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ORIGINAL ARTICLE

Correction of Posttraumatic Cubitus Varus Deformity by Dome and Modified Step-Cut Osteotomy: A Prospective Randomized Comparative Study

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Background Cubitus varus is a complex multiplan deformity of the elbow where the extended forearm is deviated towards the midline of the body. It is commonly found as a complication following neglected or improperly reduced supracondylar humeral fracture in children. Different osteotomy techniques were described for the correction of this deformity. Dome and modified step-cut osteotomies are among the commonly used techniques. In this study, the authors aimed to compare the clinical and radiological results of both types of osteotomies.

Patients and Methods A total of 39 children with cubitus varus deformities following supracondylar humeral fracture were managed either by a dome (group I) or modified step-cut (group II) osteotomy. Correction was performed within a mean of 3 years (1.5–5 years) from the incident of fracture. Patients were assessed in terms of the carrying angle, elbow range of motion, and lateral prominence index. Preoperative planning was done for every case, and osteotomies were fixed by K-wires in dome osteotomies and by K-wires or screws in modified step-cut osteotomies.

Results Fifteen patients had excellent results, and five patients had good results in group I, while in group II, 14 patients had excellent results, and five patients had good results. The carrying angle, elbow range of motion, and lateral prominence index were significantly improved in both groups. No significant complications were encountered in any of these patients throughout the study.

Conclusions Both dome and modified step-cut osteotomies are reliable techniques for correcting cubitus varus in children. Both were comparable in achieving deformity correction and minimizing the lateral condylar prominence. However, dome osteotomy has been found to be technically easier.

Keywords Cubitus varus, Deformity, Dome osteotomy, Lateral condylar prominence, Step-cut osteotomy.
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INTRODUCTION

Posttraumatic cubitus varus deformity (CVD) is one of the commonest complications following neglected or poorly managed displaced supracondylar humerus (SCH) fractures in children, with an incidence ranging from 0 to 30% [1–4]. For a long time, it was considered as a cosmetic issue in children with no functional worries. However, nowadays, there is an increasing interest in its long-term functional impact. Occasionally, it may cause delayed-onset pain of lateral elbow, symptomatic posterolateral elbow rotatory instability, snapping of the triceps tendon, delayed ulnar neuropathy, progressive elbow joint varus deformity, or may predispose to frequent lateral humeral condyle fractures [5–9].

Although corrective osteotomy of the distal humerus is the treatment of choice aiming to restore the elbow carrying angle to the normal range of 5–15^{o}, the indication and timing of surgery is still a debatable issue [4]. CVD is a complex Tri planar deformity that includes varus, internal rotation, and hyperextension. Many osteotomies have been described for correcting this deformity with variable results. The most common among these osteotomies are

French, dome, step-cut, and wedge osteotomies [10]. Ideal corrective osteotomy should be multi-axial to address all components of the deformity and avoid postoperative residual deformity [11,12].

Although simple lateral closing-wedge osteotomy has been commonly used for correction of CVD in children, it may leave residual deformity and cause lateral elbow prominence, leading to poor cosmetic results [13–15]. Since the main indication for correction is cosmetic appearance, several three-dimensional corrective osteotomies were developed to address all components of the deformity and minimize the lateral translation of the distal fragment that led to the lateral prominence [16].

In the literature, a dome-shaped osteotomy has been used for the correction of cubitus varus and has reported good results. It has the advantage of being a single-line osteotomy without taking out a bony wedge and the possibility of secondary adjustment without adding a second osteotomy. In addition, it provides mechanical stability and avoids lateral condylar prominence by placing the center of rotation in the mid-humeral line [17,18].

A step-cut osteotomy was first described by DeRosa and Graziano [19]. In this osteotomy, a lateral bony spike remains on the distal part to be fixed with a screw to the proximal segment after closing the wedge. Although it corrects the varus deformity, it was commonly complicated by lateral displacement of the distal fragment, which badly affects the appearance of the limb. Bali *et al.*, [20] developed a modification of the original step-cut osteotomy to allow correction of the deformity and minimize the lateral condylar prominence.

In this study, we reported the results of comparing the dome and modified step-cut osteotomy in the management of posttraumatic CVD in children using the para-tricipital (triceps-sparing) approach.

PATIENTS AND METHODS

In the period between January 2018 and December 2021, children presenting with CVD after SCH fracture were discovered, admitted, and treated in our department at Mansoura University Hospitals.

Children up to the age of 14 years old with a posttraumatic CVD of more than 8^{0} of coronal deformity presented at least 1 year after injury with no limitation of elbow range of motion with postoperative follow-up more than 12 months were included in this study. The exclusion criteria included nontraumatic CVD, older children who would require plate fixation of the osteotomy, traumatic CVD presented less than 12 months after injury, previous open elbow surgery, associated nerve or vascular injury in the same limb, limited elbow range of motion, and patient failed to complete 12 months of regular follow-up.

After obtaining approval from the institutional review board, obtaining valid written consent from the child's guardians for inclusion in the study, and discussing the aim and possible complications, patients were randomly divided into two groups: group I (GI), including patients managed by dome osteotomy and group II (GII) including patients managed by step-cut osteotomy. When admitted, patients were randomly assigned to one of the authors for surgery.

