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Two-stage strategy for neglected Monteggia fracture in children

A retrospective study of 51 patients

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Abstract

A neglected Monteggia fracture is defined as the fracture of the proximal ulna associated with radial head dislocation (RHD) without undergoing any treatment for 4 weeks or more after injury. One-stage operation of ulnar corrective osteotomy and open reduction of RHD might result in many complications. Therefore, a two-stage strategy, including ulnar osteotomy (UO) with or without annular ligament reconstruction (ALR), was adopted at our institute since 2010.

We performed a retrospective review of 51 patients with neglected Monteggia fracture between January 2010 and January 2018. Patients with bilateral problems or concomitant injuries in the ipsilateral extremity were excluded. Radiological and clinical data were collected from Hospital Database and clinical visits. All patients were divided into 2 groups based on the status of the ALR: the UO alone (UO) group and the ALR group.

There were 15 patients in the UO group and 36 patients in the ALR group. The age in the UO group (6.1 ± 2.3, year) was significantly younger than the ALR group (9.8 ± 2.8, year) ($P < .001$). Concerning the duration from initial injury to surgery, there was a significant difference between the UO group (8.6 ± 3.2 months) and the ALR group (23.3 ± 12.6 months, $P < .001$). Concerning the preoperative elbow function, there was no significant difference between the UO group (67.6 ± 5.0) and the ALR group (66.6 ± 4.4) according to the Mayo elbow performance score (MEPS) ($P = .51$). Concerning the postoperative parameters, including postoperative ROM of the joint, removal of external fixator (6.7 ± 0.8, 6.9 ± 0.9 weeks) ($P = .55$), lengthening (8.9 ± 2.5, 10.3 ± 2.5 mm) ($P = .10$) and MEPS (92.7 ± 2.1, 91.6 ± 2.1) ($P = .08$), there was no significant difference between the UO group and ALR group.

Two-stage strategy is a reasonable choice for selected patients with long-lasting RHD with ulnar deformity.

Abbreviations: ALR = annular ligament reconstruction, RCJ = radio-capitellar joint, RHD = radial head dislocation, UO = ulnar osteotomy.

Keywords: annular ligament reconstruction, Monteggia fracture, radial head dislocation, ulnar osteotomy

1. Introduction

Monteggia fracture is a relatively rare injury in children.[1] Around 25% to 50% of these injuries may be missed by the health care providers at first encounter, depending on their expertise and experience.[2]

The natural history of chronic Monteggia lesions is not well elucidated, but some patients present with pain, loss of motion (especially flexion and supination), elbow deformity, and even arthritis.[3] Many procedures have been described to treat this condition, including open reduction and annular ligament reconstruction (ALR),[4] radial osteotomy,[5] open reduction and ulnar osteotomy (UO),[6] radial head excision.[7] However, there is no unanimous consensus for neglected Monteggia fracture in children.

A neglected Monteggia fracture is defined as the fracture of the proximal ulna associated with radial head dislocation (RHD) without undergoing any treatment for 4 weeks or more following injury.[2,3,7] Ulnar corrective osteotomy to restore the normal length of the ulna, and the relationship between radius and ulna was reported.[8] But, in certain patients, UO alone is not able to reduce RHD and maintain the reduction afterward.[9] Therefore, a two-stage strategy was adopted at our institute since 2010. The first stage is UO and lengthening; the second stage is the removal of the external fixator (EF) with or without open reduction and

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JL and XZ have contributed equally to this work.

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ALR. This retrospective study aims to review the clinical outcomes of patients treated with two-stage strategy.

2. Materials and methods

We performed a retrospective review of 51 patients with neglected Monteggia fracture between January 2010 and January 2018 at Union Hospital, Tongji Medical College, Huazhong University of Science and Technology. This study was approved by the Ethics Committee of Tongji Medical College, Huazhong University of Science and Technology (IORG No. IORG0003571) on December 20, 2019. Written consent was obtained from the patient's legal guardians.

Among 51 patients (see Table 1), 15 patients were included in the UO alone (UO) group and 36 patients were included in the UO + open reduction and ALR group. All patients were younger than 14 years at the surgery and followed up for more than 24 months. Patients with bilateral problems and/or concomitant injuries in the ipsilateral extremity and incomplete medical records were excluded. Radiological and clinical parameters were collected from the Hospital Database and out-patient visits. The elbow joint function was evaluated using the Mayo elbow performance score (MEPS)[10] during the out-patient visits by the surgeon in charge.

All descriptive data were presented as the mean±SD. Statistical analysis was performed using SPSS (SPSS Inc, Chicago, IL). A P value of $<.05$ is regarded as statistical significance.

