

ORIGINAL PAPER

[Translated article] Fractures of the lateral condyle of the humerus associated with elbow dislocation in children. A systematic review of the literature



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KEYWORDS

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Abstract

Background: Lateral humeral condyle fractures are the second most common fracture around the elbow in children. However, the association of an elbow dislocation is a rare entity. Therefore, literature on young patients with this uncommon combination is sparse. We aimed to perform a systematic review of the literature searching for paediatric lateral condyle humerus fractures associated to elbow dislocation.

Methods: A systematic review of the PubMed and Embase databases was conducted for peer-reviewed literature between 1960 and 2020. Two reviewers filtered the results, looking for articles in English and Spanish that reported fractures of the lateral condyle of the humerus associated to elbow dislocation in skeletally immature patients. Outcomes included patient and injury characteristics, treatment strategies, complications, and final outcomes including range of motion.

Results: The initial search yielded a total of 851 studies. After initial screening, 16 studies were included, with 67 patients available for review. Age reported at the time of injury ranged from 2 to 12 years. The lesion occurred more commonly in males (60%) with Milch II, and Jakob type 3 fractures. The direction of the dislocation was posteromedial in most cases. Open reduction by lateral approach and Kirschner pin placement was the most performed treatment. The reported follow-up ranged from 3 to 156 months. Fourteen studies reported complications in 1/3 of the patients including: limited range of motion, cubitus varus, instability, hardware prominence, delayed union, nonunion, malunion, heterotopic ossification, neurological injury, and hardware failure. Thirteen studies reported clinical outcomes, which were rated as fair or poor in 2 out of 10 patients.

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PALABRAS CLAVE

Fracturas de cóndilo lateral humeral;
Luxación de codo;
Niños;
Tratamiento

Conclusions: Current evidence is level IV and suggests that the complication rate after surgical management of lateral condyle fractures is substantial in the context of an associated elbow dislocation, with an elevated percentage of suboptimal results. The most frequent complications in this series were elbow stiffness and cubitus varus.

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Fracturas del cóndilo lateral del húmero asociadas a luxación de codo en niños. Una revisión sistemática de la literatura

Resumen

Introducción: Las fracturas de cóndilo humeral lateral representan del 12-17% de las fracturas de codo pediátrico. La asociación de esta fractura con luxación de codo es poco común, siendo escasa la bibliografía y generalmente limitada a reportes de casos. Nuestro objetivo fue revisar sistemáticamente la literatura sobre las fracturas del cóndilo lateral del húmero asociadas a luxación de codo en niños.

Métodos: Se realizó una revisión sistemática mediante una búsqueda exhaustiva en las bases de datos PubMed y Embase de literatura revisada por pares entre 1960 y 2020. Dos revisores filtraron los resultados y buscaron artículos en inglés o español que reportan pacientes esqueléticamente inmaduros con fracturas del cóndilo lateral del húmero asociadas a luxación de codo. Los resultados analizados incluyeron características del paciente y de la lesión, estrategias de tratamiento, complicaciones y resultados finales.

Resultados: La búsqueda inicial arrojó un total de 851 estudios. Después de la revisión, se incluyeron 16 estudios, con 67 pacientes disponibles para revisión. Las edades reportadas al momento de la lesión variaron entre 2 y 12 años. La lesión se presentó más comúnmente en varones con fracturas tipo Milch II, Jakob tipo 3. La dirección de la luxación fue posteromedial en la mayoría de los casos. La reducción abierta por abordaje lateral y la colocación de clavijas Kirschner fue el tratamiento más comúnmente realizado. El seguimiento reportado se presentó en un rango 3-156 meses. Catorce estudios informaron complicaciones en un tercio de los pacientes, que incluyen: limitación del rango de movimiento, cúbito varo, inestabilidad, prominencia del implante, retraso de la consolidación, pseudoartrosis, consolidación viciosa, osificación heterotópica, lesión neurológica y fallo del implante. Trece estudios informaron resultados clínicos, que se calificaron como regulares o pobres en 2 de cada 10 pacientes.

