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The outcome of loose bone fragments in pediatric supracondylar humerus fractures: a retrospective study

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We evaluated the clinical and imaging outcomes of loose bone fragments in children with supracondylar humerus fractures after closed reduction with percutaneous pin (CRPP) fixation. A retrospective review was conducted on 12 children with fragments on imaging after closed reduction of displaced humeral supracondylar fractures (Gartland III). Primary radiographic assessment included fragment outcome, postoperative Baumann angle, carrying angle and loss of reduction. Clinical outcome included the elbow range of motion (ROM), Flynn grade and other complications. Between January 2015 and January 2018, 460 children (2–14 years old) with supracondylar humerus fractures were treated at our center, including 12 (2.6%) with loose bone fragments on postoperative X-ray. Union or absorption of fragments was noted in all 12 patients at 1 year postoperatively, with good radiographic and clinical outcomes. The mean Baumann angle was 15.5°±4.3° and the mean carrying angle was 11.2°±2.8°. All patients had a normal elbow ROM. Ten patients achieved an excellent and two a good result according to the Flynn criteria. Good results were achieved after CRPP fixation in 12 children with supracondylar humerus fractures and loose bone fragments. The fragments were mainly absorbed or achieved union to the humerus within 1 year. *J Pediatr Orthop B* 31: 12–17 Copyright © 2020 The Author(s). Published by Wolters Kluwer Health, Inc.

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Introduction

Supracondylar humerus fractures are the most common pediatric elbow fracture in children [1]. The current preferred treatment for a displaced fracture is closed reduction with percutaneous pin (CRPP) fixation [2,3]. However, complications such as iatrogenic nerve palsy, loss of reduction, cubitus varus deformity, pin tract infection and restricted range of motion (ROM) still cannot be completely avoided [4,5]. Loose bone fragments after surgical treatment of pediatric supracondylar humerus fractures are not so common and have rarely been reported before. The presence of these fragments on X-ray will cause the parents concern about treatment and prognosis. The purpose of the study was to try to evaluate the clinical and imaging outcomes of these loose bone fragments after CRPP.

Between 2015 and 2018, we treated 460 children with supracondylar humerus fractures, including 12 (2.6%) with unsatisfactory bone fragments on postoperative X-ray. We presented the details of their general data and clinical results.

Patients and methods

We searched the diagnosis card index files at our department between January 2015 and January 2018 for patients of supracondylar humerus fractures with loose bone fragments on postoperative X-ray. Totally, 460 children with supracondylar humerus fractures were treated at our center, and 12 (2.6%) patients (nine boys, three girls; average age 6.1 years; range 2–9 years) with loose bone fragments on postoperative X-ray were enrolled in the study. This study was approved by the Human and Ethics Committee for Medical Research at Sichuan University in accordance with the Declaration of Helsinki. Written informed consent was obtained from parents of all individual participants included in the study.

All children with supracondylar humerus fractures were assessed for vascular and neurologic status and underwent emergency surgery within 2 days. Anteroposterior and lateral radiographs were performed pre- and postoperatively.

Surgery was performed by a senior pediatric orthopedic surgeon well-trained in this technique. All patients underwent general anesthesia and were in a supine position with the injured elbow placed on the side of the table for reduction and X-ray image intensifier. Closed reduction included a longitudinal traction with the elbow in extension, and then a force from the medial or lateral side of the distal fracture to correct the lateral displacement and finally applying a force from the posterior side

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together with elbow hyperflexion to achieve reduction of posterior displacement. The reduction was confirmed using the X-ray image intensifier, and three smooth pins of 2.0 mm were inserted from the lateral epicondyle in parallel or divergent configuration. The pins were bent and cut off for the splint fixation and pins removal.

Postoperatively, the extremity was placed in a well-padded splint with the elbow flexed to 60–80°. Immediate postoperative radiographs were taken to determine maintenance of the reduction. Patients were followed for at least 1 year. The splint and pins were removed without anesthesia at week 4.

During outpatient follow-up, all patients were assessed clinically and radiologically by another independent pediatric orthopedics, including measurement of carrying angle, Baumann angle, fragment healing, loss of reduction and ROM. Complications, including neurovascular status, infection and compartment syndrome, were documented. Clinical evaluation was graded as excellent, good, fair and poor according to the criteria of Flynn.

