Missed Monteggia fracture in children: is annular ligament reconstruction always required?

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Received: 7 April 2009 / Accepted: 26 August 2009 / Published online: 19 September 2009
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Abstract

Background Missed radio-capitellar joint dislocation is one of the feared complications of Monteggia fractures, especially when associated with subtle fractures of the ulna bone. Many treatment strategies have been described to manage the chronic Monteggia fracture and the need for annular ligament reconstruction is not always clear. This study is an attempt to address the issue of annular ligament reconstruction in the surgical management of missed Monteggia fracture.

Materials and methods A retrospective study was performed in 12 patients who presented with missed Monteggia fracture. All children underwent open reduction of the radio-capitellar joint. Five children (Group A) were treated with ulna angulation–distraction osteotomy and annular ligament reconstruction, and six cases required only an ulna angulation–distraction osteotomy without ligament reconstruction. The duration of missed dislocation was from 3 to 18 months (mean 9 months). Ten patients were classified as Bado I, and one each as Bado II and III, respectively.

Results The mean follow up period was 22 months. All ulna osteotomies healed uneventfully. The mean loss of pronation was 15° in Group A and 10° in Group B. Elbow flexion improved from the preoperative range and no child complained of pain, deformity and restriction of activity. In one case (Group A), there was 3 mm of radiographic subluxation of the radial head, but this child was clinically asymptomatic. The elbow score was excellent in ten cases and good in two cases.

Conclusion Distraction–angulation osteotomy of the ulna suffices in most cases of missed Monteggia fracture and the need for annular ligament reconstruction is based on the intra-operative findings of radial head instability.

Keywords Missed Monteggia · Annular ligament reconstruction · Ulna osteotomy

Introduction

Delayed diagnosis is a known complication observed after acute Monteggia fracture and its equivalents. This usually occurs if there is a lapse in diagnosis or if the injury films have been inadequately taken. Classical teaching amongst orthopaedic residents still emphasises the need to take bi-planar radiographs in any limb injury with clear visualisation of the joints proximal and distal to the injured segment of bone. It is not uncommon to see that, in many missed Monteggia fracture, either the X-rays have been less than optimal or the injury has been completely overlooked.

A late or missed Monteggia lesion is defined as one presenting 4 weeks after the initial trauma [1, 2].

The indications for surgery in children with chronic Monteggia fracture are unclear. Rarely does the child get

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pain and functional limitations are minimal. Progressive valgus deformity of the elbow, limitation of forearm rotation and pain with strenuous activity are some of the reported indications for surgery [3, 4].

The true incidence of missed Monteggia fracture is not known, but the management of the chronic injury poses several challenges. The difficulty of obtaining a satisfactory function is directly proportional to the duration of 'missed dislocation.' This is because the surgical strategies required to achieve an anatomical reduction become proportionally complex as the duration of the 'missed dislocation' increases [5, 6]. Kim et al. [5, 7] have discussed the dysplastic changes which occur in the radio-capitellar joint and the role of radial osteotomy and ulna notchplasty in some long-standing cases.

Several treatment options are available to manage this difficult problem: open reduction of the radio-capitellar joint is almost always required and some form of ulna osteotomy is needed to maintain the radial head in position. There is no clear consensus if annular ligament reconstruction is required to stabilise the radial head. Some authors have performed ligament reconstruction in every case, whereas others have reported its use only when there is residual instability of the radial head after ulna osteotomy [7, 8]. Also, annular ligament reconstruction is not without complications, hence, its use in every case may not be required [4, 9–13].

There have been recent reports using external fixation with gradual lengthening and angulation of the ulna osteotomy leading to radial head reduction without even the need for exposing the radio-capitellar joint [14–16]. This suggests that annular ligament reconstruction is not always required to achieve stability of the radial head.

No single treatment will fit exactly in managing every case of missed Monteggia fracture and a rationale approach is recommended on a case-to-case basis [17].

The purpose of this study is to highlight the management of missed Monteggia fracture with particular emphasis on the utility of annular ligament reconstruction.

