A blunt needle endoluminal cracking over the strained through-and-through wire for balloon crossing the heavy calcification and chronic total occlusion in critical limb ischemia

Suthas Horsirimanont, MD, *and* Nutsiri Kittitirapong, MD, *Bangkok, Thailand*

ABSTRACT

The Achilles heel of revascularization in chronic limb-threatening ischemia is that a balloon is sometimes unable to cross the severely calcified below-the-knee lesion. We presented a new technique for crossing this lesion using the blunt needle endoluminal cracking over the strained through and through wire (BECOST) technique. (J Vasc Surg Cases Innov Tech 2025;11:101712.)

Keywords: Heavy calcified; Crossing; Chronic total occlusion; Novel technique; BECOST

Endovascular techniques for revascularization in chronic limb-threatening ischemia are widely used.[1-3] One of the problems of recanalization is heavy calcification. Heavy calcification results in difficulty in puncturing a vessel, guidewire passage, balloon crossing, balloon dilatation, stent placement, and short- and long-term outcomes.[4-6] Although new technologies in endovascular equipment have been developed, crossing a balloon in heavy calcification remains a problem of revascularization. We present a new technique for crossing a heavily calcified lesion using a blunt needle called the blunt needle endoluminal cracking over strained through-and-through wire (BECOST).

This study was conducted according to the principles of the Declaration of Helsinki and was approved by the institutional review board. All patients gave informed consent to publish their case details and images.

CASE REPORT

From January 2020 to January 2024, five patients underwent the BECOST technique. All patients presented with considerable tissue loss from chronic limb-threatening ischemia and below-the-knee (BTK) lesions. There were four cases of total occlusion and one of severe stenotic lesions. Endovascular treatment was an alternative option because of the high perioperative cardiovascular risk and severe calcified BTK lesions as limitations for bypass surgery. A balloon could not cross any of the lesions, even though a wire could pass through. All patients experienced failure of the balloon deployment using the forcible manner (BADFORM) technique,[7] which is widely accepted for overcoming this lesion.

PROCEDURAL DETAILS

We used an ipsilateral antegrade approach because the patients had BTK lesions. A long 4F sheath inserted 60 cm was into the lower third of the popliteal artery. Angiography was performed (Fig 1). We used a Hi-Torque Command™ ES 300-cm guidewire supported by an Armada XT 2/20 balloon catheter (Abbott Vascular International BVBA, Diegem, Belgium). After passing the wire through the lesion, we could not pass the balloon over the heavily calcified lesion. We initially attempted to perform the BADFORM technique.[7] The BADFORM technique is widely used when a balloon becomes stuck in a lesion. The first step was to create a through-and-through wire. Two strategies were used to create the through-and-through wire. First, we used retrograde puncture and exteriorized the wire via the retrograde needle. Second, a catheter and wire were inserted in a retrograde manner after retrograde puncture. An antegrade wire was cannulated to a retrograde catheter, or a retrograde wire was cannulated to an antegrade catheter. In the BADFORM technique, after creating the through-and-through wire, the bottom of the antegrade balloon is locked with the wire, and the wire with the balloon is pulled from below. If we were unsuccessful in pulling the balloon down, it resulted in two markers or dots of the balloon coming closer (Fig 1), and we then changed to the BECOST technique.

During the BECOST technique, we inserted a blunt-tip needle retrogradely over the through-and-through wire, aiming to forcefully crack and pass the calcified arterial segment. A blunt-tip needle was preferred for cracking the calcium and enlarging the lumen because it causes less trauma to the wire and the artery. Additionally, the adjustable curve of the needle shaft enabled easier

From the Division of Vascular and Transplant Surgery, Department of Surgery, Faculty of Medicine, Ramathibodi Hospital, Mahidol University.

Correspondence: Nutsiri Kittitirapong, MD, Division of Vascular Surgery, Department of Surgery, Faculty of Medicine Ramathibodi Hospital, Mahidol University, 270 Rama VI Rd, Bangkok 10400, Thailand (e-mail: nutsiri.kit@mahidol.ac.th).

