

# Ulnar osteotomy and the ilizarov mini-fixator for pediatric chronic monteggia fracture-dislocations

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## Abstract

Treatment of chronic Monteggia fracture-dislocations remains controversial in skeletally immature patients. The present study aimed to review the clinical outcomes of surgical treatment with an Ilizarov mini-fixator for chronic Monteggia fracture-dislocations in children. From April 2003 to March 2014, 5 pediatric patients (4 males, 1 female) with chronic Monteggia fracture-dislocation were treated with an Ilizarov mini-fixator at our institution. The median age at the time of surgery was 9 years (range 5–14 years), median duration from injury to surgery was 31 months (range 2–125 months), and median duration of follow-up was 12 months (range 11 months–10 years). All patients underwent opening wedge osteotomy of the proximal ulna followed by the application of an Ilizarov mini-fixator. Although closed reduction was attempted after ulnar osteotomy and application of the Ilizarov mini-fixator, open reduction of the radial head was required in all patients. In 4 patients, dense scar tissue in the radiocapitellar joint was excised to enable reduction of the radial head; the remaining patient had traumatic radioulnar synostosis, and underwent separation of the synostosis followed by anconeus interposition arthroplasty. No patient received bone grafting at the ulnar osteotomy site, repair or reconstruction of the annular ligament, or temporary fixation of the radial head with transarticular wire. The median period of external fixation was 10 weeks (range 8–13 weeks). Although there were no severe complications such as deep infection and neurovascular disturbance, asymptomatic radial head subluxation occurred in 2 patients. The patient with traumatic synostosis had residual posterior subluxation with limitation of forearm rotation, and another patient with radial head enlargement had residual anterior subluxation. The median postoperative ranges of motion in pronation, supination, extension, and flexion were 90°, 90°, 0°, and 140°, respectively. The median Kim's elbow performance score was 65 (range 50–75) preoperatively, which improved to 94 (range 80–100) at final follow-up. The outcome was rated as excellent in 4 cases, and good in 1. In pediatric chronic Monteggia fracture-dislocations, ulnar osteotomy followed by the application of an Ilizarov mini-fixator is a viable option that is less invasive than plate fixation.

**Abbreviation:** ROM = range of motion.

**Keywords:** chronic Monteggia fracture-dislocation, Ilizarov mini-fixator, malunion, opening wedge osteotomy, radial head dislocation

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The present study was a retrospective, human, non-interventional study. According to public health law in Japan, institutional review board approval is not required for human non-interventional studies. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki. Informed consent was obtained from the guardians of all patients for surgery and for case publication.

Informed consent was obtained from all individual participants included in the study.

The authors declare no conflicts of interest.

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## 1. Introduction

Chronic Monteggia fracture-dislocations involve persistent plastic deformation or malunion of the ulna with concomitant unreduced dislocation of the radial head,<sup>[1–17]</sup> which are uncommon injuries in children. Chronic Monteggia fracture-dislocations are usually defined as those that are present more than 4 weeks after injury,<sup>[1,16]</sup> and this delay after injury makes the treatment challenging.<sup>[1,10]</sup> The treatment of persistent unreduced dislocation of the radial head in skeletally immature patients is still controversial.<sup>[1–3,5,7–10,14–23]</sup> As there is limited conflicting evidence regarding the treatment of these injuries, a non-surgical approach was advocated in the past.<sup>[24]</sup> However, some reports indicate that the injuries occasionally result in marked disability, including residual pain, stiffness of the elbow joint, neurological compromise, deformity of the elbow, osteoarthritis, and even instability of the distal radioulnar joint.<sup>[1,4,15,25]</sup> Treatment of chronic Monteggia fracture-dislocation via watchful waiting has not been recommended in recent studies.<sup>[1,4,10,15]</sup>

Surgical treatment of chronic Monteggia fracture-dislocations poses several challenges. Restoration of the alignment of the radiocapitellar joint is important for satisfactory long-term functional outcome.<sup>[6,10,23,26,27]</sup> Many authors have described various operative procedures for the treatment of chronic

