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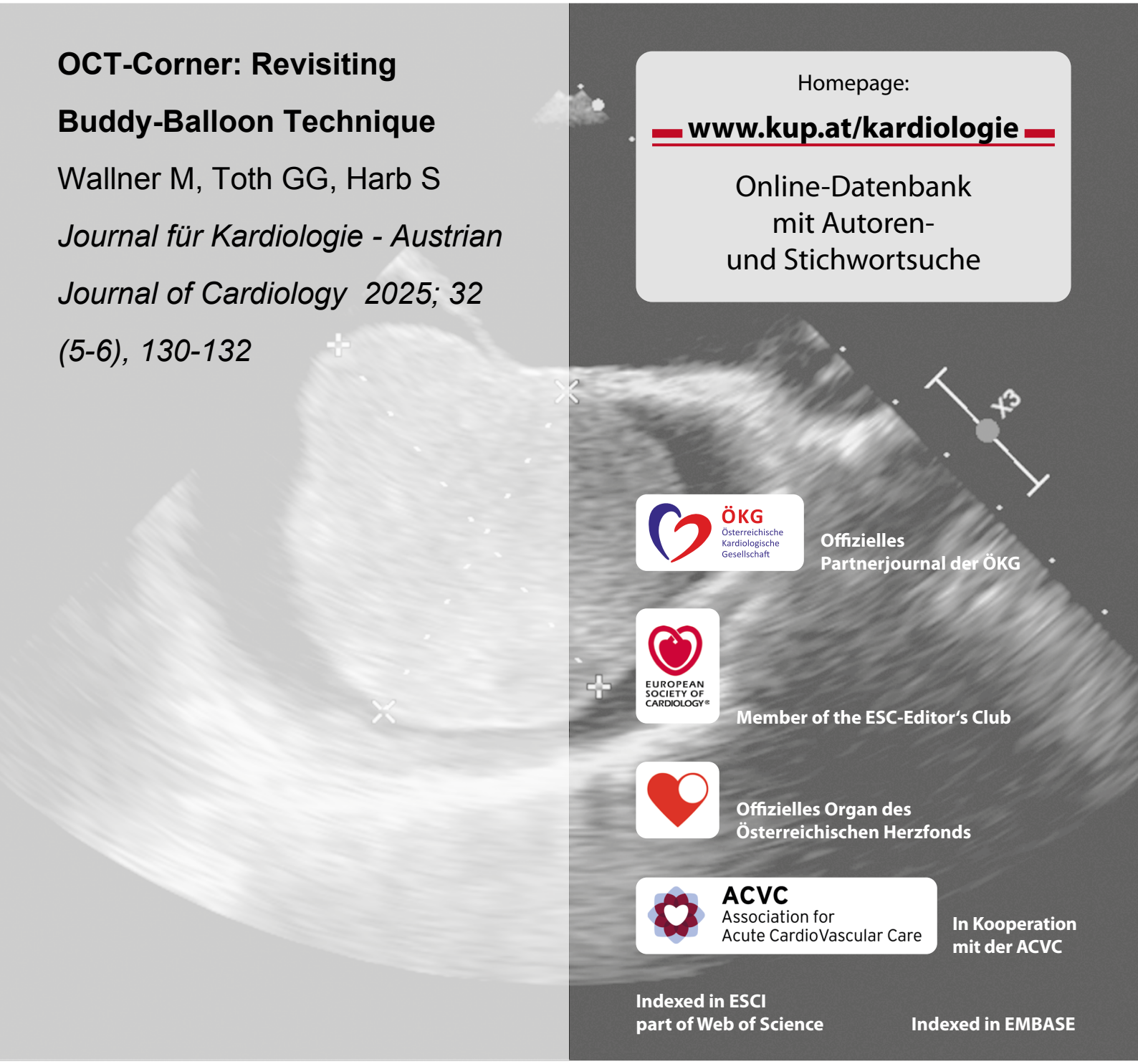

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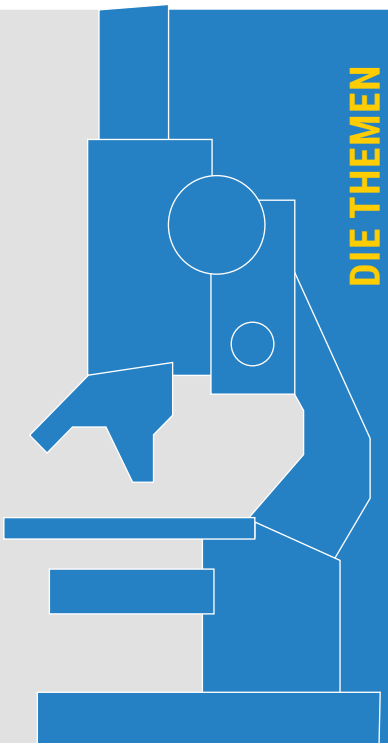

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Revisiting Buddy-Balloon Technique

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Introduction

Based on a pooled analysis from two large-scale randomized controlled trials – ACUITY and HORIZONS-AMI – that included 6.855 patients presenting with acute coronary syndrome (ACS), about one third of the target lesions showed moderate or severe calcification.