2.1. Surgical Technique

Stage 1: The proximal part of the ulna is exposed through the dorsal approach. A sagittal Z-shaped osteotomy of the ulna was performed, and then 2 Schanz screws were placed in the distal and proximal part of the ulna at an angle as per the preoperative plan. After the insertion of the Schanz screws, the pins were adjusted to be parallel and installed into the unilateral external fixator. Excessive bony spikes on the dorsal side might be shaved off to prevent prominence on the dorsal aspect. The arm was immobilized in a long-arm slab for 4 to 6 weeks according to the lengthening process. Lengthening was initiated at the rate of 1 mm/day and started once the pain was subsided, usually at 5 to 7 days. The patient was followed up at the out-patient clinic weekly. If severe pain or nerve palsy occurred, the lengthening would be suspended for 3 to 5 days and then continued. If the length of the ulna was restored, the lengthening process would be stopped regardless of the status of the radial head. The external fixator was not removed until the consolidation of the osteotomy site was evident.

Stage 2: After the evidence of bony union of the osteotomy site, if the radial head was reduced and stable, the external fixator was removed during the out-patient visits (Fig. 1). If the radial head was not reduced, then open reduction of radial head and ALR was performed. Boyd approach or Henry approach was used to expose the radio-capitellar joint (RCJ). Any residual scar hindering the reduction was thoroughly debrided. The fascia of the triceps was used as the reconstructive material, and in some cases, a suture anchor was used for the fixation. After ALR, the stability of reduction was evaluated with passive pronation and supination intraoperatively. The joint capsule was then closed with absorbable sutures. After the open reduction, the elbow was immobilized at 90° flexion and full supination for 4 to 6 weeks (Fig. 2).

Table 1

baseline information of the patients.

Parameters	UO (n = 15)	ALR (n = 36)	*P* value
Age(years)	6.1 ± 2.3	9.8 ± 2.8	<.001
Sex			
male	7	21	.46
Female	8	15	
Side			
Left	6	14	.95
Right	9	22	
Bado classification			
Type I	14	36	.12
Type III	1	0	
From initial injury to surgery (m)	8.6 ± 3.2	23.3 ± 12.6	<.001
Follow-up time (years)	3.5 ± 1.1	3.4 ± 1.0	.75
Pre-op ROM of elbow			
Extension	−1.8 ± 1.8	−2.2 ± 1.9	.53
Flexion	108.1 ± 5.8	112.0 ± 6.1	.047
Pronation	69.3 ± 9.0	63.0 ± 8.7	.034
Supination	73.3 ± 4.3	71.9 ± 5.3	.34
Pre-op MEPI score	67.6 ± 5.0	66.6 ± 4.4	.51

ALR = annular ligament reconstruction, UO = ulnar osteotomy alone.

2.2. Postoperative rehabilitation

After the removal of the slab, active rehabilitation was encouraged with or without the help of the physical therapists. All patients were followed up at out-patient visits at the interval of 2 to 3 months (Fig. 3).

3. Result

As shown in Table 1, the average age of the UO group (6.1 ± 2.3, year) was significantly younger than the ALR group (9.8 ± 2.8, year) ($P < .001$). No statistically significant differences were observed between the 2 groups concerning baseline information, including sex, operative side, Bado classification, follow-up time. Statistically significant difference was observed concerning the duration from initial injury to surgery between the UO group (8.6 ± 3.2 months) and ALR group (23.3 ± 12.6 months) ($P < .001$). There was no statistically significant difference between the UO group (67.6 ± 5.0) and ALR group (66.6 ± 4.4) ($P = .51$) group was observed according to the MEPS. Concerning the preoperative flexion, there was a significant difference between the UO group (108.1 ± 5.8) and ALR group (112.0 ± 6.1) ($P = .047$); with regard to the preoperative pronation, there was a significant difference between the UO group (69.3 ± 9.0) and ALR group (63.0 ± 8.7) ($P = .034$); there was no significant difference between the UO group and ALR group concerning extension (−1.8 ± 1.8; −2.2 ± 1.9) ($P = .53$) and supination (73.3 ± 4.3;71.9 ± 5.3) ($P = .34$).

Radiographs of the full-length forearm were used to validate the reduction of the radial head and the alignment of the upper extremity.

As shown in Table 2, concerning the the postoperative parameters including postoperative ROM of the joint, removal time of EF (6.7 ± 0.8, 6.9 ± 0.9 weeks ($P = .55$), lengthening (8.9 ± 2.5, 10.3 ± 2.5 mm) ($P = .10$) and MEPS (92.7 ± 2.1, 91.6 ± 2.1) ($P = .08$), there was no significant difference between the UO and ALR group.

