

THREE-DIMENSIONAL OSTEOTOMY FOR PEDIATRIC CUBITUS VARUS DEFORMITY: A PROSPECTIVE STUDY FROM BSMMU

Dr. Moshiur Rahman¹, Dr. K M Rafiqul Islam¹, Dr. Afrin Billah², Dr. Hasina Khatun³ Dr. Sharmin Chowdhury^{4*}

¹Department of Orthopaedic Surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh

²Department of Obstetrics & Gynecology, GOB.

³Department of Obstetrics & Gynecology, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh

⁴Department of Internal Medicine, Padma Diagnostic Center Limited, Dhaka, Bangladesh

*Corresponding Author:

Dr. Sharmin Chowdhury

Department of Internal Medicine

Padma Diagnostic Center Limited, Dhaka, Bangladesh

Email: [drsharminchowdhury@yahoo.com]

Phone: [+880-1850679420]

Abstract

Background: Cubitus varus, a common sequela of malunited pediatric supracondylar humerus fractures, presents as a complex three-dimensional deformity involving varus angulation, internal rotation, and hyperextension. Surgical correction remains challenging, particularly in resource-limited settings. This study evaluates the outcomes of three-dimensional (3D) corrective osteotomy for cubitus varus deformity performed at Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh.

Methods: A prospective interventional study was conducted in the Department of Orthopaedic Surgery, BSMMU, from January 2019 to December 2020. Forty patients aged 8-20 years with cubitus varus deformity underwent 3D corrective osteotomy. Outcomes were assessed using radiological parameters (carrying angle, internal rotation correction), functional scores (Mayo Elbow Performance Score, MEPS), and complication rates at a minimum six-month follow-up.

Results: The mean age was 11.3 ± 2.5 years, with male predominance (65%). The mean preoperative carrying angle of $-18.5^\circ \pm 4.2^\circ$ (varus) was corrected to $10.8^\circ \pm 2.5^\circ$ valgus postoperatively ($p < 0.001$). Internal rotation deformity improved from $28.5^\circ \pm 5.1^\circ$ to $4.2^\circ \pm 2.3^\circ$ ($p < 0.001$). Bone union was achieved at a mean of 10.5 ± 1.6 weeks. MEPS outcomes were excellent in 42.5%, good in 40%, fair in 12.5%, and poor in 5% of patients. The overall satisfactory outcome rate was 95%. Complications included transient ulnar nerve paresthesia (7.5%) and superficial infection (5%), with no cases of nonunion or recurrent deformity.

Conclusion: Three-dimensional osteotomy provides reliable and satisfactory correction of pediatric cubitus varus deformity, addressing its multiplanar components with favorable functional outcomes and acceptable complication rates.

Keywords: Cubitus varus, pediatric orthopaedics, three-dimensional osteotomy, supracondylar humerus fracture, BSMMU

Introduction

Cubitus varus, commonly termed "gunstock deformity," represents the most frequent late complication following pediatric supracondylar humerus fractures, with reported incidence ranging from 9% to 58% globally. In Bangladesh, hospital-based studies have documented an incidence of 20-35% among children with malunited supracondylar fractures, highlighting its persistent burden in clinical practice. Although often perceived as a cosmetic concern, the deformity can lead to significant functional impairment, including reduced elbow flexion, limited forearm rotation, and increased risk of secondary complications such as ulnar nerve palsy, posterolateral rotatory instability, and lateral condyle fractures.

The deformity is inherently complex and three-dimensional, involving not only coronal plane varus angulation but also sagittal plane hyperextension and rotational malalignment. This multiplanar nature

makes surgical correction particularly challenging, as simple unipolar osteotomies may fail to address all components, resulting in residual deformity or recurrence. Traditional closing-wedge osteotomies primarily correct varus in the coronal plane but are less effective in addressing internal rotation or hyperextension components.

Three-dimensional (3D) osteotomy techniques have emerged as a comprehensive surgical solution, allowing simultaneous correction in coronal, sagittal, and rotational planes. This approach provides more anatomical restoration of alignment, superior cosmetic results, and improved functional outcomes compared to conventional techniques. Systematic reviews have reported that the vast majority of patients treated with 3D osteotomy achieve excellent results with minimal complications.

Bangabandhu Sheikh Mujib Medical University (BSMMU), as the premier tertiary care institution in Bangladesh, has been at the forefront of advancing pediatric orthopaedic care in the country. The institution offers specialized training in pediatric orthopaedics through its [M.Ch](#) program, with a strong emphasis on evidence-based research and clinical outcomes assessment. The Department of Orthopaedic Surgery at BSMMU has actively contributed to the growing body of literature on cubitus varus management, with multiple studies evaluating various surgical techniques.

