Scholars Journal of Medical Case Reports
Abbreviated Key Title: Sch J Med Case Rep
ISSN 2347-9507 (Print) | ISSN 2347-6559 (Online)
Journal homepage: https://saspublishers.com

OPEN ACCESS

Radiology

Unmasking a Post-Traumatic Carotid-Cavernous Fistula: The Key Role of CT Imaging – A Case Report

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DOI: https://doi.org/10.36347/sjmcr.2025.v13i10.089 | **Received:** 28.08.2025 | **Accepted:** 22.10.2025 | **Published:** 25.10.2025

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Abstract **Case Report**

Carotid-cavernous fistulas (CCFs) are rare vascular anomalies involving abnormal communication between the carotid arterial system and the cavernous sinus. Direct CCFs, often post-traumatic, occur mainly in young males after craniofacial trauma. We report the case of a 28-year-old male presenting with progressive pulsatile exophthalmos and eyelid edema following a road traffic accident. Non-contrast CT and CT angiography identified multiple craniofacial fractures, early enhancement of the superior ophthalmic vein, and asymmetrical bulging of the cavernous sinus, confirming a direct post-traumatic CCF. This case emphasizes the essential role of CT imaging, as a non-invasive tool, in early detection and management planning of post-traumatic CCFs, particularly in settings where immediate angiography may not be available.

Keywords : Carotid-cavernous fistula, Post-traumatic, CT angiography, Doppler ultrasound.

INTRODUCTION

Carotid-cavernous fistulas (CCFs) are rare vascular anomalies characterized by an abnormal communication between the carotid arterial system and the cavernous sinus. [1] They are classified into two types: direct fistulas, which involve a high-flow connection between the internal carotid artery (ICA) and the cavernous sinus, and indirect (dural) fistulas, which result from low-flow shunts involving dural branches of the ICA or external carotid artery.[2]

Direct CCFs are most commonly of post-traumatic origin, accounting for the majority of cases, particularly in young male patients following craniofacial trauma. They may present acutely with rapidly progressive ophthalmologic symptoms such as proptosis, chemosis, ocular bruit, and cranial nerve palsies. Although rare—estimated to occur in 0.2 to 0.3% of craniofacial trauma cases—they represent a serious complication, potentially threatening both visual and vital prognosis. [3,4]

CT angiography (CTA) and MR angiography (MRA) are valuable non-invasive tools in the initial assessment, but digital subtraction angiography (DSA) remains the gold standard for diagnosis and treatment planning. [5] The advent of endovascular embolization has revolutionized the management of CCFs, offering high success rates with minimal invasiveness. [6]

The aim of this report is to highlight the diagnostic value of CT imaging through a case of a direct post-traumatic CCF in a 28-year-old patient.

PATIENTS AND METHODS

Observation:

We report the case of a 28-year-old male with no significant medical history, who presented to the emergency department two days after a road traffic accident with a craniofacial point of impact. The patient complained of right palpebral swelling and progressive exophthalmos.

On clinical examination, there was a marked right eyelid edema with a grade III pulsatile exophthalmos, associated with conjunctival chemosis, ocular motility restriction, and elevated intraocular pressure. Visual acuity was slightly reduced on the affected side, but pupillary reflexes were preserved. No neurological deficit was noted.

A non-contrast craniofacial CT scan, performed at admission, showed no traumatic parenchymal brain injury but revealed: (Figure 1)

- A complex parasymphyseal mandibular fracture extending toward the alveolar process near tooth 44.
- A comminuted right low subcondylar fracture with ipsilateral TMJ subluxation.
- Fractures of the medial and lateral plates of the right pterygoid process.
- Minimally displaced fractures of the lateral walls of the maxillary and sphenoidal sinuses, with hemosinus.
- A fracture of the right zygomatic arch.