Preoperative assessment

With the elbow completely extended and the forearm fully supinated, anterior–posterior radiographs of both upper extremities were taken. The humeral-elbow-wrist angles were calculated using the Oppnheim method, and the angle of correction was estimated (Figure 1) [21]. When the measured angle was varus, a negative value was given, and when it was valgus, a positive value was given. In addition to measuring the affected elbow's range of motion, complaints of pain, loss of motor power, and cosmesis were recorded. According to Wong *et al.,* [14], the lateral condylar prominence index (LCPI) was calculated from radiographs taken before and after surgery. Measured from the longitudinal mid-humeral axis, the index is the difference between the medial and lateral widths of the distal part of the humerus and represents a percentage of the distal part of the humerus's overall width [14] (Figure 2).

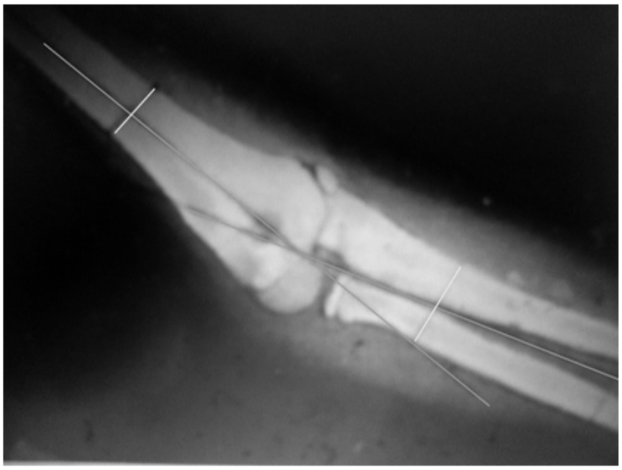

Figure 1: The carrying [humerus-elbow-wrist (HEW)] angle is calculated from the angle of intersection of the forearm and the humeral axis.

The patient was asked to lean slightly forward, with the forearm behind the back, the shoulder hyperextended maximum, and the elbow flexed 90^{0}, in order to quantify the degree of internal rotational deformity. In this posture, the patient's arm endures the greatest internal rotation strain. The internal rotational deformity angle (Yamamoto's angle) is the angle formed by the midline of the forearm and the horizontal plane of the back [22].

Figure 2: The lateral condylar prominence index (LCPI)=(AC−BC)X100/AB. There is usually a slight medial prominence, making the LCPI predominantly negative.

Preoperative plan for osteotomy

For both groups, the angle of correction is measured on tracing papers as the difference between the carrying angles of both elbows. For GI patients, the dome supracondylar osteotomy was performed according to the technique described by Tien *et al.,* [23]. The affected side's mid-humeral axis was first drawn by tracing the affected elbow's outline from the anteroposterior radiograph on a transparent piece of paper (Figure 3). We designated point O as the intersection of the superior edge of the olecranon fossa and the mid-humeral axis. Point A is where the lateral condylar epiphysis and the distal humerus's lateral cortex meet. Draw line OA by joining points O and A. The center of rotation can be found at point O. With OA as the base, the desired angle of correction was sketched; B was the location where the angle of correction met the distal humerus's lateral cortex. Using point "O" as the center and OB as the radius, an arc was drawn across the distal humerus on the template. The osteotomy site was shown by the arc.

For GII patients, the planning for the step-cut osteotomy was done according to the modification of Bali *et al.,* [20] (Figure 4). A horizontal line (AB) 1.5–3cm is drawn above the olecranon fossa vertical to the lateral supracondylar ridge. Another line is drawn from point B till reaching the lateral cortex on point C. The angle between AB and BC is the angle of correction previously measured, and the length of AB equals that of BC. A line is drawn from A to C, and ABC is the wedge to be removed. Removal of the wedge on the planning paper and assessment of alignment and any additional bone that needs to be excised from the proximal fragment to align the distal humerus without lateral displacement of the distal fragment to avoid lateral condylar prominence was planned preoperatively.

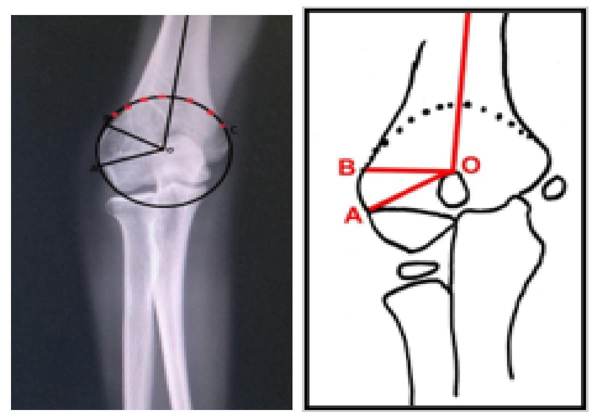

Figure 3: Template preparation: the upper edge of the olecranon fossa is bisected by the mid-humeral axis at point O. Point A is located where the distal humerus's lateral cortex and lateral condylar epiphysis meet. After sketching the angle of correction with OA as the base and O as the center of rotation, point B is shown on the lateral cortex. The arc of the osteotomy is sketched with OB as the radius.

