CASE REPORT: SUCCESSFUL STAGED EMBOLIZATION OF A DIRECT CAROTID-CAVERNOUS FISTULA USING COMBINED COIL AND LIQUID EMBOLIC TECHNIQUE

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ABSTRACT

Carotid-cavernous fistulae (CCFs) are a common complication after head trauma, accounting for 75% of all cases. They typically present with proptosis, ocular bruit, and chemosis, known as the classical triad. However, other symptoms may occur depending on the involvement of vascular and neural structures in the cavernous sinus. Digital Subtraction Angiography (DSA) is the gold standard for diagnosing CCFs. Traditionally, treatment involved open surgical procedures such as carotid ligation, trapping, and cavernous sinus exploration. Other options include conservative management and radiosurgery. In recent years, endovascular treatment (EVT) has become the preferred approach. Both transarterial and transvenous embolization using various agents aim to completely close the fistula while preserving carotid artery flow.
This report presents the successful management of a right direct CCF in a 47-year-old male following a motor vehicle accident (MVA). A staged embolization approach, combining transvenous and transarterial techniques, effectively reduced the residual fistula without immediate complications. This case highlights the complexities of post-traumatic CCF treatment and the importance of tailored endovascular strategies.

Keywords: Neurointerventional surgery, carotid-cavernous fistula, digital subtraction angiography, endovascular procedure, therapeutic embolization

INTRODUCTION:

Carotid-cavernous fistulae (CCFs) are abnormal arteriovenous connections between the carotid arterial system and the cavernous sinus, often resulting from head trauma. These fistulas can cause increased venous pressure, leading to significant ophthalmological and neurological symptoms such as proptosis, chemosis, elevated intraocular pressure, vision impairment, and cranial nerve dysfunction. Symptoms vary depending on the severity of the fistula and its impact on vascular and neural structures [1-6]. CCFs are classified based on the Barrow classification. Type A (Direct CCF) is a direct connection between the internal carotid artery (ICA) and the cavernous sinus, often caused by trauma. Types B-D (Indirect CCFs) involve branches of the internal or external carotid artery and are usually spontaneous or due to underlying vascular abnormalities [7-9]. Diagnostic approach involving the noninvasive imaging methods, such as CT, MRI, and CT/MR angiography, can help identify cavernous sinus enlargement, superior ophthalmic vein dilation, and extraocular muscle swelling, which are suggestive of CCF. However, digital subtraction angiography (DSA) remains the gold standard for definitive diagnosis and treatment planning [5]. Management strategies involving the endovascular treatment (EVT) has become the first-line approach due to its minimally invasive nature and high success rates. The goal is to completely occlude the fistula while preserving carotid artery function. Mild or low-risk CCFs may resolve spontaneously.

Urgent intervention is needed for cases with pseudoaneurysms, large venous varices, cortical venous drainage, or venous thrombosis, which increase the risk of hemorrhage or neurological deterioration. Two primary endovascular techniques are commonly used. Transarterial embolization is preferred for direct, high-flow CCFs, often using detachable balloons or other embolic agents. However, complications such as balloon rupture, premature deflation, or detachment may occur. Transvenous embolization is used for indirect fistulas or cases where transarterial access is challenging. Studies report a 70–90% success rate with this approach [1].

This case report presents the successful management of a post-traumatic direct CCF in a 47-year-old male following a motor vehicle accident. A staged embolization approach combining transvenous and transarterial techniques was performed, leading to significant reduction of the fistula without immediate complications. This case highlights the complexities of CCF treatment and emphasizes the importance of tailored endovascular strategies based on individual patient anatomy and fistula characteristics.

