ORIGINAL ARTICLE

Translational Step Cut Osteotomy: Modified Technique and its Initial Results

MUMTAZ HUSSAIN[1], SHAHZAD ANVER QURESHI [2], AYESHA SAEED[3], AFZAL HUSSAIN[4]
[1]*Associate Professor, Pediatric Orthopedic Surgery Department, The Children's Hospital Lahore,*
[2]*Fellow Pediatric Orthopedic Surgery, Mayo Hospital Lahore,*
[3]*Assistant Professor, Pediatric Orthopedic Surgery Department, Children's Hospital and Institute of Child Health, Faisalabad.*
[4]*Consultant Orthopedic Surgeon, PSRD Orthopaedic Hospital Lahore.*
Correspondence to Dr. Mumtaz Hussain, Email: drmumtazchohan@gmail.com, Cell. 0323 4200564

ABSTRACT

Aim: To describe our experience of modified technique of translational step cut osteotomy for the correction of cubitus varus deformity in children and to access the functional outcome at 6th month of follow-up.
Methods: We enrolled 27 children of either gender or side between ages from 5 to 12 years having cubitus varus deformity at our institute. After clinical and radiological workup, all children underwent correction of the deformity using modified technique of translational step cut osteotomy.
Results: Mean age of children was 8.41±2.15 years and duration from initial injury to presentation was 14.2 ± 5.71 months having male predominance. The mechanism involved were fall (55.6%), followed by road traffic accident (22.2%) and playground area (22.2%). Most children had right side deformity (66.7%). 51.9% children have initial treatment from bonesetter making cosmesis and functional reasons as main factor for parents to seek medical advice. Radiological union was achieved in the mean duration of 5.00 ± .62 weeks. The mean pre-operative humero-ulnar angle of the involved side was 199±10.58o and post-operative angle at the end of 6th month of the involved side was 170.62±4.12o.
Conclusion: Step-cut translational osteotomy humerus is very good procedure for correction of cubitus varus deformity with negligible complications and excellent to good outcomes according to Flynn's criteria.
Keywords: translational step cut osteotomy, cubitus varus deformity, Flynn's Criteria.

INTRODUCTION

Cubitus varus deformity is the most common deformity due to mal-union of displaced supra-condylar fracture humerus in children. Its incidence range 0-30%.[1,3]. After supra-condylar fracture, deformity is three-dimensional and it is characterized by extension, varus and internal rotation of distal fragment of humerus. The cause of deformity is usually mal-union that do not correct after remodeling[4-6]. Although chances of mal-union are 2-8% in experienced hands but definitely people are required who have experience in pediatric orthopedic surgery[2]. Usual complain is mild pain, decrease range of motion of elbow and mainly cosmesis that is due to varus deformity[1,7,8].

For management of cubitus varus, multiple techniques have been described in literature with variable results. These techniques include lateral closing wedge method, medial opening wedge, dome osteotomy distal humerus, step-cut osteotomy, French osteotomy, and multi-planar osteotomy. Each having its own advantages and disadvantages[9-18]. Many complications are associated with these osteotomies like under-correction, over-correction, persistent prominent lateral condyle, delayed union, persistent stiff elbow, deep wound infection and neurological injuries[12,19-22]. Most common technique is lateral closing wedge osteotomy due to its easy procedure.
After evaluating results, advantages and disadvantages of different osteotomies, we decided to start translational step-cut osteotomies with little modification in procedure as described by David, Lamoreaux and Brookeret al procedure at my institution many years back[45]. This technique was initially described by DeRosa and Graziano, that correct varus, extension and lateral condyle prominence[10]. Postoperative results of patients who underwent this procedure were collected in the form of functional range of motion, carrying angle, cosmesis and satisfaction.