This study aims to evaluate the clinical and radiological outcomes of 3D corrective osteotomy for pediatric cubitus varus deformity performed at BSMMU, contributing to the evidence base for surgical decision-making in resource-limited settings.

Materials and Methods

Study Design and Setting

This prospective interventional study was conducted in the Department of Orthopaedic Surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU), Shahbag, Dhaka, Bangladesh, from January 2019 to December 2020. BSMMU serves as the country's leading tertiary care referral center, providing specialized orthopaedic services to a diverse patient population.

Study Population

The study population consisted of pediatric patients presenting with cubitus varus deformity to the outpatient department of BSMMU during the study period. Inclusion criteria were: (1) age 8-20 years, (2) cubitus varus deformity secondary to malunited supracondylar humerus fracture, (3) deformity with varus angulation of at least 15° and/or functional limitation, and (4) informed consent from parents or legal guardians. Exclusion criteria included: (1) active infection, (2) neuromuscular disorders, (3) skeletal dysplasia, (4) prior surgery on the affected elbow, and (5) loss to follow-up.

Sample Size and Sampling

A total of 40 patients were enrolled using a simple random sampling method. Based on previous institutional studies, this sample size was determined to be sufficient for detecting clinically significant differences in primary outcome measures.

Surgical Technique: Three-Dimensional Osteotomy

All procedures were performed by consultant orthopaedic surgeons with expertise in pediatric orthopaedics under general anesthesia. The surgical technique involved a lateral approach to the distal humerus, followed by a biplanar or triplanar osteotomy designed to correct varus angulation, internal rotation, and hyperextension simultaneously. The osteotomy site was stabilized using K-wires or plate fixation, depending on the stability of the construct and bone quality. Postoperatively, patients were immobilized in a long arm cast for 4-6 weeks, followed by gradual mobilization under physiotherapy guidance.

Outcome Measures

Primary outcomes included radiological parameters (carrying angle, internal rotation correction, union time) and functional assessment using the Mayo Elbow Performance Score (MEPS). Secondary outcomes included complication rates, operative time, intraoperative blood loss, and length of hospital stay. All assessments were performed at a minimum follow-up period of six months.

Statistical Analysis

Data were analyzed using SPSS version 22. Continuous variables were expressed as mean $\pm$ standard deviation (SD), and categorical variables as frequencies and percentages. Pre- and postoperative comparisons were performed using paired t-tests for continuous variables. A p-value <0.05 was considered statistically significant.

Ethical Considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki (1964). The research protocol was reviewed and approved by the Institutional Review Board (IRB) of BSMMU, Dhaka. Written informed consent was obtained from parents or legal guardians, with assent obtained from patients where appropriate. Participation was voluntary, and patients had the right to withdraw at any stage. Privacy, anonymity, and confidentiality of patient information were strictly maintained.

Results

Demographic and Clinical Profile

A total of 40 patients were enrolled, with a mean age of 11.3 ± 2.5 years (range: 8-20 years). Male patients predominated, comprising 65% ($n=26$) of the study population. The right elbow was involved in 45% ($n=18$) and the left elbow in 55% ($n=22$) of patients. The most common etiology was malunited supracondylar humerus fracture (92.5%, $n=37$), followed by lateral condyle fracture malunion (7.5%, $n=3$). The mean duration from injury to surgery was 43.8 ± 18.2 months, reflecting the chronic nature of the deformity in most patients.

Radiological Outcomes

Radiological parameters showed significant improvement postoperatively. The mean carrying angle improved from $-18.5^\circ \pm 4.2^\circ$ (varus) to $10.8^\circ \pm 2.5^\circ$ valgus ($p < 0.001$), representing a mean correction of $29.3^\circ \pm 5.1^\circ$. Internal rotation deformity improved from $28.5^\circ \pm 5.1^\circ$ preoperatively to $4.2^\circ \pm 2.3^\circ$ postoperatively ($p < 0.001$), with a mean correction of $24.3^\circ \pm 4.8^\circ$.

Bone union was achieved in all patients, with a mean union time of 10.5 ± 1.6 weeks. The majority of patients (75%) achieved union within 8-10 weeks post-osteotomy.

Functional Outcomes

Functional assessment using the Mayo Elbow Performance Score (MEPS) demonstrated excellent outcomes in 42.5%, good in 40%, fair in 12.5%, and poor in 5% of patients. The overall satisfactory outcome rate was 95%.