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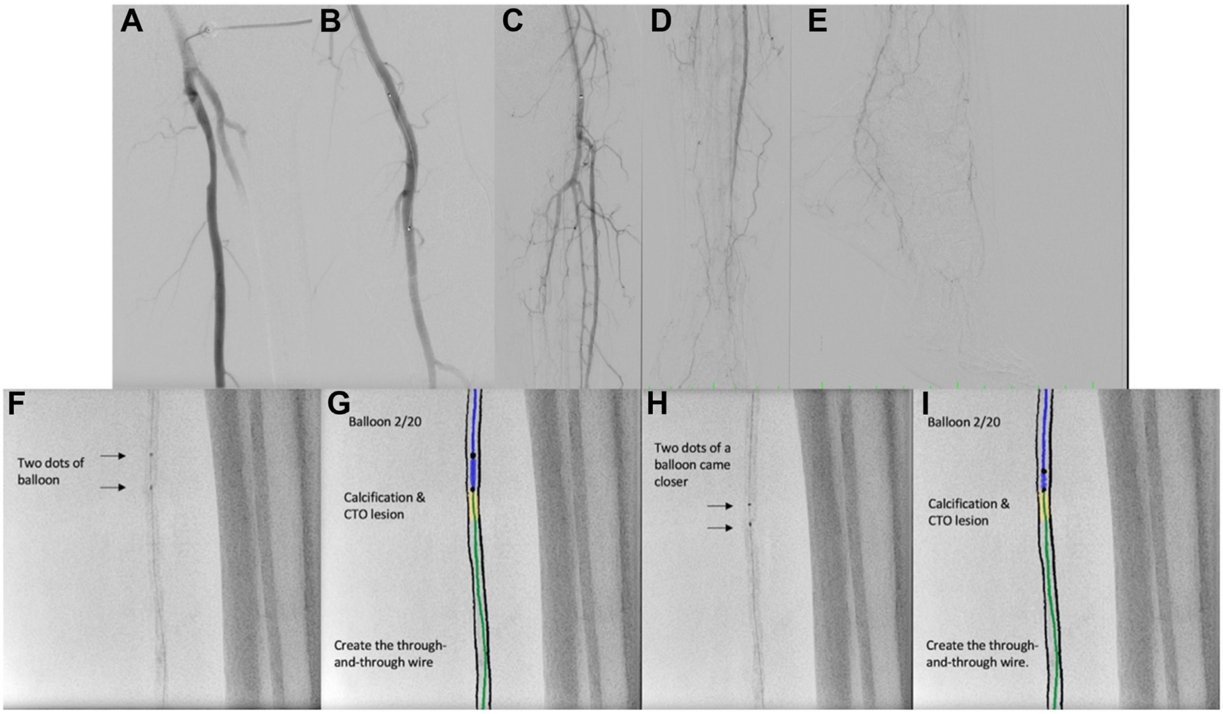

Fig 1. Results of angiography. The superficial femoral and popliteal arteries are patent **(A** and **B)**. However, the mid to distal part of the posterior tibial artery is occluded **(C-E)** owing to heavy calcification **(F)**. After passing a wire through the lesion, we could not pass the balloon over the heavily calcified section. We first tried to use the balloon deployment using the forcible manner (BADFORM) technique, which involves creating a through-and-through wire by externalizing the wire using retrograde puncture of the target vessel and then pulling the system, wire, and balloon down. If we fail to pull the balloon and the two balloon dots come closer **(F-I)**, we consider the BADFORM technique a failure. In this case, we turned to the blunt needle endoluminal cracking over strained through-and-through wire (BECOST) technique. *CTO*, chronic total occlusion.

