



A new approach for surgical treatment of chronic Monteggia fracture in children

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ABSTRACT

Purpose: The aim of the study was to investigate the clinical outcomes of a combined anterior and posterior approach for the surgical treatment of chronic Monteggia fractures in children.

Materials and methods: From November 2010 to January 2018, 33 patients (27 boys and 6 girls) with chronic Monteggia fracture who were treated surgically by one surgeon of our department were retrospectively analyzed. In the surgical procedure, open reduction and excision of fibrous scar were performed with the anterior Henry's approach, while ulnar osteotomy was carried out with a posterior approach. In cases of unstable radial head reduction, a trans-capitellar K wire was applied. Repair or reconstruction of the annular ligament (ALR) was not undertaken.

Results: The average follow-up of the patients was 33.8 months (range 8–87 months). At the last follow-up, Mayor Score and function of flexion and extension showed significant improvement compared to preoperative condition ($p < 0.05$). Two patients with palsy of the deep branch of the radial nerve with neurolysis recovered to normal over a 3-month follow-up. Redislocation occurred in two patients while subluxation occurred in one. One patient suffered a mild ischemic contracture but gradually recovered. Other severe complications, nerve injuries, heterotopic ossification, or synostosis, were not noted in the follow-up.

Conclusion: A combined anterior and posterior approach for surgery resulted in a satisfactory outcome due to the advantages of better exposure, more convenient intraoperative management, and facilitate for radial nerve exploration. Our study provided a new approach for the surgery of chronic Monteggia fractures.

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Introduction

Monteggia fractures are commonly and frequently missed injuries in Chinese children [1–4], among which radial head dislocation (RHD) is associated with plastic deformation or green-stick fractures of the ulna [5]. About 25–50% of these injuries may be initially missed due to the lack of expertise and careful examination [5]. If the injury is not properly treated within four

weeks, it can develop into a chronic Monteggia fracture. The delayed diagnosis results in bony and soft tissue changes, malunion of the ulna, and the subsequent imbalance in the length of the ulnar bone, which prevents reduction of the radial head conservatively [6,7]. Surgical management is necessary to achieve a stable reduction, while open reduction, combined with osteotomy and angulation of the ulna, are widely recognized options [5].

At present, Boyd's posterolateral approach is the most common surgical approach in clinical practice [8–11]. Other approaches, which are less common, include Kocher's approach [3,12–15], Henry's approach [1,4], and the anterolateral approach [16]. Boyd's approach could effectively avoid injuring the major neurovascular structures and facilitate the reconstruction of the annular ligament (ALR) [9]. However, previous studies have reported that poor

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exposure of the anterior surgical field for reduction is uncondusive to radial nerve exploration, and that postoperative complications such as heterotopic ossification and radiocapitellar synostosis may occur with Boyd's and Kocher's approach [7,9,17]. Lu [1,4] used the anterior Henry's approach to the elbow which could identify the radial nerve and gently retract it radially. Degreef and De Smet [18] performed the open reduction of the radial head with Kaplan's approach and combined it with a dorsal opening wedge osteotomy of the ulna. Hence, the best approach to perform the surgery remains controversial. In this study, we combined the anterior Henry's approach and the posterior approach for open reduction and ulnar osteotomy to treat chronic Monteggia fractures in children since November 2010. Ultimately, satisfactory clinical results were obtained.

Materials and methods

General information

From November 2010 to January 2018, the combined anterior and posterior approach for surgery was adopted in a total of 33 children with chronic Monteggia fractures. Finally, 33 patients (27 boys and 6 girls) were followed up. The protocol was approved by the Ethical Committee of the First Affiliated Hospital of Guangxi Medical University. Written informed consent was obtained from all patients of their parents. The left elbow was involved in 14 patients, the right in 19 cases. The age of the patients ranged from 2 to 12 years (average 6.9 years). The interval between injury and surgery ranged from 1 month to 5 years (median 7 months). All patients had a history of trauma, which was missed or not provided to the hospital. According to the Bado classification, 27 cases were type I (an anterior RHD with a fracture of the ulnar diaphysis) and 6 were Bado III (a lateral RHD). The preoperative radiograph was characterized by dislocation of the head of the radius, excessive growth of the radius or radial head, and even a bending ulna towards the radial or palmar side. Some of the cases revealed ossification around the radiocapitellar joint. Most of the children complained of increasing valgus deformity, elbow disability, or a palpable mass. A case injured after five years had mild pain with activity, and had 25° valgus deformity. Valgus deformities ranging from 30° to 35° were found in three other patients. Two patients presented with a palsy of the deep branch of the radial nerve.