**Table 1****Preoperative status of five pediatric patients with chronic Monteggia fracture-dislocation.**

Case	Gender	Affected side	Bado type	Age at injury (years and months)	Age at surgery	Delay between injury and surgery (years and months)	Discomfort	Associated preoperative Complication	Radial head
1	M	R	1	2y 8m	5y3m	2y 7m	slight-mild	Synostosis of forearm	Dislocated
2	M	L	1	8y 6m	8y8m	2m	slight-mild		Dislocated
3	M	L	1	5y 2m	9y	3y 10m	slight-mild		Dislocated
4	M	R	1	10y 4m	10y8m	5m	slight-mild		Dislocated
5	F	R	1	5y	14y2m	>7y 2m	slight-mild	Enlargement of radial head	Dislocated

m = month; y = year.

Monteggia fracture-dislocations, including only open reduction of the radial head dislocation, open reduction of the dislocation combined with opening wedge osteotomy of the ulna, and a combination of open reduction and ulnar osteotomy with or without annular ligament reconstruction,<sup>[1–3,5,7–10,14–23]</sup> however, the optimal treatment remains unclear. Furthermore, there are 2 main procedures used for the fixation of the osteotomy of the ulna: plate fixation<sup>[6,7,14,15,17,27–32]</sup> and application of external fixation.<sup>[23,33,34]</sup> These fixation procedures both have advantages and disadvantages. Plate fixation obtains rigid fixation, but is more invasive than external fixation, while external fixation can result in pin tract infection.<sup>[23,34]</sup>

In our institution, an Ilizarov mini-fixator (Ito Medical Instrument, Tokyo, Japan) has been used for chronic Monteggia fracture-dislocations in children since 2003. The mini-fixator enables correction of the angular and rotational deformity of the ulna, which allows controlled reduction of the radial head. The purpose of the present study was to present the clinical outcomes of opening wedge osteotomy of the ulna combined with the application of an Ilizarov mini-fixator for chronic Monteggia fracture-dislocations in children.

## 2. Materials and methods

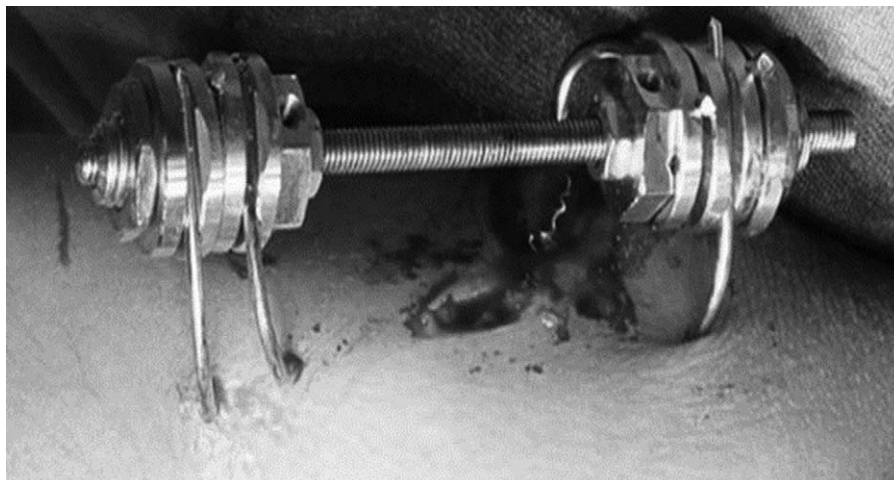
The present case series was treated at our institution. Patient demographic characteristics, medical history, imaging findings, and follow-up data were retrospectively extracted from the medical records.