Received on 13-12-2020
Accepted on 24-02-2021

MATERIAL AND METHOD

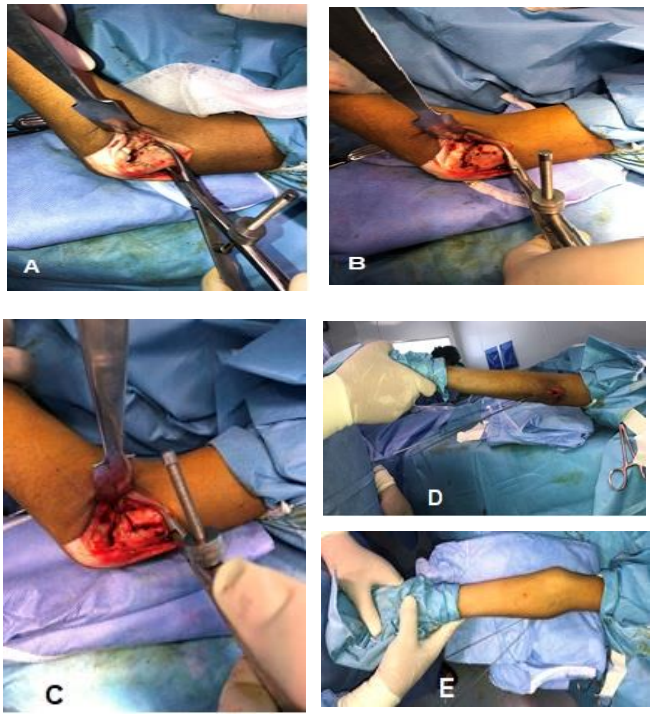
The study was conducted in the department of Paediatric Orthopaedic surgery at The Children's Hospital & ICH, Lahore from November 2017 to December 2018. After ethical approval, 27 children with diagnosis of cubitus varus deformity presenting in the Outdoor Clinic were enrolled in the study. Our inclusion criteria included all children of either gender or side having cubitus varus deformity between ages of 5 to 12 years with intact neurology. Children who had complications associated with the deformity like Volkmann ischemic contracture of the forearm, skin compromise at the elbow and neurological complications were excluded from the study.

After admission, demographic profile (name, age, sex, hand dominance, side involved) was obtained. Detailed history regarding mechanism of initial trauma, treatment taken at that time, deformity formation and progression was recorded. Physical examination of the involved elbow was done which included measurement of carrying angle, active range of motion of elbow, pronation and supination of the forearm and assessment of distal neurovascular structures. Radiographs of both elbows were taken for the pre-operative measurement of Humero-Ulnar Angle and Bauman's Angle. Consent was taken prior to surgery after pre-operative assessment from the anesthesia team and surgical procedure was explained to the parents.

SURGICAL TECHNIQUE:
Under general anesthesia and the patient in supine position, we used lateral approach of the distal humerus. Under tourniquet application, an incision of size 4 to 5 cm was given with the center over the prominence of the lateral condyle and extending proximally and distally. Carefully identifying the plane between triceps and brachioradialis by reflecting the triceps posteriorly and brachioradialis anteriorly, distal Humerus is exposed. Osteotomy site was marked under fluoroscopy guidance and it was performed by making a proximal, transverse cut at 90^0 to the axis of the humerus. First cut was made in a distal lateral direction and the other cut was made in the proximal medial segment. Next cut was perpendicular to the angular correction at its lateral end creating a step cut in the distal humerus. Distal humeral segment was mobilized and the segment is translated to the proximal humerus segment. At this time, we clinically assess the correction of carrying angle and if it's not satisfactory then bony cuts are made as desired.

After reduction, the segments were fixed with two cross Kirschner wires of size 1.5 mm. One wire was passed from the lateral and other from the medial end taking care to preserve ulnar nerve from the medial side or both wires from the lateral side in divergent fashion. Wire placement was seen under fluoroscopy and wound was washed with saline. Closure was done and back slab with elbow in flexion was applied. Tourniquet was removed and hemostasis SECURED AND distal neurovascular status was checked. skin closed in layers with subcutaneous absorbable sutures (Figure 1).

Figure 1: Steps of osteotomy. **(a)** proposed site of osteotomy **(b)** marking the osteotomy **(c)** Osteotomy site reduction **(d)** fixation with K wires **(e)** correction of cubitus varus deformity



Post-operative follow up: Post-operative radiographs were done and patients were discharged on 2nd post-operative day with follow up in OPD after 2 weeks for repeat radiographs and for any complaint regarding wound. Wires were removed at 4-5 weeks and passive range of physiotherapy is advised at 6th week. Radiological Union was noted. Active range of elbow physiotherapy was advised at 8th week. Final Outcome of the treatment was evaluated at 6th months by radiological assessment of humero-ulnar and Baumann's angle and using Flynn's Criteria.

