Efficacy of Navigating Through the Intraplaque Route using AnteOwl WR Intravascular Ultrasound in Femoropopliteal Chronic Total Occlusion

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Abstract

Background

There is no consensus on the optimal guidewire passage route for femoropopliteal (FP) chronic total occlusion (CTO). If intraplaque wiring can be performed, a stent-less strategy using a drug-coated balloon (DCB) can be realized even with FP CTO, and there is a high possibility that good expansion can be obtained even when stent deployment is performed. AnteOwl WR (AnteOwl) is a novel intravascular ultrasound (IVUS) device useful for navigating the second guidewire into the intraplaque route under IVUS observation from the subintimal space. Here, we describe representative cases of FP CTO in which CTO-specific IVUS was extremely useful.

Case presentation

Case 1 was a 79-year-old man undergoing hemodialysis who presented with claudication of the left lower limb. Control angiography showed total occlusion of the left superficial femoral artery (SFA). We performed antegrade wiring, but the guidewire was advanced into the subintimal space. We advanced AnteOwl into CTO. Using the AnteOwl IVUS transducer and IVUS-wire bias, we found that the IVUS-wire is at the top and the transducer is at the bottom, and based on this information, a plaque to aim exists on the right side of the IVUS catheter at right anterior oblique of 30°. By aiming the wiring in that direction, we succeeded in traversing the center of the plaque and finally succeeded in obtaining good expansion using the DCB. Case 2 was of an 76-year-old woman with ulceration and gangrene of the left foot. Control angiography showed total occlusion from the SFA to the popliteal artery (Pop A). When AnteOwl was placed on the wire and advanced to the Pop A, the subintimal space in the middle of the SFA could be visualized. We employed an IVUS-guided parallel wire technique and succeeded in passing through all intraplaque routes. Although the CTO was long, we could easily advance through the intraplaque route by reflecting the information obtained from AnteOwl in angiography.

Conclusions

AnteOwl is an effective IVUS technique for FP CTO and facilitates a complex IVUS-guided procedure.

Background

Developments in endovascular therapy (EVT) led to one of the first-line treatment strategies for femoropopliteal (FP) occlusive diseases (Norgen et al., 2007; Aboyans et al., 2017). Various techniques and devices have improved guidewire crossing and initial success for FP chronic total occlusion (CTO) (Kawasaki et al., 2008; Urasawa et al., 2014; Kitrou et al., 2015; Tan et al., 2017; Hayakawa et al., 2020). Some studies have reported the usefulness of performing an intraluminal approach with intravascular ultrasound (IVUS) guidance (Mori et al., 2017; Tsubakimoto et al., 2020). Alternatively, IVUS-guided intraplaque wiring requires high technical skills, and problems such as procedure time and the number of wires tend to be highlighted.

AnteOwl WR (AnteOwl) (TERUMO, Tokyo, Japan) is a novel IVUS device that is specialized in CTO (Fig. 1A). The transducer profile is small (2.6 Fr), and the length from the tip to the transducer is short (8 mm). Durable coating and the long proximal guidewire lumen improve crossability within the CTO. We can easily convert IVUS images into angiographic images for navigating the second guidewire through an intraplaque route under IVUS observation from the subintimal space using the asymmetrical structure of the transducer and IVUS guidewire (Fig. 1B, C). This IVUS device has a pullback transducer system, and the frequency is 40 MHz; this can be evaluated sufficiently in a peripheral artery (Fig. 1D). We have used Eagle-Eye Platinum ST IVUS (Philips, Amsterdam, The Netherlands) and Navifocus WR IVUS (TERUMO, Tokyo, Japan) mainly for EVT. Eagle-Eye Platinum IVUS has excellent pushability, but the tip has a symmetrical structure, and converting IVUS images into angiographic images was difficult. In addition, it can only produce 20-MHz images, which contains blood vessel information that is inferior to that shown in 40-Mhz images. Navifocus WR IVUS is the predecessor of AnteOwl, and its structure is similar to that of AnteOwl. However, AnteOwl has a shorter distance from the tip to the transducer and has an improved coating, which makes it more convenient to use in navigating through CTOs. In addition, AnteOwl has a pullback transducer system, making wiring within CTOs much easier.

The usefulness of AnteOwl in the coronary CTO field has been reported (Okamura et al., 2020; Tanaka et al., 2020), but not in the EVT field. Therefore, here we describe representative cases of FP CTO in which AnteOwl was useful.

