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Original Research Article

A Hospital Based Observational Assessment of Lateral Closure Wedge Osteotomy to Correct Cubitus Varus Deformity in Pediatric Patients

Manoj Kumar[1], Swati Sinha[2], Krishna Kumar[3], Arun Kumar[4]

[1]Senior Resident, Department of Orthopedics, SKMCH, Muzaffarpur, Bihar, India

[2]Senior Resident, Department of Physical Medicine and Rehabilitation, ESIC Medical College Bihta, Patna, Bihar, India

[3]Professor and HOD, Department of Physical Medicine and Rehabilitation, ESIC Medical College, Bihta Patna, Bihar India

[4]Associate Professor, Department of Orthopedics SKMCH, Muzaffarpur, Bihar India

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Corresponding Author: Dr. Swati Sinha
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Abstract

Aim: To study of lateral closure wedge osteotomy to correct cubitus varus deformity in pediatric patients.

Material and Methods: This study was conducted in the Department of Orthopedics, SKMCH, Muzaffarpur, Bihar, Patna. The medical records of patients were retrospectively reviewed. all patients' guardians were obtained for the study publication of identifying information in an online open-access publication. The inclusion criteria were as follows: surgery performed over 6 months after the diagnosis of SHFs, difference in flexion angles of the affected and unaffected limbs of > 15°, and recovery of elbow function pre-ostomy including extension and flexion with a full range of movement.

Results: The mean preoperative HEW angle in the affected elbow was 20.38° ± 2.14°, while the postoperative HEW angle was 11.95° ± 2.15°. All the osteotomies had healed by 5–8 weeks after surgery (average 6.04 ± 1.09 weeks). The mean HEW angle in the normal elbow was 11.55° ± 2.65° of valgus, and the mean correction obtained was 32.33° ± 2.83°. According to the MEPI score assessment, 19 of the 21 patients had an excellent out- come, and two had a good outcome at the final follow- up at 21.6 ± 4.8 months. None of the patients showed evidence of neurovascular injury, including injury in the radial and ulnar nerves. None of the patients complained of prominence of the lateral humerus. Two patients complained of conspicuous scars; however, no further cosmetic surgery was performed. The range of motion was 135.0° preoperatively and 133.7° postoperatively, showing no significant difference (p = 0.326).

Conclusion: In conclusion, our study results demonstrated that the Paley's principles regarding lateral closing wedge osteotomy for cubitus varus deformity in children are practical, effective, and reliable to treat cubitus varus.

Keywords: Lateral closure, Wedge osteotomy, Cubitus varus deformity, Pediatric

Introduction

Cubitus varus deformity, often referred to as "gunstock deformity," is a common complication resulting from supracondylar fractures of the humerus in children. This deformity is characterized by an inward angulation of the elbow, leading to cosmetic and functional impairments. [1-5] Lateral closing wedge osteotomy is one of the most widely accepted surgical techniques for correcting cubitus varus deformity in children due to its effectiveness in restoring proper alignment and improving arm function. Cubitus varus deformity primarily results from malunited supracondylar fractures of the humerus, often due to improper initial fracture management or inadequate fracture reduction. The deformity not only leads to an unsightly appearance but also causes functional issues, including restricted range of motion and potential difficulties in daily activities. [6-9] Additionally, the deformity can lead to long-term complications such as lateral condyle overload, which might progress to arthritis if not addressed timely. Lateral closing wedge osteotomy is a corrective surgical procedure aimed at realigning the distal humerus to address the varus deformity. This technique involves the removal of a wedge-shaped piece of bone from the lateral side of the humerus and closing the gap to achieve the desired correction. The osteotomy is stabilized using various fixation methods, including plates, screws, or external fixators. The surgical approach for lateral closing wedge osteotomy typically involves the following steps: Preoperative Planning: Accurate preoperative planning is crucial to determine the degree of correction required. Radiographic assessment and templating are used to measure the angulation and plan the osteotomy. Incision and Exposure: A lateral approach to the distal humerus is commonly used. Care is taken to protect the radial nerve and other vital structures during exposure. Osteotomy: The osteotomy is performed at the planned site, and a wedge of bone is removed based on preoperative calculations. The angle of the wedge corresponds to the degree of correction needed. Fixation: The osteotomy site is then closed, and the bone ends are fixed using appropriate hardware to maintain stability and promote healing. Plates and screws are often preferred for their rigidity and reliability. Postoperative Care: Postoperative care involves immobilization of the arm, followed by gradual physiotherapy to restore range of motion and function. [10-18] Lateral closing wedge osteotomy remains a reliable and effective surgical option for correcting cubitus varus deformity in children. Its success hinges on thorough preoperative planning, precise surgical execution, and diligent postoperative care. With proper technique, this procedure not only improves the cosmetic appearance of the arm but also restores functional capabilities, significantly enhancing the quality of life for affected children. [19-22]