Table 1. Demographic data and outcome of the 12 children with supracondylar humerus fracture

Characteristics	*n*=12
Mean age, years[a]	6.1±1.9
Sex, male/female[b]	9/3
Side, left/right[b]	7/5
Follow-up time, years[a]	20.4±10.6
Postoperation carrying angle[a]	11.2±2.8
Postoperation Baumann angle[a]	15.5±4.3
Flynn grading	
Excellent[b]	10
Good[b]	2
Infections[b]	0
Loss of reduction[b]	0

[a]Values are given as the mean and SD.
[b]Values are given as the number of patients.

Final clinical and radiologic outcome was assessed at 1 year postoperatively.

Results

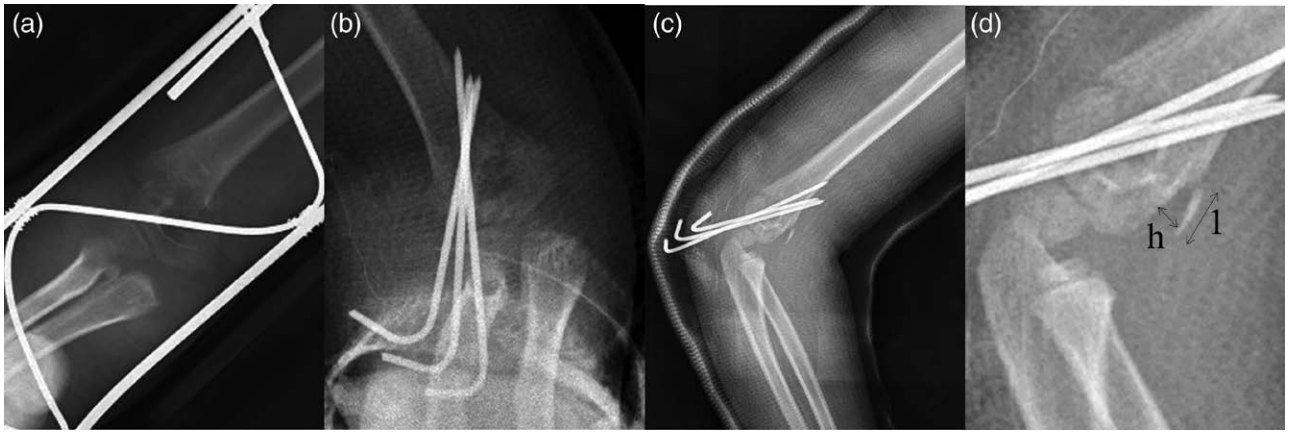
All fractures were of the extension type, classified as Gartland III (the left side in seven patients and the right side in five). No patient had any other associated or open fractures. The common injury mechanism was falling on an outstretched hand. There was no brachial artery injury. Only one child had a median nerve injury with an unsatisfactory thumb opposition after injury, which resolved 1 month postoperatively.

CRPP was performed by a senior pediatric orthopedic surgeon under general anesthesia within 48 h after injury. Patients were followed up for more than 1 year at 1, 4, 8, 12 weeks, 6 months, 12 months and then every 12 months from the second year. No case of compartment syndrome, iatrogenic neurovascular injury or infection occurred. Only one patient suffered pin tract irritation, which was relieved by pin removal. No patient had a forearm rotational deformity, elbow extension dysfunction or major loss of reduction requiring reoperation. All patients had good elbow flexion (mean flexion 136.6° and range 130–145°). According to the Flynn criteria, 10 patients achieved an excellent and two a good result (Table 1).

Anteroposterior and lateral radiographs (Syngo Imaging V31; Siemens AG Medical Solutions, Germany) revealed a mean postoperative Baumann angle of 15.5° (range 10–24°) and mean carrying angle of 11.2° (range 6–15°).

