Exploring Serration-Enhanced BTK Angioplasty

Investigators share case-based perspectives and trial experiences with the Serranator PTA Serration Balloon Catheter, now FDA-cleared for use below the knee.

WITH MICHAEL LICHTENBERG, MD, FESC; ANDREW HOLDEN, MBCHB, FRANZCR, EBIR; AND MARIANNE BRODMANN, MD

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Chronic limb-threatening ischemia (CLTI) is the clinical end stage of peripheral artery disease (PAD) and continues to be a challenge to treat effectively. No two cases are the same, and patients are often frail with multiple comorbidities. The ideal outcome is to save the limb, reduce and/or alleviate pain, improve wound healing, increase quality of life, and prevent the need for reintervention. Clinically, the aim is a substantial increase in lumen, restoring vigorous blood flow while avoiding dissections or the need for a stent. In an ideal world, I would have a singular endovascular tool that could quickly and reliably cross lesions, open the artery with low atmospheric pressure (reducing the likelihood of dissections), eliminate recoil, and avoid reintervention.

As a pragmatist, I know that no single tool can resolve the diversity of such a complex disease. A comprehensive set of tools will always be required. As endovascular specialists, we challenge ourselves to treat lesions that we wouldn't have otherwise attempted 10 years ago. Interestingly, despite some advances in endovascular tools and imaging that have enabled us to treat longer, narrower, more tortuous, and at times heavily calcified lesions, our mainstay tool remains plain old balloon angioplasty (POBA), which has been used for 40 years. Why is that? POBA remains an easy-to-use, low-cost tool; however, it is imperfect because it often yields unpredictable and undesirable results.

When treating below-the-knee (BTK) vessels, I am constantly concerned about causing more damage to the vessel with POBA and making an already bad situation worse. The procedural challenges I wrestle with when selecting POBA or another tool for each case include: Am I sizing the balloon appropriately? Am I crossing the true lumen? Will there be recoil after the balloon is removed? Am I going to cause a dissection and need a bailout? Is there adequate blood flow? Is this procedure taking too much time with too much contrast agent infusion? Will this intervention heal the patient's wound? Most importantly, was I able to prevent a major amputation?

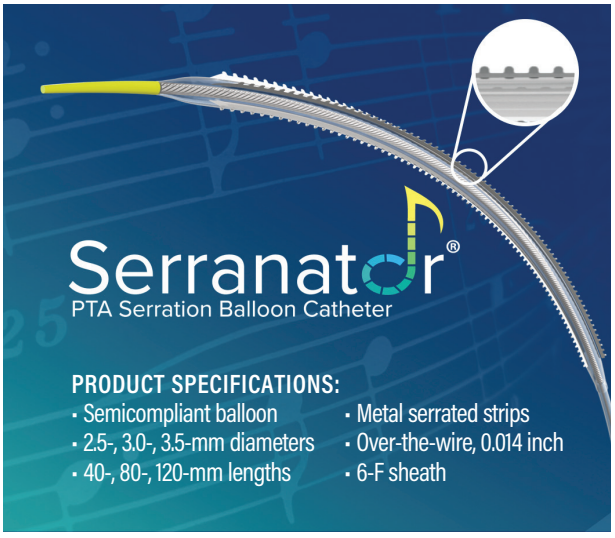
A new technology is being explored that offers the potential to (1) open BTK lesions repeatedly and reliably with minimal dissection and low atmospheric pressure and (2) reduce the need for stents using a novel mechanism of action. The PRELUDE BTK study, which recently completed enrollment, is assessing the Serranator balloon (Cagent Vascular) in infrapopliteal arteries. In this article, I review one of my case experiences using the device and interview my co-investigators Prof. Marianne Brodmann and Dr. Andrew Holden, who also share their own cases. Could this device be a long-awaited replacement for POBA in CLTI treatment?

THE SERRANATOR PTA SERRATION BALLOON CATHETER

The Serranator Percutaneous Transluminal Angioplasty (PTA) Serration Balloon Catheter is an FDA 510(k)-cleared, over-the-wire balloon dilatation catheter designed to perform PTA for peripheral indications. The Serranator is a nylon semicompliant balloon with three embedded external metal strips. These strips have unique serrated scoring

DID YOU KNOW?

