Mid- to Long-term Outcomes after Surgical Treatment of Chronic Anterior Dislocation of the Radial Head in Children

ABSTRACT

Background

To evaluate the mid- to long-term clinical and radiographic outcomes after surgical treatment of chronic radial head dislocation in children.

Methods

Open reduction was performed in 16 children (mean age, 9.3 years [range, 2.6–13.6 years]) with chronic anterior dislocation of the radial head. Twelve patients had a history of preceding injuries, with a mean interval between injury and surgery of 24 months (range, 2–86 months); 4 patients did not have injuries. Eight patients who had undergone reduction within 16 months were treated by open reduction and ulnar osteotomy. The other 8 patients who had not sustained trauma or had been injured >2 years previously required either annular ligament reconstruction or radial shortening in addition to ulnar osteotomy.

Results

The average preoperative Kim's elbow performance score was 77.2 ± 10.5, which significantly improved to 97.5 ± 5.8 at the final follow-up. The radial head was maintained in a reduced position in 14 patients and was subluxed in 2. Slight osteoarthritic changes of the elbow were observed in 2 patients with good reduction. The functional results were excellent in 15 and were good in 1 patient with an average follow-up of 6.5 years (range, 2.6–15.1 years).

Conclusions

Our surgical procedure provided good mid- to long-term clinical and radiographic outcomes.

INTRODUCTION

Chronic radial head dislocation in children may trigger morphological changes such as radial head hypertrophy or the development of a shallow radial notch of the ulna [1] and loss of the radiocapitellar joint congruity may lead to a cubitus valgus deformity with subsequent ulnar or radial nerve disturbances. Over time, these deformities may cause secondary osteoarthritis, resulting in restricted elbow motion and functional loss [2-5]. Treatment for chronic radial head dislocation remains controversial. Observation only has been previously recommended [6,7]. However, recently, surgical treatment has been accepted, following careful patient selection. The number of reports on multimodal surgical intervention for pediatric cases with chronic radial head dislocation has increased [8-13]. However, few reports have described the long-term surgical outcomes after surgical intervention for chronic radial head dislocation [14,15].

We have performed oblique ulnar osteotomies for reducing dislocated radial heads with or without annular ligament reconstruction [16]. This report describes our surgical technique and evaluates its mid- to long-term clinical and radiographic outcomes.

PATIENTS AND METHODS

We assessed 16 children (11 boys, 5 girls) who had been surgically treated for chronic anterior dislocation of the radial head at our hospital between 1992 and 2009 (Table 1). The surgeries had not been indicated for congenital dislocations and dislocations with moderate or severe radial head deformity. All protocols for this retrospective study were approved by the Institutional Review Board of our hospital. Patients who presented >2 months post-injury were included. The mean age at the time of surgery was 9.3 years (range, 2.6–13.6 years); 10 patients injured their right elbow and 6 injured their left. None of the patients had been initially treated at our hospital. Twelve patients had a confirmed history of trauma, with a mean interval of 24 months (range, 2–86 months) between injury and surgery. The episode of trauma had not been confirmed in the other 4 patients and these patients had dome-shaped radial head (Table 1). However, they did not have other associated anomalies, their family history was negative, the dislocation was unilateral. They did not meet the criteria of congenital radial head dislocation defined either by McFarland [17] or Mardam-bey and Ger [18]. Therefore, although the pathology of dislocation was unclear, we treated these 4 patients following the same method as that used for post-traumatic patients.

Outcome measures

All patients were evaluated by two investigators to determine their elbow motion, stability, and deformity. Elbow extension/flexion (E/F) and forearm pronation/supination (P/S) of the upper extremities were measured using a goniometer. Kim's elbow performance score [19] (Table 2) for the overall elbow function was used to evaluate functional outcomes preoperatively and at the final follow-up. The total score was graded as excellent (≥90), good (89–75), fair (74–60), or poor (<60). Postoperative complications were also assessed.