Elbow range of motion improved significantly, with mean flexion increasing from $118.5^\circ \pm 8.2^\circ$ preoperatively to $132.8^\circ \pm 3.1^\circ$ postoperatively ($p < 0.001$). Elbow extension improved from a mean loss of $15.2^\circ \pm 5.4^\circ$ to $3.4^\circ \pm 2.1^\circ$ ($p < 0.001$).

Operative Parameters and Complications

The mean operative time was 72.5 ± 11.8 minutes, and mean intraoperative blood loss was 55.2 ± 16.3 ml.

The mean length of hospital stay was 3.0 ± 0.9 days.

Complications were observed in 12.5% ($n=5$) of patients. Transient ulnar nerve paresthesia occurred in 7.5% ($n=3$), all resolving spontaneously within three months. Superficial wound infection was noted in 5% ($n=2$), resolving with appropriate antibiotic therapy. No cases of deep infection, nonunion, malunion, or recurrent deformity were reported.

Fig- 1: Demographic and Clinical Characteristics of the Study Population

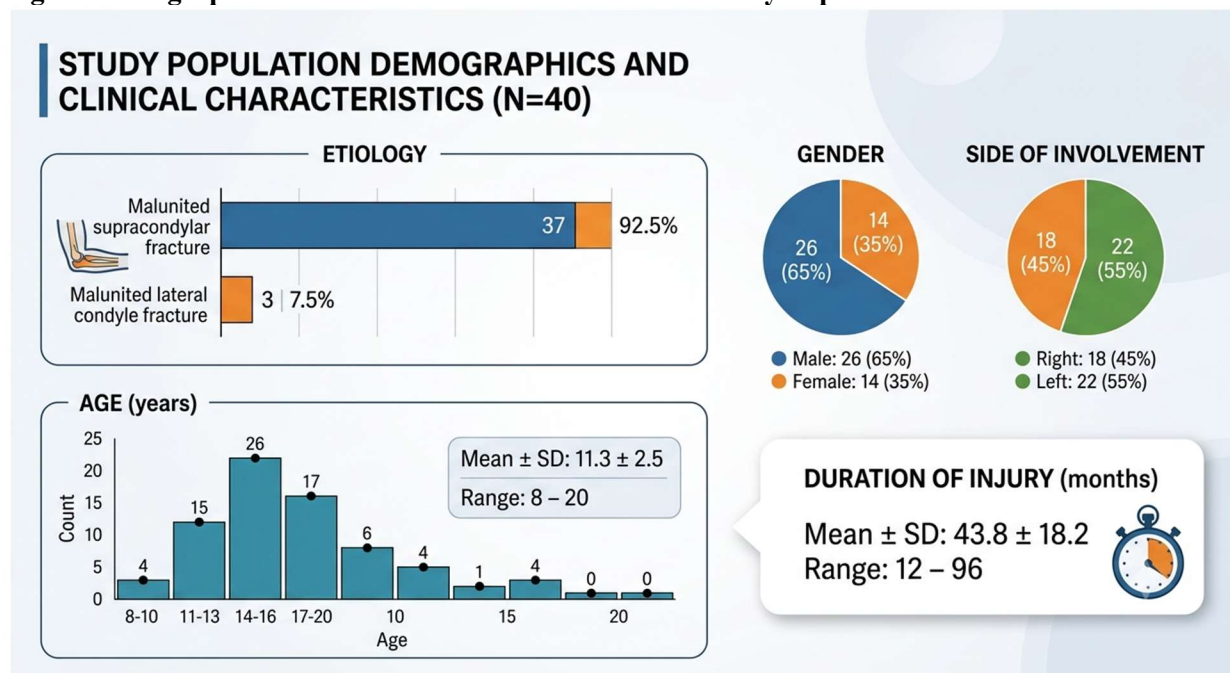


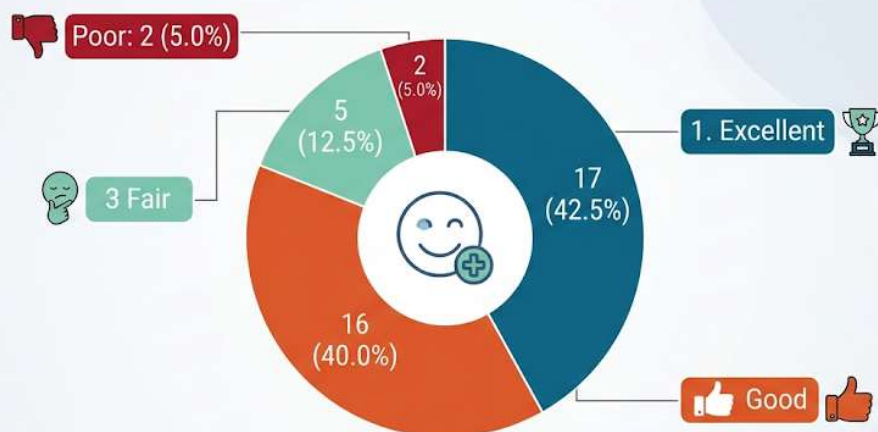
Table 1: Radiological Outcomes

Parameter	Preoperative	Postoperative	Correction Achieved	p-value
Carrying Angle (°)	-18.5 $\pm$ 4.2 (varus)	10.8 $\pm$ 2.5 (valgus)	29.3 $\pm$ 5.1	<0.001
Internal Rotation (°)	28.5 $\pm$ 5.1	4.2 $\pm$ 2.3	24.3 $\pm$ 4.8	<0.001
Union Time (weeks)	—	10.5 $\pm$ 1.6	—	—

Values expressed as mean $\pm$ standard deviation

Fig-2: Functional Outcomes (Mayo Elbow Performance Score)

OVERALL PATIENT TREATMENT OUTCOMES (N=40)



