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Step cut closing wedge osteotomy and lateral plating for cubitus varus in adults

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Abstract
Background: Various osteotomies have been in use for correction of varus deformity at elbow in adults. The objective of the study was to determine the clinical, radiological and cosmetic outcome of closing wedge step cut osteotomy and lateral plating in adults with cubitus varus.
Methods: This retrospective study was conducted among 15 cases of cubitus varus at an average age of 23.94 years (range, 18-31 years) and underwent closing wedge step cut osteotomy. Osteotomy was fixed with precontoured lateral locking plate. The carrying angle and range of motion of the elbow in preoperative period and final postoperative follow up was evaluated.
Results: The average carrying angle improved from 20.8° (range, 12°-30°) varus to 8.66° (range, 5°-14°) valgus. Osseous union was radiographically demonstrated in all patients at an average of 13.33 weeks (range, 10-18 weeks). Lateral condylar prominence index improved from a mean of 6 (ranging from 2.5 to -8) to -12(ranging from -8 to -14). The preoperative (127.85°) and postoperative (124°) range of motion was almost similar. The average preoperative internal rotation was 14.66◦ (range, 0-25), which was corrected to 4.66◦ (range, 0–10) postoperatively. According to Oppenheim criteria, results were excellent in 6, and good in 9. The average final Mayo Elbow Performance Score was 93.33 points (range, 85–100 points). No patient had residual or recurrence of varus deformity, ulnar nerve palsy, elbow instability, implant failure or wound problems.
Conclusions: Closing wedge step cut wedge osteotomy with lateral plating is an effective, reliable and technically less demanding corrective surgery in adults with minimum complications.

Keywords: Osteotomy, cubitus varus, adult, step cut

Introduction
Cubitus varus deformity occurs due to malunion of supracondylar fractures of humerus in children. Corrective surgery is usually done before adulthood; thus, cubitus varus deformity is not that common in adults. [1] In developing countries like India where due to ignorance and limited access to good health services, these patients are mostly treated either by local bone setters or by simple closed reduction and slab application without pinning. Even after malunion in children patient are not treated at correct age as malalignment rarely leads to malfunction. Many patients came at adulthood due to poor cosmoses, occupational hindrance like disqualification in army recruitments, obstacle in marriage and social stigma. Corrective osteotomy for cubitus varus is usually done in children who have high healing potential. Its treatment outcomes are better in children, because of superior growth correction and better achievement of elbow range of motion. [2] Corrective osteotmy and fixation of cubitus varus in adults is more challenging due to mature skeleton, poor remodelling, inherent instability at osteotomy site, risk of nonunion, implant failure, infection, stiffness and nerve complications. [3]

Different methods of osteotmy are used for varus deformity in adults including lateral closing wedge osteotomy [3-5], three-dimensional osetotomy [1], dome osteotomy [6], oblique osteotomy [7], step-cut osteotomy [8] and modified step cut osteotomy with spike translation [9] .Various fixation technique are used for fixing the osteotomy like lateral plating [7], bicondylar plating [3] and y plate [1] . Step-cut osteotomy for distal humerus varus deformity, as suggested by DeRosa and Graziano [8] is one of the techniques of corrective osteotomy having inherent stability.

In this closing-type osteotomy technique, right angled defect with lateral spike is formed in which the proximal part is inserted. Hence we use step cut osteotomy for the correction of cubitus deformity in adults. We evaluated our functional and radiological outcome of lateral closing wedge step cut osteotomy with lateral plating for correction of cubitus varus in adults.

Methods

Between 2015 and 2018, 15 patients, nine males and six females, with cubitus varus deformity were admitted to our institute and underwent corrective step-cut osteotomy. We retrospectively analysed these patients operated with close wedge step cut osteotomy and fixed with lateral locking plate. This study was performed under a protocol approved by our institutional review board. Informed consent was obtained from all the patients prior to the study. The average age of the patients was 23.94 years (range, 18–31 years).

All patients had history of significant elbow trauma when they were from 6 years to 13 years of age and were apparently normal prior to that. Nine of them had been treated by local bonesetters, five treated by closed reduction and cast and one treated with close reduction and k wire fixation. The interval between the initial trauma and the corrective osteotomy averaged 15.04 years (range 10–27 years). Minimum follow up was 12 months (average, 23 months; range, 17–45 months). The reason for surgery was cosmetic and not functional problems such as decrease range of motion, pain, ulnar nerve symptoms or elbow instability.