Radiographic evaluations were performed on the anteroposterior and lateral elbow radiographs. Lateral radiographs were obtained with the forearm in pronation, neutral position, and supination. The radial head position was classified as reduced, subluxed, or dislocated. Subluxation of the radial head was judged when a line drawn down the center of the radial neck did not pass through the central one-third of the capitellum on the lateral radiograph. The presence of radial head hypertrophy, dome-shaped deformations, and osteoarthritic changes were assessed using radiographs, three-dimensional computed tomography, and occasionally arthrography. Radial head hypertrophy was determined using measurements of the diameter of the radial head at the widest portion of the metaphysis, adjacent to the physis (a), and the narrowest portion of the neck, just proximal to the bicipital tuberosity (b). Radial head hypertrophy was defined as present if $a \div b$ was >1.5 [20]. Dome-shaped deformation was defined when there was a prominence of the proximal articular surface in addition to the loss of concavity of the radial head. Elbow arthritis was evaluated radiographically using the grading system described by Morrey et al. [21] (Table 3). Radiographic results were evaluated as good (complete reduction of the radial head without osteoarthritic changes of the elbow), fair (reduction with radial head subluxation or osteoarthritic changes of the elbow), or poor (radial head dislocation), as described by Nakamura et al. [13].

Preoperative findings

Seven patients had an elbow E/F arc of <130°, and 2 had a forearm P/S arc of <100° (90° and 30°). These 2 patients had severe restriction of pronation due to prolonged immobilization in supination, with or without pinning during their initial treatments (patient nos. 3 and 5), and they had disturbances in daily activity. Two patients had valgus deformities of >20° (22° and 23°), and 11 had had valgus deformities of <20°. All the patients had instability of <10° during the manual stress test. One patient (no. 14) had pain during elbow extension that did not limit activities, whereas the other patients did not have pain.

All the patients had complete anterior dislocations of their radial heads. Radial head deformity was observed in six patients, including dome-shaped radial heads (6 patients) and radial head hypertrophy (2 patients) (Fig. 1a–c; Table 1). Of these, 4 patients had no clear histories of trauma, and the other 2 patients had undergone surgery >6 years post-injury. None of the patients had osteoarthritic changes preoperatively.

Surgical technique

The surgical technique involved a Kocher approach with the skin incision extended along the ulnar shaft. The radiocapitellar joint and the ulnar shaft were exposed via the same incision. We released the anterior joint capsule, but the origin of the lateral ulnar collateral ligament at the lateral humeral epicondyle was preserved to prevent aggravating elbow instability. The radial head, covered with dense fibrous scar tissue, was located, and the scar tissue was carefully excised. Radial head reduction was attempted, and its subsequent stability was evaluated.

Usually, ulnar osteotomy is essential to ensure stability of the radial head. An oblique osteotomy was performed at the proximal metaphysis of the ulnar shaft (Fig. 2). The osteotomy site was distracted and angulated to correct the deformity. Ulnar lengthening was also necessary to prevent excessive pressure on the radial head. The osteotomy site was temporary fixed by Kirschner (K-)

wires, which ensured stability of the radiocapitellar congruity during passive P/S motion. After optimal correction was determined, the ulna was rigidly fixed using a plate that was bent to match the ulnar configuration; 2.7-mm dynamic compression plates or 2.7-mm reconstruction plates (Synthes, West Chester, PA, USA) were used.

Following ulnar osteotomy, if the radial head was unstable due to the shallow radial notch, notchplasty was performed at the proximal ulna (i.e., a chisel was used to scrape a concave surface for the radial head). If the radial head was still unstable during P/S motion, augmentation by annular ligament reconstruction was performed. A distally based strip of the triceps tendon was harvested from the thickest part of the tendon, and then the tendon was wrapped around the radial neck and sutured back to itself. We did not create holes in the ulna to attach the ligament because we were concerned about ossification developing in the vicinity of the proximal radio-ulnar joint. To avoid possible complications, we also did not perform temporary radiocapitellar or radio-ulnar fixation using a K-wire to secure reduction of the radial head [22].

Postoperatively, a cast was applied to the elbow in 90° flexion and to the forearm in neutral rotation. Active forearm rotation was started 2 weeks postoperatively, and F/E of the elbow was initiated 1–2 weeks after forearm rotation.

Statistical analysis

Pre- and postoperative elbow E/F arc, forearm P/S arc and Kim's scores were compared using the Wilcoxon signed rank test. A p-value <0.05 was considered significant.

RESULTS

Surgical treatment

Open reduction of the dislocated radial heads and ulnar osteotomies were performed in all patients (Table 4). Eight patients who had been reduced within 16 months from the time of the original injury underwent ulnar osteotomies only (group A). The other 8 patients required additional procedures (group B); annular ligament reconstruction was performed in 7, and radial notchplasty was performed in 2 (patient nos. 13 and 14). In patient no. 12, radial shortening was performed at the diaphysis to reduce overload of the reduced radial head (Fig. 3).

