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A Case of Congenital Cranial Vascular Foramen Misdiagnosed as a Fracture: A Forensic Clinical Analysis

Fuqiu Mo[1], Xiuqiong Zhou[1], Yongping Wei[2], Huaqi Wang[3], Ning Wang[4]*

[1]Guangxi Zhongbang Judicial Expertise Center, Nanning 530000, Guangxi Zhuang Autonomous Region, China
[2]Judicial Expertise Center, The First Affiliated Hospital of Guilin Medical University, Guilin 541000, Guangxi Zhuang Autonomous Region, China
[3]Liuzhou Zhengdian Judicial Appraisal Institute, Liuzhou 545000, Guangxi Zhuang Autonomous Region, China
[4]Guangxi Jingui Forensic Science Institute, Nanning 530000, Guangxi Zhuang Autonomous Region, China

***Corresponding author:** Ning Wang, 2446080044@qq.com

Abstract: Congenital cranial vascular foramina may mimic fractures on imaging, potentially leading to errors in forensic injury severity assessment. This article reports the case of a 42-year-old male who sustained a blunt force head trauma. Multiple computed tomography scans initially revealed a linear hypodense shadow in the left temporal bone, diagnosed as a skull fracture and subsequently assessed as Minor Injury Grade II. Upon forensic re-evaluation, a longitudinal comparison with pre-injury imaging was conducted. Detailed analysis utilizing three-dimensional reconstruction technology demonstrated that the radiological finding was present prior to the injury. Furthermore, post-injury follow-up scans showed no morphological change or callus formation, characteristics consistent with a congenital vascular foramen rather than an acute fracture. Consequently, the injury severity was revised to Slight Injury. This case underscores the critical importance in forensic clinical practice of obtaining detailed medical history, systematically reviewing pre-injury imaging, and employing advanced image post-processing techniques for differential diagnosis. Such an approach helps prevent misdiagnosis due to anatomical variants, ensuring the objectivity and accuracy of injury severity assessment and upholding judicial integrity.

Keywords: Congenital cranial vascular foramen; Skull fracture; Forensic medicine; Misdiagnosis; Injury assessment; Computed tomography

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1. Brief case history

On July 1, 2022, at approximately 8:30 PM, a 42-year-old man was involved in an altercation with a neighbor during which he was struck on the head multiple times with a plastic stool. Witnesses reported that the assault lasted about one minute, and the victim immediately experienced bleeding from two scalp sites. He was transported by family members to a local hospital emergency department.

Upon arrival, the patient reported dizziness, headache, and generalized pain but denied loss of consciousness, nausea, or vomiting. Physical examination revealed a sutured laceration measuring approximately 3.5 cm in the left temporal region with surrounding soft tissue swelling, and a second sutured laceration of approximately 2.5 cm in the right frontal region. Given the mechanism of injury and the presence of scalp wounds, a non-contrast head computed tomography (CT) was obtained to exclude intracranial pathology. The initial CT scan performed on the day of admission (July 1, 2022) demonstrated bilateral temporoparietal scalp soft tissue swelling and scattered air in the left frontotemporoparietal scalp, but no obvious signs of skull fracture or intracranial hemorrhage.

Due to persistent clinical suspicion, follow-up head CT scans were performed on July 2 and July 11, 2022. After multidisciplinary review by multiple radiologists, a linear hypodense shadow was identified in the left temporal bone, which was interpreted as suggestive of a nondisplaced skull fracture. Based on these radiographic findings, the clinical diagnosis was amended to left temporal bone fracture with associated scalp lacerations and mild closed head injury.

On July 14, 2022, at the request of law enforcement, a local forensic appraisal institution issued an injury severity assessment based exclusively on the post-injury imaging reports. The assessment concluded that the left temporal bone finding represented an acute traumatic fracture, leading to classification as “Minor Injury Grade II” under the Chinese judicial standards for human injury assessment. This classification carries significant legal consequences, potentially subjecting the assailant to criminal liability, incarceration, and substantial financial penalties.