Materials and methods

Twelve cases of chronic Monteggia fracture treated between 2002 and 2008 were reviewed retrospectively at the Children Orthopaedic Clinic, Mumbai, India. The mean age was 7.4 years (range 4–12 years) and there were seven boys and five girls in the study. The mean duration from initial injury to presentation, i.e. 'missed dislocation' was 9 months (range 3–18 months). Ten cases were Bado [18] type I injury, where the radial head had dislocated anteriorly, one was type III (Case 7) where there was lateral dislocation of the radial head and one case (Case 5) was

treated by external fixation of the ulna that progressed to non-union with posterior angulation of the ulna and posterior dislocation of the radial head, i.e. type II pattern.

In all cases, except one (Case 5), the ulna fracture had united.

For the study, informed consent was sought from the parents and the children's records were available for review.

Presenting symptoms and signs

The details of the 12 patients and treatment regimens are given in Table 1. At initial presentation, only three patients complained of pain. Two of them had cubitus valgus of 15° (Cases 7 and 8) and one patient had a painful non-union of the ulna (Case 5). Seven children were dissatisfied with their elbow appearance and complained of 'popping-like sensation' due to anterior prominence of the radial head.

The forearm and elbow motion was compared to the opposite uninjured elbow of the same child. The mean normal flexion was 13°, the mean carrying angle was 10° and the mean pronation and supination was 85° and 90°, respectively. All movements were recorded from a neutral position: neutral rotation and extension were recorded as 0°. Since many children have hyperextension due to elbow laxity, this was recorded as the number of degrees beyond neutral extension. Details of the range of motion in the normal and affected elbows are given in Table 2. Terminal 10–20° of flexion was restricted in nine cases and two cases with pain had progressive elbow valgus (Cases 7 and 8). The carrying angle measured 15° in these two cases, with the normal being 10°. Two children had flexion contracture of 10° (Cases 8 and 9). One patient had complete loss of supination (Case 5) and, in four cases, there was terminal restriction of 10°. Pronation was mildly restricted in three cases. In one case, an external fixator was applied for the treatment of missed Monteggia fracture, but this technique had failed and this patient presented with painful non-union of the ulna, shortening and deformity of the forearm, and gross limitation of elbow motion (20–60° of flexion was present. This patient had complete loss of supination (Case 5). No child had any neurovascular deficit.

No pre-operative computed tomography (CT) scans or magnetic resonance imaging (MRI) scans were done to assess the shape of the radial head, capitellum and elbow joint.

Treatment

All patients underwent surgery using the posterolateral approach described by Boyd [19], where a single incision was made to expose the radio-capitellar joint and the ulna

Table 1 Details of the 12 patients with missed Monteggia fracture

Case	Age (years)	Gender (type)	Bado	D ^a	Group	Signs	Pain	FU ^b (months)
1	7.2	B	I	8	A	Ant prominence	Nil	22
2	6.3	G	I	7	A	Ant prominence	Nil	21
3	7.4	B	I	18	A (BG)	Ant prominence	Nil	23
4	6.2	G	I	9	A	Nil	Nil	25
5	8.9	G	II	6	A (BG)	Ulna non-union	Pain	14
6	4.3	B	I	3	B	Ant prominence	Nil	8
7	6.4	G	III	8	B	15° valgus elbow	Pain	24
8	5.6	B	I	14	B	15° valgus elbow	Pain	26
9	8.7	B	I	9	B	Nil	Nil	24
10	6.9	B	I	9	B	Ant prominence	Nil	26
11	12.2	B	I	10	B (BG)	Ant prominence	Nil	25
12	9.3	G	I	7	B	Ant prominence	Nil	26

BG bone grafting done

Group (treatment group): A annular ligament reconstruction performed, B annular ligament reconstruction not performed

