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Research Article

Ulnar Osteotomy, Recontructe Annular Ligament by Fascia Lata for Neglected Monteggia Fracture Dislocation in Children

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Abstract

Background: Neglected Monteggia fracture dislocations in children cause significant disability in terms of pain, stiffness, deformity, neurological deficits, and limitation of activities of daily living. Various surgical techniques have been described for the treatment of neglected Monteggia fracture dislocations.

Materials and Methods: In a prospective study, 35 patients with a mean age of 10 years 1 month, with neglected Monteggia fracture dislocations were studied. All children underwent open surgery to reduce the ulna, ulna osteotomy with angle reduction, and reconstruction of the annular ligament using the latissimus dorsi. The author used the Kim scale to evaluate results.

Results: There were 35 patients, the gender of the cases was 21 girls and 14 boys; the right side was affected 13 cases and the left side was affected 22 cases. The mean time from injury to presentation was 10.1 months. 17 patients were classified as Bado type I; 12 patients as Bado type II and 6 as Bado type III. The mean preoperative flexion-extension range of motion was (100.7°) and the mean postoperative range of motion was (131.25°), resulting in a mean increase of 43° (283°-240°) in the range of motion. All patients had a supination-pronation arc of >100°; the pronation range was always smaller than the pronation range. 28 patients had excellent and 6 patients had good results, and one patient had fair results at the last follow-up.

Conclusion: Surgical reduction is recommended unless radial head deformity is limited. Open reduction with ulnar osteotomy with annular ligamentotomy is the most commonly performed procedure and is expected to reduce elbow pain and deformity.

Keywords: *Missed Monteggia Fracture; Annular Ligament Reconstruction; Ulnar Reduction; Radial Reduction; Bone Graft*

Introduction

Giovanni Battista Monteggia first described the condition of joint dislocation, named after him, and anatomical elements ensuring the stability of the Elbow annular ligament (Figure 1), in 1814.

It may be present in association with humeral and ulnar fractures. However, these injuries are often overlooked at the time of initial injury [1]. Monteggia fractures are traditionally overlooked or ignored when they last longer than 4 weeks [2,3]. Patients are also significantly more brutal in less severe injuries with minimal ulnar angle, while ulnar dislocations may be overlooked. Bado reported an incidence of 1.7% in a cohort of 3,200 patients with humeral fractures [4]. Humeral fractures are common in children, accounting for approximately 20 - 30% of all ulnar fractures [5]. They are not only less common but also among the most overlooked injuries, especially in children, where radioulnar dislocations may be associated with plastic deformities or ulnar deformities. Monteggia dislocations are relatively uncommon injuries, accounting for approximately 1% of all pediatric forearm injuries [6,7] (Figure 1). Approximately 25-50% of these injuries may initially be overlooked depending on the expertise and experience of the caregiver [8].

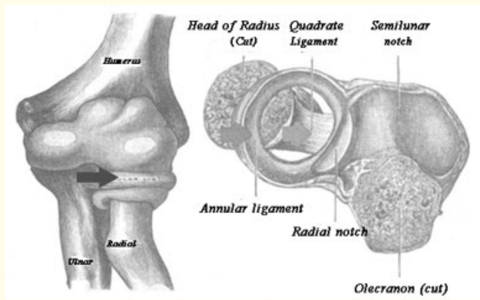

Figure 1: *Anatomical elements ensuring the stability of the Elbow annular ligament (red arrow) and quadrate ligament (red arrow) and quadrate ligament (blue arrow) (after Grey).*

Radial head dislocation (RHD) is an uncommon injury in children. In most cases, it is associated with an ulnar fracture or deformity as part of the Monteggia spectrum. The Bado classification remains the most commonly used classification for these injuries. It divides four true Monteggia injuries and several "equivalent injuries" based on the direction of the ulnar angle and the displacement of the radial head [4]. Letts., *et al*. proposed a pediatric classification, subdividing Bado type 1 based on the type of ulnar fracture (plastic, greenstick, and complete fracture) [9]. Monteggia fractures in children can have excellent outcomes if detected early and treated promptly. Restoration and maintenance of ulnar length and alignment by closed reduction or surgery usually results in stable reduction of the radiocapitellar joint. However, delayed or unrecognized radial head dislocation is the most common (16% - 50%) and serious complication of Monteggia lesions in children, especially plastic deformities of the ulna, leading to a much more complex injury with an often unpredictable surgical outcome. Irreversible dislocations of the radioulnar joint that persist for more than four weeks after injury are considered chronic [10].

The delayed recognition of Monteggia fractures continues to pose a therapeutic challenge, as evidenced by the variety of surgical techniques that have been described. Procedures include ulnar and radial osteotomies, closed or open reduction of the radial head, and repair or reconstruction of the annular ligament (ALR) [11,12], temporary fixation of the radial head with transarticular wires, or some combination of these techniques [11,13]. Some have proposed leaving the dislocated radial head intact and resecting it at skeletal maturity if pain or functional limitations are present [14].

Long-term follow-up of untreated Monteggia fractures has shown the development of early arthritis, pain, instability, loss of internal and external rotation, valgus deformity, and anterior elbow protrusion. Late nerve palsies have been reported following long-unrecognized Monteggia lesions [11,15]. Therefore, it is imperative to treat neglected fractures as soon as they are diagnosed. Fowles., *et al*. reported successful repositionings up to 3 years after injury, and Freedman., *et al.* performed reconstructions up to six years after injury [13,16].

Here, we present the clinical outcomes after treatment of chronic radial joint dislocations in children using open reduction, ulnar angle osteotomy, and annular ligament reconstruction.

Materials and Methods

A retrospective study was conducted to evaluate the results of surgical techniques performed from May 2010 to August 2022 on 38 patients with symptomatic post-traumatic old Monteggia fractures at the Department of Orthopedics, National Children's Hospital. Three patients (3 elbows) were excluded from the study due to insufficient follow-up. The remaining 35 patients (35 elbows) formed the basis for this study. The surgeries were performed by a single surgeon (Author).

The study was approved by the Ethics Review Committee of our Institute and was conducted in accordance with the principles of the Declaration of Helsinki.

All children presenting in the context of trauma with chronic dislocation of the head of the radius and union of the ulna were included in the study. No patients had a history of previous elbow surgery or pathology (no patients had congenital dislocations and no patients were initially treated at our hospital).

There were 21 females. 14 males; Left 22, Right 13. The mean age of the patients at the time of injury was 8.5 years (5.4 - 12.8 years); According to the Bado classification (Table 1), 17 patients were classified as Bado type I, 12 patients as Bado type II, and 6 patients as Bado type III. No patients were reported to have type IV.

The mean age at surgery was 9 years and 6 months (6.3 - 12.5 years); the time of opening for reduction ranged from 4 - 20 months (10 months and 1 month). The sex of the cases was 21 females and 14 males; right side affected in 13 cases and left side affected in 22 cases.

