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Editorial

Congenital Anomalies and Anatomical Variants of the Carpal Bones

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Editorial

This editorial reviews the literature on congenital anomalies and anatomical variants of the carpal bones and presents illustrative cases referred for radiographic evaluation after trauma. Both conditions may involve numerical changes or alterations in maturation and development.

1. Numerical variations

Carpal bones originate from a single mesenchymal mass, which segments into eight cartilaginous units before birth. Bone formation occurs through centripetal endochondral ossification from a central nucleus. Numerical variations may result in either fewer or extra independent, movable carpal bones, as well as mixed anomalies [1,2].

1.1 Fewer carpal bones

A reduced number of carpal bones may be observed in cases of coalition or agenesis-aplasia and may present independently or in association with syndromic or metabolic disorders.

Carpal coalition, or synostosis, is an abnormal union of carpal bones resulting from a separation defect. It is the most common congenital anomaly of the carpal bones. The term carpal fusion should be reserved for acquired cases. Carpal coalition presents in two main forms: osseous and nonosseous union, sometimes inaccurately referred to as complete and incomplete coalition. In an osseous coalition, the affected bones form a single osseous block with no visible joint space on radiographs. In a nonosseous coalition, the bones are joined by cartilage (synchondrosis), fibrous tissue (syndesmosis), or both, and radiographs show joint space narrowing [3,4].

An isolated carpal coalition usually involves two bones within the same carpal row. The lunate-triquetrum type is the most common, accounting for nearly 90% of cases, followed by the capitate-hamate type at approximately 5.6%. The general population incidence is about 0.095%, but prevalence is 10 to 100 times higher in Africans and twice as high in females compared to males. Carpal coalition is usually bilateral and inherited in an autosomal dominant, non-sex-linked pattern [5-9].

De Villiers Minnaar classified the lunate-triquetrum coalition into four types. Type I is a nonosseous union resembling pseudoarthrosis, which can be difficult to diagnose and is often missed on plain radiographs. Type II is a partial osseous union with a usually distal remnant of joint space. Type III is an osseous union without any joint remnant. Type IV is an osseous union associated with other carpal abnormalities. This classification also applies to other isolated carpal coalitions (Fig. 1) [10].

Patients with an isolated carpal coalition involving one or both carpal rows, as well as those with massive coalitions involving more than two carpal bones or between carpal bones and the radius or ulna, should be carefully evaluated for associated syndromal disorders and dysplasias, starting with the tarsal-carpal coalition syndrome, a genetic or congenital disorder (Fig. 2) [11-13].

On the other hand, acquired carpal and tarsal bone fusion, or ankylosis, may complicate rheumatic diseases, infection, trauma, and wrist surgery, or may be iatrogenic for joint stabilization [14-16].

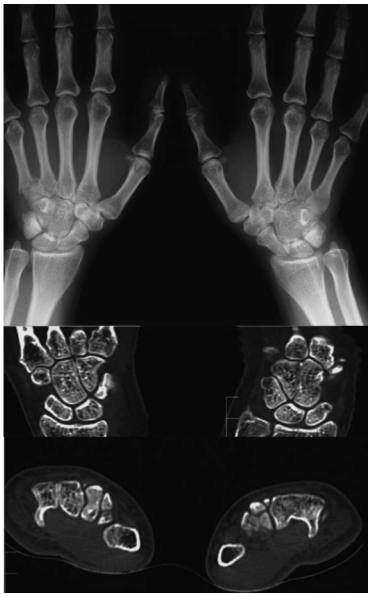

Figure 1. *A 38-year-old woman presented with a fracture at the base of the left fifth metacarpal and bilateral type II capitate-hamate coalition.*

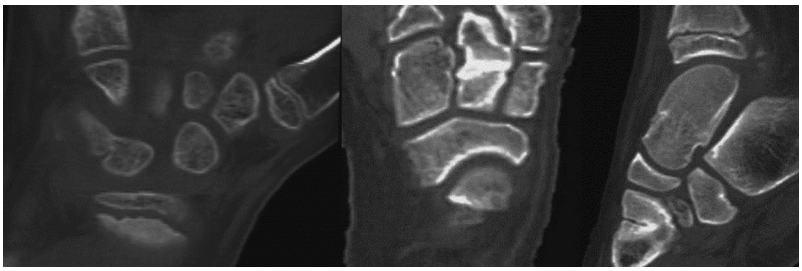

Figure 2. *A 12-year-old boy with tarsal-carpal coalition syndrome showed bilateral type II lunate-triquetral and second metatarsal-intermediate cuneiform coalition on imaging. While most coalitions involve the talocalcaneal or calcaneonavicular joints, coalitions between the tarsal bones and the base of the metatarsals are extremely rare.*

