

Oblique Close Wedge versus Modified Step Cut Osteotomy for Cubitus Varus Deformity in Children: A Prospective Non-Randomized Study

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Learning Point of the Article:

Precise deformity correction planning and execution, not osteotomy type, drives success in cubitus varus deformity. Oblique closing-wedge and modified step-cut osteotomies both deliver an equivalent, reliable, and reproducible outcome in pediatric cubitus varus correction.

Abstract

Introduction: Cubitus varus is a delayed complication of neglected supracondylar humerus fractures in children. Both oblique closing-wedge and modified step-cut osteotomies are widely used corrective techniques, but prospective comparative data are limited.

Materials and Methods: In this prospective non-randomized comparative study, 30 patients with cubitus varus deformity were divided into two groups: Oblique closing-wedge osteotomy (Group 1, n = 15) and modified step-cut osteotomy (Group 2, n = 15). Radiological correction was assessed using carrying angle, and functional outcomes were evaluated using elbow flexion-extension arc, pronosupination arc, and Mayo elbow performance score (MEPS). Radiological union time was recorded. Statistical analysis was performed using an independent t-test and Chi-square test.

Results: The mean age was 14.9 ± 2.7 years, with comparable baseline characteristics between groups ($P = 0.741$). Both groups showed significant deformity correction, with mean post-operative carrying angles of $13.0^\circ \pm 4.9^\circ$ and $11.5^\circ \pm 5.6^\circ$, respectively ($P = 0.432$). The mean MEPS was 88.0 ± 7.8 in Group 1 and 90.0 ± 8.7 in Group 2 ($P = 0.511$). Elbow flexion extension arc, pronosupination arc, and union time were similar between groups ($P > 0.05$). Both the osteotomies achieved radiological union. The mean follow-up duration was 14.2 ± 2.8 months.

Conclusion: Both oblique closing-wedge and modified step-cut osteotomies provide effective correction of cubitus varus with comparable radiological and functional outcomes. Both techniques are safe and reliable options in children.

Keywords: Cubitus varus, corrective osteotomy, step-cut osteotomy, closing-wedge osteotomy, pediatric elbow.

Introduction

Cubitus varus deformity is the most common delayed complication of malunited supracondylar fractures of the humerus in children [1,2]. Conventionally, it is considered a cosmetic deformity, but at the skeletal level, it involves a complex three-dimensional malalignment consisting of varus, internal rotation, and extension deformity [3]. In the long run, cubitus

varus leads to functional limitations, tardy ulnar nerve palsy, posterolateral rotatory instability of the elbow, secondary lateral condyle fractures, and psychological distress [4,5,6].

Various types of corrective distal humeral osteotomy are the treatment of choice for symptomatic or cosmetically unacceptable cubitus varus deformity [2,7]. Numerous techniques have been described including lateral closing-wedge,

Access this article online

Website:
www.jocr.co.in

DOI:
<https://doi.org/10.13107/jocr.2026.v16.i06.7444>

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Submitted: 07/03/2026; Review: 10/04/2026; Accepted: May 2026; Published: June 2026

DOI: <https://doi.org/10.13107/jocr.2026.v16.i06.7444>

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dome, step-cut, penta-lateral, and three-dimensional osteotomies [8,9,10]. Among these, the lateral closing-wedge osteotomy continues to be the most commonly performed technique because relatively simple pre-operative planning is required to correct the coronal plane deformity [2,11]. However, conventional lateral closing-wedge osteotomy has certain specific complications such as lateral condylar prominence, loss of fixation, and suboptimal cosmetic outcome [1, 11].

Several modifications have been proposed in the literature. Oblique lateral closing-wedge osteotomy is one such technique, which alters the orientation of the osteotomy cut to reduce lateral condyle prominence [12]. The modified step-cut osteotomy is another technique that was developed to improve

intrinsic stability by providing an interlocking configuration of bone and also reducing the lateral condyle prominence [13,14]. Most of the existing literature suggests that satisfactory outcomes can be achieved with both these techniques; however, the majority are retrospective case series [10].