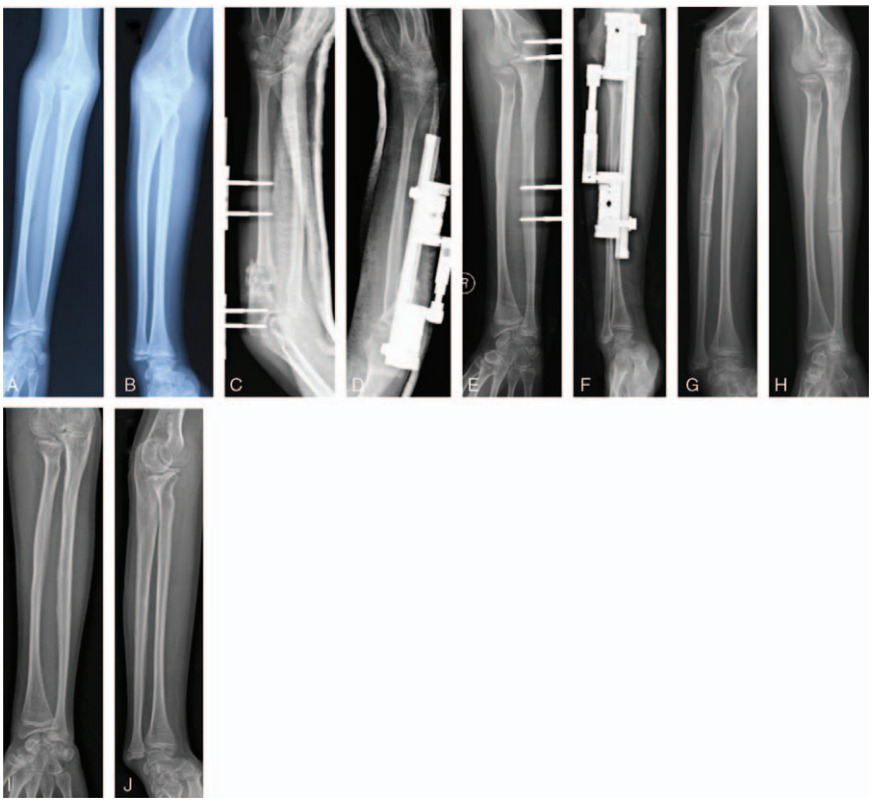

Figure 1. A 13-year-old boy of right Monteggia fracture treated with UO. A. AP view of the forearm, B. Lateral view of the forearm, C. AP view of the forearm after surgery, D. Lateral view of the forearm after surgery. E. AP view of the forearm at 3-month follow-up. F. Lateral view of the forearm at 3-month follow-up. G. AP view of the forearm after external fixator removal. H. Lateral view of the forearm after external fixator removal. I. AP view of forearm 3-month after fixator removal. J. Lateral view of forearm 3-month after fixator removal.

As shown in Table 3, there were significant differences between preoperative and postoperative ROM of elbow joint and MEPS in both groups.

4. Discussion

The two-stage strategy achieved the spontaneous reduction of RHD without ALR in selected patients. In patients without spontaneous reduction of the radial head, open reduction and ALR can be easily obtained in stage 2 with the normalized length of the ulna.

In pediatric patients with persistent dislocated radial head, surgical interventions are usually recommended since RHD may lead to loss of flexion and forearm rotation and malformation of the radial head.[11] Certain authors recommend the open reduction of RHD with or without ALR.[11–13] This approach is effective if the time from injury is less than 4 to 6 months, and the shape of the ulna is not compromised.[14,15] Besides, reduction without exposing the RCJ has also been reported using ulnar lengthening angulation osteotomy.[16,17] Moreover, certain authors recommend UO combined with open reduction of RHD.[18–20] Although all the authors reported improved outcomes after surgeries, complications are common, including radial head subluxation and instability.