Conclusiones: La evidencia actual es nivel IV e indica que la tasa de complicaciones después del manejo quirúrgico de las fracturas de cóndilo lateral es elevada en el contexto de una luxación de codo, lo que se asocia además a un alto porcentaje de resultados subóptimos. Las complicaciones más frecuentes en esta serie fueron la rigidez articular y el cúbito varo.

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Introduction

Fractures of the lateral humeral condyle account for almost 20% of paediatric elbow fractures and are the second most common fracture of the elbow in children.^{1,2} These fractures occur most frequently in children aged 4–10 years, with a higher incidence in children around the age of 6 years.³ The injury usually occurs as a result of an applied varus or valgus force to the forearm with the elbow in extension.⁴

Although most of these injuries usually occur in isolation, a smaller percentage may be associated with other injuries, such as fractures of the radial dome or proximal ulna⁵ or dislocation of the elbow. Association of this fracture with elbow dislocation is very rare. An epidemiological study of 2502 paediatric elbow fractures reported only 12 cases (.4%) over a period of 15 years.⁶ Due to the low frequency of

presentation, the literature is scarce and limited to case reports or small case series.^{6–9}

The aim of this study was a systematic review of the literature on fractures of the lateral condyle of the humerus associated with elbow dislocation in paediatric patients. We sought to characterise fracture patterns, type of treatment used and to assess clinical outcomes and complications. We hypothesised that this subtype would represent a much more severe form resulting in a higher complication rate and less favourable outcomes.

Methods**Data sources**

We conducted a systematic review in November 2020 by searching the electronic databases PubMed Medline and

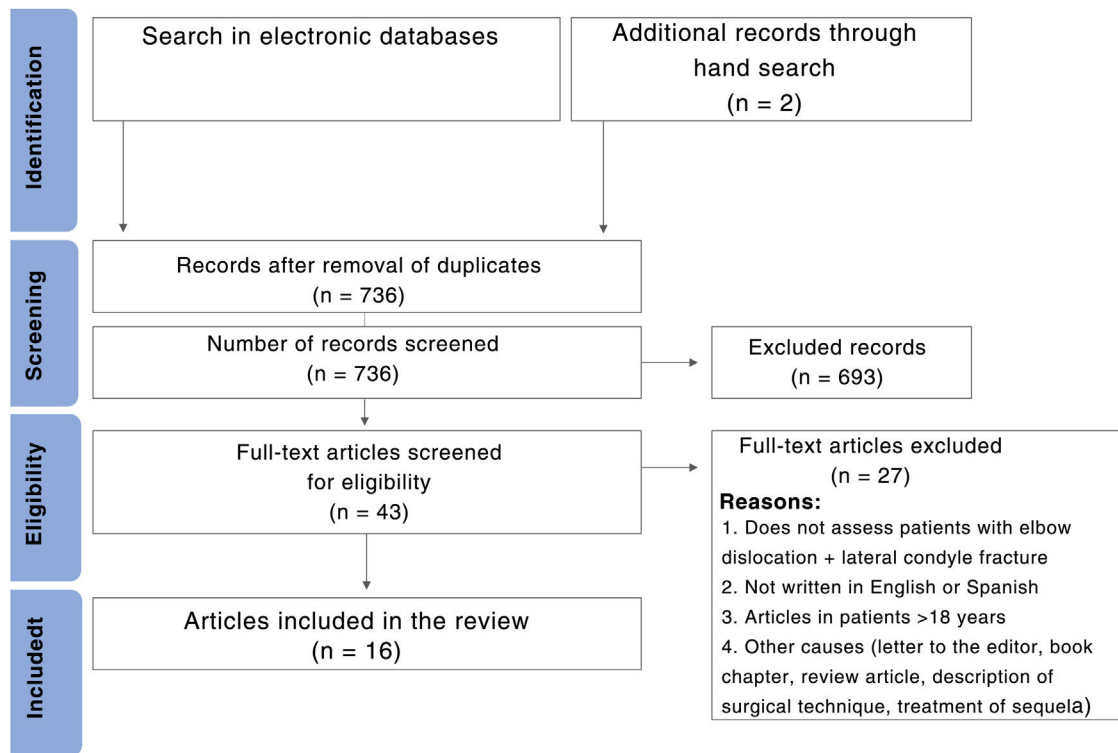


Figure 1 PRISMA diagram of the systematic review.

