

Exploiting the Non-dilated Superior Ophthalmic Vein for Embolization of Carotid-Cavernous Fistula: Systematic Review on Presentation, Clinical and Angiographic Outcomes

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Abstract

Purpose: Direct superior ophthalmic vein (SOV) access is an alternative transvenous route for carotid-cavernous fistula (CCF) embolization after failed or infeasible inferior petrosal sinus access. Whether a non-dilated, stenosed, thrombosed, or angiographically occult SOV remains usable is unclear.

Methods: We performed a PRISMA 2020-compliant systematic review of CCF or cavernous sinus dural arteriovenous fistula cases treated or attempted through direct access of a non-dilated SOV. MEDLINE, CINAHL, PsycINFO, EMBASE, the Cochrane Library, and Scopus were searched in April 2026. The protocol was registered in PROSPERO. Eligible cases required direct SOV exposure, puncture, cannulation, or attempted cannulation, with sufficient technical and outcome detail. An institutional illustrative case was described separately.

Results: Five reports contributed eight eligible access attempts in non-dilated SOV. All lesions were indirect CCFs. The SOV was thrombosed/occluded in 5/8 cases (62.5%). Prior failed or infeasible conventional access was reported in 7/8 (87.5%). Direct SOV access was successful in 6/8 attempts (75%). Coils were used in 5/6 successful cases (83.3%), including coil-only embolization in 4/6 (66.7%). Immediate angiographic cure and clinical improvement occurred in 6/6 successful treatments (100%). Visual acuity improved in 5/5 cases with extractable data. (100%) No access-related complications, periprocedural stroke, recurrence, or reintervention were reported among successful cases with available follow-up. The illustrative case achieved complete obliteration after coil embolization through a surgically exposed non-dilated SOV.

Conclusions: A non-dilated SOV may remain surgically identifiable and catheterizable. Direct SOV access should be considered a salvage strategy when conventional transvenous routes are unavailable or unsuccessful.

Key Points

- Non-dilated, stenosed, or angiographically occult superior ophthalmic vein with or without thrombosis may remain surgically identifiable and catheterizable for treatment in selected carotid-cavernous fistulas.
- Direct superior ophthalmic vein access should be considered a salvage strategy after failed or infeasible conventional transvenous access.
- Successful treatment depends on planned orbital exposure with an oculoplastic surgeon, secure venous control, fluoroscopic endovascular navigation, and a hemostatic exit strategy.
- When direct access was achievable, published cases consistently reported complete angiographic obliteration and clinical improvement, supporting the use of non-dilated superior ophthalmic vein access as a feasible salvage route in carefully selected patients.

Introduction

Carotid-cavernous fistulas (CCF) represent abnormal arteriovenous shunting between the carotid arterial system and the cavernous sinus. They may occur as direct high-flow shunts between the internal carotid artery and cavernous sinus or as indirect dural arteriovenous fistulas supplied by meningeal branches of the internal carotid artery, external carotid artery, or both.[1, 2] The cavernous sinus is a trabeculated venous plexus, and arterialization of this compartment can produce venous hypertension with clinical manifestations determined largely by the direction of venous drainage. Anterior drainage into the superior or inferior ophthalmic veins typically produces orbital venous congestion, whereas posterior drainage into intracranial venous pathways may result in cortical venous reflux and more aggressive neurologic sequelae.[3–5] Endovascular embolization is the mainstay of treatment for symptomatic, progressive, or high-risk CCFs. Although transarterial embolization remains useful in selected cases of direct CCF, indirect CCFs are often supplied by multiple small arterial feeders, which can limit durable transarterial cure and increase the risk of non-target embolization. Consequently, transvenous embolization has become a preferred strategy for indirect CCFs. The inferior petrosal sinus (IPS) is generally favored as the initial venous route because it provides a relatively short, direct posterior route to the cavernous sinus. However, IPS may be hypoplastic, thrombosed, angiographically occult, or impossible to catheterize in 31% of cases due to plexiform architecture.[6] In such cases, alternative venous approaches may be required.[4]

The superior ophthalmic vein (SOV) provides an important anterior transvenous route to the cavernous sinus, particularly when conventional access through the IPS has failed or is anatomically unavailable. Traditionally, this approach is most often considered when the SOV is dilated, arterialized, and readily visible on preoperative imaging and/or angiography. In contrast, a non-dilated, poorly opacified, stenosed, thrombosed, or apparently occluded SOV may discourage endovascular surgeons from attempting direct access. Prior experience with CCF embolization via the IPS route has shown that angiographically occult or occluded venous conduits may sometimes remain anatomically patent and traversable.[7] By extension, the SOV may also potentially remain surgically identifiable and amenable to catheterization in selected cases despite unfavorable angiographic morphology. This issue is clinically important because failure of conventional endovascular access routes may leave limited treatment options in patients with otherwise progressive ocular morbidity and/or dangerous intracranial venous reflux.

Therefore, we performed a systematic review of the literature to test the hypothesis of whether unfavorable SOV morphology should not necessarily be considered an absolute barrier to fistula access, and whether this route may remain a viable salvage strategy in selected patients. We also present an illustrative institutional case of an indirect CCF with cortical venous reflux treated by coil embolization through a surgically exposed non-dilated SOV after failed IPS access.

Methods

Study design and reporting framework

We performed a systematic review of published cases describing treatment or attempted treatment of carotid-cavernous fistulas (CCF) through direct superior ophthalmic vein (SOV) access when the accessed SOV was non-dilated. The review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 statement, and the protocol was registered in PROSPERO.[8] A PRISMA 2020 flow diagram was used to summarize study identification, screening, eligibility assessment, and inclusion. (Fig. 1) An institutional index case of transvenous coil embolization of an indirect CCF through a non-dilated SOV is also presented as an illustrative case but was not included in the descriptive synthesis or database-derived PRISMA count. The case is reported in accordance with the Declaration of Helsinki, and written informed consent was obtained for publication of de-identified clinical details and images. The systematic review used previously published data and required no additional patient consent.

Search Strategy

The original EMBASE search was composed by a medical librarian with systematic review training. A second member of the library's "systematic/scoping reviews" team provided a peer review of the EMBASE search. After making any needed revisions, CS translated the search strategy for use MEDLINE, CINAHL, PsycINFO, The Cochrane Library, and Scopus. MEDLINE, CINAHL and PsycINFO (simultaneous search via EBSCOhost), the Cochrane Library (via Wiley), and EMBASE (via embase.com) were searched on April 20, 2026, and Scopus was searched on April 21, 2026. The search strategies included subject headings (when available) and keywords for the "carotid artery-cavernous sinus fistula" concept. The "superior ophthalmic vein approach" concept was represented by a search for keywords for the "superior ophthalmic vein" concept within 15 words of keywords for the "approach/surgery" concept. To focus the search on articles about humans, articles indexed as concerning animals that were not also indexed as concerning humans were removed. No age or publication date filters were applied. Because no funds were available for translation, English language filters were applied. No publication types were removed. However, to facilitate review, publication filters were used to separate the results into four publication type groups: 1) conference abstracts, 2) case reports/series, 3) review articles, commentaries, editorials, notes, comments, books, and 4) all other articles. All search results were imported into an EndNote library dedicated to this project. A copy of the original EndNote library was de-duplicated by removing duplicates identified by EndNote and Zotero duplicate detection tools and duplicates identified by visual scans. The complete reproducible search strategies for each database, including Boolean operators, proximity operators, subject headings, and database-specific filters, are provided in Supplement 1.

