Original Article

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# Evaluating Outcomes of Step-Cut Osteotomy for Pediatric Cubitus Deformities

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**Learning Point of the Article:**

This manuscript provides a comprehensive overview of step-cut osteotomy for pediatric cubitus deformities. It covers the causes, surgical technique, outcomes, and complications associated with this procedure, as well as the knowledge needed to make informed decisions about its application in clinical practice.

## Abstract

**Introduction:** Supracondylar fractures in children often result in malunion and subsequent cubitus varus or valgus deformity. While often considered cosmetic, these deformities can lead to pain, functional impairment, and other complications. Corrective osteotomy is a common treatment option, with step-cut osteotomy being a preferred method due to its effectiveness and relative simplicity. This study aims to evaluate the outcomes of step-cut osteotomy in correcting post-traumatic cubitus deformities.

**Materials and Methods:** A prospective cohort study was conducted on patients presenting with post-traumatic cubitus varus or valgus deformity. Pre-operative evaluation included clinical and radiological assessment of the deformity. Step-cut osteotomy was performed, followed by rigid fixation with a recon plate. Post-operative outcomes were assessed in terms of deformity correction, range of motion (ROM), and complications.

**Results:** The study included 10 patients (8 male, 2 female) with a mean age of 9.6 years. The mean pre-operative carrying angle was 25.25° varus, corrected to 3.37° valgus postoperatively. Significant improvement in ROM and humerus-elbow-wrist angle was observed. While the lateral prominence index decreased, it was not statistically significant. Excellent or good results were achieved in 80% of patients. One patient experienced transient radial nerve palsy.

**Discussion:** Step-cut osteotomy effectively corrected cubitus deformities with minimal complications. While it primarily addresses coronal plane deformity, satisfactory outcomes were achieved without correction of rotational deformity. Rigid fixation with a recon plate provided stability and allowed for early mobilization. The study's limitations include a small sample size and the inability to conduct adequate follow-up due to the COVID-19 pandemic.

**Conclusion:** Step-cut osteotomy is a reliable and effective treatment option for post-traumatic cubitus varus and valgus deformities in children. It demonstrates good to excellent outcomes in terms of deformity correction, ROM, and functional improvement, with a low complication rate. Further studies with larger sample sizes and longer follow-up periods are warranted to strengthen these findings.

**Keywords:** Step-cut osteotomy, cubitus varus, cubitus valgus, supracondylar fracture, pediatric orthopedics.

## Introduction

Cubitus deformities, characterized by angular deviations of the elbow joint, are common sequelae of supracondylar fractures in children. While often considered cosmetic, these deformities can lead to significant functional impairment, pain, and psychological distress. The degree of deformity and its impact on daily activities vary widely among individuals.

Traditional treatment approaches for cubitus deformities have

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*Author's Photo Gallery*

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**Table 1:** Summary of all the observations.

| | Pre-operative | Post-operative | p value |
|---|---|---|---|
| Angle of deformity (degrees) | 30.5 | 5.9 | 0.005 |
| Range of motion (degrees) | 106 | 114.5 | 0.042 |
| Hew angle (degrees) | 18.25 VARUS | 9.8 VALGUS | 0.012 |
| Lateral prominance index | -0.5 | -0.2 | 0.762 |

**Table 2:** Results according to Oppenheim criteria

| Result | Carrying Angle (Degree) Difference From Normal Side | Loss Of Range Of Motion (Degree) | Complication | Results |
|---|---|---|---|---|
| Excellent | <5 | <5 | NO | 4 (40%) |
| Good | <10 | <10 | NO | 4 (40%) |
| Poor | >10 | >10 | YES | 2 (20%) |

evolved over time. In the past, conservative management, including bracing and splinting, was often attempted. However, these methods frequently failed to achieve satisfactory correction, especially in severe cases. As a result, surgical intervention has become the preferred treatment option for many patients.

Supracondylar fractures are very commonly encountered injuries in the skeletally immature pediatric population. The metaphysis of the distal humerus is an area of transition from a tubular configuration to a more flattened triangular cross-section and hence, it is most susceptible to fractures in this population. Anatomical peculiarity and ligamentous laxity in this age group predispose pediatric patients to supracondylar fractures of the humerus. Typically, mal-union of supracondylar fractures often leads to a cubitus varus, or classical "gunstock deformity." Cubitus varus is frequently regarded as a purely cosmetic problem in children, but occasionally it causes late-onset lateral elbow pain, symptomatic elbow posterolateral rotatory instability, triceps snapping, progressive ulnar and elbow joint varus, ulnar neuropathy, or rarely, predisposes to lateral humeral condyle fractures [1]. For this reason, it may be appropriate to offer surgical treatment in the vast majority of patients with this complaint. Various treatment options have been proposed including observation, hemiepiphysiodesis and growth alteration, and corrective osteotomy [2]. Corrective osteotomy is the preferred method, as it yields the highest probability of success [3]. All osteotomies have their own advantage and disadvantages, but no consensus has been made regarding which osteotomy is the best for deformity correction [4-7].


