Double dome osteotomy for the treatment of cubitus varus in children

Perajit Eamsobhana · Kamolporn Kaewpornsaowan

Received: 23 December 2012 / Accepted: 25 January 2013 / Published online: 13 February 2013
© Springer-Verlag Berlin Heidelberg 2013

Abstract

Purpose The purpose of this study was to report double dome osteotomy used to correct paediatric cubitus varus and to avoid lateral prominence after correction.

Methods Eighteen children with cubitus varus underwent double dome osteotomy. Preoperative templating created from radiographs was used to determine the bone cuts. Double dome osteotomy created a proximal and distal cut, then varus deformity and sagittal alignment were corrected. The osteotomies were fixed with K-wires and immobilised in a long-arm cast. Radiographics and clinical histories were evaluated. Ulna-humeral angle pre and postoperative, range of motion and lateral prominent index were evaluated.

Results The osteotomy was performed in 18 patients, with an average age of 7.5 years. All patients ended up with flexion of 130° or greater with full and symmetrical pronation and supination. The average ulna-humeral angle difference compared to the uninjured side was 3.27°. The mean of the lateral prominent index was -0.91. The mean follow up was 50.3 months (30–115 months). All of the patients had excellent clinical and radiographic alignment. No revisions were made in this series. One transient radial nerve palsy and one superficial infection occurred.

Conclusion This series demonstrates that double dome osteotomy can provide reliable correction of varus deformity and prevent lateral prominence with a minimal complication rate.

Introduction

Post-traumatic cubitus varus deformity is the most common late complication of a supracondylar fracture or a physeal

fracture of the distal humerus. Causes of cubitus varus are now believed to be either supracondylar malunion or trochlear osteonecrosis. The distal humerus malunion typically includes elements of varus, internal rotation, and hyperextension. Distal humeral osteotomy is used to correct this deformity and to avoid later complications, such as ulnar nerve palsy [1, 2], posterolateral rotatory instability [3, 4], secondary distal humeral fracture [5, 6], internal rotational malalignment, posterior shoulder instability with a Bankart lesion [7] and poor cosmesis [1–9]. A variety of osteotomies have been described with variable success and variable complication rates, including lateral closing-wedge, medial opening-wedge [8], dome [4, 7, 10, 11], pentalateral [9, 12], three-dimensional [13, 14], and step-cut osteotomies [2]. Options for osteotomy stabilisation have included casting alone, internal fixation, and K-wire fixation with casting.

Some authors report complication rates of over 20 % for corrective osteotomies of the distal humerus [15]. Ippolito et al. performed 24 supracondylar osteotomies with six immediate postoperative complications, including ulnar-nerve palsy, haematoma, and circulatory disturbance. After an average follow-up of 23 years, they found that all but two of the patients lost correction, 14 of the patients were dissatisfied with the appearance of the scar, 12 of the patients had measurable atrophy of the affected arm, and ten of the patients had loss of motion [16]. Oppenheim et al. performed 45 corrective supracondylar osteotomies in 43 children with a 24 % complication rate, including neurapraxia, sepsis, and cosmetically unacceptable scarring [17]. With slightly improved results, Labelle et al. reported 33 % unsatisfactory results after 15 supracondylar osteotomies [12]. Newer techniques of percutaneous pin fixation versus casting alone and closer postoperative observation for correction of the deformity have decreased the complication rate to less than 15 % [18]. A comparative study of 25 patients randomised between the French and dome osteotomies found

P. Eamsobhana (✉) · K. Kaewpornsaowan
Department of Orthopedics and Rehabilitation,
Faculty of Medicine, Siriraj Hospital, Bangkok, Thailand
e-mail: Peerajite@gmail.com

improved rotational correction using the dome method, but this technique was associated with significant complications, including inadequate correction, nerve palsy, loss of motion, and circulatory compromise [19].

