Case Report

The First Orbital Atherectomy in a Heavily Calcified Angulated Mid Left Anterior Descending Segment in Bangkok Dusit Medical Services.

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Abstract

This report presents the first case of Orbital Atherectomy with heavily calcified, angulated segment of mid left anterior descending artery (LAD) at the Bangkok Heart Hospital, using a new innovation to prepare the lesion, as this condition is difficult to treat with conventional percutaneous coronary intervention such as coronary balloons and coronary stents. Currently, there are multiple modalities of treatment such as cutting balloon angioplasty, rotational atherectomy, intravascular lithotripsy or orbital atherectomy. We describe the step by step management of this heavily calcified lesion with the use of an infrared optical coherence tomography to identify calcium thickness, calcium length and calcium arc before introducing the new innovation strategy, using Diamondback 360 for orbital sanding on the circumferential vessel wall, both retrograde and antegrade, at both low and high speed, before larger balloon angioplasty and stent implantation with the proper stent sizing and stent length.

Keywords: heavy calcified coronary lesion, optical coherence tomography, OCT, rotational atherectomy, RA, orbital atherectomy system, OAS, intravascular lithotripsy, IVL

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Currently, there are several modalities to detect the coronary calcium burden[1], to manage and properly treat the heavy calcified coronary segment which occurs more commonly among percutaneous coronary intervention (PCI).[2] Due to the complexity of the calcified segment, there are several disadvantages and unsatisfactory results after PCI.[3] The most common causes are friction during coronary wire passage, un-expandable balloon, stent under-expansion, stent being dislodged and coronary perforation occurring immediately during PCI. Also the long-term outcomes are poor due to high incidence of in-stent restenosis, stent thrombosis and the need for repeat revascularization such as repeat PCI or coronary artery bypass surgery.[4] In early 1990, rotational atherectomy was the device of choice to open the narrow-calcified segment especially in cases of an expected balloon failure, but this device could only drill the superficial calcium to allow for an easier balloon and stent passage.[5,6] The other treatment was to apply a cutting balloon angioplasty such as Wolverine or Angiosculpt to crack the calcium segment.[7] Intracoronary imaging is mandatory to visualize the calcium thickness, calcium segment length and to define the calcium nodule[8] using methods such as intracoronary ultrasonography (IVUS) or optical coherence tomography (OCT)[9,10] with an assisted interventionist to stratify the proper management, including cross-sectional lumen sizing, vessel sizing and proper selection of coronary stent to match the calcium segment itself.[11,12]

We prefer OCT over IVUS due to the higher resolution of the near gain behind the calcium segment when IVUS could not penetrate the calcium segment[13], and to visualize the break or crack of the calcium before stent implantation, and also to guarantee the proper stent apposition to the vessel wall and stent expansion. There are several criteria for stent optimization which could affect long-term better outcomes. Orbital atherectomy[14] using Diamondback 360 and intravascular lithotripsy[15] are the latest innovations to overcome the calcium burden, resulting in better stent expansion. In this article, we would like to demonstrate the complex high risk indicated procedure (CHIP) PCI16 in heavily calcified LAD coronary artery and drug eluting stent implantation under OCT guidance.

Case report

A 58-year-old man with a history of acute myocardial infarction underwent primary percutaneous coronary intervention (PCI) for infarct-related artery at distal right coronary artery (RCA) with incomplete revascularization at another hospital, leaving significant residual multivessel disease at the LAD, proximal right posterior descending artery (RPD), distal right posterior lateral branch (RPL). He subsequently presented severe angina and dynamic ischemic electrocardiographic (ECG) changes, prompting referrals for delayed complex high risk indicated procedure (CHIP) PCI at our center.

The patient initially presented with acute myocardial infarction and underwent immediate PCI at other hospital. The index procedure targeted the distal RCA-RPL without complete revascularization of the remaining diseased vessels. According to the patient's verbal communication, there had been an unusually prolonged procedural duration of 3–4 hours, with no documented explanation for the technical difficulties encountered. Incomplete PCI was revealed later. The reasons for procedural incompleteness and extended duration were not clarified in the transferred medical records, though the presence of severe calcification was suspected. Approximately two months following the initial acute event, the patient self-referred from our institution (Bangkok Heart Hospital) with persistent severe angina, reduced exercise tolerance, and concern regarding untreated disease in LAD territory.

