Missed monteggia fracture dislocation in children: Is ulnar osteotomy alone enough without annular ligament reconstruction?

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Introduction

Neglected radial head dislocation is one of the most important frequently over-looked injuries after Monteggia fracture dislocation. This neglected injury can result in chronic pain, instability, deformity, elbow stiffness and limitation of movement [1,2]. Treatment of this neglected injury is very important as 60% of the longitudinal forces are transmitted through the radio-humeral joint in elbow extension due to the carrying angle. So, early reduction of the radial head and stabilization, during childhood, is superior to the other option of leaving the radial head dislocated to be removed after skeletal maturity following evolution of pain and functional limitation [3,4].

In the acute injury conservative treatment is the best option. As long as the length of the ulna is restored and maintained, a stable reduction of the radial head dislocation is indirectly achieved. This may be achieved by closed reduction and immobilization in a cast or intramedullary percutaneous osteosynthesis of the ulna.

There is great controversy in the management of chronic cases after 30 days from initial injury [1]. Some authors advocate that the radial head was left in the dislocated state or would be removed at skeletal maturity when symptomatic with pain and functional limitation [5]. Others suggested open reduction, as over time flexion deformity, progressive valgus instability, pain, and limitation of elbow and forearm movement may occur [1]. Several techniques of open reduction have been proposed for the treatment of neglected Monteggia fractures-dislocations including reduction of dislocated radial head and reconstruction of the annular ligament [5], reduction of dislocated radial head associated with radial head shortening osteotomy [6], reduction of dislocated radial head with osteotomy of the ulna at the site of the initial deformity [7], or at the proximal ulnar metaphysis [5].

The purpose of this study is to present the radiographic and the functional outcomes of treating neglected Monteggia injuries by correction of the ulnar shortening and angular deformity to obtain stable reduction of the neglected dislocation of the radial head without annular ligament reconstruction.

Patients and methods

This retrospective study was conducted with approval of Ethics Committee of the University Hospitals. Inclusion criteria included pediatric patients with missed Monteggia fracture dislocation presenting more than four weeks from initial trauma. The duration from injury to surgery varied in our study from 4 to 24 months (Mean 10.47; SD 6.11). The exclusion criteria included distortion of the radial head, neurovascular...
injury and previous surgery for such injury. The study included 15 patients with an average age of 8.67 (Range 5-12.2; SD 2.03) years treated from January 2012 till April 2016. Ten patients (66.7%) were males, and five (33.3%) were females. According to Bado classification (Table 1) [8], thirteen cases were type I with anterior dislocation of radial head and two cases were type III with lateral dislocation.

Table 1: Monteggia fracture dislocation– classification according to Bado [8].

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Anterior dislocation of radial head, anterior angulation of ulnar shaft fracture.</td>
</tr>
<tr>
<td>II</td>
<td>Posterior dislocation of radial head, posterior angulation of ulnar shaft fracture.</td>
</tr>
<tr>
<td>III</td>
<td>Lateral dislocation of radial head, proximal metaphyseal fracture of ulna.</td>
</tr>
<tr>
<td>IV</td>
<td>Anterior dislocation of radial head, shaft fracture of ulna and radius.</td>
</tr>
</tbody>
</table>

In most of cases, the ulna fracture had united with anterior angulation in 13 patients, the diagnosis of dislocation was missed and the patients were treated for ulnar fracture only. Two patients had plastic deformation of ulna which was unrecognized and missed in the initial radiograph. Table 2 provides a summary of the patients’ characteristics.

At initial presentation, the most common complaints were limited elbow flexion, pain, valgus instability, radial head prominence, and wrist pain specially in long standing cases due to ulnocarpal impaction. We assessed elbow function for activity pain, range of motion (ROM), deformity and function.

Nine patients complained of pain. Seven children complained of annoying elbow appearance due to anterior prominence of the radial head. Last 20-30° of flexion was restricted in seven cases and nine cases with pain had progressive elbow valgus. Two children had flexion contracture of 10°. In eight cases, there was moderate restriction of pronation-supination ROM and mild restriction in five cases. Two children exhibited motion comparable to opposite elbow.

Radiographs revealed anterior bowing deformation of the ulna and the position of the dislocated radial head. CT was used to visualize the dysplastic changes of the radial head.