All patients were followed for at least 2.6 years (mean, 6.5 years; range, 2.6–15.1 years).

Clinical findings

The clinical data and results are shown in Table 4. Serious surgical complications such as infection, nerve palsy, and nonunion were not observed, but the plate was removed in all patients. Fourteen patients were pain-free postoperatively, whereas 2 (patient nos. 9 and 13) had slight pain during strenuous activity, although it did not limit their daily activities. The average elbow E/F arc was 129.7 ± 19.5° preoperatively, which significantly improved to an average of 141.3 ± 7.6° at the final follow-up ($p = 0.047$). The average forearm P/S was 152.8 ± 40.4°preoperatively, and the average forearm P/S at the final follow-up was 162.2 ± 18.3° ($p = 0.345$). The elbow E/F arc of each patient had full range of motion, but compared to the contralateral arm, forearm P/S was restricted in 8 patients, with an average loss of 22° (range, 10–50°). None of the patients complained of elbow deformities or difficulties during daily activity.

The average Kim's elbow performance score was 77.2 ± 10.5 preoperatively, which improved to an average of 97.5 ± 5.8 at the final follow-up. The overall results were excellent in all patients. These outcomes indicated significant postoperative improvements ($p = 0.006$).

Radiographic findings

At the final follow-up, the radial head was reduced in 14 patients and subluxed in 2. Subluxation occurred in 1 patient without a history of trauma (patient no. 13) and in another with an interval of >7 years between the trauma and surgery (patient no. 10). Grade 2 osteoarthritic changes in the elbow were observed in 2 patients (patient nos. 9 and 14) who demonstrated good reduction (Figs. 4a–c). Patient no. 9 complained of occasional pain during strenuous activities 15.1 years postoperatively, but medication was not needed. Patient no. 14 who had no history of trauma was operated on at age 13 and required notchplasty. Despite osteoarthritic changes 5.7 years postoperatively, the patient did not have any pain. Radiographic results were good in 12 patients and were fair in 4. All the fair results were observed in patients in group B. Two patients who required notchplasty did not show morphological deformity of the proximal radio-ulnar joint, but one patient resulted in subluxation of the radial head, and another showed osteoarthritic change.

DISCUSSION

Important parts of our procedure include the oblique ulnar osteotomy for elongating and angulating the ulna and the subsequent rigid plate fixation. Proximal ulnar osteotomy has been proposed for treating chronic radial head dislocation [8,11,13,14] because it is associated with good bone healing outcomes. Lengthening is necessary to provide adequate space for the radial head. Posterior angulation of the ulna is also important for maintaining the reduced position via the interosseous membrane. Oblique osteotomy can ensure bone contact between the osteotomy sites, and bone grafting is usually unnecessary. If sufficient lengthening cannot be obtained due to soft tissue restrictions following a long-standing dislocation, additional radial shortening can be performed at the midshaft to avoid excessive pressure on the radial head. Osteotomy at the proximal radius may alter angulation of the radial neck, possibly altering the axis of forearm rotation. Exploration of the proximal radius may also cause additional complications such as radial nerve palsy. However, osteotomy at the diaphysis of the radius is simple, and the postoperative rehabilitation protocol does not need to be changed.

Some investigators have reported using an external fixator to fixate and lengthen the ulna [11,12]. Although easy lengthening is one of the advantages of external fixation, 3 months with an external fixator is a relatively long time for children. Thus, we recommend plate fixation because it rigidly maintains bone alignment and allows early forearm mobilization. Boeck [10] reported that pinning the joints to ensure radial head stability did not cause any complications. However, we did not perform transarticular pinning to prevent damage to the radial head and complications due to the wires.

The role of annular ligament reconstruction in reducing the chronic radial head dislocation has never been closely analyzed [23]. Reconstruction of the annular ligament frequently causes radial neck narrowing or growth disturbances, osteolytic changes, and restrictions in pronation-supination [24-27]. We performed ligament reconstruction in 7 patients who had either no trauma episodes or >2.2 years of chronic dislocation. In these cases, incongruity of the radiocapitellar and/or the proximal radio-ulnar joint caused residual instability of the radial head. We expected additional soft tissue support for the proximal radio-ulnar joint to the reconstructed ligament. Nakamura et al. [14] performed ligament reconstruction in all cases; however, we did not reconstruct the ligament in all 8 patients in group A and in 1 patient in group B. Good clinical and radiographic final outcomes were obtained. We believe that the annular ligament is a secondary stabilizer; therefore, its reconstruction is not routinely necessary.