insertion. The blunt-tip needle was usually inserted over the retrograde wire because it was nearer to the lesion, which made it easier to push than using the antegrade manner for the BTK lesion. The length of the blunt-tip needle was determined by the distance from the distal puncture site or site of wire exteriorization to the proximal end of the stuck lesion. If the distance was less than 10 cm, we used a 0.009″- to 0.018″-guidewire introducer in an accessory kit with a copilot set (Abbott Vascular International BVBA) that was 12 cm in length. If there was a longer distance—up to 20 cm—we used the outer part of a percutaneous nephrostomy needle (18G or 22G, 20 cm) (Echotip Skinny Needle with Chiba Tip; Cook Incorporated, Bloomington, IN). Additionally, we used a 16G blunt long needle for a Protescal injection (LG Chem, Seoul, Korea) for a distance of up to 30 cm (Fig 2). We could adjust the location of the wire exteriorization to shorten the needle length.

While inserting the needle over the through-and-through wire, pulling both sides of the wire tight was crucial. A blunt-tip needle was inserted over a strained through-and-through-wire with forceful power for cracking of calcium; it was passed through, and the calcified arterial segment was opened. We attempted to pass the needle only once the first time and pull the balloon down. We used a larger needle if the balloon failed to pass the lesion. To minimize distal emboli, we

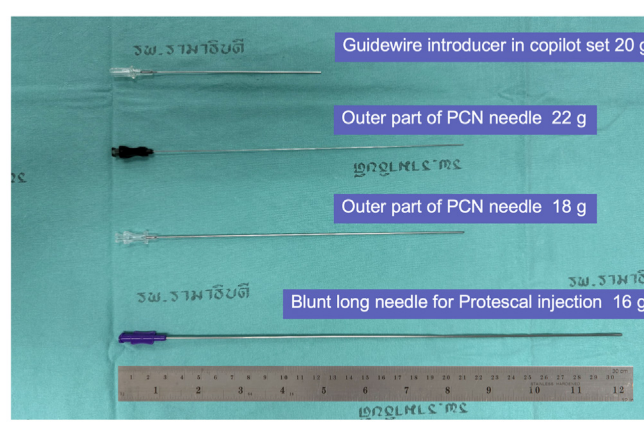

Fig 2. Blunt tip needles used in the blunt needle endoluminal cracking over strained through-and-through wire (BECOST) technique. *PCN*, percutaneous nephrostomy catheter.