Table 2: Preoperative data and operative procedures

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (years/month)</th>
<th>Sex</th>
<th>Bado type</th>
<th>Duration from injury (months)</th>
<th>Technique</th>
<th>Follow up Period (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.5</td>
<td>M</td>
<td>I</td>
<td>10</td>
<td>UO+OR</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>F</td>
<td>I</td>
<td>9</td>
<td>UO+OR</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>12.2</td>
<td>F</td>
<td>I</td>
<td>4</td>
<td>UO+IR</td>
<td>22</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>M</td>
<td>I</td>
<td>16</td>
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<td>26</td>
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<tr>
<td>5</td>
<td>6</td>
<td>M</td>
<td>1</td>
<td>10</td>
<td>UO+OR+KW</td>
<td>24</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>M</td>
<td>1</td>
<td>9</td>
<td>UO+OR+KW</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>11</td>
<td>M</td>
<td>III</td>
<td>24</td>
<td>UO+OR+KW+BG</td>
<td>21</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>F</td>
<td>I</td>
<td>5</td>
<td>UO+KW+IR</td>
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</tr>
<tr>
<td>9</td>
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</tr>
<tr>
<td>11</td>
<td>8.7</td>
<td>M</td>
<td>1</td>
<td>7</td>
<td>UO+OR+KW</td>
<td>16</td>
</tr>
<tr>
<td>12</td>
<td>10</td>
<td>M</td>
<td>1</td>
<td>6</td>
<td>UO+OR+KW</td>
<td>18</td>
</tr>
<tr>
<td>13</td>
<td>10.5</td>
<td>M</td>
<td>III</td>
<td>20</td>
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</tr>
<tr>
<td>14</td>
<td>6.8</td>
<td>F</td>
<td>1</td>
<td>8</td>
<td>UO+OR</td>
<td>22</td>
</tr>
<tr>
<td>15</td>
<td>9.5</td>
<td>M</td>
<td>1</td>
<td>4</td>
<td>UO+IR</td>
<td>14</td>
</tr>
</tbody>
</table>


Surgical Technique:

Under general anesthesia, the patients were placed in a supine position with the elbow semi-flexed and the forearm pronated on a conventional surgical table. Above elbow tourniquet was used in all cases. The elbow was accessed using Boyd’s posterolateral elbow approach where a single incision was made to expose the radio-capitellar joint and the proximal ulna [9,10].

The radio-capitellar joint was cleansed of fibrous tissue and the remnants of the annular ligament residue hindering radial head reduction. Transverse proximal metaphyseal ulnar osteotomy was performed using an oscillating saw. The osteotomy distraction angulation opening allowed reduction of the radial head by tensioning the interosseous membrane. The degree of angulation was determined so as to enable congruent reduction of the radial head.

The osteotomy was then fixed after opening of the wedge by a small dynamic compression plate after over-contouring and applied on the posterior surface of the ulna with fixation by three screws on each side of the osteotomy. In three cases (No 2, 3, 8) the radial head reduced without opening of radio-capitellar joint by indirect reduction. Radial head stability was tested in all axes of elbow motion. If instability persisted after reaching the maximum angulation distraction of the osteotomy, a transcapitellar radial pinning was done to maintain reduction of the radial head. A Kirschner wire was drilled percutaneously through the capitellum into the radial head with the elbow in full supination to tighten the interosseous membrane and 90 degrees of flexion. This was needed in ten patients (No. 4 to 13). The patients who required trans-capitellar K wire fixation
were older and with longer period of missed dislocation than those who did not require it.
Iliac bone graft was needed in ten patient in which the gap of the osteotomy was more than 1 cm after angulation distraction (No. 4, 7, 13).
The limb was immobilized in above elbow cast with the forearm in supination. After 3 weeks, the cast and the transcapitellar wire were removed, and then patients started gradual progressive range of motion.
There was no case with breakage of the trans-capitellar K wire prior to removal. Radiographs were taken after cast removal and at follow up to detect any residual subluxation and healing of the osteotomy.
All patients were reviewed at four weekly intervals for initial assessment of motion for three months; then at three- month intervals to assess the final outcome and function.
The plate was removed after about 12 months postoperatively.

Fig. (1): Preoperative lateral and anteroposterior radiograph of the elbow showing missed Monteggia fracture dislocation with malunited ulnar fracture with anterior angulation and anterolateral dislocation of the head of radius

Fig.(2): (A&B) Immediate postoperative radiograph of the same patient showing sliding angulation osteotomy of the ulna with plate and screws fixation and transcapitellar K wire with reduced radial head and bone grafting of the osteotomy

Fig.(3): Last follow up lateral and anteroposterior radiograph of the same patient after removal of the plate and screws show well-contained radial head and good remodeling at osteotomy site

Fig.(4): Clinical photograph of the same patient at 2 years follow-up showing full elbow (A) supination (B) pronation, (C) flexion, (D) Extension, (E) wrist extension and (F) flexion
The patients were evaluated using the Mayo Elbow Performance Score (MEPS) as excellent, good, fair and poor (Table 3) [11]. This scoring system has 4 parameters with 45 points given for a pain-free elbow, 20 points for normal elbow movement, 10 points for a stable elbow, and 25 points for performance of five activities of daily living. Stability of the elbow is rated as stable (no apparent varus/valgus instability), moderate (<10° varus/valgus instability), or gross (≥10° varus/valgus instability).