^a D duration of missed dislocation, i.e. time since injury

^b FU follow up period in months

Table 2 Elbow function in the 12 patients

Case	Age	Range of motion						Treatment group
		Normal unaffected elbow		Affected elbow				
		flex/n/ext	pro/n/sup	Pre-operative flex/n/ext	Post-operative flex/n/ext	Pre-operative pro/n/sup	Post-operative pro/n/sup	
1	7.2	140-0-5	90-0-80	140-0-5	130-0-0	90-0-80	80-0-80	A: ulna plating
2	6.3	135-0-5	90-0-80	120-0-5	130-0-5	90-0-80	70-0-80	A: K-wire fixation of the ulna
3	7	130-0-5	90-0-90	120-0-0	130-0-0	80-0-70	70-0-70	A: ulna plating + BG
4	6.2	140-0-0	90-0-80	130-0-5	110-0-0	90-0-90	70-0-80	A: ulna plating
5	8.9	140-0-5	80-0-90	60-20 (FFD)	120-10 (FFD)	80-0-0	70-0-40	A: ulna plating + BG
6	4.3	130-0-0	80-0-90	130-0-5	130-0-5	90-0-90	80-0-90	B: only open reduction done
7	6.4	140-0-5	90-0-90	140-0-5	130-0-0	90-0-80	80-0-80	B: K-wire fixation of the ulna
8	5.6	130-0-0	80-0-90	130-10 (FFD)	140-0-0	80-0-90	80-0-80	B: ulna plating
9	8.7	140-0-5	90-0-90	130-10 (FFD)	140-0-5 (FFD)	90-0-80	80-0-90	B: ulna plating
10	6.9	135-0-5	80-0-90	130-0-5	120-0-0	90-0-80	90-0-80	B: K-wire fixation of the ulna
11	12.2	135-0-5	90-0-80	120-0-0	130-0-0	90-0-90	80-0-80	B: ulna plating + BG
12	9.3	140-0-5	80-0-90	140-0-5	130-0-0	80-0-90	80-0-80	B: ulna plating

FFD fixed flexion deformity, flex/n/ext full flexion, neutral, full extension, pro/n/sup pronation/neutral/supination

K-wire Kirschner wire fixation of the ulna, BG autogenous bone graft used

bone. An open reduction of the radio-capitellar joint was performed in all cases and an ulna angulation–distraction osteotomy was performed in ten cases. Five of these children who underwent annular ligament reconstruction were classified as Group A and seven cases where no ligament reconstruction was performed were classified into Group B. The radio-capitellar joint was first approached and all fibrous tissue and remnants of the annular ligament were excised to facilitate reduction of the radial head. Although the radial head appeared enlarged, there were no gross

dysplastic changes in the radial head and capitellum. In one case (Case 6), simple excision of the scar tissue was sufficient and no ulna osteotomy was required to maintain radio-capitellar stability. In nine cases, an ulna apex–posterior osteotomy was performed, and in one case with type III dislocation, an apex–medial osteotomy was performed. The osteotomy site was fixed with a wire or plate, depending on the size of the bone. The amount of angulation and distraction required to maintain the radial head in position was determined intra-operatively.

The osteotomy site was provisionally fixed with a Kirschner wire or a plate with two screws, one proximal and one distal to the osteotomy, and the radio-capitellar stability was assessed in pronation and supination. The radio-capitellar joint is most stable in full supination and it usually slips out with pronation, depending on the inclination and shortening of the ulna. If the radio-capitellar joint was unstable in pronation and did not remain stable after changing the ulna angulation and distraction, then an annular ligament reconstruction was performed to augment the radial head stability. This was required in five cases, and in six cases, only the adjustment of the ulna angulation and fixation sufficed to stabilise the radial head. For annular ligament reconstruction, the lateral slip of the triceps fascia was harvested and its distal attachment to the ulna was preserved. This was then passed around the radial neck and sutured to itself and the periosteum of the proximal ulna. The ulna osteotomy was fixed with a 3.5-mm reconstruction plate in four cases and with a single Kirschner wire in one case.

The ulna plate was applied on the dorsal surface of the bone and, in two cases (Cases 3 and 5), a temporary trans-capitellar pin was inserted intra-operatively to assess the optimal alignment of the ulna before its fixation. This pin was removed once the osteotomy was fixed. In no case was a trans-capitellar wire left in situ and no case required a radius osteotomy.

