ACTA
ORTHOPAEDICA
et
TRAUMATOLOGICA
TURCICA

Acta Orthop Traumatol Turc 2010;44(1):14-19
doi:10.3944/AOTT.2010.2280

Indirect reduction of the radial head using an external fixator to treat chronic radial head dislocations

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Objectives: We evaluated the results of indirect reduction of the radial head via a circular external fixator in pediatric patients with unilateral chronic radial head dislocation.

Methods: Three male patients (mean age 6.3 years; range 5 to 8 years) with chronic radial head dislocation underwent ulnar lengthening using a circular external fixator for indirect reduction of the radial head. None of the patients had radiographic evidence for deformity of the radial head, dysplasia of the capitellum, or osteoarthritic changes. The etiologic factors were ulnar hemimelia, brachial plexus injury, and congenital radial head dislocation, respectively. Pre- and postoperative assessment of the patients included measurements of the carrying angle, flexion-extension of the elbow, and pronation-supination of the forearm, and anteroposterior and lateral radiographs, on which the congruency of the radiocapitellar joint, the orientation and length of the ulna and radius were assessed. The mean relative shortening of the ulna was 3.2 cm (range 2.5 to 4 cm) preoperatively. Distraction was begun on the seventh postoperative day at a rate of 3 x 0.25 mm per day and was continued until the achievement of reduction. Upon completion of the consolidation of the distraction callus, the fixator was removed and a brace was applied for three months to prevent fracture of the regenerated bone. The patients were followed-up for a mean of 62 months (range 42 to 98 months).

Results: Complete reduction of the radial head was achieved in all the patients within a mean of six weeks, without any loss in position and recurrence of dislocation during the follow-up period. None of the patients exhibited dysplastic or arthritic signs in the radial head at final examinations. All three patients showed improvement in the carrying angle and were satisfied with the cosmetic appearance of the elbow and the length of the upper extremity. The mean flexion-extension improved by 28.3 degrees and the mean supination-pronation improved by 31.7 degrees. The external fixators were removed within a mean of 110 days (range 90 to 135 days). The mean bone healing index was 36 days/cm (range 30 to 42 days/cm). The mean ulnar lengthening was 3.2 cm (range 2.5 to 4.5 cm). Before reconstruction, the patient with congenital radial head dislocation also had a bowing deformity of the ulna and, during lengthening, this deformity was corrected gradually through additional hinges to the Ilizarov frame. The patient with ulnar hemimelia had a history of shish-kabab osteotomy at another center for ulnar bowing. Considering his young age (5 years), after achievement of radial head reduction, the proximal radius was fixed to the frame and the lengthening of the ulna was continued for an additional 7 mm to prevent future redislocation of the radial head due to asymmetric growth. There were no serious complications. Two patients had minor pin track infections that resolved completely by local wound care and oral antibiotics.

Conclusion: Albeit technically demanding, chronic radial head dislocations in children can be treated by indirect reduction of the radial head through ulnar lengthening with the use of a circular external fixator. This technique has a very low complication rate.

Key words: Child; dislocations/therapy; elbow joint; external fixators; Ilizarov technique; osteogenesis, distraction/methods; osteotomy; radius/pathology; ulna/surgery.

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Submitted: June 3, 2009 **Accepted:** September 23, 2009

Chronic radial head dislocations in children may either be of congenital or traumatic origin.[1,2] It has been shown that, regardless of the etiology, a chronic radial head dislocation may result in valgus deformity of the elbow which subsequently may cause ulnar nerve disturbance, and in restriction of elbow flexion due to obstruction by the radial head.[3] The deformity caused by the prominence of the dislocated radial head commonly poses a cosmetic problem. Despite being relatively asymptomatic in early childhood, symptoms deteriorate over time.[1] Moreover, a chronic radial head dislocation may cause persistent interosseous nerve palsy.[4] Thus, surgical intervention is recommended to restore function, improve cosmetic appearance, and relieve pain.[1,2,5,6] In general, two main surgical options exist: early radial head resection, or reconstruction preserving the radial head. Early resection of the radial head has been reported to cause significant complications.[6] Several variations of radial head-sparing reconstructions have been defined including reconstruction of the annular ligament, osteotomy of the ulna or the radius, and a combination of ligament reconstruction and osteotomy.[3,5,7-11] Villa et al.[12] developed a classification system to define shortening of the forearm, in which ulnar shortening with radial head dislocation is termed as type IIB. For the treatment of this subgroup, Paley and Herzenberg[13] recommended lengthening of the ulna and reduction of the radial head through distal transport of the radius.