### Table 3: The Mayo Elbow Performance score (MEPS) [11]

<table>
<thead>
<tr>
<th>Pain Intensity</th>
<th>Arc of Motion</th>
<th>Stability</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>≥250 degree</td>
<td>Stable</td>
<td>Can comb hair 5</td>
</tr>
<tr>
<td>Mild</td>
<td>From 200-250 degree</td>
<td>Moderate instability 5</td>
<td>Can eat 5</td>
</tr>
<tr>
<td>Moderate</td>
<td>≤ 200degree</td>
<td>Gross instability 0</td>
<td>Can perform hygiene 5</td>
</tr>
<tr>
<td>Severe</td>
<td>0</td>
<td>Stable</td>
<td>Can don shirt 5</td>
</tr>
</tbody>
</table>

### Interpreting the Mayo Elbow Performance Score

<table>
<thead>
<tr>
<th>Excellent</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
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<tbody>
<tr>
<td>≥90</td>
<td>75-89</td>
<td>60-74</td>
<td>≤60</td>
</tr>
</tbody>
</table>

### Statistical analysis:

This was done by means of IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY, USA) with setting the significance level set at p<0.05. For descriptive statistics, frequencies and percentages were used for nominal and ordinal variables, while means, Standard Deviations (SD), and ranges were applied for scale variables. Paired-samples t-test was used for comparative analysis. Correlation studies were done by the Spearman correlation coefficient.

### Results

The mean operative time was 65 minutes. The follow-up period averaged 21 (Range 18-26; SD 2.95) months. The ulnar osteotomy united in good position with normal length and slight overcorrection of angulation of ulna in all patients. The mean healing time of ulnar osteotomy was 8.47 (Range 7-13; SD 1.55) weeks. Fourteen patients (93.33%) achieved good range of motion (ROM) with normal length, Standard Deviations (SD), and ranges were applied for scale variables. Paired-samples t-test was used for comparative analysis. Correlation studies were done by the Spearman correlation coefficient.

- One patient (case number 7) had residual posterior radial head subluxation which may be due to exaggerated over-angulation of the osteotomy. The mean flexion-extension ROM was 120.67° (Range 90°-145°; SD 14.5) preoperatively, and 134.67° (Range 110°-145°; SD 8.55) postoperatively with a mean increase in ROM by 14°. Paired-samples t-test showed significant improvement of the postoperative ROM compared to the preoperative values (p = .006). On the other hand, there was no significant change (p = .881) in pronation-supination ROM between the preoperative and postoperative times (Mean 163°; Range 140°-180°; SD 11.15) and the postoperative ROM (Mean 163.67°; Range 140°-180°; SD10.77). The range of pronation was less than that of supination. This may be due to the position of immobilization in supination or due to trans-capitellar pinning. Patients treated earlier had a greater range of movements than those treated later. At the last follow-up visit, flexion and extension showed significant improvement (P < 0.05) as did MEPS, especially as regards of the range of motion and stability (P < 0.01) (Table 2). Patients operated on less than 1 year post-trauma showed clinically significant improvement in flexion and MEPS (P < 0.01), unlike those operated on later, the difference between these 2 groups being significant (P < 0.05).

Table 4 shows the preoperative and postoperative assessment according to MEPS. At the final follow-up, no patient had any sign of instability. Based on the MEPS, the results were excellent in eight patients (53.3%), good in five patients (33.3%), fair in one patient (6.7%), and poor in one patient (6.7%). One patient (case number 7) had residual posterior radial head subluxation identified by the radio-capitellar line which eventually affected the extension range of motion. Transient posterior interosseous nerve palsy occurred in one case (6.7%) which was recovered after 4 months. Two cases (number 7, and 13) had exertional pain. Two patients (13.33%) also had superficial wound infection which was treated by local wound care and oral antibiotics.
Discussion
The disability associated with neglected radioulnar dislocation after a Monteggia fracture-dislocation includes restriction of forearm rotation, pain, valgus elbow instability, tardy ulnar nerve palsy, degenerative arthritis, and subluxation of the distal radio-ulnar joint [12]. The cornerstones for good results are early diagnosis of the injury and a stable reduction of the dislocated head radius, which requires an anatomical reduction of the ulnar fracture [13].