Suffice it to say, a clear method that achieves long-term deformity correction and complete patient satisfaction while minimising complications has yet to be fully developed. Toward that goal, we report a new double dome osteotomy of the distal humerus. First, this technique avoids a lateral prominence usually present following a simple closing wedge osteotomy, allowing for better cosmesis. Second, the method presented allows for rotation at the centre of the deformity, rather than at the edge of the closing wedge. This should result in improved rotational correction without neurovascular compromise. We also used a lateral approach to avoid postoperative extension lag. Posterior dissection distal to the olecranon fossa was avoided to prevent compromising the blood supply to the trochlea.

Methods

Between 2000 and 2010, eighteen children with cubitus varus underwent a double dome osteotomy performed by two paediatric orthopaedic surgeons. Indications for the surgery were pain, instability, secondary fracture and poor cosmesis in the affected arm. Clinical and radiographic measurements were used to determine the amount of correction. Clinically, the patients' range of motion and carrying angle were measured in the affected arm and compared to the normal arm. The differences were used to establish the angles of bone that should be corrected. Clinical and radiographic parameters were evaluated at the latest follow up. An institutional review board approved this study.

Preoperative radiographs of both upper extremities were analysed to confirm the bone cuts and also the bone that must be removed in order to correct the varus and extension deformity (Fig. 1). The lateral approach was used. A longitudinal incision, measuring approximately five to six centimetres, was made over the lateral distal humerus. The antebrachial

cutaneous nerve and its branches were identified and preserved. Dissection was carried out in the interval between the brachioradialis and triceps muscles. Subperiosteal dissection was performed to expose the distal humerus circumferentially. Posterior dissection distal to the olecranon fossa was avoided to prevent compromising the blood supply to the trochlea. A first dome osteotomy was performed just above the olecranon fossa apex of the first dome, at the centre along the axis of the humeral shaft, and apex of the second dome osteotomy at the centre along the axis of the ulna bone (Fig. 2). Translation of osteotomy site to correct the varus deformity and extension deformity was performed and fixed with 0.062-in (2-mm) Kirschner wires placed across the osteotomy site both medially and laterally (Fig. 3). These pins were left inside the skin. A goniometer was used to measure the carrying angle of the elbow, and elbow flexion and extension were then checked to ensure similarity to the contralateral side. The wound was irrigated, and a small amount of local bone graft from the excised wedge was packed around the osteotomy site. After closure, flexion, extension, and varus/valgus stability were checked under fluoroscopy to ensure that the osteotomy fixation was stable. A long-arm cast was applied in 90° of flexion, with the arm placed in neutral rotation.

The evaluation included assessment of the ulno-humeral angle, lateral prominent index from anteroposterior radiographs and measurement of the passive range of elbow motion using a goniometer before surgery and at the time of the final follow-up. We recorded complications such as infection, recurrence of cubitus varus deformity, nerve palsies, instability of the elbow, and refracture. Loss of correction was determined on the basis of the radiographic change in the ulno-humeral angle from immediately after the correction to the time of the final follow-up.

Postoperatively, the cast and pins were removed approximately eight weeks later in the operating room after callus formation was seen on the radiograph. If the callus had not yet formed, the pins were simply left in for longer. While most children do not require formal physical therapy, we generally teach the parents how to performed range of

Fig. 1 Preoperative anteroposterior (AP) and lateral radiographs of a supracondylar malunion in a 7-year-old boy

Fig. 2 a–c Osteotomy technique. **a** Apex of first dome is at the centre of line drawn along the humeral axis and the second dome apex at the centre of a line drawn along the ulna axis. **b** Template drawing of osteotomy. The black area represents the bone that needs to be removed. **c** The direction of rotation of the osteotomy

motion exercises at home. A follow-up appointment to assess the range of motion was scheduled about four weeks later, and if motion was not nearly normal at that time, physical therapy to improve elbow motion was recommended.

The lateral condylar prominence index (LCPI) is evaluated by calculation of the relationship between the medial and lateral epicondylar prominences in relation to the width of the distal humerus. The LCPI is defined as $(AB-BC)/AC$, where AB is the length from the centre of the humeral condyle to the lateral epicondyle, BC is the length from the centre of the humeral condyle to the medial epicondyle and AC is the length from the lateral epicondyle to the medial epicondyle. In the “normal” humerus, the medial condyle is slightly more prominent than the lateral, resulting in a slightly negative LCPI. The more “positive” the LCPI, the more prominent the lateral condyle.