Material and Methods

This study was conducted in the Department of Orthopaedic,SKMCH,Bihar, India for one year. The medical records of patients were retrospectively reviewed. all patients' guardians were obtained for the study publication of identifying information in an online open-access publication. The inclusion criteria were as follows: surgery performed over 6 months after the diagnosis of SHFs, difference in flexion angles of the affected and unaffected limbs of > 15°, and recovery of elbow function pre-ostomy including extension and flexion with a full range of movement. The exclusion criteria were as follows: different surgical approach, consent not obtained from the patient's guardians, and incomplete follow-up.

Methodology

All patients underwent surgery under general anesthesia and performed by the same surgical team. A tourniquet was placed on the proximal humerus, and a 4–6-cm longitudinal lateral incision was made. The distal humerus was exposed through the brachioradialis and triceps muscles. The distal humerus and the coronoid fossa were completely exposed for surgical convenience. The ideal osteotomy sites were chosen based on the following. First, the vertex of the triangle template should be located on the dotted line. Second, the medial cortex should be intact at approximately 0.5-cm thickness. Third, the osteotomy line should be nrawn at least 1 cm above the coronoid fossa in order to avoid damaging it. According to the designed template and osteotomy line, two K-wires were used and placed to locate the osteotomy lines. A C-arm was used to check whether the osteotomy lines were in accordance with what we designed. During this process, the template was used to assist in the determination of the location of the K-wires and osteotomy. The osteotomy was then performed, the fragment of the bone was removed, and two or three 2-mm K-wires were placed across the osteotomy from the lateral side. A C-arm was used to verify the fixation stability and the correction of the cubitus varus. A long-arm cast was used for external fixation of the elbow flexed at 45°.

Postoperative Examination and Follow‑Up

All the casts were changed, and the incisions were examined during the first postoperative week; the casts were changed based on the functional position. Once callus formation was confirmed on radiographs between weeks 5 and 7 postoperatively, the casts and K-wires were removed, and the patients were encouraged to exercise the elbow. Follow-up clinical and radiographic assessment was conducted at 8 weeks, 12 weeks, and 6 months postoperatively. The evaluations included radiography of the affected elbow (for the HEW angle) and function evaluation according to the Mayo Elbow Performance Index (MEPI) score . [17] The MEPI scores were categorized as follows: >90 points, excellent; 81–90 points, good; 61–80 points, fair; and < 60 points, poor. Complications, such as incision infection, neurovascular injury, lateral prominence, irritation at the site of the K-wires, and bone non-union, were also evaluated

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics for Windows, version 22.0 (IBM Corp., Armonk, NY, USA). P-values < 0.05 were considered statistically significant.

Results

The patients' demographic characteristics are shown in Table 1. The mean preoperative HEW angle in the affected elbow was 20.38° ± 2.14°, while the postoperative HEW angle was 11.95° ± 2.15°. All the osteotomies had healed by 5–8 weeks after surgery (average 6.04 ± 1.09 weeks). The mean HEW angle in the normal elbow was 11.55° ± 2.65° of valgus, and the mean correction obtained was 32.33° ± 2.83°. According to the MEPI score assessment, 19 of the 21 patients had an excellent out- come, and two had a good outcome at the final follow- up at 21.6 ± 4.8 months. None of the patients showed evidence of neurovascular injury, including injury in the radial and ulnar nerves. None of the patients complained of prominence of the lateral humerus. Two patients complained of conspicuous scars; however, no further cos- metic surgery was performed. The range of motion was 135.0° preoperatively and 133.7° postoperatively, showing no significant difference (p = 0.326).