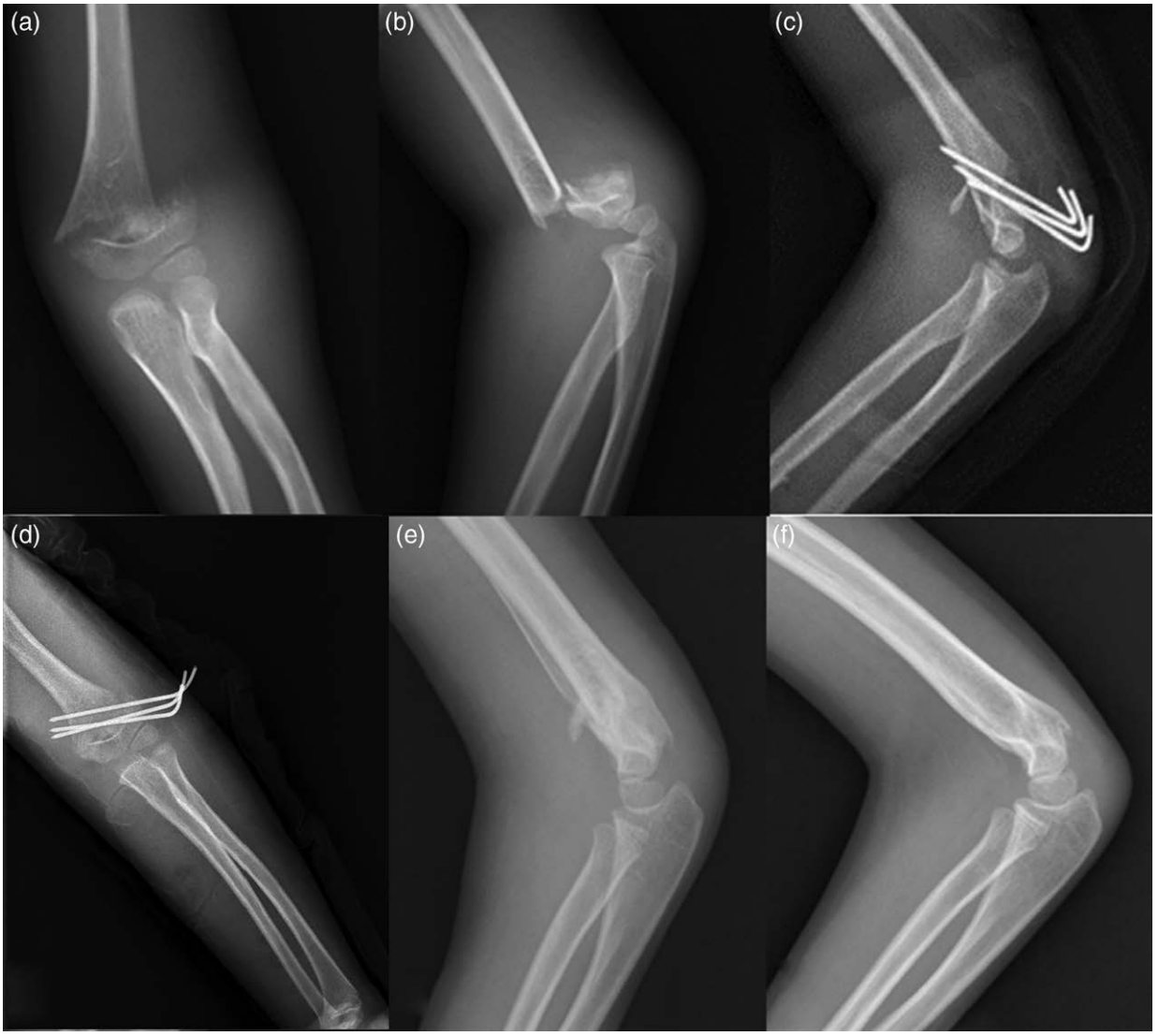
The length of loose bone fragment was measured according to the lateral view of X-ray (Fig. 1), with an average length of 8.3 mm (range 5–11 mm). The maximum distance between the fragment and the cortex was measured from the edge of fragment to the anterior cortex of

Fig. 1



Radiographic assessment of loose bone fragment after treatment of supracondylar humerus fracture. (a) Preoperative radiograph. (b and c) Postoperative radiographs demonstrate a loose bone fragment anterior to the humerus. (d) Measurement of loose bone fragment on the lateral view: *l* is the length of loose bone fragment and *h* is the maximum distance from the fragment to the cortex of humerus.