Eligibility criteria and study selection

Studies were eligible if they reported original clinical data for at least one patient with a carotid-cavernous fistula or cavernous sinus dural arteriovenous fistula, described direct puncture, surgical exposure, cutdown, cannulation, or attempted cannulation of the SOV itself, and reported a non-dilated, normal-caliber, small, stenosed, narrowed, thrombosed, or occluded SOV. For thrombosed SOVs, non-dilation was required. Reports also had to provide sufficient case-level or aggregate technical detail to determine the access site, SOV status, treatment attempt, and procedural outcome. Attempted SOV-access failures were eligible if the SOV was directly exposed, punctured, or cannulated and the failure was attributable to thrombosed or stenosed SOV anatomy. These were included in the technical-access denominator but excluded from analyses of embolic material, angiographic cure after treatment, and post-embolization clinical outcome. Only English-language articles were included.

Cases were excluded when the SOV was only a venous drainage pathway rather than the puncture or cannulation site, or when access was obtained through another route, including the inferior petrosal sinus, facial vein, angular vein, inferior ophthalmic vein, internal jugular vein, transfemoral route, or transarterial route, even if the SOV was thrombosed or occluded. Cases in which a catheter traversed or opacified the SOV, but the primary access site was not the SOV were excluded, as were cases of dilated, thrombosed SOVs. Additional exclusions included non-English reports, duplicates, non-extractable reviews, inadequately detailed abstracts, and cases in which SOV thrombosis was only a complication.

After duplicate removal, two authors screened titles and abstracts for relevance. Full texts were reviewed against predefined criteria, with discrepancies resolved by adjudication with the senior author.

Data extraction, definitions, and analysis

Two reviewers extracted data with a predefined case-level form. Patient-level variables included demographics, etiology, symptoms, symptom duration, laterality, Barrow classification, fistula type, venous drainage, orbital venous congestion, and intracranial venous reflux. Technical variables included SOV side and status, reported diameter or imaging basis for caliber assessment, prior failed access routes, rationale for SOV access, access method, cannulation technique, and hemostasis. Treatment and outcome variables included embolic material, devices, access success, number of attempts, cannulation difficulty, immediate angiographic result, repeat treatment, symptom improvement, visual and cranial nerve outcomes, complications, follow-up, recurrence, and reintervention. Aggregate data were extracted when individual data were inseparable. Missing variables were recorded as not reported and were not imputed.

The primary technical outcome was successful direct SOV access, defined as placement of an angiocatheter, microcatheter, sheath, balloon catheter, or guidewire through a directly punctured or surgically exposed SOV sufficient to reach the cavernous sinus or SOV-cavernous sinus junction and deliver therapy. Technical access failure was direct exposure or attempted cannulation without successful catheter or microwire passage to the target cavernous sinus compartment. Immediate angiographic success was complete fistula obliteration or elimination of pathologic cavernous sinus/SOV drainage at procedure conclusion, as reported by authors. Clinical improvement was improvement or resolution of ocular symptoms, orbital venous congestion, proptosis, chemosis, conjunctival injection, diplopia, ophthalmoplegia, visual symptoms, elevated intraocular pressure, or cranial neuropathy at last follow-up. Recurrence was recurrent angiographic shunting, recurrent fistula-attributable symptoms, or reintervention after initial success. Planned staged treatment

was not considered failure. SOV status was categorized according to author language or imaging description; when diameter was reported, ≤ 3 mm was considered non-dilated based on published normal SOV diameter data. [9, 10]

Given that the included evidence consisted exclusively of case reports and small case series, conventional risk-of-bias instruments designed for comparative studies were not applicable. Methodological quality was therefore assessed using the Joanna Briggs Institute (JBI) critical appraisal tools appropriate to the study design. (Supplement 2) Particular attention was paid to diagnostic confirmation, characterization of superior ophthalmic vein (SOV) morphology and access status, prior unsuccessful venous access routes, procedural technique, angiographic outcomes, complications, and clinical follow-up. No studies were excluded on the basis of quality assessment, as the primary objective was to capture all available reports describing this rare technical scenario. Although the included studies demonstrated generally acceptable methodological quality, the overall certainty of evidence remains very low owing to the small sample size, non-comparative study designs, heterogeneous reporting, incomplete follow-up, and the potential for publication bias.

Meta-analysis was not performed because of the rarity of eligible cases, absence of comparative cohorts, and predominance of case reports and small series. Data were summarized descriptively. Categorical variables are reported as counts and proportions using available-case denominators. Continuous variables are reported as median and range when available. Attempted SOV-access failures were included in the technical-access denominator but excluded from treatment-success denominators.

Results

Study selection and eligibility

The database search identified 858 records: 320 from EMBASE, 259 from MEDLINE/CINAHL/PsycINFO, 0 from the Cochrane Library, and 279 from Scopus. After removal of 473 duplicates, 385 unique records remained for title screening. Of these, 291 proceeded to abstract screening, and 121 full-text reports were sought, retrieved, and assessed for eligibility. After full-text review, 116 reports were excluded (supplement 3), leaving five published reports that met final inclusion criteria and contributed eight literature cases/access attempts. One institutional index case was added separately outside the database-derived PRISMA count and was not included in the descriptive synthesis. The included reports were published between 1989 and 2023 and originated from Japan, the United States, and Turkey. Successful treatment cases were reported by Iwaki et al., Alaraj et al., Hanneken et al., and Güven Yilmaz et al. Attempted access failures were reported by Güven Yilmaz et al. and Leibovitch et al.[11–15] (Table 1)