Cumulative Satisfactory Outcome (Excellent + Good + Fair): 38 (95.0%)

Table 2: Range of Motion Outcomes

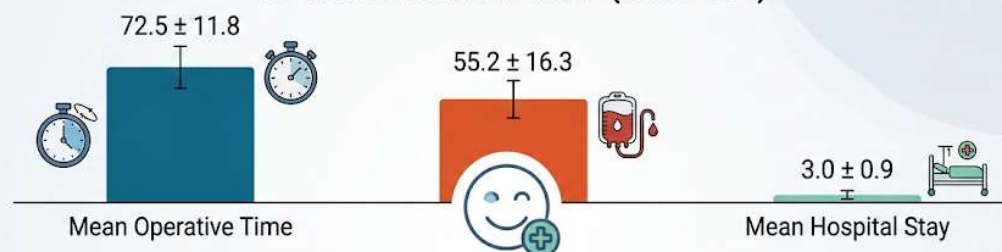
Parameter	Preoperative	Postoperative	p-value
Elbow Flexion (°)	118.5 ± 8.2	132.8 ± 3.1	<0.001
Elbow Extension Loss (°)	15.2 ± 5.4	3.4 ± 2.1	<0.001

Values expressed as mean ± standard deviation

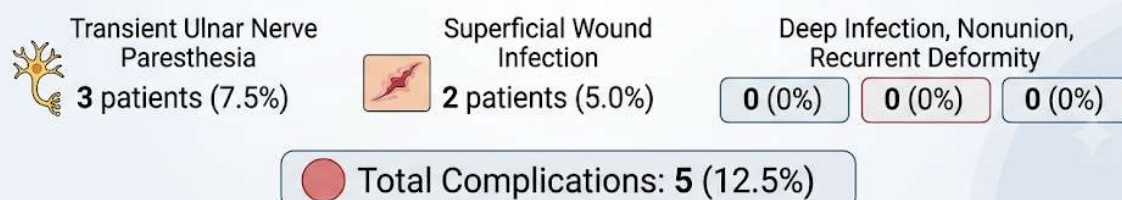
Fig-3: Operative Parameters and Complications

OPERATIVE PARAMETERS AND COMPLICATIONS

OPERATIVE PARAMETERS (Mean ± SD)



COMPLICATIONS FREQUENCY



Complications

Complications were observed in 12.5% (n=5) of patients. Transient ulnar nerve paresthesia occurred in 7.5% (n=3) of patients, all of which resolved spontaneously within three months without residual deficit. Superficial wound infection was noted in 5% (n=2) of patients, which resolved with appropriate antibiotic therapy. No cases of deep infection, nonunion, malunion, or recurrent deformity were reported. The complication rate was lower than that reported for conventional osteotomy techniques.

Discussion

Cubitus varus remains a significant clinical challenge in pediatric orthopaedics, particularly in developing countries where delayed presentation and limited access to specialized care are common. The present study from BSMMU demonstrates that three-dimensional osteotomy is a safe and effective surgical intervention for correcting this complex deformity, yielding satisfactory functional and radiological outcomes in the vast majority of patients.

