

MINI-FOCUS ISSUE: INTERVENTIONS

INTERMEDIATE

CASE REPORT: CLINICAL CASE

Orbital-Tripsy: Novel Combination of Orbital-Atherectomy and Intravascular-Lithotripsy, in Calcified Coronaries After Failed Intravascular-Lithotripsy



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ABSTRACT

Calcified coronary lesions are notorious for posing technical difficulty during angioplasty. Fortunately, more devices are available to tackle coronary calcifications. However, there remain difficult cases whereby a single modality is insufficient. Here we report the feasibility and success of a case, using Novo combination of Shockwave Lithotripsy after Orbital Atherectomy. (**Level of Difficulty: Intermediate.**) (J Am Coll Cardiol Case Rep 2020;2:2437-44) © 2020 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Heavily calcified coronary lesions are notorious for posing both technical difficulty during angioplasty, and suboptimal stent expansion, which translates to adverse outcome of stent restenosis and thrombosis (1,2). Historically, calcium modification was achieved by high-pressure dilatation or cutting/scoring balloon, which neither

debulk the calcium load, nor were they very effective. More recently, there are a number of devices available for calcium debulking or modification purpose. Three of which that are more popular worldwide include rotational atherectomy (RA) (RotaPro; Boston Scientific, Natick, Massachusetts), intravascular lithotripsy (IVL) (Shockwave Medical Inc., Santa Clara, California), and orbital atherectomy (OA) (Diamondback; CSI, Minneapolis, Minnesota). Each device has its own strengths and weaknesses (3).

RA serves better for tackling of very long, stenotic calcified lesions with relatively small vessel size, but may need multiple upside of burr to achieve large luminal gain, and larger burr may not be available in some countries. OA works well for long stenotic lesions with relatively large vessel size for larger luminal area gain, but it cannot be used in grossly dissected lesions. If marked dissection was noted at or adjacent to target lesion during OA, it should be stopped to avoid severe vessel damage or perforation. IVL works best for short stenotic segments with concentric

LEARNING OBJECTIVES

- To understand the application of intracoronary optical coherence tomography for evaluation of severity of calcification.
- To recognize the limitation of intravascular lithotripsy in very thick calcified coronary lesions.
- To demonstrate of the feasibility and successful combination of orbital atherectomy followed by intravascular lithotripsy.

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The author attests they are in compliance with human studies committees and animal welfare regulations of the author's institution and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the [Author Center](#).

Manuscript received July 29, 2020; revised manuscript received October 14, 2020, accepted October 15, 2020.

ABBREVIATIONS AND ACRONYMS

CABG = coronary artery bypass grafting

IVL = intravascular lithotripsy

LM = left main

MLA = minimal luminal area

OA = orbital atherectomy

OCT = optical coherence tomography

PCI = percutaneous coronary intervention

RA = rotational atherectomy

RCA = right coronary artery

TVD = triple vessel disease

calcification, it is simple to set up and deliver. IVL also has no slow-no-reflow phenomenon; however, its bulky balloon size renders it difficult to be delivered across a stenotic lesion, and multiple balloons will be needed to treat long diffuse lesions (4). To complicate the issue, there remain difficult cases whereby a single modality is insufficient. Hence, there is no single perfect solution for all cases.

Here we report the feasibility and success of a case, using a novel combination of OA followed by IVL, after failure of IVL to open up a highly calcified lesion.

HISTORY OF PRESENTATION

An 81-year-old man presented with chest pain and was admitted to our hospital. He was diagnosed to have non-ST-segment elevation myocardial infarction. His blood pressure was stable and was not in acute heart failure.

PAST MEDICAL HISTORY

The patient had a past medical history of atrial fibrillation, hypertension, diabetes mellitus, category C chronic obstructive pulmonary disease, hepatitis B cirrhosis, and moderate-severe aortic stenosis.

DIFFERENTIAL DIAGNOSIS

Non-ST-segment elevation myocardial infarction.

