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Loss of correction in cubitus varus deformity after osteotomy

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Abstract

We aimed to investigate the rate of loss of correction and the factors thereof in pediatric patients undergoing osteotomy for treatment of cubitus varus deformity.

Between July 2008 and July 2017, we treated 30 patients who underwent osteotomy for cubital varus. We compared the preoperative and postoperative clinical and imaging findings, including the H-Cobb and Baumman angles, in all patients. Postoperative evaluation was performed by telephonic interviews.

Our patients consisted of 17 males and 13 females. The mean age was 75 months. At the first follow-up, approximately 80% of patients had experienced a loss of correction of the humerus-cobb angle (H-Cobb angle); at the second follow-up, the incidence was 83%. Meanwhile, 57% and 43% of patients experienced a loss of correction of the Baumman angle at the first and second follow-ups, respectively. The average interval between the first and second follow-ups was 24 days, and the mean loss in the H-Cobb angle was 2.4°. There was a significant difference between the H-Cobb angles as measured before and after surgery ($P < .05$). There was no significant difference between the H-Cobb angles of the affected side and the contralateral healthy elbow at the third postoperative follow-up; however, there was a significant difference between the Baumman angle between before and after surgery ($P < .05$). The Baumman angles as measured at the second and third postoperative follow-ups differed significantly from those of the contralateral healthy elbow joint. According to the survival curve analysis, the median survival times of the H-Cobb and Baumman angles were 27 and 34 months, respectively.

The postoperative loss of the 2 angles occurred mainly during the first and second follow-up periods. Therefore, patient follow-up is particularly important in the period directly following the operation. Additional measures may be necessary to avoid rapid angle loss.

Abbreviation: H-cobb angle = humerus-cobb angle.

Keywords: cubitus varus, loss of correction, osteotomy

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YZ and CY contributed equally to this report.

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This article does not contain any studies with human participants or animals performed by any of the authors.

Ethics approval and consent to participate 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.

Informed consent was obtained from all individual participants included in the study.

The authors have no conflicts of interests to disclose.

All data generated or analyzed during this study are included in this published article [and its supplementary information files].

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1. Introduction

Cubitus varus is a widely recognized complication of pediatric supracondylar fracture that can be observed during the initial injury after conservative treatment, or even after operative treatment.[1–4]Traditionally, cubitus varus has been considered to encompass varus, extension, and internal rotation. However, several recent studies have revealed through 2- or 3-dimensional analysis that the morphologic and alignment changes of the elbow joint develop over time during the progression of varus deformities. Trochlear deformity and partial hypoplasia due to compromised growth potential after injury have been regarded as keystones for further progression to varus, misalignment, and even to late manifestations, such as posterolateral rotatory instability.[5–9] Surgical corrections for moderate-to-severe deformities have been introduced to improve cosmetic conditions and prevent functional impairment, such as restricted range of motion, instability, and ulnar nerve neuropathy.[7–19] Various corrective methods have been introduced, but some investigators have noted that osteotomy, a method that can result in a loss of correction, did not completely improve the appearance of the elbow and forearm. Moreover, it is unclear when the angle loss will occur and what the cause may be. Hence, we aimed to determine the cause of the loss of correction observed following osteotomy in order to develop an effective method to prevent angle loss.

We hypothesized that the loss of correction would continue during the postoperative period following osteotomy. However, the length of this period was unclear. More evidence is needed to determine the rate of loss of correction after osteotomy. Therefore, we retrospectively analyzed all cases of cubit varus in our hospital and recorded relevant data at each postoperative follow-up. This data was then used for the subsequent statistical analysis in order to determine the rate of angle loss and the causes thereof. These findings could offer valuable insights as to how current surgical treatment methods for the reduction or avoidance of angle loss can be improved.

2. 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 began.

Medical records and radiographs obtained between July 2008 and July 2017 at Shenzhen Children's Hospital were retrospectively reviewed.

Clinical and radiographic data were recorded. The first follow-up was performed on the third postoperative day. We obtained the following information: patient age, sex, and functional parameters; the interval between follow-ups; and radiographic parameters. We measured the humerus-cobb angle (H-Cobb angle) using the following method: in the elbow orthophoto, a line segment was drawn between the most convex parts of the inner and outer sides of the distal humerus, after which another line segment was drawn perpendicularly to the humeral trunk line. The angle between this line segment and the one between the inner and outer protrusions was considered to be the humeral H-Cobb angle. The Baumman angle was considered to be located between the long axis of the humerus shaft and the epiphyseal line of the outer edge of the small humeral head (Fig. 1). Following osteotomy, a total of 9 cases were fixed using only 1 hollow screw for each patient. In 21 cases, 2 pins were used for each patient. The single-cut osteotomy technique was used on 21 patients, and the relatively new method known as polyline osteotomy was performed on 9 patients.