Upon presentation at our center, comprehensive cardiovascular risk assessment and advanced imaging were performed. Coronary artery calcium (CAC) scoring by computed tomography demonstrated extensive calcification with a total Agatston score of 1,288, reflecting severe calcified atherosclerotic plaque burden and distributed as follows (LAD 551.8, left circumflex (LCx) 131.5, and RCA 604.5 Agatston score respectively). The markedly elevated calcium score confirmed the presence of diffuse, heavily calcified coronary disease (Figure 1), and informed procedural planning. After discussions with the Heart Team, we obtained informed consent for this complex high-risk PCI (CHIP) procedure for known heavily calcified condition. Initially, left heart catheterization was performed, revealing a left ventricular end-diastolic pressure (LVEDP) of 15–18 mmHg, indicating mild diastolic dysfunction, with no significant transaortic pressure gradient. IV hydration was initiated at 3mL/Kg/hr according to POSEIDON's protocol as set out in CHIP-PCI best practice. Coronary angiography demonstrated severe, heavily calcified LAD was seen on moving fluoroscopy 76-90%DS by GENSINI[17] of the very proximal RPD (Figure 2) and 51-75%DS by GENSINI score at the distal RPL (Figure 3) and 91-99%DS by GENSINI score at the mid triple angulated LAD (Macdonald's sign) (Figure 4-5).

The critical lesion responsible for the patient's recurrent symptoms was the heavily calcified mid LAD. Angiographic features raised significant concern for potential complications during calcium modification, including risk of rotational atherectomy burr entrapment and the presence of marked angulated segment. Pre-intervention optical coherence tomography (OCT) was attempted using Dragonfly Opstar catheter but uncrossed angulated mid LAD segment (Figure 6), provided incomplete visualization of the whole LAD, but only proximal to the most severe calcified segment, revealing a minimal lumen area (MLA) of 1.02 mm² (diameter 1.14 mm, area stenosis 83.1%), thick circumferential calcium with arc exceeding 180 degrees, and extensive of calcification from the distal left main carina through mid LAD segments.

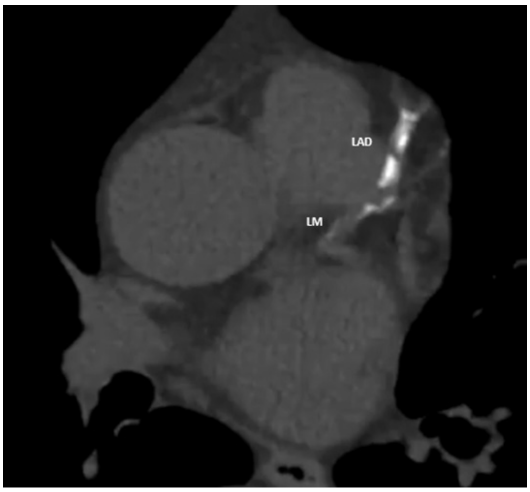

Figure 1: CT Coronary artery Calcium at the LAD (total =1,288 Agatston score).

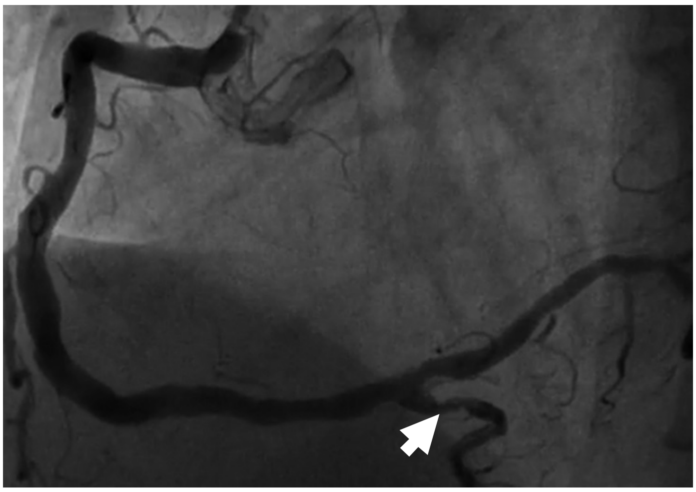

Figure 2: Right coronary angiogram revealed 51-75% diameter stenosis very proximal right posterior descending artery (RPD) (Arrow).