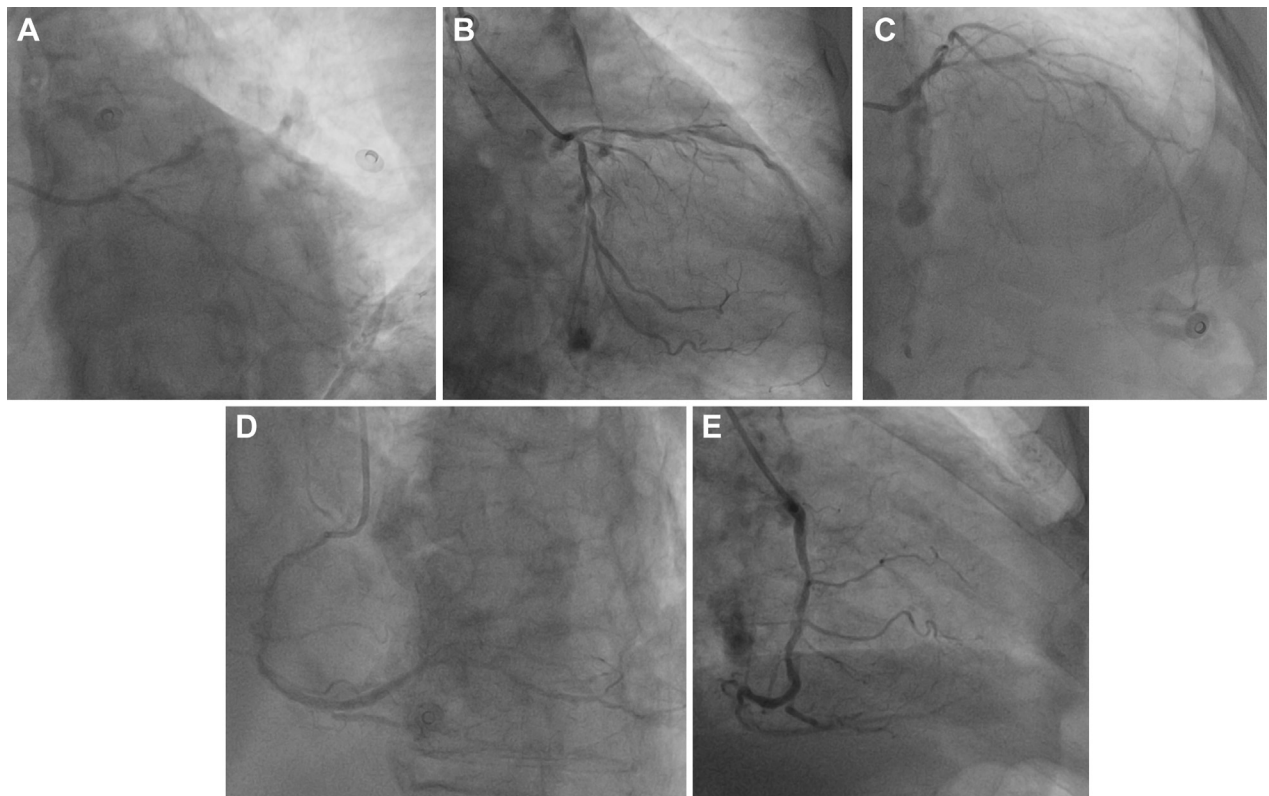
INVESTIGATIONS

Electrocardiogram, chest x-ray, high sensitivity troponin I.