In two cases (Cases 3 and 11) where the osteotomy distraction gap was greater than 10 mm, the residual gap was filled with autograft taken from the iliac crest. The case with ulna gap non-union underwent plating and bone grafting too (Case 5).

In six cases, the ulna angulation and length restoration was all that was required to maintain reduction of the radio-capitellar joint. Two osteotomies were fixed with Kirschner wires and, in four cases, a 3.5-mm reconstruction plate was used.

Post-operatively, all patients had their elbows immobilised in an above-elbow cast, which was kept for 8–10 weeks with the elbow in 90° flexion and full supination. After cast removal, the patients were referred for physiotherapy.

Radiographs were taken after cast removal and at follow up to detect any residual subluxation and healing of the ulna osteotomy.

The mean follow up period was 22 months (range 8–26 months). At the last follow up, all patients were rated according to the functional elbow score devised by Kim et al. [7]. The elbow was assessed for deformity, pain, range-of-motion and function. The four parameters were weighted equally, 25 points each, for a perfect score of 100 points: (1) deformity: 25, no concern; 15, minor concern; 0, major concern; (2) pain: 25, no pain; 15, intermittent mild

pain but not limiting activities; 0, pain, limiting activities; (3) range of motion (sum of the flexion–extension and pronation–supination arcs): 25, >250°; 15, 250°–200°; 0, <200°; (4) function: five activities of daily living (comb hair, feed self, open door knob, hold on to subway overhead rail, put on shoes with hands) were identified and were given a weight of five points each if the patient could perform such tasks without a problem. If the patient could not accomplish these tasks, a zero was given for each task that he or she failed to perform without difficulty. The total elbow performance score was graded as excellent (90 or more points), good (89–75 points), fair (74–60 points) or poor (<60 points).

Results

The patients were divided into two groups: Group A children underwent an ulna osteotomy and annular ligament reconstruction and Group B children had only an ulna osteotomy, without annular ligament reconstruction.

The mean age in Groups A and B was 6.8 and 7.1 years, respectively, and the mean duration of ‘missed dislocation’ was 9.6 and 8.5 months, respectively.

The mean healing time for the ulna osteotomy for all children was 8 weeks (range 6–14 weeks). The elbow range of motion was recorded for all patients.

The mean loss of elbow flexion (10°) was comparable between the groups. The mean loss of pronation was 15° and 10° in Groups A and B, respectively. Supination was mildly restricted in three cases (<10°). One child in Group A (Case 4) had re-subluxation of the radial head which did not require any treatment. One child in Group B had superficial wound infection which resolved with local dressing. No infection was seen in Group A.

Comparing the flexion–extension and pronation–supination arcs in both groups, for Group A, excluding the case of non-union (Case 5), the mean flexion arc reduced by 20°. In group B, there was a mean gain of 10°. The pronation–supination arc reduced in both groups (excluding Case 5) with a mean loss of pronation of 15° and 10° in groups A and B, respectively. The fixed flexion deformity (FFD) in one patient (Case 8) completely corrected and, in one case (Case 9), terminal FFD of 5° was present but this did not compromise the result. Case 5 in Group A had gross restriction of movement pre-operatively but improved considerably after surgery. The flexion arc improved from 40° to 110° and the pronation–supination arc improved from 80° to 130°. The details are given in Table 3.

No child complained of activity-related pain or disability in daily functioning. No child complained of the ‘popping sensation’ experienced earlier. The carrying angle

Table 3 Details of the pre- and post-operative flexion–extension arcs and rotational arcs in 12 patients

Case	Flexion arc (°)					Pro/supination arc (°)			
	Normal side	Pre-operative	Post-operative	Change	Pain	Pre-operative	Post-operative	Change	Kim's score
1	145	145	130	–15	Nil	170	160	–10	Excellent
2	140	125	135	10	Nil	170	150	–20	Excellent
3	135	120	130	10	Nil	150	140	–10	Excellent
4	140	135	110	–25	Nil	180	150	–30	Excellent
5	145	40	110	70	Nil	80	130	50	Good
6	130	135	135	0	Nil	180	170	–10	Excellent
7	145	145	130	–15	Nil	170	160	–10	Excellent
8	130	120	140	20	Nil	170	160	–10	Excellent
9	145	120	145	25	Nil	170	170	0	Excellent
10	140	135	120	–15	Nil	170	170	0	Excellent
11	140	120	130	10	Nil	180	160	–20	Good
12	145	145	130	–15	Nil	170	160	–10	Excellent

Negative value indicates loss of motion

was restored to normal 10° in the two cases with elbow valgus (Cases 7 and 8).