Statistical analysis: Data was recorded and analyzed through SPSS version 25. Quantitative variables were calculated as mean±SD. Qualitative variables were measured as frequency and percentages. Comparison between pre- and post-operative radiological assessment was performed using paired t test taking p value of ≤0.05 as significant.

RESULTS

No children were lost in our last follow-up and the mean age presented was 8.41±2.15 years (5 to 12 years). The mean duration from initial injury to presentation in OPD was 14.2±5.71 months and there were 16(59.3%) males and 11(40.7%) females. The mechanism involved was predominantly; fall in 15 (55.6%), followed by road traffic accident in 6(22.2%) and playground area in 6(22.2%) children. 18(66.7%) children had right side deformity while 9(33.3%) had left side involvement having right sided hand dominance in 77% of children. In this study group, 14(51.9%) children had initial treatment from bonesetter followed by surgical failure in 6(22.2%), no treatment in 4(14.8%) and conservative in 3(11.1%) children. Cosmetic and Functional reasons were the main factor for parents to seek medical advice for correction of the deformity (77.8%). Other factors for surgical treatment included decreased functional range of motion around elbow (18.5%) and cosmesis in one child (3.7%) (Table 1).

Table 1: Features of cubitus varus deformity among children (n=27)

Variable	Patient
Age of Patient	8.41 ± 2.15 years
Duration of Injury	14.2 ± 5.71 months
Gender of Patient	Male 16 (59.3%) Female 11 (40.7%)
Side Involved	Right 18(66.7%) Left 9(33.3%)
Mechanism of trauma	Fall 15 (55.6%) Road traffic accident 6 (22.2%) Playground area 6(22.2%)
Initial Treatment	Bone Setter 14 (51.9%) Surgery 6 (22.2%) Conservative 3 (11.1%) No treatment 4 (14.8%)
Reason of treatment	Cosmesis 1 (3.7%) Functional 5 (18.5%) Both 21 (77.8%)
Radiological Union	5.00 ± .62 weeks

The mean pre-operative humero-ulnar angle of the involved side was 199 ± 10.58^o (range of 185^o-225^o) and when it was compared with the other side, it was 166.3 ± 5.82 (range was 155^o-177^0). The mean Baumann's Angle of the deformed elbow was 79.67±7.5^o (66-90^o) and the contra-lateral Baumann's angle was in the range of 65 to 78^o (mean of 69.85±4.7^o). Radiological union was achieved in the mean duration of 5.00±.62 weeks. Post-operative

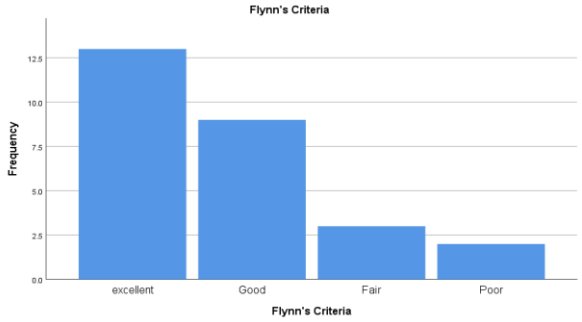
humero-ulnar angle at the end of 6th month of the involved side was 170.62±4.12º (range of 164º-177º) and Baumann's angle was 71±3.27º (range of 64º-75º). Paired T test was applied to see statistical differences between the pre- and post-operative radiological measurement and that was found to be significant (Table 2).

Table 2: Pre- operative and Post-operative radiological parameters (n=27)

Variable	Patient	P-value
Preoperative Humero-Ulnar Angle	199 ± 10.58º	<0.05
Postoperative Humero-Ulnar Angle	170.62±4.12º	
Preoperative Baumann's Angle	79.67±7.5º	<0.05
Postoperative Baumann's Angle	71±3.27º	

There were few complications associated with surgery. Two Patients had pin tract infection causing loosening of the implant. It was healed with removal of wire, back slab application and local antibiotics according to culture and sensitivity report in 10 days. The functional Outcome of the treatment was evaluated using Flynn's criteria at the end of 6th month showed 13 (48.1%) had excellent result, 9(33.3%) children had good, 3(11.1%) had fair while 2(7.4%) children had poor result (Table 3).

Table 3: Rating according to Flynn's Criteria.