Table 1
Study-level characteristics and eligibility

First author, year	Country	Study design	No. of cases eligible	Indexing database	Eligibility reason
Iwaki, 2023	Japan	Case report	1	Medline	<ul style="list-style-type: none">• CS-dAVF treated by direct puncture of the SOV with craniotomy after failed IPS and facial vein/trans-orbital SOV approaches• SOV access was difficult because of progressive SOV stenosis/subcutaneous SOV narrowing.
Alaraj, 2013	United States	Case report	1	Embase Medline	Direct SOV cannulation with blind microcatheter passage through an occluded proximal SOV segment to embolize an indirect CCF.
Hanneken, 1989	United States	Case series	1 (case #4)	Embase Medline	<ul style="list-style-type: none">• Direct surgical SOV cannulation for CCF treatment• The SOV was specifically described as “not particularly enlarged.”
Güven Yilmaz, 2013	Turkey	Case series	4 eligible cases; data partly case-level and partly aggregate.	Embase	<ul style="list-style-type: none">• 3 dural CCF cases successfully treated by retrograde embolization via thrombosed SOV• Angiocatheter was passed through the thrombosed SOV segment into the cavernous sinus• Case #1 was failed cannulation.
Leibovitch, 2006	United States	Case series	1 (Case #5)	Embase Medline	<ul style="list-style-type: none">• Difficult/unsuccessful SOV cannulation series• Case #5 involved a non-dilated SOV
NR, not reported; CCF, carotid-cavernous fistula; SOV, superior ophthalmic vein; IOP, intraocular pressure; CS-dAVF, cavernous sinus dural arteriovenous fistula; IOV, inferior ophthalmic vein; IPS, inferior petrosal sinus; ICA, internal carotid artery; ECA, external carotid artery.					

Patient and fistula characteristics

The final literature cohort consisted of eight eligible cases or access attempts. Exact age was available in 7/8 cases (87.5%). The mean age was 63.4 years, the median age was 65 years, and the range was 48–75 years. Sex was reported in 7/8 cases (87.5%): 4/7 were female (57.1%) and 3/7 were male (42.9%). All reported lesions were indirect carotid-cavernous fistulas or cavernous sinus dural arteriovenous fistulas (8/8, 100%). Barrow classification was reported in 6/8 cases (75.0%): 4/6 were Barrow type D (66.7%), and 2/6 were Barrow type B (33.3%). Seven cases were unilateral (7/8, 87.5%) and one was bilateral (1/8, 12.5%). Among all cases, right-sided involvement was present in 6/8 cases (75.0%), left-sided involvement in 1/8 case (12.5%), and bilateral involvement in

1/8 case (12.5%). Orbital venous congestion was reported in all cases (8/8, 100%). Intracranial venous reflux was not reported in any cases. Duration of symptoms before treatment was available in 4/8 cases (50.0%). The median duration was 7 months (Range:1–10 months).[11–15] (Table 2)

Table 2
Patient presentation and carotid-cavernous fistula characteristics

Study	Case no.	Age, y	Sex	Etiology(spont/infection/trauma)	Presentation / symptoms	Duration before treatment	Laterality U/B	Barrow class	Direct/ Indirect	Venous drainage pattern
Iwaki, 2023	1	65	M	Spontaneous	<ul style="list-style-type: none"> • Headache, diplopia • Conjunctival congestion, vision loss, increased IOP, Ophthalmoplegia 	NR	Right	Not specified	Indirect/ CS-dAVF	<ul style="list-style-type: none"> • Right and IO drainage • Proximal SOV stenosis noted.
Alaraj, 2013	1	Elderly, exact age NR	NR	spontaneous	<ul style="list-style-type: none"> • Progressive right eye pain, proptosis, redness, congestion, decline in visual acuity • Right ophthalmoplegia, chemosis, increased IOP 	NR	Right	D	Indirect CCF	<ul style="list-style-type: none"> • Right and IO drainage • Proximal SOV or distal ICA also or within • No facial vein drainage no IPS
Hanneken, 1989	4	48	M	Spontaneous	<ul style="list-style-type: none"> • Right proptosis, redness/injection, right orbital pain, diplopia • Moderate right abducens nerve paresis • Decreased right corneal sensation and decreased sensation in V1/V2 distribution 	NR	Right	D	Indirect CCF	<ul style="list-style-type: none"> • Venous drainage details separate description Case 4 • SOV not accessed; description not particularly enlarged
Güven Yilmaz, 2013	1	68	F	NR	• Aggregate symptoms for all 4: proptosis, eyelid edema, chemosis	8 months	Bilateral	D	Indirect CCF	NR
Güven Yilmaz, 2013	2	58	F		• EOM restriction, venous stasis retinopathy, elevated IOP, and decreased visual acuity.	10 months	Right	B	Indirect CCF	Right (intercavernous) flow
Güven Yilmaz, 2013	3	65	M		• RAPD in Cases 2 and 4; abduction paralysis in 3/4 patients.	1 month	Right	B	Indirect CCF	Specific drainage not fully reported
Güven Yilmaz, 2013	4	65	F			6 months	Right	D	Indirect CCF	Right (intercavernous) flow
Leibovitch, 2006	5	75	F	NR	NR	NR	Left	NR	Indirect CCF	NR

NR, not reported; CCF, carotid-cavernous fistula; SOV, superior ophthalmic vein; IOP, intraocular pressure; CS-dAVF, cavernous sinus dural arteriovenous fistula; inferior petrosal sinus; ICA, internal carotid artery; ECA, external carotid artery.

SOV anatomy and rationale for direct SOV access

The defining feature of the included cases was direct use, or attempted use, of a non-dilated SOV with or without thrombosis as the access route. Baseline SOV status was described as thrombosed/occluded in five cases (5/8, 62.5%), progressively stenosed/non-dilated in three cases (3/8, 37.5%). Numerical SOV diameter was not reported in any of the cases. Prior failed endovascular or conventional access/treatment attempts were reported in 7/8 cases (87.5%). These included failed inferior petrosal sinus access, failed facial vein or transorbital access, failed transarterial embolization, failed transfemoral embolization attempts, and failed transvenous access. In one case, the SOV route was selected as the initial access strategy because alternate venous routes were thrombosed.[11–15] (Table 3)

Table 3

Superior ophthalmic vein status, failed conventional access, and SOV access technique details