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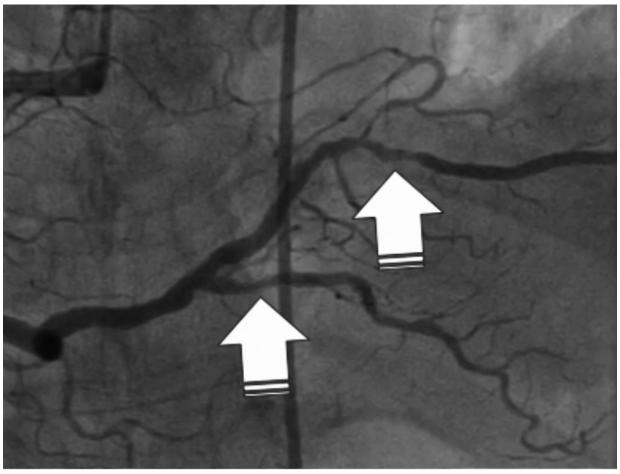

Figure 3: Right posterolateral stenosis (arrow) and RPD (arrow).

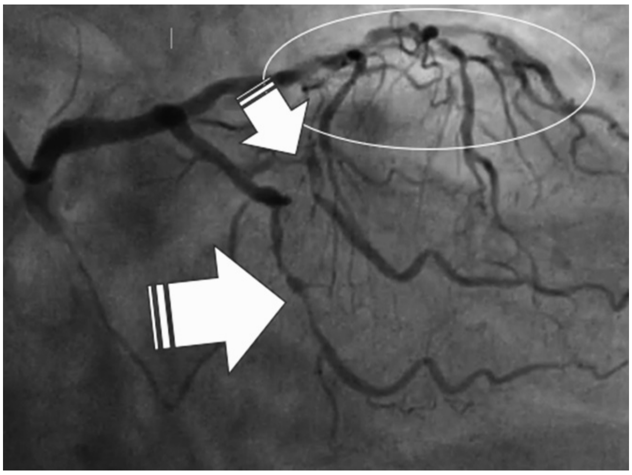

Figure 4: Left coronary angiogram, stenosis mid LAD (circle), OM1 (arrow) and distal LCX (arrow).

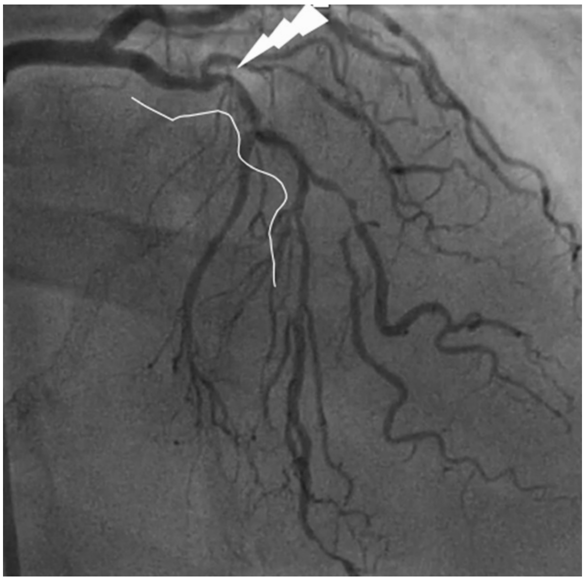

Figure 5: Left coronary angiography, lighting sign point at mid LAD with 3 angulations (MACDONALD's sign).

