

## Assessment of Functional and Cosmetic Outcomes of Cubitus Varus Deformity Correction in Children Using Ilizarov Distraction Osteogenesis: A Single-Centre Observational Study from Rajasthan

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### Abstract:

**Background:** Cubitus varus is the most common late complication following malunion of pediatric supracondylar humeral fractures, resulting in cosmetic disfigurement and potential functional impairment. The Ilizarov distraction osteogenesis technique offers gradual, controlled, multiplanar correction with the advantage of postoperative adjustability. However, data from single-centre Indian settings remain limited.

**Aim:** To evaluate the functional and cosmetic outcomes of cubitus varus deformity correction in children using the Ilizarov distraction osteogenesis technique.

**Materials and Methods:** This hospital-based, prospective, observational study was conducted in the Department of Orthopedics, SMS Medical College and Hospital, Jaipur, Rajasthan. Twenty-five patients aged less than 20 years with post-traumatic cubitus varus deformity secondary to malunited supracondylar humeral fractures were enrolled. All patients underwent supracondylar osteotomy with Ilizarov ring fixator application followed by gradual distraction. Outcomes were assessed in terms of carrying angle correction, elbow range of motion (flexion and extension), complications, and functional results using the Oppenheim grading and Mayo Elbow Performance Score.

**Results:** The mean age at trauma was  $7.05 \pm 1.11$  years and at surgery was  $16.68 \pm 1.54$  years. Males predominated (76%). The mean carrying angle improved significantly from  $12.58^\circ \pm 3.75^\circ$  pre-operatively to  $10.01^\circ \pm 1.33^\circ$  at follow-up ( $p < 0.05$ ), closely approximating the contralateral side ( $10.54^\circ \pm 1.56^\circ$ ). Elbow flexion ( $134.74^\circ \pm 3.81^\circ$  vs  $134.74^\circ \pm 3.45^\circ$ ) and extension ( $-2.58^\circ \pm 3.42^\circ$  vs  $-2.84^\circ \pm 1.90^\circ$ ) were preserved postoperatively ( $p > 0.05$ ). Complications included pin tract infection (16%), ulnar nerve paraesthesia (4%), flexion deformity (4%), and ulnar claw hand (4%). Excellent functional outcomes were achieved in 88% of patients, good in 8%, and poor in 4%.

**Conclusion:** The Ilizarov distraction osteogenesis technique is a safe, effective, and reliable method for correcting cubitus varus deformity in children, providing excellent carrying angle restoration, preserved range of motion, and high patient satisfaction with minimal complications.

**Keywords:** Cubitus varus, Ilizarov technique, distraction osteogenesis, supracondylar fracture, carrying angle, pediatric orthopedics.

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### Introduction

Cubitus varus, commonly referred to as “gunstock deformity,” is the most frequently encountered late complication following malunion of supracondylar humeral fractures in children. [1] Supracondylar fractures constitute approximately 60–70% of all paediatric elbow fractures and predominantly affect children aged 5–7 years, typically resulting from falls on an outstretched hand. [2] The resultant

deformity is characterised by varus angulation in the coronal plane, extension malalignment in the sagittal plane, and internal rotation in the transverse plane, creating a triplanar malalignment that is both cosmetically displeasing and functionally limiting. [3]

Although traditionally considered a purely cosmetic concern, cubitus varus has been increasingly

recognised as a condition with significant functional implications, including late-onset lateral elbow pain, posterolateral rotatory instability (PLRI), triceps snapping, progressive ulnar neuropathy, and impaired range of motion.[4,5] The incidence of cubitus varus following paediatric supracondylar fractures ranges from 4% to 50%, with higher rates observed in conservatively treated fractures.[6] The development of this deformity is influenced by factors such as fracture severity, adequacy of reduction, stability of fixation, and the involvement of the medial condyle.[7]