The alleged assailant contested this finding through legal counsel, arguing that (1) a plastic stool lacks sufficient mass and density to produce a cranial fracture in an adult male, (2) the absence of fracture on the immediate post-injury CT scan was inconsistent with the diagnosis, and (3) the radiographic finding might represent an anatomical variant rather than a traumatic injury. Based on these arguments, the court granted a motion for re-appraisal and formally commissioned our forensic center to conduct an independent evaluation.

To ensure a comprehensive assessment, our center requested all available imaging studies, including any pre-injury examinations that might exist in regional healthcare databases. This request ultimately yielded a critical pre-injury CT study from September 23, 2020, which proved essential for definitive diagnosis. The re-evaluation also included a detailed review of the post-injury imaging from July 1, 2022, July 11, 2022, and a subsequent CT scan performed on May 18, 2023, at another hospital, which again suggested a left temporal bone fracture.

2. Medical record summary

On July 1, 2022, the patient presented with dizziness, headache, and generalized pain for 3 hours. Emergency CT scan findings: (1) No obvious intracranial hematoma; no definite signs of skull fracture. (2) Right parietal scalp soft tissue hematoma. (3) Left frontotemporoparietal scalp soft tissue slight swelling with scattered air. Specialized examination: A sutured wound approximately 3.5 cm in length was observed in the left temporal region with surrounding soft tissue swelling. A sutured wound approximately 2.5 cm in length was present in the right frontal region, with no active bleeding, already dressed. Treatment course: After admission, relevant examinations were completed. Multiple radiologists collectively re-reviewed the July 1, 2022, non-contrast CT scan and considered the possibility of a left temporal bone fracture. A repeat head CT on July 11, 2022, revealed a linear hypodense shadow in the left temporal bone, clinically suggestive of a fracture line. Therefore, the diagnosis was amended to: (1) No obvious intracranial hematoma; (2) Left temporal bone hypodense shadow, suggestive of fracture. On May 18, 2023, a repeat non-contrast CT scan with three-dimensional (3D) reconstruction showed a linear hypodense shadow in the left temporal bone, suggestive of left temporal bone fracture.

3. Forensic clinical examination

A 3.0 cm × 0.1 cm sutured scar was observed on the left temporal region, and a 2.0 cm × 0.1 cm sutured scar on the right frontal region; no other abnormalities were noted. Review of the CT scan from September 23, 2020 (pre-injury) showed: Non-contrast CT scan revealed localized discontinuity of the left temporal bone with a lucent area; 3D reconstruction showed a small local foraminal formation at the anterior margin of the left temporal bone, with no definitive signs of bone destruction. Findings suggested: Localized small foraminal formation in the left temporal bone, likely a congenital variant vascular foramen (**Figure 1**). Review of the head CT scan from July 1, 2022 (day of injury) showed: No abnormal density in the brain parenchyma, midline structures centered, localized discontinuity of the left temporal bone with a lucent area; swelling of the left frontotemporoparietal scalp soft tissue. Findings suggested: Localized discontinuity of the left temporal bone, left frontotemporoparietal scalp hematoma (**Figure 2**). Review of the CT scan from May 18, 2023 (10-month follow-up) showed: Localized discontinuity of the left temporal bone. Compared with the two earlier imaging studies, no callus formation was seen, and the morphology of the fragment ends remained unchanged, suggestive of a congenital variant vascular foramen (**Figure 3**).

