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The Usefulness of Dynamic Ultrasonography in Nursemaid's Elbow: A Prospective Case Series of 13 Patients Reconsideration of the Pathophysiology of Nursemaid's Elbow

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Background: Nursemaid's elbow is a common musculoskeletal disorder among children under 5 years of age. However, diagnostic imaging to confirm a nursemaid's elbow diagnosis is still unavailable. Through the use of a high-frequency ultrasound probe, we determined the etiology and possible pathophysiology of nursemaid's elbow.

Methods: Thirteen consecutive patients with the clinical suspicion of nursemaid's elbows were examined. A high-frequency linear array 6 to 24 MHz hockey stick transducer was used to detect small changes (partial eclipse signs) of the radial head in the axial view before and after manipulation.

Results: All patients in this study had a successful reduction. A partial eclipse sign was found in all patients before reduction and disappeared after successful reduction.

Conclusion: These pathologic features detected through high-frequency ultrasonography suggest the role of the escaped posterior synovial fringe in the pathogenesis of the nursemaid's elbow. The specific finding of a "partial eclipse sign" could be a useful additional clue leading to the correct diagnosis of the nursemaid's elbow and may help avoid the unnecessary reduction in patients who do not have a "partial eclipse sign".

Level of Evidence: Level II, diagnostic studies.

Key Words: nursemaid's elbow, pulled elbow, ultrasonography, diagnostic image, partial eclipse sign

(*J Pediatr Orthop* 2023;00:000–000)

Nursemaid's elbow, also known as pulled elbow or radial head subluxation, is a common musculoskeletal disorder among children under 5 years of age.^{1,2}

It usually occurs with axial traction to the forearm while a child's arm is in pronated and extended positions.^{3,4}

The diagnosis of the nursemaid's elbow is based on history and physical examination.^{1,5} Children with nursemaid's elbow usually do not want to use the arm and will protect it with a slightly flexed elbow and pronated wrist position.

However, the pathophysiology of the nursemaid's elbow still lacks strong evidence. The exact pathology of the nursemaid's elbow remains to be defined.⁶

In adults, Clarke and several authors have indicated that the synovial fold could be a cause of lateral elbow pain associated with mechanical symptoms such as clicking, catching, and painful snapping.^{7–10}

The role of imaging in diagnosis has also been somewhat controversial.^{11,12} Physicians tend to order radiographs for elbow injuries that they initially perceive to be radial head subluxations when attempts at reduction fail.¹³

Using a high-frequency ultrasound probe, we attempted to determine the etiology and possible pathophysiology of the nursemaid's elbow.

Our hypothesis was that an escaped and entrapped posterior synovial fringe could be the pathogenesis of the nursemaid's elbow (Fig. 1).

METHODS

From June to October 2022, 13 children with the clinical suspicion of a nursemaid's elbow were examined in 1 orthopaedic clinic.

This study was approved by the Institutional Review Board of Mackay Memorial Hospital.

Examinations were performed by 1 orthopaedic surgeon at the clinic. Ultrasound examinations were performed by a single senior orthopaedic surgeon at the clinic.

Ultrasonography was performed using a high-frequency linear array 6 to 24 MHz hockey stick transducer on a GE Logiq E10 Ultrasound machine (GE Healthcare, Milwaukee, WI)

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The authors have not received any financial support for the study.

The author declares no conflicts of interest.

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DOI: 10.1097/BPO.0000000000002401

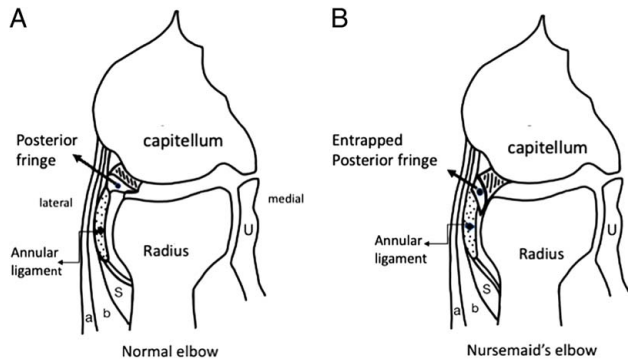


FIGURE 1. Schematic diagrams illustrating the pathology of nursemaid's elbow in the coronal section at the level of the most projecting part of the lateral epicondyle. A, Normal elbow: the posterior fringe is located in its normal position between the capitella and radial head. B, Nursemaid's elbow: The posterior synovial fringe entrapped between the radial head epiphysis and annular ligament. "a" indicates extensor digitorum muscle, "b" indicates extensor carpi radialis brevis, and "S" indicates supinator. Bold arrow indicates posterior synovial fringe and thin arrow indicates annular ligament.