Statistical analysis was performed using SPSS 21 software and included Student *t* tests, Chi-Squared tests, and Fisher exact tests, where appropriate. The survival curve analysis was performed using GraphPad Prism 7, and the correlation curves were fitted. All results were reported as means and standard deviations. Statistical significance was set at $P<.05$.

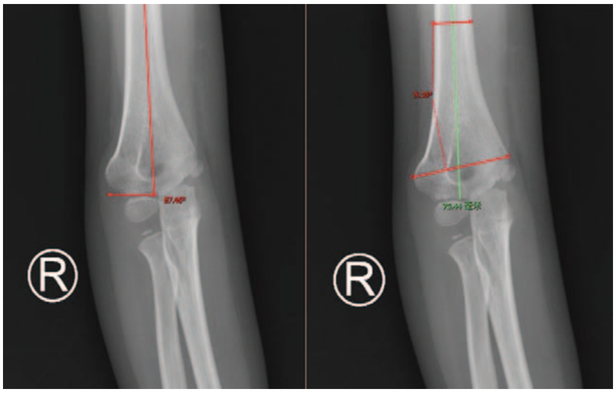

Figure 1. Baumann angle and H-cobb angle measurement method.

Table 1

The main infoemation of patients.

No. of patients	30
Age* (Mo)	75
Sex	
Male	17
Female	13
Refracture	0
Angle loss of the second follow-up (d)	24

3. Results

In our study, there were 30 patients, including 17 males, and 13 females. The mean age was 75 months (Table 1). In the first follow-up, approximately 80% of patients experienced a loss of correction of the H-Cobb angle; at the second follow-up, the incidence was 83%. With regard to the Baumman angle, a loss of correction was observed in approximately 57% of patients at the first follow-up and in 43% at the second follow-up. The average interval between the first and second follow-ups was 24 days, and the mean H-Cobb angle loss was 2.4°. There was a significant difference in the H-Cobb angles between before and after surgery ($P<.05$). There was no significant difference between the H-Cobb angle as measured in the third postoperative period and the H-Cobb angle of the contralateral healthy elbow. There was a significant difference between the Baumman angle between before and after surgery ($P<.05$), and no significant difference

Table 2

H-cobb paired *t* test.

		Mean	SD	S.E. mean	95% CI Lower limit	95% CI Upper limit	t	df	Sig. (two-tailed)
Pair 1	Third - Normal	.62500	2.09604	.38268	–.15767	1.40767	1.633	29	.113
Pair 2	Preop - First	17.84333	9.66684	1.76492	14.23367	21.45299	10.110	29	.000
Pair 3	Preop - Second	–7.76567	8.74659	1.59690	–11.03170	–4.49963	–4.863	29	.000
Pair 4	Preop - Third	–5.37933	8.45748	1.54412	–8.53741	–2.22126	–3.484	29	.002
Pair 5	First - Second	–25.60900	8.41630	1.53660	–28.75170	–22.46630	–16.666	29	.000
Pair 6	First - Third	–23.22267	9.20141	1.67994	–26.65853	–19.78681	–13.824	29	.000
Pair 7	First - Normal	–22.59767	8.58228	1.56690	–25.80234	–19.39299	–14.422	29	.000
Pair 8	Second - Third	2.38633	3.26687	.59645	1.16647	3.60620	4.001	29	.000
Pair 9	Second - Normal	3.01133	3.59397	.65617	1.66932	4.35334	4.589	29	.000

Table 3

Baumann angle paired *t* test.