Coronary calcification represents a major challenge in percutaneous coronary intervention (PCI). It is associated with higher incidence of stent malapposition and underexpansion, which are independent predictors of target lesion failure. Coronary calcification can impede delivery of devices and entail complications such as perforation and dissection [1]. Furthermore, it has been shown that moderate/severe lesion calcification is associated with poor outcomes in patients with ACS [2].

Procedural success after coronary angioplasty and stenting depends on "controlled" atherosclerotic plaque modification. Coronary atherectomy devices, such as rotational and orbital atherectomy are potent plaque modification tools and have been shown to effectively facilitate procedural success in calcified lesions [3, 4]. However, their use can be risky in certain situations, like in case of severely angulated vessels.

The armamentarium of plaque modification tools includes several balloon-assisted technologies such as non-compliant (NC) balloons, super high-pressure NC-balloons, scoring balloons, cutting balloons, and intravascular lithotripsy (IVL) [1]. NC-balloons can be inflated to relatively high pressures (up to 20–24 atmospheres, double-layered super high-pressure balloons even up to 30–40 atmospheres) with well defined pressure dependent increase their diameter. Still, depending on the resistance of calcium, especially if circular, there is always a certain risk of dog-boning or rupture in heavily calcified vessels. Both, retrospective [5] and prospective [6] data showed a favorable effect of super high-pressure NC-balloons in calcified lesions. However, given their bulkier twin-layer design, delivery of these balloons can be tricky.

Scoring and cutting balloons are balloons with one-to-three longitudinally or three-to-four helically-arranged nitinol-struts and NC-balloons with three-to-four longitudinally arranged microsurgical atherotomes bonded to their surface, respectively [7, 8]. These designs facilitate focusing the expansion forces on the 'edge-of-the-knives', increasing its plaque-modification power compared to regular NC-balloons whose force is evenly distributed over the whole balloon surface. Although proven to be effective in several trials, scoring and cutting balloons may also require adjunctive techniques like guide extensions to facilitate delivery and are limited in their effect on eccentric and nodular calcium similar to super high-pressure balloons [1].

Intravascular lithotripsy (IVL) is a novel potent technology, used for lesion preparation in calcified coronary vessels. IVL uses electrical energy to produce vapor bubbles, which rapidly expand and produce acoustic pressure waves that expand radially from the emitters. These pressure waves propagate through soft tissue with negligible effect but produce compressive and tensile stress on areas of calcification. This effect is comparable with 50–60 atmospheres, focused on the calcified material only, producing multiple fractures in both superficial and deeper calcified layers [9]. Limitations of IVL are reduced deliverability of the balloon and ischemia, induced by the time it takes to repeatedly inflate and deflate the balloon to apply the ten-second series of pulses, as one device can presently emit up to 120 pulses.

Specialty-balloon-based techniques have been shown to be effective and safe in the management of significant coronary calcification. However, deliverability of these bulky devices remains a significant issue. Furthermore, these technologies cause substantial costs for health care providers and may not be widely available in all centers.

There is an additional balloon-based technique that is relatively cheap and available in every catheterization laboratory, the **buddy ballooning technique**. Buddy ballooning was first described by Vincent Dangoisse [10, 11]. In general, the success of plaque fracturing relies on asymmetric and focused application of force to the atherosclerotic plaque. Inflation of a single NC-balloon delivers forces uniformly to the arterial wall, provided the wall is homogenously structured. As this is not generally the case, the method still works, especially by tensile forces that can break unevenly distributed plaques. When two balloons are positioned in parallel and inflated simultaneously, these forces cumulate in one plane, leading to elliptical deformation of the vessel cross-section creating tensile forces which will facilitate longitudinal fractures particularly in concentric plaques (Fig. 1). For eccentric plaques, this technique may not be as effective, because the more elastic and compliant part of the vessel may over-expand and "accommodate" the high pressure.