Case	Gender	Side	Age at injury (Years, months)	Time to Operation (month)	Age at Operation (Years, months)	Follow - up period (month)
1	Female	Left	5. 4	20	7. 0	140
2	Male	Right	5, 8	7	6. 3	87
3	Female	Left	11. 2	6	11. 8	94
4	Female	Right	8. 3	9	9. 0	64
5	Female	Left	7. 1	8	7. 5	138
6	Male	Right	9. 8	7	10. 1	26
7	Male	Right	10. 6	9	11. 5	42
8	Female	Left	12. 5	8	13. 1	84
9	Male	Left	6. 4	8	7. 0	98
10	Female	Right	7. 9	5	8. 2	50
11	Female	Left	11. 8	6	12. 4	92
12	Male	Right	8. 4	4	8. 8	58
13	Female	Right	5. 4	9	6. 3	69
14	Female	Left	6. 8	10	7. 6	95
15	Male	Left	12. 1	9	12. 10	86
16	Female	Right	7. 6	12	8. 6	48
17	Female	Left	10. 2	18	11. 8	69
18	Male	Left	6. 7	16	7. 11	67
19	Male	Left	8. 9	11	9. 8	54

20	Female	Right	11. 2	10	12. 0	74
21	Female	Left	6. 5	9	7. 2	59
22	Female	Left	7. 4	14	8. 6	45
23	Male	Left	8. 6	10	9. 4	68
24	Male	Left	11. 5	12	12. 5	87
25	Female	Right	10. 9	16	12. 1	91
26	Male	Left	8. 7	11	9. 6	59
27	Female	Left	6. 9	12	7. 9	48
28	Female	Left	8. 5	8	9. 1	64
29	Female	Right	7.9	9	8. 6	110
30	Male	Lefi	12. 8	11	13. 7	86
31	Female	Left	8. 3	9	9. 0	49
32	Male	Right	11. 4	12	12. 4	52
33	Female	Left	6. 8	10	7. 6	61
34	Male	Left	7.4	11	11.2	48
35	Female	Left	9. 6	8	10. 2	44
	Fem. 21 Mal. 14	Lef. 22 Rig. 13	Mean 8.5 SD: 25.83	Mean 10.11 SD: 25.537	Mean 9.6 SD: 71.7	Mean 61 SD: 102.77

Table 1: *Clinical data of the patients.*

Female 21. Male 14; Left 22, Right 13. The age of patients at the time of injury mean 8.5 years (5.4-12.8 years); Age at Operation mean 9 years and 6 months (6.3 - 12.5 years); open reduction ranged from 4 -20 months (10 months and 1 months). The gender of the cases was 21 girls and 14 boys; right side was affected 13 cases and left side in 22 cases.

Criteria included an interval of at least four weeks between injury and surgical repair, which varied in our study from 2 to 25 months (mean 12.1 months). Exclusion criteria included severe deformity of the radial head. No cases of posterior interosseous nerve palsy were detected preoperatively.

All patients had limited elbow and forearm mobility and pain. No child had nerve palsy. On preoperative radiographs, we noted the direction of dislocation, the bearing angle, the head-neck ratio, and any abnormal bony structures.

Radiographic criteria

Any series of radiographs of forearm fractures should include a quality AP view and lateral view of the elbow, which is essential and usually sufficient to identify radial asymmetry. In a normal elbow, the central axis of the radius should pass through the center of the radius (Storen's line). This is true for all projections and regardless of whether the head of the radius is ossified. The ulna should be examined for plastic deformity or "bowing," with the apex in the direction of the dislocation of the head of the radius. The posterior ulna cortex should be straight. The trauma film should be followed by a post-reduction radiograph to confirm concentric reduction of the ulnar-ulnar and radial-radial joints.

The reduction of the head of the radius has been assessed. A full forearm radiograph is obtained by placing the child's arm on the radiography table with the elbow flexed to 90° in the lateral position and the palm facing down (Figure 2). We have found that this method provides a true anteroposterior view of the forearm, allowing visualization of any curvature of the ulna (Figure 2). This method also allows visualization of the dislocation of the radial head by providing a true lateral view of the elbow.

Figure 2: *Head radial dislocation.*

They recommended that the maximum curvature of the ulna be measured to detect ulnar curvature. To measure this, a line is drawn on a lateral radiograph of the forearm along the dorsal margin of the ulna from the level of the olecranon to the distal ulnar junction. The presence or absence of ulnar curvature is determined by the maximum distance between this line and the axis of the ulna: a value >1 mm may indicate the presence of ulnar curvature, while a value < 1 mm indicates that the deformity does not significantly affect the rotational stability of the forearm [17] (Figure 3).

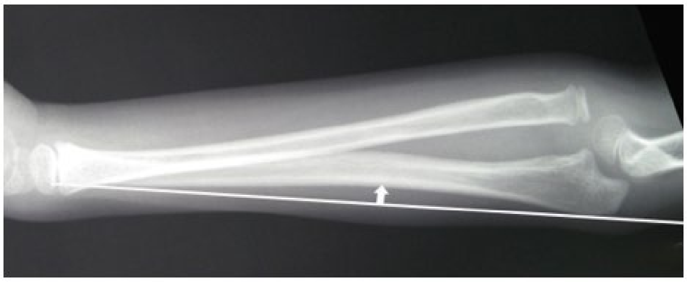

Figure 3: *Ulnar bow should be measured to detect ulnar bowing.*

Clinical criteria

Range of motion (ROM) measurement

Pre- and post-operative ROM, expressed as the sum of the flexion-extension and pronation-supination arcs, was determined using a handheld goniometer using standardized methods. We defined full flexion-extension as 140°, full pronation as 75°, and full supination as 85° [18] and figures limit neglect Monteggia (Figure 4).

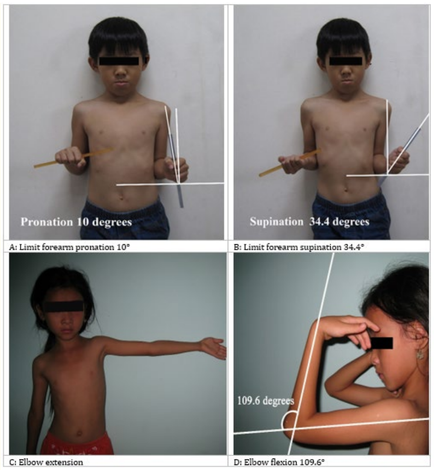

Figure 4A-4D: *Clinical neglect Monteggia.*

Elbow performance score

We adopted new standards after the study was conducted when it was determined that patient satisfaction was not limited to any single factor. For example, deformity was such a sensitive factor for patients and parents in this study that it became the sole reason for revision surgery in some patients (Figure 5). Post-operative satisfaction also varied. Therefore, the elbow scoring system currently in use cannot accurately reflect pre- and post-operative assessment of chronic radial head dislocations.

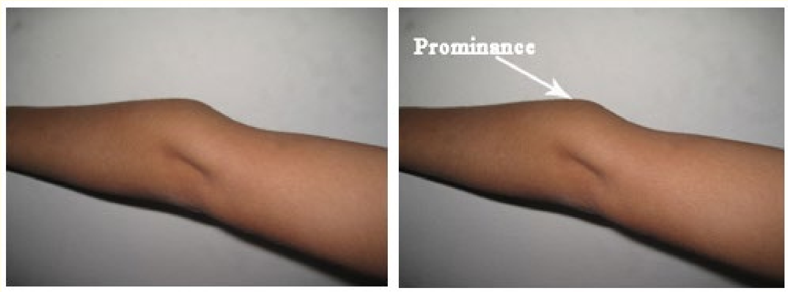

Figure 5: *Prominence under skin of radial head; deformity affects the patient's aesthetics.*

Surgical technique

The surgery was performed with the patient in the prone position with the elbow flexed. Under general anesthesia and a tourniquet applied to the upper arm, a posterolateral skin incision was made to expose the radiocapitellar joint and the abnormal position of the ulna using the Speed and Boyd method [19], which exposes the lateral surface of the ulna and the proximal quadrant of the radius. The supination reflex innervates the deep branch of the radial nerve. After the joint capsule was identified, the annular ligament, which may be intact but displaced or torn and impede reduction of the radial head, was located. The intra-articular spaces of the radiocapitellar and proximal radioulnar joints were then cleared of debris by removing any fragments of the joint capsule, ligaments, or intervening osteochondral tissue. Reduction of the radial head to the radial surface of the proximal ulna was attempted and its stability assessed. If the proximal radius remains unstable, reduction is maintained with an oblique pin from the radius to the proximal ulna. In all patients, stability could not be achieved and an ulna osteotomy was performed to ensure stability of the radial head. The proximal portion of the ulna, i.e. the site of fusion or plastic deformity, is exposed through a standard dorsal approach. The ulna shaft is approached directly and the osteotomy is performed at the proximal junction or at the angulated center of rotation. The osteotomy site is lengthened and angulated to correct the excessive ulna deformity. A straight osteotomy is performed at the ulna-shaft junction. The osteotomy site is then angulated and lengthened simultaneously. The osteotomy is then fixed with a one-third tube plate that is bent to accommodate the resulting deformity (the plate is bent 30°). The proximal screw is a cancellous screw and this simple structure combined with 4 weeks of casting is completely satisfactory (Figure 6).