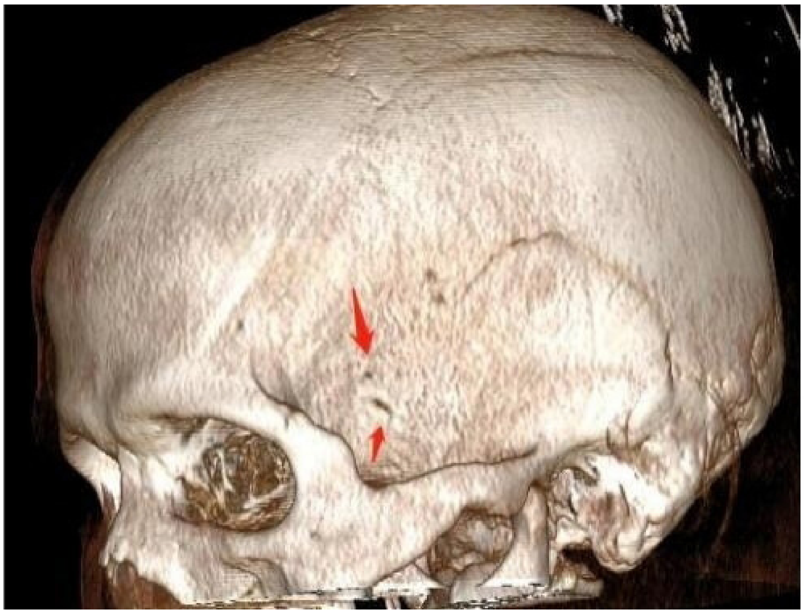

Figure 1. 3D reconstruction CT scan from September 23, 2020. Arrow indicates the congenital cranial vascular foramen

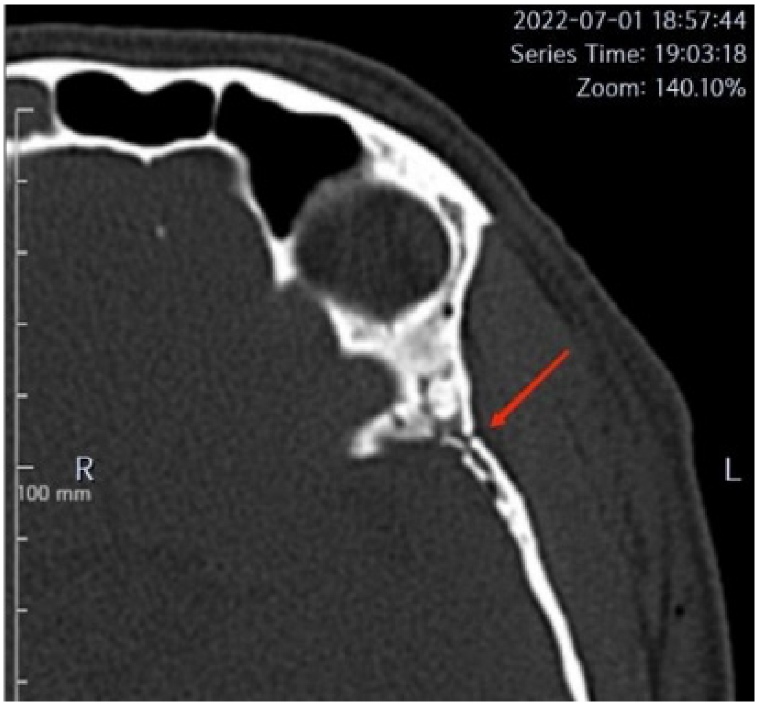

Figure 2. Non-contrast head CT scan from July 1, 2022. Arrow indicates the suspected fracture site