There is a lack of comparative studies for the evaluation of these two techniques. This prospective non-randomized comparative study aims to compare the functional, radiological, and cosmetic outcomes of both these techniques.

Materials and Methods

This prospective non-randomized comparative study was undertaken at a tertiary care level 1 trauma center from July



Figure 1: (a) Pre-operative clinical picture demonstrates cubitus varus (gunstock deformity). (b) Both elbow anteroposterior radiographs. (c) Oblique osteotomy done through the posterior approach to the elbow and provisional fixation with K-wires while the medial cortical hinge is preserved. (d) Post-operative radiography showing lateral column fixation with a locking plate and medial column fixed with 2 number of 4.0 mm CC screw without any undue lateral prominence. (e) Post-operative immobilization on an above-elbow slab, (f) Post-operative correction of coronal alignment. (g) 6-month post-operative radiograph showing union of osteotomy site and corrected coronal alignment.

2021 to December 2025, after obtaining institutional ethics committee approval (IEC 612, dated June 25, 2021) and informed consent from the participants. Children aged ≤ 15 years with post-traumatic cubitus varus deformity secondary to malunited supracondylar humeral fractures were included. Children with congenital deformities, previous corrective surgery, neuromuscular disorders, infection, or associated ipsilateral limb fractures were excluded.

Patients were allocated into two groups based on the surgical technique used: Group A underwent oblique lateral closing-wedge osteotomy and Group B underwent modified step-cut osteotomy. Allocation was non-randomized, performed on consecutive children, and largely based on the surgeon's preference.

Pre-operative evaluation included clinical assessment of the carrying angle (humerus–elbow–wrist angle), elbow range of motion, and standard anteroposterior and lateral radiographs of both elbows for deformity assessment and surgical planning.

All procedures were performed under general anesthesia through a posterior approach by a total of five different orthopedic surgeons. In Group A, an oblique lateral closing-wedge osteotomy was performed with preservation of the medial cortex. In Group B, a modified step-cut osteotomy was carried out. Fixation was achieved using plates for the lateral side and cancellous screws for medial side. Intraoperative correction was confirmed fluoroscopically. We administered 2 days of intravenous antibiotics and 5 more days of post-operative oral antibiotics.

Postoperatively, the limb was immobilized in an above-elbow slab for 3–4 weeks, followed by gradual mobilization. Physiotherapy protocols were standardized and objectively monitored across all

patients by a single team of physiotherapists. Children were followed up at 3 monthly interval for a minimum duration of 12 months. Outcomes assessed were carrying angle, elbow range of motion, radiological correction, cosmetic appearance, functional outcome, and complications. Evaluation was done by a team of orthopedic surgeons in addition to the five operating surgeons in the outpatient department.

Statistical analysis was performed using the Statistical Package



Figure 2: (a) Pre-operative clinical picture demonstrates cubitus varus (gunstock deformity). (b) Left elbow anteroposterior radiograph. (c) Modified step-cut osteotomy done through posterior approach to the elbow. (d) Intraoperative fluoroscopy image showing provisional fixation with K wires while medial cortical hinge is preserved. (e) Post-operative radiography showing lateral column fixation with a locking plate and medial column fixed with a 3.5 mm cortical screw without any undue lateral prominence. (f) Follow-up X-ray radiograph showing union at 2 months, (g) 3-month follow-up clinical picture showing correction of coronal alignment in the extended elbow. (h) 3-month follow-up clinical picture showing near-normal elbow flexion.

for the Social Sciences software with $P < 0.05$ considered statistically significant. Analysis of the results between the two groups was done by Chi-square test for categorical data, independent t-test for normally distributed data, and Mann–Whitney test for the parameters where data were not normally distributed. Normality of data distribution was tested using the Shapiro–Wilk test.