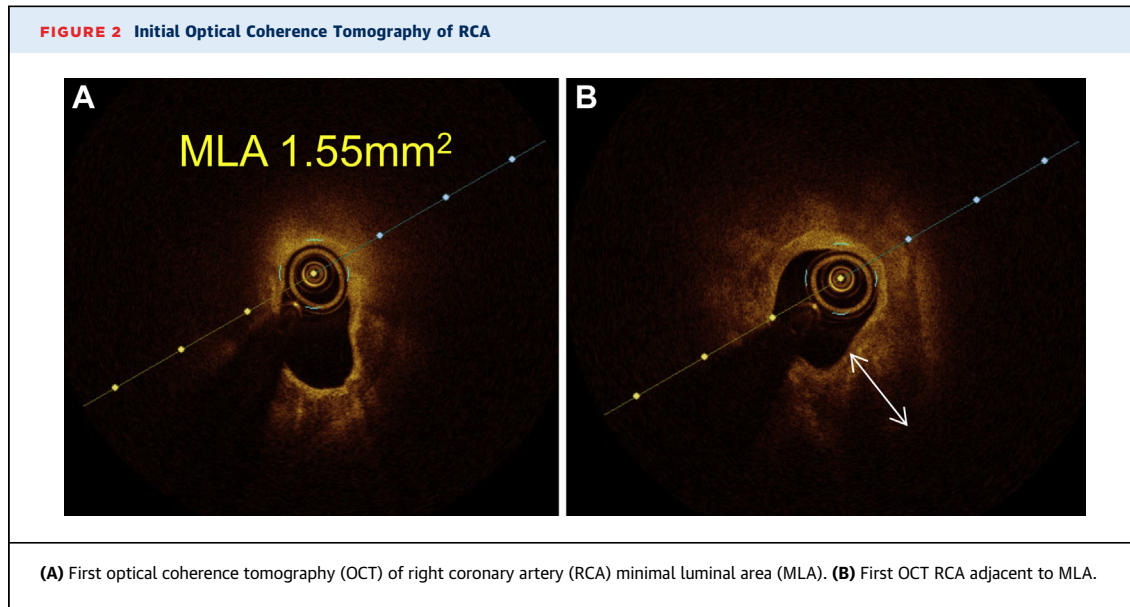
MANAGEMENT

Coronary angiogram was performed, showing heavily calcified left main (LM), triple vessel disease (TVD) (Figures 1A to 1E).

FIGURE 1 Coronary Angiogram of the Patient



(A) Left anterior oblique caudal of left coronary artery. (B) Right anterior oblique caudal of left coronary artery. (C) Right anterior oblique cranial of left coronary artery. (D) Left anterior oblique of right coronary artery. (E) Right anterior oblique of right coronary artery.



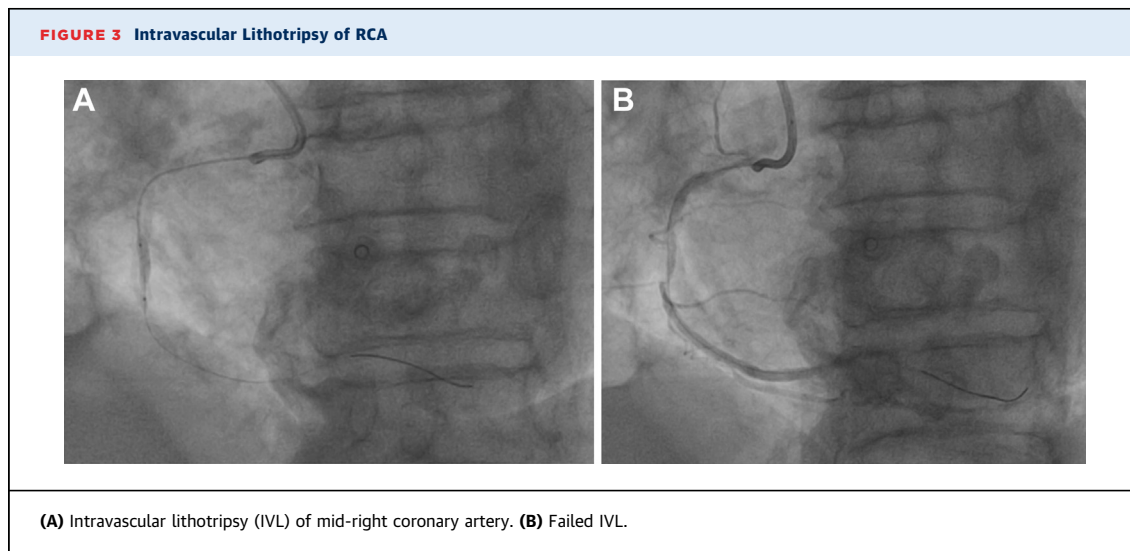
He was stratified as a high surgical risk candidate for coronary artery bypass grafting (CABG) because of multiple comorbidities, including category C chronic obstructive pulmonary disease and porcelain aorta. The patient opted for high-risk percutaneous coronary intervention (PCI) rather than CABG after discussion. The right coronary artery (RCA) was attempted first, and for staged-PCI to the left coronaries later.