		Mean	SD	S.E. mean	95% CI Lower limit	95% CI Upper limit	t	df	Sig.(Two)
Pair 1	Preop - First	24.23300	10.22271	1.86640	20.41578	28.05022	12.984	29	.000
Pair 2	Preop - Second	24.44433	11.49915	2.09945	20.15048	28.73819	11.643	29	.000
Pair 3	Preop - Third	24.05931	9.52319	1.76841	20.43688	27.68174	13.605	28	.000
Pair 4	Preop - Normal	20.02233	14.63572	2.67210	14.55727	25.48740	7.493	29	.000
Pair 5	First - Second	.21133	6.28597	1.14766	–2.13589	2.55855	.184	29	.855
Pair 6	First - Third	–.51621	7.70352	1.43051	–3.44647	2.41405	–.361	28	.721
Pair 7	First - Normal	–4.21067	11.87207	2.16753	–8.64377	.22244	–1.943	29	.062
Pair 8	Second - Third	–.98862	5.72523	1.06315	–3.16638	1.18914	–.930	28	.360
Pair 9	Second - Normal	–4.42200	10.50540	1.91801	–8.34478	–.49922	–2.306	29	.028
Pair 10	Third - Normal	–3.64379	10.42926	1.93666	–7.61087	.32328	–1.881	28	.070

was found between the H-Cobb and Baumman angles as measured after surgery. The Baumman angle measurements during the second and third postoperative periods differed significantly from those of the contralateral healthy elbow joint (Tables 2 and 3).

According to the survival curve analysis, the median survival time of the H-Cobb and Baumman angles was 27 and 34 months, respectively. Figures 2–5 indicate that the patients experienced continuous angle loss during the second postoperative follow-up.

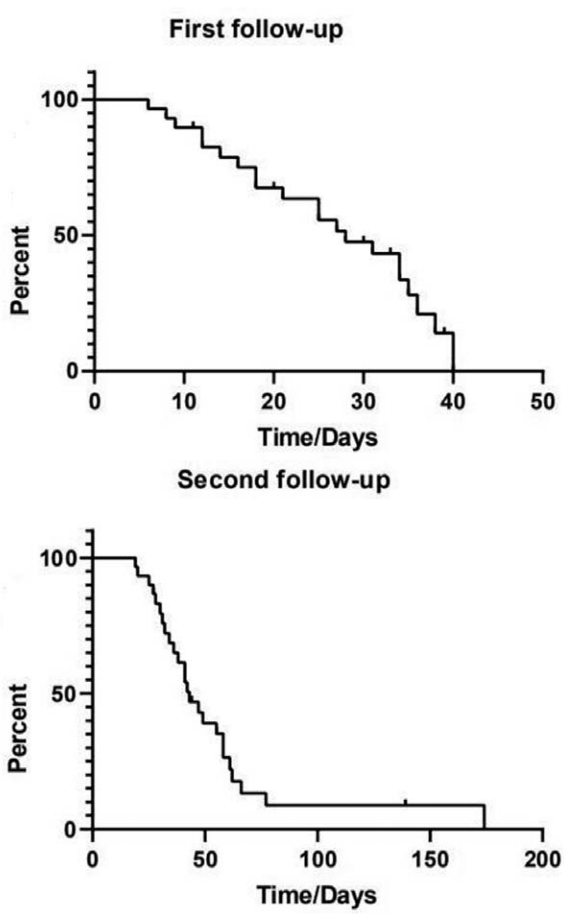

Figure 2. According to the survival curve analysis, we can see that the median survival time of the H-cobb angle is. From Figures 2 , we can see that the children's angle loss during the second postoperative follow-up is in a state of continuous loss. At the third postoperative follow-up, the angle loss of the children was stable, so we have reason to believe that the angle loss of most children had stopped before the third follow-up.