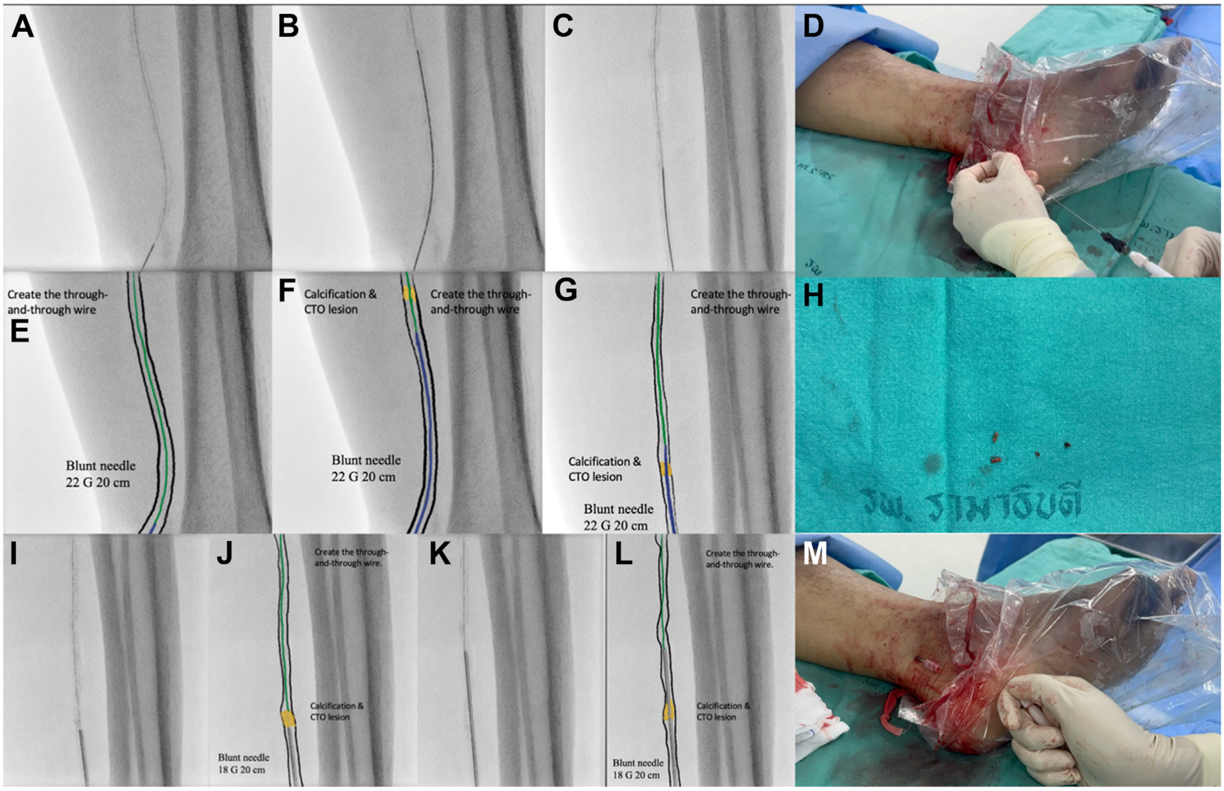

Fig 3. Details of the blunt needle endoluminal cracking over strained through-and-through wire (BECOST) technique. While inserting the needle over a through-and-through-wire, pulling tight both sides of the wire is crucial. Insert a blunt-tip needle, 22G, 20 cm **(D)**, over a strained through-and-through-wire to forceful cracking and pass through the calcified arterial segment **(A-E, B-F,** and **C—G)**. The calcium arterial segment opened after several blunt-tip needle passings and was exchanged for the bigger needle, 18G 20 cm (**M, I-J,** and **K-L**). Sometimes, the calcium was cracked and revealed in the needle hole **(H)**. *CTO*, chronic total occlusion.

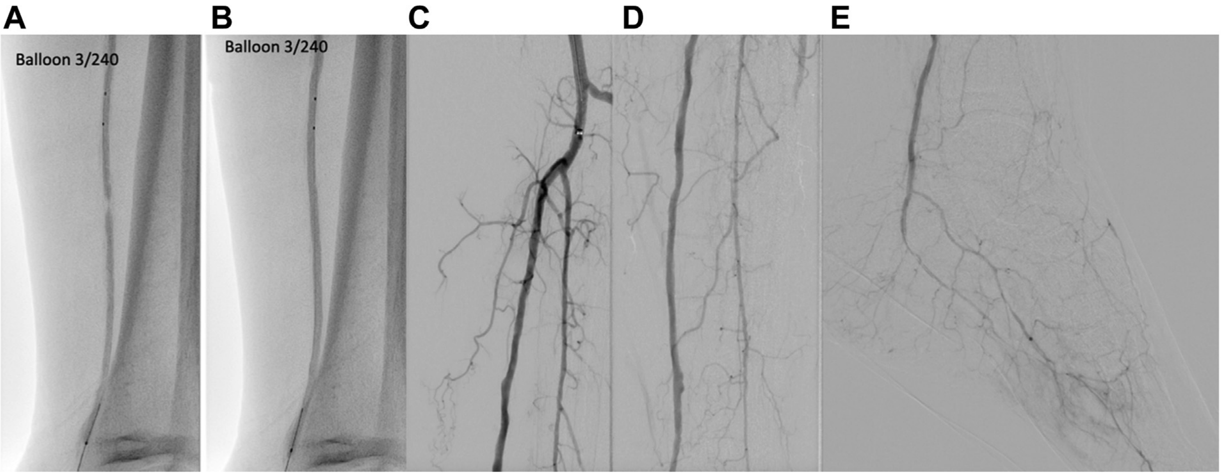

Fig 4. Steps after performing the blunt needle endoluminal cracking over strained through-and-through wire (BECOST) technique. The balloon can be passed through the lesion and inflated from the nominal pressure **(A)** to the rated burst pressure **(B)**. The new wire was exchanged and cannulated the distal posterior tibial artery. Manual compression was performed at the punctured site. Complete angiography revealed the patent of the posterior tibial artery without extravasation **(C-E)**.