Serration technology is widely used across many industries and applications to separate materials in a controlled and predictable manner. The Serranator is the first and only PTA balloon catheter that applies this technology and mechanism of action to angioplasty.



elements that apply more than 1,000 times the focal force of a plain balloon during inflation and create an interrupted line on the endoluminal surface along which the balloon energy will transfer. This enables the Serranator to modify plaque in a controlled, predictable manner and expand the artery with minimal injury.

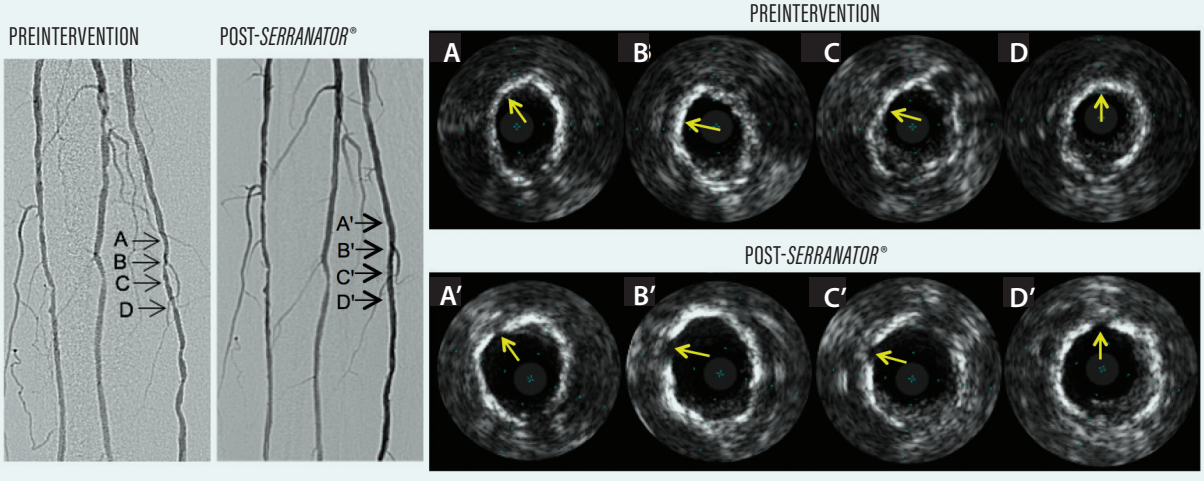
PRELUDE BTK STUDY

The PRELUDE BTK study is a single-arm, prospective, multicenter feasibility study that recently enrolled 49 patients with atherosclerotic lesions in the infrapopliteal arteries and/or CLTI. The study captured acute angiographic data of pre- and post-Serranator inflation effects. The patients will continue with 30-day and 6-month clinical follow-up, which is expected to conclude later this year. Key inclusion exclusion criteria are listed in Table 1.

Dr. Andrew Holden (Auckland, New Zealand) is the Principal Investigator of the study, and Dr. Michael Lichtenberg (Arnsberg, Germany) is the Principal Investigator of Germany. Additional investigators are Prof. Marianne Brodmann (Graz, Austria), Dr. med. Klaus

IVUS IMAGING OF POSTERIOR TIBIAL

Performed by Dr. Przemysław Nowakowski



Digital subtraction angiography showed a diffuse stenosis in right posterior tibial artery preintervention (left panel) and luminal enlargement without clear dissection post-Serranator (right panel). IVUS cross-sectional images (A–D) in preintervention angiography showed diffuse circumferential superficial calcification; and IVUS cross-sectional images (A′–D′) in post-Serranator angiography showed very discrete slits (yellow arrows) in the superficial calcium, enabling enlargement of lumen without any dissection. Discrete slits were observed in the same location longitudinally, indicating that they occurred along the length of the tibial artery. —Dr. Akiko Maehara, Cardiovascular Research Foundation.

TABLE 1. PRELUDE BTK STUDY: KEY INCLUSION/EXCLUSION CRITERIA	
Inclusion	**Exclusion**
Rutherford 3, 4, or 5 (up to 40% Rutherford class 3 allowed)	Rutherford 1, 2, or 6
Reference vessel diameter of 2.5–3.5 mm	In-stent restenotic lesions
Up to two lesions within infrapopliteal tibial arteries	Chronic total occlusion > 12 cm
Stenosis > 70%	Evidence of acute thrombus
Lesion(s) length < 12 cm	Atherectomy
De novo or nonstented restenotic lesions	Intended use of adjunctive therapies (eg, DCB or stents)

Hertting (Buchholz, Germany), Dr. Przemysław Nowakowski (Chrzanów, Poland), and Dr. Christian Wissgott (Rendsburg, Germany).