In this study, we evaluated the results of indirect reduction of the radial head via an external fixator in patients with unilateral chronic radial head dislocation.

Patients and methods

Between 2002 and 2006, three male patients (mean age 6.3 years; range 5 to 8 years) with chronic radial head dislocation underwent ulnar lengthening using a circular external fixator in order to produce an indirect effect for the reduction of the radial head. None of the patients had radiographic evidence for deformity of the radial head, dysplasia of the capitellum, or osteoarthritic changes (Fig. 1). The direction of the radial head dislocation was posterolateral in two patients, and anterolateral in one patient. The right elbow was affected in two patients and the left in one patient, and all the patients were right hand dominant. The etiologic factors were ulnar hemimelia, brachial plexus injury, and congenital radial head dislocation,

Fig. 1. Preoperative anteroposterior and lateral radiographs of the three patients: **(a, b)** 5-year old boy with ulnar hemimelia, **(c, d)** 8-year-old boy with brachial plexus injury, and **(e, f)** 6-year-old boy with congenital radial head dislocation.

respectively. Before reconstruction, a thorough neurologic examination was performed in the affected extremity of the patients. There were no neurologic deficits except in one patient with brachial plexus injury.

Detailed information on the treatment was given to the families of the patients and written informed consent was obtained from the parents. The patients and their parents were questioned regarding elbow pain, instability, cosmetic concerns, and restrictions in daily living activities. Pre- and postoperative assessment of the patients included measurements of the carrying angle, flexion-extension of the elbow, and pronation-supination of the forearm, and anteroposterior and lateral radiographs, on which the congruency of the radiocapitellar joint, the orientation and length of the ulna and radius were assessed. The mean relative shortening of the ulna was 3.2 cm (range 2.5 to 4 cm) preoperatively.

Surgical technique

An Ilizarov frame consisting of two rings was prepared prior to surgery. The proximal ring was formed from two half rings placed at a distance to permit flexion of the elbow (Fig. 2). Under image intensifier guidance, a K-wire and a Schanz screw were inserted into the ulna proximally. Distally, a K-wire was used to fix the ulna and radius while the forearm was in neutral rotation. Additionally, two Schanz screws

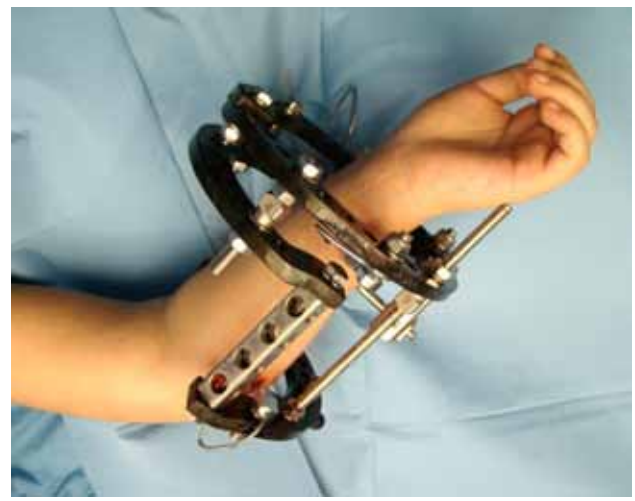

Fig. 2. The construct of the external fixator allowing elbow flexion.

were inserted into the ulna and radius, respectively. The osteotomy site at the proximal ulna was selected and marked. Through a small incision, osteotomy of the ulna was performed using the multiple drill technique (Fig. 3a). The completion of the osteotomy was confirmed by observation of full translation of the fragments under image intensifier. Then, distraction of the ulna was tested and the surgical procedure was completed.