Surgical technique

Each surgical procedure was performed using the combined anterior and posterior approach. The open reduction of the radial head and excision of the fibrous scar was performed using an anterior Henry's approach, while angulation and lengthening osteotomy of the ulna was carried out using a posterior approach. For the anterior Henry's approach, a skin incision was initiated perpendicular to the cubital crease and extended to 4–6 cm along the elbow, exposing the superficial fascia, biceps brachii, brachialis, and brachioradialis. A deep incision was made along the intermuscular space between the brachialis and the brachioradialis, identifying and protecting the radial nerve in the deep muscular space. Radial nerve compression and injury was found in two cases with symptoms of paralysis, and neurolysis was performed at the same time of surgery. After exposing the radiocapitellar joint capsule, the dislocated radial head was found to be covered with dense fibrous scar tissue, which was then excised. Repairing or reconstructing the annular ligament was not undertaken in our study. Then, we used the posterior approach for ulnar osteotomy. With a 6–8-cm longitudinal incision along the ulnar shaft, exposing the proximal of the ulna, we performed a transverse osteotomy under the olecranon of 4–5 cm, angulating

reversely and lengthening the ulna to overcorrect the deformity. Rotating the forearm, the final position of the ulna was guided by the reduction of the radial head. Reduction of the radial head was attempted, and its stability was assessed. In cases of unstable radial head reduction, a trans-capitellar K wire was applied. A plate was bent to the desired shape and applied to fix the osteotomy. An intraoperative C-arm was taken to ensure the stability of the radial head and the fixation of the osteotomized side with the plate and screw. Iliac bone-grafting was performed if necessary.

Postoperative management

All patients were immobilized in above-elbow casts with the elbow at 90° of flexion and neutral rotation or mild supination. After 4–6 weeks from surgery, anteroposterior and lateral images were taken to observe the callus growth and then remove the cast. Trans-capitellar K wire was removed with assessment. They were taken back to the outpatient department in the 3, 6, 12-month follow-ups. The plate was removed when there was a clinical and radiographic evidence of union in the 6–12 month follow-ups.

Efficacy assessment

In the follow-up, the congruency of the radiocapitellar joint, the union of the ulnar osteotomized side, and the appearance and function of the elbow were evaluated. The Mayor Score was used.

Statistical analysis

SPSS 17.0 was used for Statistical analysis. The paired *t*-test or Wilcoxon signed rank test was used to compare the range of Motion of elbow joint and Mayor Score before and after surgery. $p \leq 0.05$ was considered statistically significant.

Results

The mean follow-up of all 33 patients was 33.8 months (range 8–87 months). At the last follow-up, flexion and extension showed significant improvement compared to the preoperative stage ($p < 0.05$). A few children presented with loss of pronation, but no significant differences between the preoperative and postoperative pronation and supination ($p > 0.05$) were observed. The patients had higher total Mayor scores post-operatively. Trans-capitellar K wire was applied in 10 cases. Among them, four patients whose radial head redislocated within 48 h postoperatively were operated again. The angle of the osteotomized site was increased and transcapitellar K wire was used to ensure the stability, and it resulted in a satisfactory reduction of the radial head finally. Two children with palsy of the deep branch of the radial nerve with neurolysis recovered to normal during the 3-month follow-up.

The complications were as follows. In all patients, the radial head resulted in a stable position after surgery, except in three cases. Redislocation occurred in one patient while subluxation occurred in two. One Patient who received surgery after five years of injury, the radial head was lasted redislocated in the follow-up visit and there were distinct valgus deformity and a palpable mass in the last 3-year follow-up, but without symptomatic and restricted elbow motion. Residual subluxation of the radial head were found in two patients, however, it gradually reduced in the follow-up with a good outcome. One patient suffered compartment syndrome in the early stage, which was seen as mild flexion contracture in the middle, ring, and little fingers. He recovered fully in two months with rehabilitation exercises. We inferred that it was due to the obvious swelling of the elbow during the tight immobilization of the cast in the postoperative stage. No other

Table 1

The range of motion before and after surgery.

ROM		Flexion	Extension [*]	Pronation	Supination
Pre-operation	Mean	110.85	0	79.12	81.15
	SD	10.989	(–6 to 4)	7.149	8.059
Post-operation	Mean	135.94	0	79.27	83.39
	SD	9.387	(–5 to 1.5)	7.015	7.297
t or Z value		–11.012	–0.041	–0.232	–1.824
p value		0.000	0.967	0.818	0.078

^{*} The value of extension is skewed distribution, and was expressed as median (interquartile range), the Wilcoxon signed rank test was performed. ROM, the range of Motion; SD, Standard deviation.