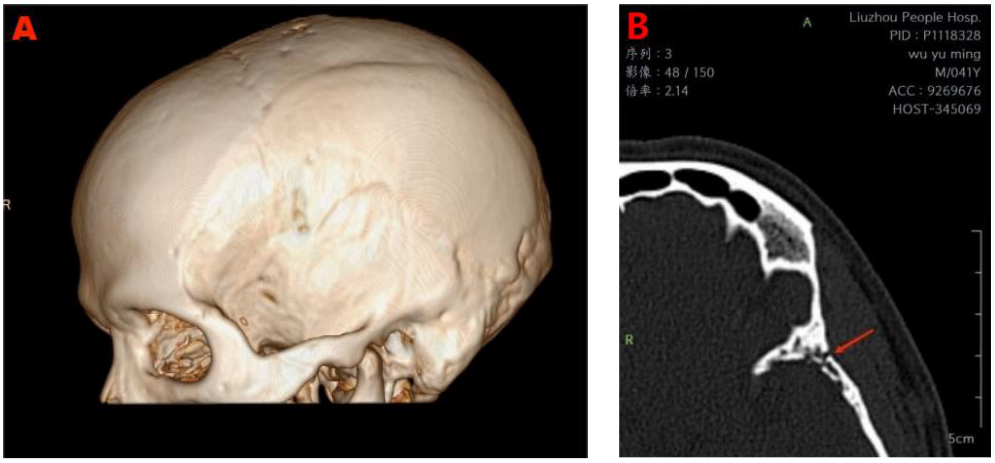

Figure 3. A shows the non-contrast CT scan of the head taken on May 18, 2023, and B displays the three-dimensional reconstruction image

4. Forensic appraisal opinion

Comparison of the head CT scans from the day of injury (July 1, 2022) and the follow-up (May 18, 2023) for the examinee revealed discontinuity in the left temporal bone. The fragment ends showed no change, which is inconsistent with the imaging evolution of fracture healing. Upon reviewing the electronic imaging data, the finding of the left temporal bone "fracture" was visible in only one axial plane. Using RadiAnt Viewer software for automatic 3D reconstruction revealed a small round hole at the anterior margin of the left temporal bone, with the remaining bone intact. This suggested the possibility of a congenital variant vascular foramen. Upon further inquiry into past medical history and retrieval of the pre-injury CT imaging data from September 23, 2020, identical findings were confirmed. Therefore, the diagnosis of left temporal bone fracture was excluded. According to the relevant provisions, the injury was assessed as a “Slight Injury.”

5. Discussion

Skull fractures represent a disruption in the continuity of the cranial vault, typically resulting from the application of blunt or sharp mechanical forces. These fractures are most commonly classified as linear, depressed, comminuted, or diastatic, with linear fractures being the most frequently encountered type in clinical and forensic settings [1,2]. Linear skull fractures usually appear on CT as sharply marginated, non-branching lucent lines, often associated with overlying soft tissue swelling or hematoma, and their orientation and location generally correlate with the impact site [3]. During the physiological healing process, a fracture line typically undergoes sequential radiographic changes over time, including the development of marginal sclerosis, periosteal reaction, callus formation, and progressive blurring of the fracture edges, culminating in complete or partial osseous remodeling [4]. These temporal changes are critical for distinguishing acute fractures from old or congenital skeletal variants [4].

In contrast, cranial vascular foramina are normal anatomical variants that result from incomplete ossification or persistent vascular channels within the cranial bones. These foramina serve as conduits for emissary veins and small arteries and are commonly observed in specific locations such as the cribriform plate, foramen ovale, foramen spinosum, and the region of the pterion [5]. During embryonic and postnatal development, certain venous channels may fail to obliterate completely, leaving permanent round or oval defects on the cranial surface. These congenital foramina are characterized by smooth, sclerotic margins, consistent morphology, and stable appearance over time. Importantly, they are not accompanied by adjacent soft tissue edema, hemorrhage, or evidence of healing, and they remain unchanged in sequential imaging studies [6].

In the present case, a comprehensive longitudinal analysis of imaging data played a decisive role in establishing the correct diagnosis. The left temporal bone lucency initially interpreted as a fracture was observed across multiple post-injury CT scans (July 1, 2022; July 11, 2022; and May 18, 2023) without any morphological alteration or evidence of bone healing. Crucially, identical imaging findings were retrospectively identified on a pre-injury CT scan performed on September 23, 2020. This pre-existing, stable lucency with well-defined sclerotic borders, absence of associated soft tissue changes, and lack of evolution over nearly three years unequivocally supports the diagnosis of a congenital vascular foramen rather than an acute or healing fracture.

