



Surgical treatment of chronic Monteggia fractures in children: a systematic review of the literature

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SUMMARY

Introduction: Monteggia fractures are rare. When diagnosed late represent a major challenge for the surgeon. Several techniques are described for the surgical treatment of this condition. We conducted a systematic review of the literature to: (1) define the level of evidence regarding reconstruction surgery, (2) determine whether surgery improves function, and (3) identify complications related to each treatment method. **Methods:** We reviewed the literature for all studies of surgical treatment of chronic Monteggia fractures. We analyzed English-language studies that evaluated functional outcomes in patients less than 18 years with 1-year minimum follow-up. We divided the patients into three groups according to treatment received: A) Reconstruction of the annular ligament, B) Osteotomy of the ulna and C) Combination of both techniques. Two researchers according to The Newcastle -Ottawa Scale (NOS) assessed the quality of evidence independently. **Results:** We analyzed 17 studies that met our inclusion criteria. All belonged to a level of evidence IV. According to NOS the average score was 8.7 points (8.4-9.5). The sample consisted of 241 patients (11-33): 22 patients in group A, 84 in group B, and 135 in group C. Group B showed a tendency to regain a higher range of motion than groups A and C. Group A showed a mean improvement of flexion-extension of 20° and decreased pronation-supination 10°. Group B improved 30° and 18° respectively. Complication rate was significantly inferior in group B, 50, 25 and 43.7% respectively ($p = 0.0022$). **Discussion:** Current evidence regarding reconstruction surgery in chronic Monteggia fractures is level IV and suggests that different surgical techniques are associated with improved function but are associated with a high rate of complications. **Evidence level: IV (Therapeutic study)**

Key words: Monteggia, annular ligament reconstruction, osteotomy ulna children.
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RESUMEN

Introducción: Las fracturas de Monteggia son raras. Cuando se diagnostican tarde, representan un gran desafío para el cirujano. Se describen varias técnicas para el tratamiento quirúrgico de esta afección. Se realizó una revisión sistemática de la literatura para: (1) definir el nivel de evidencia con respecto a la cirugía de reconstrucción, (2) determinar si la cirugía mejora la función y (3) identificar las complicaciones relacionadas con cada método de tratamiento. **Métodos:** Se revisó la bibliografía de todos los estudios sobre el tratamiento quirúrgico de las fracturas crónicas de Monteggia. Se analizaron los estudios en idioma inglés que evaluaron los resultados funcionales en pacientes menores de 18 años con un seguimiento mínimo de un año. Dividimos a los pacientes en tres grupos según el tratamiento recibido: A) Reconstrucción del ligamento anular, B) Osteotomía del cúbito y C) Combinación de ambas técnicas. Dos investigadores de acuerdo con la Escala de Newcastle-Ottawa (NOS) evaluaron la calidad de las evidencias de forma independiente. **Resultados:** Se analizaron 17 estudios que cumplieron con los criterios de inclusión. Todos pertenecían a un nivel de pruebas IV. Según NOS, la puntuación media fue de 8.7 puntos (8.4-9.5). La muestra consistió de 241 pacientes (11-33): 22 pacientes en el grupo A, 84 en el grupo B y 135 en el grupo C. El grupo B mostró una tendencia a recuperar una mayor amplitud de movimiento que los grupos A y C. El grupo A mostró una mejoría media de la flexión-extensión de 20° y una disminución de la pronación-supinación de 10°. El Grupo B mejoró 30° y 18° respectivamente. La tasa de complicaciones fue significativamente inferior en el grupo B, 50, 25 y 43.7% respectivamente ($p = 0.0022$). **Discusión:** Las pruebas actuales con respecto a la cirugía de reconstrucción en las fracturas crónicas de Monteggia son de nivel IV y sugieren que diferentes técnicas quirúrgicas se asocian con una mejoría de la función pero se asocian con una alta tasa de complicaciones. **Nivel de evidencia: IV (Estudio terapéutico)**

Palabras clave: Monteggia, reconstrucción del ligamento anular, osteotomía de cúbito en niños.
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INTRODUCTION

A chronic Monteggia fracture is defined as an unreduced dislocation of the radio-capitellar joint that is still present four weeks after injury.¹ When diagnosed late represent a major challenge for the surgeon. Chronic radial head dislocation may lead to increasing valgus deformity of the elbow with subsequent nerve disturbance, restriction of range of motion, and loss of function due to a combination of stiffness and instability.^{2,4}