Results

A total of 30 children with post-traumatic cubitus varus deformity were included in the study, with 15 patients each in Group 1 (oblique lateral closing-wedge osteotomy) and Group 2 (modified step-cut osteotomy). All patients were available for final analysis with a mean follow-up duration of 14.2 ± 2.8 months (range, 12–20 months). The mean duration of surgery was comparable between Group 1 and Group 2 (62.4 ± 8.6 vs. 64.1 ± 9.2 min; $P = 0.618$). Similarly, the mean number of fluoroscopy shots required (21.3 ± 2.4 vs. 24.8 ± 2.7 ; $P = 0.594$) was not significantly different between the groups. Mean intraoperative blood loss (1–2 blood-soaked medium-sized gauges in both the groups) and implant-related expenditure were also comparable between the groups. Results are summarized in Table 1.

Demographic data

The mean age of the study population was 14.9 ± 2.7 years (range, 11–19 years). The mean age in Group 1 was 14.7 years and in Group 2 was 15.1 years ($P = 0.741$). There were 19 males (64.5%) and 11 female children in the study. The right side was involved in 20 (67%) of cases, with a similar distribution between the groups. There was no statistically significant difference between the two groups in terms of age ($P = 0.741$), gender distribution ($P = 1.000$), or side involved ($P = 0.699$), indicating that the groups were comparable at the baseline.

Radiological outcomes

The mean pre-operative carrying angle for the entire cohort was $-21.8^\circ \pm 7.4^\circ$ (range, -35° – -10°). There was no statistically significant difference between the two groups in terms of pre-operative carrying angle ($P = 0.647$). Postoperatively, this improved to a mean of $12.2^\circ \pm 5.2^\circ$ (range, 5° – 20°), indicating satisfactory correction in both groups. Group 1 showed improvement from $-22.5^\circ \pm 7.0^\circ$ pre-operatively to $13.0^\circ \pm 5.0^\circ$ post-operatively, while Group 2

improved from $-21.2^\circ \pm 8.0^\circ$ to $11.5^\circ \pm 5.6^\circ$. The magnitude of correction was comparable between the two groups with a $P = 0.432$.

Radiological union was achieved in all patients. The mean time to union was 10.2 ± 2.3 weeks overall, with Group 1 uniting at 10.0 ± 2.5 weeks and Group 2 at 10.3 ± 2.1 weeks, with a $P = 0.698$.

Functional outcomes

At final follow-up, the mean elbow flexion-extension arc for the entire cohort was $66.7^\circ \pm 45.4^\circ$. Group 1 demonstrated a mean elbow flexion extension arc of $64.7^\circ \pm 49.3^\circ$, while Group 2 demonstrated $68.7^\circ \pm 42.8^\circ$, $P = 0.817$. Forearm rotation was well preserved in both groups, with a mean prono-supination arc of $120.1^\circ \pm 24.6^\circ$ overall (Group 1: $114.5^\circ \pm 25.9^\circ$; Group 2: $125.7^\circ \pm 22.8^\circ$, $P = 0.216$). The mean Mayo Elbow Performance Score was 88.0 ± 7.8 in Group 1 and 90.0 ± 8.7 in Group 2. The difference between the two groups was not statistically significant ($P = 0.511$). Figs. 1 and 2 represent one case each from group 1 and group 2, respectively.

Complications

A total of 5 cases of heterotopic ossification were seen, 2 in group 1 and 3 in group 2. Patients responded to oral indomethacin. No cases of lateral condyle prominence, non-union, loss of correction, or neurovascular injury were observed in either group. Cosmetic appearance was satisfactory in both the groups.

Discussion

Cubitus varus deformity following supracondylar humeral fractures is a three-dimensional deformity and the corrective

Table 1: Statistical comparison between the groups

Variable	Group 1 (mean±SD)	Group 2 (mean±SD)	P-value
Age (years)	21.07±3.99	19.80±3.59	0.369
Pre-operative carrying angle (°)	-22.47±6.98	-21.20±7.98	0.647
Post-operative carrying angle (°)	13.00±4.96	11.47±5.57	0.432
Flexion- extension arc (°)	64.73±49.30	68.67±42.75	0.817
Prono-supination arc (°)	114.47±25.92	125.73±22.76	0.216
Radiological union (weeks)	10.00±2.51	10.33±2.13	0.698
Mayo elbow performance score	88.0±7.75	90.0±8.66	0.511

Group 1: Oblique closing-wedge osteotomy, Group 2: Modified step-cut osteotomy, SD: Standard deviation



surgery is challenging in the pediatric population [3,4]. Previously, it was regarded as a benign cosmetic condition; however, subsequent studies have revealed that it might lead to elbow instability, ulnar nerve palsy, and late functional impairment, emphasizing the need for accurate deformity correction [4,5,6].