CASE REPORT:

A 47-year-old male was involved in a motor vehicle accident (MVA) in September 2024. 4 days later, he developed vision loss in his right eye, proptosis, conjunctival chemosis, elevated intraocular pressure, absence of eye movement, and pulsatile tinnitus on the right side. Initial imaging suggested a right carotid-cavernous fistula with acute intraparenchymal hemorrhage in the right cerebellum (Figure 1). He also sustained fractures of the right sphenoid and petrous part of the right temporal bone. One week after his MVA, an initial coil embolization procedure was performed using both transvenous and transarterial access. Seven fibered coils were deployed into the venous sac of the cavernous sinus, resulting in partial occlusion of the CCF. An attempt to use a detachable silicone balloon was unsuccessful due to the small orifice of the fistula. A post-procedure angiogram showed only minimal reduction in CCF flow (Figure 2). After more than six hours, the procedure was stopped, and a staged embolization approach was planned. Staged embolization involves performing embolization in multiple sessions rather than all at once. This approach helps maintain normal blood circulation, allows the body to gradually adapt, and minimizes

complications. However, there was no significant improvement, as the patient continued to experience symptoms.

A second embolization was performed 2 weeks after MVA, employing a more aggressive and multifaceted approach. One fibered coil was deployed into the right cavernous sinus, followed by the injection of 1 ml of Precipitating Hydrophobic Injectable Liquid (PHIL) 30%. An Eclipse 2L balloon catheter was inflated at the fistula point of the right ICA to prevent reflux into the parent artery. This procedure was repeated several times until satisfactory occlusion was achieved. Post-procedure angiogram showed significant reduction of the CCF flow, with only approximately 20% residual flow remaining. After five months, MRA showed complete resolution of the CCF. Vertigo, right ear ringing, right eye bulging has already resolved and right eyelid drooping improved. Patient ambulating well without assistance and able to drive again.

DISCUSSION:

This case exemplifies the complexities involved in managing direct post-traumatic CCFs and highlights several key points in their treatment. Traumatic CCFs constitute the majority of direct CCFs, accounting for approximately 87.24% of cases [4]. The patient's presentation with classic signs of orbital venous congestion is typical for high-flow direct CCFs. Endovascular embolization has become the gold standard in CCF management. The combination of transvenous and transarterial techniques, as employed in this case, offers enhanced control over embolic materials and reduces procedural risks.

The second procedure demonstrates the effectiveness of a multi-modal approach in challenging cases. The use of PHIL 30% as a liquid embolic agent, in conjunction with fibered coils and balloon-assisted techniques, provided precise control and minimized the risk of embolic migration [7]. PHIL 30% has higher viscosity enable more control and less risk of penetration beyond the venous sac of the fistulae. This approach aligns with current trends in neurointerventional practice, where combinations of embolic materials are used to achieve optimal results. The staged embolization effectively decreased fistula flow while preserving adjacent vascular structures, demonstrating the value of adaptable treatment strategies. In cases with small fistula orifices and complex venous drainage patterns, achieving complete occlusion in a single session may not always be feasible.

The incorporation of PHIL, a relatively new liquid embolic agent, in the second procedure is noteworthy. PHIL offers several advantages, including reduced artifacts on follow-up imaging and a cohesive nature that minimizes the risk of distal embolization. Its use in this case, combined with balloon protection, exemplifies the ongoing evolution of embolic techniques in neurointerventional procedures. PHIL's unique properties make it particularly suitable for CCF embolization. Its non-adhesive nature allows for more controlled delivery, while its precipitating mechanism provides rapid and stable occlusion. The tantalum-based radiopaque component offers excellent visibility during injection, enabling precise placement and reducing the risk of non-target embolization.

While multiple embolization procedures can be physically and emotionally challenging, patient accept them as necessary for better long-term results. Clear communication with the medical team, psychological support, and reassurance about the safety and benefits of staged embolization can help ease their concerns.

While staged embolization improves safety and treatment success, it increases hospitalization duration and financial strain. Patients may need financial planning, insurance support, and social assistance programs to help manage costs.

CONCLUSION:

This case report illustrates the successful management of a complex, post-traumatic direct CCF through a staged endovascular approach. The combination of transvenous and transarterial techniques, along with the use of both traditional (coils) and novel (PHIL) embolic agents, proved effective in significantly reducing fistula flow. This case underscores the importance of individualized treatment planning in CCF management. It highlights the value of a flexible approach, where initial incomplete results can be addressed through subsequent, more aggressive interventions. The use of cutting-edge embolic agents like PHIL, when combined with established techniques, offers new possibilities in tackling challenging neurovascular lesions. Future follow-up will be crucial to assess long-term outcomes and the potential need for additional treatment. This case contributes to the growing body of evidence supporting multi-modal, staged approaches in the management of complex CCFs, and underscores the ongoing evolution of neurointerventional techniques in addressing these challenging vascular anomalies.