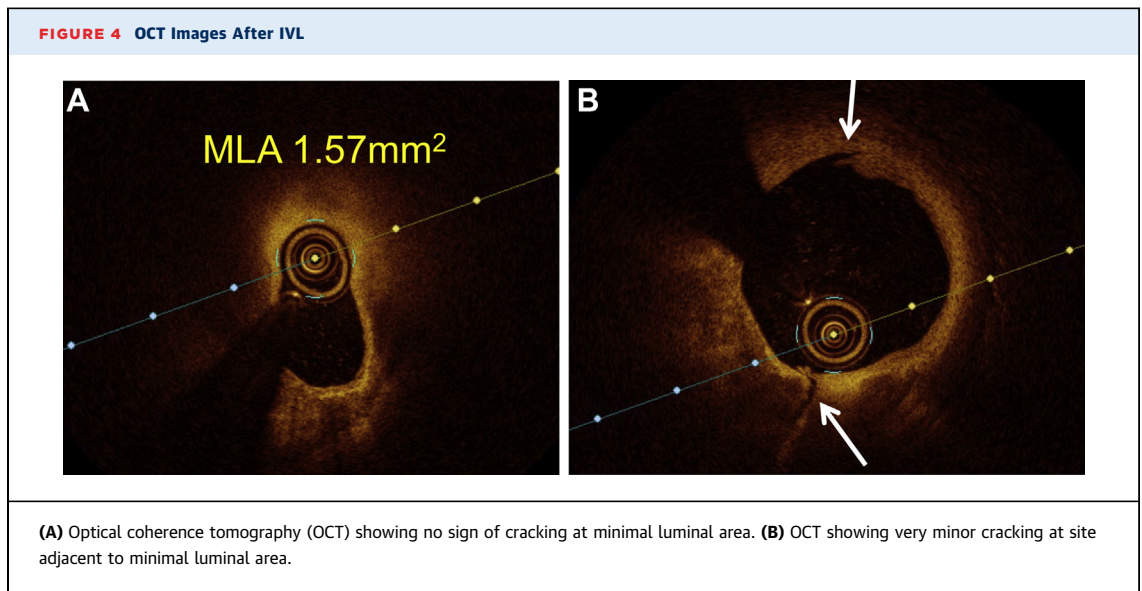
Optical coherence tomography (OCT) was performed to the RCA. At the minimal luminal area (MLA), there was circumferential thick calcification, with area of 1.55 mm² (Figure 2A, Video 1). The thickness of calcium could not accurately be measured

because of shadowing. However, adjacent to the MLA (Figure 2B), the calcium thickness was >1 mm.

Because of the large vessel size with long diffuse calcified lesions, OA was a better option to achieve larger luminal gain. Owing to the heavy calcium and plaque load, the chance of no reflow was anticipated to be high during OA. In view of underlying significant LM+TVD and moderate-severe aortic stenosis, transient no reflow may lead to catastrophic downward spiral, resulting in profound shock. Hence, IVL was performed with 3.0 × 12-mm and 3.5 × 12-mm balloons instead.

An IVL balloon was successfully delivered to the lesion; however, it failed to open up the heavily



