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Fixation of Supracondylar Osteotomy of the Humerus for Correction of Cubitus Varus – Wire Loop Versus Short Plate

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Abstract:
Background*: Cubitus varus (Gunstock deformity) is tri-planar deformity with components of varus, hyperextension and internal rotation of distal fragment of humerus. Various methods of fixation are used ranging from k-wire to Ilizarov Fixator.There is a controversy in method of osteotomy and fixation.*
Objective: *The purpose of this study is to compare the fixation method. One is the conventional method of two screws and wire loop. The other one is two holed short plate.*
Methods*: two groups of cubitus varus deformity, 22 patients each group were treated with supracondylar osteotomy of the humerus for correction of cubitus varus, in group I, two cortical screws with wire loop was used for fixation. Two holed short plate was used in group II. Two groups were compared in terms of intra-operative stability and requirement of additional fixation, breakage of the fixation, hardware prominence and overall result.*
Results*:*Mean age was 8.73 years (*SD±1.64) with range of 6 years to 12 years in group I. It ranged from 5 years to 12 years with a mean of 9.50 years (SD±1.79) in group II. Male to female ratio was 1.2: 1 in Group I and 1.4: 1 in group II. The interval between injury to surgery was 9.36 months (SD ±0.56) in group I and 10.77 months (SD ±0.64) in group II. 3 patients (13.6%) required medial k wire supplementation in group I. None had hardware breakage in both groups. 10(45%) patients complained of hardware prominence in group I. 8(36%) patients complained of the same group II.*
Conclusion:*Two holed short plate can be used instead of wire loop to fix supracondylar osteotomy of the humerus for the correction of cubitus varus.*
Keywords: *Cubitus varus, French osteotomy, supracondylar fracture*

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I. Introduction

Cubitus varus (Gunstock deformity) is tri-planar deformity with components of varus, hyperextension and internal rotation of distal fragment of humerus.[1,2] It is the most common long-term complication of supracondylar fractures of the humerus in children.[1,3] The deformity is unsightly and although function is not greatly impaired, the child's parents often request an operation to improve the appearance of the elbow.[4] The varus deformity changes the biomechanics of the elbow, which may lead to postero-lateral rotator instability of the elbow.[3,5] Various types of osteotomy and fixation methods are in use (Table-1)[1,6-15].

Author	Date	No. of Cases	Type of Osteotomy	Method of Fixation	Reported result
French[6]	1959		Lateral closing Wedge	2 screws & wire Loop	
Bellemore[7]	1984	13	Modified French osteotomy	2 screws and loop	Excellent in 10
Hernandez [8]	1994	26	Lateral wedge	Pin, two screws with wire loop and two hole plate	Good in 16 cases, 14 unstable fixation, recommended two hole plate
Kumar[9]	2000	25	Dome shape Osteotomy	Cross pinning & wiring	9 complications
Srivastava [10]	2008	21	Lateral closed wedge	two screws and wire loop with 2 -3 lateral k wires	18 excellent result

Takagi[11]	2010	86	Group I: 3-D corrective osteotomy Group II: simple coronal plane osteotomy	Cross pins and SS wire	No significant difference in 2 groups
Yuan[12]	2011	18	Computer aided design osteotomy	Plate	Satisfactory
Yukari[13]	2013	30	Computer simulation-based 3-D corrective osteotomy		27 excellent and 3 good
Belthur[14]	2016	17	Percutaneous transverse osteotomy and 3-D correction	Taylor spatial frame	Safe, accurate and reliable
Verka[15]	2017	25	Closed Dome osteotomy	External fixator	88% excellent and 12 % good

Table 1: Various osteotomy and fixation in use for correction of cubitus varus

Fixation ranges from K-wire to Taylor's spatial frame. French was the first who described a lateral closing wedge osteotomy by held with two screws and a figure of eight wire and remains the most popular method of correction.[6] Later Bellemore et al[7] modified French Osteotomy by leaving a medial soft tissue hinge. But he used plaster slab for 3 weeks post-operatively inspite of the fixation. The screws with wire loop is commonly used but large number of fixation failure is seen in Hernandez series and two holed plate was recommended.[8] But two hole is not a common fixation method. Two screws with wire loop was supplemented with two three lateral k-wire in Srivastava series.[10] It shows that consensus has not reached on the method of fixation. We need a low volume fixation with minimum complication particularly in term of fixation failure.

