

From Chaos to Clarity: Optical Coherence Tomography-Guided Thromboaspiration in a Complex In-Stent Restenosis Chronic Total Occlusion – The “Tidy the Tunnel” Approach

SAI DEVVRAT*, TANUJ BHATIA*, ABHISHEK RASTOGI*, MOHD KAZIM*, DEVENDRA SINGH BISHT†

ABSTRACT

This case report details the management of a 54-year-old male with refractory angina due to in-stent restenosis (ISR) within a chronic total occlusion (CTO) of the right coronary artery (RCA). Despite multiple prior percutaneous coronary interventions (PCIs) and maximal medical therapy, symptoms persisted. Optical coherence tomography (OCT)-guided PCI, augmented by the Penumbra CAT RX mechanical thromboaspiration system, revealed heterogeneous neoatherosclerosis and organized thrombus (Wataru-Yamamoto Type 4 ISR). The sustained negative suction of the Penumbra device (–29 mmHg), excellent trackability, and maneuverability enabled the effective debulking of late thrombus, restoring distal flow and OCT clarity. This facilitated tailored therapy: a drug-eluting stent for fibroatheroma, a drug-eluting balloon for neointimal hyperplasia, and high-pressure post-dilation for underexpansion. The case challenges the assumption of the absence of thrombus in CTOs. It underscores the value of the “P-OCT” protocol (Prepare with thromboaspiration, Optimize imaging, Characterize pathology, Treat mechanistically) in ISR-CTO.

Keywords: Penumbra CAT RX, in-stent restenosis, chronic total occlusion, optical coherence tomography, percutaneous coronary intervention

In-stent restenosis (ISR) and chronic total occlusions (CTOs) represent complex challenges in interventional cardiology. ISR, often driven by neointimal hyperplasia (NIH) or neoatherosclerosis, is compounded in CTOs by fibrocalcific remodeling and organized thrombus. Traditional angiographic guidance often fails to accurately delineate the underlying plaque morphology, resulting in suboptimal stent deployment and a higher incidence of recurrent events.

Optical coherence tomography (OCT), with its high-resolution cross-sectional imaging, has emerged as a critical tool for characterizing ISR-CTO pathology. However, thrombus remains a persistent barrier to

optimal visualization. The Penumbra CAT RX system¹, a mechanical thromboaspiration device, is traditionally reserved for acute thrombotic lesions.

This case illustrates its innovative application in a troponin-negative ISR-CTO, integrated with OCT-guided stratification using the Wataru-Yamamoto classification², to achieve a patient-specific therapeutic approach.

CASE REPORT

A 54-year-old male with a history of hypertension and multivessel coronary artery disease underwent multiple percutaneous coronary interventions (PCIs) on the following dates: right coronary artery (RCA) in 2012 and 2019, left anterior descending artery and diagonal bifurcation in 2019, and left circumflex artery in 2019. Despite receiving maximum antianginal therapy—including isosorbide mononitrate and metoprolol, he experienced 6 months of refractory angina, classified as Canadian Cardiovascular Society Class III.

Diagnostic evaluations revealed T-wave inversions in lead I, aVL, and V5-V6 on the electrocardiogram, indicating

*Dept. of Cardiology, Shri Guru Ram Rai Institute of Medical & Health Science, Dehradun, Uttarakhand

†Dept. of Cardiology, Ojas Hospital, Panchkula, Haryana, India

Address for correspondence

Dr Devendra Singh Bisht

Dept. of Cardiology, Ojas Hospital, Panchkula, Haryana, India

E-mail: bisht2416@gmail.com

lateral ischemia. A transthoracic echocardiogram showed severe left ventricular dysfunction, with an ejection fraction of 35%, global hypokinesia, prominent anterior wall involvement, and Grade I diastolic dysfunction. High-sensitivity troponin I levels were nondiagnostic at 0.01 ng/mL.

Coronary angiography revealed a CTO in the RCA, with retrograde collaterals from the left coronary system. This was classified with a Japanese CTO (J-CTO)³ score of 3 because of factors such as calcification, a blunt stump, and a bending angle exceeding 45 degrees (Fig. 1).