**Figure 1:** (a, b, c, d, e, f) demonstrating operative steps of step cut osteotomy: (a) an incision given over posterior aspect of forearm till olecranon in lateral position; (b) distal humerus exposed by retracting the muscles and; (c) triangle marked to be osteotomized; (d) after osteotomy of distal humerus; (e) Osteotomy ends held temporarily with K-wires; and (f) Final fixation with recon plate.

## Aims and objectives

The aims of this study were as follows:

1. To study the result of step-cut osteotomy in post-traumatic cubitus varus and valgus deformities
2. To study the degree of correction and range of motion (ROM)
3. To study the complications of step-cut osteotomy.

## Materials and Methods

A prospective cohort study was conducted in which all the patients presenting with post-traumatic cubitus varus and valgus deformity in our outpatient clinics between November 2019 and November 2021 were considered. All patients with post-traumatic cubitus varus and valgus deformity which was cosmetically and functionally unacceptable were included in the study. A complete demographic, personal, and clinical history was taken regarding the injury, treatment after injury, deformity, and duration. Written informed consent was taken from all

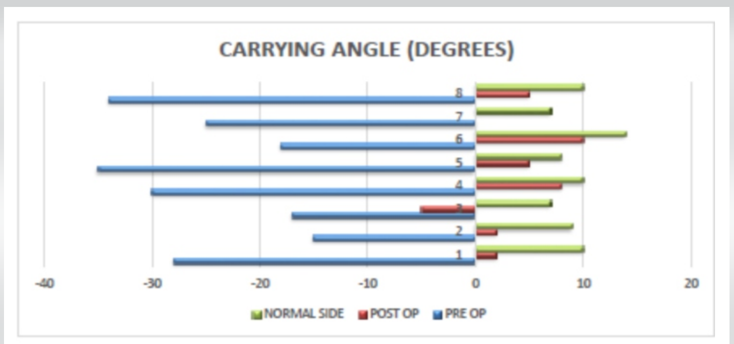


**Figure 2:** Bar diagram showing carrying angle before and after surgery and carrying angle on the normal side in cubitus varus patient.

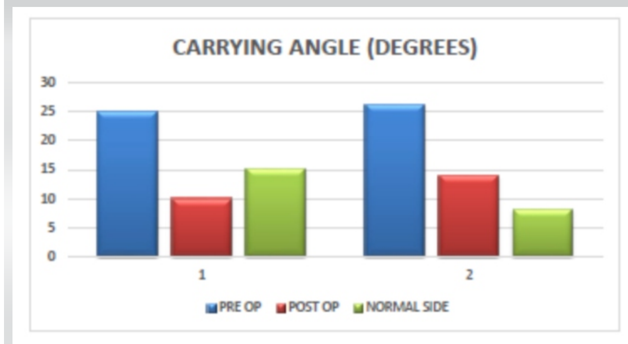


**Figure 3:** Bar diagram showing carrying angle before and after surgery and carrying angle on normal side in cubitus valgus patients.

study participants. Confidentiality and privacy were ensured at all stages.

The pre-operative evaluation included measurement of carrying angle and ROM using a goniometer. Radiological measurements of humerus Elbow Wrist (HEW) angle and lateral prominence index (LPI) were done on anteroposterior radiographs on the affected side.

## Surgical technique

All the patients were operated in either regional (brachial) anesthesia or general anesthesia. All the patients were operated in the lateral position (Fig. 1a). A tourniquet was applied and inflated after exsanguination with Esmarch. All the patients were operated on by posterior Campbell approach (triceps splitting approach). An incision of around 10 cm was given over the posterior aspect of the distal arm extending up to the tip of olecranon (Fig. 1b). An intermuscular plane was made between the long and lateral head of triceps (Fig. 1c). A triangle to be osteotomized was marked with the help of electrocautery. The medial angle of the triangle was equal to the deformity correction angle and the medial arm is longer than the lateral arm (Fig. 1d). Osteotomy was done with the oscillating saw (Fig. 1e). Osteotomized ends were temporarily fixed with K-wire and intraoperative deformity correction and ROM were assessed. Final fixation was done with a recon plate on the posterolateral surface (Fig. 1f). After fixation size and position of screws were checked under C-arm, wound was washed thoroughly with normal saline and closed in layers. The above elbow slab was applied. Stitch removal was done on the 12th day post-operative and elbow physiotherapy started. X-ray was done after 6 weeks post-operative follow-up to see the radiological union. After that, patients were followed every 3 months. Post-operative evaluation was done similar to the pre-operative evaluation, and the final result was calculated according to Oppenheim's criteria [4].