Study	Case no.	SOV side used	Baseline SOV status	Diameter / imaging findings	Imaging modality	Prior failed route(s)	Reason conventional route not feasible	Access method down/success
Iwaki, 2023	1	Right	<ul style="list-style-type: none"> Progressive stenosis No explicit thrombosis/occlusion reported 	<ul style="list-style-type: none"> Diameter NR Angiography: progressive SOV stenosis 3D-CTA used for planning. 	DSA, 3D-CTA	<ul style="list-style-type: none"> IPS approach Facial vein Transorbital approach 	<ul style="list-style-type: none"> IPS access failed. Facial vein/SOV route failed because of difficult access, including stenotic angular vein and progressive SOV stenosis/narrowing. Transorbital failed – Unable to access stenosed SOV. 	<ul style="list-style-type: none"> FTP cran orbital wall puncture. Periorbital identified and then clipped
Alaraj, 2013	1	Right	<ul style="list-style-type: none"> Occluded SOV: proximal third of SOV within orbit was occluded; distal SOV also appeared occluded near orbital rim 	<ul style="list-style-type: none"> Diameter NR Diagnostic cerebral angiography/selective angiography: proximal SOV occlusion and collateral connection through IOV 	<ul style="list-style-type: none"> Cerebral angiography Selective angiography through SOV cannula 	<ul style="list-style-type: none"> Retrograde cannulation of non-visualized/occluded right IPS failed Trans-arterial Onyx embolization via right ECA feeders failed 	<ul style="list-style-type: none"> No IPS outflow/non-visualized IPS; IPS cannulation failed Arterial feeders were small for effective Onyx penetration No facial vein drainage The collateral route from SOV to IOV was too tortuous 	<ul style="list-style-type: none"> Right ante orbitotomy with direct cannulation blind probe proximal S
Hanneken, 1989	4	Right	<ul style="list-style-type: none"> Non-enlarged SOV No thrombosis reported 	Diameter NR	Selective angiography for fistula diagnosis	Prior embolization of right and left ECA circulation feeders on two occasions failed to close fistula	Fistula remained open after embolization because of continued contribution from dural branches of both ICA and recanalized external carotid feeders.	Direct surgery via supero eyelid incision
Güven Yilmaz, 2013	1	NR	<ul style="list-style-type: none"> Thrombosed SOV. All SOV appeared as pale, thin, and tortuous 	NR	NR	NR	NR	Failed can
Güven Yilmaz, 2013	2	Right		<ul style="list-style-type: none"> Diameter NR Thrombosis noted intraoperatively by abnormal morphology 	<ul style="list-style-type: none"> Carotid angiography Doppler US: arterialized SOV flow before angiography 	<ul style="list-style-type: none"> Aggregate for case 1–3: Prior unsuccessful transfemoral embolization attempt. 	<ul style="list-style-type: none"> Aggregate for case 1–3: Due to thrombosed/limited venous routes 	<ul style="list-style-type: none"> Aggregate Upper eyelid direct SOV exposure/

NR, not reported; CCF, carotid-cavernous fistula; SOV, superior ophthalmic vein; IOP, intraocular pressure; CS-dAVF, cavernous sinus dural arteriovenous fistula; inferior petrosal sinus; ICA, internal carotid artery; ECA, external carotid artery.

Study	Case no.	SOV side used	Baseline SOV status	Diameter / imaging findings	Imaging modality	Prior failed route(s)	Reason conventional route not feasible	Access method / outcome
Güven Yilmaz, 2013	3	Right		<ul style="list-style-type: none"> • Diameter NR • Thrombosis noted intraoperatively by abnormal morphology 	Carotid angiography			
Güven Yilmaz, 2013	4	Right		<ul style="list-style-type: none"> • Diameter NR • Angiography: anterior SOV portions not opacified due to thrombus 	Carotid angiography	None	SOV approach was initial procedure because alternate routes were thrombosed	
Leibovitch, 2006	5	Left	Small SOV	<ul style="list-style-type: none"> • Diameter NR • DSA: small SOV 	DSA	Transvenous	NR	Surgical exposure

NR, not reported; CCF, carotid-cavernous fistula; SOV, superior ophthalmic vein; IOP, intraocular pressure; CS-dAVF, cavernous sinus dural arteriovenous fistula; inferior petrosal sinus; ICA, internal carotid artery; ECA, external carotid artery.

SOV exposure and cannulation technique

All eight access attempts involved direct surgical exposure, cutdown, or attempted cannulation of the SOV. Direct SOV access was successful in 6/8 access attempts (75.0%). Technical-access failure occurred in 2/8 access attempts (25.0%). In both failure cases, the SOV was stenotic, and cannulation was unsuccessful. Reported surgical corridors included frontotemporal craniotomy with orbital wall deroofing, anterior orbitotomy with SOV cutdown, superomedial upper-eyelid incision, upper-eyelid crease incision, and direct surgical SOV exposure. Among the six technically successful cases, cannulation techniques included microguidewire and microcatheter advancement after SOV incision in one case (1/6, 16.7%), 18-gauge angiocatheter cannulation with microwire passage through an occluded proximal SOV segment in one case (1/6, 16.7%), balloon-tipped catheter advancement to the SOV-cavernous sinus junction in one case (1/6, 16.7%), and 18G/20G angiocatheter-assisted catheterization through thrombosed SOV segments in three cases from one series (3/6, 50.0%).[11–15] (Table 3)

Intraoperative SOV control or hemostatic technique was described in 5/6 technically successful cases (83.3%). Reported methods included clipping, carotid tape, silk sutures, silicone vascular loops, and ligation of the SOV ends after catheter removal.

Embolization strategy and immediate angiographic outcomes

Among the six technically successful cases, coils were used in five (83.3%). Coil embolization alone was used in four cases (66.7%), combined platinum microcoils and Onyx in one case (16.7%), and a detachable balloon catheter in one historical case (16.7%). Immediate angiographic cure or complete occlusion was reported in all technically successful cases (6/6, 100%). Across all eligible access attempts, including two technical failures, immediate angiographic cure was achieved in 6/8 cases (75.0%). No staged or repeat treatment was reported after successful direct SOV treatment.[11–15] (Table 4)

Table 4
Endovascular treatment details and immediate technical results

Study	Case no.	Embolic material(s)	Microcatheter/device(s) used	Technical access success and nuances	Immediate angiographic result	Need for staged / repeat treatment
Iwaki, 2023	1	Coils, 11 total	Microguided wire and microcatheter	Direct SOV access required transorbital craniotomy after failed IPS and facial vein/SOV access and failed open transorbital SOV identification.	Complete shunt and SOV drainage disappearance after embolization.	No repeat treatment
Alaraj, 2013	1	Coils	18-gauge angiocatheter, 0.012-inch Headliner Microwire, 1.9F Prowler-14 microcatheter	<ul style="list-style-type: none"> • Technically successful with 1 attempt • Difficulty in SOV cannulation: occluded proximal SOV and tortuous SOV-IOV collateral 	Final angiogram: <ul style="list-style-type: none"> • no early filling of the right cavernous sinus after coil obliteration • SOV and IOV were disconnected from cavernous sinus 	No staged/repeat treatment reported after successful SOV approach
Hanneken, 1989	4	Detachable balloon catheter	Balloon-tipped catheter	<ul style="list-style-type: none"> • Successful direct SOV cannulation in 1 attempt despite SOV not being particularly enlarged • Catheter was threaded to the SOV-cavernous sinus junction 	Complete closure of the fistula on angiography after balloon positioning, inflation, and detachment	No repeat treatment was reported.
Güven Yilmaz, 2013	1	NA	NA	NA	NA	NA
Güven Yilmaz, 2013	2	Aggregate among successful cases:	Aggregate:	Aggregate:	Aggregate:	No repeat treatment reported
Güven Yilmaz, 2013	3	Platinum microcoils alone in 2 patients; platinum microcoils + Onyx EV3 in 1 patient. Case-specific embolic material NR.	18G/20G angiocatheter, microcatheter, silk sutures/silicone vascular loops, fluoroscopic guidance.	<ul style="list-style-type: none"> • Successful catheterization through thrombosed SOV • Case-specific difficulty not separately reported. 	Successful complete cavernous sinus embolization/obliteration in case 2–4	
Güven Yilmaz, 2013	4					
Leibovitch, 2006	5	Failed treatment	-	SOV was small, catheter could not be passed through	NR	NA
NR, not reported; NA, not applicable; CCF, carotid-cavernous fistula; SOV, superior ophthalmic vein; IOP, intraocular pressure; CS-dAVF, cavernous sinus dural arteriovenous fistula; IOV, inferior ophthalmic vein; IPS, inferior petrosal sinus; ICA, internal carotid artery; ECA, external carotid artery.						