Distraction was begun on the seventh postoperative day at a rate of 3 x 0.25 mm per day (Fig. 3b). The

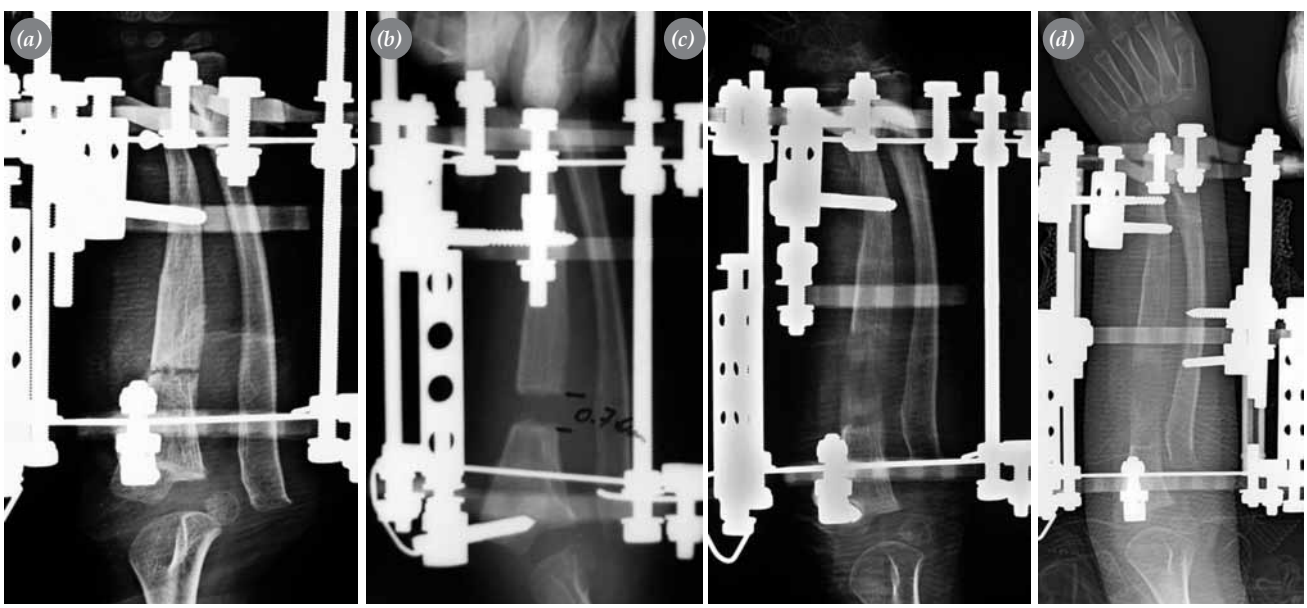

Fig. 3. Radiographs showing **(a)** the ulnar osteotomy site, **(b)** ulnar distraction and distal sliding of the radial head, and **(c)** completion of radial head reduction. **(d)** In patient with ulnar hemimelia, the proximal radius was fixed to the frame and the ulna was lengthened further by 7 mm after achievement of radial head reduction in order to prevent future radial head dislocation due to asymmetric growth.

Fig. 4. **(a)** Anteroposterior and **(b)** lateral radiographs of the patient with ulnar hemimelia after removal of the external fixator. Note the overlengthening of the ulna.

patients were encouraged for early flexion-extension exercises of the elbow. Follow-up radiographs were obtained every two weeks to assess callus formation of the ulna, lengthening at the osteotomy site, and reduction of the radial head. Once reduction of the radial head was achieved, distraction was discontinued and the consolidation phase began (Fig. 3c).

Before reconstruction, the patient with congenital radial head dislocation had a bowing deformity of the ulna as well as shortening. During lengthening, additional hinges were applied to the Ilizarov frame, and the bowing of the ulna at the osteotomy site was corrected gradually. The patient with ulnar hemimelia had a history of shish-kabab osteotomy at another center for ulnar bowing. Considering his young age (5 years), after achievement of radial head reduction, we fixed the proximal radius to the frame and proceeded with the lengthening of the ulna for an additional 7 mm to prevent future redislocation of the radial head due to asymmetric growth (Fig. 3d).