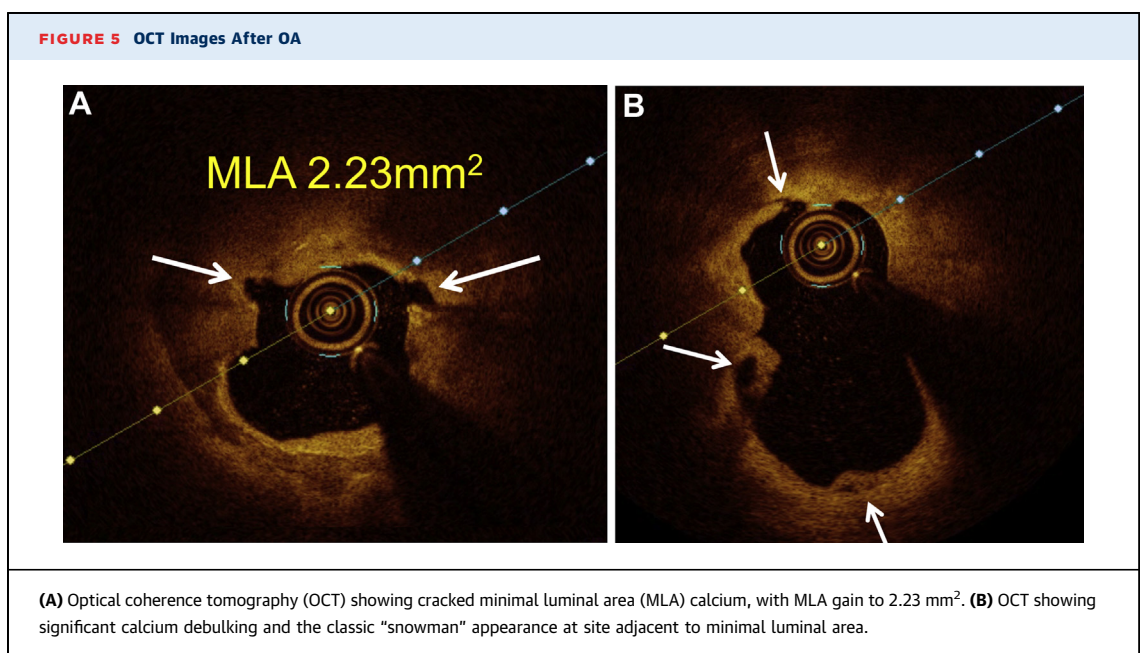


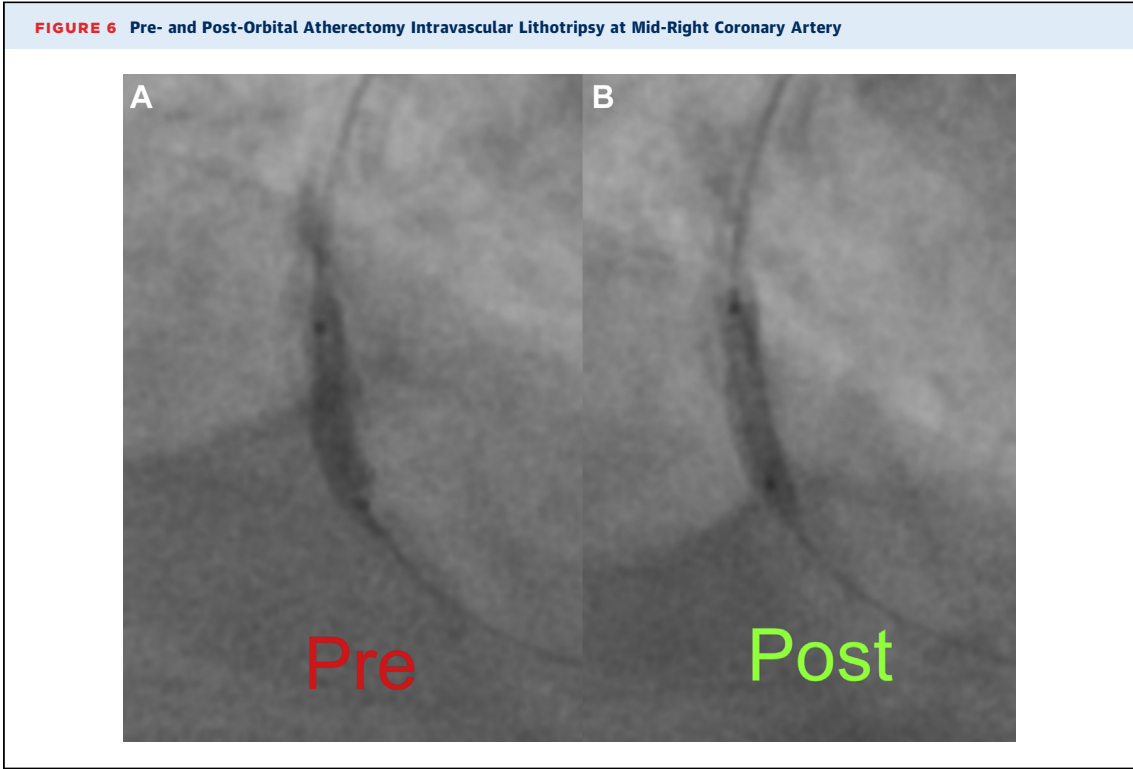
calcified mid-RCA lesion even after 8 cycles of IVL (Figures 3A and 3B). OCT showed there was no sign of calcium cracking at site of MLA (Figure 4A) and only minimal cracking at lesions adjacent to MLA (Figure 4B). Absence of significant dissection after IVL was confirmed on OCT, which would be contraindicated for OA. As the vessel size of mid-RCA was estimated to be >3.0 mm from OCT, OA was performed to mid-RCA at low-speed (80,000 rpm) and high-speed (120,000 rpm) rotation for more luminal

area gain (5), with careful hemodynamic monitoring. OCT was performed again.