The procedural strategy employed a retrograde approach using a Fielder XT-A wire and Finecross microcatheter, achieving true lumen re-entry after initial subintimal tracking. Predilation with a 2.0 mm semi-compliant balloon failed to restore distal flow (TIMI-1), prompting suspicion of neoatherosclerotic debris or thrombus.

The 5.3 Fr catheter's sustained negative suction (−29 mmHg) and exceptional trackability enabled seamless navigation through the previously stented RCA, aspirating dense, organized thrombus despite the lesion's chronicity. Its maneuverability proved critical in traversing calcified segments, achieving TIMI-2 flow post-aspiration. Subsequent OCT imaging (Ultrason 2.0) revealed layered, heterogeneous tissue in the proximal RCA (Wataru-Yamamoto Type 4 ISR) with invisible struts and neointimal rupture, indicative of organized

thrombus. Distally, fibroatheroma with minimal calcification (Gonzalo's classification: heterogeneous, non-calcified) was identified. Tailored therapy included deployment of a 3.0 × 28 mm drug-eluting stent (DES) at the fibroatheroma site, application of a 4.0 × 35 mm drug-eluting balloon (DEB) to the NIH-dominant segment, and high-pressure post-dilation with a 4.5 mm noncompliant balloon.

The final OCT confirmed TIMI-3 flow and a significant increase in the minimum lumen area from 2.79 to 7.81 mm² (Fig. 2).

DISCUSSION

This case challenges the traditional dogma that CTOs lack thrombotic components. Histopathological studies have demonstrated that ISR-CTOs frequently harbor organized thrombus beneath layered plaques, driven by chronic endothelial injury and inflammation. The “Tidy the Tunnel” philosophy—preparing the lesion with thromboaspiration before OCT—proved pivotal. Thrombus, often dismissed in CTOs, obscured critical details of neointimal rupture and layered plaque.

Penumbra's aspiration “cleared the path”, enabling OCT to classify the ISR as Wataru-Yamamoto Type 4 (heterogeneous tissue, invisible struts) and Gonzalo's heterogeneous noncalcified plaque, which guided the selection