DISCUSSION

Cubitus varus deformity is due to mal-union of supracondylar fracture distal humerus. Distal fragment usually deform in extension, varus and internal rotation. When this fracture unitewithout correction this took shape of said deformity. Resulted deformity is neither correct nor progress with passage of time in contrast to physial injury[1,4,6,8]. Regarding indication of surgery, there is debate; some people recommend early surgery as fracture become united or when elbow joint movements restored, some recommend after 3 months of initial injury, some recommend to delay surgery as long as near maturity[4,6,15,27]. Regarding choice of procedure/ osteotomy, there is again huge difference of opinion and there is no consensus on any single procedure. Every procedure has its own advantages and disadvantages[1,4,6,8,15,22]. Another debate also exist in literature regarding dimension of osteotomy i.e whether correction should be two dimensions or three dimensions. Those, infavor of three dimension correction, argue because deformity is three dimension so correction should also be three dimension. And those who recommend two dimension correction they argue that maintain alignment during healing process difficult in three dimension osteotomy procedure due to small contact area. Moreover a study also compared uni-planar and multi-planar osteotomies and concluded that elbow range of motion is more related to correction of coronal plane alignment[28]. As a result, majority of people agree for uni-planar correction, as it is also easy to perform as well.

For a long time main indications of surgery were limitation of motion and cosmesis. But it is seen now that there are multiple functional problems occur in elbows that have adequate range of motion. For example: pain, instability, delay onset neuropathy has been observed in neglected cubitus varus[7,29-34]. One author found a correlation between ipsi-lateral Bankart lesion, posterior instability of shoulder and dislocation of Ulnar nerve with cubitus varus[32]. Association with cubital tunnel syndrome and tardy ulnar nerve palsy also been reported[7,29,33]. There is increase incidence of fracture of lateral condyle of humerus in cubitus varus may be due to change in direction of torsional forces at elbow[30]. Another thing is snapping sensation at elbow during flexion that may be due displacement of medial head of triceps and ulnar nerve displacement[31,34]. After finding these things in literature we conclude that only cosmesis and decrease range of motion is not indication of surgery but functional problems are also associated with cubitus varus and surgical correction[30,32,35].

Lateral closing wedge osteotomy is most common procedure that was initially described by Siris in 1939[4,36,37]. Later DeRosa and Graziano introduced step-cut osteotomy of distal humerus with better stabilization[10]. Both of these methodsretain medial hinge or periosteam in-contact so retain better stability at osteotomy site[38,39]. One major complication of this procedure is creation of prominent lateral condyle of distal humerus[21,39,40]. This problem noted by different many researcher i.e. Voss 42%, Berrett 47%[39,41]. Doing surgery for cosmesis and correcting one deformity and creating another couldn'tbe justified. So researcher start proposing different type of osteotomies but many were not properly evaluated[36,39]. Dome osteotomy become famous as it correct all deformities at a time and also prevent lateral condyle to become prominent[13,16,17,42]. Disadvantages of these osteotomy are technically difficult and relative unstable of fixation[28]. Although lateral closing wedge osteotomy is a favorite procedure but a study also mentioned the significant failure rate of loss of fixation of lateral closing wedge osteotomy[43].

Medial translation of distal fragment is described in literature at very few places[44,45]. Main advantage of medial displacement is, it correct varus without making lateral condyle prominent.

The results of translational osteotomy are analyzed with results of other osteotomies and found comparable[1,6,10,12,16,27,38,40,42,43]. In our study HUAis170.62 ± 4.12º (range of 164º-177º) that is near average normal HUA. Average valgus angle is 71 ± 3.27º (range of 64º-75º) that is also within 5 degree of contra lateral side. Our procedure is somehow different from other step-cut osteotomy procedures in the sense that we used lateral approach, instead of posterior approach, that is familiar by most surgeons. Moreover post-operatively range of motion of elbow retained that could be compromised if posterior approach were used. Another important thing is level of osteotomy. We did osteotomy as close to joint line as possible and found that osteotomy near olecranon fossa is possible without any issue of instability even after removal

of wedge of bone. This removal of step-cut wedge near elbow joint allow correction in three dimension and we found no problem regarding fixation or lack of bone stock. On-table assessment of range of motion of elbow, immediately after fixation, gives instant results and a good idea of post-op range of motion of elbow in sagittal plan and assessment of carrying angle. We used Flynn's Criteria for assessment of humero-ulnar angle and assessment of carrying angle and found excellent results. Our complication rate is 7.5% that is lower than complication rate (19%) described in literature[19].