An isolated carpal coalition typically does not affect wrist function and is rarely symptomatic, unlike a tarsal coalition. It is often identified incidentally on radiographs taken for other reasons. Micromovement in a nonosseous coalition may cause discomfort or pain during activities such as playing musical instruments or engaging in strenuous sports. Clinicians should carefully attribute nonspecific wrist pain to anatomical variations seen on radiographs. Incidental findings generally should not alter management. Advanced imaging can help evaluate symptomatic wrists and rule out additional pathology. In osseous coalitions, restricted movement between carpal bones may cause increased motion in adjacent joints, resulting in stress-related pain. Symptomatic and complicated cases, as well as early-onset arthritis, have been reported. In syndromic cases or those associated with hand anomalies, stiffness may be the only hand symptom during infancy and often worsens with age [17-23].

Agenesis and aplasia, referring to genetic and congenital anomalies, respectively, are extremely rare. They may involve the absence of single or multiple carpal bones, as well as of the entire carpus. The scaphoid is most commonly affected, followed by the lunate and triquetrum. A missing carpal scaphoid is often associated with deficiencies of the radius and thumb, or with abnormalities of the bones and musculature on the radial side of the hand (Fig. 3). Cases with unilateral or bilateral involvement in family members have also been reported [24-26].

1.2 Extra carpal bones

An increased number of carpal bones may result from extra centers of ossification that fail to fuse during fetal development or from congenital anomalies, such as bipartite/split bones or genetic syndromes.

Extra centers of ossification are a rare anatomical variant where two or more distinct centers develop instead of the typical single center (Fig. 4). Multiple ossification centers can occur in any carpal bone, most often in the pisiform [27], the only sesamoid in the wrist. These centers usually fuse, but in rare cases, failure to unite results in a bipartite bone or an accessory ossicle.

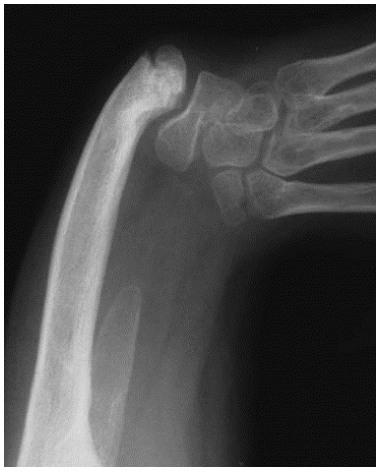

Figure 3. *A 6-year-old boy exhibited radial longitudinal deficiency, absent thumb and scaphoid, and lunate-triquetral coalition.*

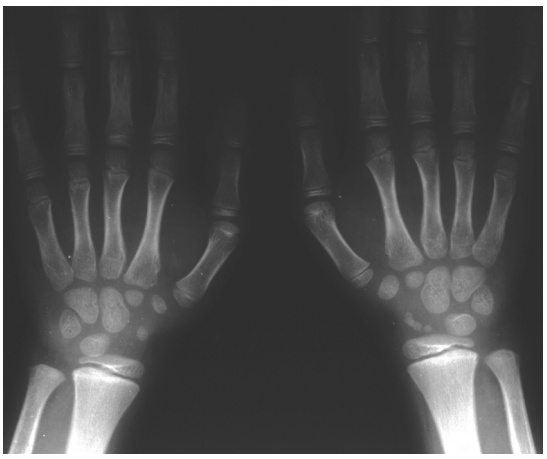

Figure 4. *A 7-year-old girl had three separate ossification centers in the right scaphoid.*

Most reported cases of bipartite or multipartite carpal bones involve the scaphoid, although the trapezium, trapezoid, triquetral, and lunate may also be affected. It remains unclear whether congenital bipartite scaphoid exists or if these cases represent fractures that have progressed to occult nonunion. Bunell proposed the following diagnostic criteria for congenital bipartite scaphoid: no trauma history, bilateral presentation, equal size and uniform density of each ossicle, absence of degenerative wrist changes, and smooth, rounded ossicle edges [28-31].