Embase. We used the search terms “paediatric elbow dislocation”, “lateral humeral condyle fracture”, “lateral condyle fracture AND elbow dislocation”. The search included studies from January 1, 1960, to the search date (November 1, 2020).

Study selection

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed to present the data obtained.¹⁰ Two authors independently reviewed all the titles from the initial search query. All titles related to the injuries mentioned were selected to ensure a broad capture of relevant studies. After removing duplicates, abstracts of selected articles were retrieved and reviewed. Studies were included of any level of evidence, published in English or Spanish, describing fractures of the lateral condyle of the humerus associated with elbow dislocation in patients younger than 18 years. Studies that did not meet the inclusion criteria, reviews, editorials, conference abstracts, technical articles, and errata were excluded. Two authors reviewed the remaining abstracts and if one or both considered it relevant, the full text was reviewed. Full-text articles that met the inclusion criteria were selected by consensus. The authors reviewed the final selections for inclusion during their review process (Fig. 1). We then performed a hand search of the reference list of included studies.

Data extraction

We collected general data including authors, year, and journal of publication. The total number of patients,

demographic information, and mechanism of injury were recorded (Table 1). Fracture characteristics were extracted using the classification by Milch^{1,11} and Jakob et al.,¹² the direction of dislocation, and the presence of associated injuries. Treatment characteristics were recorded, including the type of reduction and fixation. Complications (neurovascular injuries, infections, and limitation of motion) were analysed. Finally, flexion-extension range and clinical results of treatment were recorded. The information, when available, was adapted to classify outcomes according to the Flynn criteria.¹³

Statistical analysis

Standard descriptive abstract (means and standard deviations for continuous variables such as age, and percentage for categorical variables such as gender) were used to summarise demographic variables.

Results

The results of the initial search yielded 851 citations, of which 115 duplicates were eliminated. Of the 736 articles, 693 were excluded based on the abstract because they were not clinical studies or not related to the topic. Twenty-seven of the remaining 43 articles were excluded after a full-text review. A hand search of the references of the selected studies yielded 2 additional relevant citations. Therefore, 16 studies were included in the final analysis.^{6,14–26}

Table 1 Demographic characteristics of the patients.

Study	Author	Journal (year)	Case (n)	Age (years)	Sex	Follow-up (months)	Type of dislocation	Classification		Treatment	Approach	Type of fixation
								Milch	Jakob			
1	Roberts et al. ⁷	British Journal of Surgery (1969)	1	12	M	120	PM	NR	NR	ORIF	NR	Pins
2	Van Haaren et al. ⁸	J Trauma. (1994)	1	6	F	3	PL	2	3	ORIF	NR	1 Pin + 1 screw
3	Rovinsky et al. ⁹	J Orthop Trauma (1999)	1	11	M	11	P	1	3	ORIF	L	Pins
4	Murnaghan et al. ¹⁴	Int J Clin Pract. (2002)	3	8	M	12	PL	1	3	ORIF	L	Pins
				6	M	9	P	1	3	RC + PFI	No	Pins
				9	M	4	PM	1	3	ORIF	L	Pins
5	Kirkos et al. ¹⁵	Clin Orthop Relat Res. (2003)	4	11	M	156	PM	–	3	ORIF	L	Pins
				6	M	96	PM	–	3	ORIF	L	Pins
				12	M	72	PM	–	3	ORIF	L	Pins
				9	M	36	PM	–	3	ORIF	L	Pins
6	Rasool et al. ¹⁶	J Bone Joint Surg Br. (2004)	5	NR	NR	NR	PM (n = 5)	2 (n = 4), 1 (n = 1)	NR	ORIF	L	Pins
7	Sharma et al. ¹⁷	BMC Musculoskelet Disord (2005)	1	12	M	39	PL	2	3	ORIF	L	Pins
8	Eksioglu et al. ¹⁸	Orthopaedics (2008)	1	5	M	42	PM	2	3	ORIF	L	Pins
9	Cheng et al. ¹⁹	J Chin Med Assoc. (2009)	3	9	M	36	PM	2	3	ORIF	L	Pins
				5	M	28	PM	2	3	ORIF	L	Pins
				10	M	24	PM	2	3	RC + PFI	No	Pins