This study will build on the positive data previously reported in the PRELUDE ATK study, which examined the impact serrations had on femoropopliteal disease. The PRELUDE BTK study will further explore the device's impact on achieving optimal lumen gain at low atmospheric pressure with low dissection rates and severity. Optical coherence tomography (OCT) and intravascular ultrasound (IVUS) images will be analyzed by a core lab to visualize the material impact the serrations have on the artery (see *IVUS Imaging of Posterior Tibial* sidebar).

Case 1: Long CTO in Posterior Tibial

By Michael Lichtenberg, MD, FESC

A 78-year-old man complaining of rest pain of the right foot and necrosis of the first digit was admitted to the angiology department. His cardiovascular risk factors included poorly controlled diabetes and hyperlipoproteinemia. After performing duplex ultrasound, a short occlusion (5 cm) of the distal superficial femoral artery (SFA) was diagnosed; however, the mid and distal popliteal arteries exhibited no significant stenosis. Progression to the anterior tibial artery showed an insufficient collateralized proximal occlusion. The posterior tibial artery was the only inflow vessel to the foot, with a 150-mm-long, mildly calcified subtotal stenosis of the proximal third part of the vessel (Figure 1A). The patient's ankle-brachial index was 0.55.

> "In all the BTK cases I performed with the Serranator balloon, no adjunctive bailout therapy was necessary because no dissections or recoil reactions were recorded. Any technology that avoids vessel injury is a step toward improvement, leading to increased safety and efficacy."

CASE STUDY #1

Long CTO in Posterior Tibial

Performed by Dr. Michael Lichtenberg

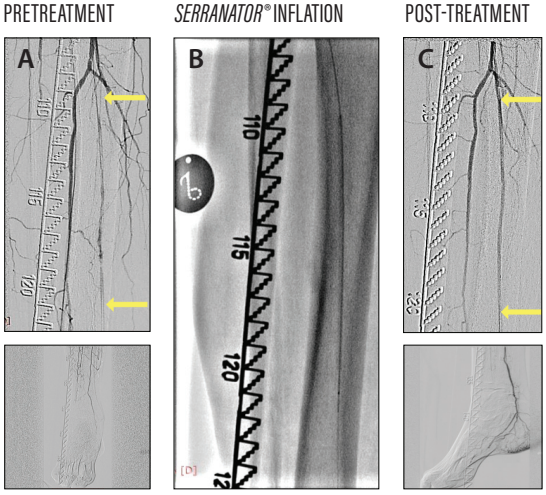


Figure 1. The reference vessel diameter was 2.15 mm, lesion length was 93.99 mm, and the percent stenosis was 100% (A). A 2.5- X 120-mm Serranator was inflated to 6 atm for 2 minutes (B). After treatment, residual stenosis was 15% (C). —SynvaCor-Prairie Education & Research Cooperative.

APPROACH

The procedure began with an antegrade access using a 6-F, 45-cm Fortress sheath (Biotronik, Inc.). Revascularization of the SFA lesion was performed with a 6- X 60-mm Pulsar-18 nitinol stent (Biotronik, Inc.) after predilatation. Target lesion intervention within the posterior tibial artery was performed after accessing with a 0.014-inch wire using the 2.5- X 120-mm Serranator device (Figure 1B). The Serranator balloon was inflated twice at 6 atm for 2 minutes across the entire length of the target lesion. Immediate postinterventional multiplanar angiography revealed a significant lumen gain of 2.5 mm within

the treated lesion, without any dissections, recoil, or need for bailout. The treatment resulted in brisk flow into the pedal arch (Figure 1C).

DISCUSSION

Having performed multiple cases with the Serranator, I selected the device for this particular case because I believe it is representative of the technology's ability to consistently minimize dissection and recoil. In contrast, dissections after POBA in BTK vessels are frequent and often even flow-limiting, forcing the interventionalist to bail out with a stent. When this happens, interventionalists are often urged to perform repetitive multiplanar angiography analysis, resulting in longer procedure times, increased contrast usage, and the possibility of leaving a scaffold behind. A tool that can reduce vessel injury and avoid these extra steps is a step toward improving safety and efficacy in BTK outcomes.

Case 2: Severely Calcified Tibioperoneal Trunk

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An 84-year-old woman presented to vascular outpatients with right lower leg CLTI, specifically a painful shin ulcer that started several months previously after minor trauma. Her comorbidities included treated hypertension and a previous coronary stent for which she was on aspirin and clopidogrel. MRA revealed right SFA stenoses as well as severely calcified tibioperoneal trunk and moderately calcified proximal peroneal artery stenosis.

