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Cardiology. At the very first international symposium addressing PCI technology in Freiburg, Germany, in January 1987, a major session was dedicated to guidewire technology, including long-wire and monorail techniques. Also in 1987, self-expandable stents were introduced by Ulrich Sigwart, and safe guarded PCI results. In 1987, I visited Julio Palmaz in San Antonio and had the chance to participate in animal testing of balloon-expandable stents. These stents, carried by monorail catheters, in a few years evolved as an accepted treatment standard.

The monorail principle was used for a variety of therapeutic and diagnostic instruments to be advanced into coronary arteries, but also cerebral and distal limb arteries, for example, for transfusion, drug delivery, or ultrasound catheters. In acute coronary syndromes, the reliable combination of adequate guidewires and stent-carrying monorail balloon catheters is now well established. The best example for wire versatility is its use for fractional flow reserve measurement.

Considering the evolution of wire technology for PCI, we can draw a continuous line from Simpson's moveable wire, to the separation of wire and balloon catheter by Kaltenbach, and to the monorail system, which added, together with stents, safety, ease of use, and versatility. Thus, in coronary artery disease (with a few exceptions), the combination of wire and monorail catheter technology has been the basis for instrumental treatment innovations and for the enormous propagation of PCI.

*Tassilo Bonzel, MD

*Adalbertstrasse 39
36039 Fulda
Germany
E-mail: tassilo@bonzel.de

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Please note: Prof. Bonzel has reported that he has no relationships relevant to the contents of this paper to disclose.

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RESEARCH CORRESPONDENCE

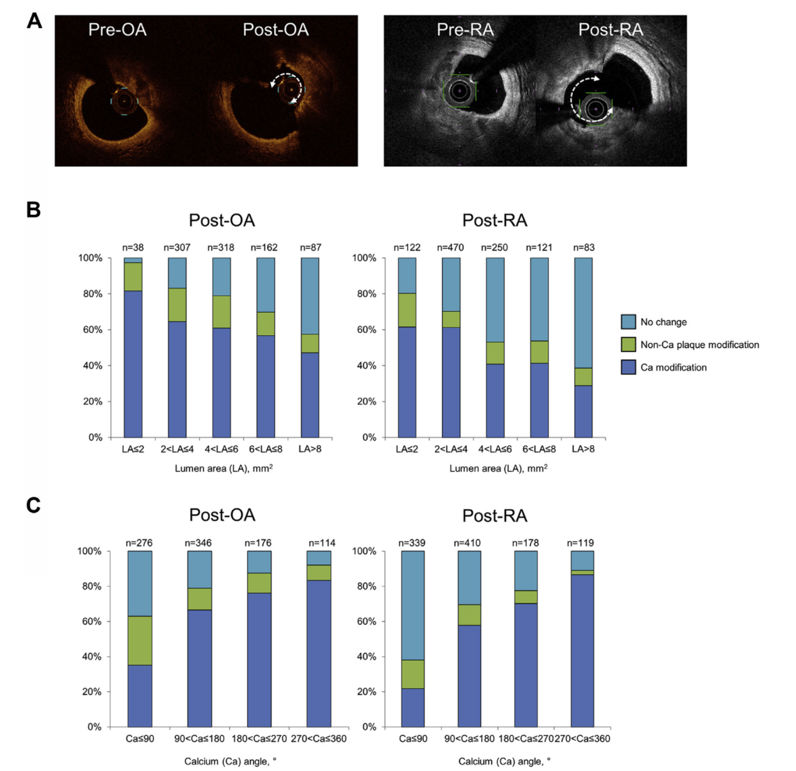
Mechanisms of Orbital Versus Rotational Atherectomy Plaque Modification in Severely Calcified Lesions Assessed by Optical Coherence Tomography

Rotational atherectomy (RA) and orbital atherectomy (OA) are designed to ablate calcified plaque, but differences in their mechanisms of action in vivo are not well described (1,2), despite the importance of atherectomy in treating complex coronary artery disease.

This was a retrospective observational study comparing the effects of OA ($n = 30$) versus RA ($n = 30$) on severely calcified lesions (maximum calcium angle by OCT $>270°$) followed by stenting from March 2014 to August 2016 at 3 centers (NewYork-Presbyterian Hospital, New York, New York: $n = 6$ [RA], $n = 6$ [OA]; Showa University Northern Yokohama Hospital, Yokohama, Japan: $n = 24$ [RA]; St. Francis Hospital, Roslyn, New York: $n = 24$ [OA]). OCT images were acquired with the ILUMIEN OPTIS system (St. Jude Medical, St. Paul, Minnesota) and the Dragonfly Duo or Dragonfly OPTIS imaging catheter (Abbott Vascular, Santa Clara, California) or the Lunawave optical frequency domain imaging system and FastView coronary catheter (Terumo, Tokyo, Japan). OCT was performed pre-intervention (if possible), post-atherectomy (RA or OA), and post-stenting.

Calcium cross-sectional area (CSA) at the maximum calcium ablation site was identified by comparing pre- and post-atherectomy images and measured by manual segmentation. Calcium angle and lumen CSA were measured every 1 mm throughout the calcified plaque in the post-atherectomy image. Calcium modification was identified as a round, concave, polished lumen surface (**Figure 1**). Noncalcified plaque modification was a round shape of the noncalcified plaque surface post-atherectomy. Stent malapposition (distance between stent strut and lumen surface >0.2 mm), asymmetry index (1 – minimum/maximum stent diameter irrespective of location), and eccentricity index (minimum/maximum stent diameter at same location) were evaluated. Calcium fracture was defined as discontinuity of the luminal surface in the calcified plaque.