The treatment of missed Monteggia fracture-dislocation in children is still open to controversy. The first question often raised is for how long a neglected dislocation may be accepted as being reversible before the secondary adaptive changes disrupt the end result. This interval varied among authors and ranges from 6 months to 6 years [2, 14]. Another important point to achieve a good functional outcome is the maximum age of the patient undergoing potential bone remodeling. Five patients of the current series were over 10 years at the time of surgery, with the oldest being 12.2 years of age.

In chronic radial head dislocation following a Monteggia fracture, several surgical methods have been reported to reduce and maintain the dislocated radial head. Most authors suggest open reduction of the radial head [1, 2, 15] and removal of the interposition scar tissues to facilitate the reduction. However, there are series of relocating the head without opening the radio-capitellar joint [16, 17].

In the present series, relocating the dislocated radial head was obtained indirectly without opening the radio-capitellar joint in three patients after ulnar osteotomy by increasing angulation and distraction. This allowed maximum tensioning of the interosseous membrane which created a posterior pulling force on the radius. These three patients have the least duration of missed dislocation. In the remaining thirteen patients, open reduction was done after removing the scar tissue and remnants of the annular ligament to facilitate reduction. Annular ligament remnants may be a part of a fibromeniscoid tissue, but it is generally not distinguishable at the time of surgery [18].

It is important to remove the scar tissue to facilitate reduction of the radial head in cases of missed dislocation more than six months. At the same time, open reduction of the radial head may prevent the risk of nerve entrapment [19].

Open reduction alone may not be enough to achieve and maintain reduction of the dislocated radial head and has been used only in a limited number of studies [18]. De Boek [20] operated four patients with chronic radial head dislocation (RHD) using only open reduction without ulnar osteotomy or ALR, with good results. However, patients with deformed ulna or malunited ulnar fractures were excluded from this study, so we considered that ulnar osteotomy is the key in achieving and maintaining reduction as it directly addresses the primary deformity in the ulna. Altered length and the angulation of the ulna in the opposite direction to the dislocation of the radial head are the most important obstacle leading to persistence of RHD. The aim of ulnar osteotomy is to restore the width of the interosseous membrane through maintaining the normal relationship between the radius and the ulna. As the forearm bones behave as a joint unit in supination and pronation, the interosseous membrane is an important factor in maintaining the stability of the radio-capitellar joint.

The osteotomy depends on the interosseous membrane to pull the radial head back to the anatomical position. The radio-capitellar joint is very sensitive to the deformity of the ulna. So, subtle changes in the ulnar alignment, as in plastic deformation, can lead to radial head subluxation. Therefore, osteotomy of the ulna is an essential procedure in the correction of the pathological anatomy of the lesion.

The amount of angulation and elongation at the osteotomy site is intraoperative decision till relocating the dislocated head. Then, the stability was tested in all planes of elbow motion to decide the need for trans-
capitellar radial pinning by k wire. The wire must be thick enough to avoid breakage before removal.

Trans-capitellar pinning was needed in nine patients (Table 2). Most of these children had duration of missed dislocation of more than six months, and had an average age of two years older than those did not need pinning.

Nakamura et al. [21] used a pre-operative tracing on lateral radiographs to determine the dorsal angulation and the amount of ulnar elongation required for correction.

In the current study, ulnar osteotomy was done at the metaphyseal-diaphyseal junction to reduce the risk of non-union and to have enough proximal length to accommodate three cortical screws. Some authors did the osteotomy at the site of maximum deformity [22]. A proximally located osteotomy has the advantage of preserving as much as possible of interosseous membrane, creating more reduction force for reduction of the radial head, and maintaining forearm rotations [23]. Ulnar osteotomies should be fixed to maintain reduction of the radial head [24]. We used over-contoured plate and six screws to fix the osteotomy. This provided more rigid fixation with a lower risk of late loss of reduction. Most of recent studies recommend this [22,25].

Regarding annular ligament reconstruction (ALR), its role in maintaining radial head reduction has never been critically analyzed. Some authors have advocated its use in every case that requires open surgery on the radio-capitellar joint [26]. There is no consensus on the need for ALR, although majority of the studies have used it in all or some of their patients [18, 26, 27]. Others believed that reconstruction of the annular ligament was not necessary and the ulnar osteotomy alone is enough for relocating the dislocated radial head. They believe that ulnar osteotomy plays the most important role in achieving anatomical reduction of the radial head [28-30].