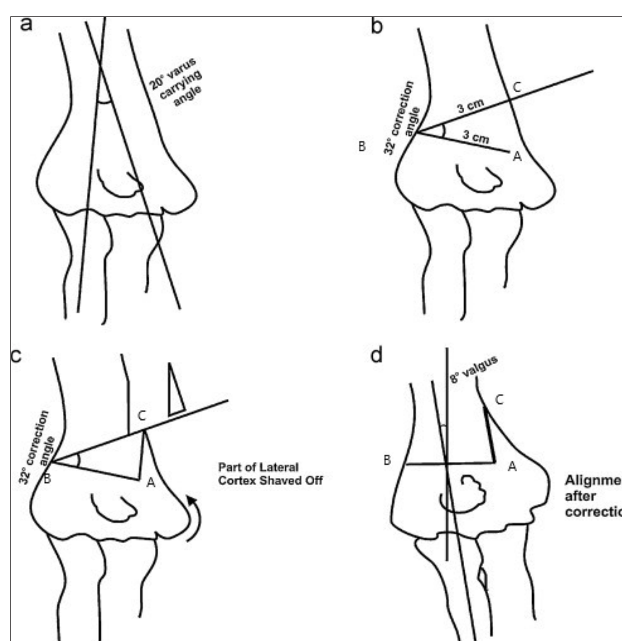

Figure 4: Preoperative planning for modified step-cut osteotomy.

Surgical technique

Under general anesthesia, all patients were placed in a lateral position with the affected arm supported by an armrest with the elbow flexed while allowing free range of motion of the elbow. Careful adequate padding of the contralateral shoulder to avoid pressure sores. After the inflation of a pneumatic upper arm tourniquet, a posterior midline longitudinal skin incision was made starting from the distal upper arm to the olecranon process. The ulnar nerve was routinely explored and protected with a Penrose drain during the operation. The triceps muscle complex was separated from the posterior surface of the lateral intermuscular septum and subperiostealy dissected from the posterior aspect of the metaphysis and diaphysis of the distal humerus and retracted medially to expose the posterior aspect of the distal humerus.

In GI patients (dome osteotomy), finding the distal humerus's perichondral and periosteal junction was essential for precise template placement. To prevent injury to the physis and perichondrium, the thick part of the periosteum was carefully separated. Points A, B, and the osteotomy's dome were marked using the preoperative template. Point A represents the periosteal and perichondral junctions on the lateral aspect of the distal humerus. Drilling holes along the marked site of the dome was done using a 2.5-mm drill bit. During the osteotomy, the anterior neurovascular bundle was protected by retractors placed along the anterior cortex of the humerus. Decortication of the lateral cortex of the distal humerus, which will be moved inside the osteotomy, was done. A quarter-inch osteotome was then used to join the drill holes, completing the osteotomy [18]. The distal fragment was then rotated coronally (Figure 5), and the rotational deformity was simultaneously fixed. After adequate correction of the deformity and ensuring good contact with the osteotomy site, the osteotomy was fixed with K-wires [18] (Figure 6).

Figure 5: After completion of the osteotomy.

Figure 6: (A): Dome osteotomy preoperative photo; (B): Intraoperative; (C): Last follow-up showing range of motion and cosmetic appearance of the elbow.

For GII patients (step-cut osteotomy), after careful planning, drilling holes along the marked site of the wedge was done using a 2.5-mm drill bit. The osteotomy was then completed by connecting the drill holes using a quarter-inch osteotome, and the planned wedge was then removed. The osteotomy site was then closed and any additional fragment needed to be trimmed from the proximal fragment to close the osteotomy site without further lateral translation of the distal fragment was resected and then the osteotomy was fixed with K-wires or 3.5mm screws (Figure 7).

