International Journal of Research in Orthopaedics
Khan MZH et al. Int J Res Orthop. 2024 Nov;10(6):1126-1130
http://www.ijoro.org

Original Research Article

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20242650

Management of cubitus varus deformity by three-dimensional osteotomy: analysis of outcome

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Received: 10 June 2024
Revised: 07 August 2024
Accepted: 28 August 2024

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ABSTRACT

Background: Cubitus varus deformity, commonly resulting from malunited supracondylar fractures of the humerus, is prevalent in pediatric and adolescent populations. Traditional treatment methods often fall short in addressing the complex three-dimensional nature of this deformity. This study aims to evaluate the efficacy and outcomes of three-dimensional osteotomy in correcting cubitus varus deformity.
Methods: This prospective interventional study was conducted at the Department of Orthopaedic Surgery, BSMMU, Shahbag, Dhaka, from March 2016 to September 2018. A total of 40 patients aged 8 to 20 years with cubitus varus deformity were enrolled. Participants underwent three-dimensional osteotomy, and outcomes were assessed using the Mayo Elbow Performance Score (MEPS) and functional recovery parameters.
Results: The majority of patients (75%) achieved bone union within 8-10 weeks post-osteotomy. The MEPS results were promising, with 40% of patients scoring 'Excellent' and 45% scoring 'Good'. Functional outcomes were predominantly positive, with 95% of patients reporting satisfactory results. The complication rate was low, with 80% of patients experiencing no postoperative complications.
Conclusions: Three-dimensional osteotomy is an effective and reliable surgical intervention for treating cubitus varus deformity, offering high rates of patient satisfaction, minimal complications, and improved functional outcomes. This technique presents a promising option for orthopedic surgeons in managing this complex deformity.

Keywords: Cubitus varus deformity, Mayo elbow performance score, Pediatric orthopedics, Three-dimensional osteotomy

INTRODUCTION

Supracondylar fractures of the distal humerus are notably prevalent in children aged 2 to 8 years, accounting for up to 30% of fractures in this demographic.[1] They represent the majority of elbow fractures in children, with an incidence of about 75%.[2] A significant long-term complication of these fractures is cubitus varus, with an average incidence of 30% across various management strategies.[3] This deformity, characterized by medial displacement, posterior tilt, and rotation of the distal fragment, is predominantly caused by varus tilting of the distal fragment. Additionally, growth disturbances in the distal humerus, especially overgrowth of the lateral condyle, have been implicated. Osteonecrosis and delayed growth of the trochlea, leading to a progressive cubitus

varus deformity, although rare, are significant concerns.[4] Cubitus varus, while rarely limiting elbow function, leads to a noticeable cosmetic deformity. This often prompts requests for intervention, especially from concerned parents.[5] Prolonged cubitus varus can lead to secondary complications such as lateral condylar fractures, postero-lateral rotatory instability, and tardy ulnar nerve palse.[6,7] Humeral osteotomy, employed to correct this deformity, faces challenges due to the complexity of the deformity, which includes hyperextension and internal rotation. Various osteotomy techniques such as lateral closing-wedge, medial opening-wedge, dome, three-dimensional, and step-cut osteotomies have been proposed to address these issues.[8-10] Anatomically accurate correction is crucial for optimal functional outcomes in upper extremity surgeries.[11] Traditional two-dimensional radiographs often fall short in providing a comprehensive understanding of complex three-dimensional deformities.[12,13] This gap necessitates a more nuanced approach, such as three-dimensional corrective osteotomy, for a holistic correction encompassing varus, posterior tilt, and internal rotation deformities. Historically, various osteotomy techniques have been explored. King and Secor described a medial opening wedge osteotomy with an 84% 'perfect correction' rate.[14] Success rates in lateral closing wedge osteotomy ranged from 35% to 85% in some studies.[15] However, data on newer techniques like dome, penta-lateral, and three-dimensional osteotomies are limited, especially in Bangladesh.[4] Our study aims to evaluate the clinical and radiological outcomes of three-dimensional corrective osteotomy for cubitus varus deformity, addressing all three components of the deformity. This approach promises to maintain normal elbow biomechanics and provide a more stable and rigid fixation.[13] Cubitus varus or 'gunstock' deformity, a common sequel to supracondylar humerus fractures, includes varus, extension, and internal rotation deformities. These are often compounded by poor bone quality, making accurate reduction and stable fixation challenging.[16] Three-dimensional osteotomy has been advocated to improve cosmetic appearance and physiological joint motion around the elbow.[17-19] In Bangladesh, no study has yet investigated this issue to the best of the researchers' knowledge. Therefore, this study aims to provide clinical evidence supporting the use of three-dimensional osteotomy and aid in selecting the best possible implant for internal fixation. Takeyasu et al conducted a significant study on thirty patients with cubitus varus deformity, demonstrating the efficacy of three-dimensional osteotomy.[17] They reported improvements in the humerus-elbow-wrist angle and tilting angle, alongside normalized elbow hyperextension and shoulder internal rotation. Similar studies by Takagi et al and Murase et al reinforced these findings, underscoring the role of three-dimensional osteotomy in achieving more accurate corrections and superior clinical outcomes.[18,19] Chung and Baek focused on adult patients with cubitus varus deformity, observing substantial improvements in varus and internal rotation angles following three-dimensional osteotomy. They endorsed this method for skeletally mature adults due to the lack of recurrence of the deformity. Another Japanese study by Takeyasu et al on nine patients further validated the efficacy of three-dimensional osteotomy in correcting malunited upper extremity fractures, demonstrating its precision and positive clinical outcomes.[17] In summary, the breadth of literature underscores the necessity and potential efficacy of three-dimensional corrective osteotomy in addressing the multifaceted nature of cubitus varus deformity. This study aims to extend this knowledge base by exploring the outcomes of this surgical approach in a Bangladeshi context, thus contributing to a more comprehensive understanding of the treatment of this complex orthopedic challenge.