Results

The osteotomy was performed in 18 patients: 15 males and three females (Table 1). The average age at surgery was

Fig. 3 Postoperative demonstration of K-wire fixation following osteotomy with medial and lateral fixation with three Kirschner wires

7.5 years (range, 4–15 years). All patients ended up with flexion of 130° or greater, which is commonly accepted as sufficient flexion for activities of daily living. All patients had full and symmetrical pronation and supination preoperatively and postoperatively.

The ulno-humeral angle was measured pre and postoperatively. The average ulnohumeral angle was 18.7° of varus preoperatively (range, 12–27°), and an average of 6.8° of valgus postoperatively (range 2–15°). The average angular correction was 25.5° (range, 17–37°). The average contralateral ulnohumeral angle was 7.7° of valgus (Figs. 1, 2, 3 and 4). Mean follow up was 50.3 months (range, 30–115 months).

There were no operative revisions. All patients were satisfied with the cosmetic and functional results of the surgery. One patient had a postoperative superficial infection and recovered following oral antibiotic treatment. A transient radial nerve palsy occurred in one patient and recovered in six weeks. No patient had any late complications such as ulnar nerve palsy, posterolateral rotatory instability, or refracture.

Discussion

The accuracy of the initial reduction best predicts the incidence of subsequent cubitus varus deformity in paediatric supracondylar fracture of the distal humerus. Despite modern treatment techniques, cubitus varus remains a complication of supracondylar humerus fractures. The consequences of cubitus varus include an increased risk of lateral condylar fractures, pain, posterolateral rotatory instability, tardy ulnar nerve palsy, internal rotational malalignment, and poor cosmesis.

The distal humerus malunion typically includes elements of varus, internal rotation, and hyperextension. Numerous

Table 1 Data for 18 patients who underwent double dome osteotomy for the treatment of cubitus varus

Patient	Age at osteotomy (years), gender	Preop. affected elbow ROM	Postop. affected elbow ROM	UHA preop. (varus)	UHA postop. (valgus)	UHA contralateral (valgus)	Lateral prominent Index	Follow up (months)
1	7, female	–10–120	0–130	25	4	5	–2.21	36
2	8, male	–10–100	0–140	23	2	8	–0.1	46
3	11, male	0–140	0–140	13	12	10	–2.8	80
4	10, male	0–120	0–140	13	5	13	–1.72	75
5	4, female	5–140	0–140	15	6	10	2.11	70
6	5, male	0–130	0–140	21	3	5	2.87	32
7	8, male	0–140	0–140	30	6	10	–3.23	55
8	8, male	0–100	0–140	14	10	10	0.27	30
9	5, male	0–100	0–140	30	5	9	1.24	34
10	4, male	–10–120	–10–140	14	10	15	–2.25	115
11	6, male	0–120	0–140	25	6	10	–3.84	48
12	4, female	0–130	0–130	20	15	15	–1.89	60
13	10, female	0–100	0–130	25	7	11	0.71	34
14	8, male	0–120	0–140	16	14	10	–3.26	34
15	9, male	0–140	0–140	20	13	10	1.17	43
16	5, male	0–100	0–130	20	5	10	1.58	35
17	8, male	–10–140	–10–140	20	9	10	–2.12	71
18	15, male	0–120	0–140	21	10	12	–3.01	42

ROM range of motion, UHA ulnohumeral angle

osteotomy techniques have been described with variable success and variable complication rates.

Kim et al. used a wedge osteotomy, stabilised with a Y-shaped humeral plate. All patients had good alignment and the desired range of motion. One patient had a tardy ulnar nerve palsy, and another patient had considerable scarring [20]. Another case series of 22 children was reported by Yun et al. in 2007 using a similar osteotomy, which had generally excellent results and two complications. One patient had an undisplaced fracture intraoperatively that healed satisfactorily, and another patient had a tardy ulnar nerve palsy [21].