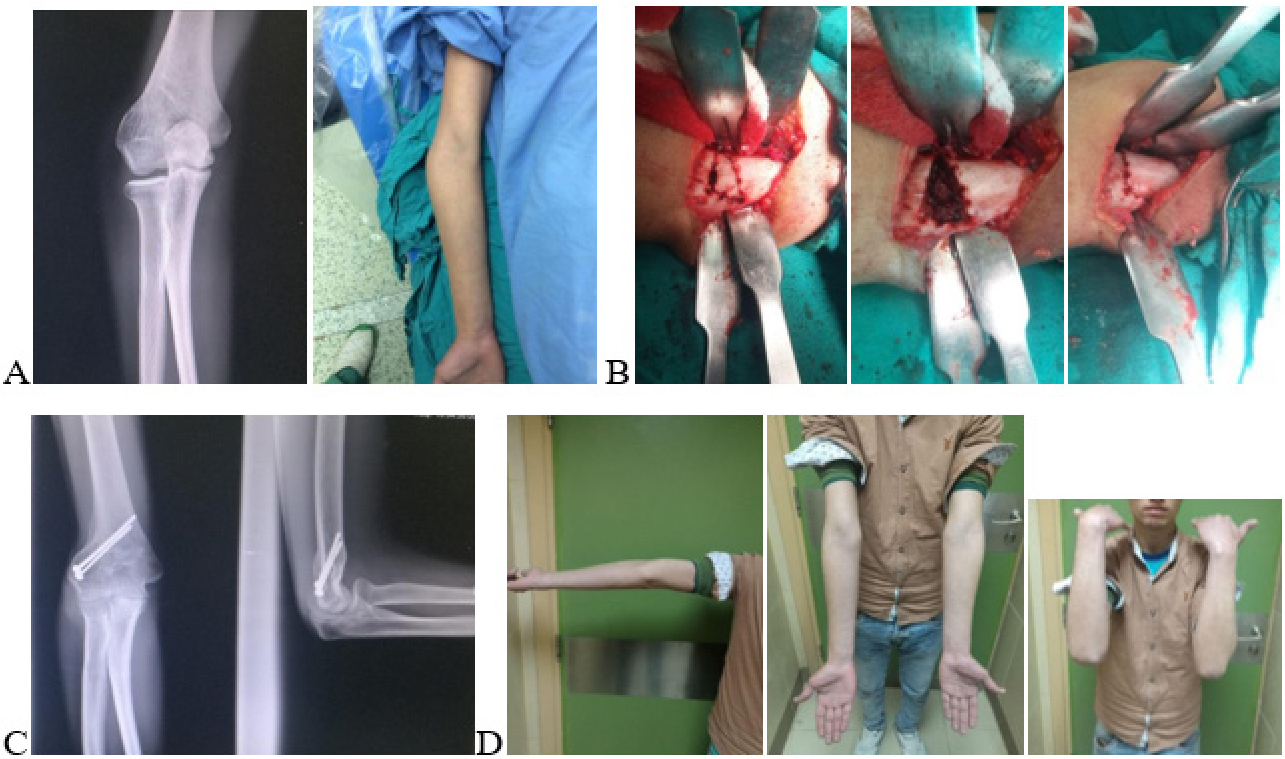

Figure 7: (A): Modified step-cut osteotomy preoperative photo and radiograph; (B): Intraoperative; (C): Last follow-up radiograph; (D): Last follow-up photos showing a range of motion and cosmetic appearance of the elbow.

In both groups, after the tourniquet release, adequate hemostasis was done before wound closure in layers.

A long arm splint was applied with the elbow in 90° of flexion and the forearm in mid-supination. The operating time was recorded in all our cases. The first follow-up visit was after 10 days for wound inspection and stitch removal, then every 2 weeks till achieving a nice radiographic union. After that, patients were followed up monthly. For both groups, after the radiological union of the osteotomy in about 4–6 weeks (average 5 weeks), K-wires were removed, followed by gentle elbow active and passive range of motion exercises.

At the final follow-up, the outcome evaluation was done by an independent consultant using the evaluation method reported by Bellemore *et al.,* [24] and LCPI. Excellent result was given when the difference in carrying angle between the normal and deformed side was less than 5^0, postoperative motion limitation was 10° or less of preoperative range of motion, and there was no increase in the LCPI. When the LCPI increased by less than 2.5%, the carrying angle difference was between 6 and 10^0, and the range of motion loss was 20^0 or less, a good result was provided. Meanwhile, a carrying angle difference of more than 10°, range of motion loss of more than 20°, and LCPI rise of more than 2.5% were all considered poor results.

Statistical analysis

Preoperative and postoperative range of motion and LCPI were compared statistically using the Student paired *t* test. Significant differences were defined as those with a *P* value less than 0.05.

RESULTS

Throughout the study 40 children were divided between the two study groups. During follow-up, one child was missing from GII and, therefore was excluded from the study. By the end of the study, only 31 children were included. Group I included 20 children (11 boys and nine girls) with an average age at the time of surgery of 10.2 years (range: 5–14 years) that were operated by dome osteotomies, while GII included 19 children (12 boys and seven girls) with an average age of 9.2 years (range: 6–13 years) that were operated by modified step-cut osteotomies. The average time between injury and surgery in GI was 32.4 months (range: 18–60 months) and 36.7 months (range: 23–60 months) in GII. The average follow-up period was 22.9 months (range: 12–36 months) for GI and 22.6 months (range: 13–36 months) for GII. In GI, the left side was affected in 11(55%) children and the right side was affected in nine children. In GII the right side was affected in 10(52%) children and the left side was affected in nine children.

In GI, 15 patients had excellent results, and five had good results, compared to GII where 14 patients had excellent results and five had good results. The mean carrying angle on the normal side was 12.3° (range: 7–18°) of valgus in GI and 11.1° (range: 8–15°) of valgus in GII.

The mean preoperative carrying angle of the affected side was –19.8° (range: –11 to –32°) in GI and was –23.8° (range: –18 to –32°) in GII.

Postoperatively, the mean carrying angle was 12° (range: 5–17°) in GI compared to 10.4° (range: 3–17°) in GII ($P\leq0.05$).

