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Neonatal separation of the distal humeral epiphysis can be treated orthopedically without reduction

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Keywords:

Distal epiphyseal separation humerus; humeral fractures; orthopedic treatment; osteosynthesis; reduction.

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Abstract

Background:

Neonatal separation of the distal humeral epiphysis (NSDHE) is a very rare injury. On one hand, anatomical reduction is usually required in pediatric elbow fractures due to limited remodeling potential at the distal humerus. But on the other hand, neonatal fractures often show favorable evolution without reduction, even in cases of severe displacement. NSDHE, often associated with traumatic deliveries, remains underreported, controversial, and its management lacks standardized protocols. Furthermore, its diagnosis can be difficult on X-rays as the distal humeral epiphysis is not ossified at birth. The study questions are: Can non-reduction orthopedic treatment of distal humeral epiphyseal separation yield good clinical and radiological outcomes? Are there risk factors for distal humeral epiphyseal separation? What relevant additional examinations should be performed?

Hypothesis:

Orthopedic treatment without reduction may yield satisfactory clinical and radiological outcomes in NSDHE.

Patients and methods:

This multicenter retrospective study included patients with NSDHE with at least two years of follow-up from four university hospitals. Data on delivery, diagnostic methods, and treatment types were collected. At the last follow-up, joint range of motion, clinical outcomes, and elbow radiographs were evaluated.

Results:

Fifteen patients were included, with a mean age of 8,8 years at the last follow-up (ranging from 2 years to 29 years). All patients underwent an initial elbow radiograph, which was misinterpreted as an elbow dislocation in two cases. Two radiographs were initially deemed normal, necessitating further examinations (ultrasound, arthrography, Magnetic Resonance Imaging). Twelve patients were treated by immobilization without reduction, while two underwent surgical treatment with reduction under general anesthesia and percutaneous pinning. The non-operated patients had complete and symmetrical range of motion without complications, except for one case of resolving cubitus varus. One of the operated patients developed osteitis that required reoperation and also presented with resolving cubitus varus at 4 years old.

Discussion:

Orthopedic treatment through immobilization without reduction appears to be a viable option for neonatal epiphyseal separation of the distal humeral, which are frequently mistaken for elbow dislocations on initial radiographs. Complementary examinations, such as ultrasound, can be useful to confirm the diagnosis. This series yields promising results, although the sample size remains limited.

Conclusion:

Neonatal separation of the distal humeral epiphysis may represent an exception among displaced elbow fractures, as conservative management without reduction can lead to good clinical and radiological outcomes.

Level of evidence:

IV; Retrospective case series.

1.Introduction

The neonatal separation of the distal humeral epiphysis (NSDHE) is a very uncommon injury, often associated with obstetric trauma [1]. Although the humerus is the second most common site for fractures at birth after the clavicle, NSDHE remains sparsely described in the literature, with primarily sporadic cases reported [2–10].

The absence of the ossification center of the capitellum at birth makes the NSDHE invisible on radiographs. The diagnostic challenges—both clinical and radiographic—related to this injury can result in errors or delays in the initial diagnosis. To enhance diagnostic accuracy, the use of advanced imaging techniques such as ultrasound [3,5,11], MRI [12,13], and arthrography [14] has been suggested. The usual treatment for a displaced humeral supracondylar fracture in children involves anatomical reduction combined with immobilization and/or osteosynthesis. There is minimal growth and, consequently, little remodeling at the distal humerus, which means that imperfect reduction of a humeral condyle fracture can lead to mobility deficits and/or alignment issues in children.

In infants, the growth potential is so significant that most 'obstetric' fractures (occurring during delivery) are managed conservatively with simple analgesic immobilization without reduction, regardless of the initial displacement. Based on this principle, we have chosen not to reduce neonatal epiphyseal separations of the distal humerus for several years. However, this treatment approach remains controversial, and the management of this lesion is not standardized. The current study aims to address this controversy and provide new data on the outcomes of non- reduction orthopedic treatment.

The study questions are:

Can non-reduction orthopedic treatment of distal humeral epiphysis separation lead to good clinical and radiological outcomes?

Are there risk factors associated with distal humeral epiphysis separation?

What relevant complementary examinations should be conducted?

Hypothesis: Non-reduction orthopedic treatment may yield satisfactory clinical and radiological outcomes.

2.Patients and methods

2.1.Study design

This retrospective multi-center study was conducted in four university hospitals according to the STROBE guidelines.

