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EDITORIAL

Fine-tuning the arc of orbital atherectomy: navigating eccentric calcium in tortuous vessels

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Calcified coronary lesions are strongly associated with technical challenges and adverse outcomes during and after percutaneous coronary intervention[1]. Despite the continued expansion of the interventional toolbox, which now includes a wide variety of calcium modification technologies[2], eccentric calcification, particularly in tortuous vessels, remains a significant procedural challenge. While intravascular lithotripsy has demonstrated consistent efficacy in both concentric and eccentric calcium and is increasingly adopted[3], its utilisation can be limited by deliverability, especially in the context of vessel tortuosity and stenosis severity. This limitation underscores the continued role of atherectomy devices for the treatment of severe calcium in balloon-uncrossable and/or -undilatable lesions[4].

Among the available atherectomy techniques, rotational and orbital atherectomy (OA) differ fundamentally in their mechanisms of action. Rotational atherectomy employs a concentrically spinning burr that advances along a guidewire, ablating in a forward direction, guided by the direction of wire bias, and with an ablation width the size of the chosen burr. This wire-tracking behaviour leads to less plaque modification in eccentric stenoses, particularly when the calcium lies on the outer curve of a bend in the coronary vessel on the opposite side of the wire. By contrast, OA features an eccentrically mounted crown on a drive shaft that causes the crown to orbit around the vessel when spinning, thereby generating a wider zone of ablation despite the use of an only a 1.25 mm crown[5]. The OA design therefore holds a theoretical advantage of producing more ablation in eccentric morphologies[5], given its reduced dependence on the exact location of the wire (determined by wire bias). Ablation can additionally occur bidirectionally (with forward or backward movement). While promising in concept, the performance of OA in eccentric calcified lesions at tortuous segments remains incompletely characterised.

In this issue of AsiaIntervention, Tanaka and colleagues attempt to address this question using *in vitro* models that simulate key anatomical features of tortuous and eccentrically calcified vessels[6]. Their study assessed the performance of OA in vessels with different curvature radii and bend angles, focusing on the influence of calcium location along either the inner or outer curve. Understanding the behaviour of OA across these geometries may help predict the extent and distribution of plaque modification in complex anatomies, including eccentric calcified lesions, and guide more informed procedural planning. Vessel models were created by combining two curvature radii (10 mm and 20 mm) with two bend angles (60 degrees and 100 degrees), and two calcium locations (inner and outer curve). Real-time high-speed photo/videography was performed, and calcium modification was evaluated using microcomputed tomography before and after ablations.

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The authors report a clear and consistent finding: while OA was able to modify calcium along the outer curve of vessels, it was generally more effective at modifying calcium located along the inner curve of vessels. While the theory of wire bias provides a foundational explanation for the predominance of inner curve ablation, it does not fully account for the minor variations in the degree of inner plaque modification observed across the various models, nor the differences between inner and outer plaque modification across different vessel geometries. Instead, the findings point to a more complex interplay in which vessel geometry, specifically bend angle and curvature radius, influences the natural elliptical trajectory of the eccentrically mounted crown in OA, which in turn influences ablation distribution beyond what wire bias alone would predict. The crown's elliptical path, by virtue of its longer sweeping axis, inherently favours engagement and movement toward the inner curve of a bend, even when the wire theoretically remains centralised. In tortuous vessels, the inner curve lies physically closer to the crown's orbital path along its longitudinal axis, increasing the likelihood of contact and ablation. This natural tendency may help explain the consistent predominance of inner curve ablation observed across models.

This geometric influence emerges on two levels. First, when comparing the degree of inner plaque modification across models, vessels with larger radii and shallower bends demonstrated greater inner ablation than more sharply curved vessels, even though the latter are expected to produce greater wire bias. One possible explanation is that in more tortuous models with sharper bends, the crown's engagement and movement along the inner curve (its inherent preference) becomes less stable and consistent, thereby reducing the ablation in that region despite the presence of greater anticipated wire bias in sharper geometries. Conversely, and perhaps counterintuitively, for a given curvature radius, shallower angles likely generate shorter arcs, thereby limiting crown contact time with the outer curve, while sharper angles likely extend arc length and promote sustained contact along the outer wall. This helps explain why a radius of curvature of 20 mm with a 100-degree bend (arc length of ~35 mm) achieved greater outer curve ablation than a radius of curvature of 20 mm with a 60-degree bend (arc length of ~21 mm).

From a clinical perspective, these findings reinforce the importance of intravascular imaging to characterise plaque morphology, location, and to guide tool selection. In cases of eccentric calcium located along varying curvatures of a tortuous vessel segment, operators may begin to start anticipating in advance the likelihood of effective plaque modification with this (and other) technologies. Notably, the technique used to ablate will likely also factor into the efficacy of modification; in the present study, OA technique principally involved slow (backward) retraction of the crown, followed by the forward advancement of the crown for inner curve calcium models, and forward advancement of the crown for outer curve calcium models. This was an empirical choice by the study authors and reflects a recognition of the presumed mechanism of ablation as well as a concern to optimise device safety, as forward advancement of the crown along a tortuous inner segment of vessel wall may have a higher risk of vessel injury and possible perforation.

Ultimately, the study by Tanaka and colleagues highlights the need for further research into lesion-specific outcomes with calcium modification tools. As interventional cardiology continues to tackle increasingly complex anatomy, bench data such as these provide a critical foundation for informing procedural planning, facilitating device selection, and refining technique.

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Conflict of interest statement

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