The purpose of this study is to compare two fixation methods, two screws with wire loop and two holed short plate for the lateral closing wedge supracondylar osteotomy of the humerus for the correction of cubitus varus in children.

II. Material And Methods

The study was conducted on patients with cubitus varus deformity in the Department of Orthopedics, Regional Institute of Medical Sciences, Imphal, after taking permission from research ethics board from September 2017 to August 2019. 44 patients were studied after dividing into 2 groups of 22 patients each, group I was fixed with two screws and wire loop and group II was fixed with short plate.

2.1 Inclusion criteria

1. Patients with Cubitus varus deformity following supracondylar fracture with age less than 12 years or less than 30 kg of body weight.
2. Age of the fracture more than 3 months.

2.2 Exclusion criteria

1. Cubitus varus deformity due to other cause.
2. Stiffness or reduced range of motion compared to normal side.
3. Associated neurological impairment of the upper extremity.
4. Age more than 12 years or body weight more than 30 kg.
5. Loss to follow up.

2.3 Age incidence:

	TYPE OF SURGERY	N	Mean age (in years)	Std. Deviation
AGE	GROUP I	22	8.73	1.638
	GROUP II	22	9.50	1.793

2.4 Sex distribution:

		TYPES OF SURGERY		Total
		GROUP I	GROUP II	
SEX	MALE	12	13	25
	FEMALE	10	9	19
Total		22	22	44

2.5 Time interval between surgery and injury:

	TYPE OF SURGERY	N	Mean	Std. Deviation
DURATION BETWEEN INJURY AND SURGERY IN MONTHS	GROUP I	22	9.36	2.629
	GROUP II	22	10.77	3.023

2.6 Pre operative planning:

Antero-posterior (elbow in full extension and forearm in full supination) and lateral radiographs of both elbows was taken. The humerus-elbow-wrist (Carrying angle) angle was measured on both sides in all patients. The long axis was drawn by joining two mid diaphyseal points taken at two different levels in a bone. The carrying angle is the angle between long axis of the arm and long axis of the forearm. Angle of correction was estimated by the following method. Before surgery we measured the varus angle (X) of the deformed elbow and the carrying angle (Y) of the healthy side of the arm in each patient. We then calculated the angle of correction (X+Y). Base of the wedge was calculated based on the amount of the deformity.

For a particular case in this study,

Carrying angle in the affected side (right) (X) = - 5 degrees (or varus angle = 5 degrees). Carrying angle in the normal side (left) (Y) = 9 degrees

Therefore, the desired correction (X+Y) = 14 degrees. It is shown in figure no.1 along with base of wedge calculation.

Figure 1: wedge calculation of lateral cortex

Humero-capitellar angle, which is is the angle formed between long axis of humerus and long axis of capitellum in lateral view radiograph was measured in both sides as shown in figure 2 and wedge for correction of hyperextension was calculated as shown in figure 3.

Humero-capitellar angle in the affected side (right) = 60 degrees. Humero-capitellar angle in the normal side (left) = 48 degrees. Therefore, the desired correction= (60-48) degrees= 12 degrees