The initial misdiagnosis in this case underscores several important considerations in forensic clinical practice. First, in acute trauma settings, the clinical focus is often directed toward identifying life-threatening conditions such as intracranial hemorrhage, cerebral contusion, or midline shift. In such contexts, subtle skeletal findings may receive insufficient scrutiny, and linear lucencies can be prematurely attributed to fracture without rigorous differential consideration. Second, the presence of a scalp laceration or contusion overlying the bony defect may create a cognitive bias, reinforcing the assumption of an underlying fracture due to anatomical concordance with the mechanism of injury. Third, reliance solely on axial CT images without multiplanar or three-dimensional reconstruction can obscure the true morphology of bony abnormalities. In this case, the suspected fracture line was visible in only a single axial slice, and its true nature—a small, rounded foramen—was only appreciated after three-dimensional reconstruction using dedicated software such as RadiAnt Viewer. This highlights the indispensable role of advanced image post-processing techniques in forensic radiology, particularly when atypical or ambiguous findings are encountered.

Furthermore, this case emphasizes the importance of obtaining and reviewing all available antecedent imaging when conducting forensic evaluations. The absence of pre-injury imaging would have left the appraiser without a definitive reference point, potentially perpetuating the misdiagnosis. By retrieving the 2020 CT study and performing a temporal comparison, it became possible to demonstrate that the bony defect predated the traumatic event and remained entirely unchanged post-injury. Such longitudinal analysis is a cornerstone of evidence-based forensic practice, enabling objective differentiation between congenital variants, old injuries, and acute traumatic lesions.

From a medicolegal perspective, the distinction between a fracture and a congenital variant carries substantial implications for injury severity classification. Under the Chinese judicial standards for human injury assessment, a diagnosis of skull fracture typically qualifies as "Minor Injury Grade II," whereas an isolated scalp laceration or scar falls under the category of "Slight Injury." In this case, the correction of the diagnosis fundamentally altered the legal classification of the injury, thereby affecting the potential legal consequences for the involved parties. This underscores the broader responsibility of forensic experts to ensure that their conclusions rest upon sound scientific evidence and comprehensive data analysis, as errors in interpretation can directly impact judicial outcomes.

Moreover, this case illustrates the divergence between clinical and forensic perspectives on diagnostic findings. In clinical medicine, a provisional diagnosis of fracture based on trauma history and imaging may be sufficient to guide conservative management, and such a diagnosis may not be revisited if the patient recovers uneventfully. In forensic medicine, however, the standard of proof is higher: the injury must be objectively verified, temporally linked to the alleged event, and accurately classified according to legal definitions. This necessitates a more rigorous analytical framework, including dynamic assessment of injury evolution, exclusion of pre-existing conditions, and, where possible, corroboration by multiple imaging modalities and expert consultations.

In light of these considerations, we advocate for the routine integration of multiplanar and three-dimensional reconstruction techniques in forensic radiology, particularly for cranial trauma cases where linear lucencies are identified. Additionally, we recommend that forensic practitioners actively seek prior imaging records and perform side-by-side comparisons to identify congenital variants, old fractures, or other non-traumatic abnormalities. Continuing education in advanced imaging anatomy and forensic radiology is also essential to enhance diagnostic accuracy and minimize interpretive errors.

6. Conclusion

Although the misdiagnosis of congenital cranial vascular foramina as skull fractures is a relatively uncommon occurrence in forensic practice, the present case provides a compelling illustration of the diagnostic challenges posed by anatomical variants and the critical importance of rigorous, multidimensional evaluation. Through detailed analysis of serial imaging studies—including pre-injury, acute post-injury, and follow-up scans—and the application of advanced three-dimensional reconstruction techniques, it was possible to definitively exclude the diagnosis of fracture and establish the presence of a benign congenital foramen. This correction not only rectified the injury classification from "Minor Injury Grade II" to "Slight

Injury” but also ensured that the legal assessment accurately reflected the true nature of the injury. The case highlights the indispensable role of temporal imaging comparison, multiplanar reconstruction, and interdisciplinary collaboration in forensic medicine. As imaging technologies continue to advance and forensic standards become increasingly refined, the incidence of such misdiagnoses is expected to diminish. Ultimately, adherence to objective, scientific, and methodologically sound principles remains the foundation of forensic practice, safeguarding both medical accuracy and judicial integrity.

Disclosure statement

The authors declare no conflict of interest.

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