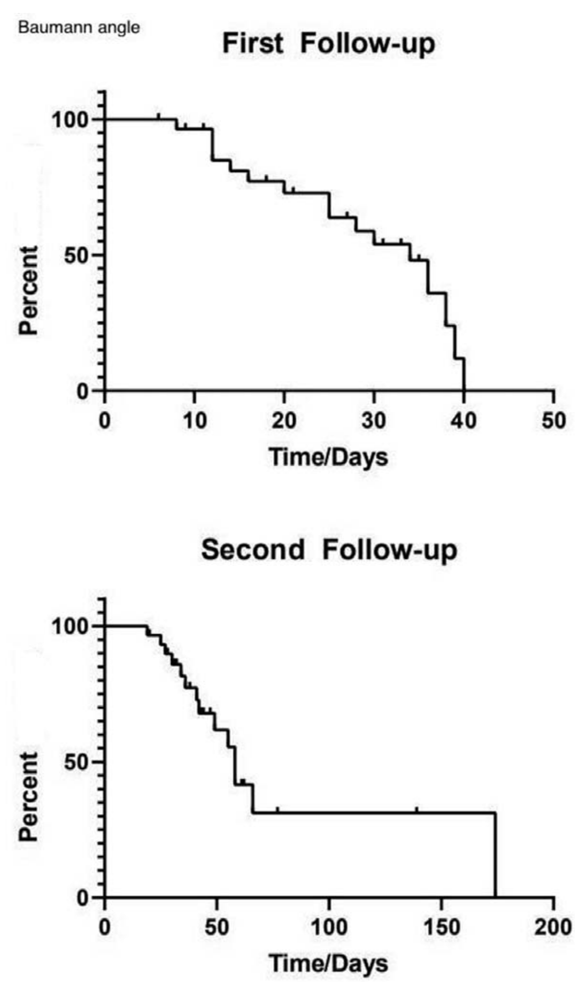

Figure 3. According to the survival curve analysis, we can see that the median survival time of the Baumann angle is. From Figures 3, we can see that the children's angle loss during the second postoperative follow-up is in a state of continuous loss. At the third postoperative follow-up, the angle loss of the children was stable, so we have reason to believe that the angle loss of most children had stopped before the third follow-up.

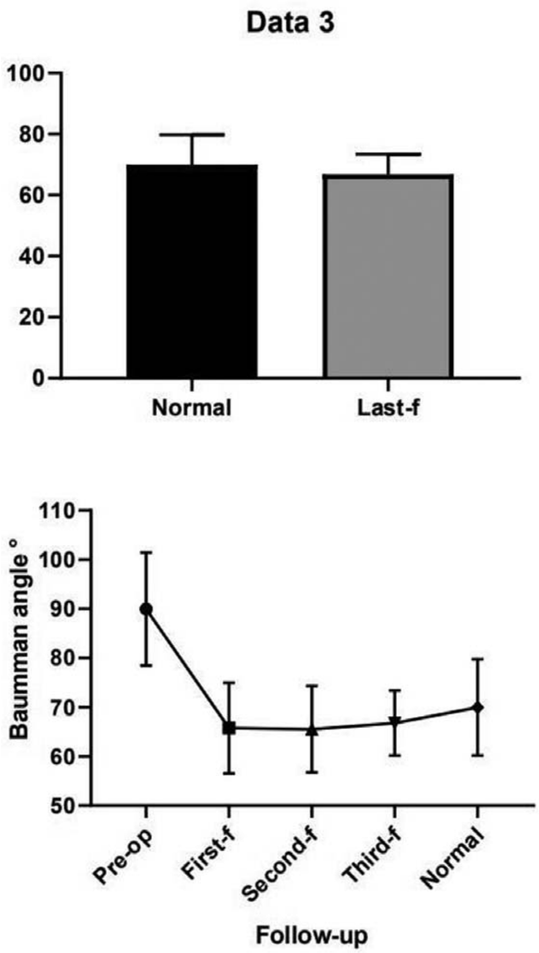

Figure 4. The Baumann angle were significantly improved after surgery. The value of the Baumann angle of the affected limb at the last follow-up was not significantly different from that of the healthy side.

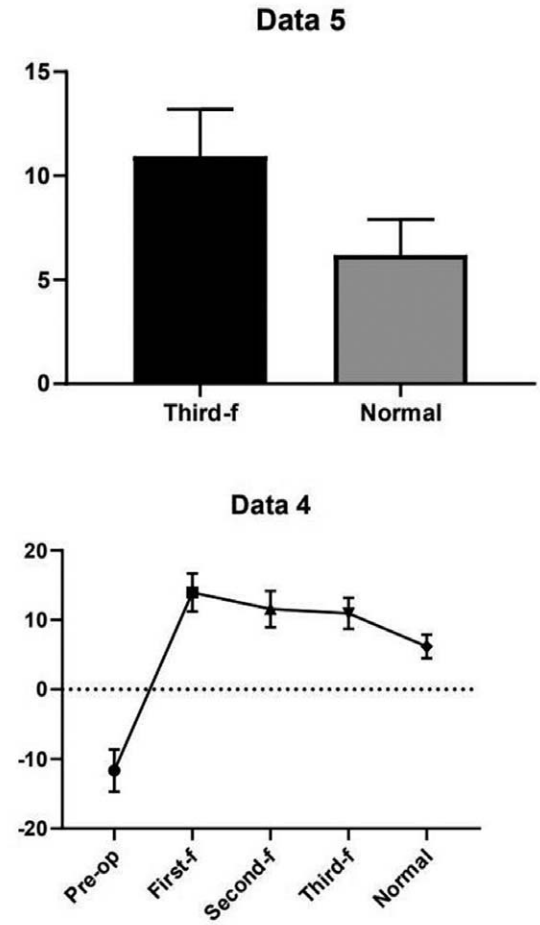

Figure 5. The H-cobb angle were significantly improved after surgery. there was a statistical difference in the H-cobb angle value between the last follow-up and the healthy side.