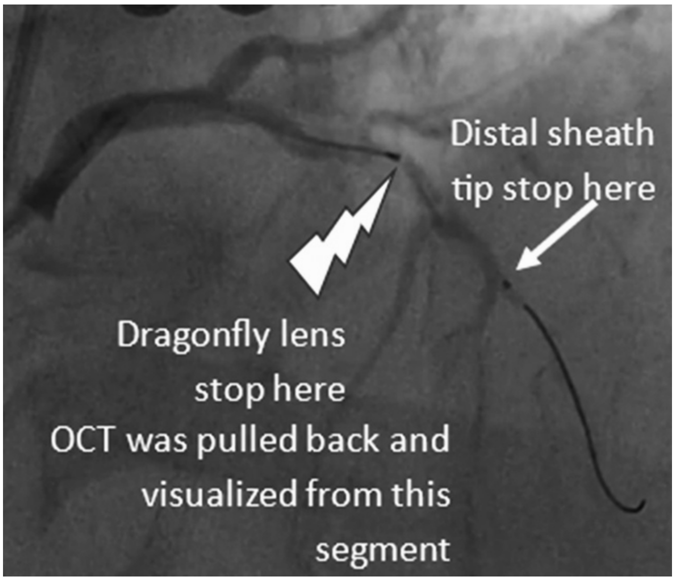

Figure 6: Uncrossed Dragonfly Opstar at the first angulation due to thick calcium nodule.

Given the extreme calcific burden, marked vessel tortuosity, high risk of rotational atherectomy complications, and prior incomplete revascularization, a staged revascularization strategy employing orbital atherectomy was planned after the multidisciplinary heart team discussion. The procedure was performed with continuous hemodynamic monitoring. A 6 French EBU 3.5 Launcher guiding catheter provided support. A Fielder FC guidewire was advanced into the distal LAD with the assistance of an ELONG microcatheter and successfully traversed the heavily calcified, angulated segment. The wire was then exchanged for a ViperWire to facilitate the Diamondback 360 orbital atherectomy system (OAS) delivery. Using Glide-Assist technique, the Diamondback 360 (1.25 mm crown) was carefully advanced through the angulated mid-LAD to the distal landing zone. Orbital circumferential sanding for calcium modification was performed with three retrograde and two antegrade sanding passes at preferred low speed (80,000 rpm), each short passage with a 0.5–1.0 mm/sec, with meticulous attention to auditory feedback, device vibration, and avoidance of prolonged contact to prevent device entrapment or coronary perforation. The patient reported severe angina pain with significant ST-T depression in chest leads, puff coronary angiography was immediately done to exclude any possible extravasation or coronary perforation, confirming patent coronary blood flow.

Post-atherectomy OCT demonstrated successful calcium fracture with multiple circumferential calcium cracks, short intramural hematoma formation was observed and an improved MLA of 1.22 mm² (diameter 1.24 mm, area stenosis 68.4%), however, the Dragonfly Opstar catheter remained uncrossed through the most severe calcified segment, reflecting persistent mechanical resistance despite effective calcium modification. Sequential lesion preparation was performed using another non-compliance balloon angioplasty with 2.75×15 mm and 2.0×12 mm scoring balloons in the distal and mid LAD segments. Due to persistent difficulty with stent delivery despite adequate lesion preparation, an Expressman mother-and-child catheter was introduced, incorporating with balloon tracking technique to advance Expressman until no further forward movement, then we advanced the tracking balloon downstream to mid LAD and inflated as anchoring points to further advance this mother and child catheter over the angulated mid LAD. Then we advanced the first 2.75×22 mm Xience Skypoint to cover the mid LAD lesion, pulled back the Expressman proximal to this stent, and deployed at 14 atm, followed by second 3.5x15mm Xience Skypoint, then the mother and child catheter was pulled back, adjusting the position using stent boost to meticulously overlap the proximal stent edge, then second Xience Skypoint was deployed at the same pressure. We performed post-stent inflation using non-compliance balloon (NCB) with high inflation for the distal half of this stent as the distal optimization technique (DOT) and another larger NCB with high pressure inflation at the proximal half for proximal optimization technique (POT) using a 3.5×8 mm NC POT-PCI balloon at 18 atmospheres x40 seconds. Mild haziness at the distal stent edge was noted and addressed with additional low-pressure balloon inflation. Final OCT demonstrated a minimal stent cross-sectional area (MSA) = 4.95 mm² with 89% stent expansion, well-apposed struts and no edge dissection. Final angiography showed excellent angiographic results with Thrombolysis in Myocardial Infarction (TIMI) 3 flow, no residual stenosis, and no procedural complications. The patient remained hemodynamically stable throughout the procedure and was transferred to the cardiac care unit for overnight observation.