METHODS

This prospective, interventional study was conducted from March 2016 to September 2018 at the Department of Orthopaedic Surgery, BSMMU, Shahbag, Dhaka. Ethical clearance for the study was obtained from the Institutional Review Board (IRB) of BSMMU. The sample size was determined using a statistical formula, resulting in a total of 20 participants. The study population comprised patients attending the Orthopaedic Surgery department at BSMMU, Shahbagh, Dhaka, for the treatment of cubitus varus deformity within the defined period. Inclusion criteria for the study were patients with cubitus varus deformity following malunited supracondylar fracture of the humerus, aged between 8 to 20 years, and with a duration of fractures exceeding one year. Exclusion criteria included marked osteoarthritic changes of the elbow joint on radiographs, any neurological deficit, patients who were mentally or physically unfit, anesthetically unfit patients, and those associated with other serious injuries or co-morbid medical illnesses. The study procedure involved selecting patients based on these criteria, who were then diagnosed clinically and radiologically. After obtaining informed consent, a detailed history and physical examination of each patient were performed using a structured case record form. The patients underwent thorough clinical and radiological assessments, and preoperative planning was conducted for correcting the deformity. The varus angle was measured by adding the valgus angle of the opposite normal side, and posterior tilt and internal rotation deformity were also measured. A surgical intervention was performed where a skin incision was made at the posterolateral aspect of the deformed arm. A three-dimensional pyramidal-shaped bone was removed from the anterolateral base to the posteromedial apex in the metaphyseal region of the distal humerus, correcting all three deformities. After removing the pyramid-shaped bone, the osteotomy site was closed, and fixation was achieved using a reconstruction plate, distal humeral plate, or K-wires. This osteotomy provided stability to the corrected structure. The outcomes of the three-dimensional osteotomy were measured by assessing the carrying angle, range of motion, and the Mayo Elbow Performance Score (MEPS).[20] The final follow-up was scheduled for 6 months or later. All data were compiled,

sorted, and analyzed statistically using the Statistical Package for Social Sciences (SPSS-22).

RESULTS

The study evaluated 40 participants with cubitus varus deformity. In terms of age distribution, the majority of the participants (45%) were in the 11-15 years age group, followed by 30% in the 16-20 years bracket, and 25% were aged between 8-10 years. Regarding gender, 60% of the participants were male, while 40% were female. As for the mechanism of injury leading to the deformity, the most common cause was a fall while playing, accounting for 55% of the cases. This was followed by falls from bicycles, which were responsible for 30% of the injuries, and road traffic accidents, contributing to 15% of the cases. When examining the side of the deformity, it was found that the right side was more commonly affected, with 55% of the participants having deformities on this side, while the left side was involved in 45% of the cases (Table 1).

Table 1: Distribution of the participants by baseline characteristics (n=40).

