

Article

A Modified Technique for Medial Pin Placement in Pediatric Supracondylar Humerus Fractures

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Abstract

Background: Displaced pediatric supracondylar humerus fractures (PSHFs) commonly require surgical treatment. Medial pin placement can cause iatrogenic ulnar nerve injury. This study presents a modified, step-by-step cross-pinning technique for PSHFs designed to avoid iatrogenic ulnar nerve injury. **Methods:** We retrospectively included patients with PSHF (Gartland types III or IV) who underwent closed reduction and percutaneous cross-pinning at our hospital from June 2014 to December 2024. Demographic data, fracture type, and preoperative and postoperative neurological deficits were recorded. **Results:** A total of 40 patients (16 boys and 24 girls) with a mean age of 6.6 ± 2.2 years (range, 2–14) were included. Most injuries were type III (35/40; 87.5%), whereas five patients (12.5%) had type IV injuries. Our technique resulted in no new cases of postoperative ulnar neuropathy. **Conclusions:** This study describes a modified medial pin insertion technique for unstable PSHFs. Careful attention to medial pin placement can minimize iatrogenic ulnar nerve injury.

Keywords: medial pin; pediatric supracondylar humerus fracture; iatrogenic ulnar neuropathies; complications



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1. Introduction

Supracondylar humerus fractures are the most common elbow fractures in pediatric patients and often require surgical management. Pediatric supracondylar humerus fractures (PSHFs) are classified as flexion (1.2%) or extension (98.8%) types [1]. Based on distal fragment displacement and stability, extension-type fractures can be further categorized by the Gartland classification as types I–IV; types III and IV are unstable. Gartland type IV denotes multidirectional instability [2].

The treatment of displaced PSHFs typically involves closed reduction and percutaneous pinning. The two main pin configurations are crossed (medial and lateral) and lateral-only pins. Crossed pinning is considered biomechanically stronger than lateral pinning [3–5], and some authors recommend it for Gartland types III or IV [6]. However, medial pin placement may result in iatrogenic ulnar nerve injury [5,7,8]. Consequently, many surgeons avoid the use of medial-entry pins. However, crossed pins may be necessary

for persistent rotational instability following lateral-pin placement when the medial wall is comminuted.

In this study, we present a modified, step-by-step cross-pinning technique for displaced PSHFs that minimizes the risk of iatrogenic ulnar nerve injury.

2. Materials and Methods

This retrospective study was approved by our Institutional Review Board. Patients with PSHF (Gartland types III or IV) who underwent closed reduction and percutaneous cross-pinning at our hospital between June 2014 and December 2024 were included. We reviewed charts and radiographic records and recorded demographic data, fracture type, and preoperative and postoperative neurological deficits. We excluded patients with insufficient clinical or radiographic data, open fractures, multiple fractures, flexion-type fractures, or those who underwent open reduction.

Surgical technique

After anesthesia, patients were placed supine on the operating table. The injured upper limb was placed under the image intensifier. During the procedure, patients were positioned near the edge of the table to optimize fluoroscopic imaging. The C-arm was positioned perpendicular to the table (Figure 1).