Clinical outcomes, complications, follow-up and recurrence

Clinical improvement was reported in all technically successful treatment cases (6/6, 100%), including reduction or resolution of conjunctival congestion, chemosis, proptosis, orbital edema, orbital pain, diplopia, ophthalmoplegia, elevated intraocular pressure, and visual symptoms. Visual acuity improved in all successful cases with extractable pre- and post-treatment visual acuity data (5/5, 100%). Explicit post-treatment ocular motility data were available in 2/6 successful cases and showed improvement. Iwaki et al. reported improved eye movement disorders, with Hess chart evidence of omnidirectional improvement at 6 months. Hanneken et al. reported resolution of right abducens nerve paresis and diplopia over several months. Alaraj et al. reported no other cranial nerve palsy but did not separately document resolution of presenting ophthalmoplegia, and the Güven Yilmaz series reported preoperative abduction paralysis at aggregate level without separately reporting post-treatment ocular motility outcomes for eligible successful cases.[11–15] (Table 5)

Table 5
Clinical outcomes, complications, and follow-up

Study ID	Case/pt no.	Symptom improvement	Visual outcome	Other Cranial nerve outcomes	Other neurologic outcome eg. Cranial reflux, stroke etc	Access-related complication(s)	Other peri-procedural complication(s)	Follow-up duration and outcome	Follow-up outcome
Iwaki, 2023	1	Improvement in conjunctival congestion and eye movement disorders.	<ul style="list-style-type: none"> Improved immediately right vision improved from 0.3 [20/40] to 1.2 [20/16] after treatment 	<ul style="list-style-type: none"> Eye movement disorders improved Hess chart at 6 months showed omnidirectional improvement of right eye movement. 	No neurologic complication noted	None reported	None reported	<ul style="list-style-type: none"> 6 months DSA follow-up Latest clinical follow-up also noted no daily-life inconvenience 	No daily-life inconvenience
Alaraj, 2013	1	Yes <ul style="list-style-type: none"> IOP decreased after treatment from 39mm Hg to 15 mm Hg 	Improved from 20/200 at presentation to 20/80 at 1-month follow-up	No other cranial nerve palsy reported	None	None reported	None reported	1 month	<ul style="list-style-type: none"> Improved vision No significant complications No significant complications
Hanneken, 1989	4	Yes, ocular injection, chemosis, diplopia, and other symptoms resolved over the next several months	Baseline visual acuity was 20/30 OD and 20/25 OS; post treatment visual outcome not separately quantified.	Right abducens nerve paresis/diplopia resolved over several months	None reported	None reported	None reported	Several months exact duration not specified	<ul style="list-style-type: none"> Improved vision Long-term follow-up
Güven Yilmaz, 2013	1	Visual acuity did not improve significantly <ul style="list-style-type: none"> Orbital symptoms slowly regressed after the procedure 	Preoperative: 20/200 OD, 20/400 OS Postoperative: 20/100 OD, 20/1000 OS	NR	NR	NR	NR	64 months	2 episodes of vitreous hemorrhage, resolved after treatment. Residual optic atrophy
Güven Yilmaz, 2013	2	Aggregate: <ul style="list-style-type: none"> Orbital symptoms improved in all 3 patients, along with normalization of visual acuity and IOP. 	Improved from 20/200 OD, 20/50 OS to 20/20 OD, 20/20 OS.	Aggregate: <ul style="list-style-type: none"> Baseline of abduction paralysis was noted in 3/4 patients. 	No stroke or intracranial neurologic complication reported	None reported	None reported	15 months	<ul style="list-style-type: none"> No significant complications No significant complications
Güven Yilmaz, 2013	3		Improved from 20/40 OD to 20/25 OD.	<ul style="list-style-type: none"> No reported post-treatment outcome. 				24 months	<ul style="list-style-type: none"> No significant complications No significant complications
Güven Yilmaz, 2013	4		Improved from 20/100 OD, 20/50 OS to 20/25 OD, 20/20 OS.					3 months	<ul style="list-style-type: none"> No significant complications No significant complications
Leibovitch, 2006	5	Gradual resolution	NR	NR	NR	NR	NR	<ul style="list-style-type: none"> 3 months Resolution of signs and symptoms 	No significant complications

NR, not reported; CCF, carotid-cavernous fistula; SOV, superior ophthalmic vein; IOP, intraocular pressure; CS-dAVF, cavernous sinus dural arteriovenous fistula; ophthalmic vein; IPS, inferior petrosal sinus; ICA, internal carotid artery; ECA, external carotid artery.

The two technical failures were excluded from post-embolization success denominators. In one failure case, visual acuity did not significantly improve, although orbital symptoms slowly regressed. The patient later developed two episodes of vitreous hemorrhage secondary to pre-retinal neovascularization and underwent anti-VEGF treatment and laser photocoagulation.[12] In the other failure case, gradual clinical resolution was reported at 3 months.[11] No access-related complication was reported among successful cases (0/6), and no peri-procedural stroke or intracranial neurologic complication was reported.

Exact follow-up duration was available in 5/6 successful cases. Mean follow-up was 9.8 months (median: 6 months, Range: 1–24 months). No recurrence or reintervention was reported among successful cases with available follow-up.[11–15] (Table 5)

Illustrative case

The index patient was an 82-year-old woman who presented with 6 months of horizontal diplopia and mild left-sided proptosis. Ophthalmologic examination demonstrated diffuse conjunctival injection with corkscrew episcleral vessels and mild asymmetric proptosis. Digital subtraction angiography (DSA) confirmed a Barrow type D indirect carotid-cavernous fistula with marked retrograde cortical venous reflux from the cavernous sinus into the brain. The SOV was not dilated, with a maximum diameter of 2.13 mm posteriorly near the superior orbital fissure and 1.74 mm anteriorly. An initial inferior petrosal sinus approach failed because of atretic channels bilaterally.