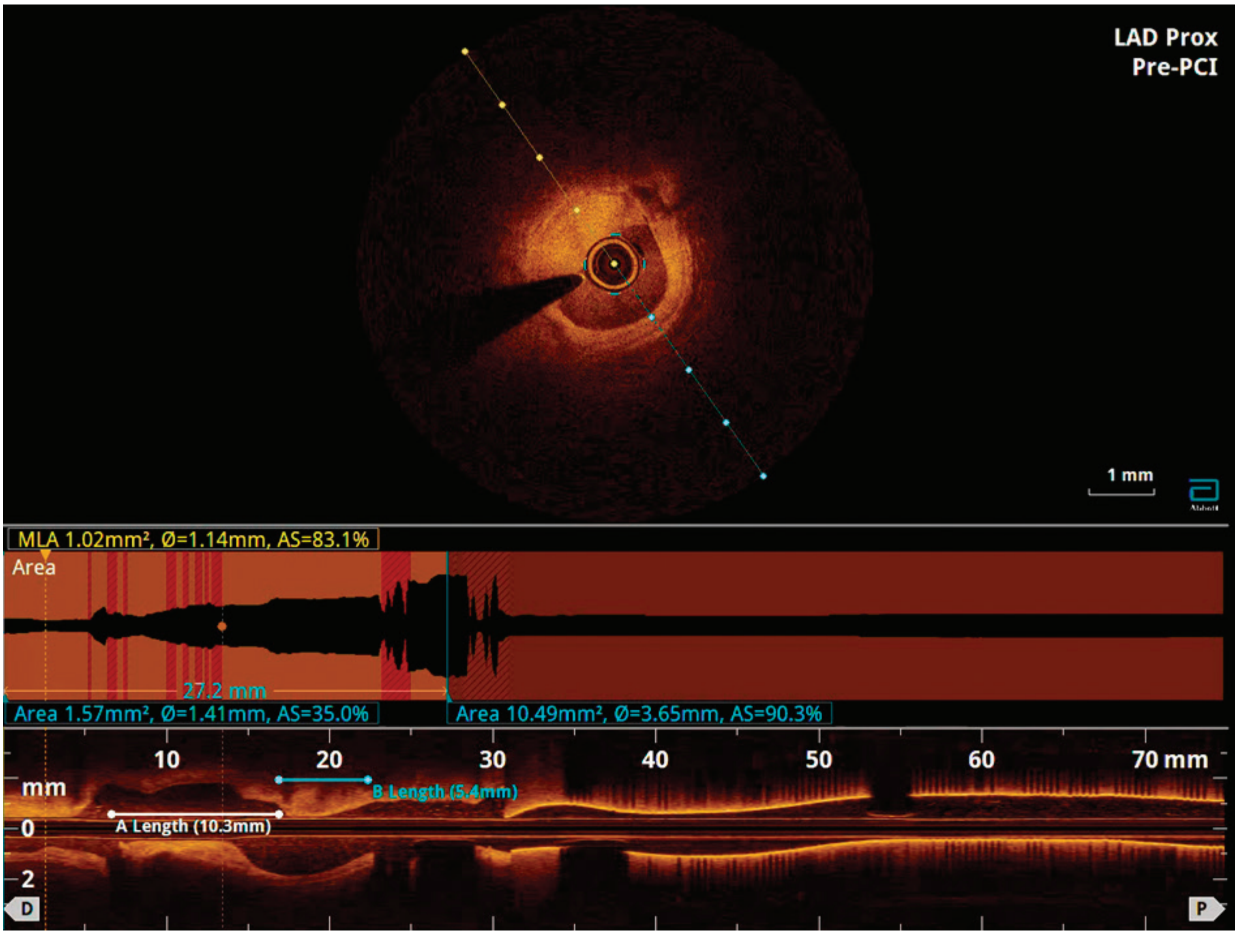

Figure 7: Optical coherence tomography image.

