Correction of Malunion after Pediatric Supracondylar Elbow Fractures

Closing Wedge Osteotomy and External Fixation

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Abstract

Background: Malunion is the most common complication after pediatric supracondylar fractures. Cubitus varus may be cosmetically disturbing, consolidation in hyperextension restricts flexion. There is a considerable rate of complications for corrective osteotomies reported in the literature (incomplete correction, loss of correction, and unsightly scars).

Patients and Methods: 13 patients (six boys and seven girls), average age 11 years (5–23 years), underwent supracondylar closing wedge osteotomies and lateral external fixation. Cubitus varus deformity averaged 23° (15–50°). Four patients were treated by flexion osteotomies, six by valgus osteotomies, and three by combined flexion-valgus osteotomies.

Results: Nine patients showed symmetric carrying angles, three had 5° more valgus on the operated arm. One patient had 10° more varus which still resulted in a physiologic valgus. One patient had slight lateral bony prominence despite symmetric carrying angles. Three patients complaint about unsightly scars. All three had previous open reduction of their fractures with keloids. All patients had already reached a range of motion at the time of metal removal which was within 15° of the values at the time of the latest follow-up. Seven patients with significantly decreased elbow flexion regained an average of 28° of flexion (20–35°). Two superficial pin track infections healed under oral antibiotics.

Conclusion: External fixation facilitates correction by empirically searching for the desired carrying angle, cosmetic appearance, and function of the elbow. Functional aftertreatment shortens the recovery period. Metal removal is easy. Our experience confirms the excellent results in previous series on external fixators.

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Key Words
Cubitus varus · Supracondylar fracture · Osteotomy · External fixation

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Introduction

Malunion after pediatric supracondylar fractures is reported in recent papers to occur in up to 20% after closed or open reduction and internal fixation [1–3]. Cubitus varus, which never remodels with growth, or malunion in antecurvatum, which only remodels in younger children, accounts for this most common complication after pediatric elbow fractures. A patient's desire for restoration may arise either from impaired cosmetic due to cubitus varus or from disabling lack of elbow flexion due to consolidation in hyperextension or from a combination of both (Figures 1 to 4). Various combinations of osteotomy techniques and fixation devices have been described. The specific supracondylar bony anatomy not only renders primary fracture treatment difficult but also represents an obstacle in achieving and maintaining correct alignment and satisfactory cosmetic appearance of the elbow. Incomplete correction of the deformity or loss of correction contributes significantly to poor results in up to 50% in early series [4–7]. Recent studies report higher success rates [8, 9].

This retrospective study reports our experience with supracondylar hinged and nonhinged closing wedge osteotomies followed by lateral external fixation.

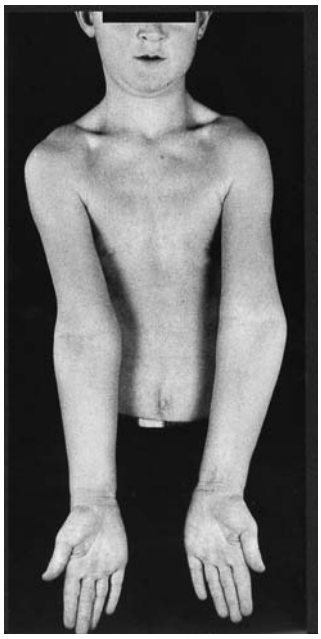

Figure 1. Patient no. 6; 10-year-old boy with a 20° cubitus varus 2 years after a supracondylar fracture of his left elbow.

