

Distal Humerus Osteotomy for Supracondylar Fracture Malunion in Children: A Study of Perioperative Complications

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Abstract

Previous studies have found a wide range of perioperative complications associated with distal humerus osteotomies for malunion of supracondylar fractures in children. Our hypothesis was that the surgery would have few perioperative complications when performed at a pediatric center.

We examined perioperative complications of corrective osteotomy for malunited supracondylar humerus fractures in 41 patients treated at Childrens Hospital Los Angeles between 1987 and 2002, and we established the risk factors associated with these complications.

The overall complication rate was 32% (13/41). In the early surgeries, performed between 1987 and 1997, the complication rate was 53% (10/19); 6 (32%) of the 19 patients required reoperation. In the later surgeries performed during 1998 and 2002, the complication rate was 14% (3/22); no patient required reoperation. The complication rate was significantly lower ($P = .0005$) when lateral-entry pins were used to fix the osteotomy (13% [2/15]) than when other fixation methods were used (42% [11/26]).

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Using current techniques and performing the surgery in a pediatric center, we report a 0% reoperation rate and a 14% complication rate in distal humerus osteotomies for surgeries performed after 1997, a rate that we believe is acceptable. Furthermore, there are fewer complications of the surgery when lateral-entry pins are used to fix the osteotomy compared with other fixation methods.

Varus malunion, a well-recognized complication of supracondylar humerus fractures in children, can lead to cosmetic and functional problems. The classic "gunstock deformity" results in the typical cosmetic deformity because of varus malunion. Other problems associated with varus malunion of the elbow include lateral condyle fracture,¹ tardy ulnar nerve palsy,²⁻⁴ tardy posterolateral rotatory instability of the elbow,⁵ and, according to anecdotal reports, elbow discomfort.

Because of these cosmetic and functional problems, surgery is often performed to correct supracondylar malunion. Results of such corrective osteotomies vary widely, and reported complication rates range from 0%^{6,7} to 40%.⁸ Oppenheim and colleagues⁹ reported a complication rate of 24% (11/45); ulnar nerve palsy occurred in 11% of cases. Ippolito and colleagues¹⁰ reported a 21% complication rate (5/24): 2 ulnar nerve palsies (8%), 2 hematomas (8%), and 1 wound dehiscence (4%). Other reported complications are infection, hardware failure and loosening, and recurrent or residual deformity.^{8,11,12} Because of the high rate of complications reported in some series, some patients with posttraumatic cubitus varus may have been discouraged from undergoing such corrective surgery.

In this article, we examine perioperative complications of corrective osteotomy for malunited supracondylar humerus fractures treated at Childrens Hospital Los Angeles and establish the risk factors associated with these complications. Our hypothesis was that the rate of perioperative complications would be low when surgery was performed at a tertiary pediatric center.

MATERIALS AND METHODS

After obtaining approval from our institutional review board, we conducted a medical record search for patients treated with osteotomy for supracondylar humerus malunion between 1985 and 2003. Fifty-seven such patients were identified. The patients had undergone surgery by 13 different surgeons. We then retrospectively reviewed these



Figure 1. Preoperative anteroposterior (A) and lateral (B) radiographs of elbow with cubitus varus and extension deformity.

patients' medical records and radiographs. We excluded 16 patients whose preoperative and postoperative radiographs documenting their healing were unavailable for review, leaving 41 patients in the study group.

Charts were reviewed for sex, injury side, age at time of fracture and at time of osteotomy, and preoperative and postoperative range of motion (ROM). Paired *t* test was used to compare preoperative and postoperative ROM.

Several operative variables were noted (surgical approach, osteotomy type, fixation type, date surgery was performed) and several complications recorded (infections, postoperative stiffness, pain, refracture, deformity recurrence, hardware failure, neurovascular compromise). The Fisher exact test was used to analyze the relationship between each surgical variable and the complication rate. Residual varus was noted and included as a complication.

Radiographic data included preoperative and postoperative ulnohumeral angles. Degrees of correction were recorded. Paired *t* tests were used to compare preoperative and postoperative radiographic data. Preoperative and postoperative radiographs of a case example are pictured in Figures 1 and 2.