Case Report

Case 1

A 79-year-old man undergoing hemodialysis owing to diabetes mellitus presented with claudication of the left lower limb. The patient's ankle–brachial index was 0.70 on the left side. A 6-Fr guiding sheath (Destination® guiding sheath; TERUMO, Tokyo, Japan) was inserted into the right common femoral artery (CFA) via the contralateral approach. Control angiography showed a tandem stenotic lesion in the left proximal SFA and total occlusion of the left middle to distal aspects of the SFA (Figure 2A, B). First, 0.014-inch guidewire (Gladius MGES® guidewire; Asahi Intec, Aichi, Japan) and 2.6-Fr microcatheter (Ichibanyari PAD2® microcatheter; Kaneka, Tokyo, Japan) seemed to be advanced into the subintimal space. We advanced AnteOwl (AnteOwl WR® IVUS; TERUMO, Tokyo, Japan) into the CTO. IVUS showed that the guidewire was in the subintimal space proximal to the CTO. To convert the direction of IVUS findings to angiography, first, we performed rotational angiography from right anterior oblique (RAO) 40°to left anterior oblique (LAO) 40°, whose direction was the orthogonal axis against the CTO, to understand which was the upper side of the transducer and IVUS-wire. The transducer was on the left side at RAO 30°, and the transducer and IVUS-wire almost overlapped at LAO 15° (Figure 2C, D). On the basis of these findings, we confirmed that the transducer was at the bottom and the IVUS-wire was at the top. The detector direction at which the transducer and IVUS-wire coincided on the angiographic image was LAO 15°. Next, the detector direction where the transducer and target plaque were maximally separated was at RAO 30°, which was at 45° rotation to the clockwise direction from LAO 15° to RAO 30°

(Figure 2E). We advanced a 0.014-inch guidewire (Astato XS9-40® guidewire; Asahi Intec, Aichi, Japan) and 2.6-Fr microcatheter (Ichibanyari PAD2® microcatheter; Kaneka, Tokyo, Japan) a few millimeters to the right (LAO side) of IVUS on angiography, and we could advance through the intraplaque route and succeeded in penetrating the lesion (Figure 2F, G). After the predilation, we dilated a 6.0- × 150-mm drug-coated balloon (DCB) (In.Pact Admiral® DCB; Medtronic, Minneapolis, MN, USA) at the SFA lesion to prevent restenosis (Figure 2H, I). The final angiography showed good antegrade flow without any dissection and residual stenosis (Figure 2J).

Case 2

An 76-year-old woman with diabetes mellitus and old cerebral infarction presented with ulceration and gangrene of the left foot. Preoperative contrast-enhanced computed tomography showed total occlusion beyond the left external iliac artery (EIA) (Figure 3A). First, we treated the EIA to the CFA using a transradial approach (Figure 3B). Next, we treated FP CTO using an ipsilateral antegrade approach. Control angiography showed total occlusion from the SFA proximal to the Pop A (Figure 3C, D). We advanced a 0.014-inch guidewire (Gladius MGES® guidewire; Asahi Intec, Aichi, Japan) and 2.6-Fr microcatheter (Ichibanyari PAD2® microcatheter; Kaneka, Tokyo, Japan) to the Pop A. We advanced AnteOwl IVUS into the CTO (Figure 3E). Because it was a subintimal route from the distal aspect of the SFA shown in the IVUS findings, we performed an IVUS-guided parallel wiring technique through the intraplaque route. As AnteOwl had a pullback system, performing the parallel wiring technique in real time was possible while observing the lesion in front without inserting and removing the IVUS catheter advanced to the distal aspect of the CTO. By reflecting the IVUS findings into an angiographic image in the same manner as in Case 1, we found that the left side (RAO side) of the IVUS catheter on angiography should be aimed at the distal aspect of the SFA, and the right side (LAO side) of the IVUS catheter should be aimed at the Pop A (Figure 3 F–I). We advanced a 0.014-inch guidewire (Astato XS9-40® guidewire; Asahi Intec, Aichi, Japan) and a 2.6-Fr microcatheter (Ichibanyari PAD2® microcatheter; Kaneka, Tokyo, Japan) and succeeded in accessing the lesion (Figure 4A, B). After the predilation, we deployed three drug-eluting stents (Eluvia® drug-eluting stent; Boston Scientific, Marlborough, MA, USA) from the SFA to the Pop A. The final angiography showed good antegrade flow (Figure 4C–E).