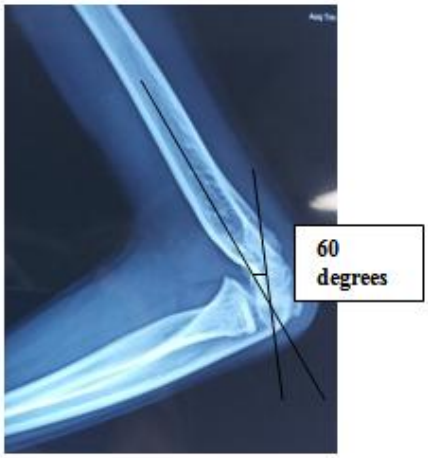

Figure 2: Humero-capitellar angle in affected side

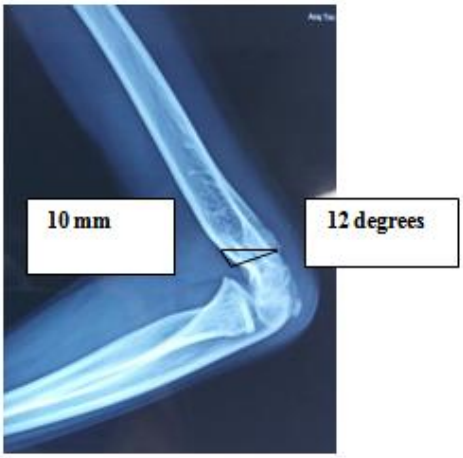

Figure 3: Wedge calculation for correction of hyperextension

The internal rotation was measured using Yamamoto method.[16]

LPI measurement is shown in figure no. 4

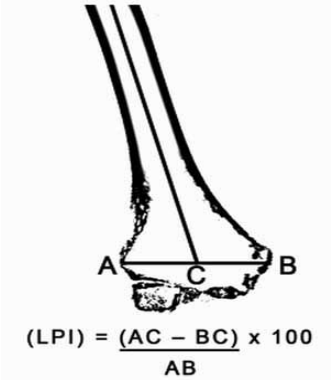

Figure 4: Lateral Condylar Prominence Index (LPI)

2.7 Operative procedure in group I:

The humerus was approached through a lateral incision. The lateral epicondyle was palpated on the lateral aspect of the distal arm. A 3 to 4 cm long straight incision was made on the lateral aspect of the elbow over the lateral supracondylar ridge. The deep fascia was incised in line with the skin incision. A plane was developed between brachioradialis anteriorly and triceps posteriorly. The periosteum was incised and elevated. Intra-operative wedge calculation was made using a plastic template of desired degrees of correction, prepared before the operation and sterilized by putting in glutaraldehyde solution. Two k- wires were passed, one just proximal to the olecranon fossa, parallel to the elbow joint line and another proximal to the desired osteotomy site at an angle that was equal to the angle of the wedge. After checking the placement of k-wires under the c-arm, two 3.5 cortical screws were inserted, one proximally and one distally parallel to the pre-placed k wires. After correcting the rotation, another wedge, based anteriorly was cut from the proximal fragment to correct the hyperextension, if the magnitude was more than 20º. After removing the cut wedge, the fragments were aligned with the help of pre-placed k-wires. The fixation was then secured with the help of figure of eight wire loop around the screws' heads and the k-wires removed. The wound was closed in layers and covered with sterile dressing pads. The osteotomy was protected with a back-slab (with the arm held at 90 degree) till sutures were removed and active mobilization was then gradually started.

2.8 Operative procedure in group II:

The humerus was approached using lateral incision and osteotomy was done as in groupI. Plate was prebent using plate benders. To prevent deformation of the screw holes during bending, they were pegged with screw heads. After required correction was achieved, osteotomy was fixed with 3.5 mm locking reconstruction plate of 2 holes. C-arm images were taken to confirm that no screw went through the growth plate. Rest of the steps were same as in group I.

2.9 Post-operative management:

Check x-ray was done on 1st post-operative day. A cephalosporin antibiotic was administered 12 hourly for five days after surgery.

2.10 Follow-up:

The patients were followed up every 2 weeks for the first 8 weeks after surgery to supervise physiotherapy, then at 3rd month and then at 6th month and clinical assessment, radiological assessment and functional assessment done.

2.11 Result interpretation:

At the end of the study period, the final assessment of the study was done by measuring correction of carrying angle, correction in degree of internal rotation, correction of hyperextension in terms of range of motion in flexion and final outcome based on the the criteria laid down by Bellemore MC et al[7] .

2.12 Statistical analysis:

- Data was checked for completeness and consistency.
- The patient data and the study variables were recorded and entered in Microsoft excel sheet (Microsoft office 2007 professional) and Statistical package for social sciences (SPSS) for windows version 21.0 software, Chicago, SPSS Inc. was used for statistical analysis.
- The data were compared among 2 groups using Independent t-test and Chi-square test.
- P-value of <0.05 was considered statistically significant.