The lesion at MLA was successfully cracked with luminal gain to 2.23 mm² (Figure 5A) from 1.55 mm², with even more significant calcium debulking at site adjacent to MLA (Figure 5B), with the classic “snowman” appearance.

The “snowman” appearance is not uncommonly seen after OA, with a larger circle of the original lumen (snowman’s body), and creation of a





smaller “arthrected” lumen (snowman’s head). This occurs more often with curved/tortuous segment (with “arthrected” lumen on the wire-biased outer curvature). This is important to note the extent of the “snowman’s head” and the transition neck region to avoid complication with excessive ablation.

However, the luminal size at the MLA was still quite small with reference to the vessel size, and the calcium remained very thick even after multiple arthrectomies. Further significant luminal gain was

unlikely achievable simply by noncompliant/cutting balloon dilatation. Hence, IVL was performed again with 3.5×12 -mm balloon (Figure 6).

After Orbital-Tripsy, very significant luminal gain was observed with angiogram (Figure 7) and OCT (Figure 8).

Ostial to mid-distal RCA was stented with 2 overlapping drug-eluting stents (3.5×35 mm, 3.5×40 mm) with noncompliant balloon (4.0×12 mm) postdilatation. The final result was as shown (Figures 9 and 10, Video 2).

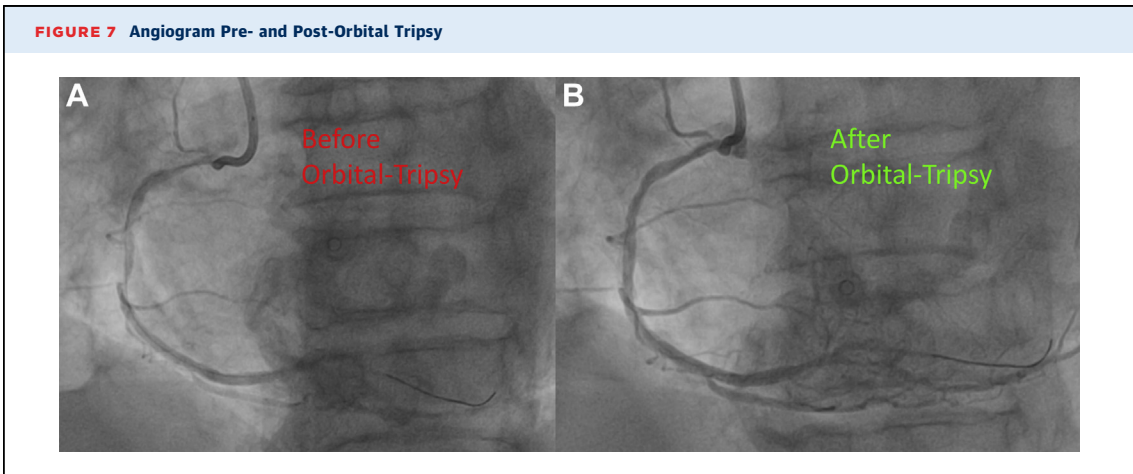
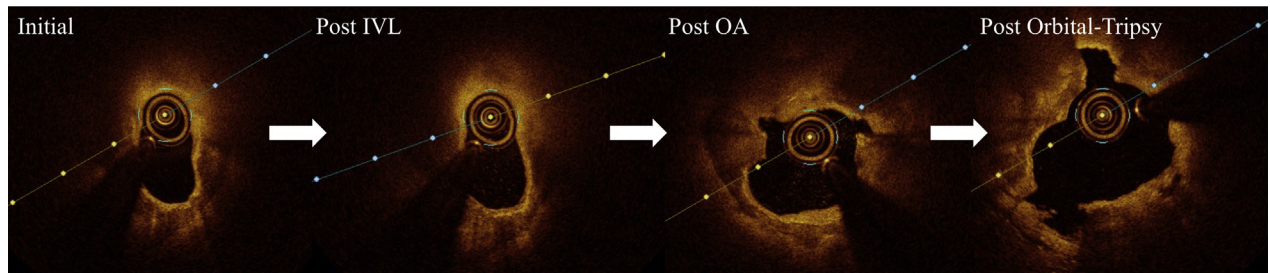


FIGURE 8 Optical Coherence Tomography Series of Minimal Luminal Area From Beginning of Procedure



N.B. Images in same scale.