Ulnar flexion osteotomy

In cases where the ulna is bent forward, preventing the stability of the radial head or rotation during internal-external rotation, a closed wedge flexion osteotomy is performed in the area of the most abnormal curvature according to the amount measured preoperatively. The ulnar flexion osteotomy is performed through a posterior skin incision along the posterior ulna axis and is fixed with a metal plate and screws.

Figure 6: *The osteotomy site is angulated and lengthened simultaneously. The osteotomy is then fixed with a one-third tubular plate.*

Annular ligament reconstruction

Bone tunnels are created using a 3.5 mm drill at the level of the annular ligament (Figure 7). A fascial band 1 cm wide and 6 - 8 cm long is taken from the distal third of the thigh and is passed through and wrapped around the neck of the radius from the ulna and fixed through a drill hole in the ulna (Figure 8).

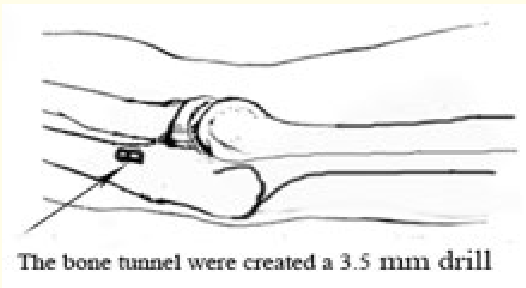

Figure 7: *The bone tunnel were created a 3.5 mm drill.*

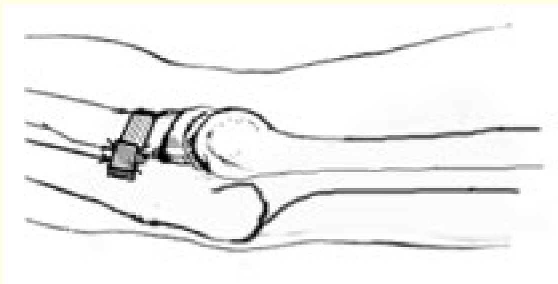

Figure 8: *The fascia lata is passed and wrapping it around the radial neck from the ulnar and securing it through a drill hole in the ulna.*

Kirschner wires were drilled through the skin through the head of the radius into the head of the radius with the elbow at 90° of flexion and supination (Figure 6). The patient's ulna was fixed with a plate and screws. No radius osteotomy was required and temporary fixation was done with a radial-radial head wire.

Postoperatively, the elbow was fixed at 90° of full flexion and supination for six weeks, followed by gradual mobilization.

At the final follow-up, the patient was asked about pain, stability, and disruption of daily and sporting activities. The physical examination included assessment of the range of motion of the elbow and forearm. Function was assessed using the elbow performance score, which takes into account four parameters, namely deformity, pain, range of motion, and function, weighted equally on a scale from 0 (worst) to 100 (best) [20]. Anteroposterior and lateral radiographs were obtained to determine the adequacy of the radioulnar joint and the presence of any deformity or changes due to arthritis. A new scoring system was then developed based on the four parameters that patients considered most problematic: deformity, pain, ROM, and function. The four parameters were weighed equally, each with 25 points, for a perfect score of 100 points: 1) deformity: 25, no concern; 15, minor concern; 0, major concern; 2) pain: 25, no pain; 15, mild intermittent pain with no limitation of activity; 0, pain, limitation of activity; 3) range of motion (sum of flexion-extension and radial-radial-radial arcs): 25, >250°; 15, 250°- 200°; 0, <200°; 4) Function: Five activities of daily living (combing hair, feeding oneself, opening door handles, holding onto overhead rails on a subway, putting on shoes with one hand) were determined, and a weighted score of 5 points was assigned to each activity if the patient could perform these tasks without difficulty. If the patient could not complete these tasks, a score of 0 was assigned to each task that the patient could not perform without difficulty. The total elbow performance score was classified as excellent (90 points or more), good (89-75 points); fair (74-60 points); or poor (< 60 points) [20].

Results

In this study all cases had regular thorough follow up for a period mean 40.8 months (24-61 months) (Table 1). All patients were operative ulnar osteotomy with angulation at osteotomy site mean 19.6°; Ulnar lengthening at osteotomy site mean 09. cm (Table 2). All wounds healed primarily with no infection. There were no neurovascular complications, compartment syndrome, or implant breakage. One patient who underwent a diaphyseal osteotomy at the center of rotation of angulation developed a nonunion (Patient number 3), requiring bone grafting with auto bone graft, 6 months postoperatively with rapid consolidation.

Case	Gender	Side	Age at injury (Years, months)	Time to Operation (month)	Age at Operation (Years, months)	Follow - up period (month)
1	Female	Left	5. 4	20	7. 0	140
2	Male	Right	5, 8	7	6. 3	87
3	Female	Left	11. 2	6	11. 8	94
4	Female	Right	8. 3	9	9. 0	64
5	Female	Left	7. 1	8	7. 5	138
6	Male	Right	9. 8	7	10. 1	26
7	Male	Right	10. 6	9	11. 5	42
8	Female	Left	12. 5	8	13. 1	84
9	Male	Left	6. 4	8	7. 0	98
10	Female	Right	7. 9	5	8. 2	50
11	Female	Left	11. 8	6	12. 4	92
12	Male	Right	8. 4	4	8. 8	58
13	Female	Right	5. 4	9	6. 3	69

14	Female	Left	6. 8	10	7. 6	95
15	Male	Left	12. 1	9	12. 10	86
16	Female	Right	7. 6	12	8. 6	48
17	Female	Left	10. 2	18	11. 8	69
18	Male	Left	6. 7	16	7. 11	67
19	Male	Left	8. 9	11	9. 8	54
20	Female	Right	11. 2	10	12. 0	74
21	Female	Left	6. 5	9	7. 2	59
22	Female	Left	7. 4	14	8. 6	45
23	Male	Left	8. 6	10	9. 4	68
24	Male	Left	11. 5	12	12. 5	87
25	Female	Right	10. 9	16	12. 1	91
26	Male	Left	8. 7	11	9. 6	59
27	Female	Left	6. 9	12	7. 9	48
28	Female	Left	8. 5	8	9. 1	64
29	Female	Right	7.9	9	8. 6	110
30	Male	Lefi	12. 8	11	13. 7	86
31	Female	Left	8. 3	9	9. 0	49
32	Male	Right	11. 4	12	12. 4	52
33	Female	Left	6. 8	10	7. 6	61
34	Male	Left	7.4	11	11.2	48
35	Female	Left	9. 6	8	10. 2	44
	Fem. 21 Mal. 14	Lef. 22 Rig. 13	Mean 8.5 SD: 25.83	Mean 10.11 SD: 25.537	Mean 9.6 SD: 71.7	Mean 61 SD: 102.77

Table 1: *Clinical data of the patients.*

Female 21. Male 14; Left 22, Right 13. The age of patients at the time of injury mean 8.5 years (5.4-12.8 years); Age at Operation mean 9 years and 6 months (6.3 - 12.5 years); open reduction ranged from 4 -20 months (10 months and 1 months). The gender of the cases was 21 girls and 14 boys; right side was affected 13 cases and left side in 22 cases.