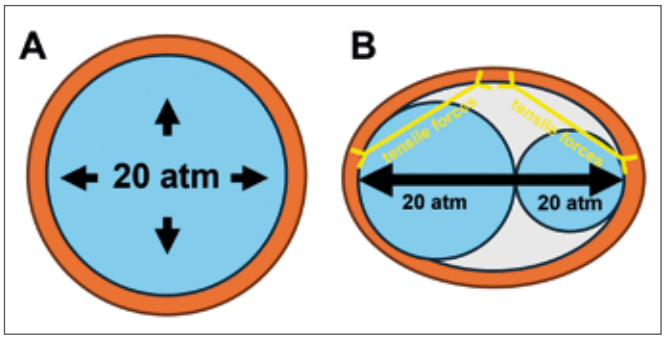

Figure 1: Single NC-ballon applies very high pressures uniformly against the diseased arteries' wall **(A)**. Buddy balloon technique using 2 NC-balloons delivers the same pressures but causes tensile forces facilitating plaque fracture in severely calcified lesion **(B)**.

Case Report

We describe a case of a 73-year old patient who presented with unstable angina in our emergency department. A coronary CT-scan, which was performed one month earlier due to angina, showed highly stenotic severely calcified plaque in the proximal LAD (Fig. 2). The angiogram showed a narrow proximal LAD, whereas CX and RCA were not significantly stenosed. OCT revealed a fibro-calcified plaque with lipid deposits in the LAD with a minimal luminal diameter of 2.5 mm (Fig. 3).

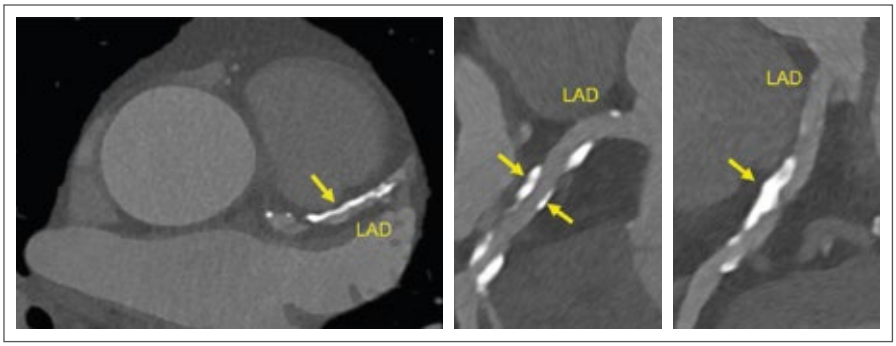

Figure 2: Coronary-CT scan showing heavy calcified plaques in the proximal LAD

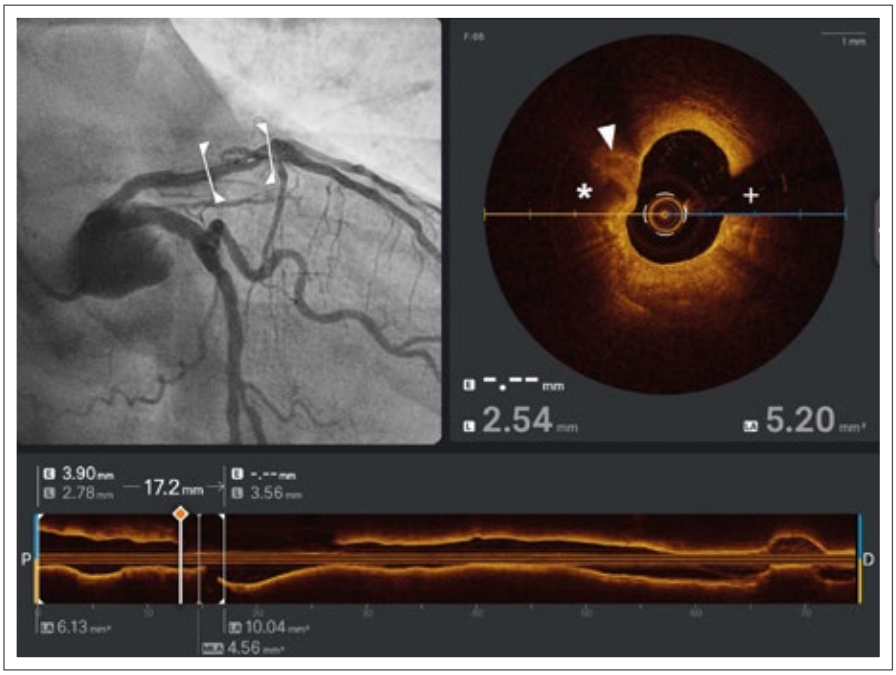

Figure 3: OCT revealed a fibro-calcified plaque with lipid deposits (* = calcified areas, arrowhead = lipidic/fibrotic plaque, + = guidewire artefact)