## Results

A total of 10 patients underwent step-cut osteotomy, of which eight were male and two were female. The mean age of the patients was 9.6 years (Range: 6–16 years). Eight patients had varus deformity while two had valgus deformity. The left side was involved in nine of the patients while one of the patients had right side involvement. The right side was the dominant side in all the patients.

The mean pre-operative carrying angle was 25.25° varus (range 15–35°) and it was 3.37° valgus (range: 5° varus–10° valgus) postoperatively. The mean carrying angle on the normal side was 9.37° valgus (range: 7–14°). The mean correction was 28.62 (range 11–41°) (Fig. 2).

The mean pre-operative carrying angle was 25.5 valgus (range 25–26°) and it was 12° valgus (range: 10–14°) postoperatively. The mean carrying angle on the normal side was 12.5° valgus

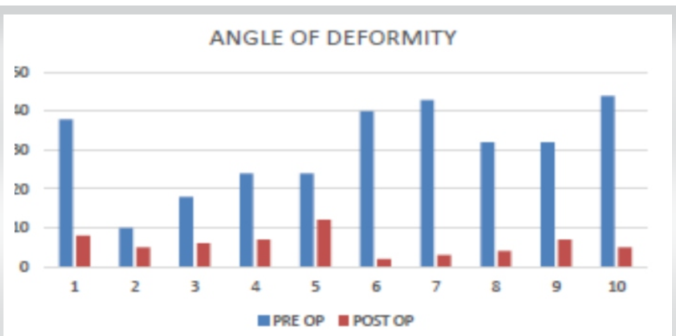


**Figure 4:** Bar diagram comparing the angle of deformity before and after correction.

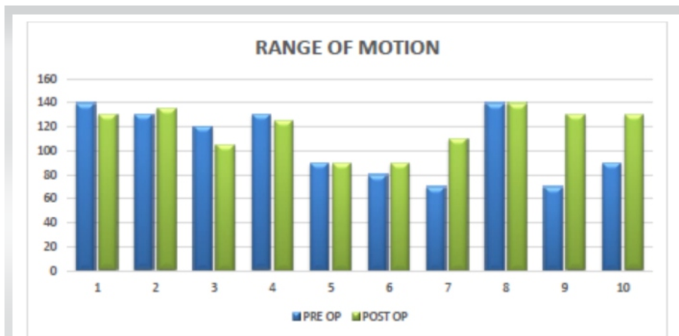


**Figure 5:** Bar diagram comparing range of motion before and after correction.

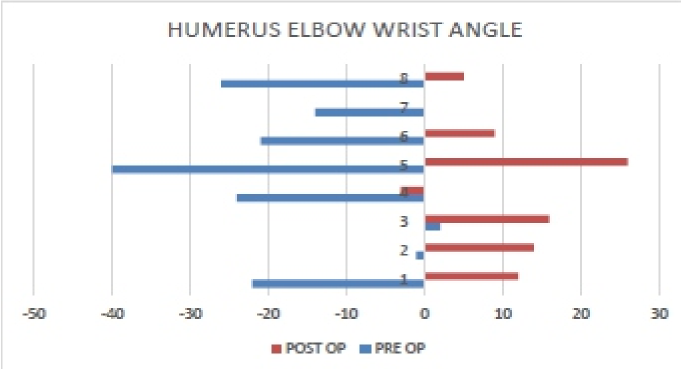


**Figure 6:** Bar diagram comparing humerus Elbow Wrist angle before and after correction.

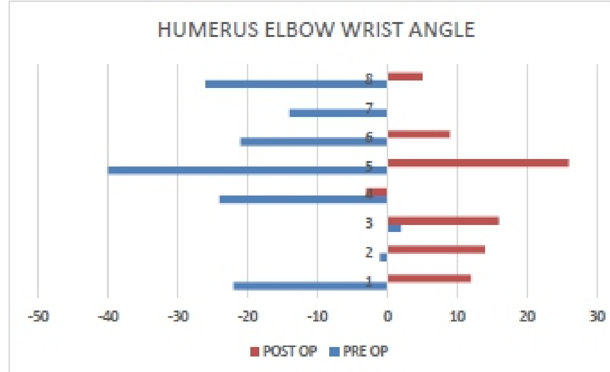


**Figure 7:** Bar diagram comparing lateral condylar prominence index before and after correction.

(range: 8–15°). Mean correction was 13.5° (range 12–15) (Fig. 3).