Table. Details of the patients' characters, lesion character, procedural technique, type of needle, and outcome

Patient no.	Sex	Age, years	Presentation	DM	On HD	Lesion	Location of balloon could not cross	Lesion	Location of retrograde punctured	Length from retrograde punctured site to lesion that balloon could not cross, cm	Needle type
1	Male	74	Major tissue loss	Yes	No	BTK	Distal third ATA	Occlusion	Distal ATA	10	Guidewire introducer in Copilot set 20G
2	Male	77	Major tissue loss	Yes	Yes	BTK	Mid ATA	Occlusion	Distal ATA	15	Outer part of PCN needle 22 G
3	Male	59	Major tissue loss	Yes	Yes	BTK	Distal ATA	Stenosis	DPA	6	Outer part of PCN needle 22G and 18G
4	Male	60	Major tissue loss	Yes	No	BTK	Mid PTA	Occlusion	Distal PTA	18	Outer part of PCN needle 22G, 18G and blunt long needle for Protescal injection 16G
5	Female	89	Major tissue loss	No	No	BTK	Lateral plantar branch of PTA	Occlusion	Distal PTA	8	Outer part of PCN needle 22G

ATA, Anterior tibial artery; *BKA*, below-the-knee amputation; *BTA*, below-the-ankle lesion; *BTK*, below-the-knee lesion; *DES*, drug-eluting stent; *DPA*, dorsalis pedis artery; *HD*, hemodialysis; *PCN*, percutaneous nephrostomy catheter; *PTA*, posterior tibial artery.

applied a tiny needle via a retrograde wire. If there were any emboli, they immediately became trapped at the distal puncture site upon needle withdrawal in the subcutaneous tissue because of the lower resistance compared with the native vessel. Sometimes, the calcium was cracked and revealed in the needle hole (Fig 3). After we performed the BECOST technique, we used the BADFORM technique to create the through-and-through wire, lock the bottom of the balloon with the wire, pulled the wire together with the balloon, and dilate the vessel. To prevent dissection, we used a smaller needle at the first passing and dilated the lesion using a high-pressure balloon to the target vessel diameter for at least 3 minutes. If there was flow-limiting dissection and acute elastic recoil, we placed a drug-eluting stent in that area. Hemostasis of the punctured vessels was performed using hand compression from the outside and internal compression using balloon dilatation. The procedural steps are illustrated in Figs 3 and 4. We defined the technical success of the BECOST technique as the ability to pass the balloon over a lesion in which the BADFORM technique failed, and we restored blood flow to the foot.

RESULTS

The technical success of the BECOST technique was 100%, without any guidewire breakdown or bending, and without vessel rupture. All lesions were dilated without problems using a high-pressure balloon. Three cases had minimal non-flow-limited dissection after ballooning, and one required a drug-eluting stent. Faced with a puncture site problem, we successfully performed manual compression in four cases, and only one case required a balloon-assisted thrombin injection. Three cases had complete wound healing within 3 months after minor amputation. One case had successful foot loop recanalization, but no outflow from the foot loop. Therefore, amputation below the knee was performed. One case required reintervention within three months because of restenosis. The Table shows the patient characteristics, lesion characteristics, procedures, and outcomes.

DISCUSSION

Heavy calcification remains a major problem of endovascular revascularization in chronic limb-threatening ischemia. Sometimes, a balloon cannot cross a heavily calcified lesion, but a wire can. The dilemma for surgeons is whether to continue to attempt the procedure or to give up. The coronary balloon is a monorail system that lacks sufficiently strong support to cross heavily calcified lesions. To address this issue, we used the Armada XT 14 as a supportive catheter because of its small profile and good support capabilities through an over-the-wire system. Although orbital atherectomy is effective in treating a proximal BTK lesion, difficulty can arise in distal tibial vessels with heavy calcification. Additionally, this method

Table. Continued.