DISCUSSION

Calcified coronary lesions are well known to impose technical difficulty during PCI. Moreover, severe calcified coronary lesion is an independent predictor

of stent thrombosis, target lesion revascularization (6). Hence, optimal lesion preparation should be done for better outcome (7). Good intracoronary imaging assessment is prerequisite to understand the arc, length, and thickness of calcification for optimal

FIGURE 9 Post-Stenting Optical Coherence Tomography

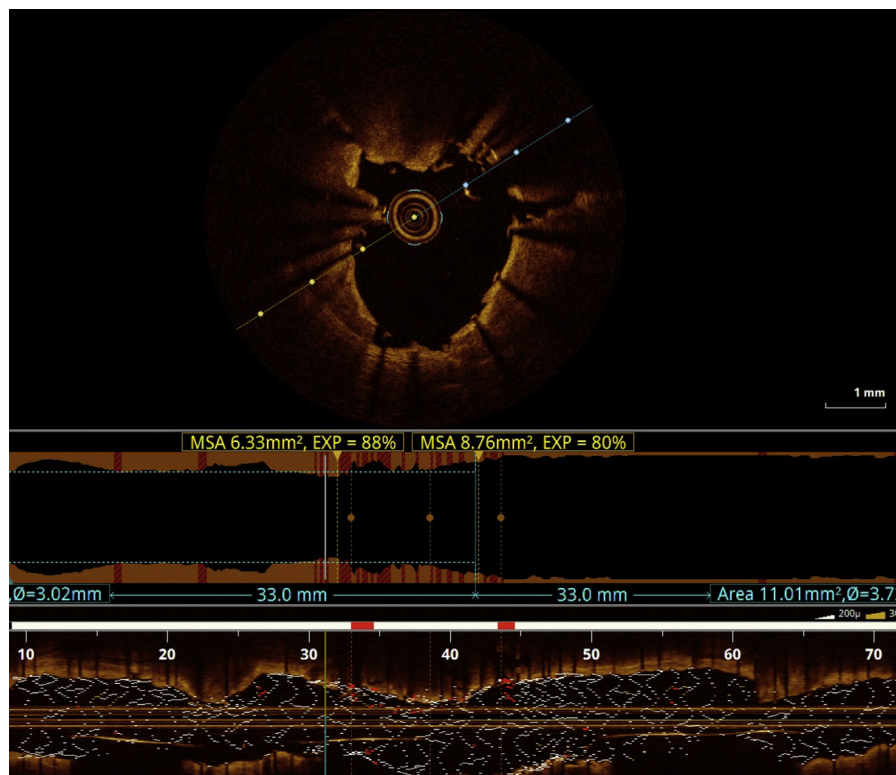
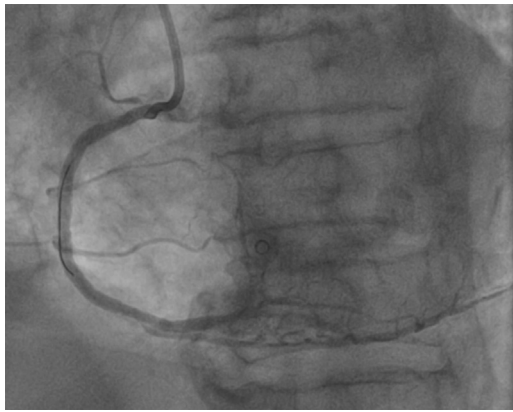


FIGURE 10 Final Angiogram of Right Coronary Artery



planning of strategy used. OCT helps to better assess the calcification compared to intravascular ultrasound (8).