Study	Author	Journal (year)	Case (n)	Age (years)	Sex	Follow-up (months)	Type of dislocation	Classification		Treatment	Approach	Type of fixation
								Milch	Jakob			
10	Sharma et al. ²⁰	Int Orthop. (2009)	12	8.2 (prom)	M	NR	L (n = 1), P (n = 4), PL (n = 7)	–	3	ORIF	L	Pins (n = 3), screws (n = 6), no fixation (n = 3)
11	Lemme et al. ²¹	Am J Orthop. (2009)	10	6.7	9 M/1 F	NR	NR	NR	NR	ORIF	L	Pins
12	Abu-Jayyab et al. ²²	J Pak Med Assoc. (2011)	1	8	F	6	PL	2	3	ORIF	L	Screws
13	Rincon et al. ²³	Acta Ortop Mex. (2014)	1	5	F	NR	PL	2	3	RC + PFI	No	Pins
14	Silva et al. ²⁴	J Pediatr Orthop. (2015)	12	5.5 (prom)	7 M/5 F	12.8	PM (n = 11), PL (n = 1)	2	NR	RC + PFI (n = 3), RC + ORIF (n = 9)	NR	Pins
15	Tomori et al. ²⁵	Medicine (2018)	3	1	F	16	PM	1	3	ORIF	PL	Pins
				7	M	12	PM	2	3	ORIF	PL	Tension band
				9	F	16	PM	1	3	ORIF	PL	Tension band
16	Lan et al. ²⁶	Int Orthop. (2018)	8	7.3 (prom)	5 M/3 F	33	PM (n = 8)	2	NR	ORIF	L	Pins

CR + ORIF: closed reduction of the elbow dislocation and open reduction internal fixation of lateral condyle fracture; CR + PFI: closed reduction and percutaneous pin fixation; F: female; L: lateral; M: male; NR: not reported; ORIF: open reduction internal fixation; P: posterior; PL: posterolateral; PM: posteromedial.

Study design

The literature on this topic consists of case reports, small case series or cases included in series on fractures of the lateral condyle or elbow dislocation. All the studies included were retrospective and classified as level IV evidence, with very low quality of evidence according to the GRADE guidelines.²⁷ Table 1 summarises the characteristics of the 16 studies selected for review.

Injury and treatment characteristics

After the review, 67 patients were included for analysis. The mean age at the time of injury was 7.9 years (range, 2–12 years). The injury occurred most in males (60%) with Milch II (fracture extends medially to the trochlear groove), and Jakob type 3 (fragment rotated and displaced laterally and proximally) fractures. The direction of dislocation was posteromedial in 65% of cases. Open reduction using a lateral approach and placement of Kirschner pins was the most performed treatment. The average follow-up was 20.1 months (range 3–156 months). Table 1 details the characteristics of each case.

Complications and clinical results

Fourteen studies (56 patients) reported complications. Nineteen of these patients (34%) had 26 complications including in order of frequency: range of motion limitation ($n=12$), ulnar varus ($n=4$), instability ($n=2$), implant protrusion ($n=2$), delayed union ($n=1$), pseudoarthrosis ($n=1$), malunion ($n=1$), heterotopic calcification ($n=1$), neurological injury ($n=1$), and implant rupture ($n=1$).