Data regarding physical and radiographic examinations were reviewed retrospectively from case sheets and radiographs done previously. For final functional and radiological evaluation, patients were contacted telephonically to come to our hospital. The assessment of cubitus varus deformity was done by using goniometer clinically. Anteroposterior radiographs of both elbows with the elbows in full extension and supination were obtained. Pre-operative and post-operative final carrying angle (CA, humeroradioulnar wrist angle) was measured on the anteroposterior radiograph as angle between the bisecting line of arm and forearm in both normal and affected side. Lateral prominence index was measured in both preoperative film and last follow up film. The index is calculated as the difference between the medial and lateral widths of the distal part of the humerus, a measured from the longitudinal midhumeral axis, and is expressed as a percentage of the total width of the distal part of the humerus. Rotational deformity was measured by physical examination in which the angle between the forearm and the back was measured with the elbow in 90° flexion and the shoulder in hyperextension. Range of motion of the both the elbows was measured using the goniometer while holding the medial and lateral condyle in the same horizontal plane. Union was said to occur when there was no pain on movements and when x rays shows trabeculae crossing the osteotomy site.

Patients were operated under regional or general anaesthesia using tourniquet with patient in lateral position. Posterior approach with triceps retraction was used to expose the distal humerus. A template corresponding to the amount of correction required was placed as lateral closing wedge just superior to the olecrenon fossa. The triangle is removed and the right angled defect with lateral bone spike on the distal fragment is formed in which the proximal part is inserted. The reduction was provisionally held by Kirschner wires and assessed under C-arm. Then fixation of the fracture was done with precontoured lateral locking plate. The triangular bone removed is broken in pieces and used as bone graft around the osteotomy side. Long arm slab applied with elbow in 90 degree of flexion for 2 weeks. Suture and slab was removed on 14th day, only arm pouch sling continued for 4 more weeks. Range of motion exercise was started at 2 weeks of operation and follow up X ray done at 2, 6, 10, 12, 14, 16, 18, 20 weeks.

Range of motion, union, carrying angle, lateral prominence index was measured at final follow up and result analysed (Table 1). The final results (excellent, good, poor) were assessed by criteria described by Oppenheim *et al*. [10] The Mayo Elbow Performance Score (MEPS) was used to evaluate postoperative elbow function. [11] The data collected was analyzed using SPSS (Statistical Package for Social Sciences) Version 15.0 statistical Analysis Software. The differences between the preoperative and postoperative range of motion and radiographic values for each deformity were determined by paired t test. Significance was established at $P < .05$.

Table 1: Patients' radiographic and clinical data preoperatively and postoperatively compared with the normal side

Patient	Age and sex	Time injury to surgery (years)	CA Normal	CA Varus (pre)	CA (post)	ROM (pre)	ROM (post)	Elbow internal rotation (pre)	Elbow internal rotation (post)	Union time (weeks)	LPI (pre)	LPI (post)	Outcome*	MEPS (post)
1	18 /M	10	10	-12	10	0-130	0-125	10	5	10	2.5	-10	E	100
2	21/ F	13	12	-14	14	0-135	0-125	15	5	12	5	-12	G	95
3	25/ M	18	8	-18	10	5-120	10-130	20	10	14	7.5	-12	G	90
4	24/F	15	14	-20	12	0-130	0-125	20	5	16	6	-15	E	85
5	20/M	10	12	-22	10	5-125	5-125	15	0	16	8	-10	E	95
6	23/F	15	16	-25	8	-5-125	0-125	25	10	14	5	-8	G	100
7	26/M	20	8	-30	5	10-130	5-130	10	5	18	7	-10	E	90
8	31/M	20	12	-25	6	0-120	5-120	15	5	10	3	-10	G	100
9	28/M	15	12	-20	8	-5-130	0-125	20	10	12	7	-12	G	95
10	22/M	14	10	-16	7	10-130	5-130	5	0	16	3	-14	E	90
11	18/F	10	14	-14	10	0-130	5-125	0	0	14	5	-10	G	100
12	28/M	18	6	-18	6	5-125	0-130	10	0	16	4	-8	G	85
13	26/F	18	12	-24	8	0-130	5-125	15	5	12	5	-12	G	90
14	24/M	18	8	-26	8	0-135	0-130	15	0	10	5	-10	E	95

15	25/F	17	10	-28	8	0-140	0-130	25	10	10	4	-8	G	90
Average	23.94 M=9,F=6	15.04	10.93	-20.08	8.66	127.85	124	14.66	4.66	13.33	6	-12	E=6 G=9	93.33