Fig. 2



Radiograph of a patient with left supracondylar humerus fracture, Gartland type III who underwent CRPP. (a and b) Preoperative radiographs. (c and d) Postoperative radiographs demonstrate a loose bone fragment anterior to the humerus. (e) Radiograph at 6 months shows partial absorption of the fragment. (f) Radiograph at 1 year shows disappearance of the fragment, which mainly was absorbed.

the humerus on the lateral X-ray (Fig. 1), with an average maximum distance of 6.3 mm (range 4–9 mm). On the anteroposterior X-ray, these bone fragments could not be clearly distinguished and measured.

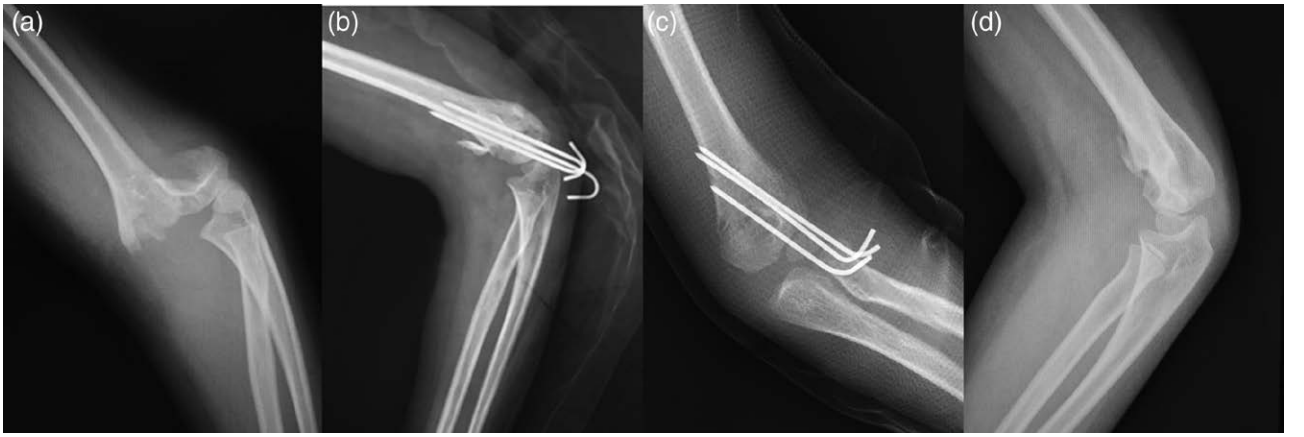
Supracondylar humerus fractures healing time was about 2 months after CRRP. All fragments 'disappeared' on X-ray at 1–year after surgery, whether due to absorption (eight patients; Fig. 2) or fusion to the humerus (four patients; Fig. 3).

Discussion

Supracondylar humerus fractures are common in children. The standard treatment for displaced fractures is CRPP [6,7]. Open reduction with percutaneous pinning is an accepted treatment for severely displaced, vascular injury or irreducible distal humeral fractures [8,9], which seems to have little increased risk in complications, such as infection, iatrogenic neurovascular compromise and scarring when compared to CRPP [10,11]. Saarinen [12] reported a significant difference in surgical outcome for supracondylar humerus fractures among the surgical specialties and experiences. During closed reduction procedure, the anatomic alignment of these loose bone fragments is difficult to achieve, especially for the less-experienced surgeons.

To our knowledge, no study has proven that an open procedure should be performed in cases of such a small loose bone fragment anterior to the humerus. In our study, the

Fig. 3



Radiographic outcome of a patient with a left supracondylar humerus fracture, Gartland type III, who underwent CRPP. (a) Preoperative radiograph. (b and c) Postoperative radiographs demonstrate a loose bone fragment anterior to the humerus. (d) Radiograph at 1 year shows the fragment mainly fused to the humerus.

remained small fragments with length less than 11 mm and maximum distance to humerus less than 9 mm were not an indication for open surgery, because they were all absorbed or healing and rarely caused other complications. However, we did not believe that all loose bone fragments remaining postoperatively would 'disappear', especially when the fragments were too large or located too far away from the humerus. However, the accepted fragment size and distance to humerus were depended on the surgeon's experience and lack of accurate assessment, which was a limitation of our study. A computed tomography (CT) scan or MRI may be helpful for more accurate assessment, but whether such a need exists remains to be discussed [13].