Controversy exists regarding patient age limitations and the acceptable interval between injury and late reduction. Stoll et al. [28] reported that successful reduction can be achieved in children under 10 years within at least 4 years after the initial injury. Nakamura et al. [14] suggested an age limitation of <12 years and within 3 years of the injury. However, based on the three-dimensional morphologic evaluations of chronic radial head dislocations, Oka et al. [1] reported that the shapes of the radial heads and radial notches were nearly normal in patients within 3 years post-injury. When radial head dislocation is left unreduced, morphological changes such as radial head hypertrophy or the development of a shallow radial notch in the ulna may develop.

In our series, 3 of 6 patients with a dome-shaped radial head had fair radiographic results. In contrast, all 10 patients without dome-shaped radial heads demonstrated good reduction. Regarding the interval, of 3 patients who had >3-year intervals, 2 had a dome-shaped radial head and 1 had a normal radial head with a good radiographic result. Whether the extent of radial head deformity may be more important to prognosis rather than the actual interval from injury.

Bone remodeling and the healing potential depend on age. Additionally, patients' sex should be considered. An upper extremity growth spurt occurs in girls between 11 and 12 years, which is 1 year earlier than in boys (12–13 years) [29]. After the growth spurt, appropriate morphological adaptations in the newly reduced position may be difficult to expect. Regarding the growth spurt, 2 patients had completed their growth spurt, and they had fair radiographic results. Although our patient population was small, considering previous reports and our experiences, successful reduction can be achieved in patients before the growth spurt and without deformity of the radial head (usually within 3 years post-injury).

Preoperatively, we investigated the morphological changes of the radial head and the proximal radio-ulnar joint using three-dimensional computed tomography or arthrography, and we accepted the slight changes as reducible despite the presence of a deformity (e.g., a dome-shaped radial head). To obtain better surgical outcomes and expand the surgical indications, static adaptation of the radial head and proximal radio-ulnar joint stability during forearm rotation should be evaluated pre-operatively.

Two patients with good reduction showed osteoarthritic changes on their final radiography; one was pain free at the 5.7-year follow-up and the other had slight pain at the 15.1-year follow-up. Forced reduction may have increased stress on the radial head, or normal kinematics of the proximal radio-ulnar joint may not have been completely reconstructed by our techniques. Osteoarthritic changes can be adaptive changes in the proximal radio-ulnar joint, which we have occasionally observed at the distal radioulnar joint after ulnar shortening osteotomy [30]. Further long-term follow-up is necessary to determine the incidence of osteoarthritic changes after reduction and determine the clinical relevance of the radiographic changes.

Our study was limited by the small number of patients; thus, we were unable to perform multivariate logistic regression analysis of the significant risk factors related to the outcomes.

We demonstrated that our surgical procedure provides good functional results without serious complications, and the functional outcomes did not deteriorate within an average 6.5-year follow-up.

CONFLICT OF INTERESTS

None declared.

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FIGURE LEGENDS

Figure 1. An 11.8-year-old boy (patient no. 15) presented with left chronic radial head dislocation and radial head hypertrophy. a: Preoperative anteroposterior and lateral radiographs showing anterior dislocation of the radial head and radial head hypertrophy. b: Open reduction of the radial head and corrective osteotomy with annular ligament reconstruction was performed. This postoperative radiograph shows the reduced radial head and ulna, which is distracted and angulated posteriorly. c: Anteroposterior and lateral radiographs showing good reduction of the radial head without osteoarthritic changes at 11.4 years postoperatively.

Figure 2. The radiocapitellar joint and the ulnar shaft are exposed between the anconeus and extensor carpi ulnaris muscles. Reduction of the radial head was attempted while using oblique osteotomy of the ulna at the proximal metaphysis.

Figure 3. An 11.8-year-old boy (patient no. 12) presented with right chronic radial head dislocation (4.3 years post-injury). Additional radial shortening was performed to avoid excessive pressure on the radial head after ulnar osteotomy.