CASE ILLUSTRATIONS:

Picture showing cubitus varus deformity of the right side of a patient osteotomy

X-ray taken on post operative day 1

Post correction of cubitus varus

Picture showing cubitus varus deformity of right side in a patient belonging to group II

X-ray taken at post op day 1

Post correction of Cubitus Varus

III. Result

1.1 Pre-operative carrying angle:

	TYPE OF SURGERY	N	Mean	Std. Deviation
PRE-OP CARRYING ANGLE	GROUP I	22	-8.06	1.578
	GROUP II	22	-8.73	1.609

1.2 Post-operative carrying angle:

	TYPE OF SURGERY	N	Mean	Std. Deviation
POST-OP CARRYING ANGLE	GROUP I	22	9.09	2.348
	GROUP II	22	9.18	2.648

1.3 Correction of carrying angle:

Mean correction of carrying angle in group I was 17.14± 2.55 and in group II was 17.91± 2.83. The p value was 0.35 which means the comparison is insignificant.

1.4 Pre-operative internal rotation:

Mean pre-operative internal rotation in group I was 35.59± 2.99 degrees in group I and 34.50± 2.35 degrees in group II. The p value was 0.19 which means the comparison is insignificant.

1.5 Correction of internal rotation:

Mean correction of internal rotation in group I was 27.86± 3.48 degrees and in group II was 26.95± 3.36 degrees. The p value is 0.38 i.e., insignificant.

1.6 Pre-operative LPI:

Mean LPI in group I was 166.41± 10.82 and that in group II was 165.68± 12.17. The p value is 0.83 which means the comparison is insignificant.

1.7 Correction in LPI:

Mean correction of LPI was 30.45± 4.07 in group I and that in group II was 30.50± 4.37. The p value is 0.95 which means the comparison was insignificant.

3.8 Union time:

	TYPE OF SURGERY	N	Mean	Std. Deviation
UNION TIME (IN WEEKS)	GROUP I	22	7.86	1.037
	GROUP II	22	7.36	.848

3.9 Final result:

Based on the criteria laid down by Bellemore et al[7], there were 18 excellent, 3 good and 1 poor result in the French osteotomy group, whereas among the patients who underwent lateral close wedge osteotomy there were 19 excellent, 2 good and 1 poor result

3.10 Complications:

Complications	Group I	Group II
Damage of medial soft tissue hinge requiring k wire supplementation	3(13.6%)	0
Non-union	0	0
Prominent hardware	10(45.5%)	8(36.4%)
Unsightly scar	14(63.6%)	12(54.5%)
Breakage of implant	1(4.5%)	0

IV. Discussion

Plate osteosynthesis after osteotomy in adult is accepted method of fixation. Conventional plate is not described for fixation of supracondylar osteotomy in child. In children various methods are used as shown in table-1. Taylor spatial frame, external fixator are bulky devices for this problem. Fixation should be stable enough to start early range of motion exercise. Other problems related with cubitus varus are type of osteotomy, whether to correct rotation and hyperextension all the time and timing of operation. As we wait long there is adaptive changes at distal humerus and correction is more difficult. Regarding correction of hyperextension and malrotation, the complexity of operation is increased if we try to correct these in all cases. So we correct hyperextension in this study, when it is more than 20 degree. Lesser amount of hyperextension is left uncorrected to get remodeled later. We try to correct rotation in all cases, but the correction is incomplete as shown by pre-operative and corrected internal rotation. Our post-operative carrying angle of 9.09 degrees (range 5 to 13 degrees) in group I and 9.18 degrees (Range 5 to 14 degrees) is comparable to that of voss FR et al[17] where the mean carrying angle was 10.2 degree.

Post operative LPI of 135 (range 121 to 155) in group I and 134.7 (Range 121 to 155) is comparable to 156±38.4 of Ahmed I et al[18].

As per the criteria laid down by Bellemore et al[7], there were 18 excellent, 3 good and 1 poor in group I and 19 excellent, 2 good and 1 poor result in group II which was comparable to 10 excellent out of 13 patients of Bellemore series.

V. Conclusion

Two holed short plate can be used instead of wire loop to fix supracondylar osteotomy of the humerus for the correction of cubitus varus.

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