Table 2

The Mayor Score before and after surgery.

		Mayor Score	Pain	Motion	Stability	Daily life	Total
Pre-operation	Mean	34.1	17.4	10.0	17.9	79.4	
	SD	6.784	2.538	0	2.804	7.579	
Post-operation	Mean	45.0	20.0	10.0	22.6	97.7	
	SD	0	0	0	2.829	2.82	
t value		9.238	5.831	0.000	6.526	12.333	
p value		0.000	0.000	1.000	0.000	0.000	

severe complications, such as nerve injuries, heterotopic ossification or radiocapitellar synostosis, were noted in the follow-up (Tables 1 and 2).

Discussion

We present a retrospective series of chronic Monteggia fracture in children treated with surgery. Open reduction with ulnar osteotomy is the most commonly performed procedure and was adopted in our study, resulting in reduced pain and elbow deformity. Otherwise, our study was the first to perform the surgery with the combined anterior and posterior approach and without ALR. However, there are still several controversial issues that need to be explored.

There is no consensus on the need for ALR. The majority of studies have used it in all or some of their patients which could get good outcomes [9], however, redislocation or subluxation still happened. As a result of that, when any ligament reconstruction, stretching and attenuation of the reconstructed ligament may be seen over time, and it might be torn by the dislocation force [13]. Losing the locking force of the radial head would result in recurrent subluxation or redislocation [5]. Meanwhile some authors suggested that ALR was not necessary after the osteotomy, as they believe that ulnar osteotomy and angulation plays the main role in maintaining the reduction of the radial head [5]. Chen et al. [3] showed that the patients benefited from the procedure with significant improvement in elbow pain and stability, as well as improved flexion of the elbow with stable radial head reduction. Bhaskar et al. showed similar clinical outcomes with and without ALR [19]. Thus, ALR might not help to maintain the stability of radial head over time. In our series, redislocation was found to occur in one patients while residual subluxation in two during the follow-up [accounting for 9.1% (3/33)], which was similar to the reported studies without ALR [4,14,20]. The limitation of forearm rotation, particularly pronation, may be more often seen with ALR. Seel and Peterson reported a loss of pronation of 20.2° after ALR [5]. Gyr et al. reported 9 in 15 children with ALR loss at an average of 37° of supination [13]. Among 33 patients in our study who did not receive ALR, the forearm rotation was maintained postoperatively in most of them. However, two patients experienced loss of pronation of 30° and 20° respectively. It might be due to the unmatched of the enlarged radial head and the capitellum, or lack

of functional exercise postoperatively. We also determined that the radial head can be maintained in position by elongating and angulating the ulna. Thus, it is not necessary to perform ALR to surgically treat chronic Monteggia fracture in children.

Boyd's approach was the most commonly used approach for open surgery in the literature, as well it could avoid injuring the major neurovascular structures of the elbow effectively, and facilitate the reconstruction of the annular ligament [2,9]. As previously mentioned, the effect of reconstruction of the annular ligament was challenged, and it was not used in our study. Moreover, the posterolateral approach led to inadequate exposure of the anterior components of the elbow, such as anterior part of capsule, deep branch of radial nerve, membranous of annular ligament. Most studies reported that the patients suffered from radial nerve palsy and postoperative nerve injury, which made the posterolateral approach uncondusive to radial nerve exploration and nerve protection. In our study, we combined the anterior Henry's approach and posterior approach for open reduction and ulnar osteotomy, which might provide following benefits to us: Firstly, with the accurate incision, it could get distinct exposures for surgery. The anterior approach could directly deal with radiocapitellar pathological changes and facilitate radial nerve exploration and protection. Two patients with palsy of the radial nerve after neurolysis, the function of extending thumb both recovered. Meanwhile, the posterior approach is convenient for ulnar osteotomy. Secondly, with the skin incision, the surgical field could be directly approached through the intermuscular space, without distracting the muscle strictly and injuring the interosseous membranes. The anterior and posterior approaches were not connected, whereas postoperative complications such as heterotopic ossification and radio-ulnar synostosis rarely occurred. Thirdly, the position of the ulna being guided by the reduction of the radial head during the operation. It could exactly access the reduction of the radial head through the anterior approach and reduce the exposure of X-ray. Furthermore, two incision were more convenient for surgeons' cooperation. The only disadvantage of the combined approach was an added incision, which might result in increased chances of postoperative infections, but could be avoided by careful nursing.