Patient position: the child was seated on the lap of their parent or caregiver with the lateral side of the child's affected elbow facing the doctor.

Transducer position: short axis view at the level of the radial head (Fig. 2).

The reduction was attempted in the clinic, and we used the hyperpronation technique in all children.¹⁴ The child was seated on their parent's lap, with the hand of the affected arm clasped. The free hand was used to support the patient's elbow. The patient's wrist was hyperpronated. A click may be felt or heard. Dynamic and static images before and after reduction were obtained and saved for later review. All sonographic pictures were saved and analyzed by a physiatrist who was also a musculoskeletal ultrasound sonographer. The physiatrist



FIGURE 2. In the ultrasonographic examination, the probe was placed on the involved site perpendicular to the radial head of the patient.

was blinded to any patient's clinical information. Interrater agreements about the eclipse sign between the physiatrist and the clinician were calculated. In this study, the interrater reliability and intrarater reliability were tested with the Cohen Kappa coefficient.

Diagnostic Criteria

The diagnostic criterion for posterior synovial fringe entrapped between the radial head and annular ligament was a "partial eclipse sign" (Fig. 3).

In the dynamic view, the surrounding tissue, including the extensor digitorum, extensor carpi radialis brevis, extensor digiti minimi, extensor carpi ulnaris, and anconeus aponeurosis, will be pulled and move in the same direction while pronating the radial head, which also limits the range of movement in pronation of the radial head.

RESULTS

All patients in this study had a successful reduction.

In the axial view, a "partial eclipse sign" was found in all patients before reduction and disappeared after successful reduction (Figs. 5–7).

The impingement of the posterior synovial fringe between the annular ligament and radial head could also be detected in the long-axis view of the lateral elbow (Fig. 8).

In the dynamic pronation and supination video, we can see that the entrapped posterior fringe causes the surrounding tissue, including the extensor digitorum, extensor carpi radialis brevis, extensor digiti minimi, extensor carpi ulnaris, and anconeus aponeurosis, to be pulled and move in the same direction of pronation. It also caused limitations of the range of motion in full pronation and supination.



FIGURE 3. Axial image of the left elbow showing the "partial eclipse sign" (arrow): radial head obscured by the entrapped posterior fringe. ECU indicates extensor carpi ulnaris; ECRL, extensor carpi radialis longus; EDC, extensor digitorum common; S, supinator tendon.

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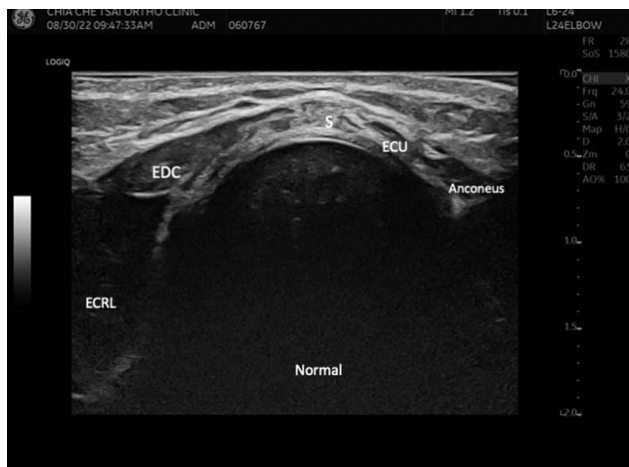


FIGURE 4. Axial image of the left elbow showing the normal relationship around the radial head. ECU indicates extensor carpi ulnaris; ECRL, extensor carpi radialis longus; EDC, extensor digitorum common; S, supinator tendon.