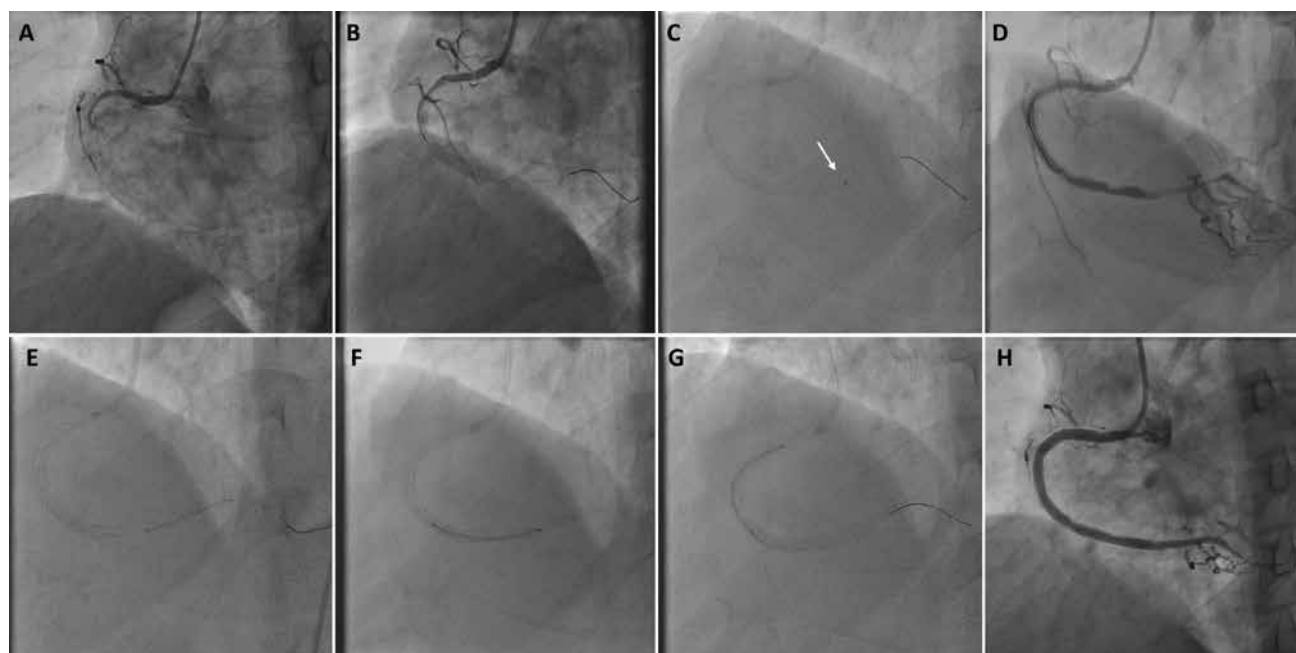


Figure 1. Angiographic images (A to H) illustrate the procedure as follows: (A) Baseline RCA showing 100% in-stent restenosis, (B) no-reflow phenomenon following balloon dilation, (C) Penumbra-guided thromboaspiration, (D) improved distal flow, (E & F) drug-eluting stents placement in the distal and mid segments, (G) drug-eluting balloon treatment in the proximal segment based on optical coherence tomography findings, and (H) the final angiographic outcome of the RCA.