2.2. Patients

We included newborns who presented with distal humeral epiphysis separation treated between January 1995 and December 2022 with a minimum follow-up of two years. Written consent was obtained either from the patients themselves, if they were adults at the time of contact, or from their legal representatives when they were still minors. This study adhered to the recommendations of the Declaration of Helsinki.

2.3. Data collected

Patients were seen in consultation at last follow up. For each patient, we collected the following data:

Anthropometric measurements, including age, sex, and the side of the lesion.

Delivery process: The presentation (cephalic/breech), mode of delivery (cesarean/vaginal), presence of dystocia during delivery, the use of instruments, and birth weight.

Diagnosis: Time to diagnosis, diagnostic methods used (X-ray, ultrasound, arthrography, MRI), as well as the type of initial displacement of the NSDHE (posteromedial or posterolateral).

Treatment: Details on the type of treatment administered (orthopedic with or without reduction, surgical with percutaneous fixation), and the occurrence of any immediate postoperative complications.

Clinical Data: At the last follow-up, clinical evaluation included assessment using a goniometer of the range of motion of the shoulder (external rotation elbow at the body ER1, external rotation shoulder at 90°abduction ER2, abduction, adduction, forward flexion, backward flexion), and the elbow (flexion, extension, pronation, supination). An assessment for any deviation of the upper limb axis (cubitus varus/valgus) and residual pain was performed. Additionally, the Mayo Elbow Performance Index (MEPI) score was calculated for all the children. The MEPI is a scoring system used to evaluate the function of the elbow, taking into account pain, motion, strength, and function [15]. A higher MEPI score reflects better elbow function, with a maximum possible score of 100. It is commonly used in clinical settings to assess the outcomes of elbow treatments or surgeries.

Radiographic Data: Analysis of initial X-rays, with particular attention to the direction of displacement. Analysis of final X-rays of the elbow (anterior and lateral views) to evaluate the alignment of the upper limb, particularly focusing on the measurement of the Baumann angle on the anterior radiograph, and the Shaft condylar angle on the lateral radiograph. In addition to the initial X-rays, the majority of patients also underwent additional imaging studies, such as ultrasound, arthrography, or MRI.

2.4. Statistical analysis

Descriptive statistics were used to summarize the demographic and clinical characteristics of the patients. Continuous variables were presented as means with standard deviations, and categorical variables were presented as frequencies and percentages.

3. Results

3.1. Patients

Fifteen patients were included in the study, consisting of 10 boys and 5 girls. At the last follow-up, the average age was 8.8 years (ranging from 2 years to 29 years, standard deviation 7.64 years).

3.2. Risk factors

Eleven of the 15 patients had at least one risk factor for traumatic birth, primarily dystocic delivery, breech presentation, macrosomia and twin pregnancy (Table 1). Among the four other patients, three were born by cesarean section. Only one patient had a delivery without any particularity.

3.3. Diagnostic methods

The diagnosis of neonatal epiphyseal separation of the distal humerus was made during the first week of life, following clinical suspicion of a deformed elbow (Fig. 1), except for one patient in whom the diagnosis was confirmed after 3 months. An X-ray of the elbow was systematically performed. Two radiographs were initially interpreted as normal, while two others were mistakenly interpreted as elbow dislocation (Fig. 2). All patients presented with an initial posteromedial displacement of the fracture. Thirteen patients received additional imaging alongside standard radiographs: 11 had ultrasound, 2 had both ultrasound and MRI, and 2 had arthrography (Table 1) (Figs. 3 and 4), all the exams were interpreted by a trained and senior pediatric radiologist.



Fig. 1. Deformed right elbow in a newborn from our study.

Table 1
Risk factors, Time to Diagnosis, Diagnostic Methods, and Treatment Type in Patients (D = day).