The treatment of this condition remains controversial, as evidenced by the numerous procedures that have been proposed. Suggested strategies range from nonsurgical treatment^{5,6} to late reconstruction of the annular ligament,⁷⁻⁹ accompanied by either corrective ulnar osteotomy^{3,10,11} or radial shortening osteotomy.¹² Others have advocated leaving the radial head dislocated and excising it at skeletal maturity if pain or functional limitations are present.^{13,14}

We conducted a systematic review of the literature to: (A) define the level of evidence regarding reconstruction surgery, (B) determine whether surgery improves function, (C) identify complications related to each treatment method, and D) to suggest a treatment algorithm. For analysis of functional outcomes and complications, we divided the patients into three groups according to treatment received: annular ligament reconstruction, ulnar osteotomy and combination of both techniques.

METHODS

Literature search

We searched PubMed, EMBASE, and the Cochrane Library on June 1, 2013, for articles published between 1950 and May 2013. The search terms used were «Chronic Monteggia», «Chronic Monteggia fracture», «Missed Monteggia», «Missed Monteggia fracture», and «Neglected Monteggia». Additionally, references of the included studies were also searched to identify relevant studies. All citations were imported into EndNote® to remove duplicate studies. Collectively, our searches identified 74 articles. Each article underwent abstract review by two of the authors (DT, JJM). Full-text publications were obtained for studies that appeared to be relevant and potentially meet our inclusion criteria. Two reviewers (DT, JJM), after reviewing each full report, independently assessed eligibility of all relevant studies based on our inclusion criteria. Disagreements between the reviewers were resolved by discussion. Studies were included only if they were peer-reviewed,

published in English, reported functional results and complications in patients under 18 years-old, treated with surgery and, had a minimum of 1 year follow-up. All study designs from Level I to IV were eligible. We excluded from analysis duplicated studies, retracted studies, and case series with less than five patients.

Quality assessment

The methodological quality of the selected articles was assessed by two independent researchers (DT, JJM). Disagreements were resolved by discussion. If no consensus was reached, a third researcher (ATG) was asked and a final decision was made. The quality of evidence was assessed according to The Newcastle-Ottawa Scale (NOS).¹⁵ The NOS contains eight items, categorized into three dimensions including selection, comparability, and –depending on the study type– outcome (cohort studies) or exposure (case-control studies). For each item a series of response options is provided. A star system is used to allow a semi-quantitative assessment of study quality, such that the highest quality studies are awarded a maximum of one star for each item with the exception of the item related to comparability that allows the assignment of two stars. The NOS ranges between 0 up to 9 stars. Only high quality studies, defined a priori as those achieving seven or more stars, were included in this review.

Data from selected studies were recorded using *Microsoft Office Excel 2007*. The file included information on bibliographic data, study characteristics, patient characteristics (age, gender), duration from injury to surgery, type of treatment, complications, and functional results.

Statistical analysis

For analysis, we divided the patients into three groups according to treatment received: A) reconstruction or annular ligament repair, B) osteotomy of the ulna (with or without radiocapitellar joint exploration), and C) combination of both techniques. Continuous variables were tested for normality and are reported as mean (\pm SD). The comparison between the three treatment groups was performed using a one-way ANOVA. The strength of the association between the categorical variable «Complications» was measured with Odds Ratios, hypothesis testing with Chi-square test of RxC considering the three groups. The peer group analysis was performed using a Yates corrected Chi-square test. Confidence intervals are reported at 95%. A $p < 0.05$ was considered statistically significant.

RESULTS

A total of 71 references were identified in the literature search. Following abstract review 60 references were excluded and the full texts of 14 articles obtained, and a further 3 from relevant articles' citations (*Figure 1*).