### 2.1. Patients

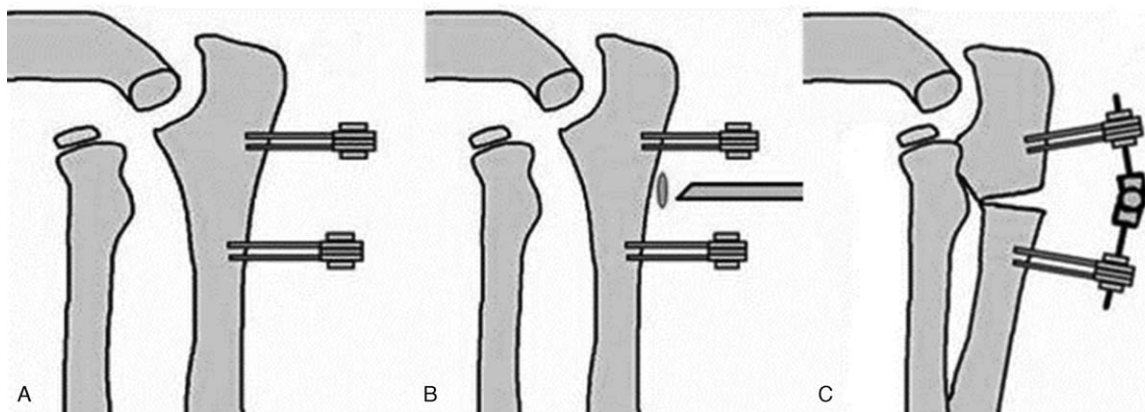
A total of 6 elbows in 6 patients aged less than 15 years with chronic Monteggia fracture-dislocations underwent opening wedge osteotomy of the proximal ulna<sup>[6]</sup> followed by the application of an Ilizarov mini-fixator between April 2003 and March 2014. One patient who was followed-up for less than 6 months postoperatively was excluded from the present study. A final total of 5 chronic Monteggia fracture-dislocations in 5 patients (4 males and 1 female) were evaluated by direct examination. The preoperative statuses of the 5 patients with chronic Monteggia fracture-dislocations are shown in Table 1. The median age at the time of injury was 5 years and 2 months (range 2.7–10.4 years), median age at the time of surgery was 9 years (range 5.2–14.2 years), median duration between initial injury and surgery was 31 months (range 2 to more than 125 months), and median follow-up period was 12 months (range 11 months to 9.6 years). According to the classification of Bado,<sup>[35]</sup> all 5 patients had type I fractures. Preoperatively, 1 patient had a traumatic radioulnar synostosis, and 1 other patient had radial head enlargement.

### 2.2. Surgical techniques

All surgeries were performed by a hand surgeon (TS), with the patients under general anesthesia and a tourniquet applied. An external fixator (the Ilizarov mini-fixator developed by the Russian Ilizarov Scientific Center) was first applied to the ulna to provide external fixation (Fig. 1). The mini-fixator is able to link



**Figure 1.** The Ilizarov mini-fixator, developed for external fixation by the Russian Ilizarov Scientific Center.



**Figure 2.** Illustrations demonstrating the application of the Ilizarov mini-fixator. A. The dedicated pins (1.5 mm diameter) are inserted into the proximal and distal parts of the presumptive site of the ulnar osteotomy, and attached to the Ilizarov mini-fixator units. B. Ulnar osteotomy is performed through a 1 cm skin incision at the proximal third of the ulna or at the fracture site. C. Each fixator unit is held and the proximal ulna is angulated to attempt closed reduction of the radial head.

with all other units 3-dimensionally by combining the rod, hinge, and posts; it can also be used for bone elongation. Briefly, the dedicated pins (1.5 mm diameter) were inserted into the proximal and distal parts of the presumptive site of the ulnar osteotomy, and were attached to the Ilizarov mini-fixator units (Fig. 2A). Ulnar osteotomy was performed through a 1 cm skin incision at the proximal third of the ulna, or at the fracture site (Fig. 2B). After osteotomy of the ulna, each of the fixator units was held, and the proximal ulna was angulated to enable closed reduction of the radial head (Fig. 2C). When anatomical reduction of the radial head was unable to be obtained, open reduction was performed using the Boyd approach.<sup>[24]</sup> An incision was started approximately 2.5 cm proximal to the elbow joint just lateral to the triceps tendon, and extended distally over the lateral side of the elbow tip to the olecranon on the medial side. The anconeus and extensor carpi ulnaris on the lateral side were then separated from the ulna. After the anconeus muscle was elevated from the bone and reflected radially, the dislocated radial head was reduced by manipulation under direct visualization.

