced supracondylar fractures of the humerus is close reduction and percutaneous pinning under an image intensifier.

In order to determine the most effective surgical method for treating children's supracondylar fractures of the humerus (SFH), [23] compared cross-pinning versus percutaneous pinning with side wires. Controlled trials conducted at random with the Medline, CAPES, and BIREME. (1) Randomized controlled studies (RCTs) evaluating percutaneous wire fixation procedures, (2) SFH Gartland II B, III, and IV, and (3) children aged 1-14 years were the inclusion criteria for articles. The occurrence of ulnar nerve iatrogenic damage and loss decrease were employed as the primary factors. Eight trials including a total of 521 patients were chosen to compare surgical therapy and pinning for children with supracondylar fractures of the humerus (Gartland II type B, III, or IV). The cross-pinning approach showed a higher iatrogenic damage to the ulnar nerve (RR 0.28 and $p = 0.03$) than the mini-open technique (RR 0.14 and $p = 0.2$). FSU Gartland III and IV showed a statistically significant higher loss of decrease in the lateral pinning ($p = 0.04$). The following is advised in light of this meta-analysis of prospective randomized clinical trials: In children with supracondylar fractures of the humerus who are categorized as Gartland II type B, (1) percutaneous pinning with lateral wires is used; (2) crossing wires are used for Gartland type III or IV, with the medial wire being inserted utilizing the mini-open technique.

According to a retrospective cohort research [24] of pediatric patients managed surgically for supracondylar humerus fractures, those managed by non-pediatric orthopedists (NPOs) had a greater rate of unsatisfactory fracture repair than patients treated by pediatric orthopedists (POs)3. On the other hand, there was no difference in the rates of clinical problems, malreduction, and postoperative loss of reduction between POs and NPOs. This study examines the radiographic and clinical results of juvenile supracondylar humerus fractures managed by non-pediatric orthopedists (NPOs) versus pediatric orthopedists (POs) after surgery. Pediatric patients with surgically treated supracondylar humerus fractures were the subjects of a retrospective cohort study. Three months of clinical follow-up were necessary for clinical outcomes analyses, which meant that 90 patients total—33 treated by NPOs and 57 by POs—were included in the sample. Three months of clinical and radiographic follow-up were necessary for radiographic outcomes analyses; as a result, 57 patients total—23 treated by NPOs and 34 by POs—were

included in the sample. Patients treated by NPOs had a greater rate of unsatisfactory fracture fixation (43.5%) compared to patients treated by POs (14.7 %; p = 0.030). However, there was no difference in the rates of clinical problems, malreduction, and postoperative defect reduction. Patients managed by NPOs had a higher therapy frequency of open reduction (33.3%) compared to patients treated by POs (3.5%); p < 0.001. Patients treated by NPOs required an operating room longer overall (110.9 min) than patients treated by POs (82.9 min; p < 0.001). There were differences between POs and NPOs in terms of rates of the more significant and definitive results, such as clinical adverse effects, malreduction, and postoperative loss of reduction, but not in terms of patients handled by POs and NPOs in relation to several intermediate results, such as having a lower rate of open reduction and a lower rate of insufficient fracture fixation.

[25] conducted a retrospective analysis on 101 patients who had supracondylar humeral fractures. The study indicated that 82.7% of the patients underwent crossing pinning, whereas 17.3% underwent lateral pinning. The purpose of this study was to assess the clinical outcomes of treating children with cross and lateral pinning for supracondylar humeral fractures. We also sought to evaluate the relationship between clinical outcomes and sociodemographic information. A retrospective analysis was conducted on 75 individuals under the age of 18, who underwent surgery for a supracondylar humeral fracture between September 2010 and June 2021. For comparison, two treatment modalities—crossed pinning and lateral pinning—were examined. Thirteen patients (17.3%) underwent lateral pinning, while 62 patients (82.7%) underwent crossed pinning. During the trauma, the average age was 6.83 years (2–14). When comparing the group handled crosswise to the group handled from the side, there was a significant increase in the occurrence of current complaints (p = 0.03) (54% vs 32% of patients indicated current complaints, respectively). The following criteria were examined: the existence of current neurological disorders, the degree of satisfaction with the limb's current function, the Baumann angle of the operated limb, the Mayo Elbow Score, the Flynn criteria, and the current VAS (Visual Analogue Scale) pain score. No significant differences were found between the types of fixation and any of these factors.

