

A double-closed wedge broken-line osteotomy for cubitus varus deformity

Chao You, MD, Yibiao Zhou, MD, Jingming Han, MD*

Abstract

Various osteotomy methods have been proposed in the treatment of cubitus varus. We designed an improved stepped osteotomy to achieve improved deformity correction. We refer to this new approach as double-closed wedge broken-line osteotomy and report a series of clinical and imaging results (deformity correction, range of motion [ROM], function, osteotomy healing, and complications) of patients with cubitus varus treated with this technique.

Between July 2014 and July 2019, we treated 9 cases of cubitus varus using the new technique. The study was conducted in accordance with the principles of the Declaration of Helsinki, and the study protocol was approved by the ethics committee of Shenzhen Children's Hospital. We obtained written parental consent for the minors before the study was begun. We compared preoperative and postoperative clinical and imaging parameters (humeral elbow-wrist angle, elbow ROM) in all patients. Postoperative evaluation was performed by telephone interview and outpatient review. The median follow-up was 23.2 months (range, 3–63 months).

The median humeral elbow-wrist angle modified from -14.27 to 15.15 . The median clinical and imaging parameters after correction of deformity were not different from that of the normal side. Using our rehabilitation program, all patients recovered preoperative elbow ROM at the last follow-up.

Our double-closed wedge broken-line osteotomy has a larger cancellous bone contact surface. The deformity correction is satisfactory, the osteotomy healing is reliable, and the incidence of complications is low.

Level of Evidence: Level IV.

Abbreviations: HEW = humeral elbow-wrist angle, LPI = lateral condylar protrusion index, ROM = range of motion.

Keywords: cubitus varus deformity, double-closed wedge broken-line osteotomy, surgical technique

1. Introduction

Angular and rotational malunion, especially after supracondylar fractures of the humerus, is a well-known complication that

develops in children with distal humerus fractures. Lateral condyle fractures are also associated with varus or valgus deformity due to epiphyseal growth disturbance or malunion. These deformities are usually associated with rotational malalignment.^[1] The deformity is thought to include extension and varus malalignment, and internal rotation.^[2–4]

Among children with supracondylar fractures, the incidence of multiple malalignments is relatively high (50%),^[1] while the incidence of cubitus varus is between 9% and 57%.^[5,1,6] More effective new methods have been used to treat these fractures and can greatly reduce complications.^[3] Although complications after fracture rarely affect upper limb function, the aesthetic appearance of deformities is often unacceptable for families.^[7,3,8]

Previously, due to the high incidence of complications of valgus osteotomy, such as stiffness, loss of reduction at osteotomy, infection, ossifying myositis, and neurovascular injury, orthopedic osteotomy has rarely been performed.^[7,9] Presently, an increasing number of osteotomies and fixation methods have been proposed to correct cubitus varus deformity.^[10–13] As described by DeRosa and Graziano,^[14] stepped osteotomy is currently one of the most popular orthopedic osteotomies. Following wedge removal and closure, a screw was used for fixation. Although it can effectively correct varus malalignment, distal lateral displacement is a common complication of this technique, affecting the appearance after osteotomy.^[1,2,14]

A new modification of the classic wedge step osteotomy not only corrects this deformity but also creates a larger area of contact for early healing after rigid fixation. We describe our new technique and report clinical and radiological results. We

Editor: Johannes Mayr.

CY and YZ contributed equally to this work.

The study was conducted in accordance with the principles of the Declaration of Helsinki, and the study protocol was approved by the ethics committee of Shenzhen Children's Hospital.

The study was supported by the Sanming Project of Medicine in Shenzhen (SZSM202011012).

The authors have no conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Department of Orthopedic Ward II, Shenzhen Children's Hospital, Shenzhen, China.

* Correspondence: Jingming Han, Department of Orthopedic Ward II, Shenzhen Children's Hospital, Yitian Road, Futian, Shenzhen, Guangdong, China (e-mail: hanjmingwj@126.com).

Copyright © 2021 the Author(s). Published by Wolters Kluwer Health, Inc. This is an open access article distributed under the terms of the Creative Commons Attribution-Non Commercial License 4.0 (CCBY-NC), where it is permissible to download, share, remix, transform, and buildup the work provided it is properly cited. The work cannot be used commercially without permission from the journal.

How to cite this article: You C, Zhou Y, Han J. A double-closed wedge broken-line osteotomy for cubitus varus deformity. *Medicine* 2021;100:23(e26124).