In this study, the specific “partial eclipse sign” was found in all 13 patients who underwent detailed ultrasonography before reduction (Fig. 3). After reduction, a normal relationship between the radial head and annular ligament was observed, and the “partial eclipse sign” disappeared (Fig. 4). The entrapment sign could also be detected in the long-axis view, but the “partial eclipse sign” was more significant and more easily detected in the axial view, as the posterior fringe in children is very tiny, normally not larger than 3 mm (Fig. 8).

Intrarater and interrater agreement for the detection of the eclipse sign showed almost perfect agreement according to the Cohen Kappa value (intrarater reliability $k = 1$ and interrater reliability $k = 0.925$, respectively).

DISCUSSION

Nursemaid’s elbow, also known as radial head subluxation or pulled elbow, is the most common cause of upper extremity immobility in preschool children. However, the pathophysiology is not very clear, as the diagnosis is still made based on history and clinical examination. Sankar¹⁵ reported that 30% of the patients in his study had no history of traction. Some children can have elbow fractures or other pathologies that can mimic the physical findings of the nursemaid’s elbows.^{16–18} Reduction attempts in these cases can cause iatrogenic displacement of the fracture and unnecessary pain. By ultrasonography, it has become possible to obtain objective diagnostic images of the nursemaid’s elbow.

The exact pathology of the nursemaid’s elbow also remains to be defined. Subluxation of the radial head is possible because of the anatomy of the proximal radius.¹⁹ Salter and Zaltz¹⁹ found that traction on the pronated forearm with the elbow extended could cause a transverse tear of the distal attachment of the annular ligament, allowing the partial escape of the radial head. However, almost all these patients were pain-free immediately after

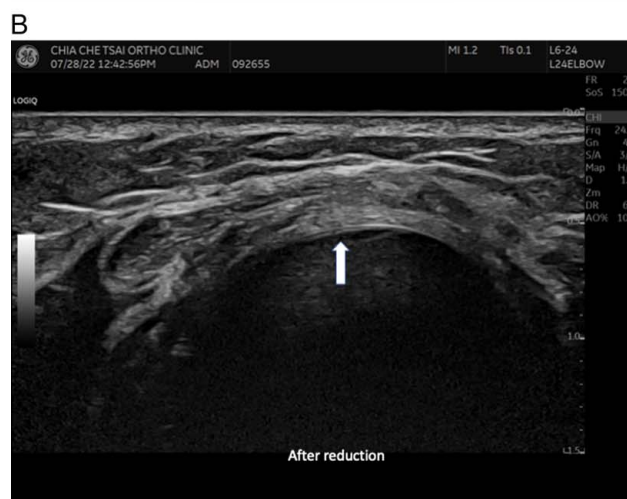


FIGURE 5. A, Sonographic image of the left side of a nursemaid’s elbow in a boy aged 4 years and 5 months. The posterior fringe (arrow) was entrapped between the radial head epiphysis and annular ligament. It obscured the radial head like a solar eclipse. B, After reduction, the “partial eclipse sign” disappeared, and the normal relationship between the radial head and annular ligament returned. The radial head epiphysis is rounded again (arrow).

successful reduction. It seems that the annular ligament was not torn in all these patients.

Snapping is palpable, audible, and often visible. It used to be a sign of the successful relocation of a nursemaid’s elbow. In adults, the synovial plica is a cause of painful snapping of the elbow joint and was first described by Clarke¹⁰ in 1988. Several authors have indicated that the fold could be a cause of lateral elbow pain associated with mechanical symptoms such as clicking, catching, and snapping.²⁰ The synovial fringe, also termed the synovial fold, plica, or meniscus-like structure, has been of interest to surgeons because of its perceived relationship with symptoms such as snapping, clicking, and pain. It has a consistent morphology in both adults and embryos.²¹ The outside of the synovial fold is composed of synovial tissue