In our medical center, one-stage operation, including UO with angulation and lengthening, with or without ALR, with or without radius shortening, was performed before 2010. But the outcomes were not always satisfactory, consistent with reports by certain authors.[7,21–22] UO is based on the concept that the abnormal shape of the ulna prevents the reduction of the radial head, and tightening the interosseous membrane through ulnar angulation and lengthening can return the radial head to an acceptable position or even complete reduction. However, the intraoperative distraction of the ulna is limited, and in certain cases, acute osteotomy with angulation and lengthening is unable to reduce the radial head. Over-distraction during the surgery increased the risk of delayed union or nonunion of osteotomy site, nerve palsy and postoperative compartment syndrome.[7,16–18,23] Besides, the gap of the osteotomy site should be filled with bone graft.[7,23]

UO with angulation and gradual distraction using a unilateral external fixator is a less invasive approach without extensive exposure.[24,25] The angulation was calculated before the surgery; however, the angulation might not be maintained as planned since the external fixator cannot provide rigid stability. Gradual lengthening overcame the soft tissue contracture, reduced the risk of delayed union or nonunion, and lowered the incidence of nerve palsy and compartment syndrome.[25] There was no patient with delayed union or nonunion in our study, and the incidence of nerve palsy was nil. The potential disadvantages of external fixator included pin tract infection (PTI) and the inconvenience of wearing clothes. In this study, all patients of PTI were easily ameliorated by oral antibiotics.

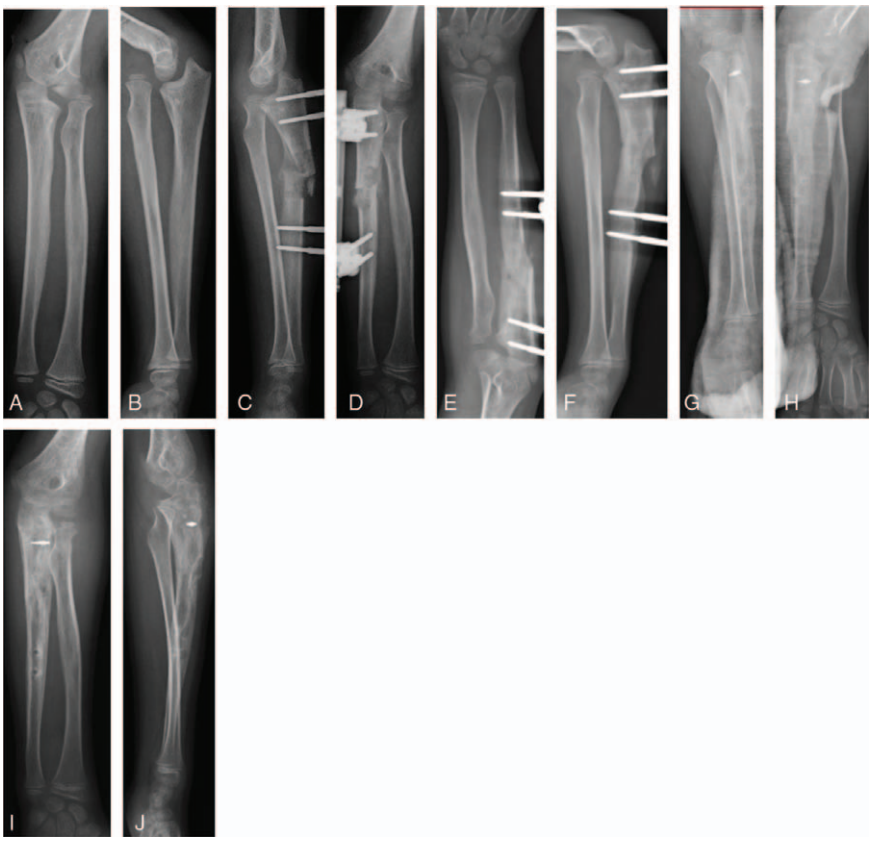

Figure 2. A 10-year-old boy of Monteggia fracture treated with UO + ALR. A, AP view of the forearm, B. Lateral view of the forearm, C. AP view of the forearm after surgery, D. Lateral view of the forearm after surgery, E. AP view of the forearm at 2-month follow-up, F. Lateral view of the forearm at 2-month follow-up, G. AP view of the forearm after external fixator removal and ALR, H. Lateral view of the forearm after external fixator removal and ALR, I. AP view of forearm 2-month after fixator removal and ALR, J. Lateral view of forearm 2-month after fixator removal and ALR.

Figure 3. The appearance of an 11-year-old boy treated with UO+ALR. A. The appearance of the elbow at extension, B. The appearance of the elbow at flexion, C. The appearance of the elbow at pronation, D. The appearance of the elbow at supination.

Table 2

Clinical parameters.