The patient subsequently underwent SOV cutdown in coordination with the oculoplastic team. (Fig. 2A-B) Because the distal SOV was not easily accessible, the vein was dissected and traced approximately 2 cm in depth to an arterialized segment, which was confirmed with intraoperative Doppler. The SOV was cannulated, and intraoperative fluoroscopy confirmed microwire position within the cavernous sinus. (Fig. 2C-E) The patient was then transferred to the angiography suite. A Headway Duo microcatheter (Microvention, Inc., California, USA) was navigated over a Synchro 14 wire (Stryker Neurovascular, Utah, USA) via the micropuncture sheath and then into the cavernous sinus. Venography demonstrated catheter location in the fistula, with significant bilateral cortical venous reflux. (Fig. 3A-E) Transvenous coil embolization with bare platinum coils was performed until cortical venous reflux was eliminated, and the SOV was coil embolized as part of definitive treatment. (Fig. 3F) Her postoperative course was complicated by a groin hematoma requiring vascular surgery intervention. She subsequently recovered well and was discharged on postoperative day 5. At follow-up, she was clinically well without visual complaints, and her proptosis and conjunctival injection had resolved. Repeat DSA at 3-month follow-up demonstrated complete obliteration of shunting and no evidence of intracranial reflux.

Discussion

Indirect carotid-cavernous fistulas (CCFs) are usually treated through transvenous routes, with the inferior petrosal sinus (IPS) traditionally preferred. The superior ophthalmic vein (SOV) is an effective alternative, with reported high complete-occlusion rates and potentially lower recurrence.[4, 16, 17] However, surgeons may be discouraged from SOV access when the vein is not grossly dilated, poorly visualized angiographically, or partially/completely thrombosed. Our index case challenged this assumption and prompted this review. We found that even without marked SOV dilatation, the vein may remain surgically identifiable, cannulable, and clinically useful as a transvenous route. A non-dilated SOV should therefore not automatically deter this approach.

Direct SOV access appears effective for CCF embolization. In a 21-year single-center experience, Catapano et al. reported attempted direct SOV cannulation in 19 patients, with one aborted procedure and angiographic cure plus symptomatic improvement in 17 of 18 treated patients. Their literature review identified 45 additional patients treated through direct SOV cannulation, with angiographic cure in 43, a 96% cure rate.[16] These outcomes compare favorably with larger endovascular series of indirect CCFs. Alexander et al. reported fistula obliteration in 86.5% of 267 patients, including 86.9% of exclusively transvenous treatments.[18] These data should not be interpreted as proof of superiority over IPS or other conventional routes, because studies differ in case selection, fistula anatomy, route feasibility, prior treatment history, and reporting methods. Rather, SOV access is valuable as a highly effective alternative when standard venous access is unavailable, thrombosed, or unsuccessful.

These cases represent a niche population of non-dilated SOVs in indirect CCFs. Prior failure or non-feasibility of conventional access was reported in most, including failed IPS catheterization, facial vein or transorbital approaches, and transarterial embolization. Baseline SOV anatomy was unfavorable in all cases: five attempts involved thrombosed or occluded non-dilated SOVs, and three involved small, stenosed, or non-dilated SOVs. Despite these constraints, SOV access succeeded in six of eight attempts (75%). Two failures were attributable to severely atretic veins.[11–15]

Several technical lessons emerge. First, angiographic non-visualization or apparent SOV occlusion does not necessarily preclude surgical identification. In selected cases, direct exposure, Doppler confirmation of arterialized flow, venous control, and fluoroscopic/roadmap-guided microwire manipulation allowed the SOV to serve as a cavernous-sinus conduit. Second, thrombosis was not uniformly prohibitive. Third, failures define the limits of this strategy: a small, fibrotic, tortuous, or fragile SOV may not safely accommodate catheterization despite exposure.[11–15]

Poorly visualized IPS cannulation provides a useful conceptual parallel. Halbach et al. showed that even when the IPS was not angiographically demonstrable, transvenous embolization through this route remained possible in selected patients.[7] This principle was used by Bendorff and Leikkhong to embolize CCFs through thrombosed IPS.[6] However, the SOV is more fragile and requires a different risk calculus. It is a thin-walled, valveless orbital vein that may be fragile, arterialized, or difficult to control in CCF-related venous hypertension. Small caliber, tortuosity, thrombosis, and anatomic variability can make cannulation difficult and increase risks of venous rupture, orbital hemorrhage, optic nerve injury, inadvertent arterial puncture, thrombophlebitis, infection, and incomplete embolization.[19] Leibovitch et al. cautioned that deeper orbital dissections carry greater bleeding risk, particularly in older patients or those with fragile veins.[11] When unfavorable SOV anatomy is anticipated, surgical cutdown with an oculoplastic surgeon may provide safer localization, circumferential control, and hemostasis than blind or percutaneous puncture. In this review, SOV-control or hemostatic techniques were reported in most successful cases, including clipping, carotid tape, silk sutures, silicone vascular loops, and suture ligation after catheter removal. Anticipating bleeding risk also permits preparation for immediate orbital decompression if warranted.[11–15]

Emboic-agent selection should be individualized. Onyx has expanded CCF treatment options, including through SOV access, but liquid embolics are difficult to control due to non-target reflux/migration, cranial neuropathy from cavernous sinus thrombosis or mass effect, and redirection of flow into the deep venous system. Coils were used as at least one embolic component in most technically successful cases, and coil embolization alone achieved complete

occlusion in several. Our case similarly achieved elimination of cortical venous reflux and complete angiographic obliteration using platinum coils alone, supporting coil-only embolization when the pathological cavernous sinus compartment can be safely accessed and densely packed.[11–15]

Limitations

This review has several limitations. The evidence base is very small, consisting of only five published reports and eight eligible literature access attempts. Accordingly, the reported percentages should be interpreted as descriptive signals from a highly selected literature rather than stable estimates of procedural efficacy or safety. The small sample size may reflect not only the rarity of this anatomical scenario but also practice-pattern and reporting bias. Interventionalists may be discouraged from attempting direct SOV access when the vein is non-dilated, stenosed, thrombosed, occluded, or poorly visualized, whereas successful salvage cases may be more likely to be reported than failed or complicated attempts. This review should therefore not be interpreted as supporting direct non-dilated SOV access as a first-line treatment strategy, but rather as suggesting that it may be considered in selected situations. In addition, complications such as venous rupture, orbital hemorrhage, retrobulbar hematoma, orbital compartment syndrome, optic nerve compression, infection, thrombophlebitis, cranial nerve dysfunction, and failed catheterization have been recognized. Other limitations include heterogeneous reporting, absent numerical SOV diameter in the published cases, short and variable follow-up, partial aggregate reporting, and exclusion of non-English studies. The true procedural denominator may never exist, as the literature cannot capture cases in which direct SOV access was considered but not attempted. The findings may also reflect operator- and center-level expertise, since successful use of this route likely depends on coordinated orbital surgical exposure and endovascular catheterization. Technical heterogeneity across reports, including differences in surgical corridor, cannulation method, embolic material, and hemostatic technique, limits conclusions about the safest or most reproducible approach.