Radiographs revealed that the osteotomy site had healed well by 8 weeks and there was good incorporation of bone graft used in two cases in Group A and one in Group B. One child had 2-mm residual subluxation of the radial head (Case 4).

At a mean follow up of 22 months, the ulna angulation osteotomy had gradually re-modelled in five cases without causing any radial head disturbance. Kim's criteria was used to score the elbow post-operatively: ten elbows reported excellent outcome and two had a good result (Cases 5 and 11). Case 5 had total motion less than 250° and Case 11 had some residual tenderness but no activity-related pain. In view of the small sample size, no comparisons were made between the groups (Figs. 1, 2 and 3).

In three children, the plates were removed after 1 year and no refractures were reported.

Discussion

Delayed treatment of missed Monteggia lesion poses several challenges. The probability of obtaining closed reduction of the radial head at that stage is almost negligible, and some form of surgery is required to restore normal anatomy [2, 7, 12]. However, the reason for surgery is not always clear. Many children are asymptomatic and only present because of the deformity. The other issue is the duration of the 'missed dislocation,' which precludes a good result. Authors of the literature have reported successful reconstruction as late as 4 years after injury and, in rare cases, as late as 7 years [20–23]. Left untreated, the children adapt well to the anomalous joint position in

missed Monteggia fracture, but advancing age can compromise the result of surgery [24]. There are few reports where surgery has been done in children over 10 years of age with good functional results [7, 24, 25]. Kim et al. [7] reported on three cases between 12 and 15 years of age with good success.

In this series, the oldest child was 12 years of age and the longest interval between injury and treatment was 18 months, and both children had an excellent to good outcome. The interval of missed dislocation in the older child was 10 months and probably did not result in significant dysplastic changes in the radio-capitellar joint.

The type of reconstruction varies and there is no clear consensus regarding the treatment of missed Monteggia fracture. Some authors have reported that an open reduction of the radial head is sufficient and an ulnar osteotomy is not required [25, 26]. Others have reiterated that ulna osteotomy is almost always necessary to restore radial head alignment [23, 26, 27]. Although simple ulna osteotomies without fixation have been described [28], the ulna angulation obtained after radial head reduction necessitates internal fixation to prevent re-displacement of the radial head [29].

Also, the role of annular ligament reconstruction in maintaining radial head reduction has never been critically analysed. Some authors have advocated its use in every case that requires open surgery on the radio-capitellar joint. Reconstruction involves harvesting a fascial slip from the triceps aponeurosis or the forearm fascia and creating a loop around the radial neck. Speed and Boyd [22] used a slip from the extensor aponeurosis, Bell Tawse [9] used the central slip of the triceps fascia and Lloyd-Roberts and Bucknill [10] modified this using the lateral slip attached distally. In theory, this fascial slip acts both as a dynamic and static stabiliser and prevents radial head subluxation.

Fig. 1 **a** Antero-posterior and lateral radiograph of a 12-year-old child with missed Monteggia fracture. **b** Post-operative radiograph showing the angulation-distraction osteotomy of the ulna with bone grafting. Annular ligament reconstruction was not required (Group B). **c** Radiograph 1 year after implant removal

Stoll et al. [2] described eight cases of missed Monteggia fracture treated with annular ligament reconstruction, but also transfixated the radio-capitellar joint with Kirschner wire in two cases to enhance the stability.