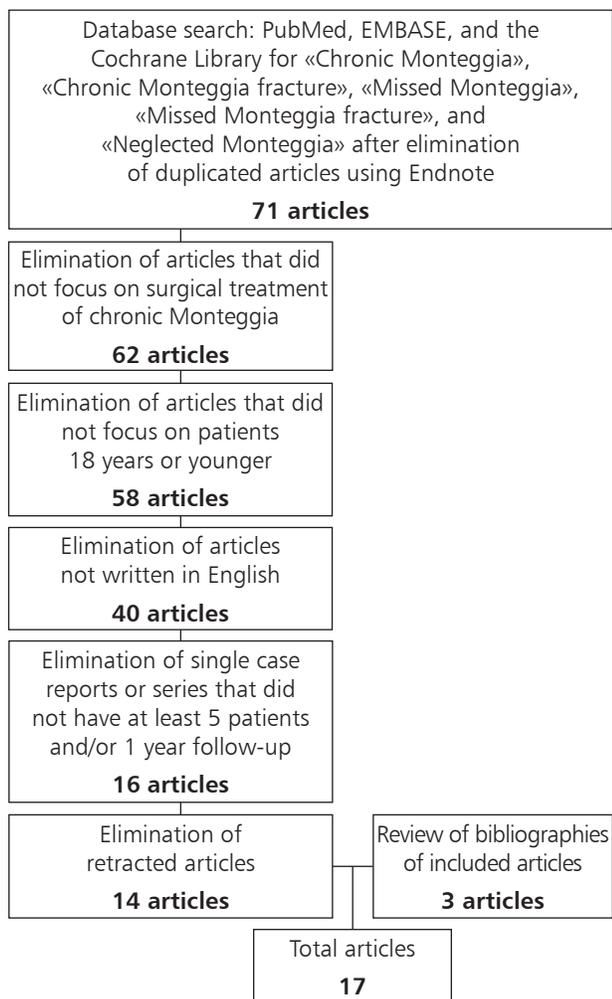


Figure 1. This flowchart depicts identification of articles included in the systematic review.

24 studies were excluded because were case reports or case series that did not have at least 5 patients or 1 year follow-up, 18 studies were not published in English, 9 did not focus on surgical treatment of chronic Monteggia, 4 studies were adult case series, and 2 were retracted (duplication).

The final review comprises of 17 retrospective studies^{8-11,16-27} reporting outcomes for 241 patients: 22 patients in group A, 84 in group B, and 135 in group C. 10 studies included patients with different treatment methods. Patients were allocated individually to the group they belonged. All of the studies included were level of evidence IV. According to NOS, the average score was 8.7 points (range, 8.4-9.5 points). There were no differences in age, and follow-up in the three groups (*Table I*).

Improvement in flexion-extension was similar in the three groups. Group A showed an improvement of 20° but this was not statistically significant. In groups B and C, this change was statistically significant. In group B, the improvement was more substantial (30°, p = 0.021) and in group C similar to group A (20°) but with a significant p value of 0.047. Pronation-supination (PS) values were similar preoperatively (p = 0.098). In group A, PS ROM decreased in 10° (p = 0.374), in group B improved in 18.33° (p = 0.294) as well as in group C, where the improvement was of 15.5° (p = 0.464) (*Table II*).

Complication rate was significantly inferior in group B (p = 0.0022) (*Table III*). Group A presented the highest rate of complications (11 in 22 patients). Distribution was as follows: Subluxation (n = 4), dislocation (n = 2), radial neck notching (n = 2), severe loss of motion (n = 2), and radio-ulnar synostosis (n = 1). Group B presented 21 complications in 84 patients: dislocation (n = 11), subluxation (n = 7), delayed union (n = 2), and nonunion (n = 1). Group C presented 59 complications in 135 patients: Subluxation (n = 15), delayed union (n = 6), superficial infection (n = 6), severe loss of motion (n = 6), nerve palsy (n = 5), osteoarthritis (n = 4), pain (n = 3), dislocation (n = 2), lost fixation (n = 2), radio-ulnar synostosis (n = 2), heterotopic ossification

Table I. Patient demographics.

Variable	Group A	Group B	Group C	p
Age	7.42 (± 1.91)	7.14 (± 5.03)	6.54 (± 1.90)	0.889
Time from injury to surgery	7.5 (± 2.65)	12.53 (± 7.57)	45.27 (± 35.58)	0.003
Follow-up	35.58 (± 10.71)	38.34 (± 29.63)	49.50 (± 29.63)	0.571
Patients (w)	22 (8.6%)	94 (37%)	138 (54.3%)	-
Papers (w)	6 (22.2%)	9 (33.3%)	12 (44.4%)	-

Table II. Pre- and postoperative range of motion.

Group	Flexion-extension				Pronation-supination			
	Pre	Post	Difference	p*	Pre	Post	Difference	p*
A	109.33 (± 4.04)	130.00 (± 11.36)	20.67 (± 12.01)	0.097	157.83 (± 23.72)	147.17 (± 16.48)	-10.67 (± 16.26)	0.374
B	118.58 (± 11.98)	148.75 (± 22.50)	30.17 (± 13.50)	0.021	123.33 (± 20.82)	141.67 (± 7.64)	18.33 (± 22.55)	0.294
C	118.18 (± 34.65)	138.27 (± 21.17)	20.08 (± 18.79)	0.047	116.67 (± 16.07)	132.17 (± 28.00)	15.50 (± 29.89)	0.464
p**	0.867	0.924	-	-	0.098	0.642	-	-

* Paired t-test, ** ANOVA.