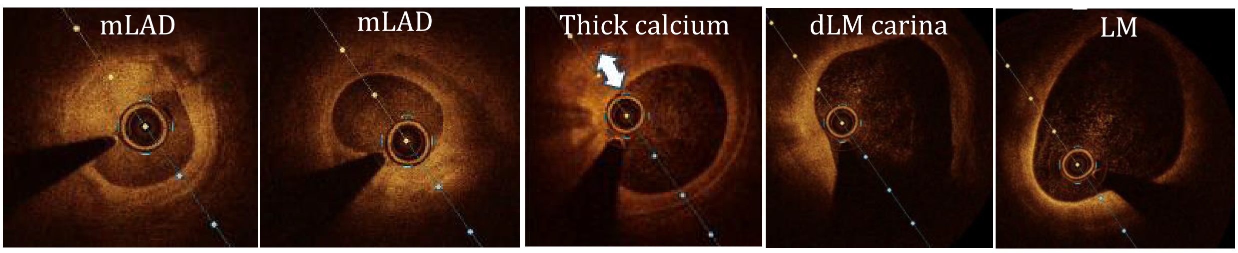

Figure 8: Cross-sectional OCT snapshot from distal to proximal LAD, Doublehead arrow shows calcium thickness.

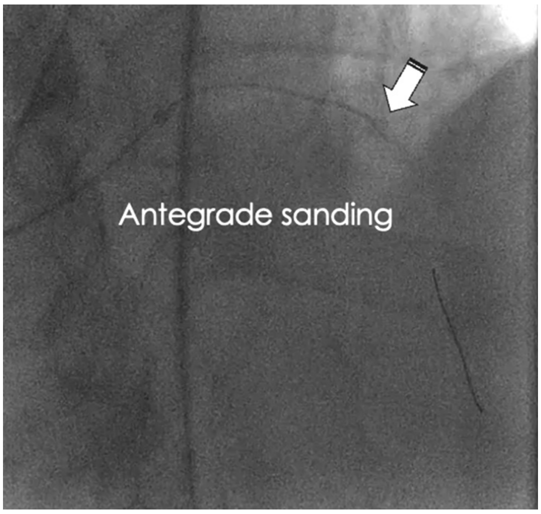

Figure 9: Diamondback 360 antegrade sanding (Arrow tip at sanding part)

Figure 10: Post-stent implantation angiographic images: left (pre-PCI), right (post-stent implantation)