Variables	Frequency	Percentage
Age (years)		
8-10	10	25.00
11-15	18	45.00
16-20	12	30.00
Gender		
Male	24	60.00
Female	16	40.00
Mechanism of injury		
Road traffic accident	6	15.00
Fall from bicycle	12	30.00
Fall while playing	22	55.00
Side of deformity		
Right side	22	55.00
Left side	18	45.00

In examining the duration of injury among the 40 participants with cubitus varus deformity, it was observed that a majority, 55%, had an injury duration of less than 35 months. The remaining 45% of the participants had been living with the injury for 35 months or more (Figure 1).

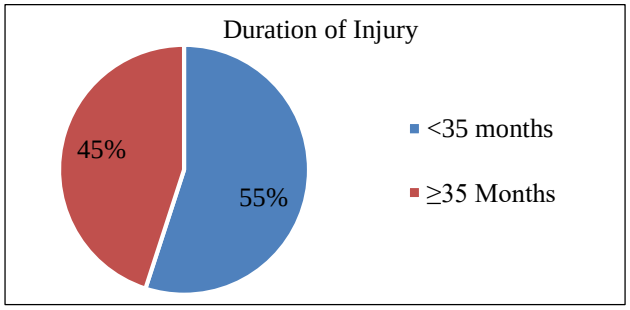


Figure 1: Distribution of participants by duration of injury (n=40).

Regarding the mode of previous treatment for their deformities, the most common method was closed reduction and cast immobilization, which was used in 75% of the cases. This was followed by closed reduction and percutaneous pinning, accounting for 15% of the previous treatments. A smaller proportion, 10%, had sought treatment from bone setters (Figure 2).

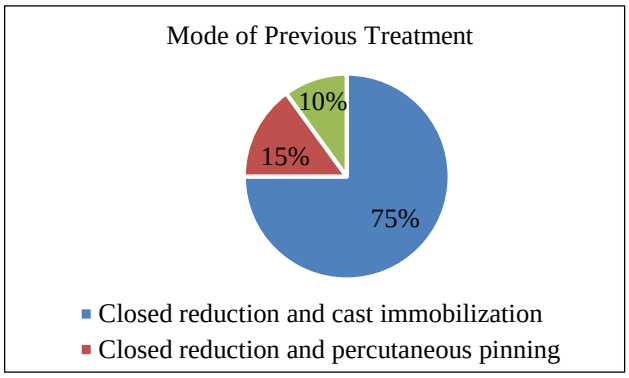


Figure 2: Distribution of participants by mode of previous treatment (n=40).

A significant majority, 75%, experienced bone union within 8 to 10 weeks post-osteotomy. A smaller group, comprising 15% of the participants, achieved bone union between 11 to 12 weeks. The remaining 10% of the study population had a bone union time exceeding 12 weeks (Table 2).

Table 2: Distribution of study population according to duration of bone union after osteotomy (n=40).

Duration	Frequency	Percentage
8-10 weeks	30	75.00
11-12 weeks	6	15.00
>12 weeks	4	10.00

In assessing the incidence of complications among the 20 participants who underwent osteotomy, it was found that the majority, 80%, did not experience any complications post-surgery. However, there were instances of complications in the remaining participants: under correction of the deformity was observed in 10% of the cases, nerve injury occurred in 5%, and another 5% experienced infection (Table 3).

The distribution of the Mayo Elbow Performance Score (MEPS) among the 20 participants post-osteotomy revealed varied outcomes. A substantial portion, 40%, achieved an 'Excellent' score (91-100), indicating highly successful outcomes. Close behind, 45% of the participants were rated as 'Good' (75-90) in their elbow performance. A smaller group, 10%, fell into the 'Fair' category (60-74), while only 5% of the participants were scored as 'Poor' (less than 60) in their postoperative elbow performance (Table 4).

Table 3: Distribution of participants by incidence of complications (n=40).

Incidence of complications	Frequency	Percentage
No complications	32	80.00
Under correction	4	10.00
Nerve injury	2	5.00
Infection	2	5.00

Table 4: Distribution of study population according to mayo elbow performance score (n=40).

MEPS	Frequency	Percentage
Excellent (91-100)	16	40.00
Good (75-90)	18	45.00
Fair (60-74)	4	10.00
Poor (<60)	2	5.00

The functional outcomes of the 20 participants following osteotomy were predominantly positive. A significant majority, 95%, reported satisfactory functional outcomes post-surgery. Only a small fraction, 5%, categorized their functional outcome as unsatisfactory (Table 5).

Table 5: Distribution of study population according to functional outcome (n=40).