Case	**Bodo type**	Plastic deformation of the ulna	**Ulnar angulation at osteotomy site (°)**	**Ulnar lengthening at osteotomy site (cm)**	**Complication**	**Kim's Score**
1	I	(-)	18	0.6	None	Excellent
2	I	(-)	19	0.7	None	Excellent
3	I	(+)	22	1.2	Nonunion	Fair
4	II	(-)	20	1	None	Excellent
5	I	(-)	18	0.7	Cubitus valgus	Excellent
6	I	(-)	25	1.2	None	Excellent
7	II	(+)	18	0.6	None	Excellent
8	I	(-)	19	0.6	None	Excellent

9	I	(-)	21	1.2	None	Excellent
10	II	(-)	20	1.1	Cubitus valgus	Good
11	III	(+)	21	0.6	None	Good
12	I	(-)	22	1.1	None	Excellent
13	I	(-)	16	0.8	Subluxation	Excellent
13	I	(-)	19	0.7	None	Excellent
14	II	(+)	20	1	None	Excellent
15	II	(-)	25	1.2	None	Excellent
16	III	(-)	19	0.6	None	Good
17	II	(-)	20	0.7	None	Excellent
18	I	(+)	18	0.9	Cubitus valgus	Excellent
19	I	(-)	20	1	None	Excellent
20	III	(+)	25	0.6	None	Good
21	III	(-)	21	1.2	None	Excellent
22	II	(-)	19	0.7	None	Excellent
23	I	(-)	18	0.9	None	Excellent
24	I	(-)	20	1	None	Good
25	III	(-)	25	0.8	None	Excellent
26	II	(+)	18	0.7	None	Excellent
27	II	(-)	19	0.8	None	Excellent
28	I	(-)	20	1	None	Excellent
29	I	(-)	18	1.2	None	Good
30	III	(-)	20	0.6	None	Excellent
31	II	(+)	21	0.8	None	Excellent
32	III	(-)	18	1.2	None	Good
33	I	(-)	19	0.9	None	Excellent
34	II	(-)	25	1.	None	Excellent
35	II	(-)	20	0.8	None	Excellent
			Mean 20.2° SD: 2.36	Mean 0.88 cm SD: 2.19		

Table 2: *Management of technique and outcome.*

According to Bado classification indication (Table 1) 17 patients were of Bado type I, 12 patients were Bado type II, and 6 were of Bado type III. No patients with type IV reported; Ulnar angulation at osteotomy site (°) mean 20.2° (18-25°); Ulnar lengthening at osteotomy site (cm) mean 0.9 cm (0.6-1.2 cm); Complication with nonunion in 1 case, Cubitus valgus with 3 cases; Surgical results: Excellent in 28; Good in 6; Fair in 1.

Elbow, wrist and forearm motion was without pain, with mean elbow flexion extension 131.5. Mean forearm pronation was 77.1, and all patients had supination of 81.7 (Table 3). There was no sign of distal radio-ulnar joint instability. Radiographs at the latest review showed that the radial head was successfully reduced in all cases. In addition, no patient had any degenerative changes in the elbow joint.

Case	Preoperative				At follow - up			
	Flex-Ext arc	Pronation arc	Supination arc	Total arc	Flex-Ext arc	Pronation arc	Supination arc	Total arc
1	110	70	70	250	130	80	85	295
2	115	65	70	250	130	70	85	285
3	80	75	80	235	125	75	75	275
4	120	75	85	260	130	85	80	295
5	110	65	75	250	125	75	80	280
6	130	70	80	260	135	75	85	295
7	90	50	55	195	140	65	85	290
8	105	70	60	235	125	75	80	265
9	95	75	70	240	140	70	85	295
10	110	75	80	260	130	75	85	290
11	105	65	40	210	125	80	80	270
12	100	55	75	230	130	75	80	285
13	110	70	80	260	125	75	85	285
13	85	65	65	235	130	75	75	280
15	95	70	70	255	124	80	80	290
16	100	70	76	250	125	80	85	295
17	115	75	80	235	130	75	85	275
18	85	65	75	255	125	75	85	280
19	95	80	65	240	140	75	75	285
20	90	75	70	245	135	80	85	275
21	100	65	75	250	125	80	75	290
22	110	85	80	235	130	85	80	285
23	95	70	65	240	140	75	80	290
24	100	75	75	250	130	80	85	285
25	90	80	65	255	130	85	80	285
26	100	75	80	250	135	75	85	280
27	105	80	76	245	135	80	85	280
28	100	75	75	260	130	85	80	285
29	95	65	65	240	140	75	75	275
30	95	80	65	235	135	75	85	275
31	100	85	70	220	135	80	85	280
32	85	75	75	215	130	80	85	265
33	95	70	75	220	135	75	75	280
2	110	65	65	210	130	80	80	285
35	95	75	70	225	135	75	85	280
Mean SD	100.07 SD:10.83	71.42 SD:7.43	71.34 SD:8.62	240 SD:16.49	131.25 SD:5.08	77.14 SD:4.42	81.71 SD:3.82	283 SD:8.06

Table 3: *Range of motion measurements (in degree).*

% Improvement + [(B-A)/A] X 100 (A: Preoperative mean ROM in each arc; B: at follow - up in each arc), Improvement Pre-Pot operation: Flexion-Extention 23.8%; arc 19.6%.

Clinical results

The mean preoperative range of motion was (100.7°), and the mean postoperative range of motion was (131.5°), resulting in a mean increase in range of motion of 43° (283° - 240°). All patients had an external-internal rotation arc >100°; the external rotation range was always smaller than the external rotation (Figure 9). The mean preoperative external-internal rotation range was 100.7° and the mean postoperative external-internal rotation range was 131.5°, resulting in a mean increase in external-internal rotation range of 20° (Table 3). Although no correlation was observed between the achieved range of motion and the time to treatment, patients treated earlier had a greater range of motion than those treated later (Table 4). The mean follow-up period was 61 months (range, 26 - 140 months). At final follow-up, no patient had any signs of instability. Based on Kim's core [20], 28 patients had excellent results, 6 patients had good results, and one patient had fair results at final follow-up (Table 2).

Figure 9A-9C: *Postoperative 6 months (Left elbow).*

Case	Preoperative					At follow-up				
	Deformity	Pain	Motion	Function	Total	Deformity	Pain	Motion	Function	Total
1	0	25	25	25	75	25	25	25	25	100
2	0	25	25	25	75	25	25	25	25	100
3	0	25	15	10	50	15	15	25	15	70
4	0	25	25	25	75	25	25	25	25	100
5	0	25	15	25	65	25	25	25	15	100
6	0	25	25	25	75	25	25	25	25	100
7	0	25	15	25	50	25	25	25	25	100
8	0	25	15	25	65	25	25	25	25	100
9	0	25	15	25	65	25	25	25	25	100
10	0	25	25	25	75	15	25	25	20	85

11	0	25	15	25	65	15	25	25	20	85
12	0	25	15	10	60	25	25	25	25	100
13	0	25	25	25	75	25	25	25	20	95
14	0	25	15	15	60	20	25	25	20	100
15	0	25	15	25	70	25	25	25	20	90
16	0	25	25	25	75	15	25	25	25	100
17	0	25	15	15	85	25	25	25	20	90
18	0	25	15	15	70	20	25	25	25	95
19	0	25	25	25	65	25	25	25	25	90
20	0	25	15	25	75	15	25	25	25	100
21	0	25	15	25	65	25	25	25	25	95
22	0	25	25	15	75	20	25	25	20	100
23	0	25	15	15	65	20	25	25	15	80
24	0	25	25	25	70	25	25	25	25	85
25	0	25	25	15	65	15	25	25	25	95
26	0	25	25	15	70	25	25	25	15	100
27	0	25	15	15	75	25	25	25	25	85
28	0	25	15	25	75	20	25	25	25	90
29	0	25	25	25	65	20	25	25	25	95
30	0	25	25	25	65	25	25	25	25	100
31	0	25	25	25	75	25	25	25	15	85
32	0	25	15	15	60	15	25	25	20	95
33	0	25	25	15	60	20	25	25	25	100
34	0	25	15	25	70	25	25	25	20	100
35	0	25	15	25	75	25	25	25	25	90
Mean SD					68.57 7.5					94.1 7.4

Table 4: *Elbow performance score.*

% Improvement + [(B-A)/A] X 100 (A: Preoperative mean ROM in each arc; B: at follow - up in each arc), 16.7%%.