Received: 1 February 2020 / Received in final form: 22 March 2021 / Accepted: 10 May 2021

<http://dx.doi.org/10.1097/MD.00000000000026124>

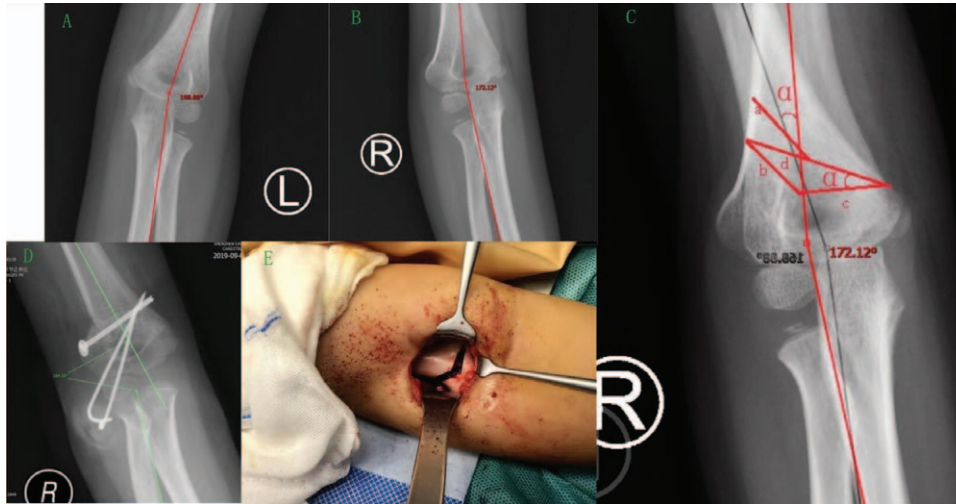


Figure 1. (A) Preoperative radiograph of the healthy elbow. (B) Radiograph of the affected elbow before surgery. (C) Comparison of the antero-posterior and lateral view of the X-ray images on the principle of mirroring, and we calculated the temporary correction angle of the humeral osteotomy angle at the affected side, taking into account the correction required on the basis of the comparison of HEW and LPI on both sides. (D) Postoperative radiograph of the affected elbow joint, elbow eversion has been completely corrected. (E) Humerus osteotomy picture during operation. HEW = humeral elbow-wrist angle, LPI = lateral condylar protrusion index.

evaluated humeral elbow angle, range of motion (ROM), Baumann angle, and complications. The overall results were determined by interviews.^[15]

We refer to this new approach as double-closed wedge broken-line osteotomy and report a series of clinical and imaging results (deformity correction, ROM, function, osteotomy healing, and complications) of patients with cubitus varus treated with this technique.

2. Surgical technique

After induction of anesthesia, the patient was placed in a supine position. First, a longitudinal incision was made along the lateral side of the distal humerus with a length of approximately 4 cm. Under the protection of the growth plate, the distal humerus “L”-shaped osteotomy was performed with an electric drill and electric saw along the upper part of the elbow capsule attachment point and above the plane of the humerus olecranon fossa. The second triangular bone mass was removed from the planned proximal lateral humerus to match the proximal lateral humerus with the distal lateral humerus. Proximal wedge osteotomy was performed to obtain the planned corrective angle and the posterior part of the osteotomy for adequate correction. Using

the X-ray image intensifier, we confirmed the correct position of the Kirschner wires. We passed the guidewire through the proximal bone cortex. After inserting a washer, a 3.0 mm hollow screw was inserted over the guide wire. Finally, the affected limb was immobilized in functional position by application of a plaster cast (Figs. 1 and 2).

The osteotomy was fixed with 2 Kirschner wires. Then, we examined the angle of the saw, medial and lateral processes, and elbow ROM. To obtain a firm fixation, we used a break-block lag screw through the spike and corresponding incision. Two weeks postoperatively, the sutures were removed, and ROM practice began. The children were protected with splints until radiologic and clinical healing occurred.

3. Patients and methods

The study was conducted in accordance with the principles of the Declaration of Helsinki, and the study protocol was approved by the ethics committee of Shenzhen Children’s Hospital. We obtained written parental consent for the minors before the study was begun. From 2014 to 2019, we treated 9 patients with cubitus varus deformity, including 6 boys and 3 girls, all of whom underwent double-closed wedge step osteotomy (Table 1). The



Figure 2. Children’s elbow ROM was good at 3mo after operation. ROM = range of motion.

Table 1
???

