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CASE REPORT

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Lyubomir Gaydarski et al., Bipartite scaphoid

The elusive bipartite scaphoid: a rare congenital variant or misdiagnosed pseudoarthrosis? A proposal for novel radiological criteria

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ABSTRACT

Variations in the development of carpal bones are uncommon, with the scaphoid bone typically forming from the fusion of the os centrale carpi and the radial chondrification center during embryogenesis. A bipartite scaphoid is a rare congenital disorder that occurs when these ossification centers fail to fuse, with a prevalence ranging from 0.1% to 0.6% in adult dissection. The differentiation between a bipartite scaphoid and pseudoarthrosis is challenging, complicating accurate diagnosis and evaluation. A 37-year-old male presented with right wrist pain following a minor fall. Physical examination revealed no visible deformity or swelling but restricted range of motion due to pain. Radiographic imaging identified a bipartite scaphoid with two distinct, similar-sized ossification centers, regular oval

shape, smooth margins, and consistent cortical-to-medullary ratio, with no acute fractures or dislocations. The patient was treated conservatively with non-steroidal anti-inflammatory drugs and immobilization. Upon follow-up, the patient reported complete pain resolution and full range of motion in the wrist. This case emphasizes the unusual occurrence of a bipartite scaphoid bone in a patient experiencing wrist pain after a minor injury. It highlights the challenge of differentiating between a congenital bipartite scaphoid and post-traumatic pseudoarthrosis, underscoring the importance of considering this uncommon developmental variant when diagnosing and treating wrist pain.

Keywords: bipartite scaphoid, wrist, diagnosis, treatment

INTRODUCTION

Variations in the development of the carpal bones are rarely encountered [21]. The scaphoid bone typically develops from the fusion of two ossification centers during embryological development — the os centrale carpi and the radial chondrification center in embryos [9]. One rare anatomical variant of the scaphoid bone is known as bipartite scaphoid. It results from the failure of the two ossification centers to fuse, classifying it as a congenital disorder [10, 16]. This condition is rarely observed in adults, with a dissection prevalence ranging from 0.1% to 0.6% [10, 16]. However, Wolff (1903) [22] disputed the existence of bipartite scaphoids by reviewing documented cases from Gruber [10] and Pfitzner [16], concluding they were all results of pseudoarthrosis after scaphoid fractures [15]. The difficulty distinguishing a bipartite scaphoid from a pseudoarthrosis complicates accurate evaluation and diagnosis by anatomists and clinicians. The debate over differentiating an unfused os centrale carpi from a scaphoid non-union has persisted for nearly a century [22]. Various authors [1, 11] have proposed several criteria for diagnosing a bipartite scaphoid, including bilateral partition, lack of injury history, clear separation with smooth joint edges, equal size and bone density of each part, and absence of degenerative changes in the radio scaphoid joint [1, 11]. Recently, Kunc et al. [13] proposed radiologic criteria for correctly identifying accessory bones: 1) having a regular oval shape, 2) displaying smooth margins, and 3) maintaining a consistent cortical-to-medullary ratio. Despite these criteria, distinguishing between congenital bipartition and non-union remains challenging.