DATA AVAILABILITY:

Further information regarding the data used for this work can be obtained from the corresponding author upon reasonable request.

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This work received no external funding.

CONFLICT OF INTEREST:

The authors have no conflicts of interest to declare and is in agreement with the contents of the manuscript.

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FIGURE LEGENDS:

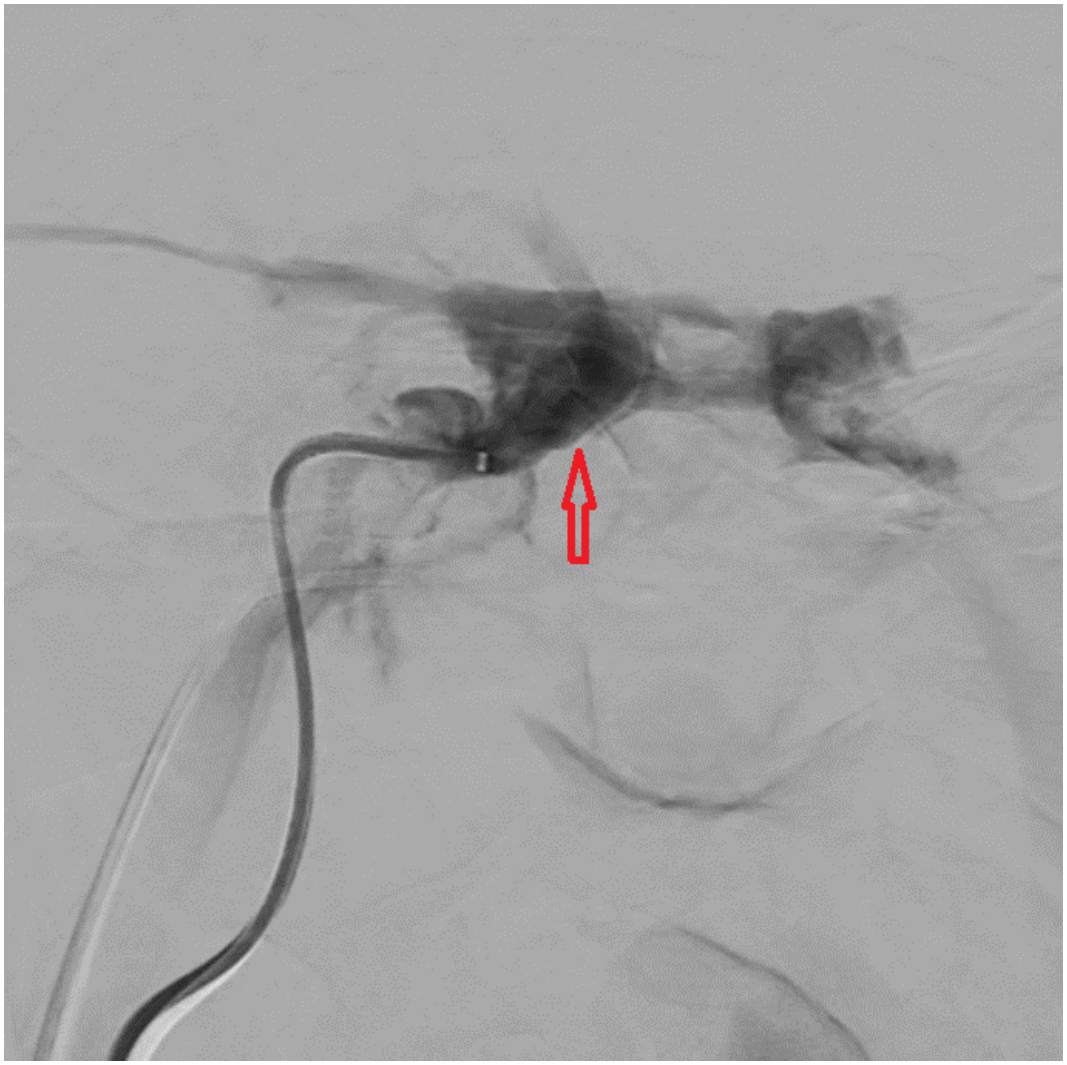

Figure 1: Cerebral angiogram pre procedural showed a right direct CCF (arrow).