The functional and radiological results of lateral and cross-pinning for 101 patients with elevated juvenile supracondylar humeral fractures were shown to be similar in a retrospective cohort analysis [26]. In order to address humeral supracondylar fractures, this study compared the functional and radiological results of lateral and cross-pinning. A retrospective research was carried out on 101 patients treated surgically between 2015 and 2019 using either of the CRPP procedures. A number of clinical measures were considered, including as the Baumann angle before and after the intervention, along with discomfort, range of motion, function, and stability scores. A statistical analysis was conducted in order to examine the results of the employed methods. About one-third of the patients in our study sample—63 men and 38 women with a mean age of 5.87 years—underwent crossing pinning fixation configuration, while the other two-thirds were treated with lateral pinning configuration. The two groups' outcomes were similar, and there was no statistical difference in the Baumann angle or Mayo elbow performance scores (MEPS). The lateral and crossing pinning groups had mean MEPS values of 93.68 + 8.59 and 93.62 + 9.05, respectively. In the lateral group, the mean Baumann angle was 72.5° + 6.46, while in the crossed-pinning group, it was 72.3° + 4.70 (P = 0.878). For displaced pediatric supracondylar humeral fractures, the fixation configurations of crossed pinning and lateral pinning yield comparable radiological and functional results.

[27] sought to examine the effects of five distinct fixation techniques for pediatric SHFs. Hypothesis: It is possible to show variations in intraoperative and short-term post-operative parameters for SHFs in children using various fixation techniques. Patients and techniques: We examined the medical records of young patients treated at our facility for SHF with significant displacement (classified as type 3 or 4 in the Lagrange-Rigault classification) between 2006 and 2016. The distal humeral epiphysis anteversion, surgical

time, and Baumann's angle were among the clinical and radiological characteristics obtained at the last follow-up and post-operatively. There were 251 patients involved in the 11-year trial; the mean follow-up was 4.7 months and the mean age was 6.4 years. Elastic stable intra-medullary nailing (ESIN, n = 16), two X-shaped pins (n = 33), two lateral pins and one medial pin (n = 144), two lateral pins (n = 33), and three lateral pins (n = 25) were the five fixation techniques employed. To place the medial pins, a minimally invasive 2-cm route was employed. Patients whose first-day radiographs showed rotational malalignment or a deficit of at least 15° in Baumann's angle or anteversion were thought to have immediate fixation instability. In each of the five internal fixation groups, the results were examined. Findings: There were no notable variations in immediate instability among the five groups. With two lateral pins, the operation took much less time (33 minutes, P = 0.046). In the ESIN group, the time to hardware removal was longer (54 days, P=0.03). The risk of nerve injury (4% vs. 3%, P=0.86) was unaffected by the use of a medial pin, but it was linked to a lower risk of secondary displacement (2.0% vs. 8.6%, P=0.04). In light of the fixation approach utilized to treat SHFs in children, this is one of the largest retrospective cohort studies on outcomes. Although adding a medial pin using a minimally invasive procedure takes longer during surgery, it increases fracture site stability and reduces the chance of secondary displacement without raising the frequency of iatrogenic nerve injury. Thus, in pediatric SHFs, the use of a medial pin merits consideration.

Lateral Kirschner wiring and closed reduction lateral external fixation were used for treatment of seven children who had intractable Gartland Type III supracondylar humeral fractures. Individuals who had an open fracture, an ipsilateral radial or ulnar fracture, or neurovascular damage prior to surgery were not accepted. Following up with each patient occurred at one, three, and six weeks as well as three and six months. Flynn's criteria were used to evaluate the final results. Every patient received satisfactory results in terms of both appearance and functionality. All patients (85.5%) with the exception of one returned to excellent and good functional and cosmetic state. A pin site infection was experienced by one patient (14.3%), however it was treated with an oral antibiotic (Checketts-Otterburn grade 2). There was no neurological impairment affecting the radial or ulnar nerves. A potential alternate treatment option for humeral supracondylar fractures is the implementation of lateral external fixation and lateral percutaneous pinning. In comparison to percutaneous pinning, this study shows that it offers good cosmetic and functional outcomes with no higher risk of problems [28].

[29]`s study to determine the prevalence of distal humerus intercondylar fractures in children and to document the clinical results of percutaneous pinning and external fixation in these injury patterns. Retrospective analysis was done on pediatric patients under 14 years old who underwent external fixation and percutaneous pinning for an intercondylar fracture of the distal humerus at the Wuhan Union Hospital between January 2013 and December 2018. The carrying angle difference (CAD) of the damaged extremity, surgical time, time to union, and comprehensive baseline data of the patients were gathered.

5. Conclusion

Effective management of supracondylar humeral fractures in pediatric patients is pivotal for optimal bone healing and functional recovery. Closed reduction with percutaneous pinning remains the cornerstone of treatment, offering reliable outcomes with minimal complications. The choice of fixation technique should be tailored to the individual fracture characteristics and surgeon expertise to ensure the best possible outcome for the pediatric patient. Further research is encouraged to refine treatment protocols and enhance the understanding of long-term outcomes in this patient group.

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