The preoperative LCPI varied from –13.64 to 13.30% for patients in GI and varied from –8.89% to 12.66% for patients in GII. Postoperatively, LCPI improved significantly with a range from –15.8% to 9.5% for patients in GI and from –10.45% to 10.22% for patients in GII ($P\leq0.05$).

In GI, the preoperative range of motion was normal in 15 patients and four patients had hyperextension of 5° in two patients and more than 5° in the three other patients. In GII, the preoperative range of motion was normal in 15 patients and four patients had hyperextension of 5° in two patients and more than 5° in the two other patients. The average range of motion was 124.3^0 before surgery compared to 127° after surgery for GI and 123^0 before surgery compared to 130^0 after surgery for GII.

The average operative time in GI was 64.75min (range: 50–85min) compared to 100.8 min (range: 85–115min) in GII. The result is statistically significant ($P\leq0.05$).

The average follow-up time was 22.85 months (average: 12–36 months) in GI and 22.68 months (average: 13–36 months) in GII.

No patient had unsightly scarring or a prominent lateral condyle. No patient reported pain. The average union time was 1.8 months (range: 1.5–2 months (for GI and 1.6 months (range: 1.5–2 months (for GII. Three patients in GI and one patient in GII had superficial wound infection that was resolved with proper antibiotic therapy. Only one patient in GII had transient ulnar nerve neuropathy that was resolved after 2 months.

For both groups, there was no loss of correction during the healing stage nor fixation failure. None of our patients needed revision surgery. No motor weakness or atrophy of the arm musculature was reported (Tables 1, 2).

DISCUSSION

The main cause of CVD is posttraumatic following malunited SCH fracture. Although this deformity may be associated with multiple complications, including an increased risk of lateral condylar fractures, elbow joint pain, delayed posterolateral rotatory elbow instability, tardy ulnar nerve neuropathy, and internal rotational deformity, the ugly appearance of the elbow joint remains the chief concern of the parents [24].

Even though anatomical reduction and stable fixation of the initial supracondylar fracture is the keystone to work against the development of posttraumatic cubitus varus, there is still a risk for the development of cubitus varus deformity with Gartland type III-A fractures due to the possibly associated physeal injury. Cubitus varus is considered a complex multiplanner deformity, including mainly varus, internal rotation, and hyperextension, rather than a simple monoplanner deformity [25].

Usually, the elbow function is not affected by the CVD apart from some difficulty in carrying a heavy weight with a fully extended elbow; however compensation for this problem occurs by rotation of the shoulder. The unsightly cosmetic appearance remains the main indication for operative correction of the deformity [26].

It is recommended that the ideal time for correction of posttraumatic CVD should be at least 12 months after fracture to allow for complete healing and remodeling of the fracture and restoration of elbow motion. On the other hand, several studies recommended early surgical correction once the fracture was fully united and normal elbow range of motion was restored [19,21,27,28]. In the current study, the average time between injury and surgery in GI was 32.4 months (range: 18–60 months) and 36.7 months (range: 23–60 months) in GII.

Different types of corrective osteotomies are available for the management of CVD. In 1939, the lateral closing-wedge osteotomy was first described [29], and since then, many other techniques have been developed, including the closing-wedge [30,31], dome [32,33], simple step-cut [19], step-cut translation [5,6], lateral invaginating peg [34], and three-dimensional [16] osteotomies. The availability of

Table 1: Summary of the results of the group I cases (dome osteotomy):

					Elbow flexion		Elbow extension		Carrying angle (deg.)			LCPI (%)					
Patients	Age (years)	Sex	Affected side	Injury surgery interval (months)	Preoperative	Postoperative	Preoperative	Postoperative	Normal	Preoperative	Postoperative	Preoperative	Postoperative	Operative time (min)	Complications	Follow-up (months)	Results
1	6.5	Male	Left	18	100	130	−5	0	12	−18	9	−3.64	−4.11	60	None	36	Excellent
2	6	Female	Left	18	135	125	0	0	11	−20	11	−8.95	−15.8	55	None	36	Excellent
3	13	Female	Right	20	125	130	−10	0	12	−16	12	−5.95	−4.7	65	None	34	Excellent
4	8	Male	Left	32	110	125	−5	0	10	−28	14	−3.34	0	70	None	30	Excellent
5	7	Female	Right	33	135	135	0	3	16	−25	15	5,56	3.5	60	None	29	Excellent
6	8	Male	Right	20	130	125	0	0	7	−24	8	−8.11	0	65	None	28	Good
7	5	Male	Left	40	125	130	0	0	10	−11	13	0.07	−0.83	75	Superficial infection	24	Excellent
8	14	Female	Left	55	90	120	−5	0	14	−14	16	−7.82	−9.4	50	None	24	Excellent
9	9	Female	Left	59	125	130	0	5	11	−15	5	−3.42	−5.9	75	None	22	Good
10	11	Male	Right	60	130	115	0	0	18	−22	16	−13.64	−14.6	60	None	22	Excellent
11	9	Female	Right	18	135	130	0	0	11	−16	14	−8.24	−9.11	65	None	21	Excellent
12	8	Female	Left	18	125	125	0	0	13	−15	12	−5.75	0	80	Superficial infection	20	Good
13	14	Male	Right	19	130	130	0	3	12	−13	13	−5.65	−8.7	60	None	19	Excellent
14	9	Male	Left	22	120	125	0	0	11	−24	11	13.3	9.5	65	None	19	Excellent
15	12	Female	Right	30	135	135	0	0	14	−29	12	7.56	3.5	55	None	18	Excellent
16	14	Male	Right	20	135	125	0	0	9	−26	10	−9.12	0	75	None	18	Good
17	14	Male	Left	40	125	130	0	0	14	−14	13	−6.89	9.3	85	Superficial infection	17	Excellent
18	13	Female	Right	55	110	120	−8	0	12	−15	17	−6.82	−8.4	60	None	16	Excellent
19	13	Male	Left	29	135	130	0	5	15	−18	6	3	2.4	50	None	12	Good
20	11	Male	Left	41	130	125	0	0	14	−32	13	3.64	1.6	65	None	12	Excellent
Average	10.2			32.4	124.3	127	−1.7	0.8	12.3	−19.8	12	−2.5	−2.6	64.75		22.85	