CASE PRESENTATION

A 37-year-old male presented to the emergency department with complaints of pain in his right wrist. He had tripped and fallen from a height three days prior. The patient initially experienced wrist pain, which subsided an hour after the incident. However, his wrist was swollen and stiff the following morning, and he had dull pain upon movement. The patient reported no other medical issues. Upon examination, the initial evaluation showed no visible deformity or swelling in the wrist and no tenderness in the anatomic snuffbox. The patient had a limited range of motion due to pain but no signs of acute fracture. The hand's neurovascular status was normal. Based on the injury and symptoms, a wrist X-ray was ordered. The X-ray revealed a rare type of bipartite scaphoid with two distinct ossification centers in the scaphoid region. The two particles were of similar size, with regular oval shape and smooth margins. The two fragments maintained a consistent cortical-to-medullary ratio throughout the entire circumference, and the distance between them was similar to the distance between the other carpal bones. No acute fractures or dislocations were seen (Fig. 1). No roentgenography, on the other hand, was performed. A follow-up computed tomography (CT) scan and magnetic resonance imaging (MRI) were scheduled, but the patient did not agree to have them. Based on the reported clinical manifestation and radiological findings, a diagnosis of bipartite scaphoid was made. The patient was treated conservatively with non-steroidal anti-inflammatory drugs (NSAIDs) for pain management and immobilization with a volar orthosis for a week. Activity modification was advised, with a follow-up appointment two weeks later. Upon follow-up, two weeks post-injury, the patient reported complete resolution of pain and a return to full range of motion in the wrist. Repeat imaging was not performed, given the absence of pain and the recovery of function.

DISCUSSION

Accessory bones of the upper extremity are rarely encountered [7, 8]. In the present article, we report a case of a rare entity known as the bipartite scaphoid. As it stands, the etiology of the bipartite is unclear. Most authors favor the congenital theory, which implies that the bipartite results from the failed fusion of os centrale carpi and the radial chondrification center [9]. There are several documented cases in the literature, as the oldest article dating back to 1877 when Gruber [10] described five different instances of bipartite scaphoid from his practice and a sixth one reported by Struthers out of 3007 dissections. Moreover, Gruber [10] provided a detailed morphological description of the bipartite as he reported that the radial part was larger and triangular-pyramidal. The ulnar part was smaller and wedge-shaped, with its articulation surface being C-shaped, indicating a precise fit

without dislocation [10]. The connection between the two parts varied from a synchondrosis (cartilaginous joint) to a fully formed joint. The hyaline cartilage covering the joint surfaces of the bipartite was intact and healthy, showing no signs of dislocation or damage, which suggests a congenital origin rather than a result of fracture [10]. The next instance in the literature regarding the bipartite is the work of Pfizner 1900 [16]. In his work involving 1456 adult wrists, he concluded an incidence rate of the bipartite between 0.5% and 0.6%. Further, he elaborated the congenital theory as, according to him, the bipartite results from the failed fusion of the two ossifying centers of the scaphoid [16]. In his review, Wolf [22] disregarded the works of Gruber [10] and Pfizner [16] and pointed out that the bipartite scaphoid is an infrequent entity. Furthermore, Wolf suggested that macroscopic and microscopic assessment of the articular cartilage was essential, as the pseudoarthrosis may closely resemble normal hyaline cartilage on a macroscopic level [22]. One notable issue with these earlier reports is the lack of photographic evidence or poor quality of the existing evidence, which hinders any modern evaluation. Lindgren [14], in 1941, reported one fascinating case of a 19-year-old man who sustained trauma to the left wrist after falling from his height due to slipping. The patient complained of swelling and pain in the left wrist, and three weeks after the incident, an X-ray was conducted, reviewing two parts of the scaphoid that were similar in size and a thin line of 1-2 mm between them. A follow-up X-ray was conducted one year after the first one, and no differences existed. Thus, the author concluded a diagnosis of bipartite scaphoid [4]. Jerre reported a case of bilateral bipartite scaphoid, which was initially diagnosed and treated as a fracture of the left scaphoid, as the patient presented with complaints of pain after trauma. Upon follow-up X-ray, they discovered that the “fracture” hadn’t healed as the scaphoid was separated in two, identical to the initial X-ray. A substantial X-ray of the right wrist was performed, and an identical separation of the right scaphoid was reviewed [11]. Cotta et al. [3], in 1960, described an interesting case of unilateral bipartite. Initially, the authors describe post-traumatic pseudoarthrosis on the left hand, and after a comparative X-ray of the right hand, they found a bipartite scaphoid present. On further investigation, they discovered a prior X-ray of the left wrist of the patient from an older accident, which reviewed a very slim line separating the left scaphoid — a fracture line. Since the fracture was not properly treated, as the patient was initially misdiagnosed with a sprung wrist, pseudoarthrosis occurred. The presented case highlights the difference between both conditions. Louis and colleagues [15] conducted a study involving 196 human fetuses and found no evidence of congenital bipartition of the scaphoid. Furthermore, they examined 5365 X-rays of children aged 4.5 to 12.5 years and identified three cases of multiple ossification centers in boys aged 7 to 8. In