Discussion

We demonstrated the feasibility of EVT for FP CTO using the AnteOwl IVUS-guided approach. In these cases, we could pass through all intraplaque routes via an antegrade approach despite the complexity of the CTO lesion. Studies have reported the use of AnteOwl IVUS in the coronary artery CTO field (Okamura et al., 2020; Tanaka et al., 2020); however, to the best of our knowledge, this is the first case report on the use of AnteOwl IVUS in the EVT field. In the coronary artery CTO field, a method for advancing guidewire in IVUS has been reported (Matsubara et al., 2004; Okamura et al., 2010; Okamura et al., 2014). However, in the EVT field, no studies have explained specifically how to navigate guidewires through the intraplaque route using IVUS guidance.

In AnteOwl, the structures of the proximal transducer and IVUS-wire are asymmetrical, which can convert IVUS images into angiographic images to allow accurate navigation of the second guidewire into the intraplaque route. Once the IVUS is advanced to the distal aspect of the CTO, the lesion can be observed without moving the IVUS itself in and out using the pullback transducer system. The pullback system eliminates the need to insert and remove the IVUS, prevents the expansion of a large subintimal space, causes less interference with the second guidewire, and is expected to shorten the procedure time. In Case 2, although the first guidewire progressed spirally in the subintimal space, accurately reflecting the IVUS findings into an angiographic image was easy; thus, despite the long CTO exceeding 30 cm, we succeeded in accessing the CTO using only the antegrade approach.

There is no consensus on the optimal guidewire passage route for FP CTO lesions (Soga et al., 2013, Mori et al., 2017). However, recently, some clinical studies have reported that IVUS-guided wiring improves the clinical outcomes of EVT for FP CTO (Mori et al., 2017; Tsubakimoto et al., 2020). The advantages of intraplaque guidewire crossing are as follows: a stent-less strategy can be realized using a DCB even for CTO lesions, it can be expanded reliably and safely even when a stent is implanted, and the antegrade guidewire passage may reduce the need for an extra distal puncture for the retrograde approach.

In our cases, the initial success of the procedure and good short-term prognosis were confirmed; however, the usefulness of AnteOwl IVUS-guided EVT in various cases and its long-term results remain unclear. A much larger study is required to confirm the efficacy of AnteOwl IVUS-guided EVT for FP CTO.

Conclusions

AnteOwl IVUS was effective for FP CTO and enabled us to simplify complex IVUS-guided procedures. Using AnteOwl IVUS provides access to the complex CTO lesion via intraplaque routes.

Abbreviations

FP, femoropopliteal; CTO, chronic total occlusion; IVUS, intravascular ultrasound; DCB, drug-coated balloon; SFA, superficial femoral artery; Pop A, popliteal artery; EVT, endovascular therapy; CFA, common femoral artery; RAO, right anterior oblique; LAO, left anterior oblique; EIA, external iliac artery

Declarations

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

Ethics approval and consent to participate: All procedures were performed in accordance with the ethical standards of the institutional and/or national research committees and the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Consent for publication: Written informed consent was obtained from the patients described in this case report.

Availability of data and material: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: NH, KT, SS, and SS performed the procedures and pre- and post-procedure follow-ups. SK drafted the manuscript and revised it critically for important intellectual content. JK provided the final approval for the submitted manuscript. The authors read and approved the final manuscript.