Accessory ossicles are typically asymptomatic and found incidentally on imaging. More than 20 accessory ossicles have been identified in the wrist (Fig. 5, 6). These ossicles originate during embryonic development and may persist into adulthood as normal anatomical variants, as those found in other locations [32,33]. The os styloideum, or ninth carpal bone, is located on the back of the wrist between the capitate, trapezoid, and the bases of the second and third metacarpals. It is usually misdiagnosed as a ganglion cyst. It is referred to as the etiopathogenesis of the carpal boss syndrome when symptomatic [34].

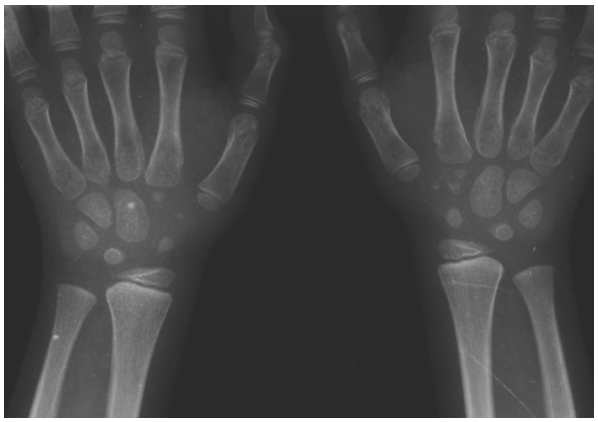

Figure 5. *An 8-year-old girl presented with os centrale carpi in the right wrist, an accessory ossicle located dorsally between the scaphoid, trapezoid, and capitate. This ossicle typically fuses with the scaphoid before the fetal stage of development, which begins after the 8th week of pregnancy. A bone island (enostosis) was also observed on the left capitate.*

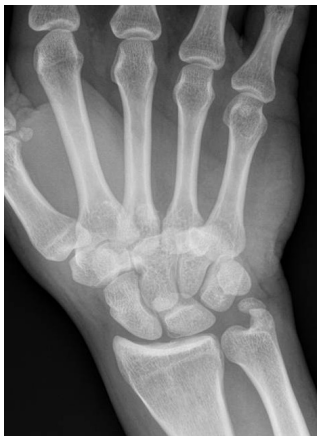

Figure 6. *A 20-year-old man was referred for an acute fracture-dislocation of the right hand. A lunula was incidentally identified on radiographs. This accessory ossicle is located at the tip of the ulnar styloid and may fuse with it, resulting in an elongated styloid process. Differential diagnoses include: 1) ulnar styloid fracture, 2) persistent ulnar styloid ossicle, which occurs when the ulnar styloid process does not unite with the ulna, and 3) os triangulare (also known as os intermedium antebrachii or os triquetrum secundarium), which is located more radially, between the ulnar styloid, lunate, and triquetrum.*

Extra carpal bones, aside from accessory ones, require thorough evaluation for underlying systemic anomalies or associated medical or syndromal disorders. Referral for genetic counseling and molecular analysis is recommended, as Larsen syndrome may present with supernumerary carpal bones as the only clinical finding [35].

1.3 Mixed anomalies

Mixed anomalies of the carpal bones, combining coalitions with supernumerary bones, have been reported in the literature. These anomalies can occur as isolated asymptomatic or in complex congenital limb malformations and syndromal disorders [36]. In our practice, we diagnosed a patient with two carpal coalitions: one between an accessory ossicle and a carpal bone, and a second between another accessory ossicle and the ulnar styloid (Fig. 7) [37].

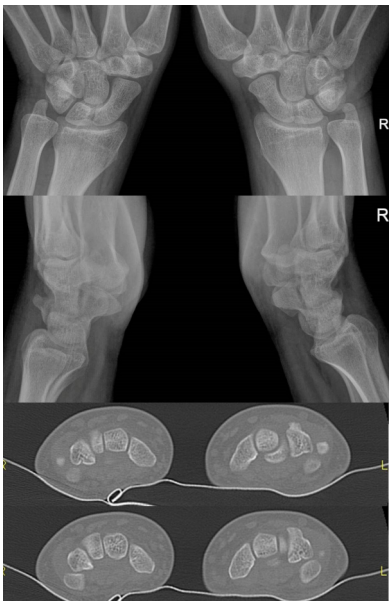

Figure 7. *A 25-year-old man was diagnosed with a unilateral bony overgrowth on the dorsal aspect of the triquetrum due to a carpal coalition between an os epitriquetrum (epipyramis) and the triquetrum. The os epitriquetrum is a rare accessory ossicle situated dorsally in the medial intercarpal space between the lunate, triquetral, capitate, and hamate bones. The bilateral elongated appearance of the styloid process was attributed to a fused lunula with the ulnar styloid process.*

2. Altered maturation and development

The maturation of the single center of ossification (primary) of the carpal bones is influenced by several factors, which can lead to a delayed or accelerated maturation and skeletal development. Wrist radiography of the non-dominant hand is an historical gold standard in bone age assessment.