Conclusion

Access of superior ophthalmic vein for embolization of indirect CCF may be feasible even in the presence of limited angiographic patency due to non-dilatation, with or without thrombosis. Instead of facing discouragement with such an imaging finding, endovascular practitioners should consider direct SOV access as a potential viable alternative or salvage strategy in carefully selected patients when standard approaches are unavailable or unsuccessful. It is important to achieve safe surgical exposure, reliable venous control during catheterization and endovascular navigation, and a sound exit strategy to avoid complications.

Declarations

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Author Contribution

S.S. : Data curation; Formal analysis; Writing original draft; Writing - review and editing; Project administration
K.M. : Data curation, Screening
Y.J. : Data curation, screening, review and editing
B.T. : Data curation; Screening
L.A. : Data curation
V.S. : Data curation
A.P. : Data curation
C.I. : Review and editing
J.O. : Review and editing
C.B. : Review and editing
J.R. : Screening
P.O. : Methodology; Validation
C.S. : Methodology; Resources (search strategy and data acquisition support)
L.N. : Methodology, Validation
N.B. : Supervision; Validation
D.S. : Supervision; Validation
W.T. : Supervision; Validation
M.S. : Conceptualization; Methodology; Supervision; Writing review and editing; Guarantor of the work (overall responsibility for study integrity and final manuscript).

Data Availability

All data supporting the findings of this study are available within the paper and its Supplementary Information.

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Figures

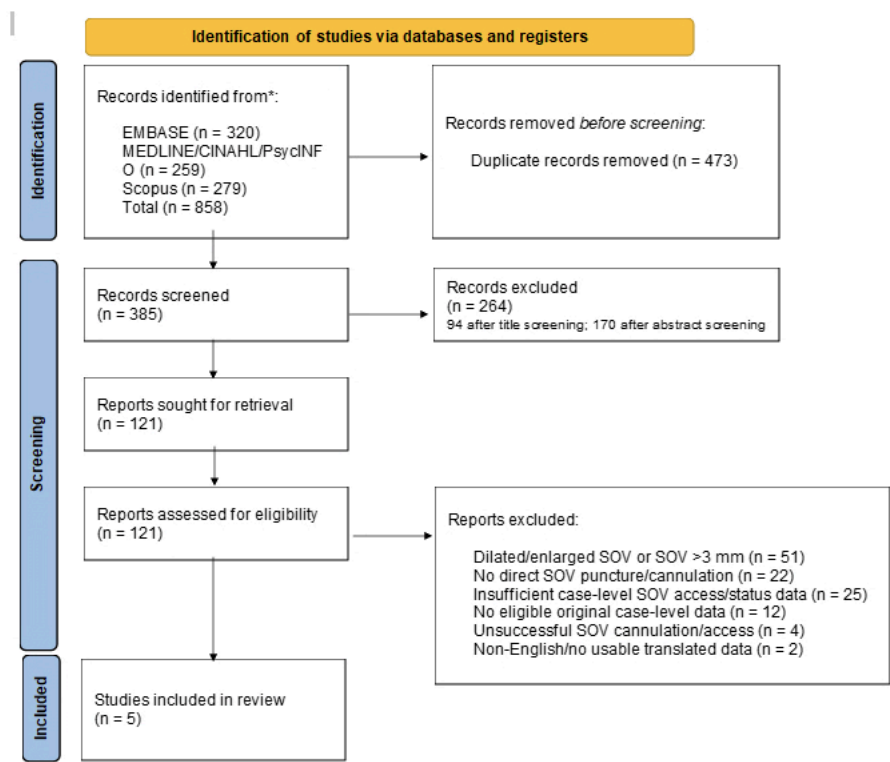


Figure 1
PRISMA flowchart summarizing the literature search, screening, eligibility assessment, and study inclusion process undertaken in the systematic review.