Subluxation and redislocation were the most common complications at follow-up. Redislocation occurred in one patients and residual subluxation in two in our postoperative visits. We tried to figure out the reasons as follows: Firstly, the age at the time of surgery and the interval between injury and surgery: The older the child at the time of open reduction and the longer the interval from injury to open reduction [21] Besides, a consistent enlargement of the radial head and a tendency for early closure of the proximal radial physis occurred when RHD was left unreduced [7]. Nakamura et al. [21] indicated that reduction after a period of more than three years after injury tends to increase the risk of complications. The radial head in children who are more than 12 years of age tends to lose the capability of remodeling itself. Secondly, whether the interosseous membrane is damaged or not: The osteotomy tightened the interosseous membrane sufficiently to keep the radial head in a correct anatomical position and also prevent excessive pressure at the radiocapitellar joint [21]. The interosseous membrane might be damaged in the trauma, or stretched and attenuated gradually by dislocation of the radial head. Thirdly, the degree of ulna angulation and elongation: Relatively decreased length of the ulna and the angulation of the ulna in the direction opposite to the dislocation of the radial head were the most important findings leading to persistence of RHD. Lengthening ulnar osteotomy with overcorrection was well recommended [5]. Inoue et al. [22] were the first to compare the results of simple and overcorrection osteotomy of the ulna and found that subluxation or redislocation oste happened less with overcorrection osteotomy. The patient whose radial head

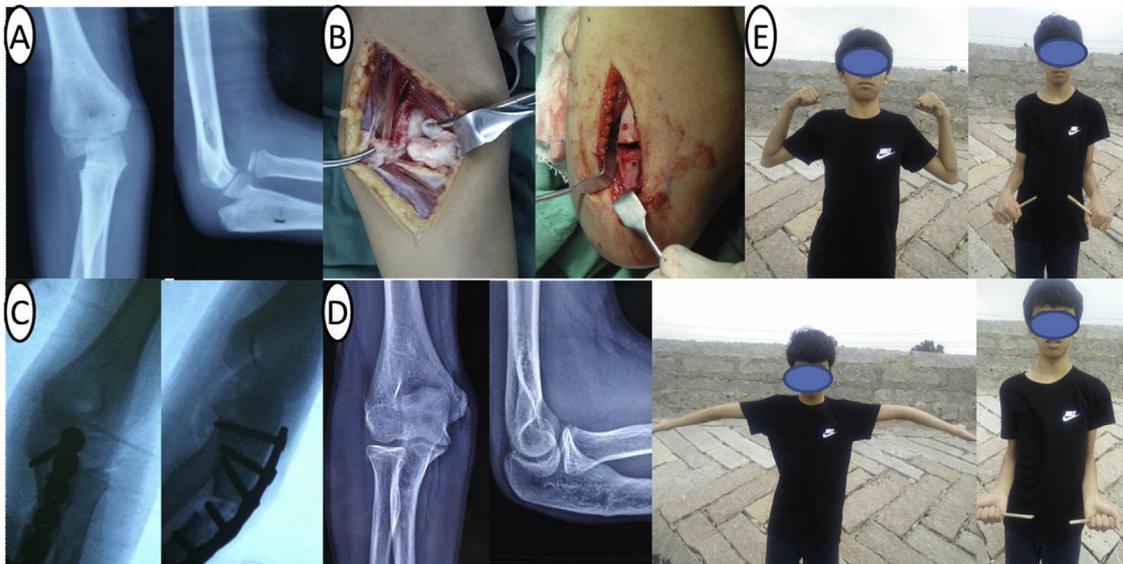


Fig. 1. Typical case 1: A 10-year-old boy, presented a 12-month chronic Monteggia fracture of his right elbow in the 57-month postoperative visit. (A) A history of trauma 12 months prior showing a Bado type I radial head dislocation in the anteroposterior and lateral radiographs. (B) The anterior Henry's approach and the posterior approach for open reduction and ulnar osteotomy in the operation. (C) The radiographs after open reduction and ulnar osteotomy in the operation. (D–E) In the 57-month postoperative visit, the function of elbow joint was satisfactory and reduction was maintained.

remained dislocated in the follow-up visit, his interval time between injury and surgery was five years, and the severe deformity of enlarged radial head and radial notch, capitellum as well as stretched interosseous membrane might be the reason of the poor outcome. The two patient had a residual subluxation of radial head postoperatively, we presumed it was the mismatching of humeroradial joint and proximal radioulnar joint, and the less accurately evaluation of the stability in ulna angulation procedure, it may be due to the lack of experience of the surgeon during the early phase, but, their radial head gradually reduced in the follow-up with a good outcome. We hypothesized that the re-tightened

interosseous membrane after surgery pulled the radial head back and maintained the reduction. However, there were still need more studies to verify that.