2.1 Delayed maturation and hypoplasia

Delayed maturation (Fig. 8) and hypoplasia (Fig. 9) are rarely isolated issues; they are typically associated with genetic skeletal dysplasias, endocrine or metabolic disorders, systemic conditions, and syndromes. The scaphoid is the most commonly involved carpal bone. Congenital hypoplasia of the scaphoid is usually associated with musculoskeletal deficiencies confined to the radial aspect of the hand and forearm [38].

2.2 Accelerated maturation and hyperplasia

Accelerated maturation and hyperplasia are usually caused by specific pediatric endocrine and hormonal anomalies, genetic syndromes, and skeletal dysplasias. In addition, they are characteristic early radiographic findings in children with juvenile idiopathic arthritis due to increased blood flow resulting from the chronic synovial inflammation in the affected limb, particularly in the oligoarticular subtype [39].

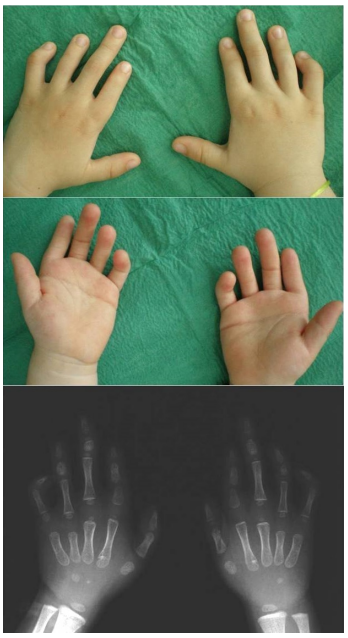

Figure 8. *A 3.5-year-old boy with type A1 (Farabee type) bilateral brachydactyly showed a single palmar crease, which, while not diagnostic, is associated with more severe cases. Ossific nuclei in the carpal bones appeared significantly delayed compared to normal bone maturation.*

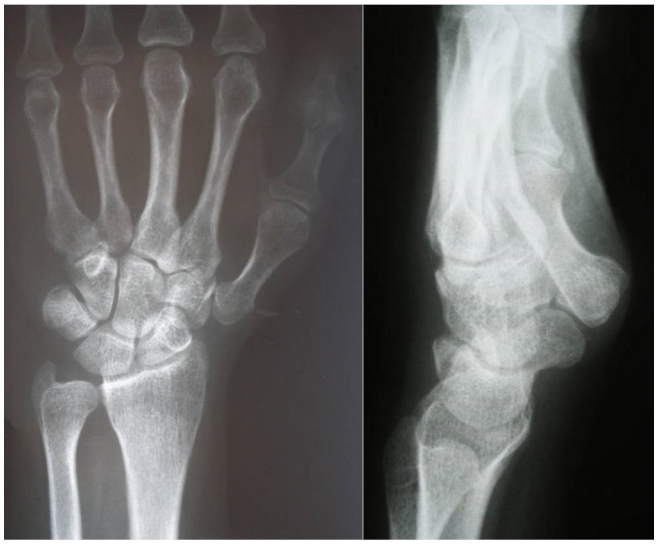

Figure 9. *An extremely rare congenital anomaly involved an underdeveloped trapezium and a small, unstable first metacarpal base. This may be associated with absent or underdeveloped thenar muscles and narrowing of the first webspace. It can occur as an isolated finding, as part of radial longitudinal deficiency, or in association with a syndromal disorder.*

Conclusion

Anatomical variants may be evident in wrist radiography, including multiple ossification centers in children and accessory ossicles in both children and adults. Carpal coalitions should be further evaluated with bilateral wrist radiographs. A potential tarsal-carpal coalition syndrome should be initially examined following the diagnosis of carpal coalition. The recent literature has documented the deficit of a single diagnosis in patients with congenital anomalies of the hand or upper limb [40]. It may be prudent to consider that patients with congenital carpal anomalies should be referred to a specialist pediatric department to document potential associated anomalies and medical or syndromal disorders.

Conflict of Interest

The author declares that he has no competing interests.