In the patient with a post-traumatic radioulnar synostosis, the synostosis was exposed and separated while care was taken to protect the vascular and nervous structures. After the separation of the synostosis, the anconeus muscle was interposed around the ulna and anchored to the radial tuberosity.<sup>[36,37]</sup> Briefly, the proximal anconeus muscle was elevated as a full-thickness

myofascial flap, which was then raised subperiosteally off the proximal ulna to its origin on the lateral epicondyle. The proximal attachment of the anconeus muscle was left intact at the lateral aspect of the olecranon to preserve the vascular pedicle. The forearm was pronated, and the distal tip of the flap was sutured to the periosteum of the radial tuberosity.

After the osteotomized ulna was angulated and the radial head was reduced, the Ilizarov mini-fixator units were fixed. No patient underwent bone grafting at the osteotomized site of the ulna, repair or reconstruction of the annular ligament, or temporary fixation of the radial head with a transarticular wire. A representative case is shown in Fig. 3. Active range of motion (ROM) exercise was encouraged immediately after surgery.

**2.3. Postoperative evaluation**

The median duration of external fixation was investigated. When open reduction of the radial head was required, the perioperative factors inhibiting reduction of the radial head were investigated. Postoperative complications were evaluated, including pin infection or neurovascular lesion. Clinical outcomes (including pain or discomfort of the elbow joint), pre- and postoperative ROM for forearm pronation/supination and elbow extension/flexion, and Kim’s elbow performance scores (Table 2)<sup>[15]</sup> were evaluated. Anteroposterior and lateral radiographs were used to



**Figure 3.** Radiographs from case 3: a 5-year-old male. A. Preoperative anteroposterior and lateral views. B. Postoperative lateral view. C. Four months after surgery. D. Two months after surgery. E. Twelve months after surgery.

**Table 2**

**Kim's elbow performance scoring system<sup>[15]</sup>.**

	Score
Deformity	
No concern	25
Minor concern	15
Major concern	0
Pain	
No pain	25
Intermittent pain but not limiting activities	15
Pain, limiting activities	0
Range of motion (sum of the flexion-extension and pronation-supination arc)	
>250	25
250–200	15
<200	0
Function (five activities of daily living)	
Comb hair	5
Feed self	5
Open door/knob	5
Hold on to subway overhead rail	5
Put on shoes with hand	5

evaluate the congruency of the radiocapitellar joint and the presence of any deformity or arthritic changes.

**3. Results**

The postoperative outcomes of the 5 pediatric patients with chronic Monteggia fracture-dislocations are shown in Table 3. The median duration of external fixation was 10 weeks (range 8–13 weeks). The patient with post-traumatic radioulnar synostosis

(case 1) required open reduction of the radial head after separation of the synostosis. Four patients (cases 2–5) initially underwent attempted closed reduction of the radial head after application of the mini-fixator and opening wedge osteotomy of the ulna; however, anatomical reduction of the radial head was not obtained. As a result, open reduction of radial head was required. The annular ligament was not identifiable in all patients. The dense fibrous tissue surrounding the dislocated radial head seemed to be fibrous scar tissue and the remnants of the annular ligament; this was interposed between the radio-capitellar joint, and inhibited the anatomical reduction.

There were no severe complications, such as pin infection or neurovascular disturbance. Bone union of the ulna was obtained in all patients. Although the alignment of the radial head was restored in 3 of 5 patients, 2 patients had residual subluxation of the radial head. One patient (case 1) who had post-traumatic radioulnar synostosis had posterior subluxation of the radial head (Fig. 4). Another patient with radial head enlargement preoperatively (case 5) had residual anterior subluxation of the radial head on radiography at final follow-up (Fig. 5).