The main shortcoming of our study is small sample size. Due to limited no of patients, actual assessment of complication rate is difficult. Complications like delay-onset mal-union etc, need long follow-up. So all these things can be addressed by increasing more no of patients and their long follow-up with clinical and radiographic evaluation.

CONCLUSION

Step-cut translational osteotomy humerus is very good procedure for correction of cubitus varus deformity with negligible complications. With some modification in traditional technique like, use of lateral approach and use of more distal level of osteotomy, it corrects deformity in all three dimension planes. Give quite stable fixation. And allow assessment of degree of correction in sagittal and coronal plan (carrying angle), immediately after fixation on-table during procedure.

REFERENCES

1. Labelle H, Bunnell WP, Duhaime M, et al. Cubitus varus deformity following supracondylar fractures of the humerus in children. J Pediatr Orthop. 1982;2:539–546.
2. Pirone AM, Graham HK, Krajbich JI. Management of displaced extension-type supracondylar fractures of the humerus in children. J Bone Joint Surg Am. 1988;70:641–650.
3. Skaggs DL, Cluck MW, Mostofi A, et al. Lateral-entry pin fixation in the management of supracondylar fractures in children. J Bone Joint Surg Am. 2004;86-A:702–707.
4. Griffin PP. Supracondylar fractures of the humerus. Treatment and complications. Pediatr Clin North Am. 1975;22:477–486.
5. McCoy GF, Piggot J. Supracondylar osteotomy for cubitus varus. The value of the straight arm position. J Bone Joint Surg Br. 1988;70:283–286.
6. Oppenheim WL, Clader TJ, Smith C, et al. Supracondylar humeral osteotomy for traumatic childhood cubitus varus deformity. Clin Orthop Relat Res. 1984;188:34–39.
7. Ogino T, Minami A, Fukuda K. Tardy ulnar nerve palsy caused by cubitus varus deformity. J Hand Surg [Br]. 1986;11:352–356.
8. Wilkins KE. Residuals of elbow trauma in children. Orthop Clin North Am. 1990;21:291–314.
9. Carlson CS Jr, Rosman MA. Cubitus varus: a new and simple technique for correction. J Pediatr Orthop. 1982;2:199–201.
10. DeRosa GP, Graziano GP. A new osteotomy for cubitus varus. Clin Orthop Relat Res. 1988;236:160–165.
11. Horstmann HM, Blyakher AA, Quartararo LG, et al. Treatment of cubitus varus with osteotomy and Ilizarov external fixation. Am J Orthop. 2000;29:389–391.
12. Kanaujia RR, Ikuta Y, Muneshige H, et al. Dome osteotomy for cubitus varus in children. Acta Orthop Scand. 1988;59:314–317.
13. Kim HT, Lee JS, Yoo CI. Management of cubitus varus and valgus. J Bone Joint Surg Am. 2005;87:771–780.
14. Koch PP, Exner GU. Supracondylar medial open wedge osteotomy with external fixation for cubitus varus deformity. J Pediatr Orthop B. 2003;12:116–122.
15. Levine MJ, Horn BD, Pizzutillo PD. Treatment of posttraumatic cubitus varus in the pediatric population with humeral osteotomy and external fixation. J Pediatr Orthop. 1996;16:597–601.
16. Tien YC, Chih HW, Lin GT, et al. Dome corrective osteotomy for cubitus varus deformity. Clin Orthop Relat Res. 2000;380: 158–166.
17. 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;11:327–331.
18. Yun YH, Shin SJ, Moon JG. Reverse V osteotomy of the distal humerus for the correction of cubitus varus. J Bone Joint Surg Br. 2007;89:527.
19. Weiss JM, Kay RM, Waters P, et al. Distal humerus osteotomy for supracondylar fracture malunion in children: a study of perioperative complications. Am J Orthop (Belle Mead NJ). 2010;39:22–25.
20. Laupattarakasem W, Mahaisavariya B, Kowsuwon W, et al. Pentalateral osteotomy for cubitus varus. Clinical experiences of a new technique. J Bone Joint Surg Br. 1989;71:667–670.