Upon completion of the consolidation of the distraction callus, the fixator was removed and a brace was applied for three months to prevent fracture of the regenerated bone (Fig. 4-6). The patients were followed-up for a mean of 62 months (range 42 to 98 months).

Results

Complete reduction of the radial head was achieved in all the patients within a mean of six weeks, without any loss in position and recurrence of dislocation during the follow-up period. None of the patients exhibited dysplastic or arthritic signs in the radial head

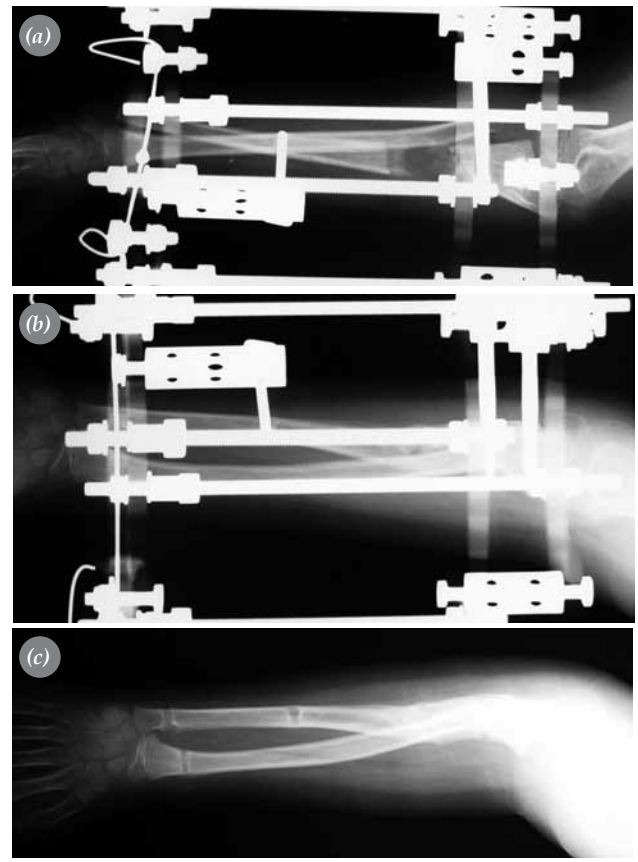

Fig. 5. Radiographs of the patient with brachial plexus injury **(a, b)** at the end of the lengthening and **(c)** after removal of the external fixator.

at final examinations. All three patients showed improvement in the carrying angle. There were no complaints about scarring and/or cosmetic appearance of the elbow. All patients were satisfied with the cosmet-

Fig. 6. **(a)** Anteroposterior and **(b)** lateral radiographs of the patient with congenital radial head dislocation at the end of the treatment.

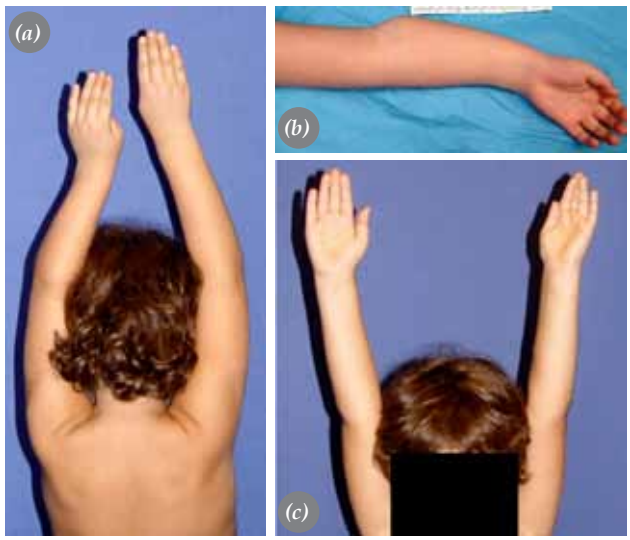

Fig. 7. Preoperative views showing **(a)** limb-length discrepancy and **(b)** cosmetic appearance. **(c)** The appearance of the patient at the end of the treatment.

ic appearance of the elbow and the length of the upper extremity (Fig. 7). There was no limitation in the movements of the elbow and forearm after the operation. Instability or restriction in daily living activities were not observed. The mean arc of flexion-extension improved by 28.3 degrees (from preoperative 103.3° to postoperative 131.6°) and the mean arc of supination-pronation improved by 31.7 degrees (from preoperative 105° to postoperative 136.7°).