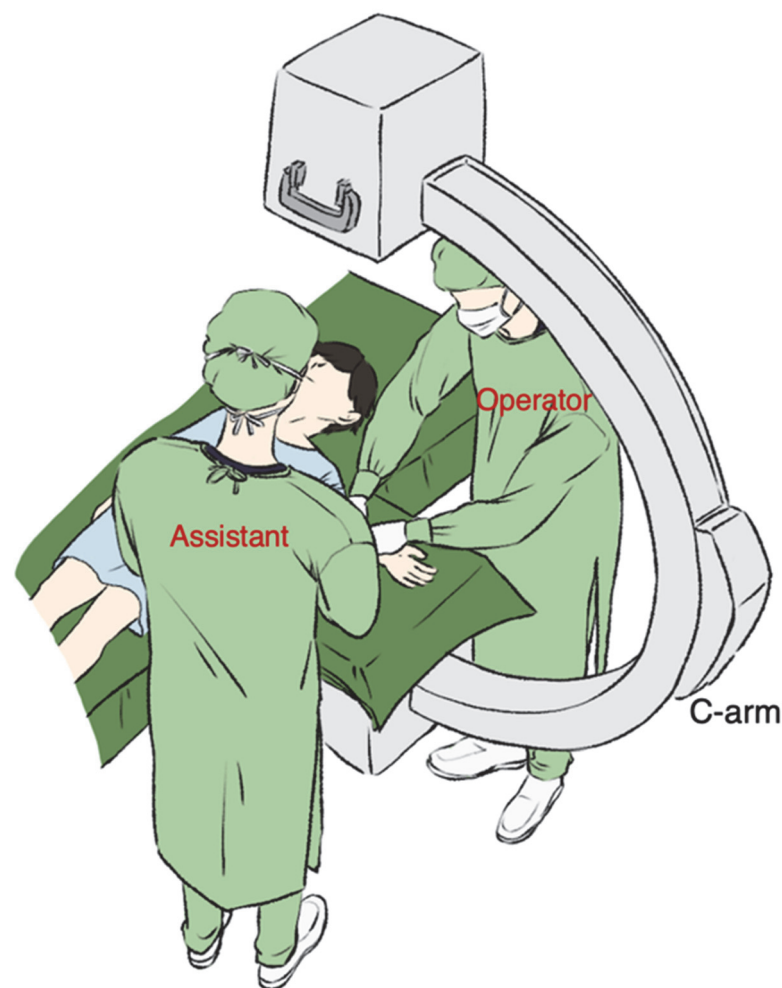


Figure 1. Arrangement of the operating table and image intensifier.

The injured arm was disinfected and draped in a standard sterile manner. Reduction began under anteroposterior (AP) fluoroscopic view. Coronal translation and rotation of

the distal fragment were corrected under AP view, after which the view was switched to lateral fluoroscopy to restore sagittal alignment. Sagittal reduction was performed using the joystick method: the surgeon inserted the blunt end of a Kirschner wire (K-wire) into the fracture site and used it as a lever to correct sagittal-plane malalignment (Figure 2).

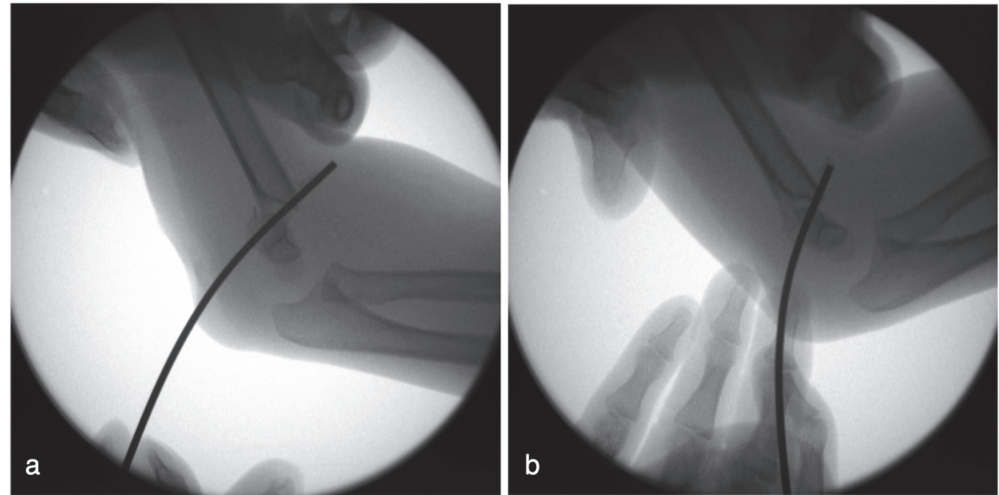


Figure 2. Reduction in sagittal-plane malalignment using the joystick method. (a) Blunt end of a K-wire inserted into the fracture site. (b) Restored sagittal alignment.

