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# Longitudinal SS-OCT choroidal imaging following thrombosis of the superior ophthalmic vein

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ABSTRACT

*Purpose:* To report longitudinal changes in choroidal thickness and the choroidal vasculature using SS-OCT imaging in a patient with superior ophthalmic vein thrombosis (SOVT).

*Observations:* In a 93-year-old woman with a left-sided SOVT, the choroid in the left eye was thickened and the choroidal vessels were dilated both superiorly and inferiorly, with greater changes evident in the inferotemporal region of the choroid. After the superior ophthalmic vein was decompressed, a decrease in the choroidal thickness and choroidal vessel dilatation was observed both superiorly and inferiorly.

*Conclusions and importance:* In an eye with thrombosis of the superior ophthalmic vein, longitudinal SS-OCT choroidal imaging showed a greater increase in choroidal thickness and choroidal vessel dilation away from the obstructed quadrant, which improved after treatment. These observations associated with outflow obstruction may be applicable to other choroidal diseases characterized by venous overload.

## 1. Introduction

Superior ophthalmic vein thrombosis (SOVT) is a rare entity that can have devastating ophthalmic consequences and can be caused by infection, trauma, inflammation, neoplasm or orbital crowding.[1] The superior ophthalmic vein (SOV) originates from the orbit, specifically from the union of the angular and supraorbital veins, and drains multiple venous systems including the central retinal vein and vortex veins from the choroid, but the central retinal vein may also drain directly into the cavernous sinus.[2] The SOV passes through the superior orbital fissure and terminates in the cavernous sinus. The involvement of the choroid is of particular interest because the vortex veins drain into the SOV. Choroidal outflow obstruction should result in choroidal venous dilation that can be visualized using indocyanine green angiography,[3] but only swept-source optical coherence tomography (SS-OCT) imaging can show both the dilated choroidal vessels and the abnormally thickened choroid.[4,5]

Choroidal features such as mean choroidal thickness (MCT) and choroidal vascular index (CVI) can be analyzed noninvasively using SS-OCT imaging.[4] In this report, choroidal changes in a case of SOVT are shown using SS-OCT (PLEX® Elite 9000, Carl Zeiss Meditec, Dublin, CA) before and after surgery to alleviate the obstruction. The observed changes should be useful for understanding the pathophysiological alterations of choroidal veins observed in diseases such as idiopathic central serous chorioretinopathy (CSC) and other venous overload conditions.[6,7] The images were obtained as part of a prospective SS-OCT imaging study approved by the University of Miami institutional review board, and the research adhered to the tenets of the Declaration of Helsinki with participants signing an informed consent.

## 2. Case report

A 93-year-old woman presented with a 2-week history of left periorbital edema with restricted eye movements. Her past medical history included hypertension and hyperlipidemia. She had a history of amblyopia of the left eye. Visual acuity was 20/25 in the right eye and 20/70 in the left eye. Intraocular pressure was 13 mmHg in the right eye and 14 mmHg in the left eye. Ocular examination revealed left periorbital swelling with proptosis. Pupils were equal and reactive without an afferent pupillary defect. Conjunctival chemosis with dilated

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episcleral vessels was noted. The cornea was clear, and the anterior chamber and retinal evaluations were unremarkable with a normal appearing optic nerve. Ocular motility was severely restricted in all directions. No signs of endophthalmitis were apparent. Laboratory findings for systemic disorders potentially causing this presentation were unremarkable. Computed tomography angiography with contrast detected a markedly engorged and nonspecified left SOV compatible with acute thrombosis of the left SOV. However, partial cavernous sinus thrombosis and the possibility of a superimposed orbital cellulitis could not be excluded. Intravenous antibiotics were started at that time. Endoscopic sinus surgery was performed two days later to decompress the left orbit and drain the sinuses. Bacterial cultures at the time of drainage were negative. One month later, ocular motility was normal, the other ocular signs and symptoms at presentation also resolved, and visual acuity remained at 20/70 in the left eye.