Number	Age (yr)	Gender	Preoperation			Postoperation		
			HEW (°)	LPI%	Baumann (°)	HEW (°)	LPI%	Baumann (°)
1	8	Male	-15.1	-4.9	92.85	11.46	31.0	68.7
2	5	Female	-29.36	-26.9	98.47	5.58	30.9	73.11
3	3	Male	-19.32	-14.7	85.83	13.89	22.7	66.05
4	9	Male	-10.09	-6.7	75.6	11.79	16.5	69.07
5	7	Male	-6.63	9.8	66.71	12.48	9.6	57.13
6	7	Male	-13.7	-11.7	89.86	18.27	16.8	54.5
7	6	Male	-7.6	-5.9	91.78	19.42	7.8	64.9
8	5	Female	-10.44	0.02	86.23	21.13	3.8	68.81
9	7	Female	-16.15	-2.5	86.54	22.35	27.4	58.44

HEW = humeral elbow-wrist angle, LPI = lateral condylar protrusion index.

median age of the patients was 6.33 years. The median follow-up was 23.2 months (range, 3–63 months). The reason for the patient’s orthopedic outpatient visit was an unacceptable deformity rather than a functional problem of the elbow, such as ulnar nerve paralysis or elbow instability.

We compared the angle and lateral condylar protrusion index (LPI) of the affected and healthy sides to determine the patient’s correction angle. We compared the 2 sides of the X-ray on the principle of mirroring and calculated the correction degree of the humeral osteotomy angle of the affected side, taking into account the correction required based on the comparison of humeral elbow-wrist angle (HEW) and LPI on both sides. Additionally, the intraoperative distal fragment displacement was calculated to correct the lateral protrusion, and the surgery was performed according to the abovementioned surgical technique.

We evaluated all patients postoperatively until maximum elbow ROM was achieved, and healing was complete without any complications. The patients were followed up at 1, 6, and 12 weeks postoperatively and once every 3 months. At each follow-up, the elbow X-ray was performed to check for progress in osteotomy healing, and elbow ROM was examined using an angle-measuring instrument.

We used SPSS 21 in the descriptive and statistical analyses. To compare 2 dependent means of variables in patients, we used the paired *t*-test. A *P*-value < .05 was considered statistically significant.

4. Results

Radiographic elbow alignment improved in this series of patients. The median HEW angle improved from -14.27° to 15.15°. The difference in the HEW angle between the preoperative and postoperative periods was significantly different (*P* = .00). The preoperative median Baumann angle was 85.94° (range, 66.71°–98.41°). The postoperative median Baumann angle was 64.52° (range, 54.5°–73.11°). The median postoperative LPI was 18.5 (range, 3.8–31) compared with the median preoperative value of -7.05 (range, -26.1 to 9.8) (Tables 1 and 2). The median LPI (*P* = .003) after correction of the deformity was significantly different from that before correction.

All patients achieved completed bone union at 2 months postoperatively, good alignment, and desired ROM of the elbow. No patient had ulnar nerve palsy and wound problems. No patient suffered from hypertrophic scarring.

5. Discussion

There are various methods of osteotomy in the treatment of cubitus varus deformity. We designed an improved stepped osteotomy to achieve better deformity correction. We describe this new technique and report a series of clinical and imaging results in patients who have been treated with this technique for cubitus varus correction.

Different osteotomy techniques have been proposed for correction of cubitus varus. The main methods include closed wedge,^[13,16] dome,^[4,17] simple step cutting,^[14] step cutting translation,^[7,8] lateral invaginating peg,^[18] and 3-dimensional^[19] osteotomy. In stepwise translational osteotomy as described by Kim et al,^[18] the outer surface of the distal segment is in contact with the osteotomy site. Considering this problem and the fact that the lateral side is the tension side in the daily activities of the distal radius, this osteotomy may lead to delayed healing.^[20] Additionally, the technique described by Kim et al had more technical requirements.^[8] A simple stepped osteotomy or simple lateral closed wedge osteotomy is detrimental to the lateral condyle of humerus. In a simple step incision osteotomy,^[14] the authors noted that this protrusion is exacerbated by atrophy of the muscle tissue postoperatively. A previous study^[18] overcame this problem by invading the proximal nail of the bone marrow. Dome osteotomy allows the distal fragments to be reoriented in

Table 2
???

No. of patients	9
Age* (yr)	6.33
Sex	
Male	6
Female	3
Preoperative data*	
HEW	-14.27 ± 2.336
LPI	-7.05 ± 3.405
Baumann angle	85.94 ± 3.180
Final follow-up data	
HEW	15.15 ± 1.829
LPI	18.5 ± 3.382
Baumann angle	64.5233 ± 2.124
<i>P</i>	<.001
Refracture	0
Duration of follow-up (m)	23.2 (3–63)

HEW = humeral elbow-wrist angle, LPI = lateral condylar protrusion index.
P.

the coronal and horizontal planes. However, due to the contraction of the surrounding soft tissue, the rotation of the distal fragments in the coronal plane is often difficult, so the condyle still protrudes.^[8] Three-dimensional osteotomy^[19] may be associated with neurological paralysis or myositis. Siris first corrected lateral closure wedge osteotomy in 1939,^[21] which led to the development of many other techniques.