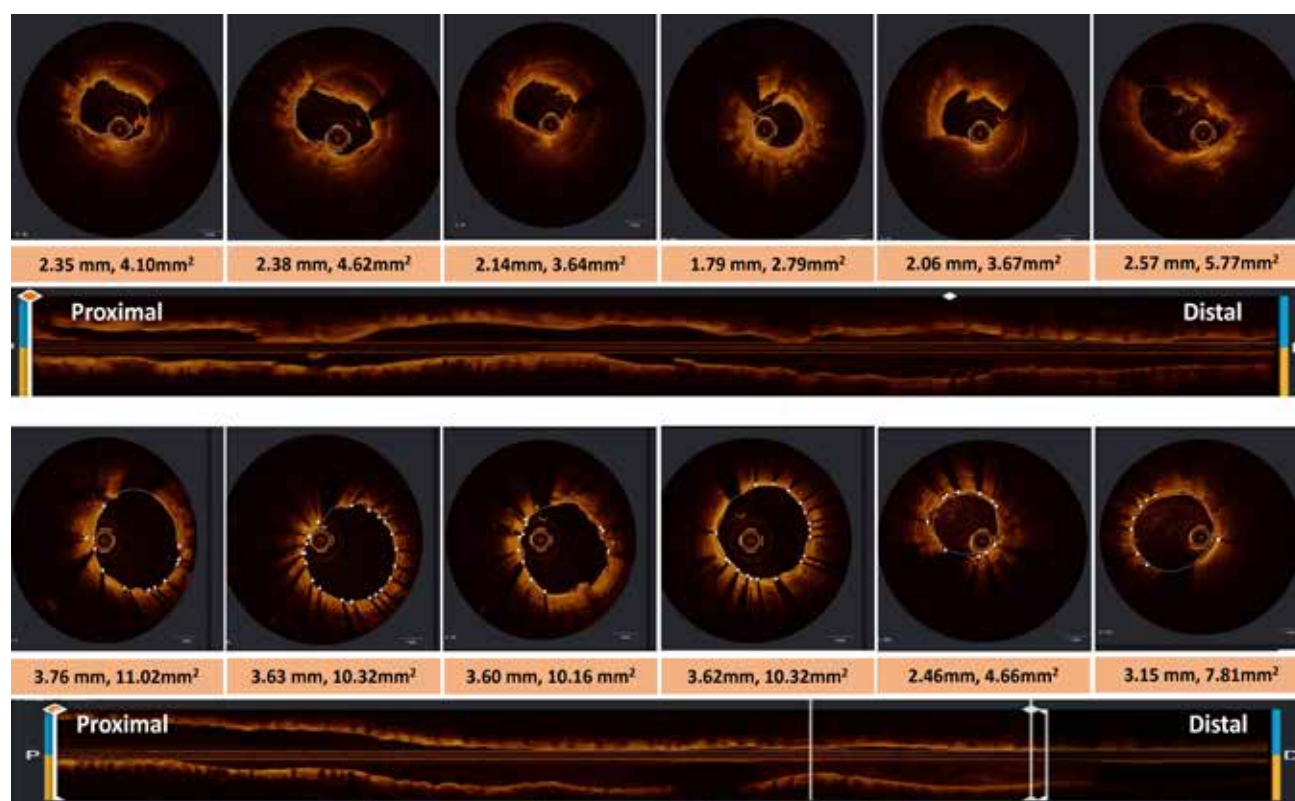


Figure 2. OCT images acquired after Penumbra-guided thromboaspiration (*upper panel*) and final OCT images following stent placement (*lower panel*).

of DES/DEB. The Wataru-Yamamoto classification, which integrates OCT findings, provides granular insights into ISR morphology. In this case, Type 4 ISR (heterogeneous tissue with invisible struts)⁴ correlated with prolonged stent duration and thrombotic remnants, necessitating a multifaceted approach to treatment.

The Penumbra system's mechanical thromboaspiration uniquely addresses both soft atheroma and organized thrombus, debulking lesions resistant to conventional predilation. This contrasts with rheolytic or ultrasound-based devices, which risk distal embolization in calcified CTOs. Prior studies, such as the TROFI trial⁵, have linked residual thrombus to higher rates of major adverse cardiovascular events (MACE), justifying its use even in non-acute settings.

OCT-guided stratification further allowed differentiation of fibroatheroma (targeted with DES) from NIH (treated with DEB), aligning with the “P-OCT” protocol (Prepare with thromboaspiration, Optimize imaging, Characterize pathology, Treat mechanistically). This approach aligns with recent guidelines recommending OCT for stent optimization in complex lesions.

The Wataru-Yamamoto classification² revealed neointimal rupture, a feature exclusive to Type 4 ISR—prompting

DES deployment. Conversely, NIH-dominated regions received DEB, avoiding unnecessary stenting. This precision, unattainable angiographically, underscores the role of OCT in personalizing ISR therapy.

CONCLUSION

This case redefines ISR-CTO management by integrating advanced thromboaspiration and OCT stratification. The Penumbra CAT RX's mechanical efficacy in chronic thrombus debulking, coupled with the Wataru-Yamamoto classification, enables a shift from blind stenting to pathology-driven therapy. The “Tidy the Tunnel” approach—preparing the lesion before imaging or intervention—should be prioritized in complex ISR cases to mitigate under sizing, residual thrombus, and MACE.

REFERENCES

1. Gilchrist IC Jr, Fordham MJ, Pyo R, Reilly JP, Chen O. Mechanical aspiration thrombectomy using the Penumbra CAT RX system for patients presenting with acute coronary syndrome. *Cardiovasc Revasc Med*. 2022;40S:316-21.
2. Yamamoto W, Fujii K, Otsuji S, Takiuchi S, Kakishita M, Ibuki M, et al. Optical coherence tomography charac-

- teristics of in-stent restenosis after drug-eluting stent implantation: a novel classification and its clinical significance. *Heart Vessels*. 2020;35(1):38-45.
3. Morino Y, Abe M, Morimoto T, Kimura T, Hayashi Y, Muramatsu T, et al; J-CTO Registry Investigators. Predicting successful guidewire crossing through chronic total occlusion of native coronary lesions within 30 minutes: the J-CTO (Multicenter CTO Registry in Japan) score as a difficulty grading and time assessment tool. *JACC Cardiovasc Interv*. 2011;4(2):213-21.
 4. Mehran R, Dangas G, Abizaid AS, Mintz GS, Lansky AJ, Satler LF, et al. Angiographic patterns of in-stent restenosis: classification and implications for long-term outcome. *Circulation*. 1999;100(18):1872-8.
 5. Onuma Y, Thuesen L, van Geuns RJ, van der Ent M, Desch S, Fajadet J, et al; TROFI Investigators. Randomized study to assess the effect of thrombus aspiration on flow area in patients with ST-elevation myocardial infarction: an optical frequency domain imaging study--TROFI trial. *Eur Heart J*. 2013;34(14):1050-60.

■ ■ ■ ■