If reduction was unsatisfactory, the surgeon made fine adjustments by applying gentle thumb pressure over the distal fragment. Once acceptable reduction was achieved, fixation was performed using a configuration of two lateral pins and one medial pin. A K-wire was inserted diagonally from the lateral condyle, through the fracture, to engage the medial supracondylar ridge. A second lateral-entry pin was then inserted more medially on the lateral condyle, either divergent from or parallel to the first pin, to further stabilize the fracture (Figure 3a). After inserting the two lateral K-wires, we assessed fixation stability by flexing, extending, and rotating the elbow. If instability was observed (for example, relative displacement or angular change under C-arm fluoroscopy), we proceeded to place a medial pin. The elbow was then held in approximately 60° flexion. Because the lateral pins stabilized the fragments, mild extension maintained alignment and relaxed the ulnar nerve, reducing the risk of anterior subluxation (Figure 3b). We identified the medial epicondyle by palpation. If swelling precluded palpation, we used C-arm fluoroscopy to confirm the positions of the medial epicondyle and the ulnar groove. A 1.6 mm smooth K-wire was secured in a universal chuck and held by the surgeon. The K-wire penetrated the skin over the medial epicondyle, and its tip was advanced toward the anteromedial aspect of the epicondyle. After the K-wire touched the bone, we verified the entry point under C-arm fluoroscopy. Care was taken not to insert the K-wire through the ulnar groove or the posterior aspect of the epicondyle (Figure 3c) to limit the risk of ulnar nerve penetration or irritation. The cortex of the medial epicondyle was punctured after confirming the K-wire trajectory under image guidance. The wire was then advanced manually using oscillatory clockwise–counterclockwise rotation until bicortical fixation was achieved (Figures 3d and 4).

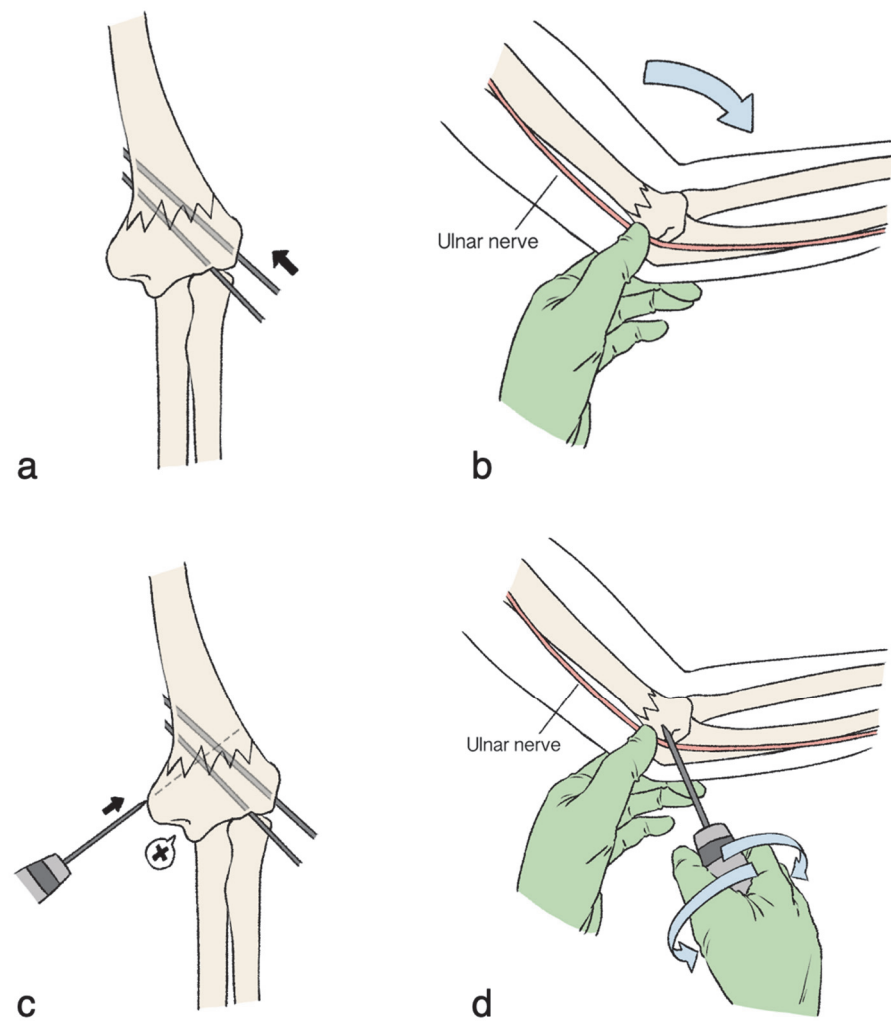


Figure 3. Fixation steps. (a) Initial stabilization with two lateral-entry pins. (b) Elbow extension relaxes the ulnar nerve. (c) Medial pin entry point checked with the C-arm to avoid inserting the K-wire through the ulnar groove. (d) K-wire held with a pin chuck and advanced manually using oscillating clockwise–counterclockwise rotation until engaging the far cortex.