SS-OCT 12 × 12 mm angiographic scans were performed on both eyes before surgery, 1 month after, and 9 months after surgery in the left eye. Choroidal thickness maps, choroidal vasculature maps, and CVI measurements were obtained by using a semi-automated algorithm[4,8] and are shown in the Fig. 1. In the left eye with SOV thrombosis, the choroid was thickened, and the choroidal vessels were dilated both superiorly and inferiorly before surgery, more prominently in the inferotemporal region of the choroid. After the superior ophthalmic vein was decompressed, a decrease in the choroidal thickness and choroidal vessel dilatation was observed both superiorly and inferiorly, and these changes persisted at the last follow up visit that was 9 months after surgery. Of note, there was a more significant decrease of 40.0 μm in choroidal thickness in the inferotemporal region one month after surgery, compared to a decrease of 29.9 μm in the superotemporal region. The CVI measurements had a more significant decrease of 0.06 in the inferotemporal region one month after surgery, compared to a decrease of 0.03 in the superotemporal region (Table 1). Fig. 2 shows a diagram of quadrants used to assess the regional choroidal thickness and CVI measurements.

## 3. Discussion

Since the SOV drains the choroid primarily through the superior vortex veins into the cavernous sinus and the inferior ophthalmic vein primarily drains the choroid through the inferior vortex veins into the cavernous sinus, we had expected that the occlusion of the SOV would redirect blood flow from the superior venous drainage area through collateral vessels to the inferior choroidal vessels.[2,3,9] This would result in greater blood flow through the inferior vortex vein with choroidal thickening due to an increase in the choroidal vascular volume in these regions since choroidal thickness is known to correlate directly with the choroidal vascular volume.[8] This explains why there is an increase in both the superior and inferior choroidal thickness, but it is noteworthy that a greater thickness is appreciated towards the inferotemporal vortex vein, although the 12 × 12 mm scan does not image the vortex veins directly.

In this report, longitudinal 12 × 12 mm SS-OCTA scans in a case with SOVT show that the thickened choroid and the dilated choroidal venous vasculature decreased after the obstruction was alleviated. The greatest increase in the choroidal thickness and choroidal vascularity arises from the drainage area of the inferior vortex vein even though the obstruction primarily affected drainage in the superior ophthalmic vein. We explain this observation based on the likely divergence of blood flow away from the obstructed superior drainage field resulting in greater blood flow towards the unobstructed drainage field of the inferior vortex vein. This hemodynamic explanation on the changes in choroidal parameters when obstructions arise should help our understanding of where to localize an outflow obstruction in other diseases characterized by a thickened choroid and dilated choroidal vessels. Thus, rather than assuming the obstruction is located in the quadrant where these increased choroidal features are found, this case suggests that the most conspicuous