Thirteen studies with 51 patients reported clinical outcomes, which were rated as excellent in 70.6% ($n=36$), good 7.8% ($n=4$), fair 2% ($n=1$), and poor in 19.6% ($n=10$) of the patients. Table 2 summarises the complications and clinical outcomes of the patients selected for the review.

Discussion

Lateral humeral condyle fractures associated with elbow dislocation are rare but very serious injuries. The main findings of this systematic review were the high complication rate (34%) related to this injury, resulting in one in 5 patients having a poor outcome. The studies were all of a low level of evidence, with a variety of methodologies that could lead to bias. However, these findings contrast with the series of isolated displaced fractures of the lateral humeral condyle where the complication rate is significantly lower.^{28–30}

Dislocations of the elbow are the most common dislocations in children located in large joints.³¹ Dislocations of this joint can be associated with fractures as well as damage to the static supporting structures of the elbow. In this review, the most frequent complication was loss of elbow motion. Twenty-one percent of patients had some degree of limitation of motion, extension in the main. The association of an intra-articular fracture and soft tissue injuries resulting from dislocation would encourage bleeding and the release of inflammatory agents involved in the repair process.³² In

some cases, the response to trauma may result in excessive scar formation and joint capsule contractures or heterotopic bone formation in the adjacent capsule or musculature. In other cases, loss of motion may be facilitated by longer post-operative immobilisation time. Although the immobilisation time is not detailed in all the articles we reviewed, in some cases it was up to 6 weeks.^{24,25}

In our review, 3.6% of cases had chronic instability as a sequela. The supporting structures were generally injured from lateral to medial in the following order: the lateral collateral ligament, the anterior capsule, the posterior capsule, and the medial collateral ligament.^{33,34} It is therefore important to check the integrity of these structures after reduction and osteosynthesis testing for stability.

Ulnar varus is a complication that can occur after a lateral condyle fracture and generally associated with malunion. In this series, 9% of patients presented with ulnar varus or malunion. Although abnormal loading angles could also occur due to abnormal distal humeral physis growth, the latter only provides 20% of the total growth of the humerus and is therefore considered an infrequent cause.² Although not described as a complication in these series, lateral overgrowth of the condyle can occur in a high percentage of surgically treated patients. This overgrowth may be clinically mistaken for an abnormal loading angle; however, it does not require treatment since it does not cause long-term impairment of function.³⁵

The type of fixation might also influence the potential for complications. A biomechanical study³⁶ has shown that fixation with 2 pins, maximising divergence at the fracture site, would provide sufficient stability in torsional and valgus loading. Other authors have shown that the addition of a third K-wire in a divergent orientation would increase stability.³⁷ More recently, the use of cannulated screws has been proposed. This method of fixation would have the advantage of providing interfragmentary compression and requiring less immobilisation time, resulting in greater biomechanical stability, faster improvement in elbow range of motion and fewer complications such as infection, pseudoarthrosis and lateral overgrowth.^{38,39} In this review, 85% of patients received pin fixation, which limits the possibility of analysing the fixation method as a predictor of complications. Although the evidence is not strong enough to support a change, it is logical to consider that screw fixation could play a role in these injuries, as it would allow earlier mobilisation and more intensive rehabilitation; however, it has the disadvantage of requiring a second procedure to remove the material.

This study has limitations that need to be mentioned. Although we conducted an exhaustive literature search, the quality of the selected articles is of low evidence. All studies are retrospective and only 5 papers present series of more than 5 patients, which limits performing a more rigorous statistical analysis. This is a constant in systematic reviews of rare injuries. However, from the findings we detect substantial differences in complication rates and outcomes compared with series of lateral condyle fractures without dislocation.

To conclude, the evidence reviewed in this study shows that the complication rate after surgical management of lateral condyle fractures is significantly higher in the context of elbow dislocation, which is also associated with a

Table 2 Results and complications reported in the studies included.