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Figures

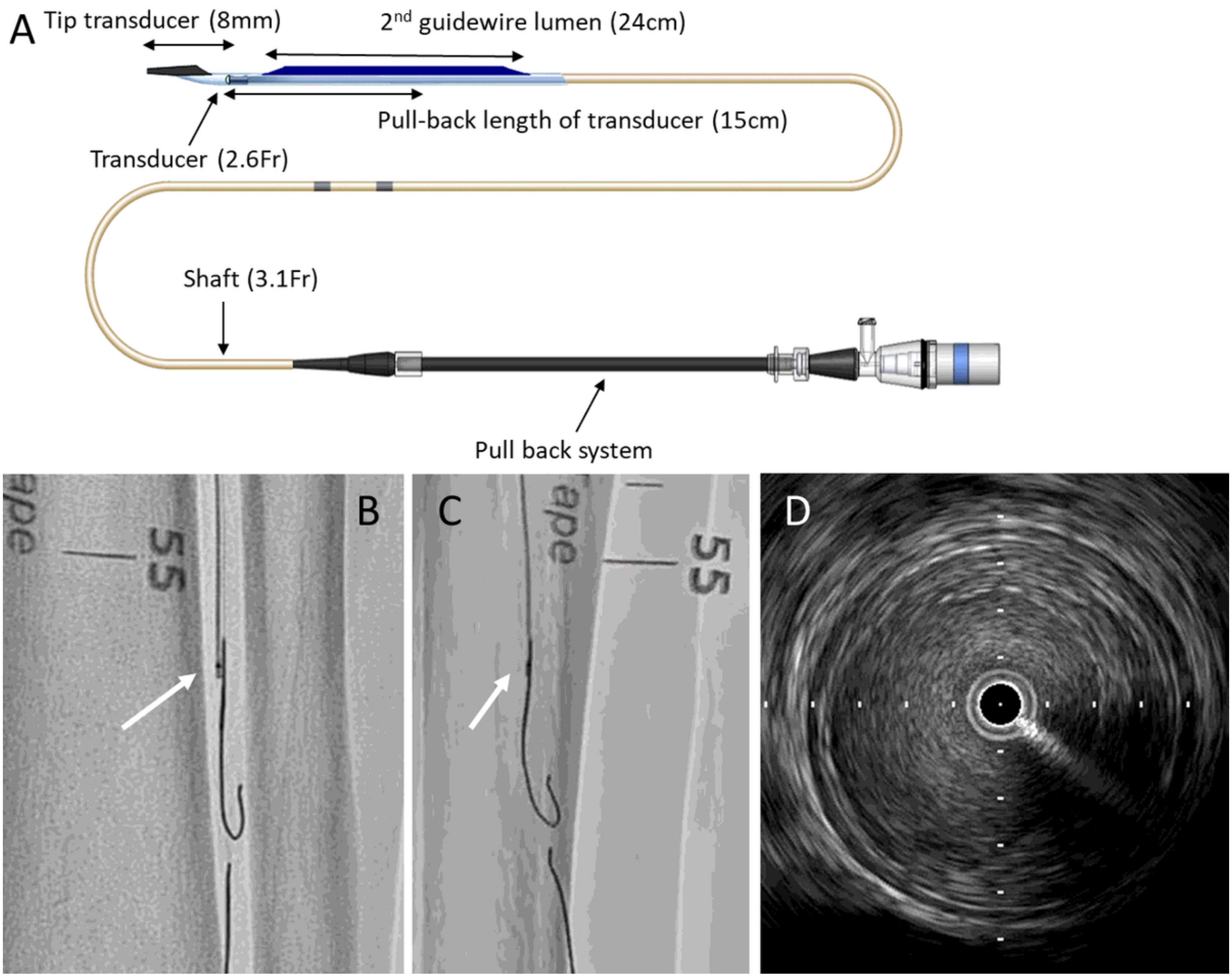

Figure 1

A Structure of AnteOwl WR (AnteOwl) intravascular ultrasound (IVUS). B, C Angiographic image of AnteOwl IVUS. B is right anterior oblique and the transducer is to the left of the IVUS-wire. Alternatively, C is left anterior oblique, and the transducer and IVUS-wire are almost the same. The positional relationship between the transducer and IVUS-wire can be understood in this way using rotational angiography. D Typical image of a superficial femoral artery lesion on AnteOwl IVUS.