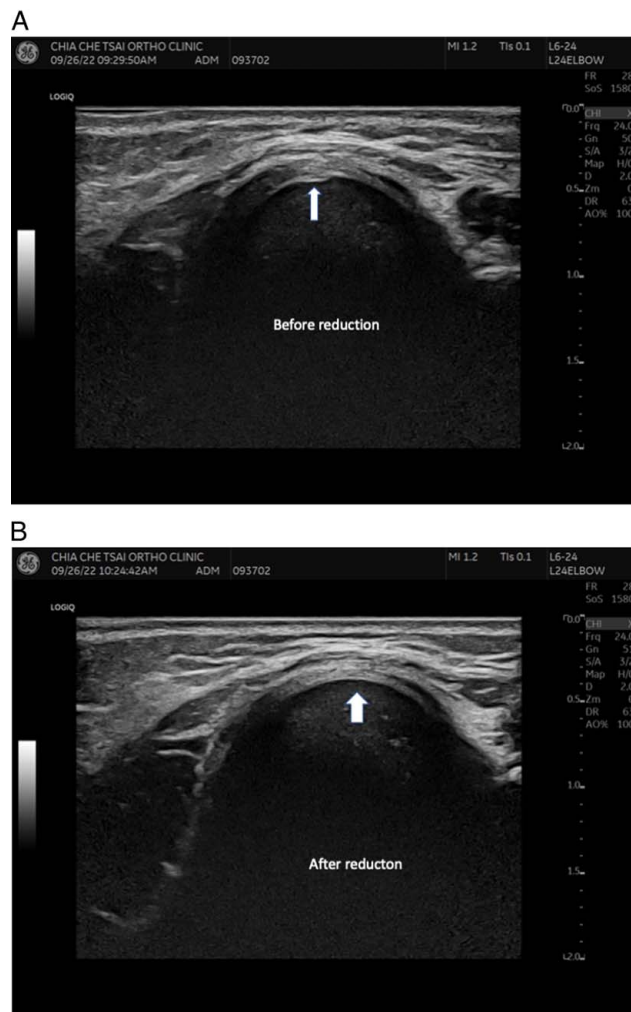
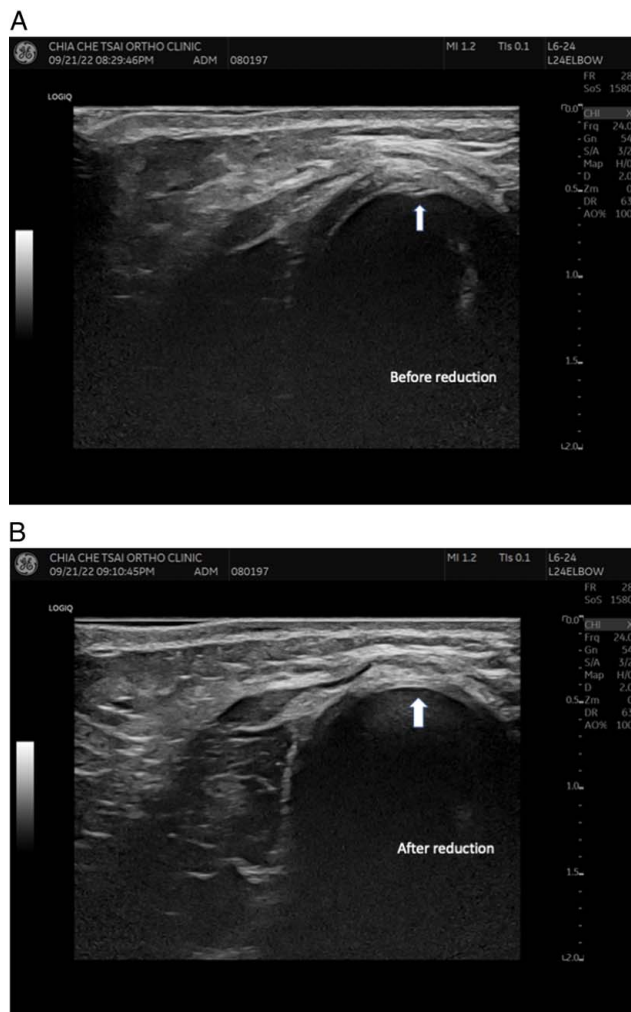


FIGURE 6. A, Sonographic image of the left side of a nursemaid’s elbow in a boy aged 2 years and 10 months. The posterior fringe (arrow) was entrapped between the radial head epiphysis and annular ligament. B, After reduction, the “partial eclipse sign” disappeared (arrow).