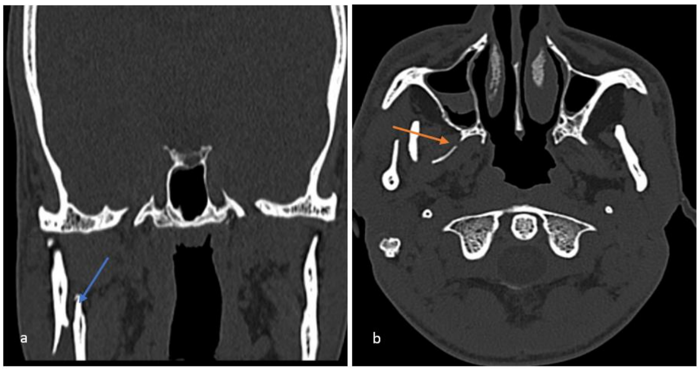

Figure 1: Coronal (a) and axial (b) CT scans in bone window showing a comminuted right low subcondylar fracture (blue arrow) and fractures of the lateral plate of the right pterygoid process (orange arrow)

Given the progressive pulsatile exophthalmos, a contrast-enhanced CT angiography was performed, revealing: (Figure 2)

- No intraocular foreign body.
- Grade III exophthalmos with preserved globe morphology.
- Dilated and early-enhancing superior ophthalmic vein, confirmed on ultrasound by arterialized Doppler flow.
- Bulging, heterogeneous right cavernous sinus with convex lateral border.
- Infiltration of the intra- and extraconal orbital fat, and preseptal and malar soft tissues, without collection or abscess.
- Fracture of the lateral orbital wall without muscle entrapment.

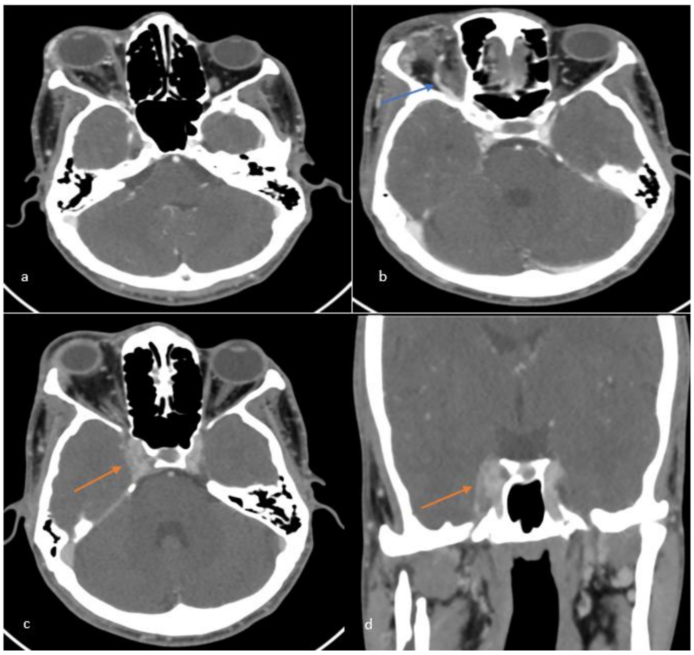

Figure 2: Axial (a, b, c) and coronal (d) CT images in parenchymal window showing grade III right exophthalmos with preserved globe morphology (a), dilated and early-enhancing superior ophthalmic vein (b; blue arrow), bulging and heterogeneous right cavernous sinus with convex lateral border (c, d; orange arrow), and infiltration of intra-/extraconal orbital fat as well as preseptal and malar soft tissues, without evidence of collection or abscess

These findings were highly suggestive of a right-sided direct carotid-cavernous fistula, secondary to trauma. The diagnosis was reinforced by the arterialization of the superior ophthalmic vein, cavernous sinus distension, and the clinical context.

DISCUSSION

A carotid-cavernous fistula (CCF) is an abnormal arteriovenous shunt between the carotid arterial system and the cavernous sinus.[1] While rare, traumatic CCFs are serious complications of craniofacial trauma, representing the most common type of intracranial arteriovenous fistula. They are typically unilateral, of high-flow, and often occur in young male patients following severe head trauma.[7]

According to the Barrow classification, CCFs are divided into four types based on angiographic findings: [8]

- Type A (Direct): A high-flow shunt between the intracavernous segment of the internal carotid artery (ICA) and the cavernous sinus, most often post-traumatic.
- Types B–D (Indirect): Low-flow dural shunts involving branches of the ICA (type B), external carotid artery (ECA) (type C), or both (type D), often occurring spontaneously in elderly or predisposed patients.