Table 2: Summary of the results of the group I cases (dome osteotomy):

					Elbow flexion		Elbow extension		Carrying angle (deg.)			LCPI (%)					
Patients	Age (years)	Sex	Affected side	Injury surgery interval (months)	Preoperative	Postoperative	Preoperative	Postoperative	Normal	Preoperative	Postoperative	Preoperative	Postoperative	Operative time (min)	Complications	Follow-up (months)	Results
1	8	Male	Right	24	110	125	−10	0	10	−19	9	−7.56	−9.32	85	None	36	Excellent
2	6	Female	Left	24	120	130	0	0	10	−20	10	−8.62	−10.45	90	None	34	Excellent
3	9	Male	Left	30	135	130	−5	0	8	−28	9	−5.44	−8.8	95	None	32	Excellent
4	7	Male	Right	28	130	130	0	0	10	−30	17	−3.56	1.2	100	None	29	Good
5	12	Male	Left	26	110	125	0	0	9	−25	10	−4.45	−5.35	105	None	28	Excellent
6	11	Female	Right	29	120	130	0	0	13	−20	6	3	1.6	90	Transient ulnar neuritis	26	Good
7	8	Female	Left	38	135	130	0	0	14	−18	14	−3.4	−5.2	110	None	24	Excellent
8	9	Male	Left	50	110	130	0	0	11	−22	11	−4.34	−5.5	115	None	23	Excellent
9	13	Female	Right	60	100	125	0	0	15	−32	14	−5.3	−7.9	95	None	22	Excellent
10	7	Female	Right	42	130	130	0	0	9	−24	10	−7.2	−8.8	100	None	22	Excellent
11	11	Male	Right	44	135	130	0	0	12	−26	11	12.66	10.22	115	None	21	Good
12	13	Female	Right	40	125	135	0	0	14	−19	13	−8.89	−9.22	100	None	20	Excellent
13	10	Female	Right	55	110	130	−7	0	8	−30	9	−5.33	−4.92	85	None	19	Excellent
14	7	Male	Left	39	125	135	0	0	12	−28	6	9.56	7.54	95	Superficial infection	19	Good
15	7	Male	Right	40	130	125	−5	0	10	−26	3	7.23	6.33	115	None	18	Good
16	9	Female	Left	26	120	130	0	0	9	−22	10	−6.97	−8.95	110	None	16	Excellent
17	8	Male	Right	36	135	135	0	5	12	−20	12	−8.34	−9.2	100	None	15	Excellent
18	11	Female	Left	23	130	135	0	0	15	−23	14	−8.45	−9.6	115	None	14	Excellent
19	9	Female	Left	43	130	125	0	0	10	−20	10	−9.4	−10.4	95	None	13	Excellent
Average	9.2			36.7	123.2	129.7	−1.4	0.3	11.1	−23.8	10.4	−3.4	−5.2	100.8		22.68	

multiple osteotomy techniques indicates the lack of general agreement about which method yields the best results with the fewest complications.

Although the lateral wedge closing osteotomy is a simple procedure, it leaves a more prominent lateral condyle, an unsightly cosmetic problem that the more complex step-cut osteotomy was developed to avoid, but it is not simple to correct multiplanar deformities using this osteotomy. On the other hand, dome osteotomy can provide both, being a simple one-step osteotomy that can effectively correct multiplanar deformities [35]. Compared to other osteotomies, dome osteotomy has better mechanical stability as its center of rotation is in the midline of the humerus [6]. It avoids the prominence of the lateral condyle by allowing its translation under the dome of osteotomy without a lateral shift of the distal fragment. Other advantages include enhanced bone healing due to broad bony contact area, secondary adjustment without the need for a second-line osteotomy, and no humeral shortening [6,16,23,36].