addition, they analyzed 11,280 X-rays of individuals older than 12 years and found no instances of bipartite scaphoid. As a result of their research concluded that multiple ossification centers in the scaphoid fuse into the adult form and proposed that congenital bipartite scaphoid is likely a consequence of trauma rather than a congenital condition [15]. Doman and Marcus [4] detailed a bilaterally present bipartite scaphoid case. The authors conducted a comprehensive radiological examination of a patient at ages 8, 13, and 17 [4]. This case provides strong evidence of the bipartite's congenital origin, despite the radiographs' suboptimal quality. Kim et al. [12] documented a case of chronic pain in the right hand due to bilateral bipartite. The patient underwent surgery, during which the two fragments were united using Kirchner wires on the russe method, leading to the patient's full recovery without complications. However, the authors also noted fibrosis between the two fragments, suggesting a potential pseudoarthrosis resulting from an unrecognized traumatic incident in childhood. Saccomanni [17] reported a case of a suspected bipartite in the right wrist, complicated by a fracture of the proximal pole of the radial fragment of the bipartite. The patient underwent osteosynthesis and recovered without complications, although they continued to experience dull pain, for which a brace was prescribed. The patient had a history of laceration to the base of the thumb at the age of three [17]. Subsequent imaging at 16 years of age revealed two ossification centers of the scaphoid, referred to as the supposed bipartite scaphoid [17]. However, it is more likely a case of pseudoarthrosis due to sustained childhood trauma. Unfortunately, the patient declined an MRI of both hands, leaving uncertainty as to whether it is indeed bipartite or post-traumatic pseudoarthrosis. Chang [2] described a case of bilateral bipartite in a 12-year-old boy admitted after minor trauma to the right wrist. Scaphoid-specific tests were negative, and an X-ray of the right wrist confirmed a bipartite scaphoid. A similar result was observed on the left wrist X-ray. Subsequent bilateral MRI revealed bilateral bipartite with normal cartilage between the segments of both scaphoids. Moreover, the distance between the two fragments on both wrists was similar to that between the other carpal bones [2]. Stewart and McCombe [20] described an interesting case of a bilateral coalition of the scaphoid, trapezoid, and trapezoid with bilateral bipartite scaphoid. The authors have interpreted bipartite as pseudoarthrosis despite a lack of trauma history [20]. We believe aseptic arthritis was present due to the altered biomechanics resulting from the described bone malformations. Stewart and McCombe first attempted conservative treatment for the pain in the dominant right hand due to the bipartite scaphoid. However, the treatment only partially alleviated the pain. Subsequently, they performed a surgical fusion of the two parts of the bipartite scaphoid on the right side, resulting in symptom improvement

[20]. Takemitsu et al. [21] also reported a similar case of bilateral bipartite scaphoid in a 47-year-old male with chronic wrist pain. Despite negative clinical tests for scaphoid fracture, X-rays revealed the characteristic appearance of the bipartite scaphoid in both wrists [21]. Additionally, Dufour et al. described three cases of bipartite scaphoid — one bilateral case, one in the left wrist, and one in the right wrist – in three patients with similar presentations [5]. A summary of all the clinical cases can be found in Table 1. Please note that the cadaver cases are not included in the table.