The mean pre-operative angle of deformity compared to the normal side was 30.5 (range 10–44°) and it was 5.9 (range 2–12°) postoperatively. Which was found to be significant (P = 0.005) (Fig. 4).

The mean pre-operative ROM was 106 (range: 70–140°) and it was 118.5 (range: 90–140°) postoperatively, which was found to be significant (P = 0.042) (Fig. 5).

The mean pre-operative HEW angle was 18.25° varus (range: 1–40°) and it was 9.8° valgus (range: 3° varus–26° valgus) postoperatively, which was found to be significant (P = 0.012) (Fig. 6).

The mean pre-operative lateral condylar prominence index (LCPI) was −0.5 (range: −4.2–2) and it was −0.2 (range: −2–4) postoperatively. It was found insignificant (P = 0.762) (Fig. 7) (Table 1).

The final outcome was calculated according to Oppenheim's criteria, which showed that four (40%) patients had excellent, four (40%) patients had good and two (20%) patients had poor results (Table 2).

## Discussion

Cubitus varus deformity results from malunion of supracondylar fracture which is non-progressive and does not correct with time [4-7]. The distal fragment is in varus, extension, and internal rotation. Most of the authors have recommended early intervention once the fracture has united and the elbow ROM has been gained [4, 6, 8]. A number of corrective surgeries have been described in the literature. However, till now there is no consensus about which method of correction is best [4-8]. The primary indication for the correction is cosmetic correction. However, some authors have reported pain, functional impairment, and delayed onset neuropathy as the indication for surgical correction of the deformity [9-14]. Increased incidence of lateral condyle fractures has been reported. However, in our study, the indication of surgery was a cosmetic correction in all the patients. No patient had pain, functional impairment, neuropathy, or lateral condyle fracture.

Step-cut osteotomy corrects only coronal deformity. Many multi-planer osteotomies have been described in literature like dome osteotomy which corrects coronal, sagittal, and rotational deformities simultaneously. However, it is technically demanding and unstable [15]. Takagi et al. [16] reported no significant difference between the group that underwent both coronal plane and rotational correction and the group with only coronal plane deformity also, hyperextension need not to be corrected when correcting coronal plane deformity in <10 years old patient as sagittal plane remodeling occurs with time. North et al. [17] reported adequate remodeling of the hyperextension deformity in children <10 years of age and the internal rotation deformity is well tolerated by the patient. Excessive derotation may lead to the formation of an anterior bulge with restriction of flexion [15]. Therefore, we could achieve satisfactory results despite the non-correction of rotational deformity.

Rigid fixation is required to avoid non-union and achieve good results. Davids et al. [10] used multiple K-wires for the fixation of the osteotomy. On the other hand, Kim et al. [18] used a Y-plate for the fixation of step-cut osteotomy. Dhruvas [19] fixed the osteotomy with a T-plate and Bali et al. [20] used a posteriorly positioned plate for osteotomy fixation. A rigid fixation is required to prevent loss of correction particularly in older children and for early physiotherapy. In our study, we used a recon plate for the fixation of osteotomy with excellent results as there was no loss of fixation.

The mean age of the patients in our study was 9.8 years. Anjum et al. [21] studied the epidemiological pattern of supracondylar fracture in 263 patients; the mean age was 7.9 years. On the other hand, Barr [22] reported that the median age of supracondylar fracture in 163 patients was 6.1 years. The higher mean age in our study is probably due late presentation of the patient. Furthermore, most of our patients presented after 1 year of primary injury. In our study, 9 (90%) out of 10 patients has non-dominant side involvement. In the study by Mangwani et al. [23], 61% of patients had non-dominant limb involvement. Herdea et al. [24] also reported an increased incidence of supracondylar fracture on the non-dominant side probably due to children tend to protect their dominant hand by falling on their non-dominant one. In our study, the mean pre-operative angle of deformity compared to the normal side was 30.5 (range 10–44°) and it was 5.9 (range 2–12°) postoperatively. Similarly, in the study by Kim et al. [25], the mean pre-operative angle of the deformity was 29.1° and it was 3.2° postoperatively. In the study performed by Davids et al. [10], the mean pre-operative deformity was 33° and 8° postoperatively. In a different type of study (Dome osteotomy) done by Pankaj et al. [26], the mean carrying angle was 21.5° varus (range: 15–30°) preoperatively and 10.8° valgus (range: 5–15°) postoperatively. Deformity correction in our study was comparable to the study by the above-described authors.