We decided to utilize a buddy balloon technique for lesion preparation. A 1.5 × 15 mm and 2.5 × 15 mm non-compliant (NC) balloon was used, not exceeding the reference vessel diameter of 4 mm measured by OCT even when applied with high pressure. Both balloons were advanced into the proximal LAD and simultaneously inflated several times in different positions (Fig. 4). To confirm sufficient plaque fractures, another OCT run was performed showing several longitudinal cracks in the calcified plaques (Fig. 5). For the subsequent PCI a 4.0 × 28 mm drug-eluting stent was used. A post-dilation using a 4.0 × 15 mm NC-balloon was performed at the level of the distal stent part.

Another OCT run confirmed good final result with non-significant proximal edge dissection, good stent apposition and expansion (90%) with a minimal stent area (MSA) of 9.35 mm² (Fig. 6).

Conclusion

The buddy ballooning technique utilized in the present case proved to be simple, inexpensive, and applicable in every catheterization laboratory at any time.

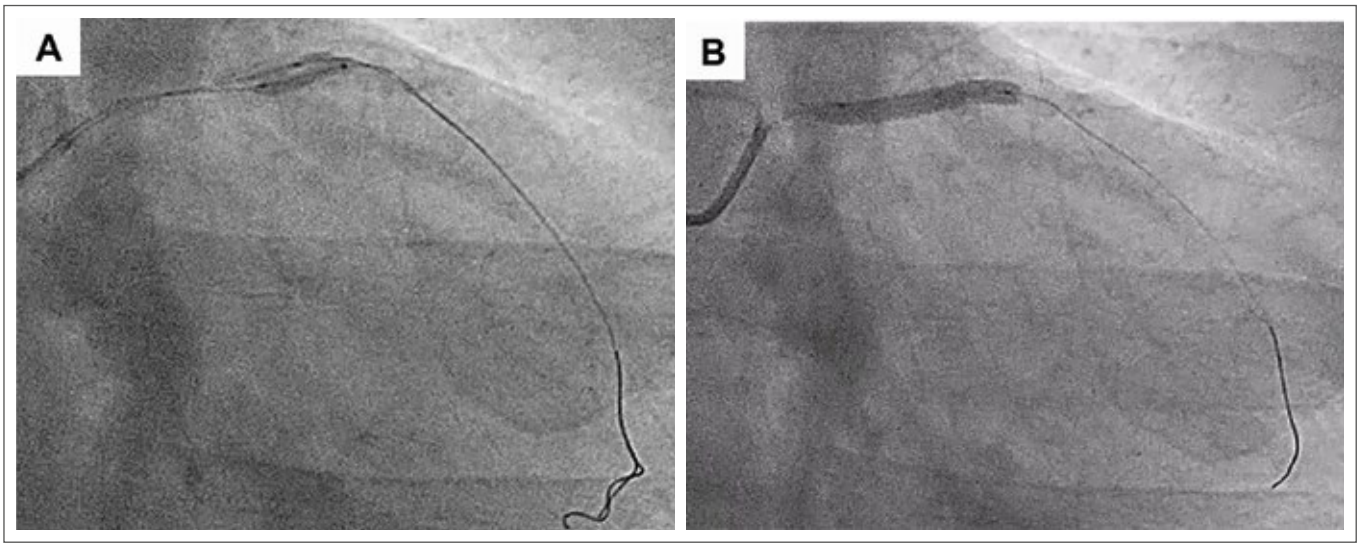

Figure 4: Buddy ballon technique: 2 wires (Turntrac™) advanced into the LAD. 1.5 (1 dot in the centre) and 2.5 mm (two dots at the edges) NC-balloons placed in parallel in the heavy calcified proximal LAD and inflated simultaneously with high pressure **(A)**. Stent deployment (DES; 4.0 x 28 mm) **(B)**