A bipartite scaphoid, also known as bipartite navicular or os naviculare bipartitum, refers to the incomplete fusion of two ossification centers: the scaphoid bone (os scaphoideum; os naviculare manus) and the os centrale (os centrale carpi). This condition is classified as a congenital anomaly in humans [6]. In contrast, scaphoid pseudarthrosis involves the failure of a scaphoid fracture to properly heal, leading to non-union. It is crucial to distinguish between a bipartite scaphoid and scaphoid fractures or pseudarthrosis, as their treatment approaches differ significantly [18]. The comparative analysis of Durand et al. [6] has identified shared morphological and morphometric characteristics of the os centrale across the studied specimens. The os centrale is noticeably smaller than the scaphoid, with an elongated shape following the anteroposterior direction of the scaphoid. Its position is consistently distal to the scaphoid along the proximodistal axis. A key distinguishing feature of the bipartite scaphoid, resulting from the presence of the os centrale, is the continuous structure of the scaphoid from its proximal to distal poles along the z-axis. This is a significant differentiator from scaphoid fractures, pseudarthrosis, or the uncommon coronal scaphoid fracture [19]. In human specimens, even if the os centrale is removed, the scaphoid remains intact and maintains a normal appearance. Conversely, in cases of scaphoid fracture or pseudarthrosis, removing a fragment results in a deformed, shortened scaphoid. [6]. As was already stated, the bipartite scaphoid is an infrequent and controversial entity, and we have reviewed studies supporting both theories regarding its origin. However, in our opinion, both are true. Still, only the congenital form should be considered the true bipartite scaphoid, as the post-traumatic one is a pseudoarthrosis in its core and should not be considered an anatomical variety. This further raises the necessity for correct differentiation between these two entities. In 1947, Jarre [11] outlined the initial criteria for diagnosing bipartite scaphoid bone, which was later reviewed and modified by Bunnel and Boys [1] in 1970:

- bilateral bipartition indicates the same condition in the contralateral carpus;
- there should be no history or signs of injury associated with this incidental finding;

- there should be a clear space between the components with smooth edges at the joint surfaces;
- each part should have equal size and bone density;
- there should be no degenerative changes in the radial scaphoid articulation.

These criteria were analyzed further by Takemitsu et al. [21], who pointed out unilateral cases of bipartite scaphoid, which likely depict congenital bipartite scaphoid [5, 21]. Many patients with a bipartite scaphoid seek medical attention after hand injuries, and the diagnosis is made through radiological signs of clear and smooth bipartition [3, 11, 14]. Some patients with non-union of the carpal scaphoid do not recall any specific wrist injury [4, 12, 20]. Therefore, a history of injury is not crucial for distinguishing between bipartite scaphoid and non-union [21]. Reports indicate degenerative changes in bipartite scaphoids are common, as shown in radiographs [21]. Dufour et al. [5] emphasized the benefits of three-dimensional CT (3D CT) in differentiating congenital bipartite and pseudoarthrosis. In our opinion, the recently proposed criteria for differentiating an accessory bone from pseudoarthrosis by Kunc et al. [13] include: 1) having a regular oval shape, 2) displaying smooth margins, and 3) maintaining a consistent cortical-to-medullary ratio throughout the entire circumference should also be included. Additionally, the criteria should be:

- no history or signs of prior trauma, especially childhood trauma (before three years of age);
- the components have smooth edges (X-ray) and are covered with hyaline cartilage on the articular surfaces (MRI);
- the cortical-to-medullary ratio is maintained throughout the entire circumference;
- there is a clear space between the two fragments, consistent with the space between the other carpal bones;
- each part has equal size and bone density;
- no fibrosis is observed between the fragments.