Total elbow score: Excellent. ≥ 90; Good, 89-75; Fair, 74-60; Poor ≤ 60. Surgical results: Excellent. 28; Good 6; Fair 1.

Radiographic findings

Initial preoperative radiographs showed nine patients with Bado type I fractures, three with Bado type II fractures, and one with Bado type III fractures (Table 2). Three patients had a plastic deformity of the ulna, measured at <1 mm in this study (Figure 2).

At final follow-up, head radiographs showed hemidislocation of the radial head on head radiographs without treatment. The mean healing time of the ulna osteotomy was 9 weeks (range, 7-12 weeks) (Figure 10). One child had bone union and bone grafting 5 months after surgery.

Figure 10A and 10B: *A: Preoperative radiography; B. Postoperative 6 months.*

Complications

There was one patient with an anterior hemidislocation of the radial head (case 13), three patients with Cubitus valgus (cases 5, 10, and 18), and one patient with partial dislocation (case 3). There were no cases of growth disturbance, heterotopic bone formation or radioulnar synostosis, arthritis, pain, stiffness, deformity, nerve damage and limitation of activities of daily living, elbow instability, secondary osteoarthritis, late neuropathy, overgrowth of the radial head, late nerve palsy and underlying osteoarthritis, nonunion, avascular necrosis of the radial head, nerve injury and infection, and tumors on the anterior aspect of the elbow.

Discussion

The diagnosis of radial head dislocation can be easily overlooked because the history is often vague, the clinical findings are vague, and the radiographic features are relatively subtle.

Careful radiographic examination is key to the diagnosis. Isolated radial head dislocations due to remote trauma and without obvious ulnar injury have been mistaken for congenital radial head dislocations [21]. Lincoln and Mubarak described a slightly anteriorly bowed ulnar arch. They suggested that the term isolated radial head dislocation is a misnomer and that these are actually variants of Monteggia type I injuries [22,23].

Although the absence of an associated ulnar fracture is partly due to the plasticity of the ulna in children, Hudson., *et al*. did not find any ulnar curvature or periosteal reaction suggestive of fracture in their series of isolated radial head dislocations [24]. Radial head dislocations can occur secondary to rupture of the weak annular ligament even in the absence of significant ulnar injury.

Although the exact mechanism of injury in radial head dislocations remains unclear, most injuries are associated with sports activities and falls on an outstretched arm. The most common mechanism of injury involves a fall on an outstretched arm with the forearm pronated, the elbow fully extended, and an additional valgus force applied to the ipsilateral elbow. In cadaveric specimens, anterior dislocations occur with the forearm in extreme supination, with complete rupture of the anterior capsule and annular ligament, and an anterior force applied to the posterior aspect of the radial head [22]. Occasionally, a tear of the superior interosseous membrane may precede the dislocation. Radial head dislocations may occur in a variety of conditions, such as neuromuscular disorders; posttraumatic, with or without a fracture of the ulna; secondary to tumors of the forearm; or congenital, as seen in associated syndromes and diseases. Good and Wicks [25] suggested that radial head dislocation can be divided into three types: congenital (when present at birth), developmental (due to abnormalities during growth), and post-traumatic. Other authors suggested that radial head dislocation always occurs after trauma, which may cause a plastic deformity of the ulna, also known as 'traumatic ulnar vault' [17,26]. Many of these so-called congenital dislocations may actually be birth injuries leading to congenital radial head dislocation. True congenital radial head dislocation often

Figure 10A and 10B: *A: Preoperative radiography; B. Postoperative 6 months.*

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The time between injury and treatment and the maximum age at which a dislocated radial head can be successfully reduced without compromising elbow function vary according to the literature. Many authors have stated that reconstruction should be performed within 2 years of the initial injury [12,30], thus implying that after 2 years the outcome is so poor that surgical intervention is not warranted. Best [31] reported a successful outcome in a child 6 years post-injury. In our series, the mean time from injury to surgery was 37 months and one patient underwent reconstruction 10 years post-injury with recovery of nearly full range of motion. Seven of our patients were more than 2 years post-injury at the time of reconstruction. We do not feel that there is a fixed time frame for performing Bell-Tawse reconstruction and we would offer surgical intervention to any patient who we felt would benefit from this approach. The time from initial injury to surgery was 7.2 months (range 2 - 25 months) in this study. The treatment of neglected Monteggia fractures in children remains controversial. The first question that often arises is how long a neglected dislocation can be accepted as reversible before secondary adaptive changes disrupt the final result. This period varies - depending on the author - from 6 months to 6 years [15].

The best outcome is the maximal extent of patients undergoing open osteotomy. Three of the patients reported here were over 10 years of age at the time of surgery, with the oldest patient being 12 years of age [16]. Although potential variations of conservative approaches exist in appropriate cases of Monteggia injury, it is important to replace the radial head in an appropriate relationship to the metaphysis. This is especially true in children under 12 years of age. The mean age of patients at surgery was 8.6 years (range, 6.1-12.2 years) in this study. The decision to proceed with open treatment should be made after careful consideration by the patient, parents, and oncologist.

The Kocher and Boyd procedures are the most commonly used approaches to reduce the radial head. We can extend distally along the subcutaneous border of the ulna to resect the proximal ulna [32,33]. Dense epiphyseal scarring and fusion are the most common findings in cases of attempted open epiphyseal reduction [11,14]. This must be excised to reduce the epiphysis. The remaining archwire may be part of this cartilage [2], but is often not possible to separate at the time of the procedure.

Surgical correction

Surgical reduction is justified in cases of irreversible and missed/overlooked anterior dislocation of the radial head in children. Chronic dislocation of the radial head may result in progressive valgus deformity of the elbow with subsequent ulnar or radial nerve dysfunction, limited flexion due to compression by the radial head, and loss of function due to stiffness and instability [22].

The present case concerns an anterior dislocation of the radial head in a 7-year-old boy. He fell while running with his entire body weight on his extended left hand, pronated forearm, and extended elbow. With such hyperextension of the elbow, the radial head is at risk of anterior displacement through the annular ligament. Furthermore, when falling on an outstretched hand, the force is transmitted down the radial axis and the annular ligament is ruptured anteriorly, resulting in isolated radial head dislocation [24].

Perforation of the annular ligament causes the radial head to dislocate. Over time, the ligaments contract, become fibrotic, and intertwine with the radiocapitellar joint. In such situations, closed reduction is less likely to be successful, resulting in missed dislocations. Therefore, in these cases, immediate open reduction should be performed, as attempts at closed reduction will only increase cartilage damage or nerve damage. When surgical repair of the dislocation is delayed, a more extensive surgical procedure may be required to achieve a successful outcome.

For isolated traumatic radial head dislocations with annular ligament injuries in children, surgery should be the treatment of choice and should include open reduction and annular ligament reconstruction. Since the role of annular ligament reconstruction in maintaining reduction of the radial head has been rigorously analyzed, the authors have advocated its use in all cases requiring open radiocapitellar joint surgery.

Reconstruction involves taking a piece of fascia from the triceps fascia or forearm fascia and creating a loop around the neck of the radius. This fascial slide acts as both a dynamic and a static stabilizer, thus preventing partial dislocation of the radial head.