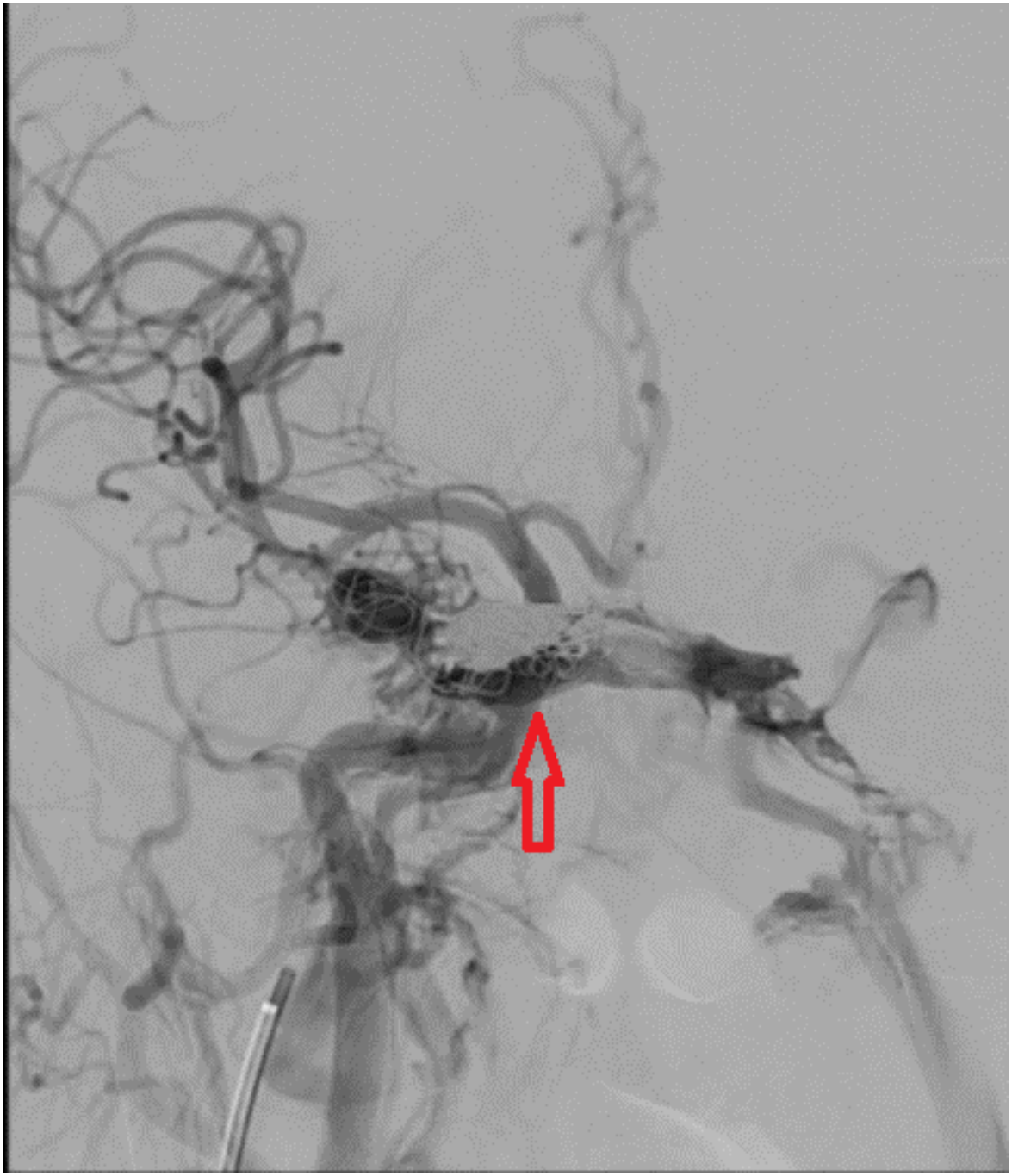

Figure 2: Partial occlusion of the CCF after 1st embolization procedure with seven fibered coils (arrow) successfully deployed into the venous sac of the cavernous sinus.