Clinical outcomes	UO (n = 15)	ALR (n = 36)	*P* value
Post-op ROM of elbow			
Extension	−1.8 ± 1.8	−2.2 ± 1.9	.53
Flexion	123.2 ± 5.0	126.0 ± 3.2	.07
Pronation	88.6 ± 1.6	87.8 ± 1.7	.12
Supination	87.1 ± 2.0	87.4 ± 1.8	.68
Removal (weeks)	6.7 ± 0.8	6.9 ± 0.9	.55
Lengthening (mm)	8.9 ± 2.5	10.3 ± 2.5	.10
Post-op MEPI Score	92.7 ± 2.1	91.6 ± 2.1	.08

Many authors recommend open reduction and repair or reconstruction of the annular ligament.[7,12,23] However, in surgical exploration, the remnants of the annular ligament are usually difficult to recognize. In order to facilitate the reduction of the radial head, the fibrous scarring tissue needs to be removed, and ALR might be performed simultaneously. The reconstruction materials included the forearm fascia,[26] palmaris longus,[27] and triceps tendon.[28] At our institute, the fascia of the triceps tendon was used as reconstruction material. In our study, no severe complications such as a noticeable restriction of forearm rotation and radial head necrosis were observed during the follow-up.

Certain authors advocated open reduction without ALR,[29,30] and they emphasized the importance of restoring the normal alignment of the ulna. As for our study, in stage 2, after removing the fibrous scarring tissue, all the radial head could be easily reduced. However, it was not very stable. Therefore, ALR was performed to reduce the incidence of delayed subluxation or instability. Besides, trans-capitellar Kirschner wire was not used at our institute because of its futility of maintaining stability and its possibility of breakage.[3] The incidence of subluxation and redislocation in our study was quite low.

It is reported that the radial head shifts more as the angulation of ulna increased,[7,19,23] consistent with our findings. There was no clarified indication that the osteotomy should be performed at the maximum of deformity[24] or as proximal as possible.[7] A higher rate of delayed union and nonunion, reduced rotation of forearms, and a reduced shift of the radial head were observed in the UO at the distal level.[15] Therefore, in our study, the osteotomy site was determined by the insertion of proximal pins, and it should be as proximal as possible. As shown in the result, the decreased rotation of the forearms was not noticeable.

In our study, 30% of patients manifested spontaneous reduction of radial head after ulnar lengthening. After removing the external fixator, the reduction of the radial head was stable during the rotation of the forearm. Compared with the patient receiving open reduction and ALR, patients with a spontaneous reduction of RHD displayed similar postoperative elbow function.

Although the angulation of UO was calculated preoperatively, but it is often necessary to over-correct the ulna dorsal angulation.[7] The normal ulnar dorsal angulation angle in children during the growth has not been thoroughly investigated. The over-correction of dorsal angulation and distraction cannot be meticulously planned and executed. It might be the cause of different outcomes of the UO. Besides, abundant scarring tissue or heterotopic bone formation might also prevent the spontaneous reduction of the radial head. As for patients without spontaneous reduction after lengthening, we performed open reduction + ALR when removing the external fixator.

Our result showed a significant difference between the UO group and ALR group concerning the age of surgery and the duration from initial injury to surgery. Therefore, in younger children with a shorter history of injury, there might be no need for open reduction and ALR.

The limitations of our study include the small sample size and the retrospective nature without long-term follow-up. It is a rare condition, and larger series from multiple centers might deliver a more convincing conclusion.

Table 3

Clinical outcomes comparison.

3.1 Ulnar osteotomy alone			
Clinical parameters	**Pre-op**	**Post-op**	***P* value**
ROM of Elbow			
Extension	−1.8 ± 1.8	−1.8 ± 1.8	>.999
Flexion	108.1 ± 5.8	123.2 ± 5.0	<.001
Pronation	69.3 ± 9.0	88.6 ± 1.6	<.001
Supination	73.3 ± 4.3	87.1 ± 2.0	<.001
MEPI Score	67.6 ± 5.0	92.7 ± 2.1	<.001
3.2 Ulnar osteotomy + OR + ALR			
Clinical parameters	**Pre-op**	**Post-op**	***P* value**
ROM of Elbow			
Extension	−2.2 ± 1.9	−2.2 ± 1.9	>.999
Flexion	112.0 ± 6.1	126.0 ± 3.2	<.001
Pronation	63.0 ± 8.7	87.8 ± 1.7	<.001
Supination	71.9 ± 5.3	87.4 ± 1.8	<.001
MEPI Score	66.6 ± 4.4	91.6 ± 2.1	<.001

5. Conclusion

The two-stage strategy is a reasonable choice for selected patients with long-lasting RHD with ulnar deformity.

Author contributions

Conceptualization: Pan Hong.
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Software: Yuhong Ding, Ruikang Liu.
Writing – original draft: Pan Hong.
Writing – review & editing: Jin Li, Xiaolong Zhao, Saroj Rai, Pan Hong.

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