Boyd used a slide from the extensor fascia, Bell-Tawse used a central slide from the triceps fascia, and Lloyd-Roberts used a lateral slide but attached it distally [22]. The triceps fascia is commonly used for reconstruction of the annular ligament, mainly because it is located close to the surgical wound and causes less surgical trauma and shorter operative time than using other tissues; the fascia is stiff and thick with rigid fixation and has a low risk of re-dislocation. Seel and Peterson suggested that patient age and duration of dislocation are not important factors to consider when choosing a treatment for this injury. Their criteria for choosing surgical repair were the presence of a normally concave radial head articular surface and normal shape and contour of the ulna and radius.

Some authors recommend that, in addition to open reduction of the radial head and reconstruction of the annular ligament, angulated osteotomy and ulnar lengthening are often necessary to maintain reduction of chronically dislocated radial heads. However, ligament reconstruction alone may stabilize the radial head when forearm alignment is normal. Clearly, surgical procedures should be minimized, but the orthopedist must perform the procedures necessary to stabilize the elbow.

Ulnar osteotomy

We agree with the author's opinion that "ulnar osteotomy is the key to reducing the radial head" [20,29]. The treatment we propose has been described previously and is based on the hypothesis that the main problem is an uneven ulnar fusion that prevents reduction of the radial head. Therefore, the surgical technique consists of ulnar osteotomy with lengthening and angulation. Lengthening allows reduction, providing sufficient space for the dysplastic head while avoiding excessive pressure on the radial head. The angulation creates overcorrection, helping to hold the head in the correct position for the time necessary for stabilization. If satisfactory reduction cannot be achieved by closed means, we recommend performing a direct arthrogram to rule out the possibility that the reduction is prevented by a pseudocapsule around the neoradial-humeral joint or possibly by remnants of the interosseous annular ligament in the radioulnar-capillary joint. In both cases, this will indicate simple removal of this fibrous tissue.

Ultratomy is the main procedure to achieve and maintain reduction because it addresses the primary deformity in the ulna [34]. Reduction of ulna length and ulna angle in the opposite direction to the dislocation of the head of the radius are the most important findings leading to persistent right lateral dislocation of the radius [35]. The aim of ulna osteotomy is to restore the normal relationship between the radius and ulna and the width of the interosseous membrane. Since the forearm acts as a joint unit during supination and pronation, only such procedures can restore function. The interosseous membrane is an important factor contributing to the stability of the radiocapitellar joint. Osteotomy depends on the interosseous membrane to return the ulna to an acceptable position. The radiocapitellar joint is very sensitive to the alignment of the ulna. Small changes in the ulna, such as those occurring with plastic deformation, can lead to dislocation of the radial head [36]. Therefore, ulna resection is an essential step to correct the pathological anatomy of the lesion. Resection of the proximal portion of the resection has the advantage of preserving more of the interosseous membrane, reducing the force required to move the radial head, and preserving rotational motion of the forearm. The distance from the ulna resection to the olecranon should be sufficient to stabilize the ulna after osteotomy [38].

Different types of ulna resections have been used in the literature. Hirayama., *et al*. [40] recommended extended ulna resection with overcorrection of the ulna deformity. Garget., *et al*. [32] is the largest series of neglected RHD. Both groups had ALR using the triceps fascia. The mean improvement in range of motion and Mayo elbow performance index were significantly better in the former group. Inoue., *et al*. [34] compared the results of simple ulnar osteotomy and overextended ulnar osteotomy and found that the results were significantly better with overextended ulnar osteotomy. This was because simple ulnar osteotomy was not sufficient to correct the ulnar deformity, resulting in residual dislocation. The mean forearm rotation arc was also higher in the group treated with overextended ulnar osteotomy. Overextended ulnar osteotomy has also been recommended by other authors [26,40] and may also help to remove the mechanical block to the rotation of the radius from scar tissue or fibrous tissue.

The treatment strategy we used in our cases was based on the hypothesis that the main problem was an intact ulnar or ulnar fusion that prevented reduction of the radial head. The surgical technique consisted of ulnar osteotomy with lengthening and angulation. Lengthening allowed reduction, providing sufficient space for the radial head while avoiding excessive pressure on the radiocapitellar joint. The angle creates overcorrection and tension in the interosseous membrane that holds the epiphysis in place for the time necessary to stabilize the epiphysis [41,42]. All of our osteotomies are internally fixed with a plate and pre-bent screws to reduce the risk of secondary displacement and allow for early mobilization. This technique requires removal of scar tissue or posterior interosseous nerves at the radioulnar joint and the annular ligament. We and other authors have undergone extensive fascial reconstruction [3,43].

Radial osteotomy

There is little literature on radial osteotomy as a primary treatment for RHD. Hui., *et al.* [34] performed a radial osteotomy in one patient, with poor results. Several authors have used radial osteotomy, although in some of their patients [20,42,43]. There is no clear indication for radial osteotomy or preference for it over ulnar osteotomy.

The ulnar osteotomy should be fixed to maintain correction of the radial head [12]. Intramedullary wires and plates are the most commonly used techniques for internal fixation. Most recent studies have used plates for internal fixation [26,36]. They provide more rigid fixation with a lower risk of late loss of correction. The problem of K-wire protrusion and late removal is also avoided. Plates should be contoured to fit the osteotomy site. External fixators have also been used to stabilize ulnar osteotomies [45]. An advantage of an external fixator is that it provides modularity in all three planes to adjust the length and angle of the ulna if reduction of the radial head is not found to be adequate in the postoperative period [46].

Some authors [15,47] have stated that internal fixation after ulnar osteotomies is not necessary. We had one patient who had an ulnar osteotomy without initial internal fixation and his radial head dislocated again, requiring subsequent surgery to nail the ulna and reduce the radial head. Therefore, we recommend internal fixation for all ulnar osteotomies after reduction of the radial head. We performed internal fixation for all ulnar osteotomies in this study.

Annular ligament reconstruction

There is controversy regarding the reconstruction of the annular ligament. Nakamura., *et al*. [50] and David-West., *et al*. [51] advocate this in all cases while others such as Devnani [2] completely ignore it. Others such as Bhaskar., *et al*. [3] prefer to base the intraoperative decision on the stability of the reduction. There seems to be no value in reconstructing or repairing the ligaments around the neck that are altered by the dysplastic head, as the latter will gradually regenerate after reduction leading to reduced graft thickness and a subsequent risk of re-dislocation. On the other hand, a short graft will lead to tightening of the radial neck and limited function, as demonstrated by the previously reported postoperative thinning of the neck after the Bell Tawse procedure [52]. Although temporary layering of the neck with annular ligaments holds the head in place, this does not seem to us to be a physiologic issue. If re-dislocation occurs, we believe it is not related to failure to reconstruct the annular ligament but to the non-angular resection of the ulna. In our study, one patient underwent arthrography 1 month postoperatively for suspected dislocation but actually had a deformed radial head. Such pseudo-dislocations have been described previously [26].

Another point that is often raised is the choice of surgical technique used to treat these injuries. There is controversy regarding reconstruction of the annular ligament. Nakamura., *et al*. [37] and David-West., *et al*. [50] advocate this approach in all cases while others such as Devnani [2] and Bhojraj., *et al*. [53] completely reject it. Others such as Bhaskar., *et al*. [3] prefer to make intraoperative decisions based on the stability of the reduction. Garg., *et al*. [32] reported better results with reconstruction of the annular ligament using a Palmaris longus muscle graft. Freedman., *et al*. used a technique in which the annular ligament was not reconstructed but the radial bone surface was deepened to achieve stability [49,53]. Several sources have been used for reconstruction of the annular ligament: grafts from the forearm fascia [9,54], vastus femoris fascia [43,55], palmaris longus tendon [12], triceps tendon [41,43], and extensor fascia [12], as well as nylon sutures [54]. However, each of these tissues has its own disadvantages. The forearm fascia and palmaris longus tendon are too weak to hold the radius. Furthermore, an additional incision is required to harvest the vastus femoris fascia. Non-absorbable synthetic suture materials, such as nylon, are intolerant and cannot accommodate the continued growth of the radius, which can lead to narrowing of the radius neck. Bell Tawse and Lloyd-Roberts., *et al*. reported good results using a triceps fascia slider [12,56]; therefore, we used the same material and obtained similarly good results.