Corrective osteotomy remains the gold standard treatment for established cubitus varus deformity.[8] Various surgical techniques have been described, including lateral closing wedge osteotomy, medial opening wedge osteotomy, dome osteotomy, step-cut osteotomy, and three-dimensional osteotomy.[9] However, these conventional methods provide only single-stage correction, limiting the scope for postoperative adjustments. Studies have reported that up to 30% of cases experience suboptimal outcomes due to loss of reduction or difficulty in maintaining precise alignment with internal fixation alone.[10]

The Ilizarov distraction osteogenesis technique, pioneered by Gavriil Abramovich Ilizarov in the 1950s, offers a paradigm shift in deformity correction. The technique employs a circular external fixator to achieve gradual, controlled correction through distraction osteogenesis, enabling simultaneous correction in all three planes.[11,12] Key advantages include the ability to perform fine-tuned postoperative adjustments, preservation of the soft-tissue envelope, early mobilisation, and avoidance of complications associated with traditional open surgery such as neurovascular injury and joint stiffness.[13,14] The ideal conditions for distraction osteogenesis include stable fixation, low-energy osteotomy, a latency period of 5–7 days, and a distraction rate of 1 mm/day in divided increments.[15]

Despite these advantages, data on the application of the Ilizarov technique specifically for cubitus varus correction in Indian paediatric populations remain scarce. This study was therefore undertaken to evaluate the functional and cosmetic outcomes of cubitus varus deformity correction in children using the Ilizarov distraction osteogenesis technique at a tertiary care centre in Rajasthan, India.

## Materials and Methods

**Study Design and Setting:** This was a hospital-based, prospective, observational study conducted in the Department of Orthopedics at SMS Medical College and attached Hospital, Jaipur, Rajasthan, India. The study was initiated after obtaining approval from the Institutional Ethics Committee

(Ref. No. 59, MC/EC/2023, dated 08/11/2023). Data collection commenced after ethical approval and continued until May 2025 or until the required sample size was achieved.

**Study Population and Sample Size:** A total of 25 consecutive patients presenting with cubitus varus deformity were enrolled. The inclusion criteria were: (i) patients with cubitus varus deformity secondary to malunited supracondylar fracture of the humerus (post-traumatic aetiology); (ii) age less than 20 years; and (iii) patients who were fit for surgery and willing to undergo the procedure. Patients with active infection at the time of evaluation were excluded. Written informed consent was obtained from all patients and/or their legal guardians prior to enrolment.

**Surgical Procedure:** All patients underwent supracondylar osteotomy of the distal humerus with application of an Ilizarov ring fixator under general anaesthesia or supraclavicular brachial plexus block. A transverse osteotomy was performed through a lateral small incision without bone wedge removal. The Ilizarov circular external fixator was assembled with two to three rings, secured by transfixion wires and half pins. Postoperatively, distraction was initiated on day 7 at a rate of approximately 1°–2° per day. Pin-site care was performed regularly with antiseptic dressings. Oral antibiotics, analgesics, and anti-inflammatory medications were prescribed postoperatively.

**Follow-up and Outcome Assessment:** Patients were followed up through clinical and radiographic examinations every two weeks. During each visit, assessments were made for pain, fever, joint stiffness, signs of infection, and neurovascular status. Radiographic evaluations monitored the distraction process, complications, and ossification of the regenerate bone. Once the planned carrying angle correction was achieved and adequate bony consolidation confirmed on radiographs, the external fixator was removed. An intensive physiotherapy programme was then initiated to restore full range of motion and muscle strength. The primary outcome measures were: (i) carrying angle correction; (ii) elbow range of motion (flexion and extension); and (iii) complications. Functional outcomes were assessed using the Oppenheim grading and Mayo Elbow Performance Score.

**Statistical Analysis:** Continuous variables were expressed as mean  $\pm$  standard deviation (SD), and categorical variables as frequencies and percentages. Pre-operative and post-operative measurements were compared using the paired t-test. A p-value of less than 0.05 was considered statistically significant. All analyses were performed using SPSS software.