DeRosa and Graziano [19] described the step-cut osteotomy as a modification of the lateral closing-wedge osteotomy of Siris [30] to gain better stability at the osteotomy site, but it did not improve the prominence of the lateral condyle [5,32]. This was improved by the translation step-cut osteotomy, which is a modification of the original step-cut osteotomy [29]. The medial translation of the distal fragment minimizes the lateral condylar prominence, improving the cosmetic appearance of the elbow and preventing the subluxation of the medial head of the triceps and the ulnar nerve, avoiding tardy ulnar neuropathy and cubital tunnel syndrome [5,33].

In the current study, we aimed to compare the functional outcome of dome osteotomy and modified step-cut osteotomy. Both osteotomies were effective in correcting deformity with good functional outcome and acceptable rate of complications. However, there was no statistically significant difference between the two groups in terms of correction of the deformity, functional outcome, and rate of complications. On the other hand, the operative time was significantly lower in the dome osteotomy compared to the modified step-cut osteotomy group (P<0.05).

In this study, we utilized the posterior midline para-tricipital approach in all cases. The appearance of the elbow with the posterior approach is much better, as it leaves less remarkable scars, unlike the lateral approach that may be complicated by unpleasant eye-catching scars [17,23].

The osteotomy line is most commonly fixed with multiple K-wires, as recommended by many authors. The step-cut osteotomy can be fixed using a lag screw, K-wires, or plate. In older children, rigid plate fixation is recommended to avoid loss of correction [3,6,19,29]. In our study, we excluded children older than 14 years as they may need plate fixation to improve the stability of the osteotomy site since plates may induce adhesion that may affect the range of motion and may need additional surgery for removal. We did not notice any cases of postoperative loss or reduction in either group.

The distal fragment's lateral protrusion (caused by the proximal and distal fragments' uneven breadth) results in the prominent lateral epicondyle, which becomes more noticeable when the forearm's flexor muscles are atrophied. Medialization of the distal fragment may reduce this lateral prominence following a simple lateral closing-wedge osteotomy [20].

In the modified step-cut osteotomy, the lateral condyle protrudes less because the distal fragment perfectly fits into the proximal one [6].

A dome osteotomy can realign the distal fragment in both the coronal and horizontal planes, preventing residual prominence of the lateral condyle. The contracted surrounding soft tissue makes the rotation of the distal portion in the coronal plane difficult, leaving some prominence on the lateral condyle [4,6,11]. In the literature, Wong *et al.,* [14] and Cho *et al.,* [36] suggested that the lazy S deformity remodels with time. On the contrary, Ippolito *et al.,* [15] found that it does not remodel. Jain *et al.,* [27] concluded that an established varus deformity does not improve with time.

CONCLUSION

Both dome and modified step-cut osteotomies are reliable techniques for correcting cubitus varus in children. Both were comparable in achieving correction of the deformity and in minimizing the lateral condylar prominence; otherwise, the dome osteotomy would have been technically easier.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