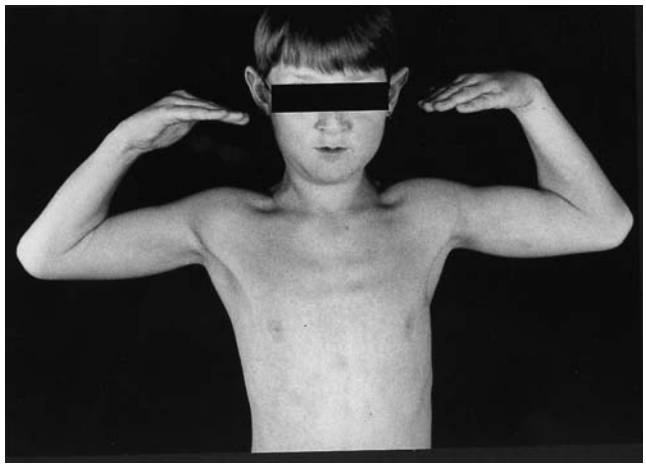

Figure 2. 25° restriction of left elbow flexion due to malunion in hyperextension.

Figure 3. Preoperative AP radiograph. Cubitus varus. Open physis.

Figure 4. Preoperative lateral radiograph. Distal humerus malunited in extension.

Patients and Methods

During the period 1997–2002, 13 patients (six boys and seven girls) with an average age of 11 years (5–23 years) underwent supracondylar osteotomies and external fixation for malunion at our institution (Table 1). Five patients had injured their right elbow and eight patients their left elbow. Five patients had sustained a supracondylar Gartland type II fracture with initial plaster treatment in four cases and closed reduction and plaster treatment in one. Seven patients had suffered from a supracondylar Gartland type III fracture with open reduction and K-wire fixation in all but one patient who was initially treated with closed reduction and K-wire fixation. One patient had sustained a displaced transcondylar fracture. One patient (case 1) had already been treated with a corrective osteotomy and plate osteosynthesis for cubitus varus 8 years ago but complained of a disabling flexion deficit of his elbow.

The cubitus varus deformity averaged 23° (15–50°).

The decision for a flexion osteotomy was made if the patient complained about the loss of function and spontaneous remodeling of the antecurvated distal humerus could not be expected (patient's age > 7 years).

The decision for a valgus osteotomy was always based on cosmetic impairments. There were no cases with elbow instability.

Four patients were treated by a flexion osteotomy, six by a valgus osteotomy, and three by a combined flexion-valgus osteotomy. The interval between trauma and corrective osteotomy averaged 42 months (5–144 months). The average follow-up was 14 months (4 months to 6 years).

Preoperative and follow-up documentation included clinical assessment of elbow range of motion, standard anteroposterior (AP) and lateral radiographs of the elbow and clinical photographs of both elbows' flexion, extension, both forearms' pronation and supination, and carrying angles of both elbows.

Surgical Technique

Operations were performed in supine position on an arm board with no tourniquet. Sterile draping of both arms was done in order to find the optimal amount of correction for a symmetric result. The position of the most distal pin was assessed under image intensifier

Table 1. Patients. CR: closed reduction; F: flexion; OR: open reduction; OS: osteosynthesis; OT: osteotomy; V: valgization. Varus minus; valgus plus.

	Type of fracture	Prior procedures	Interval to trauma (months)	Age (years)	Removal of metal (weeks)	OT	Flexion-extension (°)		Varization (°)	Carrying angles (°)			Complications
							Preop.	Postop.		Injured Preop.	Postop.	Uninjured	
1	Supracondylar	OT and plate OS for cubitus varus 8 years ago	144	23	14	F	90-0-0	110-5-0	0	5	5	5	Anterior translation of the fragment
2	Supracondylar	OR, K-wires, anterior approach	17	12	10	F	90-0-10	120-10-0	0	5	5	5	
3	Supracondylar	OR, K-wires, posterior approach to open arthrolysis	17	11	8	F	95-20-0	130-20-0	0	5	5	5	
4	Supracondylar	OR, external fixation, lateral approach	18	13	8	VF	95-0-0	125-5-0	20	–10	5	10	Superficial infection
5	Supracondylar		18	9	8	F	115-0-20	140-0-5	0	10	10	10	
6	Supracondylar		22	10	9	VF	115-0-25	140-0-5	15	–10	5	5	
7	Supracondylar		72	10	8	V	140-0-10	125-0-0	30	–25	5	5	
8	Supracondylar		50	7	9	V	140-0-20	140-0-15	25	–25	5	0	
9	Supracondylar	CR	5	5	9	VF	105-0-20	135-0-5	30	–20	10	10	
10	Transcondylar Y	OR, K-wires, lateral approach	50	6	8	V	120-0-0	140-0-5	50	–35	15	15	
11	Supracondylar	OR, K-wires, lateral approach	30	8	8	V	125-0-0	125-0-0	20	–10	10	10	
12	Supracondylar	CR, K-wires	48	12	10	V	150-0-10	150-0-0	20	–15	5	5	Superficial infection
13	Supracondylar	OR, K-wires, lateral approach	60	15.5	8	V	140-0-5	140-0-5	25	–5	10	20	