RESULTS

The study had 41 patients: 16 girls (39%) and 25 boys (61%). Mean age at time of original injury was 5.2 years (range, 1-12 years). The right elbow was injured in 20 children (49%) and the left in the other 21 (51%). Mean age at time of injury was 5 years (range, 2-13 years). Mean age at time of surgery was 7.5 years (range, 2 years 1 month to 15 years). Mean follow-up was 9 months (range, 3 weeks for osteotomy healing to 5 years).

The overall complication rate was 32% (13/41). In the early surgeries, performed between 1987 and 1997, the complication rate was 53% (10/19); 6 (32%) of the 19 patients required reoperation. In the later surgeries, performed between 1998 and 2002, the complication rate was 14% (3/22); no patient required reoperation. The 13 total complications consisted of 4 transient ulnar nerve palsies, 4 deformity recurrences or loss of fixation requir-



Figure 2. Postoperative anteroposterior (A) and lateral (B) radiographs after osteotomy to correct cubitus varus.

ing reoperation, 4 elbows healed in residual varus, and 1 deep infection requiring operative treatment. There were 2 complications in 1 patient.

Of the 41 osteotomies, 33 were fixed only with Kirschner wires (K-wires), 4 with tension band constructs (eg, French technique), 3 with plates, and 1 with external fixation. Fifteen of the K-wire-only osteotomies involved lateral-entry pins; in all but 1 of these cases, 3 K-wires were used in the osteotomy. In total, 4 (10%) of the 41 osteotomies were complicated by transient ulnar nerve symptoms. Two of these osteotomies were fixed with plates (posterior approach in each case), 1 with a tension band (lateral approach), and 1 with cross-pins (medial approach, ulnar nerve transposition). Complication rates were 29% (5/17) for cross-pinning, 100% (1/1) for medial pins, 67% (2/3) for plates, and 50% (2/4) for tension bands, for a total complication rate for these methods of 38% (10/26). The complication rate for lateral-entry pins was 13% (2/15).

Complications were not clustered around younger or older patients. Age at surgery, fixation type, date of surgery, and complications are listed in the Table.

Mean preoperative ROM was 121° of flexion to -4° of extension (many patients hyperextended), and mean postoperative ROM was 129° to 0°. Paired *t* test showed that there was no statistically significant difference between preoperative and postoperative ROM arc. Among the 12 patients who lost ROM, the mean loss was 23°. Largest loss of ROM (75°) was in a patient lost to follow-up after the osteotomy was healed (and therapy prescribed) at 3 weeks; repeat ROM values were not available for this patient. For some patients, ROM arc increased after surgery. The Table lists ROM details.

Preoperative pronation and supination data were poorly documented. Only 6 charts had complete information. Twelve patients lost ROM.

The surgical approach was lateral in 35 cases, posterior in 2, and medial in 4. Of the ulnar nerve palsies, 2 occurred with a medial approach, and 2 occurred with a lateral approach. Forty osteotomies were lateral closing wedge, and 1 was a dome osteotomy.

Mean ulnohumeral angle for the injured elbow was 18° of varus before surgery (range, 0°-40° of varus) and 6° of valgus

Table. Surgery Date, Age at Surgery, Fixation Type, Complications, and Preoperative and Postoperative Ulnohumeral Angle, Extension, Flexion, ROM Arc, and Change in ROM Arc