M=Male, F=Female, CA=Carrying angle, pre=Preoperative, post=Postoperative, ROM = Range of motion, LPI = lateral prominence index, MEPS= Mayo Elbow Performance Score, E=Excellent, G=Good
*Outcome expressed as Oppenheim's criteria

Results

In our study, we had total of 15 adult patients of post-traumatic cubitus varus with 9 males and 6 females. The complete data of the all the patients are given in table 1. The mean time since injury to corrective osteotomy was 15.04 years (range 10—20 years). Almost equal percentage of right (8, 53%) and left (8, 47%) sided cubitus varus were affected.

The mean preoperative range of motion was about 127.85◦ (range 120—140◦), while the mean range of motion at the time of the last follow-up was about 124 (range 125—135◦). This difference was not statistically significant ($p>0.05$). Compared with the normal side, the average preoperative internal rotation was 14.66◦ (range, 0-25), which was corrected to 4.66◦ (range, 0–10) postoperatively. Before the operation, ten patients had more than 10◦ internal rotation, but after the operation, no patient had more than 10◦ internal rotation deformity. Carrying angle (CA) on the normal side ranged from 6-16 degrees with a mean of 10.93 degrees. The mean CA was −20.08° (range, −30° to −12°) before surgery and 8.66° (range, 5°–14°) at the final follow-up, the difference was significant ($p<0.05$). In 2 elbows, the difference of the CA between the affected and the normal elbow was more than 5°, and in rest it was between 0° and 5°. Mean time for union was 13.33 weeks, ranging from 10-18 weeks. Lateral condylar prominence index improved from a mean of 6 (ranging from 2.5 to 8) to 12 (ranging from -8 to -14).

On the basis of Oppenheim's criteria, there were 6 patients with excellent results and nine patients had good results. The recent MEPS score averaged 93.33 points (range, 85–100 points), with the results rated as excellent in 13 and good in 2. No elbow had residual or recurrence of varus deformity. No patient had ulnar nerve palsy, elbow instability, implant failure or wound problems, and no patient needed removal of the plate till the last follow up. There was no loss of correction once achieved, observed in any of our patients following modified step-cut osteotomy.

Discussion

Cubitus varus is common deformity following supracondylar fracture due to neglect, maltreatment and conservative management. Corrective osteotomy for cubitus varus is usually done in children having good functional and radiological outcome in comparison to adults. Although there are several studies about correction of cubitus varus in children but literature for surgical correction of cubitus deformity in adults is lacking (Table 2).

Table 2: Literature review of outcomes of corrective osteotomy for cubitus varus in adults

Authors	Number of patients sex age	Osteotomy	Fixation	CA (pre)	CA (post)	ROM (pre)	ROM (post)	Outcome	Complications
Chung MS *et al* [1] 2003	23 21M/2F 26 years (range, 17–47)	Three-dimensional corrective osteotomy	Y Plates	-26	3	11-136	3-129	NA	5 patients: complete radial nerve palsy in 1, myositis ossificans in 1, and incomplete radial nerve palsy in 3.
Pandey S *et al* [3] 2012	8 5M/3F 22.3 years (15 -29)	Lateral closing wedge osteotomy	Bicondylar reconstruction plate	-20.16		135	134.3	NA	Nil
Gong HS *et al* [7] 2008	12 5M/7F 39years (24-45)	Oblique Closing Wedge Osteotomy	Lateral congruent pate	-23.3	8	130	129.6	E=9 G=3	2 patients: scar hypertrophy in 1, limb shortening in 1
Hahn SB *et al* [6] 2009	16 12M/4F 33.12years (18-50)	Dome osteotomy	Bicondylar plate	-17.87	6.1	137.31	128.31	E=12 G=4	Nil
Lim TK *et al* [5] 2011	20 12M/8F 47.9 years (41-55).	3-dimensional Lateral closing wedge osteotomy	Singe reconstruction plate in 8 cases Double reconstruction plate in 12 cases	-21.4	8.7	123.5	121	E=13 G=6 P=1	Fixation failure in 2 cases with single plating.
Kim *et al* [12] 2005	19 patients 23 years (16-43)	Step-cut translation	Y plate	-17.4	8.6	134	134	E=13 G=4	Nil

M=Male, F=Female, CA=Carrying angle, ROM=Range of motion, pre=preoperative, post=postoperative, E=Excellent, G=Good, P=poor, NA= Not available

Chung MS [1] *et al.* corrected 23 adult patients of cubitus varus deformity with three dimensional osteotomy. The clinical and radiological correction of deformity is comparable to our study but with one case of myositis ossificans and four cases of radial nerve palsy. The cause of complications might be more complex osteotomy technique and the use of Y plates.