Fig. 2 **a** A 7-year-old girl with missed Monteggia fracture for 18 months. **b** Lateral radiograph of elbow and forearm after open reduction, ulna osteotomy, bone grafting and annular ligament reconstruction. **c** Radiograph at final follow up. She had no symptoms and the graft has healed well. The radial head is well maintained

We had five cases in which ligament reconstruction was required to maintain the radial head reduction and, in six cases, no ligament reconstruction was performed. The mean age, duration of dislocation and type of lesion were comparable in both of the groups. The decision to perform

Fig. 3 **a** Osteolysis around the radial neck following ligament reconstruction. This patient also had 3-mm anterior translation of the radial head. **b** Remodelling of the radial head. Asymptomatic anterior subluxation persists

annular ligament reconstruction was based on the intra-operative stability of the radio-capitellar joint obtained after fixation of the ulna osteotomy. Often, slight distraction with posterior angulation of the ulna would enhance the anatomical alignment of the radio-capitellar joint. This presumably occurs due to the tautness in the interosseous membrane, which provides adequate stability to the radial head in some cases. The precise angulation and distraction would vary in each case, but future biomechanical studies on this subject should clarify the relationship between ulna angulation and enhanced radio-capitellar stability [30].

Some authors have used gradual ulna distraction with an external fixator to effect radial head reduction without even opening the joint [14, 16]. These reports highlight the importance of ulna lengthening and, particularly, angulation in maintaining stability of the radial head. Hasler et al. [20] reported on 15 cases of missed Monteggia fracture in which external fixation of the ulna osteotomy was combined with open reduction of the radio-capitellar joint [29].

In their study, no patient underwent annular ligament reconstruction and no re-displacement of the radial head was reported at a mean follow up of 22 months.

Preliminary intra-operative external fixation may help determine precise ulna distraction and angulation before plate fixation. This could obviate the need for annular ligament reconstruction in some cases where radio-capitellar stability may be restored. Although we did not use this technique in any of our cases, external fixation has a potential role in the management of this complex injury.

Inoue and Shionoya [27] stressed the importance of ulna angulation, as three of their six patients with simple osteotomy without angulation had persistent dislocation of the radial head. Three cases in this series required bone grafting; one case for non-union and the other two to enhance the stability of radial head reduction.

The child with missed lesion for 18 months required annular ligament reconstruction to stabilise the radial head and also ulna distraction–angulation osteotomy with bone grafting. One child in group B required angulation–distraction with bone grafting. The duration of missed dislocation was 11 months. Perhaps the key to adequate radial head reduction is the technique of ulna osteotomy and only a large multicentre series or meta-analysis can shine some more light on this intriguing problem.

Annular ligament reconstruction is not without complications. Gyr et al. [11] reported on 15 children who underwent annular ligament reconstruction. All children had some limitation of forearm rotation and four cases had asymptomatic radial head re-subluxation. They emphasised that the ligament reconstruction can prevent the need for radial head excision in the future, as dysplastic changes occur commonly in untreated cases. After ligament reconstruction, the restriction of forearm rotation has been reported by several authors, and, also, nerve injury, myositis ossificans and re-displacement of the radial head are some of the documented complications [31–33].

In this study, all children in group A and B had limitation of forearm rotation, pronation was more limited and this could, perhaps, be related to the position of forearm immobilisation in supination and the prolonged duration. However, the limitation of elbow motion did not affect the function of the child.

Residual radial head subluxation was seen in one case in our study. This could be due to laxity in the reconstructed ligament or due to poor initial repair. This has also been reported in other series and is asymptomatic and rarely affects function. Hui et al. [12] reported residual subluxation in 2 of 15 cases and Rodgers et al. [31] reported it in 2 of 7 cases in their series.

Seven of the children in this series did not need ligament reconstruction and this probably reflects the favourable results in this series. Eight children in total required ulna

plating and, hence, needed bigger incisions. Although we did not look specifically for cosmesis, no child had complained about the scar.

In conclusion, this study stresses the importance of ulna alignment in restoring radial head stability and that annular ligament reconstruction is not always necessary. It would be prudent to quote a line from Campbell's textbook of Orthopaedics, "regardless of how little or how much remodelling has taken place, an osteotomy is usually necessary to *lengthen* the ulna and produce a stable radial head reduction."

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