Fig. 4 Postoperative AP and lateral elbow radiographs at 4-year follow up. Lateral prominent index is –3.23

Tachdjian initially mentioned the dome osteotomy in 1972, with Higaki and Ikuta later describing the technique more thoroughly [22]. Kanauija et al. reported dome osteotomies on 11 children to correct varus deformities. This involved a posterolateral approach, the use of Ikuta's fixation device, and crossing Kirschner wires for fixation. The correction was satisfactory in all of the cases, and there was no serious complication.

Other described techniques include step-cut, interlocking wedge, and arc osteotomies. DeRosa and Graziano used a step-cut technique of distal humerus valgus osteotomy using one cortical screw for fixation in 11 patients. They found no radial or ulnar nerve injuries, nonunions, infections, or hypertrophic scars. One patient had residual varus [23]. Miura et al. treated 20 patients with an interlocking wedge osteotomy, with only one poor result [24]. Matsushita and Nagano treated 12 patients with an arc osteotomy, and they observed no complications [25].

This series demonstrates that double dome osteotomy through a lateral approach can provide reliable correction of varus with a low complication rate. This osteotomy has several advantages. It reliably corrects varus deformity without producing a lateral prominence. We recommend this technique for the treatment of supracondylar humerus fracture malunions in children. In this series we corrected only varus and hyperextension deformity; the reasons for omitting internal rotation deformity from this study are that it

may make a difficult and unstable K-wire stabilisation and the rotation correction will create anterior prominence limiting flexion [20, 21, 26]. Rotational deformity is not the primary disability in residual cubitus varus because it is easily compensated for by rotation of the shoulder joint [4].

O'Driscoll et al. [4] reported that displacement of the triceps brachii, which causes the instability, results from the varus deformity rather than from the internal rotation. In our series with simple coronal plane correction, no patient developed tardy posterolateral rotatory instability.

Mitsunari et al. showed that an internal rotation deformity contributes to the onset of tardy ulnar nerve palsy. With correction of the varus deformity, anterior compression of the nerve by the medial head of the triceps brachii is relieved. We believe it is sufficient to perform anterior transposition of the nerve at the time of the osteotomy in patients with preoperative symptoms related to the ulnar nerve. In our series, none had an ulnar nerve palsy preoperatively, and we did not encounter any patients with tardy ulnar nerve palsy, even among those in whom the internal rotation was not corrected.

For the problem of sagittal alignment, Gadgil et al. [27] reported that patients over ten years of age who were treated with straight-arm traction after distal humeral supracondylar fracture had some terminal restriction of flexion, indicating limited remodelling capacity in this age group. We also noted no significant remodelling in patients over ten years of age without surgical correction of flexion. In this series we simultaneously correct sagittal alignment along with varus correction in every patient except those under ten years old.

In conclusion, in the surgical treatment of post-traumatic cubitus varus deformity, correction of internal rotation malalignment may not be needed as it is difficult to maintain the corrected carrying angle because of the small area of osseous contact. It is possible to treat tardy ulnar nerve palsy by anterior transposition and to treat tardy posterolateral rotator instability with ligament reconstruction in symptomatic patients, even if the internal rotation is not corrected. In this series we performed double dome osteotomy to correct varus deformity and also checked for proper sagittal alignment simultaneously in all cases.

Conflict of interest None of the authors received financial support for this study.