References

1. Hsu PA, Light TR. Disorders of the immature carpus. Hand Clin. 2006;22(4):447-63. PMID: 17097466. DOI: 10.1016/j.hcl.2006.08.002.

2. Kelikian H. Anomalies of carpal bones. In: Kelikian H, ed. Congenital deformities of the hand and forearm. Philadelphia, WB Saunders; 1974.

3. Delaney TJ, Eswar S. Carpal coalitions. J Hand Surg Am. 1992;17(1):28-31. PMID: 1538108

4. Senecail B, Perruez H,Colin D. Numerical variants and congenital fusions of carpal bones. Morphologie. 2007;91(292):2-13. PMID: 17556000 DOI: 10.1016/j.morpho.2007.02.001

5. Carlson DH. Coalition of the carpal bones. Skeletal Radiol. 1981;7(2):125-7. PMID: 7330662

6. Sferopoulos KN, Tsitouridis I. Carpal coalition: A rare coincidence with hand deficiencies. Acta Orthop Belg. 2003;69(4):317-20. PMID: 14526635

7. Spaans AJ, Beumer A. Carpal coalitions; failures of differentiation of the carpus: A description of cases. Open Journal of Radiology. 2013;3(1):1-6.

8. Pruszczynski B, Saller J, Rogers KJ, Holmes L Jr, Ty JM. Incidence of carpal coalition in the pediatric population. J Pediatr Orthop. 2016;36(8):e106-10. PMID: 26398433 DOI: 10.1097/BPO.0000000000000639

9. van Hoorn BT, Pong T, van Leeuwen WF, Ring D. Carpal coalitions on radiographs: Prevalence and association with ordering indication. J Hand Surg Am. 2017;42(5):329-34. PMID: 28284456 DOI: 10.1016/j.jhsa.2017.02.002

10. De Villiers Minnaar AB. Congenital fusion of the lunate and triquetral bones in South African Bantu. J Bone Joint Surg Br. 1952;34:45-8. PMID: 12999869 DOI: 10.1302/0301-620X.34B1.45

11. Poznanski AK, Holt JF. The carpals in congenital malformation syndromes. Am J Roentgenol Radium Ther Nucl Med. 1971;112(3):443-59. PMID: 5570355

12. Singh P, Tuli A, Choudhry R, Mangal A. Inter-carpal fusion: A review. Journal of the Anatomical Society of India. 2003;52(2):183-8.

13. Defazio MV, Cousins BJ, Miversuski RA Jr, Cardoso R. Carpal coalition: A review of current knowledge and report of a single institution's experience with asymptomatic intercarpal fusion. Hand (NY). 2013;8(2):157-63. PMID: 24426912 DOI: 10.1007/s11552-013-9498-5

14. Resnik CS, Grizzard JD, Simmons BP, Yaghmai I. Incomplete carpal coalition. AJR Am J Roentgenol. 1986;147(2):301-4. PMID: 3487948 DOI: 10.2214/ajr.147.2.301

15. Isidro A, Díez-Santacoloma I, Méndez-López J. Approach to the diagnosis of unusual carpal ankylosis from ancient Egypt. Clin Exp Rheumatol. 2015;33(1):50-5. PMID: 25437122

16. Maldonado-Cocco JA, García-Morteo O, Spindler AJ, Hübscher O, Gagliardi S. Carpal ankylosis in juvenile rheumatoid arthritis. Arthritis Rheum. 1980;23(11):1251-5. PMID: 7447961

17. Simmons BP. Injuries to and developmental deformities of the wrist and carpus. In: Bora FW Jr, ed. The pediatric upper extremity. Diagnosis and management. Philadelphia, WB Saunders; 1986.

18. Imamura T, Miura T. The carpal bones in congenital hand anomalies: A radiographic study in patients older than ten years. J Hand Surg Am. 1988;13(5):650-6. PMID: 3241032

19. Gross SC, Watson HK, Strickland JW, Palmer AK, Brenner LH, Fatti J. Triquetral-lunate arthritis secondary to synostosis. J Hand Surg Am. 1989;14(1):95-102. PMID: 2723374

20. Ritt MJ, Maas M, Bos KE. Minnaar type 1 symptomatic lunotriquetral coalition: A report of nine patients. J Hand Surg Am. 2001;26(2):261-70. PMID: 11279572 DOI: 10.1053/jhsu.2001.21520

21. Cowan A, Panattoni J. Kienböck disease and carpal coalitions: A potential correlation. J Hand Surg Am. 2016;41(10):e379-81. PMID: 27524690 DOI: 10.1016/j.jhsa.2016.07.093