Rahbek et al. [31] compared functional outcomes between six patients treated by ulnar osteotomy alone, with 10 patients treated by ligament reconstruction with ulnar osteotomy. They reported no significant difference between the two groups.

Bhaskar [26] tested the intra-operative stability of the radial head in full pronation after adjustment of the ulnar length and angulation to assess the need for annular ligament reconstruction. Five of his 12 cases required ALR. He did not use trans-capitellar pin in any case.

ALR is not sufficient as a single procedure. Oner and Diepstraten [32] operated on seven patients with chronic RHD using ALR without ulnar osteotomy. Two patients in this series had persistent subluxation of the radial head.

Tan et al. [33] studied the intraoperative findings in 35 pediatric patients with acute Monteggia fractures. They found that the annular ligaments detached from the capsular ligament and retracted into the radio-capitellar joint and were not ruptured. Thus, even in those patients who achieved anatomical reduction radiographically, the annular ligament was found entrapped in the radio-capitellar joint. As the annular ligament in children was very thin (2–3 mm), relocation and normal range of movements were possible even with the annular ligament entrapped in the joint. Thus, successful reduction is possible even in the absence of a functional annular ligament.

The most commonly used tissues for ALR is triceps fascia, forearm fascia and Palmaris longus tendon [26,34]. However, there are many reported hazards or complications with ALR including (1) requirement of longer or additional skin incisions, (2) more soft tissue stripping [22, 35], (3) Donor site morbidity, (4) restriction of the rotation of the radial neck specially pronation [39], (5) avascular necrosis of the radial head (6) Notching of the radial neck [32], (7) myositis ossificans, (8) nerve injury, (9) re-displacement of the radial head [36, 37], (10) Radio ulnar synostosis [38], and (11) redisplacement of radial head [26].

Some authors have reported that ALR is not necessary [18, 29]. Bhaskar [26] documented the importance of alignment of the ulna in keeping radial head stability and sub-sequentially reconstruction of the annular ligament is not always necessary. In that study, he reported similar clinical outcomes with and without ligament reconstruction. He performed annular ligament reconstruction only when the stability of the radio-capitellar joint could not be maintained after ulnar osteotomy over angulation and distraction.

In the present study, we removed only the interposed soft tissues of the radiocapitellar joint while preserving the lateral collateral ligament. Trans-capitellar K wire fixation was only done when reduction cannot be maintained. This was needed in ten patients. Thick trans-capitellar K wire was kept for three weeks combined with four to six weeks of long-arm cast to reduce the risk of K wire breakage. Regarding bone grafting of ulnar osteotomy we needed to do bone graft in three patients in which the osteotomy gap was 1 cm or more. No case suffered delayed or non union. This was comparable with Bhaskar [26]. Wang and chang [22] used bone graft with gaps of more than 2 mm. Trans-capitellar k wire may be important cause of loss of range of motion specially pronation. However, Rahbek et al. [31] found no significant difference in radiological or function scores between two groups of patients with and without using transcapitellar K wires. Also, Song et al. [27] reported no compromise in function with trans-capitellar wiring and immobilization for 6 weeks. So, indications for the use of a trans-capitellar wire cannot be generalized, but it can be avoided in patients with a stable reduction after ulnar osteotomy over angulation.

The remodeling potential in cases with Bado type I (deformity in the plane of elbow movement) is better than those with Bado type III with lateral deformity of the ulna. So, we had poor results in our series with Bado type III and this result is comparable with Delpont et al. [38]. This was seemed to be due to less effective radial head traction via the interosseus membrane with lateral dislocation of the radial head. In such cases with lateral dislocation (Bado type III) the corrective osteotomy should create a medial or postero-medial opening to enable relocation of the radial head.
Conclusion

Missed Monteggia fracture dislocation with persistent dislocation of radial head is a relatively rare injury, but needs surgical treatment as early as possible to prevent long-term disabilities. The malunion or plastic deformity of the ulna leading to an altered radioulnar relationship needs to be corrected to reconnect the radial head into position. Angulation and lengthening osteotomy of the ulna is the current recommended surgical procedure to achieve and maintain relocation of the radial head. The technique of angulation distraction osteotomy with plate fixation is a simple and technically less demanding procedure, which achieves lengthening and angulation simultaneously. Annular ligament reconstruction does not seem to be mandatory and is not without complication.

References:
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17- Kawoosa AA et al. Stable relocation of the radial head without annular ligament reconstruction using the Ilizarov technique to treat neglected Monteggia fracture: two case reports. 2010, J Med Case Rep 4:344.