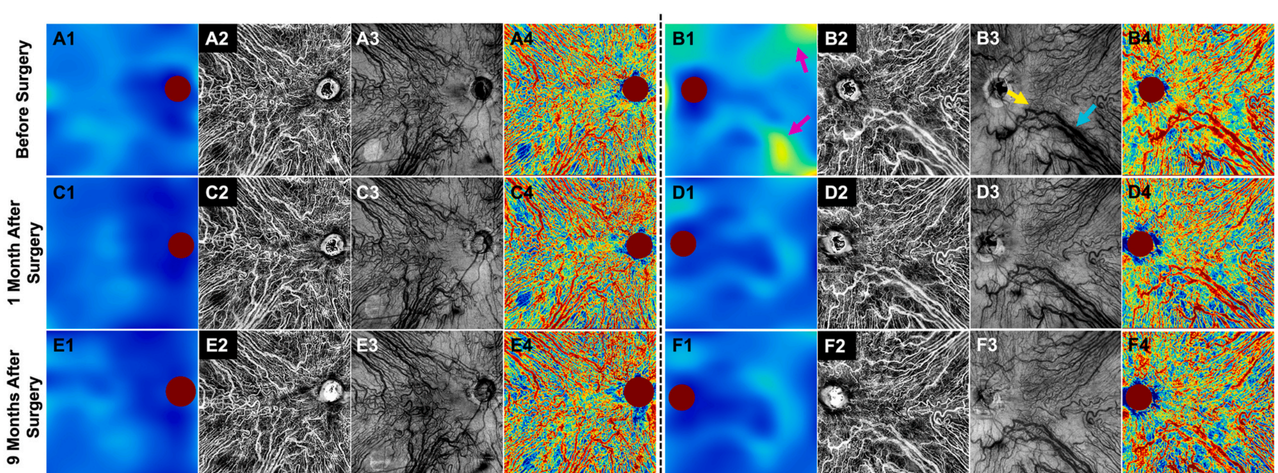


**Fig. 1. CAPTION**:
Mean choroidal thickness (MCT) maps, and choroidal vasculature maps from both eyes before and after the surgery in a patient with thrombosis of the left superior ophthalmic vein. (**A1, B1**) MCT maps of both eyes derived from the algorithm before surgery, (**C1, D1**) 1 month after surgery, and (**E1, F1**) 9 months after surgery. (**A2, B2**) Choroidal vascular maps of both eyes derived from the algorithm before surgery, (**C2, D2**) 1 month after surgery, and (**E2, F2**) 9 months after surgery. (**A3, B3**) *En face* structural maps of both eyes generated from the instrument by using a 50 μm thick slab with segmentation boundaries positioned 60–110 μm below Bruch's membrane before surgery, (**C3, D3**) 1 month after surgery, and (**E3, F3**) 9 months after surgery. (**A4, B4**) Choroidal vascularity index (CVI) maps of both eyes derived from the algorithm before surgery, (**C4, D4**) 1 month after surgery, and (**E4, F4**) 9 months after surgery. **A, C, E** are from the right eye. **B, D, F** are from the left eye. (Pink arrows in **B1**) The choroidal thickness map of the left eye before surgery shows thickening of both the superior and inferior portion of the choroid with dilated choroidal vessels (**B2–B4**), but there was greater thickening and dilation in the inferotemporal region of the choroid (teal arrow in **B3**). The yellow arrow denotes collateral vessels connecting the superior and inferior choroidal veins in the horizontal watershed zone. (**D1-D4**) One month after surgery when orbit was decompressed and the thrombosis was alleviated, decreases in choroidal thickness and choroidal vessel dilation were observed both superiorly and inferiorly. (**F1–F4**) These changes persisted 9 months after the surgery. The right eye showed no significant abnormalities in the choroidal thickness or choroidal vasculature maps (**A1-A4**) at baseline, (**C1–C4**) at 1 month after surgery, and (**E1-E4**) 9 months after surgery. Scale bar of the MCT maps: 0–500 μm. Scale bar of the CVI maps: 0–1. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

**Table 1**
Regional choroidal thickness and CVI measurements in both eyes before surgery, 1 month after, and 9 months after surgery.

| | OS | | | | OD | | | |
|---|---|---|---|---|---|---|---|---|
| | Choroidal Thickness (μm) | | Choroidal vascularity index | | Choroidal Thickness (μm) | | Choroidal vascularity index | |
| | OST | OIT | OST | OIT | OST | OIT | OST | OIT |
| Before Surgery (V1) | 176.4 | **179.7** | 0.60 | **0.63** | 145.3 | 154.6 | 0.57 | 0.57 |
| 1 Month After Surgery (V2) | 146.5 | **139.7** | 0.57 | **0.57** | 118.6 | 133.4 | 0.57 | 0.59 |
| 9 Months After Surgery (V3) | 151.0 | **144.1** | 0.57 | **0.59** | 124.3 | 138.5 | 0.58 | 0.58 |
| V2–V1 | −29.9 | **−40.0** | −0.03 | **−0.06** | −26.7 | −21.2 | 0.00 | 0.02 |
| V3–V1 | −25.4 | −35.6 | −0.03 | −0.04 | −21.0 | −16.1 | 0.01 | 0.01 |
| V3–V2 | 4.5 | 4.4 | 0.00 | 0.02 | 5.7 | 5.1 | 0.01 | −0.01 |

OST = Outer superotemporal, OIT = Outer inferotemporal.