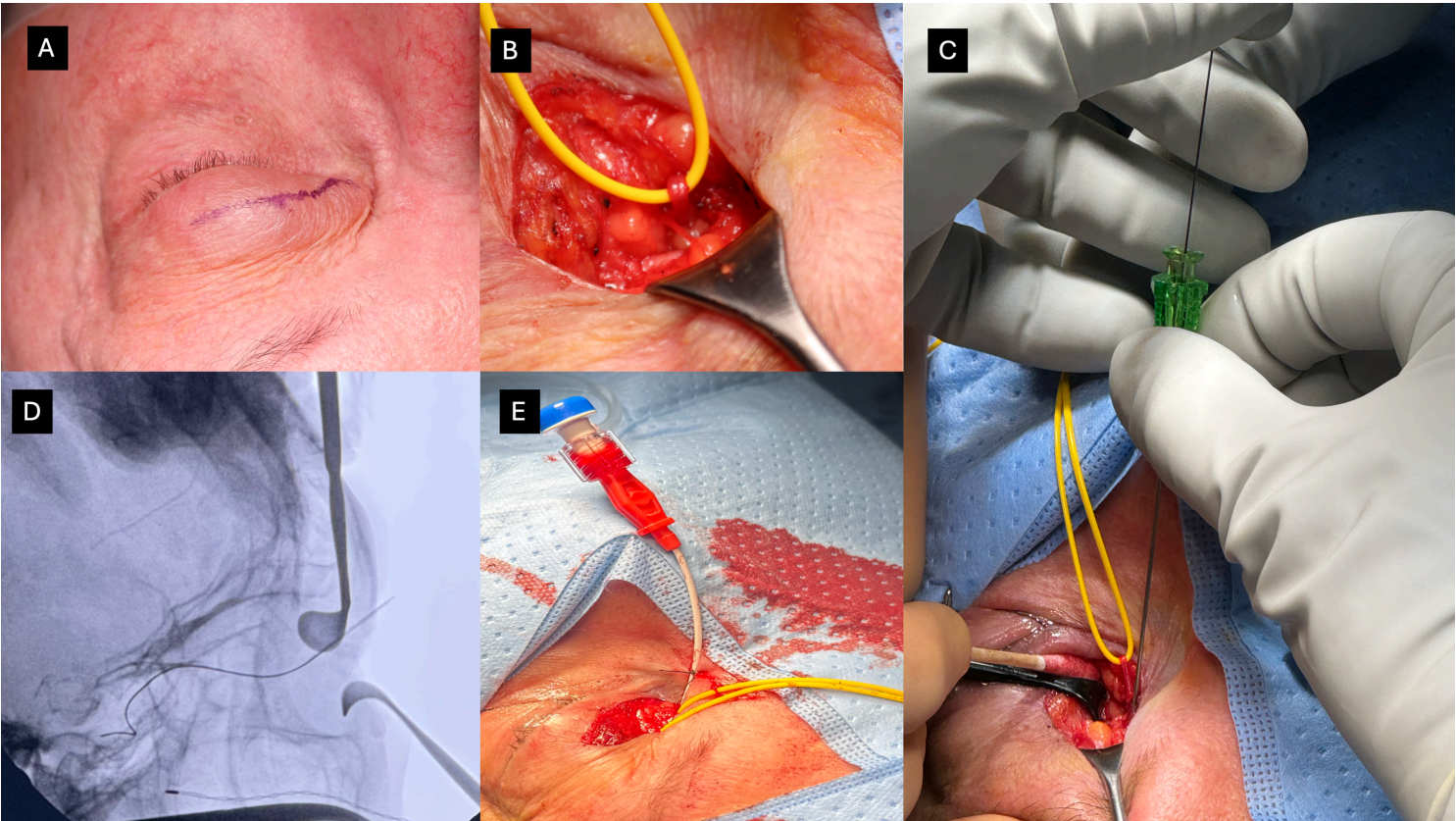


Figure 2

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Surgical exposure and cannulation of a non-dilated superior ophthalmic vein.

A: A horizontal upper-eyelid skin-crease incision was marked over the superior-medial aspect of the left orbit.

B: Intraoperative exposure of the non-dilated superior ophthalmic vein, with proximal and distal control obtained using a vessel loop.

C: Cannulation of the exposed superior ophthalmic vein using a 24-gauge needle, permitting advancement of the microcatheter system.

D: Intraoperative fluoroscopy confirming advancement of the microcatheter into the cavernous sinus through the superior ophthalmic vein access route.

E: The access sheath was advanced over the microcatheter and secured with a skin suture to prevent displacement during transfer from the operating room to the angiography suite.

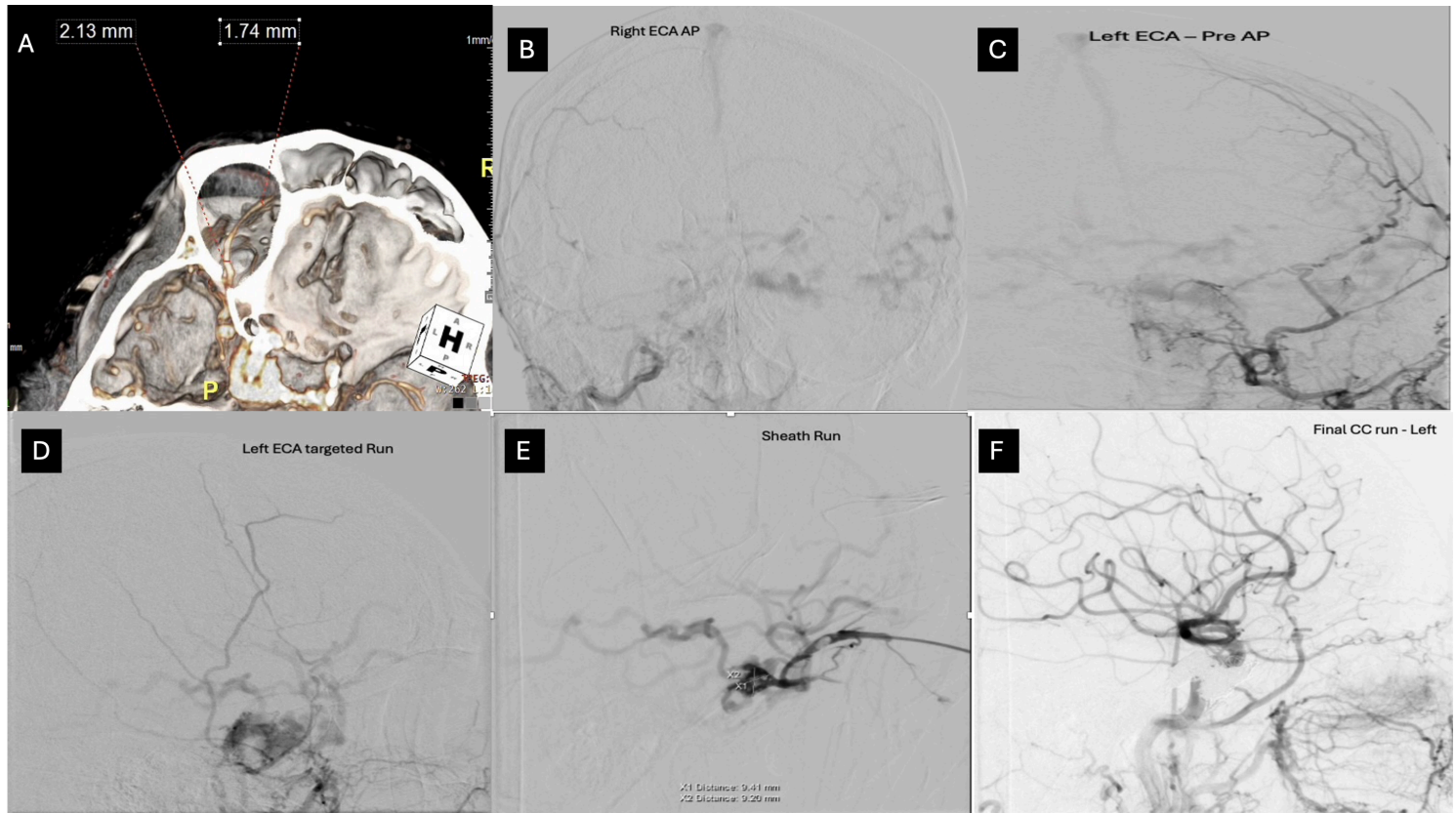


Figure 3

Preoperative venous anatomy, angiographic fistula characterization, and post-treatment result.

A: Preoperative computed tomography angiography demonstrating the caliber of the superior ophthalmic vein. The vein measured 1.74 mm anteriorly near its transition with the angular vein and 2.13 mm posteriorly toward the superior orbital fissure, confirming that the superior ophthalmic vein was not dilated.

B: Right external carotid artery angiogram, anteroposterior projection, demonstrating early cavernous sinus opacification with posterior cortical venous reflux and dilated corkscrew cortical veins.

C: Pretreatment left external carotid artery angiogram demonstrating arterial-phase cavernous sinus filling with cortical venous reflux through tortuous intracranial venous channels, consistent with a high-grade fistulous shunt.

D: Superselective left external carotid artery feeder injection demonstrating robust cavernous sinus filling with intracranial venous reflux.

E: Angiographic run performed through the superior ophthalmic vein sheath confirming access to the fistulous cavernous sinus compartment, with persistent shunting and cortical venous reflux.

F: Final left common carotid artery angiogram after embolization demonstrating dense coil packing of the cavernous sinus and superior ophthalmic vein, with complete obliteration of cortical venous reflux.

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