APPROACH

The inflow stenoses in the SFA were successfully treated before treating the tibial lesions. The 2.5- X 80-mm Serranator was used in the tibioperoneal and proximal peroneal arteries and inflated slowly to 6 atm for 120 seconds. Although flow was brisk, a minimal 10% residual stenosis was observed, and it resolved with an additional inflation to 10 atm for 120 seconds. She was discharged the day after the procedure with ongoing wound care and planned vascular clinic surveillance.

CASE STUDY #2

Severely Calcified Tibioperoneal Trunk

Performed by Dr. Andrew Holden

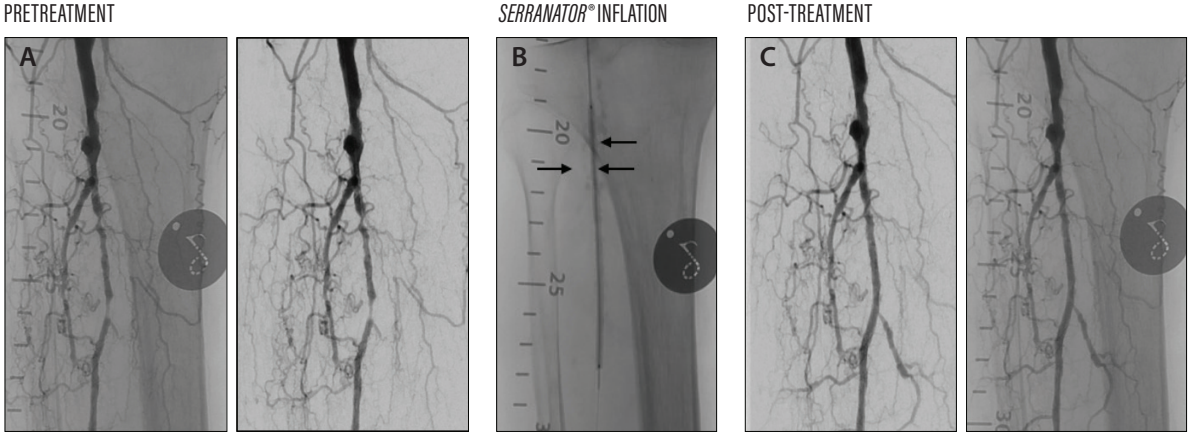

Figure 1. Angiography (unsubtracted and subtracted) showing severe stenotic disease involving the tibioperoneal trunk and proximal peroneal artery; the peroneal artery provided single-vessel runoff to the calf (A). The entire lesion was calcified and was severe in the tibioperoneal trunk (arrows; B). Completion angiography (unsubtracted and subtracted), showing excellent luminal gain and no dissection (C).

DISCUSSION

Dr. Lichtenberg: Without the Serranator, how would you normally treat this case, and what type of results would you expect?

Dr. Holden: This would normally have been treated with POBA. It is difficult to predict the result, but typically in a case like this, there would have been a reasonably high chance of dissection or residual stenosis, requiring a drug-eluting stent.

Dr. Lichtenberg: What makes this case interesting?

Dr. Holden: Angiographically, there was an excellent acute result, with no recoil or dissection despite the complexity of the lesion (Figure 1).

Dr. Lichtenberg: You are a skilled OCT operator, and you used OCT in this case. Were there any unique OCT outcomes?

Dr. Holden: OCT is the highest-resolution luminal imaging modality we have available, with spatial resolution typically of 15 µm compared to 200 µm with IVUS. OCT has been extensively used in coronary artery intervention, and the similar diameter tibial arteries are also extremely well visualized. The high spatial and contrast resolution of OCT allows unrivaled assessment of luminal gain and dissection flaps but also anatomy and pathology involving different layers of the vessel wall. Specifically, in the PRELUDE BTK study, the OCT cohort provided visualization of serrations on the intimal surface achieved by the Serranator catheter, confirming proof of concept of the serration effect (Figure 2).

Dr. Lichtenberg: Do you think there was any improvement in perfusion outcomes using this technology compared with what you would expect from POBA?