Patient	Risk factors	Diagnostic delay	Diagnostic methods	Treatment
1	None	D0: Diagnosis of "elbow dislocation" D1: Diagnosis of neonatal epiphyseal separation	-X ray -Ultrasound	Elbow immobilization with no reduction (shoulder sling)
2	Dystocic delivery	D4	-X ray -Ultrasound	Elbow immobilization with no reduction (shoulder sling)
3	Dystocic delivery Breech presentation Twin pregnancy	D0: Diagnosis of "elbow dislocation" D4: Diagnosis of neonatal epiphyseal separation	-X ray -Ultrasound	Elbow immobilization with no reduction (shoulder sling)
4	Dystocic delivery Twin pregnancy	D90	-X ray	Simple monitoring
5	Dystocic delivery	D1	-X ray -Arthrography	Surgical reduction and percutaneous pinning
6	Dystocic delivery Macrosomia	D1	-X ray -Arthrography	Surgical reduction and percutaneous pinning
7	Dystocic delivery	D5	-X ray -Ultrasound	Arm Cast with no reduction
8	None (Cesarean section)	D8	-X ray -Ultrasound	Arm Cast with no reduction
9	Dystocic delivery	D5	-X ray -Ultrasound -MRI	Arm Cast with no reduction
10	None (Cesarean section)	D1	-X ray -Ultrasound -MRI	Arm Cast with no reduction
11	Macrosomia	D1	-X ray	Elbow immobilization with no reduction (shoulder sling)
12	None (Cesarean section)	D1	-X ray -Ultrasound	Elbow immobilization with no reduction (shoulder sling)
13	Macrosomia	D4	-X ray -Ultrasound	Elbow immobilization with no reduction (shoulder sling)
14	Dystocic delivery	D2	-X ray -Ultrasound	Elbow immobilization with no reduction (shoulder sling)
15	Twin pregnancy	D1	-X ray -Ultrasound	Elbow immobilization with no reduction (shoulder sling)

3.4. Treatment

Twelve patients were treated without initial reduction, either with elbow immobilization in a sling (8 patients) (Fig. 5) or with a brachio-antebrachial-palmar cast (4 patients). Two patients required surgical reduction followed by percutaneous pinning after an arthrography (Patient 5 and Patient 6). One patient received no treatment and was only under observation.

3.5. Clinical results

At the last follow-up, all patients exhibited full and symmetrical joint mobility of the elbow and shoulder, with no axis disturbances of the upper limb (Fig. 6). In addition, every patient achieved a MEPI score of 100 points. No vascular or nerve complications were observed in any patient. One of the two surgically treated patients developed a major postoperative complication, including early extrusion of the pin and an osteoarticular infection (osteitis with abscess) that required emergency surgery and prolonged intravenous antibiotic therapy. In this same patient, a 15° cubitus varus of the elbow was noted at seven months of age, which resolved spontaneously by the age of four. The only patient with a delayed diagnosis at three months, who was managed with simple monitoring and regular follow-up, presented with a

15° cubitus varus at six months of age, which decreased to 10° by nine months and then resolved spontaneously by three years.

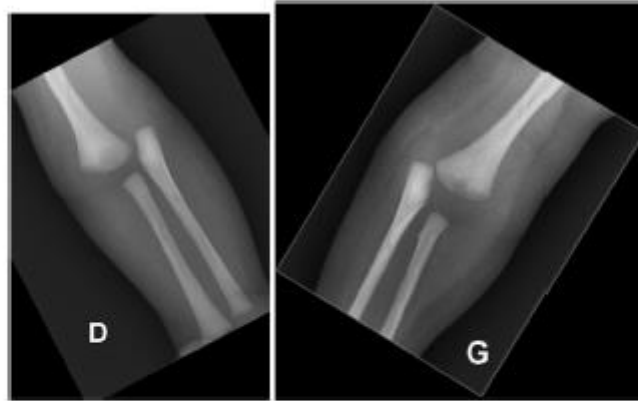


Fig. 2. Two X-ray initially interpreted as an elbow dislocation with posteromedial displacement.

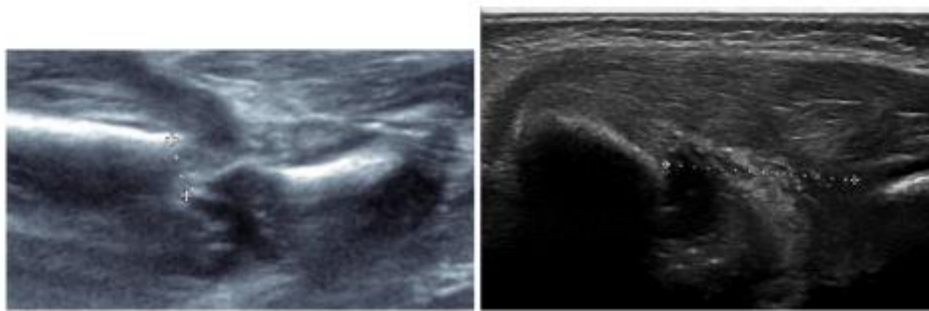


Fig. 3. Two ultrasounds of a neonatal epiphyseal separation.