Functional outcome	Frequency	Percentage
Satisfactory	38	95.00
Unsatisfactory	2	5.00

DISCUSSION

Our study's demographic findings, with a higher incidence of cubitus varus deformity in the 11-15 years age group (45%), align with the general understanding that this condition predominantly affects children and adolescents.[21] The gender distribution in our study, with a higher prevalence in males (60%), further corroborates existing literature that suggests a slight male predominance in orthopedic injuries in children.[22] The mechanism of injury in our study, predominantly falls while playing (55%), highlights the common etiology of cubitus varus deformity in active children, a finding that resonates with broader pediatric orthopedic research.[23] This observation is crucial for preventive strategies. Regarding the duration of injury, our study found that 55% of participants had an injury duration of less than 35 months. This finding is significant as it suggest a window for optimal surgical intervention.[24] In terms of previous treatment modalities, our study found that the majority of participants (75%) underwent closed reduction and cast immobilization. This reflects the standard initial treatment approach for cubitus varus deformity.[25] The duration of bone union post-osteotomy in our study, predominantly within 8-10 weeks for 75% of cases, is a critical finding. This aligns with the results of Yadav and Kumar, suggesting that three-dimensional osteotomy allows for a relatively rapid bone healing process.[21] The incidence of complications in our study was notably low, with 80% of participants experiencing no postoperative complications. This is a significant finding when compared to other studies, such as that by Li et al, who reported a similar low complication rate.[22] The distribution of the Mayo Elbow Performance Score (MEPS) in our study provides a nuanced view of the outcomes following three-dimensional osteotomy. The fact that 40% of participants achieved an 'Excellent' score and 45% were rated as 'Good' is a testament to the efficacy of this surgical approach, which is supported by other existing studies.[26,27] These high scores are indicative of not only successful surgical correction but also of preserved or enhanced elbow functionality post-surgery. Furthermore, the overwhelmingly positive functional outcomes, with 95% of participants reporting satisfaction post-surgery, underscore the clinical success of the three-dimensional osteotomy in treating cubitus varus deformity. The minimal rate of unsatisfactory outcomes (5%) in our study highlights the precision and effectiveness of the surgical technique used. In conclusion, our study's findings on demographic distribution, injury mechanism, duration of injury, previous treatment modalities, bone union time, and complication rates not only align with existing literature but also provide valuable insights for optimizing treatment strategies for cubitus varus deformity. The consistency of our results with previous studies reinforces the reliability of three-dimensional osteotomy as an effective treatment modality.

This study has limitations. The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community.