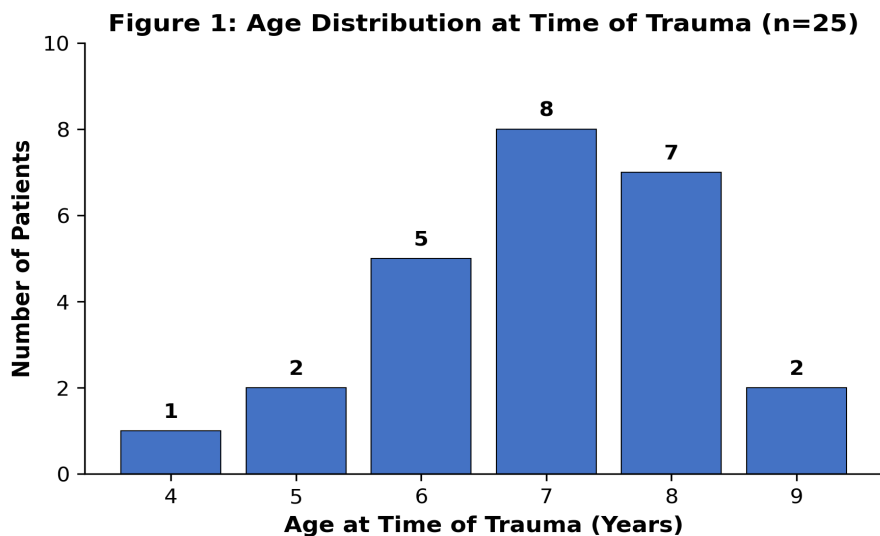
## Results

**Demographic Characteristics:** A total of 25 patients with cubitus varus deformity were included in the study. The mean age at the time of trauma was  $7.05 \pm 1.11$  years (range: 4–9 years), with the majority of patients (32%) being 7 years old at the time of initial injury. The mean age at surgery was

$16.68 \pm 1.54$  years (range: 12–19 years). Males comprised 76% (n=19) of the study population and females 24% (n=6). The right side was affected in 52% (n=13) and the left side in 48% (n=12) of cases (Table 1).

**Table 1: Demographic and Clinical Characteristics of the Study Population (n=25)**

Parameter	Value
Age at trauma (Mean $\pm$ SD)	7.05 $\pm$ 1.11 years (Range: 4–9 years)
Age at surgery (Mean $\pm$ SD)	16.68 $\pm$ 1.54 years (Range: 12–19 years)
Sex (Male : Female)	19 (76%) : 6 (24%)
Affected side (Right : Left)	13 (52%) : 12 (48%)
Mean haemoglobin (g/dL)	12.32 $\pm$ 1.04
Fixator index (days/degree)	0.61 $\pm$ 0.08
Distraction rate ( $^{\circ}$ /day)	1.64 $\pm$ 0.22



**Figure 1: Age distribution of patients at the time of trauma (n=25)**

**Mode of Injury:** The most common mechanism of injury was fall while running, accounting for 48% (n=12) of cases, followed by fall from stairs (32%,

n=8), fall from a bike (16%, n=4), and fall while playing (4%, n=1) (Table 2).

**Table 2: Distribution of Patients According to Mode of Injury (n=25)**

Mode of Injury	No. of Patients	Percentage (%)
Fall while running	12	48
Fall from stairs	8	32
Fall from bike	4	16
Fall while playing	1	4
Total	25	100