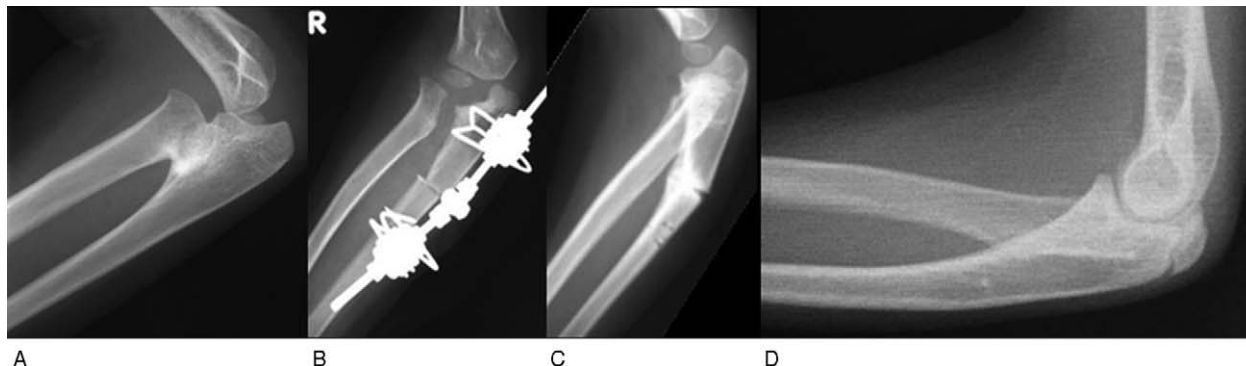
The pre- and postoperative ROM and the arcs of the forearm and elbow joint are shown in Table 4. The median postoperative ROM in pronation, supination, extension, and flexion were 90°, 90°, 0°, and 140°, respectively. At final follow-up, the median pronation-supination arc was 180° (range 110–180°) and the median extension-flexion arc was 135° (range 130–150°); the median increases in the pronation-supination arc and the extension-flexion arc were 0° and 15°, respectively. The median preoperative Kim's elbow performance score was 65 (range 50–75), which improved to 100 (range 80–100) at final follow-up. Four outcomes were rated as excellent, and 1 as good (Table 5).

**Table 3**

**Postoperative outcome of 5 pediatric patients with chronic Monteggia fracture-dislocation.**

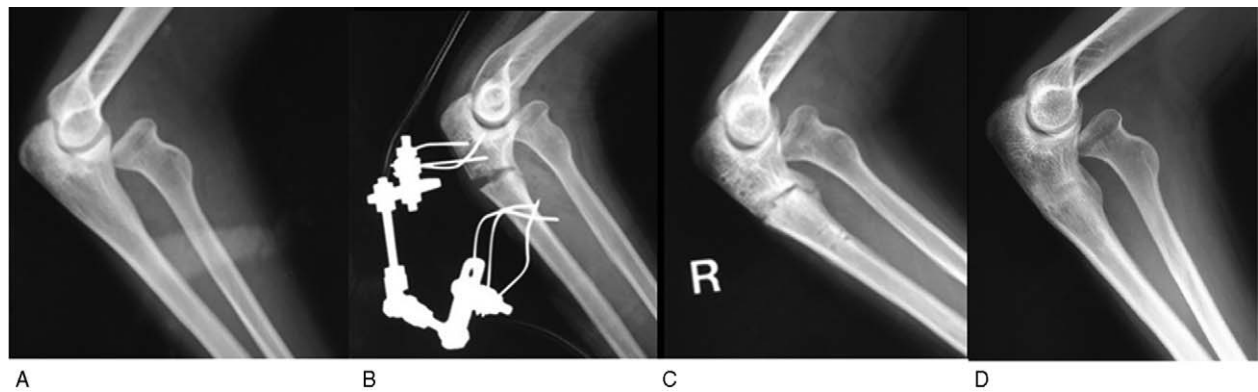
Case	Follow-up periods (months)	Reduction of radial head	Inhibitory factor	Ulnar osteotomy level	Annular ligament repair/reconstruction	Discomfort	Complication	Radial head
1	115	Open	no	Proximal ulna	Anconeus muscle interposition	no	Restriction of rotation on forearm	Reduced
2	16	Open	Annular lig	Proximal ulna	No	no		Reduced
3	12	Open	Annular lig	Proximal ulna	No	no		Reduced
4	11	Open	Annular lig	Proximal ulna	No	no		Reduced
5	12	Open	Annular lig	Proximal ulna	No	slight-mild	Posterior dislocation of radial head	Subluxation

lig = ligament.