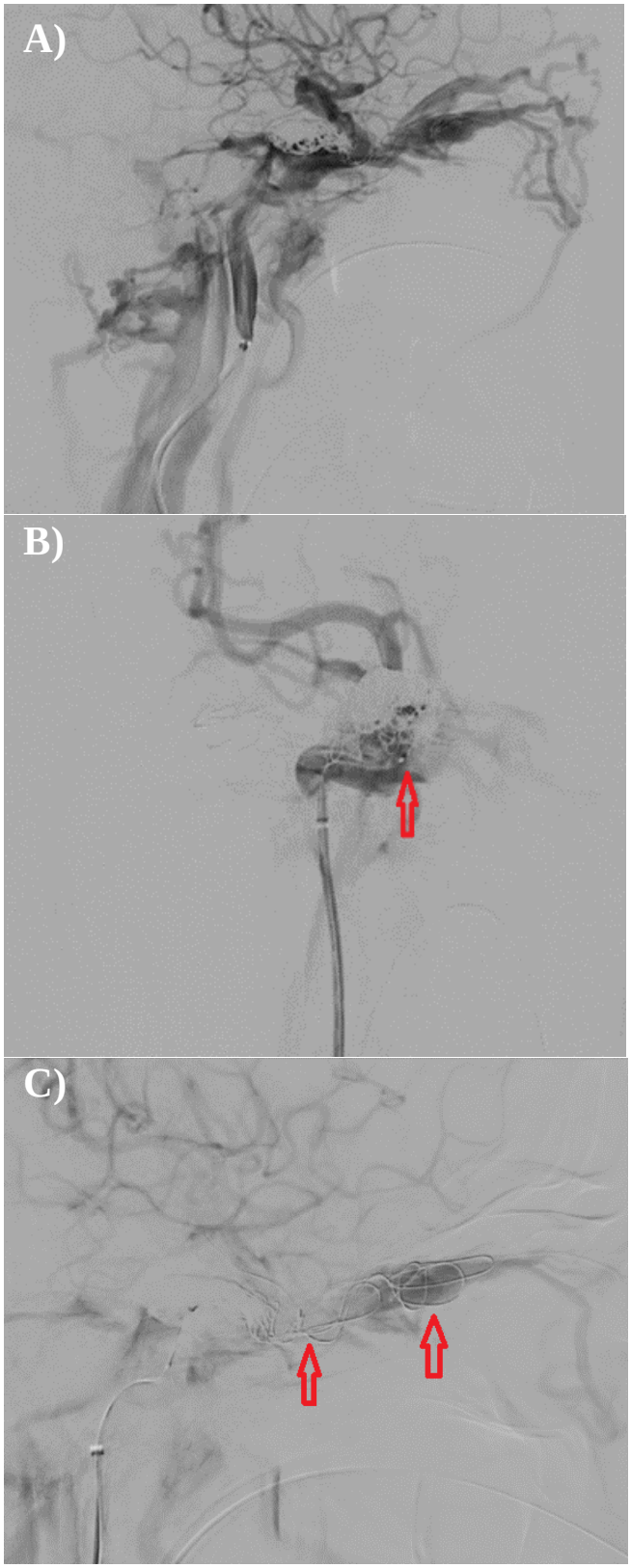

Figure 3. Cerebral angiogram, right ICA. A: lateral projection pre. B: AP projection post. C: Lateral projection post. Second embolization successfully deployed one fibered coil (arrow) followed by the injection of 1 ml of Precipitating Hydrophobic Injectable Liquid (PHIL) 30%. Cerebral angiogram post procedure showed significant reduction of the CCF flow.