Our osteotomy method is based on wedge-shaped osteotomy, and the main improvements are as follows: (1) Medial humeral cortical continuity is retained to form a stable medial humeral anchored structure to reduce lateral displacement of the humeral fracture end postoperatively. (2) A wedge-shaped osteotomy is added to the lateral side of the humeral fracture end to fit into the distal humeral osteotomy groove, increase the contact area of the fracture end to promote healing, reduce lateral displacement of the humeral fracture end, and increase stability. Therefore, our osteotomy method has clear advantages over the original osteotomy method. Clinical data show that it can effectively correct cubitus varus deformity. However, the disadvantage of this technique is that bone resection is larger than those in some techniques, such as step-cut translational,^[8] transverse closing wedge,^[20] or dome^[22–24] osteotomy. However, according to Gong et al,^[25] shortening of the humerus was not clinically detectable in most cases after corrective osteotomy for cubitus varus.

In clinical practice, a large number of patients will experience. This situation requires clinicians to conduct in-depth discussion, reflection, and improvement. In our osteotomy method, there was no significant loss of our correction angle. Generally, we believe that the angle loss after orthopedic surgery is caused by the following reasons: the medial soft tissue usually underwent contraction due to long-term varus malalignment, which causes varus forces at the medial aspect of the osteotomy in the postoperative period, and may result in loss of corrective angle postoperatively. Several complications have been described after corrective supracondylar osteotomy: internal rotation deformity may persist or recur, and this may cause tardy ulnar nerve palsy.^[26] We hypothesize that it is sufficient to advance the ulnar nerve during osteotomy if there are preoperative symptoms indicative of onset of tardy ulnar nerve palsy.^[8] None of our patients developed ulnar nerve palsy preoperatively, and even patients without corrective internal rotation did not have delayed ulnar nerve palsy.

Avulsion fractures of the lateral humerus, and distal humerus fractures, and supracondylar fractures of the humerus have been reported.^[27–30] Davids et al^[27] suggested that varus positioning may increase the tension and shear force on the lateral aspect of the distal humerus because of the normal extension of the upper arm. In a growth plate fracture, healing thickens the fracture site, thereby protecting the area from further damage, but the growth plate becomes weak. Internal rotation hardly increases the risk of re-fracture.^[7]

Our modified step-cut osteotomy can be a reasonable alternative for correction of cubitus varus deformity, with satisfactory deformity correction, reliable healing of the osteotomy, and low complication rates.

Our retrospective study has some limitations. There is a small number of patients in the series. Fortunately, methods of distal humeral fracture management have improved, and these deformities are now rare. The short-term follow-up and lack of a control group were also problems that need to be solved.

Author contributions

Conceptualization: Chao You, Yibiao Zhou, Jingming Han.

Data curation: Chao You, Yibiao Zhou.

Formal analysis: Yibiao Zhou.

Investigation: Yibiao Zhou.

Methodology: Chao You, Yibiao Zhou.

Project administration: Chao You, Jingming Han.

Resources: Chao You.

Software: Chao You.

Writing – original draft: Chao You, Yibiao Zhou.

Writing – review & editing: Chao You, Yibiao Zhou.