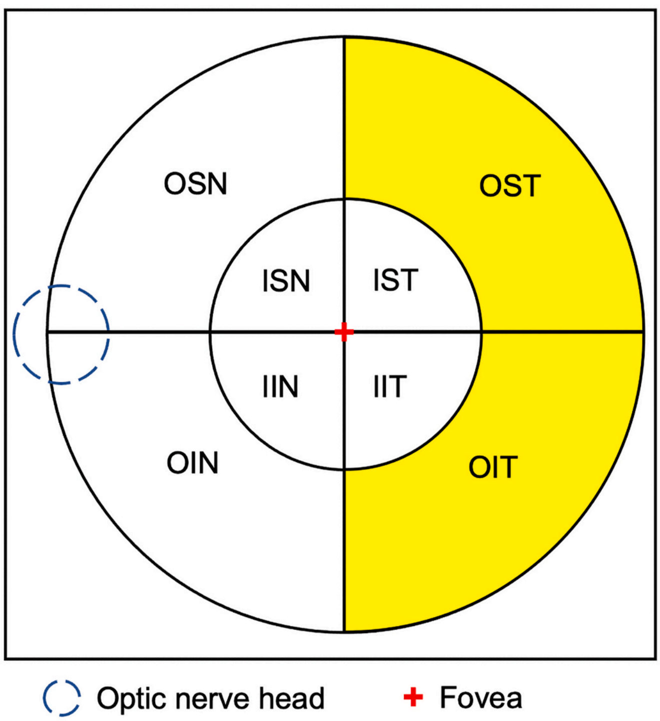


**Fig. 2. CAPTION**:
Grid used to assess regional choroidal thickness and choroidal vascularity index (CVI) measurements. The square represents a 12 × 12 mm SS-OCTA scan. The grid in this study consisted of 5-mm, and 11-mm circles centered on the fovea, with the region in the 5-mm and 11-mm circles being divided into different quadrants (ISN=Inner superonasal, OSN=Outer superonasal, IST=Inner superotemporal, OST=Outer superotemporal, IIT=Inner inferotemporal, OIT=Outer inferotemporal, IIN=Inner inferonasal, OIN=Outer inferonasal). The yellow OST and OIT regions were of interest. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

choroidal changes arise in the region away from an obstruction due to increased collateral choroidal blood flow into this region.

## 4. Conclusions

Longitudinal SS-OCT imaging of choroidal thickness and choroidal vasculature in an eye with thrombosis of the superior ophthalmic vein shows a greater increase in choroidal thickness and choroidal vessel dilation away from the obstructed quadrant compared with the unobstructed region. These changes in the choroid improved after treatment. This observation may be applicable to other choroidal diseases with outflow obstruction and venous overload.

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## Authorship

All authors attest that they meet the current ICMJE criteria for Authorship.

## Patient consent

Consent to publish this case report has been obtained from the patient(s) in writing.

## CRediT authorship contribution statement

**Mengxi Shen:** Writing – original draft, Resources, Methodology, Investigation, Conceptualization. **Prashanth G. Iyer:** Writing – original draft, Resources, Methodology, Investigation, Conceptualization. **Hao Zhou:** Writing – review & editing, Software, Formal analysis. **Yuxuan Cheng:** Writing – review & editing, Software, Formal analysis. **Jeremy Liu:** Writing – review & editing, Resources. **Omer Trivizki:** Writing – review & editing, Resources. **Ruikang K. Wang:** Writing – review & editing, Supervision, Software, Methodology. **Giovanni Gregori:** Writing – review & editing, Supervision, Project administration, Methodology. **Philip J. Rosenfeld:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization.

## Declaration of competing interest

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