Although we did not perform CT or MRI scans due to the patient's refusal, the X-ray met all the necessary criteria. Additionally, clinical tests for a scaphoid fracture came back negative. We chose not to perform an X-ray on the uninjured hand for two reasons: first, there were no clinical indications for it, and second, ordering an X-ray without clinical necessity would not align with the widely accepted principle of radiation safety — “as low as reasonably possible (ALARA)” — especially given the patient's refusal. Another essential consideration pertains to treating this condition. Typically, congenital bipartite scaphoid remains asymptomatic [21]. However, some patients may develop arthritis, particularly those

with physically demanding occupations [21]. Diagnosis of bipartite scaphoid usually occurs incidentally after minor wrist trauma and subsequent X-rays. Treatment options for symptomatic cases include conservative measures and surgical intervention [21]. Conservative treatment entails immobilization and NSAIDs, while surgical intervention involves various osteosynthesis methods, such as the use of Kirchner wires [12, 20]. In the current report, the patient fully recovered after one week of conservative treatment. Our report is subject to several limitations that should be noted. It is challenging to accurately assess the morphology of the accessory ossicle using only X-ray imaging. Due to the patient's refusal of further imaging, the absence of a CT scan and MRI restricts our ability to gather detailed information about the dimensions of the aberrant bone and additional details about the state of the articular cartilage.

CONCLUSIONS

This paper presents a rare imaging report of a divided scaphoid bone found in a patient's wrist X-ray after experiencing pain and stiffness following a minor injury. Additionally, it includes a comprehensive literature review aimed at differentiating between congenital variants and post-traumatic pseudoarthrosis. Furthermore, the article proposes new radiologic criteria for distinguishing between these conditions. Overall, it emphasizes the importance of physicians considering the possibility of a divided scaphoid bone when diagnosing and treating patients with wrist pain.

Article information and declarations

Ethics statement

This type of study did not require approval from the local Ethics Committee. All procedures and tests were made for diagnostic and treatment purposes that are consistent with the established algorithms for patients with trauma. No additional testing was performed on the patient for research purposes. We analyzed and described the findings retrospectively and patient information has been de-identified.

Authors' contributions

Lyubomir Gaydarski: project development, data collection and management, data analysis, and manuscript writing. **Georgi Mirazchiyski:** manuscript writing. **Atanas Panev:** data collection and manuscript writing. **Boycho Landzhov:** data analysis and manuscript editing. **Maria Piagkou:** data analysis and manuscript editing. **George Triantafyllou:** data analysis

and manuscript editing. **Łukasz Olewnik**: data analysis and manuscript editing. **Georgi P. Georgiev**: data collection, data analysis and manuscript editing. All authors have read and approved the manuscript.

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Conflicts of interest

There is no potential conflicts of interest.

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Table 1. Summary of the published clinical cases of bipartite scaphoid.

Authors year	Age	Sex	Diagnostic method	Hand laterality	Symptoms	Reason of finding	Treatment
Lindgren, 1941 [14]	19	Male	X-ray	Unilateral/left	Pain and swelling of the wrist	Trauma	Conservative
Jerre, 1947 [11]	18	Male	X-ray	Bilateral	Acute pain	Fall from a height of two	Conservative

						meters	
Cotta, 1961 [3]	32	Female	X-ray	Unilatera l/right	None	Accidental after trauma to the left wrist	None
Doman and Marcus, 1990 [4]	8	Female	X-ray/MRI	bilateral	Mild pain	Superficial laceration of the base of the thumb	No
Kim et al., 2005 [12]	38	Male	X-ray/MRI	Bilateral	Wrist pain	Spontaneous pain for four years	Fusion after Russe bone grafting
Saccomanni, 2009 [17]	30	Male	X-ray	Unilatera l/ right	Pain in the anatomical snuffbox	Trauma	Supporting brace
Chang et al., 2015 [2]	12	Male	X-ray/MRI	Bilateral	Wrist pain	Trauma	No
Stewart and McCombe, 2013 [20]	15	Female	X-ray/CT/ PET SCAN	Bilateral	Radial-sided wrist pain	Spontaneous pain from several months	Conservative — splint for two months/operative — fusion on the right side
Takemitsu et al., 2014 [21]	47	Male	X-ray/MRI	Bilateral	Pain and swelling/gout	Spontaneous pain for a few weeks	Referred to a gout specialist
Dufour et al., 2022	47	Male	X-ray /SPECT/CT	Bilateral	Wrist pain	Twisting of the wrist	Os centrale excision (osteonecrosis)
	37	Male	MRI SPECT/CT	Unilatera l/right	Wrist pain	Crush injury	Fusion
	19	Male	SPECT/CT	Unilatera	Wrist pain	Snowboard	Conservative

				l /left		fall	treatment
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MRI — magnetic resonance imaging; spect CT — single-photon emission computed tomography.