Type A CCF, the most common post-traumatic form, results from a direct tear in the wall of the ICA, which may occur due to shear forces, displaced bone fragments, or rupture of a pre-existing aneurysm within the cavernous segment. [9,10]

Clinically, CCFs often manifest with progressive ophthalmological signs such as pulsatile exophthalmos, chemosis, dilated episcleral veins, ocular bruit, and elevated intraocular pressure. In severe or delayed cases, complications like vision loss, oculomotor palsies, or intracranial hemorrhage may occur. In our patient, the early onset of grade III pulsatile exophthalmos, lid edema, and orbital congestion was highly suggestive. [3,4]

Neuroradiological imaging is crucial for diagnosing and managing post-traumatic carotid-cavernous fistulas. While digital subtraction angiography remains the gold standard, non-invasive imaging is essential for initial assessment.

Color Doppler ultrasound detects arterialized reversed flow in the superior ophthalmic vein, aiding diagnosis and non-invasive follow-up, especially where interventional options are limited.[11]

Transcranial Doppler directly visualizes the fistula with high sensitivity and assesses cerebral collateral circulation, which is important for planning endovascular treatment.[11]

CT and CT angiography (CTA) are pivotal in the emergency setting, especially after craniofacial trauma. While brain parenchymal injuries can be excluded, indirect signs of CCF can be highly suggestive: [3,12]

- Dilated superior ophthalmic vein**,**
- Asymmetric bulging of the cavernous sinus**,**
- Orbital fat stranding and muscle infiltration**,**
- Fractures involving the skull base or orbital walls, particularly near the cavernous sinus,
- Hyperenhancement of venous structures on arterial phase imaging.

In our patient, CTA revealed all these findings, especially the early opacification of the superior ophthalmic vein and a convex, asymmetric cavernous sinus, highly indicative of a direct high-flow shunt.

MRI and MR angiography (MRA) enhance soft tissue and vascular detail in carotid-cavernous fistula evaluation. On T1-weighted images, they reveal dilation of the superior ophthalmic vein and enlargement of the cavernous sinus, while T2-weighted sequences improve visualization of periorbital structures and sinus congestion. The 3D time-of-flight (TOF) MRA allows dynamic shunt assessment with 83% sensitivity and nearly 100% specificity. MRI is especially valuable for evaluating cranial nerve involvement, the extent of venous congestion, and differentiating conditions such as orbital pseudotumor, thrombosis, or hematoma.[3]

Nevertheless, DSA remains irreplaceable, as it not only confirms the diagnosis and determines the Barrow classification subtype, but also allows simultaneous endovascular intervention, making it both diagnostic and therapeutic. [11]

In daily clinical practice, the combination of Doppler, CTA, and MRA findings often prompts the indication for angiography. Some authors recommend immediate arteriography in cases of pulsatile exophthalmos with orbital bruit, due to the urgency and risk of vision loss or intracranial hemorrhage. [11]

Endovascular embolization is the treatment of choice for direct high-flow CCFs, aiming to occlude the fistulous tract while preserving carotid artery patency. However, in resource-limited settings, diagnosis may be delayed and therapeutic options restricted, potentially impacting visual and neurological outcomes. [13]

CONCLUSION

Post-traumatic carotid-cavernous fistulas are rare but serious complications of craniofacial trauma, risking vision and life. Prompt diagnosis is essential. CT and CT angiography quickly identify fractures and indirect fistula signs, while MRI and MRA detail soft tissue and vascular involvement. Although digital subtraction angiography is the gold standard for diagnosis and treatment, non-invasive imaging plays a vital role in initial assessment and follow-up, especially where interventional resources are limited, enabling timely management and improved outcomes.

Conflicts of Interest: The authors declare no conflicts of interest.

Contributions of the Authors: All authors contributed to the conduct of this work. They have read and approved the final version of the manuscript.

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