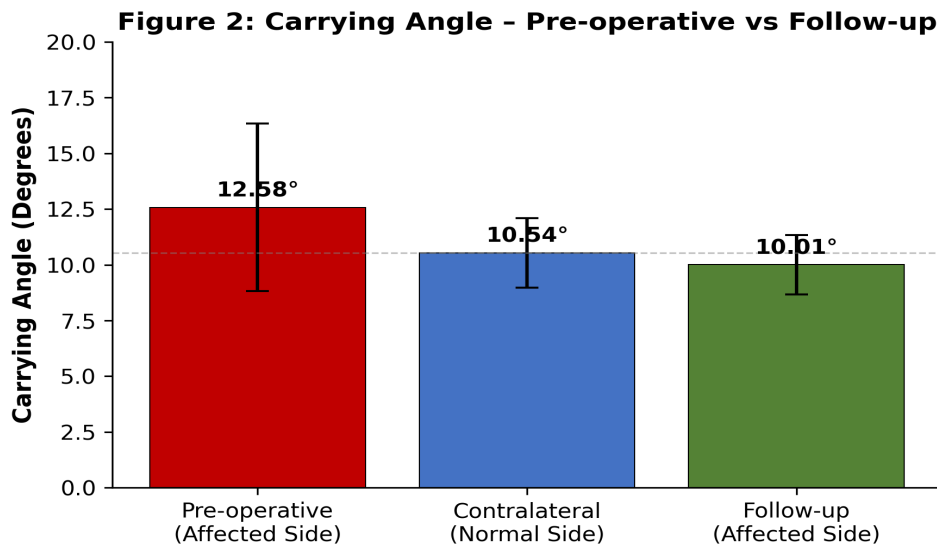
**Carrying Angle Correction:** The carrying angle showed a statistically significant improvement from the pre-operative measurement to the follow-up assessment. The mean pre-operative carrying angle on the affected side was  $12.58^{\circ} \pm 3.75^{\circ}$ , which

decreased to  $10.01^{\circ} \pm 1.33^{\circ}$  at follow-up ( $p < 0.05$ ). The carrying angle of the contralateral (normal) side was  $10.54^{\circ} \pm 1.56^{\circ}$ , indicating that the corrected carrying angle closely approximated the physiological range of the unaffected limb (Table 3).

**Table 3: Carrying Angle Measurements – Pre-operative, Contralateral, and Follow-up**

Measurement	Mean ± SD (°)	p-value
Pre-operative (affected side)	12.58 ± 3.75	< 0.05*
Follow-up (affected side)	10.01 ± 1.33	
Contralateral (normal) side	10.54 ± 1.56	–

\*Statistically significant (p < 0.05)



**Figure 2: Comparison of carrying angle – Pre-operative vs Contralateral vs Follow-up**

**Range of Motion:** Elbow flexion was well preserved postoperatively. The mean elbow flexion was 134.74° ± 3.81° pre-operatively and 134.74° ± 3.45° post-operatively (p > 0.05). Similarly, elbow extension showed no significant change, with a pre-

operative value of -2.58° ± 3.42° and a post-operative value of -2.84° ± 1.90° (p > 0.05), confirming that the surgical intervention did not adversely affect elbow mobility (Table 4).

**Table 4: Elbow Range of Motion – Pre-operative vs Post-operative Comparison**

Parameter	Pre-operative (Mean ± SD)	Post-operative (Mean ± SD)	p-value
Elbow Flexion (°)	134.74 ± 3.81	134.74 ± 3.45	> 0.05
Elbow Extension (°)	-2.58 ± 3.42	-2.84 ± 1.90	> 0.05

**Complications and Functional Outcomes:** The majority of patients (72%, n=18) experienced no complications. Pin tract infection was the most common complication, occurring in 16% (n=4) of cases and was managed successfully with local wound care and oral antibiotics. Other complications included flexion deformity of 25° in

one patient (4%), ulnar nerve paraesthesia in one patient (4%), and ulnar claw hand in one patient (4%). Functional outcomes were assessed using the Oppenheim grading and Mayo Elbow Performance Score. Excellent results were achieved in 88% (n=22), good in 8% (n=2), and poor in 4% (n=1) of patients (Table 5).

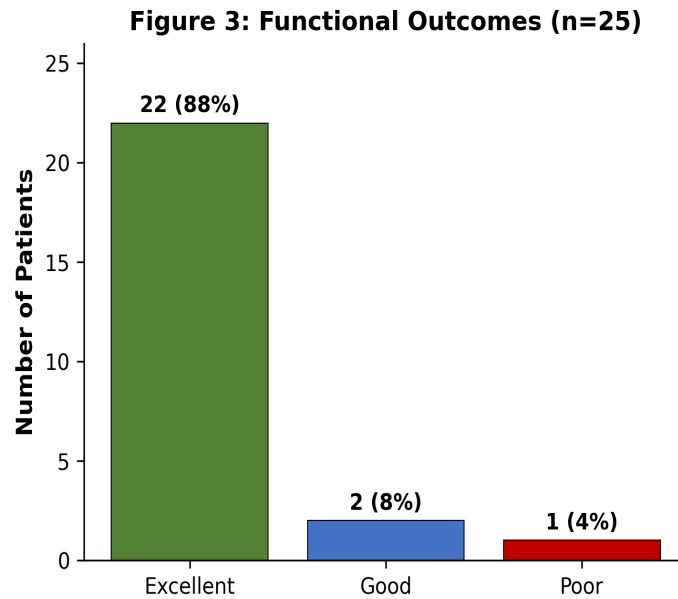
**Table 5: Complications and Functional Outcomes (n=25)**