Although complications of supracondylar humerus fractures are common in children, the long-term outcome and function are good if the fracture is diagnosed and treated appropriately [14]. Many associated complications are self-limited or amenable to functional repair with surgical intervention.

Neurological damage is one of the most common complications of supracondylar humerus fractures, with an incidence range from 5 to 19% [15,16]. Risk factors of nerve dysfunction include the initial nerve injury due to the fracture and trauma, swelling and edema, iatrogenic injury due to medial pinning or open surgery, excessive manipulation and others [17]. Ozcan *et al.* [18] found that a long and sharp bone fragment (spike) might be responsible for nerve injuries in some children. In their retrospective study of 375 children, these anterior long and sharp bone fragments were observed in 14 (58.3%) patients among all 24 patients with nerve dysfunction. However, the prognosis of these nerve injuries usually are good, and routine surgical exploration is not recommended in the literature [15]. In a retrospective study of 48 patients with nerve injuries by Khademolhosseini *et al.* [19], the nerve dysfunction resolved clinically on an average time of 3.5 months, and nerve exploration was only performed in five patients due to the open fracture or unacceptable postoperative radiographs.

Loss of ROM after treatment of pediatric supracondylar humeral fracture is often a concern of parents. It seemed that open reduction, complication of myositis ossificans, older age, longer period of immobilization and more severe injury type would increase the incidence of limited ROM or prolong the recovery in elbow motion [20,21]. Free fracture fragment near the joint is always associated with poor functional outcomes in joint or periarticular fractures [22]. Myositis ossificans is an extremely rare complication in children that can cause resticted ROM [23]. Risk factors of myositis ossificans include muscle injury, high-energy trauma, manipulation, aggressive passive range-of-motion exercises or associated head injury [24]. In this group of patients, these loose bone fragments were near the joint and might be located in the muscle or have an influence on muscle, whereas no complication of myositis ossificans or loss of ROM occurred.

With good reduction and fixation, supracondylar humerus fractures in children usually have the characteristic of quick healing. Li M *et al.* [25] described that the osteal callus formed and the fracture line disappeared usually within 1 month, and a totally successful fracture healing time was no more than 2 months. Vuckov *et al.* [26] even reported that14 days seemed to be the biological minimum time needed for this type of fracture to heal in children and adolescents. In their study of 127 patients, 14 days of pin fixation and immobilization following an immediately rehabilitation did not result in more complications. In our study, a complete bone healing of

supracondylar humerus fracture was achieved about 2 months after CRPP, and the loose bone fragments usually 'disappeared' in the second half year. However, due to the follow-up interval of 6 months, we did not get a continuous imaging for the accurate assessment of loose bone fragments union or reabsorbent timing.

Mostly, the supracondylar humerus fractures were of the extension type occurred as a result of a fall on an outstretched hand [12], and flexion of the elbow with a force applied on the displaced distal fracture from the posterior side is always required during reduction [2,27]. In our study, all loose bone fragments lay anterior to the humerus, without fragments on the posterior side. This finding might be related to the mechanism of injury, elbow flexion procedure and a force from posterior to anterior during reduction. We suspected that the injury itself caused an unstable fragment, and the force from posterior aspect to anterior during reduction led to migration of the unstable fragment, and finally the loose bone fragments anterior to humerus arose. As loose bone fragments medial or lateral to humerus were not described, there might be no correlation between loose bone fragments and the lateral-medial pins placement technique, or even the pins dimension and number of the pins. However, the exact mechanism remains unclear and we had no evidence to prove it due to the closed reduction procedure and the absence of more accurate imaging examination.

Other limitations of our study were the small number of cases, short follow-up and absence of CT or MRI evaluation. In addition, it was a retrospective case-series study. Therefore, we could not draw any firm conclusions, and further research was needed.

Conclusion

Based on our study, small loose bone fragments presenting on X-ray after closed reduction for supracondylar humerus fractures mostly will be absorbed or achieve union within 1 year. This may depend on fracture size and complications affecting bone healing. Further extensive studies are needed to confirm our findings.

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Conflicts of interest

There are no conflicts of interest.

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