Figure 4. A 9.6-year-old girl (patient no. 9) presented with right chronic radial head dislocation (2.2 years post-injury). a: Preoperative lateral radiographs showing anterior dislocation of the radial head. b: Open reduction of the radial head. Corrective osteotomy with annular ligament reconstruction was performed. This postoperative radiograph shows the reduced radial head. c: Anteroposterior

and lateral radiographs at 15.1 years postoperatively showing grade 2 osteoarthritic changes in the elbow and good reduction of the radial head.

Table 1. Preoperative Data.

Patient no.	Sex	Age at surgery (years)	Affected elbow	Period from injury to surgery (months)	E/F (°)	P/S (°)	Kim's score	Dome-shaped RH	RH hypertrophy
1	M	10.7	L	4	0/140	70/80	75	-	-
2	M	8.1	R	9	0/125	40/90	90	-	-
3	F	4.7	L	2	10/135	0/90	70	-	-
4	M	4.5	L	4	0/80	90/90	60	-	-
5	F	2.6	R	7	20/135	90/90	90	-	-
6	F	9.9	R	16	0/110	-60/90	60	-	-
7	F	10.3	L	7	5/95	70/85	75	-	-
8	M	6.8	R	2	20/120	90/90	90	-	-
9	F	9.6	R	26	0/130	70/90	75	-	-
10	M	13.6	L	86	0/130	80/90	75	+	-
11	M	10.4	R	72	0/130	90/90	90	+	-
12	M	11.8	R	51	10/115	80/90	75	-	-
13	M	10.2	R	Unclear	0/130	70/80	80	+	-
14	M	13	R	Unclear	10/130	80/90	65	+	+
15	M	11.8	L	Unclear	20/135	90/90	90	+	+
16	M	11	R	Unclear	10/130	80/90	75	+	-

M, male; F, female; R, right; L, left; E/F, extension/flexion; P/S, pronation/supination; RH, radial head

Table 2. Kim's elbow performance score [19]

Parameter	Points	Definition	Points
Deformity	25	No concern	25
		Minor concern	15
		Major concern	0
Pain	25	No pain	25
		Intermittent mild pain but not limiting activities	15
		Pain, limiting activities	0
Motion (sum of the E/F and P/S arcs)	25	>250º	25
		250–200º	15
		<200º	0
Function	25	Comb hair	5
		Feed self	5
		Open doorknob	5
		Hold onto subway overhead rail	5
		Put on shoes with hands	5
Total	100		

E/F, extension/flexion; P/S, pronation/supination

Table 3. Radiographic evaluation of elbow osteoarthritis as described by Morre et al. [21]

Grade 1	Normal elbow
Grade 2	Minimum joint narrowing with minimum osteophyte formation
Grade 3	Moderate joint narrowing with moderate osteophyte formation
Grade 4	Severe degenerative changes with gross destruction of the joint

Table 4. Postoperative Data.

Patient no.	Surgical Procedure	Follow-up (years)	E/F (°)	P/S (°)	Pain	Kim's score	RH Position	OA Change
1	UO	10.7	0/140	60/90	None	100	Reduced	-
2	UO	7.4	0/140	75/90	None	100	Reduced	-
3	UO	6.8	10/135	80/90	None	100	Reduced	-
4	UO	4.5	0/140	90/90	None	100	Reduced	-
5	UO	5.4	20/135	90/90	None	100	Reduced	-
6	UO	4.1	0/140	30/90	None	100	Reduced	-
7	UO	3.2	5/145	60/80	None	90	Reduced	-
8	UO	2.6	20/130	90/90	None	100	Reduced	-
9	UO + Lig	15.1	0/140	70/90	Slight	90	Reduced	+
10	UO + Lig	4.4	0/145	80/90	None	100	Subluxed	-
11	UO + Lig	3.1	0/130	70/90	None	100	Reduced	-
12	UO + RO	3	10/140	80/90	None	100	Reduced	-
13	UO + NP + Lig	10.3	0/130	50/80	Slight	80	Subluxed	-
14	UO + NP + Lig	5.7	0/130	80/90	None	100	Reduced	+
15	UO + Lig	11.4	0/135	90/90	None	100	Reduced	-
16	UO + Lig	6	0/130	80/90	None	100	Reduced	-

UO, ulnar osteotomy; Lig, ligament reconstruction; RO, radial shortening osteotomy; NP, notchplasty of the radial notch

E/F, extension/flexion; P/S, pronation/supination; RH, radial head; OA, osteoarthritic