The external fixators were removed within a mean of 110 days (range 90 to 135 days). The mean bone healing index was 36 days/cm (range 30 to 42 days/cm). The mean ulnar lengthening was 3.2 cm (range 2.5 to 4.5 cm). There were no serious complications. Two patients had minor pin track infections that resolved completely by local wound care and oral antibiotics.

Discussion

Several methods of reconstruction have been defined for the treatment of chronic radial head dislocations including reconstruction of the annular ligament,[7] osteotomy of the ulna or the radius, gradual lengthening,[11] and a combination thereof. Reconstruction of the annular ligament is often inadequate to maintain radial head reduction and may eventually result in redislocations.[7] It may also be associated with narrowing, rotational restriction, and growth inhibition of the radial head.[7] Ulnar flexion osteotomies, on the other hand, to reduce the radial head are nonanatomic procedures. These procedures cannot restore the normal anatomic relation between the two long bones of the forearm. Ulnar osteotomy and lengthening with a circular external fixator offer a more anatomic reconstruction, allowing indirect radial head reduction and eliminating shortening without causing secondary deformities.

Masada et al.[14] stated that radial head dislocations with ulnar shortening were associated with a less severe bowing deformity of the radius. Accordingly, we did not observe a profound bowing of the radius in our patients.

Monolateral fixators are successfully used for simple lengthening of the ulna.[2] We preferred a circular external fixator whose screws do not transfix the limb, reducing the risk for injury to tendons, nerves and vessels.[2] Although monolateral fixators offer ease of application, they may be insufficient in correction of complex deformities. Monolateral fixation is most applicable for diaphyseal lengthening; however, the diaphyseal region is not as successful as the metaphyseal region in bone regeneration, requiring a longer time for consolidation. Additionally, it is easier to fix both bones of the forearm distally when a circular fixator is used.[13]

Tetsworth et al.[15] reported an overall complication rate of 74% in patients who were treated for shortening deformities of the upper extremity with the use of the Ilizarov device. Among 14 complications, nine were major complications including three nerve injuries, two premature consolidations, two residual deformities, one hourglass-shaped regenerate, and one decreased range of motion. Likewise, Villa et al.[12] encountered 11 complications in 12 patients undergoing 13 forearm lengthening procedures (3 nerve injuries, 1 reflex sympathetic dystrophy, 2 malunions, 2 refractures, 3 decreased range of motion). The authors attributed loss of motion and nerve injuries to transfixing wires even though they had been inserted in accordance with established technique and principles. In our patients, there was functional improvement, without neurological impairment or fracture of the regenerate bone. We attributed these favorable results to the relatively slow rate of lengthening which enabled high-quality regenerate formation and to the application of preventive bracing after removal of the external fixator.

Hirayama et al.[7] suggested that the reduction of the radial head was appropriate for children younger

than 10 years, but would be inconvenient in the presence of radial head deformity, dysplasia of the capitellum, or a valgus deformity of the radial neck. Our preoperative radiographic assessments of the elbow included signs of dysmorphism of the radiocapitellar joint. However, it should be noted that, in this age group, plain radiographs may only show marked dysmorphism, so in suspected cases further investigation with magnetic resonance imaging and computed tomography may be required.

In conclusion, albeit technically demanding, chronic radial head dislocations in children can be treated by indirect reduction of the radial head through ulnar lengthening with the use of a circular external fixator. This technique has a very low complication rate. The main drawback of this technique is that the surgeon must have attained considerable competence with circular external fixation techniques. It also necessitates a higher level of patient and family compliance than required in other treatment methods.

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