21. Wong HK, Lee EH, Balasubramaniam P. The lateral condylar prominence. A complication of supracondylar osteotomy for cubitus varus. J Bone Joint Surg Br. 1990;72:859–861.
22. Ippolito E, Moneta MR, D'Arrigo C. Post-traumatic cubitus varus. Long-term follow-up of corrective supracondylar humeral osteotomy in children. J Bone Joint Surg Am. 1990;72:757–765.
23. Beals RK. The normal carrying angle of the elbow. A radiographic study of 422 patients. Clin Orthop Relat Res. 1976;119:194–196.
24. Rogers LF, Malave S Jr, White H, et al. Plastic bowing, torus and greenstick supracondylar fractures of the humerus: radiographic clues to obscure fractures of the elbow in children. Radiology. 1978;128:145.
25. Gummesson C, Ward MM, Atroshi I. The shortened disabilities of the arm, shoulder and hand questionnaire (QuickDASH): validity and reliability based on responses within the full-length DASH. BMC Musculoskelet Disord. 2006;7:44.
26. Solway S, Beaton D, McConnell S, et al. The DASHOutcome Measure User's Manual. 2nd ed. Toronto: Instititute for Work and Health; 2002.
27. Kim HS, Jahng JS, Han DY, et al. Modified step-cut osteotomy of the humerus. J Pediatr Orthop B. 1998;7:162–166.
28. Takagi T, Takayama S, Nakamura T, et al. 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. 2010;92:1619–1626.
29. Abe M, Ishizu T, Shirai H, et al. Tardy ulnar nerve palsy caused by cubitus varus deformity. J Hand Surg [Am]. 1995;20:5–9.
30. Davids JR, Maguire MF, Mubarak SJ, et al. Lateral condylar fracture of the humerus following posttraumatic cubitus varus. J Pediatr Orthop. 1994;14:466–470.
31. Dreyfuss U, Kessler I. Snapping elbow due to dislocation of the medial head of the triceps. A report of two cases. J Bone Joint Surg Br. 1978;60:56–57.
32. Gurkan I, Bayrakci K, Tasbas B, et al. Posterior instability of the shoulder after supracondylar fractures recovered with cubitus varus deformity. J Pediatr Orthop. 2002;22:198–202.
33. Hayashi Y, Kojima T, Kohno T. A case of cubital tunnel syndrome caused by the snapping of the medial head of the triceps brachii muscle. J Hand Surg [Am]. 1984;9A:96–99.
34. Spinner RJ, O'Driscoll SW, Davids JR, et al. Cubitus varus associated with dislocation of both the medial portion of the triceps and the ulnar nerve. J Hand Surg [Am]. 1999;24:718–726.
35. 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-A:1358–1369.
36. Devnani AS. Lateral closing wedge supracondylar osteotomy of humerus for post-traumatic cubitus varus in children. Injury. 1997;28:643–647.
37. Siris IE. Supracondylar fracture of the humerus-300 cases. Surg Gynecol Obstet. 1939;68:201–222.
38. Graham B, Tredwell SJ, Beauchamp RD, et al. Supracondylar osteotomy of the humerus for correction of cubitus varus. J Pediatr Orthop. 1990;10:228–231.
39. Voss FR, Kasser JR, Trepman E, et al. Uniplanar supracondylar humeral osteotomy with preset Kirschner wires for posttraumatic cubitus varus. J Pediatr Orthop. 1994;14:471–478.
40. Mahaisavariya B, Laupattarakasem W. Osteotomy for cubitus varus: a simple technique in 10 children. Acta Orthop Scand. 1996;67: 60–62.
41. Barrett IR, Bellemore MC, Kwon YM. Cosmetic results of supracondylar osteotomy for correction of cubitus varus. J Pediatr Orthop. 1998;18:445–447.
42. Matsushita T, Nagano A. Arc osteotomy of the humerus to correct cubitus varus. Clin Orthop Relat Res. 1997;336:111–115.
43. Hernandez MA III, Roach JW. Corrective osteotomy for cubitus varus deformity. J Pediatr Orthop. 1994;14:487–491.
44. Sweeney J. Osteotomy of the humerus for malunion of supracondylar fractures. J Bone Joint Surg Br. 1957;57:117.
45. Davids JR, Lamoreaux DC, Brooker RC, et al. Translation Step-cut Osteotomy for the Treatment of Posttraumatic Cubitus Varus. J Pediatr Orthop 2011;31:353–365.