**Figure 4.** Radiographs from case 1: a 2-year-old male with post-traumatic radioulnar synostosis. A. Preoperative lateral view. B. Postoperative lateral view. C. Two months after surgery. D. Posterior subluxation of the radial head was present 9 years postoperatively.





**Figure 5.** Radiographs from case 5: a 14-year-old female with preoperative radial head enlargement. A. Preoperative lateral view. B. Postoperative lateral view. C. Two months after surgery. D. Anterior subluxation of the radial head was present 12 months postoperatively.

**4. Discussion**

The treatment of Monteggia fracture-dislocations that have been present for more than 4 weeks poses several challenges.<sup>[16]</sup> Although closed reduction of the dislocated radial head should initially be attempted, it is rarely successful.<sup>[1]</sup> In our case series, closed reduction of the radial head was blocked by the presence of dense fibrous scar tissue, which was the remnant of the annular ligament. Lädermann et al<sup>[21]</sup> reported that open reduction may only be required in cases in which anatomical reduction of the radial head cannot be obtained by closed reduction after ulnar osteotomy. However, dense fibrous scar tissue between the radial head and the radiocapitellar joint is the most common finding in cases in which open reduction is performed<sup>[1,6,8,28,29,33,38]</sup>; the presence of this scar tissue in chronic Monteggia fracture-dislocations means that open reduction is inevitable.<sup>[1,10]</sup>

The necessity of reconstruction of the annular ligament remains controversial.<sup>[1-3,5,7-10,14-23]</sup> Some authors have reported that opening wedge osteotomy of the ulna followed by open reduction is sufficient to maintain the alignment of the radiocapitellar joint and radial head.<sup>[29,33,39]</sup> In our case series,

anatomical reduction of the radial head was obtained without reconstruction of the annular ligament in 3 of 4 patients, excluding the patient with post-traumatic radioulnar synostosis. One patient had residual anterior subluxation of the radial head; this was caused by the enlargement of the radial head, which resulted in malalignment of the radiocapitellar joint head and residual subluxation. Thus, congruence of the radiocapitellar joint is essential for the anatomical reduction of the radial head.<sup>[6,10,23,26,27]</sup> The patient with the synostosis had instability of the radial head after the separation of the synostosis. However, anchoring the interposed anconeus muscle to the radial tuberosity tethered and stabilized the radial neck. Thus, reconstruction of annular ligament was not needed. Hirayama et al<sup>[6]</sup> reported that hyperangulation and lengthening of the ulna stabilized the radial head due to the interosseous membrane, which is the stabilizer of the radial head in the absence of the annular ligament. Moreover, annular ligament reconstruction frequently results in restriction of forearm rotation (especially pronation).<sup>[1,7,8,27,38,39]</sup> Thus, annular ligament reconstruction is not necessarily appropriate.

**Table 4**  
Pre- and postoperative ranges of motion and arcs of the forearm and elbow joint.

Case	Before Surgery				After Surgery				Gain of Pro/Sup arc	Gain of Ext/Flex arc
	Pro-0-Sup	Pro/Sup arc	Flex-0-Ext	Ext/Flex arc	Pro-0-sup	Pro/Sup arc	Flex-0-Ext	Ext/Flexion arc		
1	0-0-60	60	0-140	140	60-0-50	110	0-140	140	50	0
2	90-0-90	180	20-110	90	90-0-90	180	0-135	135	0	45
3	90-0-90	180	0-140	140	75-0-100	175	10-140	130	-5	-10
4	90-0-90	180	0-135	135	90-0-90	180	0-150	150	0	15
5	90-0-90	180	15-80	65	90-0-90	180	0-135	135	0	55

Ext = extension; Flex = flexion; Pro = pronation; Sup = supination.