Table III. Complications rate.

Group	Absolut frequency	Relative frequency	p*
A	11	50%	0.0022
B	21	25%	
C	59	43.7%	

* Yates corrected RxC Chi-squared test.

Table IV. Complications rate: paired comparison between groups.

Group 1	n (%)	Group 2	n (%)	Odds Ratio	p*
A	11 (50)	B	21 (25.0)	2.625 (1.228-9.838)	0.0189
A	11 (50)	C	59 (43.7)	1.286 (0.672-2.667)	0.6892
C	59 (43.7)	B	21 (25.0)	1.419 (1.412-4.773)	0.0021

* Yates corrected Chi-squared test.

(n = 2), nonunion (n = 1), compartment syndrome (n = 1), radial neck notching (n = 1) (Table IV).

DISCUSSION

Monteggia fracture-dislocation represents 0.4% of pediatric fractures, but the incidence of chronic injuries is unknown. Owing to its rarity, surgical treatment of the chronic form is controversial. We reviewed the literature in order to evaluate the improvement in range of motion, and complications. Initially, our aim in this study was to evaluate function. Most studies reported results but data on patient-reported outcomes are lacking.^{19,20,22} Other authors used functional scores not validated in the pediatric population.^{17,25} For this reason we evaluated the range of motion in an attempt to reflect the improvement produced by surgery. Substantial improvement was

observed both in flexion - extension and in pronation-supination in patients treated with isolated ulnar osteotomy, or with osteotomy and annular ligament reconstruction. On the other hand, those patients treated with isolated annular ligament reconstruction showed improvement in flexion and extension but with some reduction of pronation-supination.

Many authors have reported a high rate of complications associated to surgical treatment of chronic Monteggia lesions. In our review, total rate was 38%. When analyzing the overall rate of complications of all three groups, we found significant differences (p = 0.022). The pairwise analysis of this same trait showed that group A increases odds for complications in 1.625 times when compared to group B. The rate of complications was similar between groups A (50%) and C (43.7%), OR = 1.286 (0.672-2.667, p = 0.6892). After a contingency table comparison between groups C and B, we observed that the former had significantly higher complication rate (43.7%) than the latter (25%), OR = 1.419 (1.412-4.773, p = 0.0021). This is that treatment in group C increases the odds for complications in 41.9%.

In long-standing radial head dislocations, duration of dislocation has a direct correlation to the success of the surgery due to the development of dysplastic changes in the distal humerus and proximal radius-ulna.^{9,19} Stoll et al²⁰ advocated that the prerequisites for a good result are a patient younger than 10 years and dislocated less than four years. Unfortunately, lack of raw data did not allow us to analyze a correlation between duration of dislocation and improvement in range of motion or complications rate.

This review has substantial limitations. First, the majority of studies are small, retrospective, single-surgeon case series with limited use of validated outcome measures and lack of available raw data. Second, our review was restricted to articles written in, or translated into, the English language. This

may exclude some studies that might substantially contribute to our understanding of the outcomes in this patient population. However, this was necessary for the completion of the study, because none of the authors were able to critically review any articles that were not in English. Third, the exclusion of studies that did not report range of motion may also eliminate studies that might still provide important information on complications. In addition, lack of consistency in outcomes of interest reported by some included studies also limits our results. However, this collection of data provides important and more generalized information regarding the results and complications of surgical treatment of chronic Monteggia and may be useful as baseline or comparative data for future studies.

Current evidence regarding reconstruction surgery in chronic Monteggia fractures is level IV and suggests that different surgical techniques are associated with improved function but are associated with a high rate of complications. Isolated ulnar osteotomy allows a more effective improvement of range of motion with a significantly lower complication rate. According to these observations, we suggest for the treatment of chronic Monteggia fractures to perform proximal ulnar osteotomy (lengthening and angulation) with stable fixation with plate and screws. This approach would allow the best functional outcome decreasing the chances of complications such as delayed union, nonunion or loss of fixation. In cases where intraoperative stability radiocapitellar joint is insufficient, the association of annular ligament reconstruction allows the stabilization although it is associated with a higher complication rate. Current evidence should be received with caution because of an assortment of study methods and cases of potential bias. This issue requires future comprehensive, multi-centered studies with long-term follow-up.

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Conflict of interest

The authors declare no conflict of interest.

Ethical standard

The paper involves no human nor animal researches (i.e. review articles, material tests); thus, ethical standards do not apply.

Informed consent

An informed consent was not required.

Disclosure

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