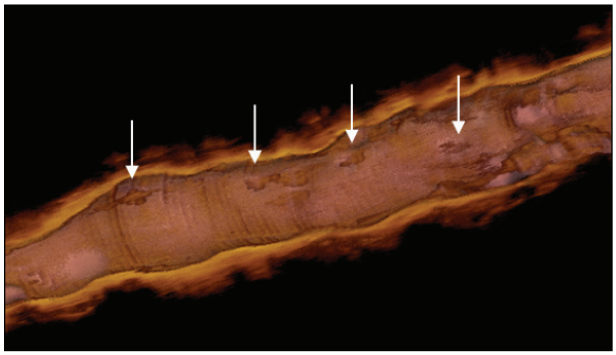

Figure 2. OCT performed after treatment with volume-rendered surface reconstruction. Note the serrations in the intimal surface produced by the Serranator catheter (arrows). An absence of dissection is also striking. —Dr. Andrew Holden

Dr. Holden: I've had the subjective experience that perfusion is better after treatment with Serranator compared with POBA.

Dr. Lichtenberg: How do you see this technology impacting the BTK treatment landscape?

Dr. Holden: Although it is too early to make any definitive conclusions, this case is a nice example of our promising experience to date. Based on experience with this catheter both above and below the knee, lesions that may respond particularly well to this technology include calcified and more complex lesions, although I wouldn't restrict the device to these cases. The role of the Serranator device in tibial artery intervention will become clearer with more experience. I am excited to continue to use this tool both in routine practice and future clinical trials. Such trials could include a randomized trial comparing the Serranator device with conventional angioplasty in tibial arteries, as well as assessing this device combined with drug-coated technologies.

Case 3: Brisk Flow Anterior Tibial

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A 71-year-old man with diabetes mellitus since 2016 currently treated with an oral antidiabetic drug, well-controlled arterial hypertension, hyperlipidemia (currently treated with statins), and a history of smoking was sent to our outpatient clinic due to a unimproved ulcer on his fifth toe. He was under regular observation at our diabetic foot clinic because the ulcer on this toe had a necrosis on the tip, but the lack of improvement required an intervention. MRA showed multiple lesions in the left BTK arteries.

CASE STUDY #3

Brisk Flow Distal Anterior Tibial

Performed by Prof. Marianne Brodmann

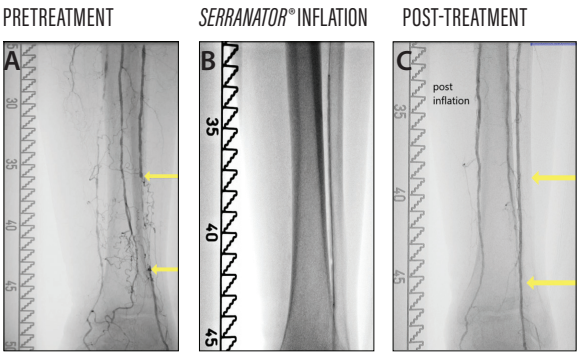

Figure 1. The reference vessel diameter was 2.2 mm, lesion length was 81.06 mm, and percent stenosis was 100% (A). A 2.5- X 120-mm Serranator was used at 4 atm for 2 minutes (B). After treatment, residual stenosis was 19% with brisk flow. —SynvaCor-Prairie Education & Research Cooperative.

CASE STUDY #3

Brisk Flow Proximal Anterior Tibial

Performed by Prof. Marianne Brodmann

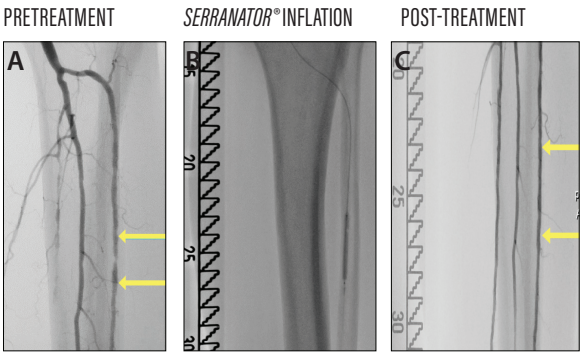

Figure 2. The reference vessel diameter was 2.28 mm, lesion length was 7.13 mm, and percent stenosis was 67% (A). A 3- X 40-mm Serranator was used at 5 atm for 2 minutes (B). After treatment, residual stenosis was 7% with brisk flow (C). —SynvaCor-Prairie Education & Research Cooperative.