**Table 5**  
Pre- and postoperative Kim's elbow performance scores<sup>[15]</sup>.

Case	Before Surgery						After Surgery					
	Disability	Pain	Motion	Function	Total	Outcomes	Disability	Pain	Motion	Function	Total	Outcomes
1	0	25	15	10	50	Poor	15	25	15	25	80	Good
2	0	25	25	15	65	Fair	25	25	25	25	100	Excellent
3	0	25	25	25	75	Good	25	25	25	25	100	Excellent
4	0	25	25	25	75	Good	25	25	25	25	100	Excellent
5	0	25	15	15	55	Poor	15	25	25	25	90	Excellent

The most common mode of treatment for chronic Monteggia fracture-dislocation is opening wedge osteotomy of the ulna followed by open reduction of radial dislocation.<sup>[1]</sup> After performing ulnar osteotomy to enable the reduction of the radial head, there are 2 main choices for the fixation of the osteotomized ulna: plate fixation<sup>[6,7,14,15,17,27–32]</sup> or application of an external fixator.<sup>[22,23,33,34]</sup>

Plate fixation has the advantage of more rigid and stable fixation of the osteotomized ulna than external fixation. However, plate fixation is invasive and disrupts the blood supply of the ulnar periosteum. In addition, plate removal in children requires general anaesthesia. Application of an external fixator is less invasive than plate fixation. Furthermore, the fixator enables correction of both angular and rotational deformity of the ulna, which enables controlled reduction of the radial head. Removal of the fixator can be done without anesthesia in an ambulatory care facility. However, external fixation can occasionally cause pin tract infection.<sup>[23,34]</sup>

Although both plate fixation and external fixation obtain stable fixation of the osteotomized ulna, the Ilizarov-mini fixator has primarily been used in our institution since 2003. The application of a unilateral external fixator has been proposed for ulnar correction.<sup>[22,23]</sup> Exner<sup>[22]</sup> reported the technique of gradual lengthening and angulation of the ulna using callotaxis in 2 cases of chronic Monteggia fracture-dislocation; however, this requires additional angulation and lengthening of the ulna under general anesthesia or sedation.<sup>[22]</sup> Kawoosa et al<sup>[19]</sup> firstly reported the treatment of 2 chronic Monteggia fracture-dislocations using the Ilizarov technique with an Ilizarov 2-ring frame in the English literature, but the ring frame would be problematic in children. Also, the presence of the superimposing proximal steel ring makes it difficult to determine reduction of the radial head on intraoperative radiography.<sup>[19]</sup>

The present study is the first report that proposed the Ilizarov-mini fixator for chronic Monteggia fracture-dislocations in children. The Ilizarov mini-fixator enables 3-dimensional insertion of the 3 dedicated pins (1.5 mm diameter) into each fragment of the proximal and distal ulna, which provides stable fixation. Thus, the Ilizarov mini-fixator results in stable fixation, which maintains the function of the arm after the application of the fixator, and allows patients to perform intensive hand therapy. Moreover, anesthesia is not required for postoperative angle adjustment and bone elongation after osteotomy without bone grafts.

We performed angulated ulnar osteotomy after the application of the Ilizarov mini-fixator in 5 cases of chronic Monteggia fracture-dislocation in children. The clinical results were good in 3 of 5 patients. Although the other 2 patients had residual subluxation of the radial head, acceptable results were obtained without substantial complications due to the fixator. The Ilizarov Mini-fixator is less invasive than plate fixation, and is a good option for treatment of chronic Monteggia fracture-dislocations in children.

The major limitations of the present study include the small sample size and the short follow-up periods. Long-term observation of additional patients is needed to evaluate the development of osteoarthritis of the radiocapitellar joint after treatment of chronic Monteggia fracture-dislocations.

## 5. Conclusion

We performed angulated ulnar osteotomy after the application of an Ilizarov mini-fixator in 5 children suffering from chronic

Monteggia fracture-dislocation. The Ilizarov mini-fixator is less invasive than plate fixation, and is a good option for the treatment of chronic Monteggia fracture-dislocations in children.

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