22. Apard T, Mariotte B, Candelier G. Arthroscopic treatment of symptomatic congenital lunotriquetral coalition. J Wrist Surg. 2018;7(4):341-3. PMID: 30174993 DOI: 10.1055/s-0038-1627444

23. Sferopoulos KN. New documentation system for ulnar longitudinal deficiency. Eplasty. 2024;24:e3. eCollection 2024.PMID: 38476516

24. Tada K, Egawa T, Ono K. The carpus in congenital anomalies of the hand. Acta Orthop Scand. 1977;48(6):592-9. PMID: 564593

25. Kuz JE, Smith JM. Congenital absence of the scaphoid without other congenital abnormality: a case report. J Hand Surg Am. 1997;22(3):489-91. PMID: 9195459. DOI: 10.1016/S0363-5023(97)80017-2.

26. De Smet L. Unilateral congenital absence of the lunate and scaphoid. Genet Couns. 2005;16(4):413-5. PMID: 16440885

27. Mespreuve M, Bosmans F, Waked K, Vanhoenacker FM. Hand and wrist: A kaleidoscopic view of accessory ossicles, variants, coalitions, and others. Semin Musculoskelet Radiol. 2019;23(5):511-22. PMID: 31556086 DOI: 10.1055/s-0039-1693974

28. Bunell S. Fractures and dislocations: injuries of the wrist. In: Boyes JH, ed. Bunnell's surgery of the hand. 5th edition. Philadelphia, JB Lippincott; 1970.

29. Louis DS, Calhoun TP, Garn SM, Carroll RE, Burdi AR. Congenital bipartite scaphoid-fact or fiction? J Bone Joint Surg Am. 1976;58(8):1108-12. PMID: 137245

30. Chloros DG, Kelalis HG, Wiesler RE. Pediatric scaphoid fractures and nonunions. In: Slutsky JD, Slade III FJ, eds. The scaphoid. New York, Thieme; 2011.

31. Gaydarski L, Mirazchiyski G, Panev A, Landzhov B, Piagkou M, Triantafyllou G, Olewnik Ł, Georgiev GP. The elusive bipartite scaphoid: A rare congenital variant or misdiagnosed pseudoarthrosis? Proposed new radiological criteria. Folia Morphol (Warsz). 2026;85:e01726015. PMID: 39764661 DOI: 10.5603/fm.103218.

32. Gursoy M, Coban I, Mete BD, Bulut T. The incidence of accessory ossicles of the wrist: A radiographic study. J Wrist Surg. 2021;10(5):458-64. PMID: 34631299 DOI: 10.1055/s-0041-1731386.

33. Sferopoulos KN. Supernumerary elbow bones and their differential diagnosis. EC Orthopaedics. 2026;17.3:01-06.

34. Park MJ, Namdari S, Weiss AP. The carpal boss: Review of diagnosis and treatment. J Hand Surg Am. 2008;33(3):446-9. PMID: 18343306 DOI: 10.1016/j.jhsa.2007.11.029

35. Govshievich A, Shararah A, Aldekhayel S, Al-Hertani W, HWilliams HB. Supernumerary carpal bones in Larsen syndrome: A review of the literature and case study. Plast Surg Case Studies. 2015;1(3):73-5. https://doi.org/10.1177/2513826X1500100307

36. Stewart DA, McCombe D. Bilateral scaphotrapezium-trapezoid coalition with bipartite scaphoid: case report. J Hand Surg Am. 2013;38(9):1718-22. PMID: 23932812 DOI: 10.1016/j.jhsa.2013.06.026

37. O'Rahilly R. Epitriquetrum, hypotriquetrum, and lunatotriquetrum. Acta Radiologica. 1953;39(5):401-11, DOI: 10.3109/00016925309136725

38. Davison, EP. Congenital hypoplasia of the carpal scaphoid bone. J Bone Joint Surg Br. 1962;44:816-27. PMID: 14040533

39. Skorpik G, Koob E, Grill F. Premature maturation of the carpal bones as an early diagnostic sign of juvenile rheumatoid arthritis. Handchir Mikrochir Plast Chir. 1991;23(4):202-6.PMID: 1937185

40. Sferopoulos KN. Congenital upper extremity anomalies misdiagnosed as ulnar longitudinal deficiency. Eplasty. 2025;25:e36. eCollection 2025. PMID: 41822393