just proximal to the distal humeral growth plate in case of still open physis or in the distal humeral epiphysis in case of ceased growth. At the same time, the site of osteotomy (1 m proximal to the second pin) was determined and skin marked with a sterile pen. The site of osteotomy was subperiosteally exposed then through a posterolateral skin before pin placement, which facilitates the approach. In the case of a former open fracture reduction, that skin incision was used except when it was an anterior approach (case 2). Two 4-mm self-drilling and self-cutting pins were placed from the lateral site into the distal fragment. Two other pins were placed into the proximal fragment in an anteroposterior direction just distal to the origin of the deltoid muscle to avoid the radial nerve. All pins were brought in through a 6- to 7-mm skin incision, which was spread by a clamp, followed by introduction of a pin guide for soft tissue protection. After pin placement, two small blunt Hohmann retractors provided subperiosteal exposure of the osteotomy site, which was usually situated 1–2 cm proximal to the supracondylar region in case of still open physis or at the supracondylar region in case of already closed physis. A closing medially hinged valgus and/or posteriorly hinged flexion wedge osteotomy was performed with a saw under continuous irrigation. The lower osteotomy was cut parallel to the elbow joint line. The external fixators (Hoffmann II compact®, Stryker Howmedica Osteonics, Geneva, Switzerland) was mounted and fixed. The arm (carrying angle, lateral bump, range of motion for elbow extension and flexion, forearm pronation and supination) was compared to the contralateral arm. In case of a still disturbing lateral bump, the

osteotomy was completed and the distal fragment medialized as much as needed. Derogation was only performed in case of impaired shoulder function compared to the contralateral side. The external fixators could be undone and refixed, until the desired cosmetic and functional result was achieved. Skin closure was achieved with continuous intracutaneous self-resorbing 3-0 suture. The incisions for the pins were left open, and sterile dressings were applied.

Aftertreatment

No physiotherapy was administered. The patients were encouraged to actively and passively move their elbow, shoulder, forearm, and wrist as soon and as much as tolerated. Patients and parents were instructed on how to take care of the pin sites. Daily showers or baths were mandatory after healing of the skin incision, usually after day 10. Radiographs were taken postoperatively, after 4 and 8 weeks.

The external fixator was removed on an outpatient basis. The patient himself decided for or against anesthesia.

Results

Inpatient Days

Average 6.4 days (3–9 days).

Consolidation

Removal of metal was carried out on an average 9 weeks after osteotomy (range 8–14 weeks). There was one secondary anterior ad latus dislocation of the distal fragment without deterioration of the alignment (case 1), which led to delayed union of 14 weeks.

Cosmetic

Nine patients showed symmetric carrying angles, three had 5° more valgus on the operated arm. One patient (case 13) had 10° more varus which still resulted in a physiologic valgus of 10°, since the other elbow had a carrying angle of 20°.

One patient had lateral bony prominence despite perfect symmetric carrying angles. She had open physis and a relatively proximal osteotomy with subsequent lateral shift of the distal fragment as a consequence of valgization.