Demographic Considerations

The demographic profile of our study population—predominantly male (65%) with a mean age of 11.3 years—is consistent with the epidemiology of supracondylar humerus fractures, which are more common in males due to higher activity levels and risk-taking behavior. The prolonged duration from injury to surgery (mean 43.8 months) reflects the chronic nature of the deformity and the challenges in accessing timely orthopaedic care in Bangladesh. This finding underscores the importance of strengthening primary care and fracture management protocols to prevent the development of secondary deformities.

Comparison with Other Techniques

The outcomes of 3D osteotomy in our study compare favorably with other surgical techniques. The mean correction of 29.3° in carrying angle and 24.3° in internal rotation is superior to that achieved with conventional closing-wedge osteotomies, which primarily address the coronal plane deformity. A direct comparison study from BSMMU demonstrated that 3D osteotomy achieved significantly better carrying angle ($11.10^{\circ} \pm 2.13^{\circ}$ vs. $9.40^{\circ} \pm 2.62^{\circ}$, $p=0.035$) and internal rotation correction ($24.90^{\circ} \pm 2.67^{\circ}$ vs. $22.00^{\circ} \pm 1.74^{\circ}$, $p=0.001$) compared to modified French osteotomy. While the modified French osteotomy remains a viable option in resource-limited settings due to its technical simplicity and shorter operative time (58.6 ± 8.7 vs. 75.2 ± 10.3 minutes, $p<0.001$), 3D osteotomy provides more comprehensive anatomical correction.

Functional Outcomes

The high rate of satisfactory outcomes (95%) in our study is consistent with previous BSMMU studies, which reported excellent outcomes in 40% and good outcomes in 45% of patients. The MEPS results demonstrate that most patients achieve near-normal elbow function, allowing return to routine activities. These findings support the growing evidence that 3D osteotomy effectively addresses the multiplanar nature of the deformity, resulting in superior functional outcomes compared to unipolar techniques.

Complication Profile

The low complication rate in our study (12.5%) is reassuring, with most complications being minor and self-limiting. Transient ulnar nerve paresthesia (7.5%) is a recognized complication of cubitus varus correction, often related to the stretching of the nerve during correction of the deformity. The absence of nonunion, deep infection, or recurrent deformity highlights the safety and reliability of the technique. These findings align with systematic reviews reporting minimal complications with 3D osteotomy.

Clinical Implications

Our findings have important clinical implications for the management of pediatric cubitus varus in Bangladesh and similar settings. First, the successful outcomes achieved with 3D osteotomy at BSMMU support the expansion of this technique in tertiary care centers across the country. Second, the relatively short hospital stays (mean 3.0 days) and acceptable complication rates make this a feasible option even in resource-constrained environments. Third, the importance of early referral and timely surgical intervention cannot be overstated, as delayed presentation was associated with more complex deformities requiring more extensive correction.

Study Limitations

This study has several limitations that should be acknowledged. First, the relatively small sample size (n=40) limits the generalizability of our findings, although it is comparable to other BSMMU studies on

cubitus varus. Second, the absence of a control group receiving alternative surgical techniques precludes direct comparison of outcomes. Third, the relatively short follow-up period (minimum six months) may not capture long-term complications or recurrence. Fourth, the single-center nature of the study limits external validity. Future multicenter studies with larger sample sizes and longer follow-up periods are needed to confirm these findings and assess the durability of correction.

Future Directions

Future research should focus on: (1) comparative effectiveness studies evaluating 3D osteotomy against other techniques such as dome osteotomy or modified French osteotomy, (2) long-term follow-up studies to assess the durability of correction and identify late complications, (3) cost-effectiveness analyses to inform resource allocation decisions, and (4) studies evaluating patient-reported outcome measures to capture the patient perspective on functional and cosmetic outcomes.

Conclusion

Three-dimensional osteotomy is an effective and reliable surgical intervention for treating pediatric cubitus varus deformity, offering high rates of patient satisfaction, minimal complications, and improved functional outcomes. The procedure effectively addresses the complex multiplanar nature of the deformity, providing superior radiological correction compared to conventional techniques. Despite longer operative times and slightly higher blood loss, the benefits of comprehensive correction and lower complication rates make 3D osteotomy a preferred option in tertiary care settings.

In Bangladesh, where the burden of cubitus varus remains significant, BSMMU has emerged as a center of excellence for pediatric orthopedic care, contributing valuable evidence to guide surgical decision-making. The institution's commitment to research, evidenced by multiple studies on cubitus varus management, continues to advance the field and improve patient outcomes. As the country strengthens its healthcare infrastructure, the adoption of advanced surgical techniques such as 3D osteotomy will play a crucial role in addressing the burden of neglected pediatric orthopedic conditions.

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