Study	Author	Journal (year)	Case (n)	Age (years)	Postoperative range of motion (flexion-extension)	Results/Flynn criteria	Complications
1	Roberts et al. ⁷	British Journal of Surgery (1969)	1	12	NR	Good	No
2	Van Haaren et al. ⁸	J Trauma. (1994)	1	6	NR	Anatomical union, Range of motion not reported	NR
3	Rovinsky et al. ⁹	J Orthop Trauma. (1999)	1	11	20°–120°	Poor	Limitation of motion: 20° extension, 10° supination, 20° pronation
4	Murnaghan et al. ¹⁴	Int J Clin Pract. (2002)	3	8	20°–140°	Poor	Delayed union, limitation of extension 20°
				6	5°–140°	Good	Limitation of extension 5°
5	Kirkos et al. ¹⁵	Clin Orthop Relat Res. (2003)	4	9	0°–140°	Excellent	No
				11	0°–140°	Excellent	No
				6	0°–140°	Excellent	No
				12	15°–140°	Good	Limitation of extension 15°
6	Rasool et al. ¹⁶	J Bone Joint Surg Br. (2004)	5	9	0°–140°	Excellent	No
				NR	NR	NR	Radial nerve injury (n = 1)
7	Sharma et al. ¹⁷	BMC Musculoskelet Disord. (2005)	1	12	NR	Excellent	No
8	Eksioglu et al. ¹⁸	Orthopaedics (2008)	1	5	5°–135°	Excellent	Limitation of extension 5°
9	Cheng et al. ¹⁹	J Chin Med Assoc. (2009)	3	9	0°–135°	Excellent	No
				5	10°–75°	Poor	Malunion, heterotopic calcification, medial instability/limitation of motion
				10	10°–70°	Poor	Pseudoarthrosis and instability of the elbow, ulnar varus, limitation of motion

Study	Author	Journal (year)	Case (n)	Age (years)	Postoperative range of motion (flexion-extension)	Results/Flynn criteria	Complications
10	Sharma et al. ²⁰	Int Orthop. (2009)	12	8.2 (mean)	0°–140° (n = 9), 20°/30°–140° (n = 3)	Excellent (n = 9), poor (n = 3)	Limitation of extension 20°–30° (n = 3), broken pin (n = 1)
11	Lemme et al. ²¹	Am J Orthop. (2009)	10	6.7	NR	Anatomical union, Range of motion not reported	NR
12	Abu-Jayyab et al. ²²	J Pak Med Assoc. (2011)	1	8	NR	Excellent	No
13	Rincon et al. ²³	Acta Ortop Mex. (2014)	1	5	20°–120°	Regular	Ulnar varus, limitation of extension 20°
14	Silva et al. ²⁴	J Pediatr Orthop. (2015)	12	5.5 (mean)	64% at 12 weeks and 99% at last follow-up (compared to contralateral)	Excellent (n = 11), poor (n = 1)	Limitation of motion (n = 1)
15	Tomori et al. ²⁵	Medicine (2018)	3	1 7 9	0°–140° 0°–145° 0°–145°	Poor Excellent Poor	Ulnar varus No Ulnar varus
16	Lan et al. ²⁶	Int Orthop. (2018)	8	7.3 (mean)	Flexion 120.63° ± 8.63° (range, 110°–135°) extension 6.88° ± 6.51° (range, 0°–15°)	Excellent (n = 7), Good (n = 1)	Implant protrusion and bursitis (n = 2)

NR: not reported.

high percentage of suboptimal outcomes. The most frequent complications in this series were joint stiffness and ulnar varus. Future multicentre studies are required to further investigate these findings and improve results.

Level of evidence

Level of evidence IV.

Author's contribution

J.J: Masquijo: study design, statistical analysis, drafting of manuscript.

M. Sanchez Ortiz M: data collection, drafting of tables.

A. Ponzone: data collection, drafting of manuscript.

L. Fernández Korosec: data collection.

A. Arkader: study design, critical review of the manuscript.

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Conflict of interests

The authors have no conflict of interests to declare.

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