Three patients complained about unsightly scars. All three had previous open reduction of their fractures with scar excision at the time of osteotomy but with recurrence of their keloids.

Function

All patients had already reached a range of motion at the time of metal removal that was within 15° of the values at the time of the latest follow-up. Seven patients with significantly decreased elbow flexion due to posttraumatic malunion in antecurvatum regained an average of 28° of flexion (20–35°) but lost only averaged 11.5° of extension (0–20°).

Complications

There were two superficial pin track infections which healed under a 7-day course of oral broad-spectrum antibiotics. No neurologic or vascular complications, pin loosening or refracture after metal removal were observed.

Discussion

Indication for Surgery

Cosmetically unaccepted cubitus varus is still the main indication for a corrective osteotomy after pediatric supracondylar fractures of the elbow. However, active athletes may also complain about specific disabilities [10]. An associated or isolated malunion in hyperextension leads to a loss of flexion and may therefore contribute to the disability. Other clinical implications of cubitus varus such as rotatory instability of the elbow, dislocation or snapping of the triceps tendon, tardy ulnar nerve palsy, and posterior instability of the shoulder are less frequent [11–14].

Timing of Surgery

Since cubitus varus deformities of the elbow have a low potential for remodeling, the decision and timing can be fully based on the patient's and parents' preferences. In case of loss of flexion due to malunion in hyperextension, remodeling can be expected in patients below the age of 7 and with a deformity of < 20–30°. However, in older patients, early correction is warranted in case of restriction of daily activities or sports.

Results

In published studies, successful restoration of a symmetric carrying angle of the elbow in children with posttraumatic cubitus varus did not lead to the desired cosmetic result in up to 60% of the patients [8, 9, 15–17]. Dissatisfied patients usually complain about the persistence of a varus deformity, lateral bony prominence or an unsightly scar. A persisting cubitus varus and/or lateral promi-

nence may be due to the osteotomy technique, excision of an inadequate wedge, or loss of fixation.

Osteotomy Technique. The most widely used osteotomy, the French method with a lateral closing hinged wedge, shifts the distal fragment laterally. The latter is also wider than the proximal thus potentially contributing to a lateral bulge. The younger the child, the more bony the remodeling will be to compensate for the initial mismatch in width [8, 17]. However, the more proximal the osteotomy is performed, the more lateral the condylar block will be shifted. With external fixation, mainly in patients with still open physis, the osteotomy is more proximal than the site of malunion and also more proximal compared to osteotomies where other implants like blade plates, staples or K-wires are used. One should consider this issue by medializing the distal fragment, if traditional hinged closing wedge osteotomy is not satisfactory. In our series, however, it was only done in one patient and should have been done in another, who was not completely satisfied with the appearance of the elbow despite anatomic restoration of the carrying angle. In other series, simple hinged medial open or hinged lateral closing wedge osteotomies followed by external fixation yielded excellent results [18–20]. One-dimensional, two-dimensional or even three-dimensional correction is easily accomplished with the external fixator which allows for empiric search of the optimal cosmetic appearance (Figures 5 and 6). The osteotomy can be securely held for intraoperative assessment of cosmetic in full extension of the elbow. The ease of application and the inherent stability of external fixation avoid more complicated types of osteotomies like dome, arc or pentalateral osteotomies, all designed to improve stability [21–24].

Figure 5. AP radiograph 6 weeks postoperatively. Lowest pin as close to the physis as possible. Consolidated closing wedge osteotomy with slight medialization of the distal fragment.

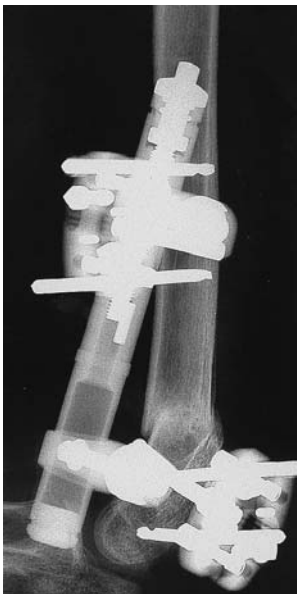

Figure 6. Lateral radiograph 6 weeks postoperatively. Flexion osteotomy corrected sagittal malunion.