**A. Complications**

Complication	No. of Patients	Percentage (%)
No complications	18	72
Pin tract infection (PTI)	4	16
Flexion deformity (FFD of 25°)	1	4
Ulnar nerve paraesthesia	1	4
Ulnar claw hand	1	4

**B. Functional Outcomes**

Functional Result	No. of Patients	Percentage (%)
Excellent	22	88
Good	2	8
Poor	1	4



**Figure 3: Distribution of functional outcomes among patients (n=25)**

### Discussion

Cubitus varus deformity has historically been treated using various corrective osteotomy techniques with different fixation methods. The first documented lateral closing wedge osteotomy for cubitus varus was reported by Siris in 1939.[16] Since then, numerous surgical approaches have been developed; however, traditional methods provide only single-stage correction with limited scope for postoperative adjustments. External fixation using the Ilizarov ring fixator offers distinct advantages, particularly in stabilising small and unstable bone fragments following osteotomy, while enabling simultaneous three-dimensional correction and postoperative fine-tuning.[17]

In the present study, the most common age group at the time of trauma was 4–7 years, accounting for 64% of patients, with a mean age of  $7.05 \pm 1.11$  years. These findings are consistent with published literature. Mishra et al. [18] reported that 82.4% of patients with cubitus varus were aged 5–10 years, with a mean age of 7.58 years. Similarly, Das et al. [19] confirmed that supracondylar fractures predominantly occur in children aged 2–8 years. The predominance of males in our study (76%) is also concordant with existing evidence. Gul et al. [20] reported a comparable gender distribution, and broader trauma epidemiology studies have demonstrated that males experience higher rates of traumatic injuries across age groups.[21]

The mean age at surgery in our cohort was  $16.68 \pm 1.54$  years, indicating a considerable interval between initial trauma and corrective surgery. This delay reflects the progressive nature of the deformity, which often becomes more pronounced

during adolescent growth spurts, as well as potential delays in referral. Lim et al. [22] demonstrated that cubitus varus in older patients can be effectively treated with corrective osteotomy, and Kim et al. [23] introduced a translation step-cut osteotomy for post-traumatic cubitus varus in adults, supporting the feasibility of surgical correction even in older age groups.

Regarding the mechanism of injury, fall while running was the most common cause (48%), followed by fall from stairs (32%). These findings are comparable with those of Khan et al. [24] who reported fall during play as the leading cause (55%) and Das et al. [19] who found a similar distribution. The near-equal laterality (right 52%, left 48%) observed in our study is also consistent with published reports.[24]

The carrying angle showed a statistically significant improvement from  $12.58^\circ \pm 3.75^\circ$  pre-operatively to  $10.01^\circ \pm 1.33^\circ$  at follow-up ( $p < 0.05$ ), closely approximating the contralateral normal side ( $10.54^\circ \pm 1.56^\circ$ ). These results compare favourably with several previous studies. Khan et al. [24] reported improvement from  $14.2^\circ \pm 2.5^\circ$  to  $10.1^\circ \pm 1.8^\circ$ , while Das et al.<sup>19</sup> observed correction from  $18.55^\circ \pm 3.46^\circ$  to  $9.50^\circ \pm 1.77^\circ$ . Piskin et al. [25] demonstrated an improvement from  $-18.7^\circ$  to  $6.1^\circ$ , and Ozkan et al. [26] reported a final follow-up carrying angle of  $11.6^\circ$ , all corroborating the efficacy of the Ilizarov technique in restoring a near-normal carrying angle.