Tan., *et al*. [57] studied the intraoperative findings in 35 pediatric patients with acute Monteggia fractures. They found that the annular ligaments were not ruptured but separated from the capsular ligaments and retracted into the radiocapitellar joint. Thus, even in patients who appeared to have achieved adequate reduction on radiographs, the annular ligament was found to be entrapped in the radiocapitellar joint. Because the annular ligament in children is very thin (2 - 3 mm), reduction and normal range of motion may occur even when the annular ligament is intraarticular. Therefore, successful reduction can be achieved even in the absence of a functional annular ligament.

Bhaskar [3] recommends that the stability of the radial head be checked intraoperatively to assess the need for ALR. If the radial head is unstable in full rotation, the length and angle of the ulna at the osteotomy site should be adjusted and stability reassessed. If the radial head is unstable despite these maneuvers, ALR should be performed.

Bone grafting of osteotomy site

The need for bone grafting can be assessed based on the gap at the osteotomy site and grafting should be used for larger gaps. Wang and Chang [58] recommended that gaps larger than 2 mm should be covered with primary bone grafting. Bhaskar [3] used bone grafting for gaps larger than 10 mm. The use of bone grafting was mentioned in five studies in this review [41,49]. Bor., *et al*. [59] presented results for patients using an Illizarov frame for correction. After a mean of 4.5 months in the frame, all the distant ends of the radius were well reduced. The mean length of the ulna was 2 cm, without the need for bone grafting or open reduction of the distal end of the radius. Ray R and Gaston M [60] showed a patient with nonunion at the osteotomy site. This was attributed to the mid-diaphyseal position of the osteotomy and the elongation of the ulna. In this study, one patient reported a 12 mm gap at the osteotomy site. Five months after surgery, the patient underwent bone grafting.

Postoperative immobilization

Most authors use postoperative splinting to preserve wound healing. Splinting duration ranges from 2 weeks [32,43] to 8 weeks [3]. Most studies use splinting for 6 weeks [58]. Splinting is performed in the neutral position [36,56] or supination position [39,50]. Immobilization in the neutral position may help prevent late loss of pronation [58].

Complications

Additional surgery to reconstruct the annular ligament may result in elbow stiffness, avascular necrosis of the radial head, heterotopic ossification, or radioulnar fusion [43].

Residual subluxation

Residual subluxation is the most common complication at follow-up [32,43,48]. Overall, surgery is associated with improved range of motion in the majority of studies [36,48,57]. ALR has been found to be associated with poorer range of motion at follow-up [3,10,20,42]. Gyr., *et al*. [43] used ALR in 15 patients. Significant loss of range of motion was observed at follow-up in both flexion-extension and supination-supination planes. Loss of pronation was the most common effect of late reconstruction on range of motion. In the series by Kim., *et al*. [20], it was observed in 11 of 15 patients.

Radial-ulnar fusion

Radial-ulnar fusion can be an important complication of open reduction of the radial head. Fusion was observed in one patient in the series by Oner and Diepstraten [47], despite no ulnar resection. Dissociation during open reduction of the radial head appears to be a greater risk factor for proximal fusion.

According to Oner and Diepstraten [47], anterior dislocations have a better prognosis after simple open reduction because the anterior curvature of the ulna (deformity in the plane of motion of the elbow) has a better potential for reconstruction than the lateral deformity of the ulna in Bado III lesions. Nonunion and hardware problems were reported only infrequently in the included studies [20,31,57].

There is a risk for the posterior interosseous nerve at the time of injury or surgery. In some studies, transient radial nerve palsy was observed preoperatively, which improved gradually [38,54,58]. There is also a risk of ulnar nerve injury in cases of progressive valgus deformity of the elbow.

Conclusion

Late open reduction of chronically dislocated radial heads in children has good to excellent results. Surgical reduction is recommended unless the radial head deformity is limited. Open reduction combined with ALR ulnar osteotomy is the most commonly performed procedure and is expected to reduce elbow pain and deformity. The degree of preoperative asymmetry associated with flexion contractures is statistically significantly correlated with follow-up elbow scores. Major complications of late treatment include radioulnar synostosis and loss of internal rotation, but these complications are uncommon and the loss of internal rotation is usually well compensated by the patient. Indications for surgery must be individualized. The decision to operate must be made by the patient, parents, and surgeon, taking into account preoperative expectations, potential complications, and postoperative recovery.

Limitations of the Study

Limitations of this study include the small patient population and the number of missed Monteggia fractures being too small to perform statistical analysis.

- Second, this is an interim report as most patients were not followed up until skeletal maturity.
- Third, the population was heterogeneous in terms of the implants used.
- Fourth, further studies are needed to evaluate the ability to limit internal and external rotation of the forearm.

Bibliography

1. Monteggia GB. Instituzioni Chirurgiche Milan, Maspero (1814).
2. Devnani AS. "Missed Monteggia fracture dislocation in children". *Injury* 28.2 (1997): 131-133.
3. Bhaskar A. "Missed Monteggia fracture in children: Is annular ligament reconstruction always required?" *Indian Journal of Orthopaedics* 43.4 (2009): 389-395.
4. Bado JL. "The Monteggia lesion". *Clinical Orthopaedics and Related Research* 50 (1967): 71-86.
5. Noonan KJ and Price CT. "Forearm and distal radius fractures in children". *Journal of the American Academy of Orthopaedic Surgeons* 6.3 (1998): 146-156.
6. Kay RM and Skaggs DL. "The pediatric Monteggia fracture". *American Journal of Orthopedics (Belle Mead NJ)* 27.9 (1998): 606-609.
7. Ring D., *et al*. "Monteggia fractures in children and adults". *Journal of the American Academy of Orthopaedic Surgeons* 6.4 (1998): 215-224.
8. Gleeson AP and Beattie TF. "Monteggia fracture-dislocation in children". *Journal of Accident and Emergency Medicine* 11 (1994): 192-194.
9. Letts M., *et al*. "Monteggia fracture-dislocations in children". *Journal of Bone and Joint Surgery. British Volume* 67.5 (1985): 724-727.
10. Stoll TM., *et al*. "Treatment of the missed Monteggia fracture in the child". *Journal of Bone and Joint Surgery. British Volume* 74.3 (1992): 436-440.
11. Bell-Tawse AJS. "The treatment of malunited anterior monteggia fractures in children". *Journal of Bone and Joint Surgery. British Volume* 47B.4 (1965): 718-723.
12. Lloyd-Roberts GC and Bucknill TM. "Anterior dislocation of the radial head in children". *Journal of Bone and Joint Surgery. British Volume* 59B.4 (1977): 402-407.
13. Hurst LC and Dubrow EN. "Surgical treatment of symptomatic chronic radial head dislocation: a neglected Monteggia fracture". *Journal of Pediatric Orthopaedics* 3.2 (1983): 227-230.
14. Steel MJ and Peterson HA. "Management of chronic posttraumatic radial head dislocation in children". *Journal of Pediatric Orthopaedics* 19.3 (1999): 306-312.
15. Kalamchi A. "Monteggia fracture dislocation in children". *Journal of Bone and Joint Surgery. American Volume* 68-A.4 (1986): 615-619.
16. Freedman L., *et al*. "Radial head reduction after missed monteggia fracture Brief report". *Journal of Bone and Joint Surgery. British Volume* 70-B.5 (1988): 846-847.
17. Lincoln TL and Mubarak SJ. "Isolated traumatic radial-head dislocation". *Journal of Pediatric Orthopaedics* 14.4 (1994): 454-457.
18. Morrey BF. "The elbow and its disorders, 3rd edition". Philadelphia: WB Sanders (2000): 262-281.
19. Speed and Boyd. "Fractures and dislocations in children". Campbell's operative orthopaedics (2013).
20. Kim HT., *et al*. "Chronic radial head dislocation in children, Part 2: results of open treatment and factors affecting final outcome". *Journal of Pediatric Orthopaedics* 22.5 (2002): 591-597.