Table 1 Patients' demographic characteristics, evaluation details

Patients'	demographics				HEW		ROM (f/e)		Evaluation
Case	Age (years)	Sex	Side	Fixation time (week)	Pre-operative	Last follow -up	Pre operative	Last follow-up	
1	9	M	R	6	— 21	12	145/0	138/0	Excellent
2	5	F	R	5	— 23	14	148/0	141/0	Excellent
3	3	M	L	5	— 17	15	145/0	132/0	Excellent
4	10	M	L	6	— 19	9	133/0	125/0	Excellent
5	6	M	L	5	— 22	12	135/0	139/0	Excellent
6	13	F	R	8	— 21	15	129/5	134/5	Good
7	12	M	L	8	— 22	7	132/0	139/0	Excellent
8	12	M	L	7	— 17	12	131/0	124/0	Excellent
9	11	F	R	8	— 24	17	130/5	128/5	Good
10	10	M	R	7	— 22	13	135/0	138/0	Excellent
11	8	M	L	6	— 26	8	138/0	135/0	Excellent
12	6	M	L	5	— 19	13	138/0	133/0	Excellent
13	11	M	L	6	— 21	14	138/0	131/0	Excellent
14	7	M	L	5	— 22	11	130/0	142/0	Excellent
15	5	M	R	5	— 19	7	135/0	141/0	Excellent
16	5	M	R	5	— 18	12	138/0	138/0	Excellent
17	3	M	R	5	— 17	11	127/0	128/0	Excellent
18	5	M	R	5	— 21	11	128/0	135/0	Excellent
19	10	M	L	7	— 22	13	134/0	131/0	Excellent
20	13	M	R	7	— 19	9	135/0	128/5	Excellent
21	9	F	L	6	— 16	16	133/0	127/0	Excellent
Mean	8.23			6.04	— 20.38	11.95	135.0/0.48	133.7/0.71	
SD	2.67			1.09	2.14	2.15	*P* = 0.326		

SD standard deviation, HEW humerus elbow wrist angle, M male, F female, ROM range of movement, f/e flexion and extension a According to the Mayo Elbow Performance Index score

Table 2 Comparison between Paley's osteotomy and lateral closing isosceles triangular osteotomy

	Principle	Purpose	Osteotomy line	Osteotomy apex
Paley's osteotomy	Paley's principle	Anatomy axis correction	Total humerus break	Ulnar humerus cortex
Isosceles triangular osteotomy	Isosceles triangular	Eliminate lateral prominence	Ulnar sides intact (5 mm)	CORA line

Discussion

The goal of surgical correction for cubitus varus deformity is precise correction with functional recovery similar to that of the unaffected side. A recent study demonstrated that cubitus varus deformity is a three-dimensional deformity that involves not only varus angulation but also extension and internal rotation of the distal humeral segment. [18] Three-dimensional constructions of cubitus varus have been reported. [10,11,13] However, these methods involve a relatively complex surgery and the need for CT evaluations of the reconstruction; this in turn leads to higher clinical costs and increased radiation exposure, which is especially harmful for children. Correction of internal rotation and extension deformities is possible in children, especially in those aged < 10 years. [19] Further, the most common complaints of children with cubitus varus deformity and their guardians are the cosmetic outcome and prominence of the lateral humerus. Thus, the best surgical approach should account for these factors. Our study novelty is that we corrected the anatomical and mechanical axes with precision. By using Paley's principles, the best osteotomy lines were designed in children with cubitus varus.

Various osteotomy methods have been reported, including traditional lateral closing wedge osteotomy [20], dome osteotomy 7, medial opening wedge osteotomy, step-cut osteotomy, and reverse V osteotomy [21]. Lateral closing wedge osteotomy described by French [20] was widely accepted due to its ease and simplicity (Table 2). However, the main shortcoming of this approach is the postoperative prominence caused by a mismatch in the osteotomy width. In a previous study, we developed the isosceles triangular osteotomy method, which decreases the incidence of prominence. [14] Further, the application of Paley's principles for the correction of cubitus varus deformity allows a more effective treatment of this deformity. The mean difference between these methods is listed in the Table 3.