Elbow flexion and extension were well preserved in our study. The mean elbow flexion remained unchanged at  $134.74^\circ$  both pre-operatively and post-operatively ( $p > 0.05$ ). Das et al. [19] reported

improvement in flexion from 117.50° to 130.00° ( $p < 0.001$ ), while Ozkan et al. [26] found a comparable post-operative flexion of 134.38°. Similarly, elbow extension showed no significant change ( $-2.58^\circ$  to  $-2.84^\circ$ ;  $p > 0.05$ ). Agrawal et al. [17] reported that the Ilizarov method effectively corrected cubitus varus without compromising elbow function, with significant carrying angle improvement while maintaining a functional range of motion. Bari et al. [27] treated 11 patients with elbow deformity using the Ilizarov method and reported 8 excellent and 3 good outcomes, supporting the technique's efficacy in preserving postoperative function.

The complication rate in our study was low, with 72% of patients experiencing no adverse events. Pin tract infection was the most common complication (16%), which is consistent with other reports in the literature. Ozkan et al. [26] reported grade-2 pin-tract infections in 14% of cases, while Hoffman et al. [28] noted an 18% rate of superficial pin-tract infections with distraction osteogenesis. Agrawal et al. [17] found PTI in 10% and Gurung et al. [29] reported 15% incidence. All infections in our study were managed successfully with local wound care and oral antibiotics. Ulnar nerve paraesthesia occurred in one patient (4%), which resolved with conservative management. Kim et al. [23] similarly found that patients regained preoperative motion arcs within an average of 2.5 months, with no significant neurovascular complications.

Functional outcomes in our study were excellent in 88% ( $n=22$ ), good in 8% ( $n=2$ ), and poor in only 4% ( $n=1$ ) of patients. These results compare favourably with existing literature. Das et al. [19] reported 85% excellent outcomes, Agrawal et al. [17] found 90% satisfactory results, and Gurung et al. [29] demonstrated a 92% success rate. Hoffman et al. [28] in their systematic review noted that distraction osteogenesis yielded the highest percentage (88.04%) of excellent outcomes among all osteotomy techniques for cubitus varus, further validating our findings. Ozkan et al.<sup>26</sup> reported 86% excellent functional recovery in their cohort, further substantiating the effectiveness of this approach.

The distraction period in our study ranged from 1 to 2.5 weeks, and external fixation duration from 6 to 8 weeks. Mishra et al. [18] reported a mean radiological union time of 6.3 weeks, closely matching our mean of 6.4 weeks. The fixator index of 0.61 days/degree and distraction rate of 1.64°/day observed in our study are within the range recommended for optimal bone regeneration and healing. [15,30]

**Limitations:** This study has certain limitations that must be acknowledged. The relatively small sample size ( $n=25$ ) may limit the generalizability of findings. The follow-up period was limited, precluding assessment of long-term durability and

late complications. The absence of a comparative control group using alternative osteotomy techniques restricts direct comparison of efficacy and complication rates. Additionally, the success of distraction osteogenesis is partly dependent on patient compliance with postoperative care and follow-up schedules.

## Conclusion

The Ilizarov distraction osteogenesis technique is a highly effective, safe, and reliable method for correcting cubitus varus deformity in children and adolescents. Unlike traditional single-stage osteotomy methods, this technique allows gradual, controlled, multiplanar correction with the advantage of postoperative adjustability, minimising the risk of residual malalignment. Our study demonstrates significant improvement in carrying angle with preservation of elbow range of motion and a high rate of excellent functional outcomes (88%). The complication rate was low, with pin tract infection being the most common but readily manageable adverse event. These findings support the Ilizarov technique as a valuable and preferred option for cubitus varus correction, particularly in tertiary care settings with adequate expertise in external fixation surgery.

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**Ethical Approval:** The study was approved by the Institutional Ethics Committee, SMS Medical College and Hospital, Jaipur (Ref. No. 59, MC/EC/2023, dated 08/11/2023).

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