Early diagnosis and treatment are fundamental to reduce the risk of subluxation or redislocation. A preoperative magnetic resonance imaging (MRI) may help to detect the injuries of the interosseous membrane [23]. The site of the osteotomy and the degree of ulna angulation and elongation should be well-designed before the surgery. A preoperative MRI was recommended to detect the interosseous membrane and evaluate its remnant function (Figs. 1 and 2).

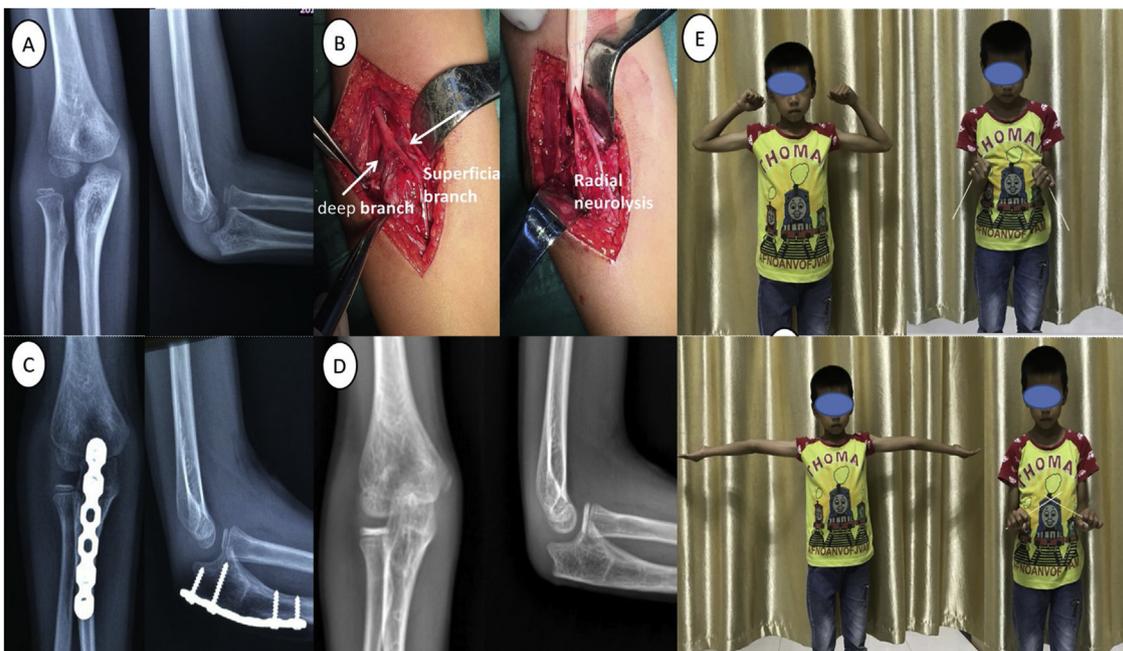


Fig. 2. Typical case 2: A 6-year-old boy, presented a 3-month chronic Monteggia fracture of his right elbow with radial nerve injury. (A) A history of trauma 3 months prior showing a Bado type I radial head dislocation in the anteroposterior and lateral radiographs. (B) The anterior Henry's approach showed the compression of the radial nerve and neurolysis was performed in the operation. (C) The radiographs in 3-month follow-up visit showed a good union of the osteotomized site. (D–E) The function of elbow joint was satisfactory and reduction was maintained in the 22-month postoperative visit.

Limitation

The number of patients in our study was not large enough to be analyzed. Another limitation of our study, a case series, is the absence of a formal control group of patients who were operated upon using only Boyd's approach as compared to the combined anterior and posterior approach for surgical treatment of our patients.

Conclusion

Excellent outcomes were achieved for open reduction and ulnar osteotomy with the combined anterior and posterior approach, which owning the advantages of better exposure, more convenient intraoperative management, and facilitate for radial nerve exploration. Our study provided a new approach for the surgery of chronic Monteggia fractures, and the combined approach might be more suitable for the patient with radial nerve palsy.

Conflicts of interest

All authors disclose no financial and personal relationships with other people or organisations that could inappropriately influence (bias) our work. No employment, consultantcies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding.

On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethical approval

The authors declare that all investigations were conducted in conformity with ethical standards.

Informed consent

Informed consent for participation in the study was obtained.

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