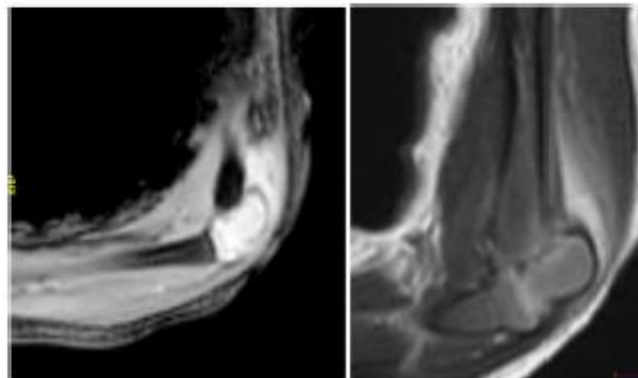


Fig. 4. MRI of a neonatal epiphyseal separation.

3.6. Radiological results

The Baumann angle and Shaft condylar angle measurements (Fig. 7) were within normal limits for all patients (Table 2). The mean Baumann angle was 69.27° with a standard deviation of 3.04°, and the mean Shaft condylar angle was 36.8° with a standard deviation of 4.4°.

The X-rays at the last follow-up showed no significant sequelae such as heterotopic ossification or necrosis of the ossification nuclei (Fig. 8), and complete bone remodeling was observed.

4. Discussion

Neonatal separation of the distal humeral epiphysis (NSDHE) can lead to favorable clinical and radiological outcomes with conservative orthopedic treatment without reduction. This approach avoids general anesthesia and unnecessary surgery in newborns, which contrasts with the prevailing opinion in the literature recommending reduction under general anesthesia, sometimes with percutaneous or open fixation, as the standard treatment [2,8,9,16–18].



Fig. 5. Elbow immobilization with shoulder sling.



Fig. 7. Method for Assessing the Baumann Angle Measurement (A) and the Shaft Condylar Angle (B).

A (left): Baumann's angle is created by drawing a line parallel to the longitudinal axis of the humeral shaft and a line along the lateral condylar physis as viewed on the AP image.

B (right): The shaft condylar angle is the angle between a longitudinal axis of the humerus and a line through the axis of the capitellum.



Fig. 6. Full and symmetrical joint mobility in patient n°1 of the study at the age of 6 years.

Several studies have investigated different treatment modalities for NSDHE (Table 3 [2,8–10,19]). Jacobsen et al. reported on six patients, two treated by closed reduction under general anesthesia, and four conservatively; after 58 months, five had excellent clinical and radiological outcomes, with one mild forearm valgus deformity [2]. Ratti et al. reviewed 33 cases and found that 88% of non-surgically treated patients recovered a normal carrying angle and 80% regained full range of motion after 22 months [19]. Galeotti et al. described 10 patients, four with closed reduction and six with percutaneous pinning; all achieved full range of motion without further surgery or physal damage [9]. Kruse et al. reported nine patients (six conservatively treated, three surgically) with full functional recovery despite two minor complications; they still recommended reduction or ORIF in cases with significant

displacement due to one cubitus varus after isolated reduction [10]. Overall, complications are more common after surgery, while conservative treatment without reduction rarely leads to adverse outcomes, supporting the strong remodeling potential of NSDHE, which contrasts with supracondylar fractures in older children. Thus, we recommend conservative treatment without reduction as long as there is no neurovascular complication.

Table 2
Measurement of the Baumann angle and schaft condylar angle.

	Patient's age at the last follow up	Baumann angle	Anteversion angle
1	6 years	65	40
2	6 years	74	42
3	3 years	70	39
4	2 years	68	32
5	6 years	71	37
6	7 years	66	40
7	16 years	73°	30
8	22 years	66	45
9	29 years	67	32
10	4 years	74	34
11	8 years	71	30
12	7 years	65	38
13	8 years	72	39
14	2 years	69	34
15	3 years	68	40

Outside the neonatal period, pediatric literature shows that surgical treatment of DHPS—especially CRPP or ORPP—leads to better outcomes with lower rates of cubitus varus (18.9%) and avascular necrosis (3.9%) compared to conservative management [20]. Wu et al. also demonstrated good results with CRPP even in delayed cases (>7 days), with 11 of 12 patients achieving excellent outcomes [21]. This contrasts with NSDHE, in which conservative treatment remains both safe and effective. It highlights the importance of distinguishing between these two conditions.