Surgery Date	Age at Surgery (y+mo)	Fixation Type	Reop	Complication(s)	Ulnohumeral Angle (°)		Extension (°)		Flexion (°)		ROM arc (°)		Change in ROM arc (°)
					Preop	Postop ^a	Preop	Postop	Preop	Postop	Preop	Postop	
02/04/87	7+11	External	—	—	25	-10	10	—	130	—	-15	—	—
04/20/88	3+9	Lateral K-wires	—	5° varus	14	-4	30	0	140	140	16	4	-12
08/05/88	4+10	Lateral K-wires	—	—	0	-3	-5	0	100	130	-5	3	27
03/07/89	10+1	Tension band	Yes	Recurrence, broken wire, weakness and paresthesia in ulnar nerve distribution	25	-2	0	0	140	122	-25	2	8
03/27/89	8+4	Cross K-wires	—	—	27	-20	0	0	140	100	-27	20	47
10/10/91	7+5	Cross K-wires	Yes	—	15	10	5	-10	110	125	-10	-20	-10
04/02/92	11+3	Lateral K-wires	—	—	15	-13	0	45	140	110	-15	58	73
05/20/92	3+11	Cross K-wires	—	—	13	-24	-15	0	120	140	-28	24	52
09/18/92	4+1	Cross K-wires	—	Resolved ulnar neuroparaxia	40	-9	-30	—	80	—	-70	—	—
09/28/92	4+3	Cross K-wires	—	—	12	-3	-5	-5	110	110	-17	-2	15
04/01/94	4+7	Cross K-wires	—	—	17	-11	-5	-5	135	135	-22	6	28
04/05/95	15+5	Plate & K-wires	—	Ulnar nerve paresthasias	19	5	-25	0	140	140	-19	-5	14
04/10/95	13+6	Tension band	—	—	22	-7	-5	0	130	140	-47	7	54
07/26/95	8+3	Cross K-wires	Yes	Ulnar nerve sensory deficit transient	5	-5	-5	0	—	—	—	—	—
08/11/95	4+10	Medial K-wires	Yes	Deep infection	10	-5	0	0	100	140	-10	5	15
05/01/96	3+10	Tension band	Yes	Recurrence of 20° varus, lacking 10° extension requiring biplanar repeat osteotomy	25	-12	—	—	—	—	—	—	—
10/09/96	6+11	Cross K-wires	—	—	10	-16	-5	—	140	—	-15	—	—
04/01/97	5+3	Cross K-wires	Yes	—	25	20	30	0	140	130	—	—	—
08/18/97	6+11	Cross K-wires	—	—	18	0	0	0	100	140	-18	0	18
12/22/98	8	Lateral K-wires	—	—	23	-15	0	0	140	95	-23	15	38
03/15/99	8+10	Cross K-wires	—	—	5	-7	-40	-15	120	140	-45	8	37
04/08/99	8+10	Lateral K-wires	—	—	3	-13	-5	0	90	130	-8	13	21
04/14/99	5+7	Lateral K-wires	—	—	23	-8	0	-5	140	135	-23	3	26
07/01/99	10+2	Plate	—	—	21	0	-25	-10	130	140	-46	-10	36
07/20/99	13+5	Plate	—	—	21	-21	-20	0	110	145	-41	21	62
09/27/99	15	Tension band	—	Transient ulnar nerve palsy	5	0	0	0	140	135	-5	0	5
12/14/99	3+3	Lateral K-wires	—	—	25	-10	5	0	90	130	-20	10	30
03/15/00	6+7	Cross K-wires	—	—	21	-9	15	—	102	—	—	—	—
04/26/00	6+2	Lateral K-wires	—	—	15	-5	-20	-5	100	130	-35	0	35
06/20/00	5	Lateral K-wires	—	—	21	-16	21	—	120	120	-42	—	—
07/19/00	15	Lateral K-wires	—	—	13	0	0	0	120	120	-13	0	13
02/21/01	6+3	Lateral K-wires	—	—	29	-5	0	0	118	125	-29	5	34
04/20/01	6+3	Cross K-wires	—	—	23	-3	-10	30	118	115	-33	33	66
06/27/01	3+3	Lateral K-wires	—	—	22	-14	-11	—	100	100	-33	—	—
07/31/01	11+1	Lateral K-wires	—	—	14	0	0	-5	130	130	-14	-5	9
02/14/02	7+5	Cross K-wires	—	—	15	-3	5	0	100	125	-10	3	13
02/20/02	5+10	Lateral K-wires	—	—	16	-13	-10	-10	120	135	-26	3	29
04/14/02	2+9	Cross K-wires	—	—	26	-12	0	10	130	130	-26	22	48
06/24/02	11+8	Cross K-wires	—	—	17	-11	0	0	140	130	-17	11	28
07/09/02	11+11	Lateral K-wires	—	—	14	5	-15	-5	140	140	-29	-10	19
10/21/02	2+1	Cross K-wires	—	—	17	10	0	0	140	140	-17	-10	7