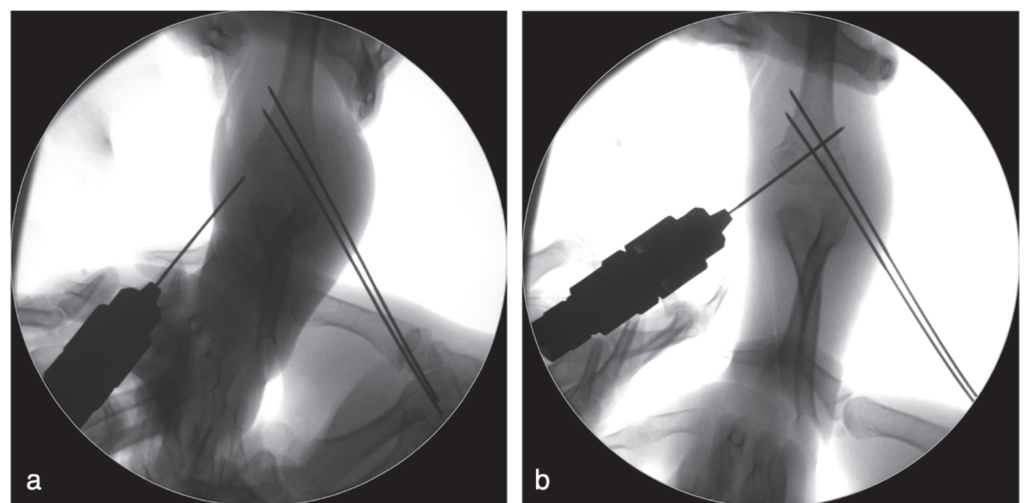


Figure 4. Radiographs before (a) and after (b) manual medial pin insertion.

The manual oscillation technique avoided twisting soft tissues, including the ulnar nerve, thereby reducing the risk of nerve injury. Final radiographs were obtained to confirm

reduction and pin configuration. The pins were bent and cut, and a long-arm cast was applied to immobilize the elbow in 70–80° flexion. The surgical steps are summarized in Table 1.

Table 1. Summary of surgical steps.

Step	Description
Patient positioning	Supine on the operating table; the injured limb is placed under the image intensifier; the C-arm is positioned perpendicular to the table.
Preparation	The injured arm was disinfected and draped.
Fracture reduction	Reduction is performed first in AP view to correct coronal translation and rotation, then in lateral view to reduce the sagittal plane using the joystick method with a blunt K-wire. Fine adjustment of the distal fragment follows.
Lateral pinning (two pins)	The first K-wire is inserted diagonally from the lateral condyle across the fracture; the second lateral-entry pin is then inserted (parallel or divergent). Stability is assessed by elbow motion and fluoroscopy.
Medial pinning (one pin)	The elbow is held at 60° flexion (to relax the ulnar nerve); the medial epicondyle is palpated or confirmed with fluoroscopy; a K-wire is inserted with a hand-held universal chuck to bone; the entry point and trajectory of the K-wire are verified with C-arm fluoroscopy; the pin is advanced manually with oscillatory motion until bicortical fixation is achieved.
Final steps	Radiographs are obtained to confirm reduction and pin configuration; the pins are bent and cut; a long-arm cast is applied with the elbow at 70–80° flexion.

The patient was discharged 1–2 days later once limb swelling stabilized and was followed up 1 week postoperatively at the clinic. Radiographs were obtained in both anteroposterior and lateral views. The patient was seen again at 3 weeks. Cast and pin removal was typically performed 3–4 weeks after surgery. When proper healing was confirmed, elbow motion was encouraged. The patient was followed monthly until complete bone union and restoration of elbow function were confirmed.

Outcome Assessment

Neurological outcomes were assessed by standardized physical examination performed by attending pediatric orthopedic surgeons preoperatively, postoperatively, and at each outpatient follow-up. Sensory testing with light touch was carried out over the median, radial, and ulnar nerve distributions, with the contralateral side used for comparison. Motor function was evaluated through representative maneuvers: thumb and index finger flexion for the median nerve, wrist and finger extension for the radial nerve, and finger abduction/adduction and pinch testing for the ulnar nerve. All examinations were consistently documented in the medical records to ensure reliability.

Radiographic union was defined as the presence of bridging callus across at least three of four cortices on AP and lateral radiographs, combined with a clinical absence of tenderness or motion at the fracture site. Malunion was defined as a loss of Baumann's angle greater than 15° compared to the contralateral side. Nonunion was defined as the absence of radiographic union by 6 months post-surgery. Final functional outcomes were assessed by measuring the active range of motion (ROM) of the elbow. Final radiographic outcomes were evaluated using Baumann's angle on the AP view.