FIGURE 1 Representative Image and Prevalence of Calcium Modification



(A) Comparing pre- and post-procedure in both orbital atherectomy (OA) and rotational atherectomy (RA), calcium modification (a round, concave, polished lumen surface; **dotted double-headed arrow**) was seen. The prevalence of calcium or noncalcified plaque modification as a function of **(B)** lumen area and **(C)** calcium angle. Compared with RA, OA creates more calcium modification, especially in a larger lumen area and more noncalcified plaque modification.

Median patient age was 69 (interquartile range [IQR]: 62 to 75) years, 65% were men, and 18% were on hemodialysis; lesions were in the left anterior descending artery in 72%, with angiographic severe calcification in 58% (no difference between OA and RA). Pre-procedural OCT imaging was performed in 33 lesions (18 OA; 15 RA). At the maximum calcium modification site, calcium CSA pre-atherectomy (OA 3.6 [IQR: 3.1 to 5.0] mm^2 vs. RA 4.5 [IQR: 3.0 to 6.5] mm^2; $p = 0.33$), post-atherectomy (OA 2.9 [IQR: 2.4 to 4.6] mm^2 vs. RA 3.8 [IQR: 2.7 to 5.9] mm^2; $p = 0.33$), and the decrease in calcium CSA from pre- to post-atherectomy (OA 0.56 [IQR: 0.38 to 0.76] mm^2 vs. RA 0.60 [IQR: 0.45 to 0.79] mm^2; $p = 0.49$) were not different between devices.

After either OA or RA, calcium and noncalcified plaque modification was colocalized at the site of the OCT imaging catheter. Among all analyzed slices, noncalcified plaque modification post-atherectomy (OA: 1,067 slices; RA: 1,389 slices) was more frequent in the OA group vs. the RA group (16.9% [IQR: 8.4% to 23.8%] vs. 10.0% [IQR: 6.4% to 14.0%] of slices per lesion; $p = 0.01$). Among slices with any OCT-defined calcium (OA: 912 slices; RA: 1,046 slices), there was a trend toward more post-atherectomy calcium modification after OA versus RA (63.6% [IQR: 43.6% to 71.3%] vs. 51.8% [IQR: 39.9% to 63.3%] of slices per lesion; $p = 0.09$), particularly at sites with a post-atherectomy lumen CSA >4 mm^2 (53.0% [IQR: 43.5% to 76.9%] vs. 35.0% [IQR: 0% to 52.2%] of slices per lesion; $p = 0.001$), but not ≤ 4 mm^2 (71.4% [IQR: 51.7% to 85.7%] vs. 66.7% [IQR: 50.0% to 85.8%] of slices per lesion; $p = 0.81$). Calcium modification was greater in slices with a smaller lumen CSA and a larger angle of calcium in both devices (**Figure 1**).

Comparing OA versus RA, minimum stent CSA (5.3 [IQR: 3.8 to 6.2] mm^2 vs. 5.0 [IQR: 4.6 to 6.1] mm^2; $p = 0.86$), stent expansion (67.4% [IQR: 55.0% to 80.5%] vs. 66.7% [IQR: 61.8% to 88.9%]; $p = 0.61$), asymmetry (0.35 [IQR: 0.26 to 0.41] vs. 0.34 [IQR: 0.24 to 0.34]; $p = 0.49$), and eccentricity (0.75 [IQR: 0.66 to 0.79] vs. 0.76 [IQR: 0.70 to 0.80]; $p = 0.29$) were similar. Although malapposition was frequent in both groups (OA: 96.7% vs. RA: 90%; $p = 0.61$), maximum malapposition CSA was limited (1.5 [IQR: 0.9 to 2.3] mm^2 vs. 1.1 [IQR: 0.8 to 1.8] mm^2; $p = 0.31$). Overall, calcium fracture behind stent was frequent (82%), with similar prevalence and length (OA: 4.5 [IQR: 1.9 to 7.9] mm vs. RA: 3.0 [IQR: 1.9 to 5.2] mm; $p = 0.38$). There was no coronary perforation.

Potentially due to the lack of randomization, patients undergoing OA had vessels with larger diameter (OA: 2.67 [IQR: 2.50 to 3.05] mm vs. RA: 2.49 [IQR: 2.30 to 2.92] mm; $p = 0.10$) and less severe narrowing (OA: 57.7% [IQR: 49.1% to 66.7%] vs. RA: 66.3% [IQR: 63.5% to 72.6%]; $p = 0.004$) in pre-procedural quantitative coronary analysis, thus a bias in device selection cannot be excluded.

With both RA and OA, guidewire bias contributes to and directs plaque modification. Compared with RA, OA creates more calcium modification in lesions with larger lumen area as well as more noncalcified plaque modification; the effect in lesions with smaller lumen area is similar between devices. Importantly, final stent expansion was similar after plaque modification with either device.

Myong Hwa Yamamoto, MD
***Akiko Maehara, MD**
Keyvan Karimi Galougahi, MD, PhD
Gary S. Mintz, MD
Yasir Parviz, MD
Sung Sik Kim, MD
Kohei Koyama, MD, PhD
Kisaki Amemiya, MD
Song-Yi Kim, MD
Masaru Ishida, MD
Monica Losquadro, MS, PA-C
Ajay J. Kirtane, MD, SM
Elizabeth Haag, RN
Fernando A. Sosa, MS
Gregg W. Stone, MD
Jeffery W. Moses, MD
Masahiko Ochiai, MD, PhD
Richard A. Shlofmitz, MD
Ziad A. Ali, MD, DPhil

*Cardiovascular Research Foundation
1700 Broadway, 9th Floor
New York, New York 10019
E-mail: amaehara@crf.org

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