At the third postoperative follow-up, the angle loss had stabilized. Hence, it is conceivable that the angle loss stopped before the third follow-up.

4. Discussion

Since the advent of thoracic pedicle screws in scoliosis, their use has been increasingly popularized for deformity correction.[20] A systematic literature review[21] reported that these constructs yielded a larger percentage of successful Cobb angle corrections compared with hooks and hybrid constructs in both AIS and the adult literature.[22] While previous reports on the loss of correction of the H-Cobb angle following cubitus varus osteotomy exist, some studies have reported that pedicle screw-only fixation during AIS was associated with significantly fewer instrumented spinal segments, shorter operating times, less need for anterior releases, and fewer thoracoplasties.[23] However, loss of correction over time may still occur in patients with AIS.[24–28] Overall, the use of pedicle screw constructs in AIS resulted in an incidence of loss of correction that was approximately half of that of hybrid constructs, occurring instead in approximately 10% of cases.[29] Although the loss of correction in AIS patients was not solely attributed to bony structure loss, this finding nonetheless provides a valuable insight into loss of correction of the H-Cobb angle in patients with cubitus varus.

In this study, we did not investigate the internationally recognized carrying angle. This was not done for a number of reasons. First, since all of our osteotomies were immobilized with plaster casts after the surgery, the X-rays were taken of the patients while they wore the plaster. Therefore, the shooting angle could not be accurately measured. Second, the optimal method for measuring the carrying angle remains controversial. At present, the most common measurement method in the scientific literature determines the carrying angle based on the appearance of the patient. The angle between the bony structures in the film can better represent the clinical significance of the carrying angle. In light of the above, we proposed the concept of the H-Cobb angle. This angle can accurately measure the loss of the postoperative correction angle when a radiograph of the orthotopic humerus is used.

According to our study, the average duration of angle loss after cubital varus osteotomy was approximately 24 postoperative days, and 80% of the patients experienced a loss of correction during this period (Figs. 2 and 5). Therefore, the first 24 days after surgery appear to constitute a critical period with regard to loss of correction following osteotomy. For this reason, preventive measures are warranted during this period. Based on Figures 2–5, the correction angle loss observed in the children during the second postoperative follow-up was continuous. At the third postoperative follow-up, the correction angle loss had stabilized, suggesting that the correction angle loss stopped before the third follow-up in most of the children. However, our sample size was small, and we did not assess risk factors, so we cannot conclusively determine the mechanism of this finding or derive any specific preventive measures therefrom. Nonetheless, in our patients, we found that polyline bone cutting reduced the occurrence of postoperative bone loss due to angle-cutting.

We found that some of the children did not experience corrective angle loss after surgery. As previously mentioned, different approaches were used for fixation in our study. A possible direction for future research would be a comparison of fixation methods with regard to angle loss.

Lastly, we found that the loss of correction of the H-Cobb angle was not always accompanied by an increase in the Baumman angle following surgery. We believe this to be due to the growth uncertainty associated with the Baumman angle, a variable which may have affected our results. Hence, the use of the Baumman angle is not recommended in research in which the angle of elbow varus is being assessed (Figs. 3 and 4).

Our study had some limitations. First is the small number of patients in the series. The short-term followup and lack of a control group were also a problem we need to solve.

5. Conclusion

The postoperative angle loss may continue for a period of time, primarily during the first follow-up period. Therefore, patient follow-up is warranted in the period following the operation, and measures should be implemented to avoid rapid angle loss.

Author contributions

Conceptualization: Chao You, Jingming Han.
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Formal analysis: Yibiao Zhou.
Funding acquisition: Chao You, Yibiao Zhou.
Investigation: Yibiao Zhou.
Methodology: Chao You, Yibiao Zhou.
Project administration: Chao You.
Resources: Chao You.
Software: Chao You.
Supervision: Chao You.
Validation: Chao You.
Writing – original draft: Yibiao Zhou.

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