Inadequate Size of Wedge. Preoperative planning, conscientious intraoperative judgment with the elbow fully extended and the forearm supinated, and clinical comparison to the contralateral elbow prevent this failure.

Loss of Fixation. This is a potential hazard mainly if simple K-wire fixation or mere plaster immobilization is used, but it is also observed in most studies with more rigid types of fixation [4, 6, 7, 10, 15, 25, 26]. In our series, with full functional aftertreatment, one moderate secondary anterior translation of the distal fragment occurred which did not interfere with the end result. Other publications on unilateral external fixation also reported maintenance or only insignificant loss of initial correction which underlines the stability of this construct [18, 19, 25].

Scars

Hypertrophic scars have a strong negative impact on the outcome of an operation which is almost exclusively done for cosmetic reasons [4, 6, 8, 10]. All three patients in our study with unsatisfying scars had preexisting keloids from previous open surgery. The risk of unsightly scars may be diminished by using previous incisions, by posterior or medial approaches to the distal humerus, by intracutaneous suturing techniques, and by postoperative skin and scar care. In case of external fixation, the incision at the pin sites should be excised and debrided at the time of frame removal, since they are always inflamed and contribute to hypertrophic scarring. Alternatively, the application of the frame and exposure of the humerus can be performed from the medial side to hide the scars. It requires transposition of the ulnar nerve and the acceptance of temporary less comfort caused by a medial fixator [18, 20].

Figure 7. 1 year postoperatively: symmetric carrying angles without lateral bony prominence.

Figure 8. 1 year postoperatively: symmetric full flexion.

Figure 9. AP radiograph 1 year postoperatively. Remodeled osteotomy.

Figure 10. Lateral radiograph 1 year postoperatively. Anatomic alignment of the distal humerus.

Complications

Apart from unsatisfactory cosmetic results, various types of complications are reported. Transient peripheral nerve palsy may occur due to stretching by retractors or by indirect stretching of the soft tissues by the corrective maneuver itself after both open and closed osteotomies [19, 27]. Theoretically, pin placement for external fixation may damage a nerve. However, no such complication has been reported. It can be avoided by placing the pins in safe zones or by open exposure of the pin sites.

Infection is generally the most frequent reported complication of external fixation. Thorough instruction of the caregivers in pin site care is essential. The infection rate in smaller series (five to six patients) of external fixation ranged from 0% to 40% [18, 25] and was 15% in our patients. All were superficial and controlled by short-term oral antibiotics.

Aftertreatment

Temporary postoperative immobilization in a posterior plaster slab in flexion or even in full extension is advocated by most authors [9]. External fixation allows for immediate active and passive motion. There is no doubt that this functional aftertreatment with full use of the operated elbow for daily activities enhances the patient's comfort and shortens the time of recovery despite avoidance of formal physiotherapy [28, 29]. All our patients had almost reached full range of motion already at the time of frame removal.

Removal of Metal

Unlike other implants, external fixation avoids a second operation for metal removal. External fixators could be removed after 9 weeks in this series comparable to other studies with external fixation [18, 19].

Conclusion

External fixation of supracondylar osteotomies facilitates correction by empirically searching for the desired carrying angle, cosmetic appearance, and function of the elbow. It even gives opportunity for closed adjustment in case of unsatisfactory correction. Stability is provided even if there is only a small area of bony contact. Immediate functional aftertreatment shortens the recovery period. Metal removal is easy. Our experience in 13 patients confirms the excellent results in previous series of unilateral and ring fixators [18–20, 25, 28] (Figures 7 to 10).

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