References

- [1] Herring JA, ed. Upper extremity injuries. In: Tachdjian's Pediatric Orthopaedics. 4th ed. New York, NY: WB Saunders; 2008: 2477–2479.
- [2] Canale ST, ed. Surgical approaches. In: Campbell's Operative Orthopaedics. Vol 2. 11th ed. St Louis, MO: CV Mosby; 2008:1592.
- [3] Kasser JR, Beaty JH. Beaty JH, Kasser JR. Supracondylar fractures of the distal humerus. Rockwood and Wilkins' Fractures in Children 5th ed. Philadelphia, PA: Lippincott, Williams & Wilkins; 2001; 577–624.
- [4] Labelle H, Bunnell WP, Duhaime M, Poitras B. Cubitus varus deformity following supracondylar fractures of the humerus in children. *J Pediatr Orthop* 1982;2:539–46.
- [5] D'Ambrosia RD. Supracondylar fractures of humerus: prevention of cubitus varus. *J Bone Joint Surg Am* 1972;54:60–6.
- [6] Mann TS. Prognosis in supracondylar fractures. *J Bone Joint Surg Br* 1963;45:516–22.
- [7] Davids JR, Lamoreaux DC, Brooker RC, Tanner SL, Westberry DE. Translation step-cut osteotomy for the treatment of posttraumatic cubitus varus. *J Pediatr Orthop* 2011;31:353–65.
- [8] Kim HT, Lee JS, Yoo CI. Management of cubitus varus and valgus. *J Bone Joint Surg Am* 2005;87:771–80.
- [9] King D, Secor C. Bow elbow (cubitus varus). *J Bone Joint Surg Am* 1951;33:572–6.
- [10] Kumar K, Sharma VK, Sharma R, Maffulli N. Correction of cubitus varus by French or dome osteotomy: a comparative study. *J Trauma* 2000;49:717–21.
- [11] Song HR, Cho SH, Jeong ST, Park YJ, Koo KH. Supracondylar osteotomy with Ilizarov fixation for elbow deformities in adults. *J Bone Joint Surg Br* 1997;79:748–52.
- [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 Pediatr Orthop* 1991;11:327–31.
- [13] Voss FR, Kasser JR, Trepman E, Simmons E, Hall JE. Uniplanar supracondylar humeral osteotomy with preset Kirschner wires for posttraumatic cubitus varus. *J Pediatr Orthop* 1994;14:471–8.
- [14] DeRosa GP, Graziano GP. A new osteotomy for cubitus varus. *Clin Orthop Relat Res* 1988;236:160–5.
- [15] Oppenheim WL, Clader TJ, Smith C, Bayer M. Supracondylar humeral osteotomy for traumatic childhood cubitus varus deformity. *Clin Orthop Relat Res* 1984;188:34–9.
- [16] Graham B, Tredwell SJ, Beauchamp RD, Bell HM. Supracondylar osteotomy of the humerus for correction of cubitus varus. *J Pediatr Orthop* 1990;10:228–31.
- [17] Matsushita T, Nagano A. Arc osteotomy of the humerus to correct cubitus varus. *Clin Orthop Relat Res* 1997;336:111–5.
- [18] Butt MF, Dhar SA, Farooq M, Kawoosa AA, Mir MR. Lateral invaginating peg (LIP) osteotomy for the correction of posttraumatic cubitus varus deformity. *J Pediatr Orthop B* 2009;18:265–70.
- [19] Chung MS, Baek GH. Three-dimensional corrective osteotomy for cubitus varus in adults. *J Shoulder Elbow Surg* 2003;12:472–5.
- [20] O'Driscoll SW. Optimizing stability in distal humeral fracture fixation. *J Shoulder Elbow Surg* 2005;14(1 Suppl S):186S–94S.
- [21] Siris IE. Supracondylar fracture of the humerus. *Surg Gynecol Obstet* 1939;68:201–22.
- [22] Kanaujia RR, Ikuta Y, Muneshige H, Higaki T, Shimogaki K. Dome osteotomy for cubitus varus in children. *Acta Orthop Scand* 1988;59:314–7.

- [23] Pankaj A, Dua A, Malhotra R, Bhan S. Dome osteotomy for posttraumatic cubitus varus: a surgical technique to avoid lateral condylar prominence. *J Pediatr Orthop* 2006;26:61–6.
- [24] Tien YC, Chih HW, Lin GT, Lin SY. Dome corrective osteotomy for cubitus varus deformity. *Clin Orthop Relat Res* 2000;380:158–66.
- [25] Gong HS, Chung MS, Oh JH, Cho HE, Baek GH. Oblique closing wedge osteotomy and lateral plating for cubitus varus in adults. *Clin Orthop Relat Res* 2008;466:899–906.
- [26] Mitsunari A, Muneshige H, Ikuta Y, Murakami T. Internal rotation deformity and tardy ulnar nerve palsy after supracondylar humeral fracture. *J Shoulder Elbow Surg* 1995;4:23–9.
- [27] Davids JR, Maguire MF, Mubarak SJ, Wenger DR. Lateral condylar fracture of the humerus following posttraumatic cubitus varus. *J Pediatr Orthop* 1994;14:466–70.
- [28] O'Driscoll SW, Spinner RJ, McKee MD, et al. Tardy posterolateral rotatory instability of the elbow due to cubitus varus. *J Bone Joint Surg Am* 2001;83:1358–69.
- [29] Park HW, Yang IH, Joo SY, Park KB, Kim HW. Refractures of the upper extremity in children. *Yonsei Med J* 2007;48:255–60.
- [30] Takahara M, Sasaki I, Kimura T, Kato H, Minami A, Ogino T. Second fracture of the distal humerus after varus malunion of a supracondylar fracture in children. *J Bone Joint Surg Br* 1998;80:791–7.