Pandey S [3] *et al.* corrected cubitus varus in a series of 8 patients (16-29 years of age) where he performed lateral closed wedge osteotomy and fixed with posterior reconstruction plate. He found excellent results in all patients except one who had lateral condylar prominence. In our study most of the results are comparable to the study of S. Pandey *et al*. All corrective osteotomy united earlier (mean 9.3 weeks) in comparison to our study (mean 13.33 weeks). The cause of this may be five patients (64%) with ≤ 20 years of age in compare to our study with 12 patients (80%) ≥ 20 years of age. It is difficult to achieve strong fixation in lateral closing wedge osteotomy, so early range of motion cannot be regained. In addition, protrusion of the lateral condyle and lazy-s deformity of the elbow may develop postoperatively [2, 13, 14].

Gong HS [7] *et al* used oblique closed wedge osteotomy and lateral plating in 12 adult patients with average age of 39 years (31-48). They found excellent functional results in all cases with improved carrying angles and negative lateral prominence index. They believed lateral oblique closed wedge osteotomy provides larger contact area with stable fixation. The disadvantage of this osteotomy in comparison to step cut osteotomy is that larger bone is resected causing shortening of bone as observed in one case in their study.

Hahn SB [6] *et al.* used dome osteotomy in 16 adult patients with a mean age of 33.12 years with average postoperative carrying angle of 6.1 degrees and good to excellent results in all cases. It permits correction of the rotational component of the deformity simultaneously, without inducing lateral or medial condylar prominence. Although procedure is simple but lack of inherent stability requires bicondylar plating. The step cut osteotomy in our study is more stable and used only lateral plating. A dome osteotomy [15, 16] can reorient the distal fragment in both the coronal and the horizontal plane but it is often difficult to rotate the distal portion in the coronal plane and frequently some prominence of the condyles remains.

Lim TK [5] *et al.* in a case series of 20 adult patients with average age 47.9 years (range, 41-55 years) used 3-dimensional closing wedge osteotomy. The osteotomy was fixed with single plating in 8 patients and with double plating in 12. The average time to union in the single-plating group was 21.0 weeks compared with 15.1 weeks in the double-plating group. The average union time in our study was 13.33 weeks, probably to younger age group with average age of 23.94 years and use of triangular bone piece removed as bone graft. Fixation failure occurred in two cases in their study with single plating due to lack of inherent stability which is present in step cut osteotomy.

Kim HT [12] *et al.* used step-cut translational osteotomy in patients with average age of 26 years where triceps muscle was divided to apply Y-plate. They achieved valgus correction in all patients with near normal range of motion and improved Lateral prominence index. 28(93%) patients achieved good to excellent results. Triceps weakening and impaired triceps extensor functioning are reported with triceps splitting approach.

Other studies on cubitus varus correction with fewer adults are there like Matsushita T [17] *et al.* which used arc osteotomy and k wire fixation in 2 adult patients with 20 and 24 years of age. They achieved correction of carrying angle with no complications but their result cannot be generalized to adults with cubitus varus deformity. Pentalateral osteotomy by Laupattarakasem W [18] *et al.* in 108 patients was done with a mean age of 14 years (range, 3-62) with satisfactory cosmetic results but data about patients older than 18 years was not clear. Tinen [19] *et al.* performed dome osteotomy via olecranon osteotomy approach in two cases with 17 and 22 years of age. The outcome was good in one and poor in one case with lost motion of 20 and 30 degrees respectively.

Advantages with the step cut closed wedge ostetotomy than other osteotomies is being inherently stable ensuring early range of motion, early union and also it avoids olecranon osteotomy and triceps weakness. Along with this, use of single plate is cost effective and shorter duration of surgery with less tourniquet time. The problem with a step-cut osteotomy is that there is limited medial and lateral translation of the distal fragment [18] causing more lateral condylar prominence. But in our study we achieved improvement in the lateral prominence index.

Conclusion

This study shows that step cut closing wedge osteotomy achieved good functional, cosmetic and radiological outcome in cubitus varus deformity in adults. Lateral locking plating with inherent stability of step cut osteotomy allows early range of elbow motion with good fracture healing.

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