Abbreviations: reop, reoperation; preop, preoperative; postop, postoperative; ROM, range of motion.
^aPositive numbers are varus, negative numbers valgus.

after surgery (range, 20° of varus to 20° of valgus). The difference between preoperative and postoperative ulnohumeral angles was significant ($P = .000$). By contrast, mean ulnohumeral angle for the uninjured elbow in patients whose contralateral radiographs were available was 8°. Eighty-five percent of the postoperative ulnohumeral angles were within 10° of those on the contralateral side, and the mean difference was 7.5°. Elbows that did not undergo reoperation included 2 that remained in 5° of varus and 1 that remained in 10° of varus. In 1 patient, whose preoperative ulnohumeral angle was 0°, the osteotomy clearly was performed mainly for flexion. The operative notes and radiographs for the other osteotomies did not routinely clarify whether flexion was addressed.

DISCUSSION

In previous studies, the frequency and severity of complications of distal humeral osteotomies performed after malunion of supracondylar humerus fractures vary considerably. Complication rates have ranged from 0%^{6,7} to 40%,⁸ with nerve complications in 8% to 20% of cases in 3 series.⁸⁻¹⁰

Perhaps this complication rate variability can be better understood in the light of the findings of the present study. The overall complication rate was 32% (13/41), which somewhat disproved our hypothesis that it would be lower when the surgery was performed at a tertiary pediatric center. However, the 53% complication rate for surgeries performed during the first decade (1987–1997) addressed in this study was much higher than the 14% rate for surgeries performed during the next 5 years (1998–2002). Factors that may account for the rate disparity may be different surgeons, improving techniques, and more experience with the techniques.

In the present series, fixation type also affected the complication rates: 13% for osteotomies fixed with lateral-entry pins and 42% for osteotomies fixed with other methods. Surgeons operating after 1997 had become very experienced in performing the lateral pinning technique, which may account for some of the complication rate disparity.

Ulnar nerve palsy, a complication of distal humeral osteotomy, has been reported in 0%^{7,12,13} to 20%⁸ of cases. Evaluation of our findings and of previously reported findings indicated that fixation type is related to incidence of postoperative nerve deficits. In a study with 11% ulnar nerve palsies, cross-pins were used to fix the osteotomies.⁹ In another cross-pin series (15 cases), there were no nerve palsies, but a posterior approach was used, and the pin entrance and exit sites were directly visualized.¹³ Voss and colleagues¹² reported no nerve complications of 36 supracondylar osteotomies. Although a lateral approach was routine (35/36 cases), they used only lateral-entry pins in 27 cases (75%) and added a medial pin in the other 9 cases (25%). In the present study, ulnar nerve palsies occurred in 4 (10%) of 41 patients, with 0% incidence for lateral-entry pins and 15% (4/26) for the other fixation types. Cross-pins appear to increase the risk for ulnar nerve injury during supracondylar osteotomy, just as they do in the pinning of supracondylar humerus fractures.^{14,15}

In the pediatric population, fixation loss and malunion are other supracondylar osteotomy complications with

wide variations in incidence. Some authors have been able to avoid such complications, whereas others have reported fixation loss in 15% to 20% of patients^{8,16} and malunion in 11% to 33% of patients.^{8,9,16-18} In our study, fixation loss and malunion accounted for 7 complications, and only 4 of these underwent reoperation.

It is difficult to explain exactly why complication frequency and severity decreased beginning in 1998, but 2 factors may be at work: Surgeons operating after 1997 had become very experienced in performing the lateral pinning technique, and 12 (57%) of the 21 osteotomies performed since 1998 were fixed with lateral-entry pins.

A weakness of this study is that it was not designed to determine the long-term efficacy of osteotomies but instead was focused on perioperative complication rates.

This study demonstrates the risk factors associated with corrective osteotomy for supracondylar malunion in children. Performed by teaching faculty at a major pediatric institution after 1997, this surgery had few complications, particularly when lateral-entry pins were used for fixation.

AUTHORS' DISCLOSURE STATEMENT

The authors report no actual or potential conflict of interest in relation to this article.

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