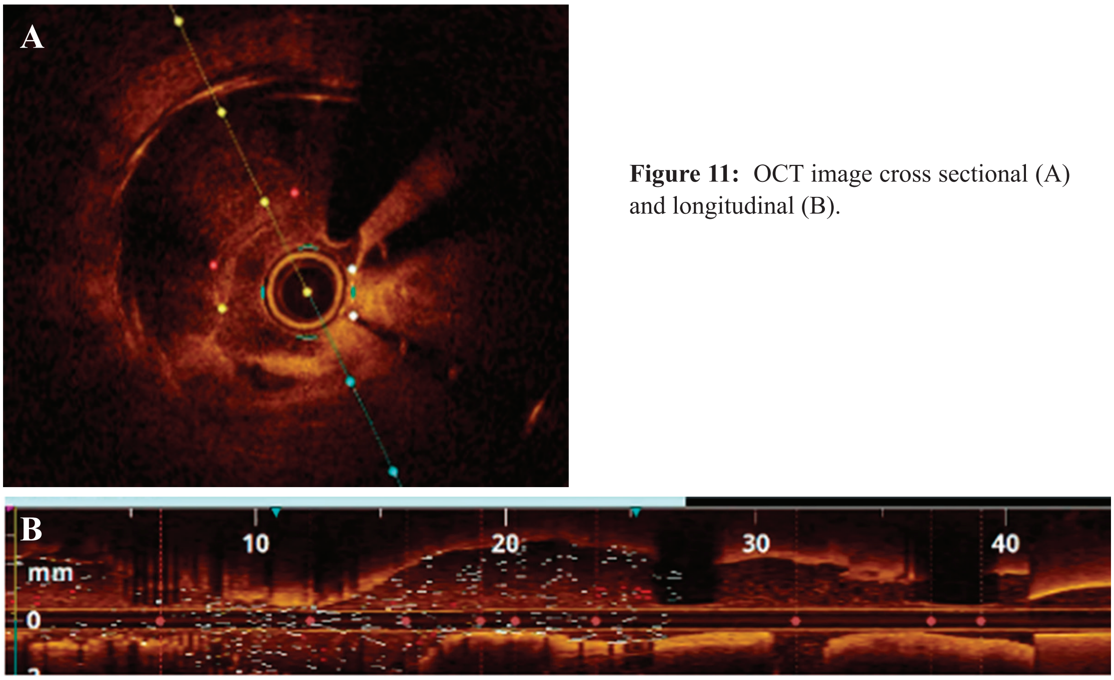

Figure 11: OCT image cross sectional (A) and longitudinal (B).

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Discussion

Severely calcified coronary lesions represent one of the most challenging subsets in percutaneous coronary intervention (PCI), particularly when compounded by marked vessel angulation. Contemporary guidelines emphasize the need for adequate lesion preparation to ensure optimal stent expansion, apposition and long term clinical outcomes.[18] Calcified nodules, eccentric calcium and hinge points significantly increase the risk of stent underexpansion—a major predictor of in stent restenosis and stent thrombosis.

In such complex anatomy, atherectomy devices play a central role. Although rotational atherectomy (RA) remains widely used, several reports have described procedural challenges in tortuous or angulated vessels, including burr entrapment, wire bias, incomplete modification of eccentric calcium, and balloon uncrossability.[19] These concerns are amplified in long, nodular or hinge point calcification. Our team elected to use orbital atherectomy (OA), which offers circumferential sanding with differential cutting, potentially more uniform calcium modification and improved deliverability in tortuous vessels. Comparative studies have shown OA may achieve greater luminal gain with lower entrapment risk in angulated segments due to its elliptical orbit and lower susceptibility to wire bias.[20]

In the present case, the combination of severe calcification and sharp angulation raised significant concern that RA could result in burr entrapment or inadequate ablation of nodular calcium. Additionally, the risk of balloon uncrossability after RA—particularly in eccentric or hinge point segments—was weighed carefully. The ability of OA to facilitate bidirectional orbit expansion and modify calcium more evenly in tortuous anatomy made it the preferred initial device for this case.

Optical coherence tomography (OCT) was critical in guiding the procedure. OCT allows precise characterization of calcium thickness, arc, length[21] and has been shown to predict the need for atherectomy and to correlate with stent expansion outcomes.[22] In our case, OCT imaging before and after OA confirmed effective calcium modification and guided balloon selection, stent sizing and final optimization. Post intervention OCT demonstrated satisfactory stent expansion and apposition, validating the decision to use OA as the primary modality.

Compared with previously published reports of RA or balloon based calcium modification in similar anatomies, this case highlights the unique advantage of OA in vessels with severe angulation and nodular calcium. Prior authors have noted that RA may be limited in cases of pronounced bends where the burr cannot maintain coaxial alignment, potentially reducing efficacy and increasing risk.[23,24] Our findings support expanding consideration of OA in such settings, particularly when combined with OCT guided optimization.[25]

Take home messages:

1) Lesion morphology and vessel geometry should guide the choice of atherectomy modality, not simply the severity of calcification.
2) OA may offer a safer profile than RA in sharply angulated, eccentric or nodular calcium where entrapment or inadequate modification is a concern.
3) OCT is indispensable for both planning and evaluating the success of calcium modification.
4) Optimal stent expansion is achievable even in complex anatomy when appropriate device selection and intravascular imaging are used.

Although this is a single case, it contributes to the growing experience supporting the role of OA in complex coronary anatomy, especially where RA carries elevated procedural risk. Further comparative studies will help refine selection criteria among available calcium modification technologies.

Conclusion

We report the demonstration in very heavy calcified LAD segment with marked angulation, which may cause rotablator burr entrapment, by using optical coherence tomography guided both retrograde/antegrade orbital atherectomy sanding both low speed and high speed to obtain larger lumen area, and debulk superficial calcium thickness thinner, with a detailed step by step orbital atherectomy with multiple strategies to accomplish a good result. This technique is an innovation which might replace the way we handle very calcified segments during PCI, avoiding unwanted lesion complications or adverse clinical outcomes.

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