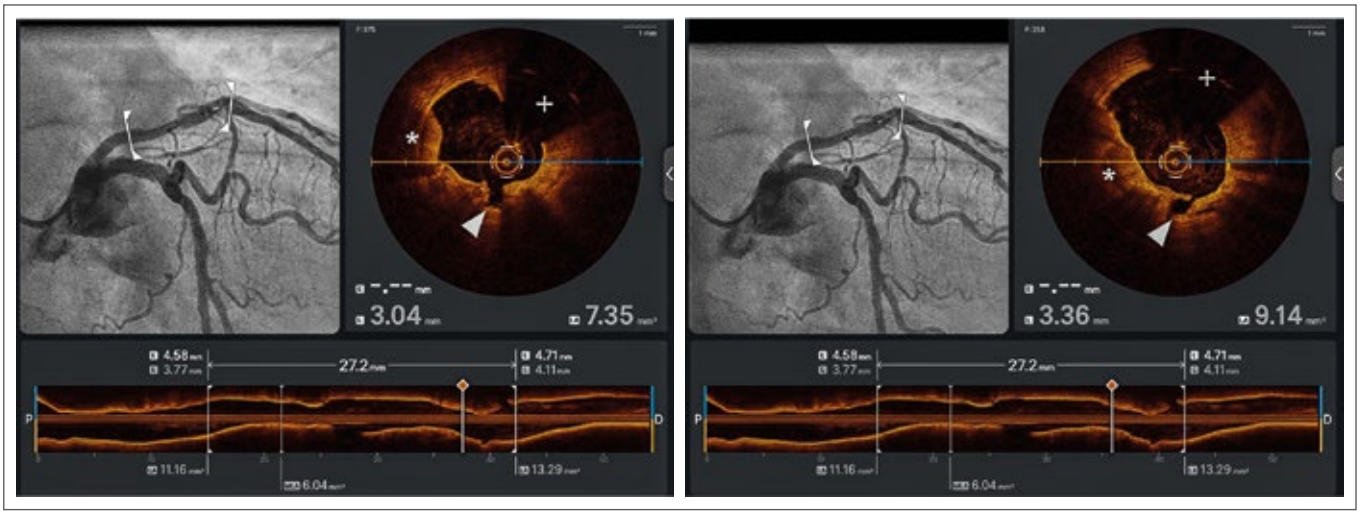

Figure 5: OCT images post ballon angioplasty using buddy ballon technique. Several cracks and fractures were displayed by OCT imaging (* = fibro-calcified plaque, arrowhead = rupture, + = guidewire artefact)

Selection of balloons with proper diameter is essential to avoid overexpansion and minimize the risk of vessel rupture. The technique allows to deliver, at least in one plane, a very high pressure with the same final balloon size as with a single NC-balloon. In certain cases buddy ballooning technique may be an effective alternative to more sophisticated and expensive balloon-based technologies such as scoring/cutting balloons and IVL.

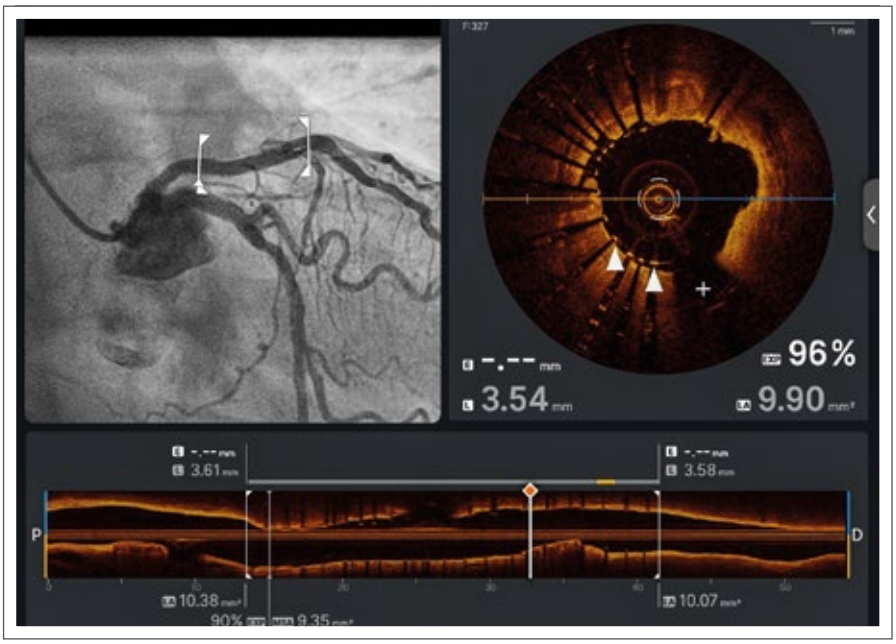

Figure 6: OCT post stent implantation showed good stent apposition and expansion and satisfying minimal stent area (arrowheads = stent struts, + = guidewire artefact)

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