REFERENCE

1. Labelle H, Bunnell WP, Duhaime M, *et al.* (1982). Cubitus varus deformity following supracondylar fractures of the humerus in children. J Pediatr Orthop. 2:539–546.
2. Pirone AM, Graham HK, Krajbich JI. (1988). Management of displaced extension-type supracondylar fractures of the humerus in children. J Bone Joint Surg Am. 70:641–650.
3. Skaggs DL, Cluck MW, Mostofi A, *et al.* (2004). Lateral-entry pin fixation in the management of supracondylar fractures in children. J Bone Joint Surg Am. 86-A:702–707.
4. Solfelt DA, Hill BW, Anderson CP, Cole PA. (2014). Supracondylar osteotomy for the treatment of cubitus varus in children: a systematic review. Bone Jt J. 96-B:691–700.
5. Davids JR, Lamoreaux DC, Brooker RC, Tanner SL, Westberry DE. (2011). Translation step-cut osteotomy for the treatment of posttraumatic cubitus varus. J Pediatr Orthop. 31:353–365.
6. Kim HT, Lee JS, Yoo CI. (2005). Management of cubitus varus and valgus. J Bone Joint Surg Am. 87:771–780.
7. Ho CA. (2017). Cubitus varus – it's more than just a crooked arm! J Pediatr Orthop. 37(Suppl 2):S37–S41.
8. Davids JR, Maguire MF, Mubarak SJ, Wenger DR. (1994). Lateral condylar fracture of the humerus following posttraumatic cubitus varus. J Pediatr Orthop. 14:466–470.
9. Kontogeorgakos VA, Mavrogenis AF, Panagopoulos GN, Lagaras A, Koutalos A, Malizos KN. (2016). Cubitus varus complicated by snapping medial triceps and posterolateral rotatory instability. J Shoulder Elbow Surg. 25:e208–e212.
10. Bauer AS, Pham B, Lattanza LL. (2016). Surgical correction of cubitus varus. J Hand Surg Am. 41:447–452.
11. Takagi T, Takayama S, Nakamura T, Horiuchi Y, Toyama Y, Ikegami H. (2010). Supracondylar osteotomy of the humerus to correct cubitus varus: do both internal rotation and extension deformities need to be corrected? J Bone Joint Surg Am. 92:1619–1626.
12. Raney EM, Thielen Z, Gregory S, Sobralske M. (2012). Complications of supracondylar osteotomies for cubitus varus. J Pediatr Orthop. 32:232–240.
13. Bellemore MC, Barrett IR, Middleton RW, Scougall JS, Whiteway DW. (1984). Supracondylar osteotomy of the humerus with correction of cubitus varus. J Bone Joint Surg Br. 66:566–572.
14. Wong HK, Lee EH, Balasubramaniam P. (1990). The lateral condylar prominence. A complication of supracondylar osteotomy for cubitus varus. J Bone Joint Surg Br. 72:859–861.
15. Ippolito E, Moneta MR, D'Arrigo C. (1990). Post-traumatic cubitus varus. Long-term follow-up of corrective supracondylar humeral osteotomy in children. J Bone Joint Surg Am. 72:757–765.
16. Chung MS, Baek GH. (2003). Three-dimensional corrective osteotomy for cubitus varus in adults. J Shoulder Elbow Surg. 12:472–475.
17. Pankaj A, Dua A, Malhotra R, Bhan S. (2006). Dome osteotomy for posttraumatic cubitus varus: a surgical technique to avoid lateral condylar prominence. J Pediatr Orthop. 26:61–66.
18. Ali AM, Abouelnas BA, Elgohary HSA. (2016). Dome osteotomy using the paratricipital (triceps-sparing) approach for cubitus varus deformity in children: a surgical technique to avoid lateral condylar prominence. J Pediatr Orthop B. 25:62–68.
19. DeRosa GP, Graziano GP. (1988). A new osteotomy for cubitus varus. Clin Orthop Relat Res. 236:160–165.
20. Bali K , Sudesh P, Krishnan V, Sharma A, Manoharan SRR, Mootha AK. (2011). Modified step-cut osteotomy for post-traumatic cubitus varus: our experience with 14 children. Orthop Traumatol Surg Res. 97:741–749.
21. Oppenheim WL, Clader TJ, Smith C, Bayer M. (1984). Supracondylar humeral osteotomy for traumatic childhood cubitus varus deformity. Clin Orthop Relat Res. 188:34–39.
22. Yamamoto I, Ishii S, Usui M, Ogino T, Kaneda K. (1985). Cubitus varus deformity following supracondylar fracture of the humerus. A method for measuring rotational deformity. Clin Orthop Relat Res. 201:179–185.
23. Tien YC, Chih HW, Lin GT, Lin SY. (2000). Dome corrective osteotomy for cubitus varus deformity. Clin Orthop Relat Res. 380:158–166.
24. Skaggs DL, Glassman D, Weiss JM, Kay RM. (2011). A new surgical technique for the treatment of supracondylar humerus fracture malunions in children. J Child Orthop. 5:305–312.
25. Eren A, Güven M, Erol B, Akman B, Ozkan K. (2008). Correlation between posteromedial or posterolateral displacement and cubitus varus deformity in supracondylar humerus fractures in children. J Child Orthop. 2:85–89.
26. Jain AK, Dhammi IK, Arora A, Singh M, Luthra JS. (2000). Cubitus varus: problem and solution. Arch Orthop Trauma Surg. 120:420–425.
27. Griffin PP. (1975). Supracondylar fractures of the humerus. Treatment and complications. Pediatr Clin North Am. 22:477–486.
28. Kim HS, Jahng JS, Han DY, *et al.* (1998). Modified step-cut osteotomy of the humerus. J Pediatr Orthop B. 7:162–166.
29. Siris IE. (1939). Supracondylar fracture of the humerus. Surg Gynecol Obstet. 68:201–222.
30. Graham B, Tredwell SJ, Beauchamp RD, Bell HM. (1990). Supracondylar osteotomy of the humerus for correction of cubitus varus. J Pediatr Orthop. 10:228–231.
31. Voss FR, Kasser JR, Trepman E, Simmons E Jr, Hall JE. (1994). Uniplanar supracondylar humeral osteotomy with preset Kirschner wires for posttraumatic cubitus varus. J Pediatr Orthop. 14:471–478.
32. Matsushita T, Nagano A. (1997). Arc osteotomy of the humerus to correct cubitusvarus. Clin Orthop Relat Res. 336:111–115.
33. Levine MJ, Horn BD, Pizzutillo PD. (1996). Treatment of posttraumatic cubitus varus in the pediatric population with humeral osteotomy and external fixation. J Pediatr Orthop. 16:597–601.
34. Butt MF, Dhar SA, Farooq M, Kawoosa AA, Mir MR. (2009). Lateral invaginating peg (LIP) osteotomy for the correction

of posttraumatic cubitus varus deformity. J Pediatr Orthop B. 18:265–270.

35. Yalamanchili RK, Kondreddi V. (2017). Our experience of dome osteotomy in cubitus varus associated triple deformity. IOSR J Dent Med Sci. 16(6 Ver. IV):120–122.

36. Cho CH, Song KS, Min BW, Bae KC, Lee KJ. (2009). Long-term results of remodeling of lateral condylar prominence after lateral closed-wedge osteotomy for cubitus varus. J Shoulder Elbow Surg. 18:478–483.