FIGURE 7. A, Sonographic image of the left side of a nursemaid’s elbow in a boy aged 1 year and 9 months. The dislocated posterior fringe obscured the radial head like a solar eclipse. B, After reduction, the normal relationship between the radial head and annular ligament returned (arrow).

and the inside is composed of a thick fibrous axis including fat and vascular tissue. Normally, the synovial fold is between the capitulum and the fovea radialis.²² After observing 40 embryo cadaveric elbows, Isogai and colleagues identified 2 types of synovial fringe: anterior fringe and posterior fringe. The lateral fold only exists in adults and elderly individuals, which may be due to degeneration.²² In the macroscopic classification, anterior folds usually showed a villous-fringed pattern, whereas posterior fringes exhibited a plicate or fringed pattern.

In the study of Tsuji et al, arthroscopy findings correlated with gross anatomy and histology findings in that the synovial fold is a capsular synovial structure located on the proximal edge of the annular ligament but distinct from the annular ligament.²⁰ The synovial fold of the humeroradial joint could be injured by chronic repeated trauma related to pronation and supination.²³

Synovial folds were considered hypertrophic if they measured 3 mm or greater in thickness.²³

As the clicking or snapping sound also occurred when the successful reduction was performed in children with nursemaid’s elbow, our hypothesis was that when traction is applied to a child’s forearm in pronation, the posterior fringe escapes from its normal position between the capitellum-radial joint, which then becomes entrapped between the annular ligament and radial head just below the lateral collateral ligament when traction is removed. The entrapped posterior fringe then limits the normal pronation and supination movement of the radial humerus joint. When successful reduction occurs, the escaped posterior fringe snaps back to its normal position between the radial head and capitellum, and a clicking sound occurs at the same time. The escaped and entrapped posterior synovial

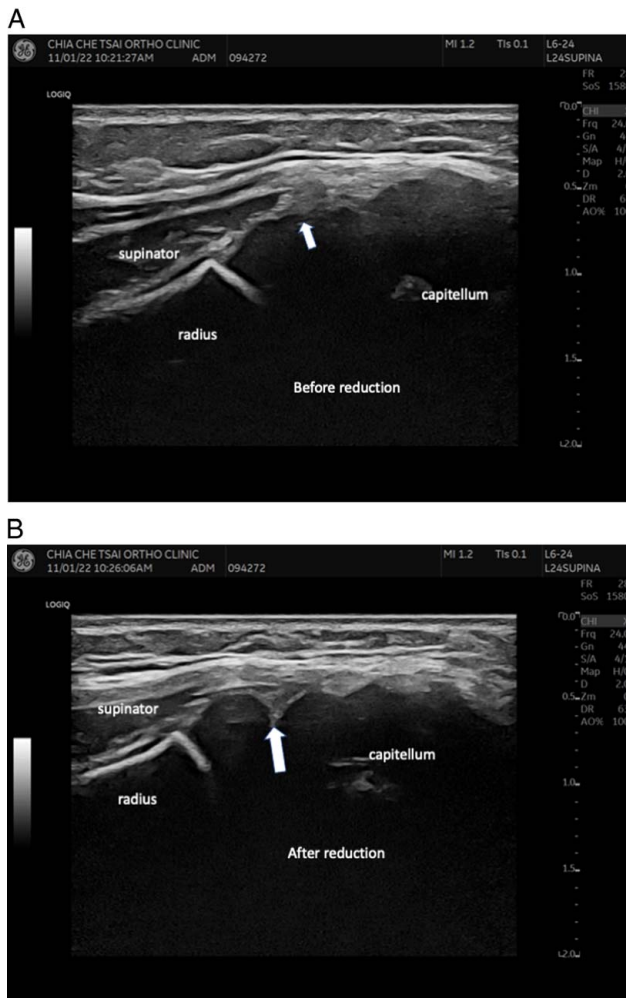


FIGURE 8. Ultrasonography of a nursemaid's elbow. Long-axis view of the radiocapitellum joint. A, Before reduction, the posterior fringe was entrapped between the radial head epiphysis and annular ligament (arrow). The distance between the radius and capitellum was not increased. B, After reduction, the normal relationship between the radial head and annular ligament returned. The escaped posterior fringe (arrow) snapped back to its normal position between the radial head and capitellum.

fringe could be the pathogenesis of the nursemaid's elbow (Fig. 1).