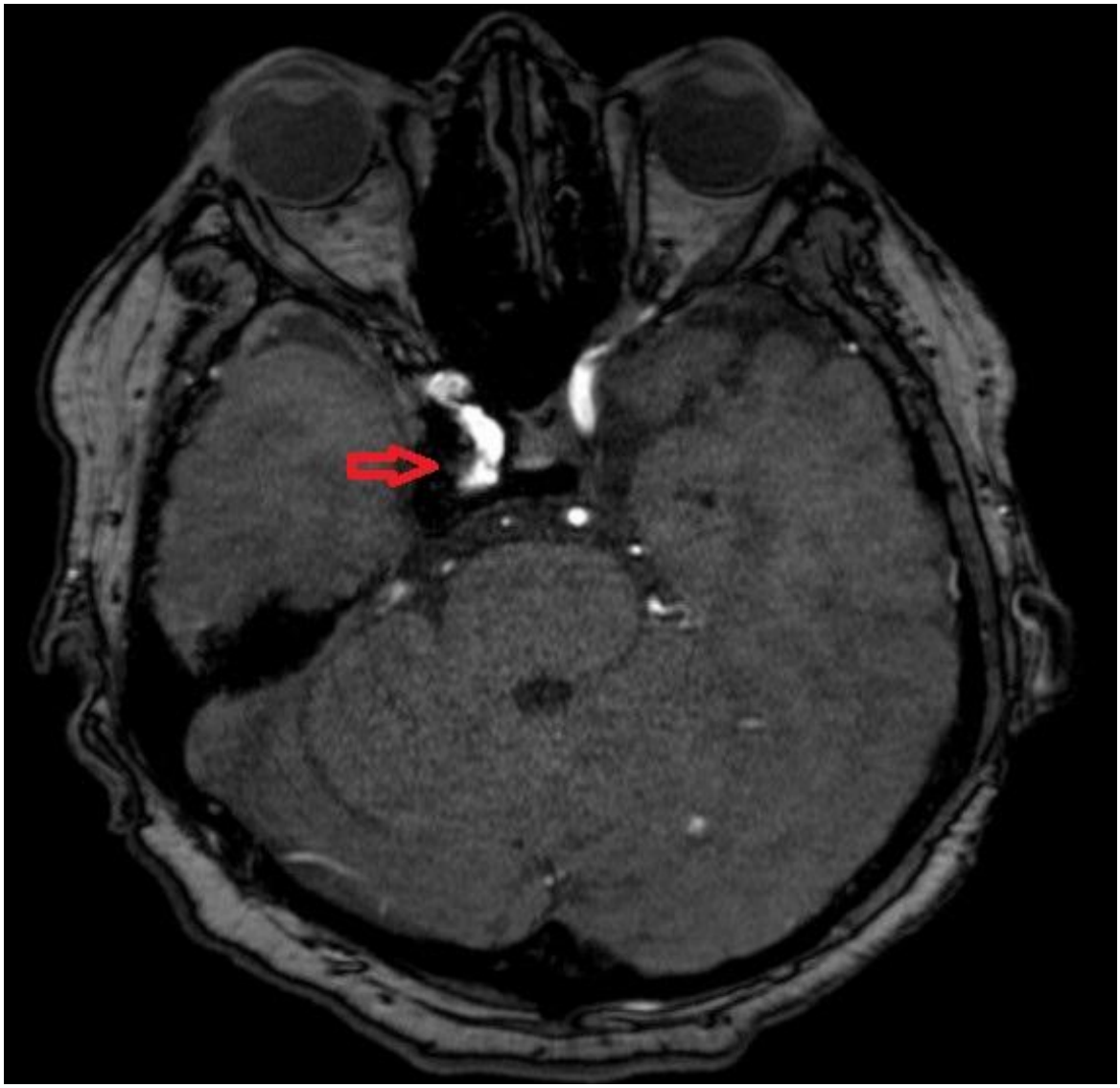

Figure 4: MRA 5 month later showed complete resolution of right CCF (arrow) with patient symptoms have improved.