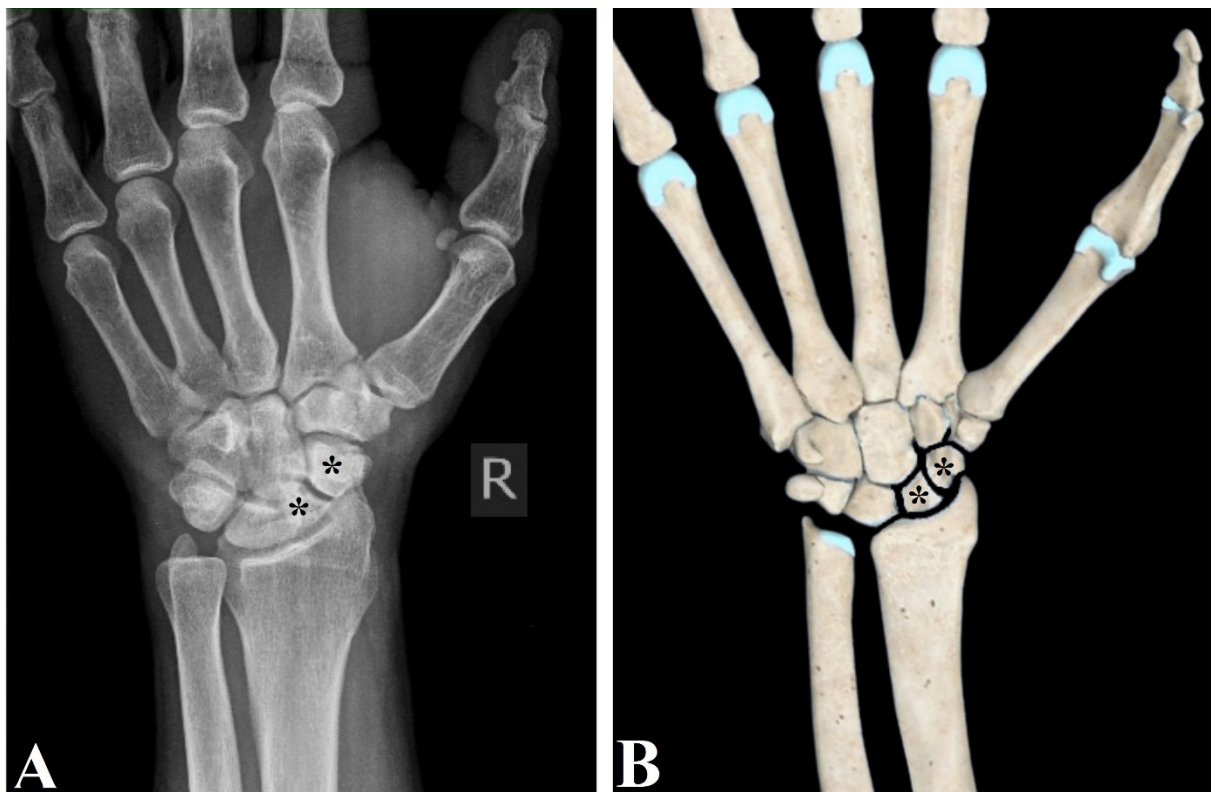


Figure 1A. Radiogram showing the bipartite scaphoid (black asterisks); **B.** A schematic view of the bipartite scaphoid showing the two parts.