Our findings align with Zhou et al. [22], who highlighted frequent misdiagnosis of transphyseal fractures as elbow dislocation in neonates and emphasized the crucial role of ultrasonography. Our study confirms this high misdiagnosis rate, mainly due to the absence of ossification centers at birth, which complicates X-ray interpretation and delays diagnosis. We showed that NSDHE typically presents with postero-medial displacement on X-rays, unlike the more common posterolateral displacement seen in elbow fractures after walking age, which are generally due to indirect trauma [9]. Ultrasound is a useful, radiation-free tool to visualize non-ossified structures and confirm diagnosis without the need for anesthesia [3,5,11]. While MRI and arthrography can provide detailed assessment, they usually require general anesthesia and may delay diagnosis due to scheduling constraints in emergencies [11–14,23].

Our study confirms previously reported birth trauma risk factors associated with NSDHE, including dystocic delivery, breech presentation, macrosomia, and twin pregnancy [2–9].

Interestingly, cesarean section was not protective. In fact, three patients born by cesarean without other risk factors suggest that traction during extraction may cause the fracture. This supports the hypothesis that mechanical forces during delivery play a significant role in the pathogenesis of NSDHE.

Despite its retrospective and descriptive nature and the relatively small cohort, our study represents one of the largest published series on NSDHE. The long follow-up enhances the relevance of the results. Our findings confirm the favorable natural course of NSDHE managed conservatively, even in significantly displaced cases. Most patients had no functional sequelae, pain, or growth disturbances in most patients, which supports avoiding surgery and anesthesia in newborns whenever possible. A major limitation is the absence of a control group, restricting direct comparison between conservative and surgical outcomes, and the very small number of surgically treated patients prevents any meaningful statistical comparison. Nevertheless, these surgical cases also evolved favorably without clear benefit over conservative treatment. Given the rarity of NSDHE, assembling a sufficiently large comparative cohort—even multicentric—is challenging. Lastly, although follow-up was long in most cases, late complications such as growth disturbances or angular deformities might appear beyond the studied period.



Fig. 8. Antero posterior and lateral radiographs of patient N° 14 at the ages of 2 weeks (a) 6 months (b), and 2 years (c).

5. Conclusion

Neonatal separation of the distal humeral epiphysis may represent an exception among displaced elbow fractures, as conservative management without reduction can lead to good clinical and radiological outcomes.

Table 3
Key studies on the treatment of NSDHE (excluding case reports) covering both surgical and non-surgical treatment.

Article	Number of patients	Type of treatment	Mean follow up	Complications/ Results
Jacobsen et al. [2]	6 patients	2 closed reduction under general anesthesia and cast immobilization 4 treated orthopedically (cast immobilization) without reduction	58 months (16-120)	The clinical and radiological results were excellent in five patients, with complete realignment of the injury. In one patient the forearm lay in slightly reduced valgus with the elbow in full extension. At follow-up, 88 % recovered completely the carrying angle and 80 % range of motion.
Ratti et al. [19]	20 case reports or small case series (total of 33 cases)	4 surgical treatment 23 reduction 6 no reduction	22 months	At follow-up, 88 % recovered completely the carrying angle and 80 % range of motion.
Gigante et al. [8]	5 patients	Closed reduction and cast immobilization under general anesthesia 4 closed reduction and cast immobilization under general anesthesia	30 months (12-60)	A 5° varus angle in only one patient. At the last follow-up, all fractures had healed with full range of motion. No clinical or radiographic deformity requiring repeated surgery or physical damage was observed.
Galeotti et al. [9]	10 patients	6 closed reduction and percutaneous pinning -6 no reduction -1 reduction under general anesthesia -3 surgically with an open reduction	37 months (12-120)	At a mean follow-up of 79 months, two complications occurred: one axillary abscess due to the immobilization (for non-operated patient) and one cubitus varus deformity (for a patient who had reduction under general anesthesia). All children had a full functional recovery.
Kruse et al. [10]	9 patients	Recommendation for severe displacement (Gartland IV) to make a reduction under general anesthesia & arthrography	79 months	At a mean follow-up of 79 months, two complications occurred: one axillary abscess due to the immobilization (for non-operated patient) and one cubitus varus deformity (for a patient who had reduction under general anesthesia). All children had a full functional recovery.

CRedit authorship contribution statement

All authors made substantial contributions to the conception of the study, data acquisition, analysis, and interpretation of the results. **MBr** and **MD** first draft of the manuscript. **MBr**,

MDT, GC, EB, CJ, MB, SP and **MD** revised the manuscript and gave their final approval of the version to be submitted.

Declaration of Generative AI and AI-assisted technologies in the writing process

AI was not used in the preparation of the manuscript.

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Declaration of competing interest

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