Chiba procedure time, minutes	Needle passing, times	Operative time, minutes	Technical success	Reintervention	Punctured site hemostatic management	Type of amputation	Time to wound heal, days
5	1	240	Yes	No	Thrombin injection	Transmetatarsal amputation	86
3	1	340	Yes	No	Compression	Second and third toe amputations	70
5	3	230	Yes	No	Compression	First toe amputation	69
8	3	510	Yes/recoil at mid PTA-DES	Yes	Compression	Transmetatarsal amputation	141
3	1	429	Yes, but after BTA intervention, no run off at foot	No	Compression	BKA	BKA after 2 days postoperative

can be expensive. Many novel techniques have been proposed to treat this type of lesion.

First, Nakabayashi et al[7] proposed the BADFORM technique, in which the wire is externalized using retrograde puncture of the target vessel, and the antegrade wire is passed through the bevel of the retrograde needle. The through-and-through wire is then created. The system, wire, and balloon are pulled down. This procedure can increase the success rate of passing the balloon by up to 70%, but a large problem is the destruction and disruption of the balloon during the process, and sometimes the balloon still cannot be passed through.

Second, Ichihashi et al[8] proposed percutaneous direct needle puncture of calcified plaques using the PIERCE technique. This technique uses percutaneous external needle punctures to crack calcified plaques under fluoroscopic guidance. A major concern regarding this technique is the risk of arterial perforation or rupture and nerve or vein injury caused by the external needle puncture. Even after performing the PIERCE technique for a calcified vessel, the balloon may not be able to pass the lesion, and sometimes the wire is destroyed.

Third, Kawarada et al[9] used percutaneous intravascular cracking with a guidewire tail, which is called the PICKING technique. This technique involves placing a 3F to 5F catheter just above the lesion. A tailed 0.018 wire is passed transluminally and parallel in the longitudinal plane with a 0.014 wire for cracking the calcium. Issues of concern for this technique include difficulty delivering the catheter and arterial perforation by the parallel wire. Sometimes, the wire cannot crack the calcium, and the balloon still cannot pass the lesion.

Fourth, Kum et al[10] proposed the DECIAP technique, which involves making a small incision over the lesion and using an external clamp to crack the calcium under fluoroscopy. The major issues with this approach are the healing of skin incisions and arterial rupture caused by clamp cracking.

Fifth, Nakama et al[11] and Takei et al[12] proposed the inner PIERCE technique. After guidewire externalization and a through-and-through wire is created, a sharp percutaneous transhepatic cholangiodrainage needle[11] or a long 20G needle[12] is advanced over the bidirectional wire using a rotational motion into the severely calcified plaque. Possible issues include bending or destruction of the guidewire and vessel wall injury by the sharp needle. The BECOST technique requires externalization of the wire. A blunt needle is inserted retrogradely over a through-and-through wire, cracking the intraluminal calcium. This technique might cause distal embolization because it cracks intraluminal calcium, but we have never observed this outcome. Other potential complications of the BECOST technique include puncture site bleeding and extravasation. The advantage of this technique is that it is effective for heavy calcified BTK lesions. The calcium can be cracked from the intraluminal pathway, and this approach seems to debulk the calcium, which can be seen in the needle hole. The other benefits of the BECOST technique are less vessel perforation, less arterial injury, and less wire injury than other techniques, as well as low cost and effectiveness. This technique could not be performed if the wire failed to cross the lesion to the intraluminal distal artery and if the wire failed to exteriorize.

CONCLUSIONS

Balloons cannot pass through severely calcified BTK lesions, which poses a challenge and affects the success of endovascular treatment. The BECOST technique is viable and provides an additional option for surgeons when necessary.

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DISCLOSURE

None.

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