APPROACH

The posterior tibial artery was treated first with POBA, and the anterior tibial branch had two lesions that qualified for treatment with the Serranator. The lower lesion was a 120-mm-long total occlusion and was treated with a 2.5- X 120-mm Serranator (Figure 1). The final inflation was at 4 atm for 120 seconds, with good results. The more proximal second lesion was approximately 20-mm-long and was treated with a 3- X 40-mm Serranator balloon at 5 atm for 120 seconds (Figure 2).

DISCUSSION

Dr. Lichtenberg: Without the Serranator, how would you normally treat this case, and what type of results would you expect?

Prof. Brodmann: Normally, we would have performed a POBA procedure and expected some kind of relevant recoil. It is normal when using POBA to hold the balloon open for more than 2 minutes and to repeat extended inflation times to reduce recoil events.

Dr. Lichtenberg: What makes this case interesting?

Prof. Brodmann: This case is exciting because of the direct comparison between both POBA and the Serranator in the same procedure. We observed a much better outcome with the Serranator-treated lesion (anterior tibial) compared with the POBA-treated lesion (posterior tibial), where some recoil was visible. In addition, the flow down to the foot was significantly better in the Serranator-treated vessel.

Dr. Lichtenberg: Did the Serranator results surprise you in any way?

Prof. Brodmann: Yes and no! Because we already had the opportunity to work with this device above the knee, we understood the underlying technology and its strength in achieving good results, so we were not surprised about that! But yes, with regard to BTK treatment, this might be an ideal treatment modality for overcoming the issues we face there: recoil and dissection. We have not seen either of these events so far after treating 15 patients at our center in the PRELUDE BTK trial.

Dr. Lichtenberg: Do the results in this case or other cases change your view on the direction of endovascular treatments for PAD/CLTI?

Prof. Brodmann: Yes, I would suggest that with this technology, we could achieve an ideal vessel prep for a drug-coated balloon in a very simple and straightforward way by increasing drug infusion into the tissue of the BTK arteries. Therefore, this would improve our CLTI treatment and be a meaningful step forward. In the above-the-knee vessel bed, I would even guess that the Serranator device could enhance drug uptake

through the vessel wall, while creating a better lumen with less recoil and lower-grade dissections.

Dr. Lichtenberg: In what types of cases would you choose to use the Serranator instead of POBA?

Prof. Brodmann: Based on my experience, I would want to use the Serranator in lieu of POBA for chronic total occlusions, which usually have a high rate of recoiling. More broadly, I see the Serranator as a tool for improving BTK outcomes, either as a prep for a drug-based therapy or as the definitive stand-alone therapy. A tool that is both easy to use and improves outcomes would be a game-changer. With improved outcomes, I would be further incentivized to use the Serranator.

WHERE DO WE GO FROM HERE IN BTK?

By Michael Lichtenberg, MD, FESC

Despite the many advances in BTK technologies, treatments remain challenging due to variability in plaque burden, difficulty in crossing long CTOs, increasing lesion lengths, and the nature of small caliber arteries. To move the endovascular treatment field forward, physicians require tools that prioritize simplicity and versatility. Simplicity refers to the use of familiar and consistent interventional techniques, and versatility refers to the ability to treat a wide variety of lesion morphologies. The disease is already challenging enough. Let's have tools to make it less so.

The core technology of angioplasty hasn't changed much in 40 years. Yes, it works; but it often results in inadequate lumen gain, recoil, and uncontrolled dissection, which is not an elegant solution. The guiding principle we are ultimately seeking is consistency in lumen gain with minimal injury. The incremental advances in angioplasty balloon design (high pressure, wire-based, ultrasonic, drug-coated) make their applications somewhat niche and are accompanied with trade-offs. For example, certain balloons are excellent for treating severely calcified lesions but are less effective in soft or eccentric plaque. Others have excellent crossing capability but have a higher probability of causing dissection or resulting in recoil. The challenge physicians face is discerning in real time which of the myriad balloon technologies will best suit a highly variable circumstance. We need a balloon that offers the versatility to treat a wide range of disease morphologies 90% of the time and takes away the pressure of selecting the exact tool needed.

> "To move the endovascular treatment field forward, physicians require tools that prioritize simplicity and versatility. Simplicity refers to the use of familiar and consistent interventional techniques, and versatility refers to the ability to treat a wide variety of lesion morphologies."

Based on my experience, the Serranator offers the versatility and simplicity that I need in my practice. It achieved excellent acute results in a range of lesion morphologies using the familiar platform of POBA. To further my experience, I would like to see additional studies to evaluate the Serranator's ability to reduce recoil, particularly in BTK lesions where recoil remains unaddressed. ■