The present study focused on a comparative analysis between oblique lateral closing-wedge osteotomy and modified step-cut osteotomy, which suggested that both techniques are equally effective for improvement in carrying angle, satisfactory elbow function, and predictable bony union. These findings are consistent with previous studies that have reported good outcomes with corrective osteotomy [2,7,11].

Lateral closing-wedge osteotomy remains the most frequently reported corrective procedure in the literature [2,11]. Bellemore et al. and French have demonstrated predictable angular correction using this technique but noted lateral condylar prominence as the cosmetic concern amongst parents of the children [1,11]. Oblique modification of the closing-wedge osteotomy was introduced to minimize this lateral prominence. This obliquity of the osteotomy plane produces a controlled translation along with rotation of the distal fragment in the coronal plane, thus reducing lateral prominence [12]. There are a few reports of improved cosmetic outcomes and maintained stability with this modification, findings that are supported by the satisfactory results in our study [12,15].

The modified step-cut osteotomy has also been advocated as an alternative technique. The idea is to further improve cosmetic appearance and fixation stability. This technique increases the surface area of bone contact and creates an interlocking osteotomy geometry, which gives inherent stability, reduces the risk of loss of angular correction, and lateral prominence [13,14]. Song et al. and Kim et al. reported high rates of excellent and good outcomes with minimal complications using the step-cut osteotomy technique, findings of which are comparable in our study [13,14].

Solfelt et al. in their systematic review have analyzed more than 900 pediatric cases of cubitus varus with the conclusion that no single osteotomy technique showed any clear superiority, and that results were more driven by the surgical planning and execution rather than by the specific osteotomy design [10]. This observation aligns with our results, where both oblique

closing-wedge and modified step-cut osteotomies produced comparable functional and radiological outcomes.

The limitations of this study include its non-randomized design, possible selection bias and relatively smaller sample size of only 30 patients, which may limit the statistical strength and generalizability of the findings. A total of 5 different orthopedic surgeons performed the procedures, and differences in surgical expertise and technical execution might have influenced the outcome. Rotational and sagittal plane deformity corrections were not quantitatively assessed, and only the degree of coronal plane deformity correction was considered. Follow-up duration was relatively short, with a mean follow-up of 14.2 months, which may not be sufficient to detect long-term complications like recurrence of deformity or tardy ulnar nerve palsy and rare complications like avascular necrosis or osteoarthritis. Nevertheless, the prospective design and direct comparison of the two most commonly employed techniques provide clinically relevant data for further research to guide the surgical decision-making. Multi-center randomized control study comparing both the techniques with a larger sample size is required to consolidate our findings and increase the applicability of the results to other healthcare settings and populations.

Conclusion

Both oblique lateral closing-wedge osteotomy and modified step-cut osteotomy provided reliable correction of cubitus varus deformity with comparable radiological union and functional outcomes in our study.

Clinical Message

Both osteotomy techniques were clinically safe, achieved predictable union and corrected alignment, allowing surgeons to choose based on familiarity and intraoperative feasibility. Emphasis should be placed on accurate pre-operative planning, stable fixation, and early pain-free mobilization to optimize functional recovery and cosmetic outcome.

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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Conflict of Interest: Nil
Source of Support: Nil

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

How to Cite this Article

Sahoo US, Rout P, Mishra SS, Samal K, Das SS. Oblique Close Wedge Versus Modified Step Cut Osteotomy for Cubitus Varus Deformity in Children: A Prospective Non-Randomized Study. *Journal of Orthopaedic Case Reports* 2026 June;16(06): 275-280.