In our study, the mean pre-operative ROM was 106° (range: 70–140°) and it was 118.5° (range: 90–140°) postoperatively. Similarly, in the study by Davids et al. [10] on step-cut osteotomy mean pre-operative ROM was 127° and 130.5° postoperatively. On the other hand, in the study conducted by Kim et al. [25] on step-cut osteotomy, there was a loss of ROM by 2.5°. North et al. [17] reported 126.6° ROM before surgery and 120° after surgery although he managed patients by modified French osteotomy. The mean ROM increased significantly after surgery in our study probably due to rigid fixation and supervised physiotherapy.

In our study, the mean pre-operative HEW angle was 18.25° varus and it was 9.8° valgus postoperatively. In the study by Davids et al. [10], the mean HEW angle was 16° varus before the surgery and 9° valgus after the surgery. In the study by Kim et al. [25] the mean pre-operative HEW was 18.9° varus and it was 7° valgus postoperatively. North et al. [17] reported HEW angle 21° varus before the surgery and 11.2° valgus after the surgery. The above-mentioned authors reported correction of deformity similar to our study.

One of the drawbacks of lateral closing wedge osteotomy is lateral bony prominence. Voss et al. [27] reported 42% of patients developed lateral bony prominence while Barrett et al. [28] found lateral prominence in 47% of the patients postoperatively after lateral closing wedge osteotomy [29, 30]. Furthermore, North et al. [17] reported an increased LPI (0.14) after modified French osteotomy. On the other hand, in our study, mean LPI was reduced from −0.5 in pre-operative (range: −4.2–2) to −0.2 in post-operative (range: −2–4). Even though it was reduced, it was statistically insignificant ($P = 0.762$). In the study by Davids et al. [10], the mean pre-operative LCPI was −0.02 and 0.1 postoperatively after the step-cut osteotomy. In a study by Pankaj et al. [26], on the dome osteotomy the mean pre-operative LPI was 0.3 and post-operative LPI was −2.6. LPI increases in modified French osteotomy and lateral closing wedge osteotomy while there is no increment in LPI in the step-cut osteotomy.

The result was assessed by Oppenheim criteria. In our study, 4 (40%) patients had excellent result, and 4 (40%) patients had good result. In the other two patients (20%), there was a poor result. Among the patients with poor results, one patient had residual cubitus varus deformity of 5° while another patient had a loss of ROM of 15°. In the study by Kim et al. [25], 21 (67.7%) patients had excellent, 7 (22.6%) patients had good and 3 (9.8%) patients had poor results. Bali et al. [20] reported excellent results in 8 (57.1%) patients, good results in 5 (35.7%) patients, and poor results in 1 (11.7%) patient. They had more patients with excellent results when compared to our study. Kim et al. [18] reported excellent results in 7 (41.1%) patients, good results in 8 (47.0%) patients and poor results in 2 (11.7%) patients and the results were similar to our study. Most of our patients had either excellent or good result as seen in the studies done by most of the authors.

The only complication in our study was transient radial nerve palsy which resolved spontaneously at 3 months follow-up. Kim et al. [19] and Davids et al. [10] also reported transient radial nerve palsy in one patient. In the study by Raney et al. [31], loss of reduction was seen in 3 (4%) patients, non-union was seen in 2 (3%) patients, unacceptable scar was seen in one (1%) patient, osteomyelitis was seen in one (1%) patient and growth arrest was seen in one (1%) patient. However, no such complications occurred in our study.

### Limitations

Our study has a few limitations. First, step-cut osteotomy corrects only coronal plane deformity without correcting coronal plane and rotational deformities. Second, our sample size was small. Third, due to COVID-19 pandemic, proper follow-up could not be done.

## Conclusion

In this study, after comparing the pre- and post-operative carrying angles, ROM, HEW angle, and lateral condyle prominence index, and calculating the results using Oppenheim's criteria, it was observed that step-cut osteotomy corrects the post-traumatic-cubitus varus and valgus deformities with excellent to good results without causing any lateral prominence or any loss of ROM with satisfactory outcomes.

**Clinical Message**

Step-cut osteotomy is a reliable and effective surgical option for correcting cubitus varus and valgus deformities in children. It offers excellent outcomes in terms of deformity correction, ROM, and functional improvement. While complications are relatively rare, early diagnosis and timely intervention are crucial to minimize long-term sequelae.

**Declaration of patient consent:** The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

**Conflict of interest:** Nil **Source of support:** None

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**Consent:** The authors confirm that informed consent was obtained from the patient for publication of this case report

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