In this pioneering study, we used a high-frequency linear array hockey stick transducer (6 to 24 MHz), which can detect tiny entrapped posterior fringes (normally smaller than 3 mm). Dynamic and static images before and after reduction were obtained and saved for review. In the static image, the escaped posterior fringe was entrapped between the radial head and annular ligament, causing an obscure sign in the hypoechoic round radial head epiphysis (Fig. 3). We called this a “partial eclipse sign”.

Kosuwon and colleagues were the first to use ultrasound to confirm a nursemaid's elbow in 1993. They found

that the distance between the radial head and the capitellum was increased, probably due to the interposition of the annular ligament.²⁴ However, in our study, under examination with a high-frequency ultrasound probe, we did not see any increase in the radiocapitellar distance in the long-axis view in any of the 13 patients (Fig. 8); therefore, we could not demonstrate any evidence of subluxation of the annular ligament into the radiocapitellar joint.

Early ultrasonographic studies of the nursemaid's elbow almost all focused on the anterior joint with a long-axis view to assess the morphology of the annular ligament and supinator muscle.^{25–29} The *J*-sign, a change in the shape of the supinator muscle and annular ligament, and enlargement of the anterior synovial fringe were found.^{27,28}

However, these findings may be based on detecting secondary changes in the joint.

In our hypothesis, when a nursemaid's elbow occurs, the posterior synovial fringe escapes from the radiocapitellar joint space and is entrapped between the annular ligament and the posterior lateral side's radial head. This can push the subluxed radial head in a more anterior and medial direction. As the posterior fringe escapes from the joint space, it also causes the rotation axis of the radial bone to change. The joint line of the radial head tilts changes as well. All these changes can cause morphologic changes in the supinator muscle and anterior joint capsule. This may be the reason for the *J*-sign in the axial view of the anterior joint. Therefore, we believe that all the ultrasonography findings in the anterior joint in the long-axis view could be a second sign of the nursemaid's elbow.

There were some limitations in this study. First, the small case number in this study may be insufficient to broadly generalize the results on current information. Accumulating data from more patients is mandatory to establish solid conclusions in future studies. However, to minimize possible bias, we conducted this study through the longitudinal collection of data in a consecutive case series. Second, another possible bias may occur due to data interpretation by only 1 examiner/physician throughout the study. However, the bias may also be reduced because all examinations were performed by a single experienced pediatric orthopaedic specialist; thus variations could be minimized.

CONCLUSIONS

To conclude, these pathologic features found by high-frequency ultrasonography suggest the role of the posterior synovial fold in the pathogenesis of the nursemaid's elbow and may justify the reduction method for the nursemaid's elbow.

The test can not only be employed for patients for whom closed reduction fails but may also be used to evaluate if the close reduction was done successfully. It is thus both a diagnostic test and a verification of satisfactory reduction.

A high-frequency ultrasound probe could be the most valuable diagnostic tool. It not only allows direct

inspection of the entrapment of the dislocated fringe but also helps in understanding the dynamic impact of the dislocated synovial fold in elbow joint motion.

All 13 patients demonstrated a partial eclipse sign, which could be a useful additional clue leading to the correct diagnosis of the nursemaid's elbow and helping to avoid the unnecessary reduction in patients with no partial eclipse sign. Although entrapment could be detected in both axillary and long-axis views, we suggest using an axillary view because it is easier and quicker to use in an uncomfortable child before reduction. A dynamic ultrasound examination is a diagnostic tool as well as a therapeutic evaluation tool for the treatment of a nursemaid's elbow. We believe that the nursemaid's elbow is caused by the dislocation of the posterior synovial fringe.

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