All patient records were systematically reviewed for both major and minor complications. Major complications were defined as iatrogenic ulnar neuropathy, nonunion, or malunion. Minor complications were defined and graded as follows:

- Pin-tract infection: Graded using a simplified classification. Minor pin-tract infection was defined as localized erythema or drainage at the pin site that resolved with enhanced pin care and/or a course of oral antibiotics. Major pin-tract infection was defined as deep infection requiring intravenous antibiotics or surgical debridement.
- Cast-related complications: Included any issues necessitating cast change or splitting, such as excessive swelling, skin breakdown, unusual patient-reported pain, or the presence of a foul odor.
- Pin migration: Defined as any loss of pin position requiring re-intervention or reoperation.

Statistical analysis

The demographic data and neurological outcomes were evaluated using descriptive statistics.

3. Results

We included 40 patients (16 boys, 24 girls; mean age 6.6 ± 2.2 years, range 2–14). Most injuries involved the left arm (57.5%, $n = 23$) compared with the right (42.5%, $n = 17$). Of these, 87.5% (35/40) had Gartland type III injuries and 12.5% (5/40) had Gartland type IV injuries (Table 2). Radiographic union was achieved in all patients. No cases of non-union were reported. The mean time to union was 5.7 ± 1.2 weeks (median 6 weeks; range 4–8 weeks). The mean follow-up duration was 13.1 ± 6.0 weeks (median 12 weeks; range 8–32 weeks). At the final follow-up, the mean elbow ROM was 135 ± 13 degrees, and the mean Baumann's angle was 73 ± 5 degrees.

Table 2. Baseline clinical patient data.

Factor	Value
Number of patients	40
Gender	
Boys	16 (40%)
Girls	24 (60%)
Age (years)	6.6 ± 2.2 (2–14)
Injury side	
Right	17 (42.5%)
Left	23 (57.5%)
Gartland classification	
Type III	35 (87.5%)
Type IV	5 (12.5%)
Nerve injury	
Preoperative	8
AIN	6
Radial nerve	1
Ulnar nerve	1
Postoperative (iatrogenic)	0

AIN: anterior interosseous nerve.

Eight patients presented with preoperative nerve deficits: six anterior interosseous nerve (AIN) palsies, one radial nerve palsy, and one ulnar nerve neuropraxia (numbness in the fourth and fifth fingers). All patients underwent closed reduction and percutaneous crossed-pin fixation (two lateral and one medial K-wire). All preoperative neurological symptoms resolved by final follow-up. No new postoperative ulnar neuropathies occurred.

In the patient with preoperative ulnar neuropraxia, symptoms did not worsen postoperatively and resolved fully within 2 months. For minor complications, our systematic case review confirmed that there were no instances of pin-tract infection, cast complications, or pin migration requiring reoperation in this cohort.

All operations were performed by one of three attending orthopedic surgeons with varying levels of experience (senior, intermediate, junior) or by a chief resident under direct supervision. The technique was readily adoptable and reproducible, with consistent clinical outcomes observed across all operators, indicating that efficacy is not dependent on senior-level surgical experience.

The mean operative time was 73.0 ± 18.0 min (median: 65.0; range: 50–120). Operative times showed reasonable consistency, with a low coefficient of variation (24.7%). The distribution of times reflected an efficient surgical workflow and high procedural stability.

4. Discussion

Displaced supracondylar humerus fractures in pediatric patients are managed surgically. Two main pin configurations are used: crossed pins (medial and lateral) and lateral-only pins. In a randomized prospective study, Kocher et al. the medial crossed-pin technique significantly reduced the risk of loss of reduction (4%) compared with lateral-only fixation (21%) [9]. Other studies have shown that two lateral pins often fail to provide adequate stability or prevent displacement in most Gartland type III fractures [10,11]. The crossed-pin technique provides more mechanical stability [5,12] and is recommended for Gartland types III or IV PSHFs [6]. However, despite their stability, crossed-pin configurations raise concerns of iatrogenic ulnar nerve injury from medial K-wire insertion. Previous studies reported iatrogenic ulnar nerve injury rates of 4.1–6% [13,14]. The AAOS Clinical Practice Guidelines therefore recommend avoiding medial-entry pins [15], although crossed-pin configurations remain indicated in certain cases.