As forementioned, no single calcium modification modality suits all types of lesions. IVL maybe less effective, even in concentric calcified lesions, if the calcium was too thick, as illustrated in this case. A combination of methods has been well described, including combination use of RA and IVL (9,10); however, in our case, despite the small MLA, the vessel size at mid-RCA estimated from segments adjacent to the most critical lesion was >3.0 mm, which may not be attainable by RA. There has been recent publication reporting the use of low-speed RA after high speed RA to achieve larger luminal gain (11), but our experience with this technique was not always as promising and may result in more no-reflow phenomenon. Hence, OA was chosen after careful intracoronary OCT imaging assessment for contraindication, such as grossly dissection lesions. OA at low speed (80,000 rpm) is sufficient for vessel size of <3.0 mm; for vessel size of >3.0 mm, OA can be repeated at high speed (120,000 rpm) to attain larger luminal area gain (4). Close and meticulous

monitoring is mandatory during OA to look for severe dissection at or adjacent to the lesion, when OA should be stopped to avoid complications. In our case, after OA, there was significant luminal gain and calcium cracking, but there still remained significant calcification, which warrants further modification. However, further OA was contraindicated and deemed unsafe. Hence, IVL was performed which resulted in further calcium cracking and luminal gain.

OA can effectively debulk calcium to facilitate further lesion cracking with IVL, which was demonstrated to be safe and synergistic to each other, attaining stepwise gain in luminal area.

FOLLOW-UP

The patient remained chest pain free postoperatively, and was discharged from hospital on the next day. The patient was seen half a year after the operation in the clinic and remained asymptomatic.

CONCLUSIONS

Calcified coronary lesions are independently associated with adverse outcome. Single modality of calcium modification may not be sufficient in severe cases. With careful peri- and intraprocedural OCT guidance, novel combination use of OA followed by IVL was demonstrated to be safe and efficacious in tackling very thick calcified lesions with large vessel size.


AUTHOR DISCLOSURES

The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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REFERENCES

1. Colombo A, Hall P, Nakamura S, et al. Intracoronary stenting without anticoagulation accomplished with intravascular ultrasound guidance. *Circulation* 1995;91:1676-88.
2. Iakovou I, Schmidt T, Bonizzoni E, et al. Incidence, predictors, and outcome of thrombosis after successful implantation of drug-eluting stents. *JAMA* 2005;293:2126-30.
3. Kassimis G, Raina T, Kontogiannis N, et al. How should we treat heavily calcified coronary artery disease in contemporary practice? From artherectomy to intravascular lithotripsy. *Cardiovasc Revasc Med* 2019;20:1172-83.
4. Kassimis G, Didagelos M, De Maria GL, et al. Shockwave intravascular lithotripsy for the treatment of severe vascular calcification. *Angiology* 2020;71:677-88.
5. Shlofmitz E, Martinsen BJ, Lee M, et al. Orbital atherectomy for the treatment of severely calcified coronary lesions: evidence, technique, and best practices. *Expert Rev Med Devices* 2017;14:867-79.
6. Généreux P, Madhavan MV, Mintz GS, et al. Ischemic outcomes after coronary intervention of calcified vessels in acute coronary syndromes: pooled analysis from the HORIZONS-AMI (Harmonizing Outcomes With Revascularization and Stents in Acute Myocardial Infarction) and ACUTY (Acute Catheterization and Urgent Intervention Triage Strategy) trials. *J Am Coll Cardiol* 2014;63:1845-54.

7. Madhavan MV, Tarigopula M, Mintz GS, Maehara A, Stone GW, Généreux P. Coronary artery calcification: pathogenesis and prognostic implications. *J Am Coll Cardiol* 2014;63:1703-14.
8. Kume T, Okura H, Kawamoto T, et al. Assessment of the coronary calcification by optical coherence tomography. *EuroIntervention* 2011;6:768-72.
9. Jurado-Román A, González A, Galeote G, Jiménez-Valero S, RotaTripsy Moreno R. combination of rotational atherectomy and intravascular lithotripsy for the treatment of severely calcified lesions. *J Am Coll Cardiol Intv* 2019;12:e127-9.
10. Chan KCA, Luk NHV, Lee KYM, Chan KT. A case of rota-shock-pella. *J Am Coll Cardiol Case Rep* 2019;1:765-70.
11. Yamamoto T, Yada S, Matsuda Y, et al. A novel rotablator technique (low-speed following high-speed rotational atherectomy) can achieve larger lumen gain: evaluation using optimal frequency domain imaging. *J Interv Cardiol* 2019;20:2019. 9282876.
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- KEY WORDS** coronary angiography, coronary calcium score, imaging, myocardial ischemia, percutaneous coronary intervention
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-  **APPENDIX** For supplemental videos, please see the online version of this paper.