21. McFarland B. "Congenital dislocation of head of radius". *British Journal of Surgery* 24.93 (1936): 41-49.

22. Stans AA and Heinrich SD. "Dislocations of the elbow". In: Beaty JH and Kasser JR editors. Rockwood And Green's Fracture in children. Philadelphia: Lippincott Williams &Wilkins, volume 2 (6th edition) (2006): 661-701.

23. Lincoln TL and Mubarak SJ. "Isolated traumatic radial-head dislocation". *Journal of Pediatric Orthopaedics* 14.4 (1994): 454-457.

24. Stanley D. "Isolated traumatic anterior dislocation of the radial head-a mechanism of injury in children". *Injury* 17.3 (1986): 182-183.

25. Good CJ and Wicks MH. "Developmental posterior dislocation of the radial head". *Journal of Bone and Joint Surgery. British Volume* 65.1 (1983): 64-65.

26. Kemnitz S., *et al*. "Radial head dislocation with plastic deformation of the ulna in children. A rare and frequently missed condition". *Acta Orthopaedica Belgica* 66.4 (2000): 359-362.

27. Sachar K and Mih AD. "Congenital radial head dislocations". *Hand Clinics* 14.1 (1998): 39-47.

28. Chambers HG and Wilkins KE. "Dislocation of the head of the radius". In: Rockwood CA Jr, Wilkins KE, Beaty JH, eds. Fractures in Children. Philadelphia, New York: Lippincott-Raven (1996): 873-878.

29. Bae Donald S. "Successful strategies for managing monteggia injuries". *Journal of Pediatric Orthopaedics* 36.1 (2016): S67-S70.

30. Dormans JP and Rang M. "The problem of Monteggia fracture-dislocations in children". *Orthopedic Clinics of North America* 21.2 (1990): 251-256.

31. Best TN. "Management of old unreduced Monteggia fracture dislocations of the elbow". *Journal of Pediatric Orthopaedics* 14.2 (1994): 193-199.

32. Garg R., *et al*. "Surgical management of radial head dislocation in quadriplegic cerebral palsy-a 5 year follow-up". *Journal of Hand Surgery (European Volume)* 32.6 (2007): 725-726.

33. Eygendaal D and Hillen RJ. "Open reduction and corrective ulnar osteotomy for missed radial head dislocations in children". *Strategies in Trauma and Limb Reconstruction* 2.1 (2007): 31-34.

34. Inoue G and Shionoya K. "Corrective ulnar osteotomy for malunited anterior Monteggia lesions in children. 12 patients followed for 1-12 years". *Acta Orthopaedica Scandinavica* 69.1 (1998): 73-76.

35. Jupiter JB., *et al*. "Reconstruction of posttraumatic disorders of the forearm". *Journal of Bone and Joint Surgery. American Volume* 91.11 (2009): 2730-2739.

36. Degreef I and De Smet L. "Missed radial head dislocations in children associated with ulnar deformation: treatment by open reduction and ulnar osteotomy". *Journal of Orthopaedic Trauma* 18.6 (2004): 375-378.

37. Nakamura K., *et al*. "Long-term clinical and radiographic outcomes after open reduction for missed Monteggia fracture-dislocations in children". *Journal of Bone and Joint Surgery. American Volume* 91.6 (2009): 1394-1404.

38. Oner FC and Diepstraten AF. "Treatment of chronic post-traumatic dislocation of the radial head in children". *Journal of Bone and Joint Surgery. British Volume* 75.4 (1993): 577-581.

39. Hirayama T., *et al*. "Operation for chronic dislocation of the radial head in children. Reduction by osteotomy of the ulna". *Journal of Bone and Joint Surgery. British Volume* 69.4 (1987): 639-642.

40. Horii E., *et al*. "Surgical treatment for chronic radial head dislocation". *Journal of Bone and Joint Surgery. American Volume* 84.7 (2002): 1183-1188.

41. Hannouche D and Begue T. "Functional anatomy of the lateral collateral ligament complex of the elbow". *Surgical and Radiologic Anatomy* 21.3 (1999): 187-191.

42. Gyret BM., *et al*. "Chronic Monteggia fractures in children: outcome after treatment with the BellTawse procedure". *Journal of Pediatric Orthopaedics B* 13.6 (2004): 402-406.

43. Inoue G and Shionoya K. "Corrective ulnar osteotomy for malunited anterior Monteggia lesions in children. 12 patients followed for 1-12 years". *Acta Orthopaedica Scandinavica* 69.1 (1998): 73-76.

44. Hasler CC., *et al*. "Open reduction, ulnar osteotomy and external fixation for chronic anterior dislocation of the head of the radius". *Journal of Bone and Joint Surgery. British Volume* 87.1 (2005): 88-94.

45. Lu X., *et al*. "Management of missed Monteggia fractures with ulnar osteotomy, open reduction, and dual-socket external fixation". *Journal of Pediatric Orthopaedics* 33.4 (2013): 398-402.

46. Oner FC and Diepstraten AF. "Treatment of chronic post-traumatic dislocation of the radial head in children". *Journal of Bone and Joint Surgery. British Volume* 75.4 (1993): 577-581.

47. Best TN. "Management of old unreduced Monteggia fracture dislocations of the elbow". *Journal of Pediatric Orthopaedics* 14.2 (1994): 193-199.

48. Nakamura K., *et al*. "Long term clinical and radiographic outcomes aieropen reduction for missed Monteggia fracture-dislocations in children". *Journal of Bone and Joint Surgery. American Volume* 91.6 (2009): 1394-1404.

49. David-West KS., *et al*. "Missed monteggia injuries". *Injury* 36.10 (2005): 1206-1209.

50. Bouyala JM., *et al*. "The treatment of old dislocations of the radial head in children by osteotomy of the upper end of the ulna. Apropos of 15 cases". *Revue de Chirurgie Orthopedique et Reparatrice de l'Appareil Moteur* 74.2 (1988): 173-182.

51. Bhojraj SD. "Surgical correction of malunited Monteggia fractures in children". *Indian Journal of Orthopaedics* 21.2 (1981): 138-144.

52. Freedman L., *et al*. "Radial head reduction after missed monteggia fracture Brief report". *Journal of Bone and Joint Surgery. British Volume* 70-B.5 (1988): 846-847.

53. Fowles JV., *et al*. "The Monteggia lesion in children. Fracture of the ulna and dislocation of the radial head". *Journal of Bone and Joint Surgery. American Volume* 65.9 (1983): 1276-1282.

54. Attarian D. "Annular ligament reconstruction in chronic posttraumatic radial head dislocation in children". *Contemporary Orthopaedics* 27.3 (1993): 259-264.

55. Tan JW., *et al*. "Pathology of the annular ligament in paediatric Monteggia fractures". *Injury* 39.4 (2008): 451-455.

56. Wang MN and Chang WN. "Chronic posttraumatic anterior dislocation of the radial head in children: thirteen cases treated by open reduction, ulnar osteotomy, and annular ligament reconstruction through a Boyd incision". *Journal of Orthopaedic Trauma* 20.1 (2006): 1-5.

57. Bor N., *et al*. "Chronic anterior monteggia lesions in children: report of 4 cases treated with closed reduction by ulnar osteotomy and external fixation". *Journal of Pediatric Orthopaedics* 35.1 (2015): 7-10.

58. Ray R and Gaston M. "Treatment of late-presenting Monteggia variant with an isolated, simple flexion ulnar osteotomy". *Journal of Pediatric Orthopaedics B* 23.5 (2014): 472-476.

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