CONCLUSION

In conclusion, this study demonstrates that three-dimensional osteotomy is a highly effective surgical intervention for correcting cubitus varus deformity, particularly in the pediatric and adolescent population. Our findings reveal that the majority of patients experienced satisfactory functional outcomes and a significant improvement in the Mayo Elbow Performance Score post-surgery. The low incidence of complications and the relatively short duration of bone union further underscore the safety and efficacy of this technique. These results are consistent with existing literature, reinforcing the notion that three-dimensional osteotomy not only corrects the physical deformity but also significantly enhances the overall elbow functionality and quality of life for patients. Our study contributes valuable insights into the treatment of cubitus varus deformity, particularly in settings similar to ours, and underscores the importance of timely, precise, and patient-specific surgical interventions. Future research should focus on long-term outcomes and the optimization of surgical techniques to further improve patient care and treatment efficacy.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Crombie A, Duncan R. Closed reduction and percutaneous fixation of displaced paediatric supracondylar fractures of the elbow. Current Orthopaedics. 2004;18(2):147-53.
2. Steenbrugge F, Macnicol M. Guidelines and pitfalls in the management of supracondylar humerus fractures in children. Current Orthopaedics. 2001;15(3):214-9.
3. Pirone AM, Graham HK, Krajbich JI. Management of displaced extension-type supracondylar fractures of the humerus in children. JBJS. 1988;70(5):641.
4. Azar FM, Canale ST, Beaty JH. Campbell's Operative Orthopaedics, E-Book. Elsevier Health Sciences; 2020:5530.
   Louw QA, Manilall J, Grimmer KA. Epidemiology of knee injuries among adolescents: a systematic review. Br J Sports Med. 2008;42(1):2-10.
5. Jain AK, Dhammi IK, Arora A, Singh MP, Luthra JS. Cubitus varus: problem and solution. Arch Orth Traum Surg. 2000;120(7):420-5.
6. Skaggs DL, Glassman D, Weiss JM, Kay RM. A new surgical technique for the treatment of supracondylar humerus fracture malunions in children. Journal of Children's Orthopaedics. 2011;5(4):305-12.
7. Usui M, Ishii S, Miyano S, Narita H, Kura H. Three-dimensional corrective osteotomy for treatment of cubitus varus after supracondylar fracture of the humerus in children. J Should Elbow Surg. 1995;4(1, Part 1):17-22.
8. Yun YH, Shin SJ, Moon JG. Reverse V osteotomy of the distal humerus for the correction of cubitus varus. J Bone Joint Surg Brit. 2007;89-B(4):527-31.
9. Solfelt DA, Hill BW, Anderson CP, Cole PA. Supracondylar osteotomy for the treatment of cubitus varus in children: a systematic review. Bone Joint J. 2014;96-B(5):691700.
10. Fernandez DL. Reconstructive procedures for malunion and traumatic arthritis. Orthop Clin North Am. 1993;24(2):341-63.
11. Bilic R, Zdravkovic V, Boljevic Z. Osteotomy for deformity of the radius. Computer-assisted three-dimensional modelling. J Bone Joint Surg Brit. 1994;76-B(1):150-4.
12. Uchida Y, Ogata K, Sugioka Y. A new three-dimensional osteotomy for cubitus varus deformity after supracondylar fracture of the humerus in children. J Ped Orthopaed. 1991;11(3):327.
13. King D, Secor C. BOW elbow (cubitus varus). JBJS. 1951;33(3):572.
14. Sweeney J. Osteotomy of the humerus for malunion of supracondylar fractures. J Bone Joint Surg Br. 1975;57:117.
15. Kumar A. A clinical and haematological profile of HIV positive patients at a teritiary care hospital with special reference to opportunistic infections. J Evolut Medi Dent Sci. 2014;3:20-9.
16. Takeyasu Y, Murase T, Miyake J, Oka K, Arimitsu S, Moritomo H, et al. Three-dimensional analysis of cubitus varus deformity after supracondylar fractures of the humerus. J Sho Elbow Surg. 2011;20(3):440-8.
17. Takagi T, Takayama S, Nakamura T, Horiuchi Y, Toyama Y, Ikegami H. Supracondylar osteotomy of the humerus to correct cubitus varus: do both internal rotation and extension deformities need to be corrected?*. JBJS. 2010;92(7):1619.
18. Murase T, Oka K, Moritomo H, Goto A, Yoshikawa H, Sugamoto K. Three-dimensional corrective osteotomy of malunited fractures of the upper extremity with use of a computer simulation system. JBJS. 2008;90(11):2375.
19. Mayo Elbow Performance Score - an overview. ScienceDirect Topics. Available at: https://www.sciencedirect.com/topics/medicine-and-dentistry/mayo-elbow-performance-score. Accessed 28 January 2024.
20. Yadav R, Kumar N. Prospective clinical study to assess the outcome of three dimensional osteotomy for cubitus varus deformity. Int J Pharmac Clin Res. 2021;13(4);489-97.
21. Li J, Wang J, Rai S, Ze R, Hong P, Wang S, et al. 3D-printed model and osteotomy template technique compared with conventional closing-wedge osteotomy in cubitus varus deformity. Sci Rep. 2022;12(1):6762.
22. Kim JR, Moon YJ, Wang SI. Translation step-cut osteotomy for posttraumatic Cubitus Varus in adults: a retrospective study. BMC Musculoskeletal Dis. 2020;21(1):820.
23. Wu J, Xu W, Liu C, Fan Y, Ma X, Liu Q, et al. [Computer-simulated osteotomy based on health-side combined with guide plate technique in treatment of cubitus varus deformity in adolescents]. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2023;37(10):1214-9.
24. Verka PS, Kejariwal U, Singh B. Management of cubitus varus deformity in children by closed dome osteotomy. J Clin Diagn Res. 2017;11(3):RC08-12.
25. Jiang L, Li H, Huang L. The efficacy of 3D printing model in the intraarticular osteotomy in the treatment of malunion of tibial plateau fracture. Orthop Surg. 2023;15(1):85-92.
26. Zhang YW, Xiao X, Gao WC, Xiao Y, Zhang SL, Ni WY, et al. Efficacy evaluation of three-dimensional printing assisted osteotomy guide plate in accurate osteotomy of adolescent cubitus varus deformity. J Orthop Surg Res. 2019;14(1):353.

Cite this article as: Khan MZH, Das KP, Islam MA, Sarker MHR, Sidny NZ. Management of cubitus varus deformity by three-dimensional osteotomy: analysis of outcome. Int J Res Orthop 2024;10:1126-30.