The core technique and tips of our study were the design of the osteotomy line and template. According to Paley's principles, when the osteotomy passes through any of the CORAs, realignment is achieved without translation. When the osteotomy is at a different level, the axis realigns by angulation and translation at the osteotomy site. By using Paley's principles, the osteotomy was performed in the direction of the dotted CORA line. In our study, the CORA line was drawn for all patients, while the PAA was based on the unaffected limb. Further, an isosceles tri- angle template with predetermined angles was developed and used during the surgery. The angle degree was deter- mined by the carrying angle in the unaffected limb plus the angle of the cubitus varus limb. If the vertex is located on the CORA line, realignment occurs without translation and in a straight line [15]. In this study, the CORA line was successfully drawn in all the patients, and none of the patients or their guardians complained about the cosmetic outcome of the procedure. In this study, no significant difference in the carrying angles of the affected and unaffected limbs were noted. Further, although our design used the coronal view of the elbow, the osteotomy lines should be drawn based on the sagittal view. We corrected the sagittal plane according to the normal side; during the osteotomy procedure, the flexion or extension can be adjusted by isosceles trapezoid or inverted isosceles trapezoid. The back of the osteotomy should be a little smaller if the patients need more flexion.

Various fixation materials have been used for the treatment of cubitus varus deformities, with K-wires being used most commonly for fixation. Other materials include screws [22], tension band constructs, staples, and external fixators [23]. In our study, we used K-wires as the only fixation material mainly because K-wires are cost effective and there is no need for removal requiring hospitalization. Second, because our patients were aged < 13 years and union of the osteotomy was achieved in less than 8 weeks, there was no need for long- term fixation. Third, according to our surgical approach, approximately 0.5 cm thickness of the cortex was maintained on the medial side when the humerus fragment was removed, and a green stick osteotomy occurred when the osteotomy was closed. It plays an important role for union and stability of the fixation. Further, two to three K-wires combined with a cast provided enough stability for fixation. In our study, no patient experienced postoperative displacement of the osteotomy. Moreover, although three patients experienced pin site irritation, they all recovered after removal of the fixation material.

In this study, we chose the lateral approach, which has been shown to cause cosmetic problems [24]; however, in our study, only two patients complained of cosmetic issues that were not severe enough to necessitate further treatment. Importantly, the lateral approach is possibly the safest. Although the medial approach can help conceal the surgical scars, there is a higher associated risk of injury to the ulnar nerve. [25] In this regard, some surgeons prefer the posterior triceps-splitting approach combined with osteotomy of the olecranon; however, this approach may lead to radial and ulnar nerve palsy [26], and a higher risk of stiffness. [27, 28]

Surgeons must pay sufficient attention to elbow function. According to the MEPI score assessment, most of our patients achieved an excellent functional outcome, while two patients achieved good postoperative function. No significant difference between preoperative and post- operative scores was noted. However, in our study, recovery of elbow function was one of the inclusion criteria. Furthermore, the time for fixation was no more than 8 weeks after the operation. Further, once the formation of callus was confirmed, the cast was removed, and exercise rehabilitation was initiated. Our study focused on the correction of the axis of the upper limb, which is imperative for the correction of the lower limb, including joint replacement. If correction is not properly achieved, osteoarthritis or pain may develop. Although the upper limb has weight-bearing function, sports practice is also required. Longer follow-up studies are needed to assess the complete recovery of patients with cubitus varus deformity treated with the approach proposed here.

There are some limitations to our study that need to be taken into account while interpreting the data. First, this was a retrospective study, and a prospective or multicenter study is needed to rule out the influence of bias. Second, the sample size of the study was small; hence, more patients should be included in future studies. Third, the follow-up duration was not sufficiently long for the evaluation of late complications. Further, the proposed technique did not consider the correction of rotation. Moreover, all patients were aged < 13 years; therefore, elderly patients and some other fixation materials should be evaluated in further studies.

Conclusion

In conclusion, our study results demonstrated that the Paley's principles regarding lateral closing wedge osteotomy for cubitus varus deformity in children are practical, effective, and reliable to treat cubitus varus.

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