References

1. Beaty JH, Kasser JR (2010) Rockwood and Wilkins' fractures in children, 7th edn. Lippincott Williams & Wilkins, Philadelphia, pp 488–532
2. Davids JR, Lamoreaux DC, Brooker RC, Tanner SL, Westberr DE (2011) Translation step-cut osteotomy for the treatment of post-traumatic cubitus varus. *J Pediatr Orthop* 31:353–365
3. Usui M, Ishii S, Miyano S et al (1995) Three-dimensional corrective osteotomy for treatment of cubitus varus after supracondylar fracture of the humerus in children. *J Should Elb Surg* 4:17–22
4. O'Driscoll SW, Spinner RJ, McKee MD et al (2001) Tardy posterolateral rotatory instability of the elbow due to cubitus varus. *J Bone Joint Surg Am* 83:1358–1369
5. Davids JR, Maguire MF, Mubarak SJ et al (1994) Lateral condylar fracture of the humerus following posttraumatic cubitus varus. *J Pediatr Orthop* 14:466–470
6. Abe M, Ishizu T, Morikawa J (1997) Posterolateral rotatory instability of the elbow after posttraumatic cubitus varus. *J Should Elb Surg* 6:405–409
7. Gurkan I, Bayrakci K, Tasbas B et al (2002) Posterior instability of the shoulder after supracondylar fractures recovered with cubitus varus deformity. *J Pediatr Orthop* 22:198–202
8. Abe M, Ishizu T, Shirai H et al (1995) Tardy ulnar nerve palsy caused by cubitus varus deformity. *J Hand Surg Am* 20:5–9
9. Spinner RJ, O'Driscoll SW, Davids JR et al (1999) Cubitus varus associated with dislocation of both the medial portion of the triceps and the ulnar nerve. *J Hand Surg Am* 24:718–726
10. Beuerlein MJ, Reid JT, Schemitsch EH et al (2004) Effect of distal humeral varus deformity on strain in the lateral ulnar collateral ligament and ulnohumeral joint stability. *J Bone Joint Surg Am* 86:2235–2242
11. Banerjee S, Sabui KK, Mondal J, Raj SJ, Pal DK (2012) Corrective dome osteotomy using the paratricipital (triceps-sparing) approach for cubitus varus deformity in children. *J Pediatr Orthop* 32:385–393
12. 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
13. French PR (1959) Varus deformity of the elbow following supracondylar fractures of the humerus in children. *Lancet* 2:439–441
14. Bellemore MC, Barrett IR, Middleton RW et al (1984) Supracondylar osteotomy of the humerus for correction of cubitus varus. *J Bone Joint Surg Br* 66:566–572
15. Raney EM, Thielen Z, Gregory S, Sobralske M (2012) Complications of supracondylar osteotomies for cubitus varus. *J Pediatr Orthop* 32:232–240
16. Ippolito E, Moneta MR, D'Arrigo C, Post-traumatic cubitus varus (1990) Long-term follow-up of corrective supracondylar humeral osteotomy in children. *J Bone Joint Surg Am* 72:757–765
17. Oppenheim WL, Clader TJ, Smith C et al (1984) Supracondylar humeral osteotomy for traumatic childhood cubitus varus deformity. *Clin Orthop Relat Res* 188:34–39
18. Wilkins KE (1997) Supracondylar fractures: what's new? *J Pediatr Orthop B* 6:110–116
19. Kumar K, Sharma VK, Sharma R et al (2000) Correction of cubitus varus by French or dome osteotomy: a comparative study. *J Trauma* 49:717–721
20. Kim HT, Lee JS, Yoo CI (2005) Management of cubitus varus and valgus. *J Bone Joint Surg Am* 87:771–780
21. Yun YH, Shin SJ, Moon JG et al (2007) Reverse V osteotomy of the distal humerus for the correction of cubitus varus. *J Bone Joint Surg Br* 89:527–531
22. Higaki T, Ikuta Y (1982) The new operation method of the domed osteotomy for 4 children with varus deformity of the elbow joint. *J Jap Ortho* 31:30–35
23. DeRosa GP, Graziano GP (1988) A new osteotomy for cubitus varus. *Clin Orthop Relat Res* 236:160–165

24. Miura H, Tsumura H, Kubota H et al (1998) Interlocking wedge osteotomy for cubitus varus deformity. *Fukuoka Igaku Zasshi* 89:119–125
25. Matsushita T, Nagano A (1997) Arc osteotomy of the humerus to correct cubitus varus. *Clin Orthop Relat Res* 336:111–115
26. 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
27. Gadgil A, Hayhurst C, Maffulli N, Dwyer JS (2005) Elevated, straight-arm traction for supracondylar fractures of the humerus in children. *J Bone Joint Surg Br* 87:82–87