The classical configuration of two lateral pins plus a medial pin has undergone several modifications to reduce the risk of iatrogenic ulnar nerve injury [9,16–21]. Proposed strategies include mini-open approaches to expose the ulnar nerve [9,16,21], ultrasound-guided pinning, or intraoperative nerve monitoring [19]. However, mini-open incisions require extra wound care and leave additional scars, while ultrasound and neural stimulation require specialized equipment and training. Surgeons may thus prefer closed methods that avoid additional equipment or surgical wounds.

Several closed methods have been proposed in the literature. Elbow extension relaxes the ulnar nerve and decreases the risk of entrapment over the medial epicondyle. Previous studies have examined elbow position during medial pin insertion [17,18,22,23]. Edmonds et al. reduced the nerve injury rate to 1% by inserting the medial pin with the elbow extended and the nerve protected by the thumb in the cubital tunnel [18]. Georgiadis et al. used a flexion–extension–external rotation technique without reporting ulnar nerve neurapraxias [22]. Wong et al. [17] inserted lateral pins first, then inserted the medial K-wire at approximately 80° flexion while protecting the nerve with the thumb and advancing the tip along the anterior medial epicondyle.

Our method begins with lateral-pin insertion, which stabilizes the fragments and allows elbow extension to approximately 60°. Extension loosens ulnar nerve tension and limits anterior subluxation. This step aligns with previously described techniques. In addition, we confirm medial pin entry with palpation, tactile feedback, and image intensification—a triple safety process.

The final step involves manual medial pin insertion using oscillating clockwise–counterclockwise motion. This technique has three advantages. First, hand-held insertion allows precise control and tactile feedback. Second, inserting directly after pin-position con-

firmation prevents loss of contact with the ideal entry point when connecting a handpiece and reduces multiple passes, which could increase the risk of ulnar nerve injury. Third, manual oscillation rather than powered drilling avoids soft tissue twisting and catastrophic ulnar nerve injury.

We avoided powered drilling because manual mode produces smaller torque and speed, making it less harmful to human tissue. Anderson et al. reported that oscillating K-wire insertion generates less heat than powered drilling [24]. Manual oscillation further reduces the risk of thermal necrosis in soft tissue and bone.

Some surgeons may question whether manual pin advancement can reliably cross cortical bone. Pediatric bone is less dense, more porous, and more pliable than adult bone, with a lower modulus of elasticity. In our series (mean age 6.6 years; maximum 14 years), manual medial pin passage through the cortex was consistently successful, requiring only 1–2 min, and no insertion difficulties were observed.

Although precise insertion times and attempt counts were unavailable, the overall consistency of operative times across 40 patients and surgeons with varying experience indirectly supports the technique's feasibility and manageable learning curve. The mean operative time was 73.0 ± 18.0 min (median 65.0; range 50–120), with a low coefficient of variation (24.7%). This variation likely reflects differences in patient anatomy and reduction difficulty rather than instability of the technique itself.

Notable limitations of this study include its retrospective design and the absence of a control group, which preclude claims of superiority over existing methods. Retrospective data collection also limited objective intraoperative analysis, including medial pin insertion time, number of attempts, and bone–pin interface temperatures. Future prospective studies should incorporate these measures to rigorously evaluate the safety and efficiency of manual oscillation compared with conventional power-driven methods. Neurological outcomes were derived from chart records, so undocumented postoperative neurological deficits could not be identified. Nevertheless, because postoperative neurological symptoms are routinely recorded in our hospital and follow-up was conducted by the operating orthopedic surgeon, the likelihood of omission was minimal.

5. Conclusions

This study presents a step-by-step modified technique for medial pin insertion to treat PSHFs. Careful attention to elbow position, entry point, pin holding, and manual passage may help minimize iatrogenic ulnar nerve injury during medial pin placement.

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Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Kaohsiung Veterans General Hospital (KSVG21-CT7-06, 14 July 2021).

Informed Consent Statement: Patient consent was waived by the Institutional Review Board of Kaohsiung Veterans General Hospital due to the retrospective design of the study and anonymization of patient data.

Data Availability Statement: All data generated or analyzed during this study are included in this article.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

PSHF	Pediatric supracondylar humerus fracture
K-wire	Kirschner wire
AIN	Anterior interosseous nerve

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