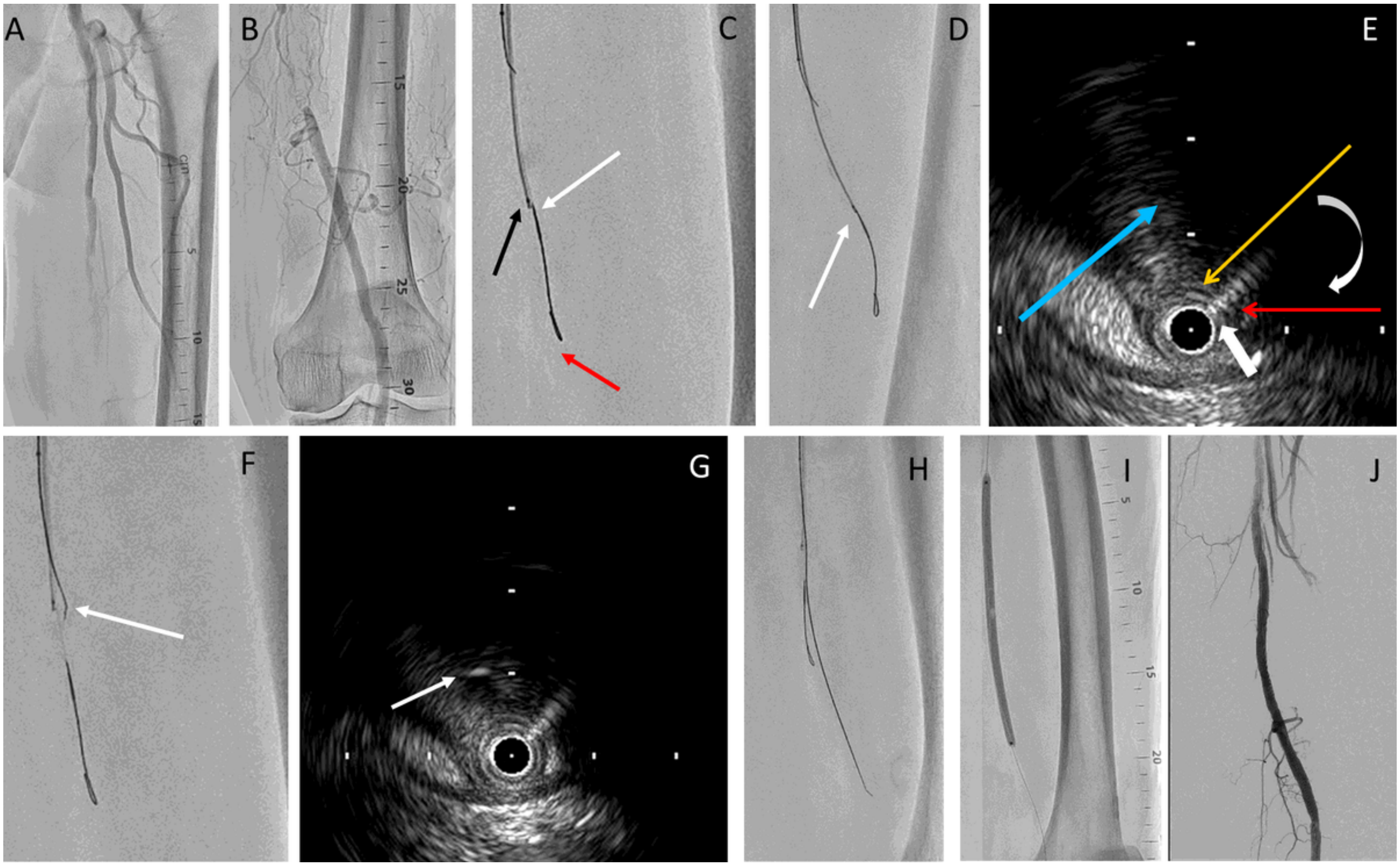

Figure 2

A, B Control angiography showed a tandem stenotic lesion in the left proximal superficial femoral artery and total occlusion of the left middle to distal aspects of the superficial femoral artery. C A 0.014-inch guidewire was advanced into the subintimal space (red arrow shows the tip of the guidewire). The black arrow shows the IVUS transducer, and the white arrow shows the IVUS-wire. The transducer was on the left side of the IVUS-wire. D The transducer almost overlapped the IVUS-wire (white arrow). On the basis of these findings, we confirmed that the IVUS transducer was at the bottom and the IVUS-wire was at the top. E IVUS findings of the CTO lesion. The white arrow shows the IVUS-wire. The detector direction where the transducer and IVUS-wire coincided on the angiographic image was left anterior oblique (LAO) 15° (yellow arrow). The detector direction where the transducer and target plaque were maximally separated at right anterior oblique (RAO) 30° (red arrow) was at 45° rotation to a clockwise direction from LAO 15° to RAO 30° (white arc arrow). The center of the target plaque was a few millimeters to the right of IVUS (blue arrow). F The second guidewire was advanced a few millimeters to the right of IVUS on the angiography (white arrow). G The white arrow shows that the second guidewire could be advanced almost into the center of the target intraplaque space. H The second guidewire could be passed through the CTO lesion. I, J We dilated the drug-coated balloon. Final angiography was good.

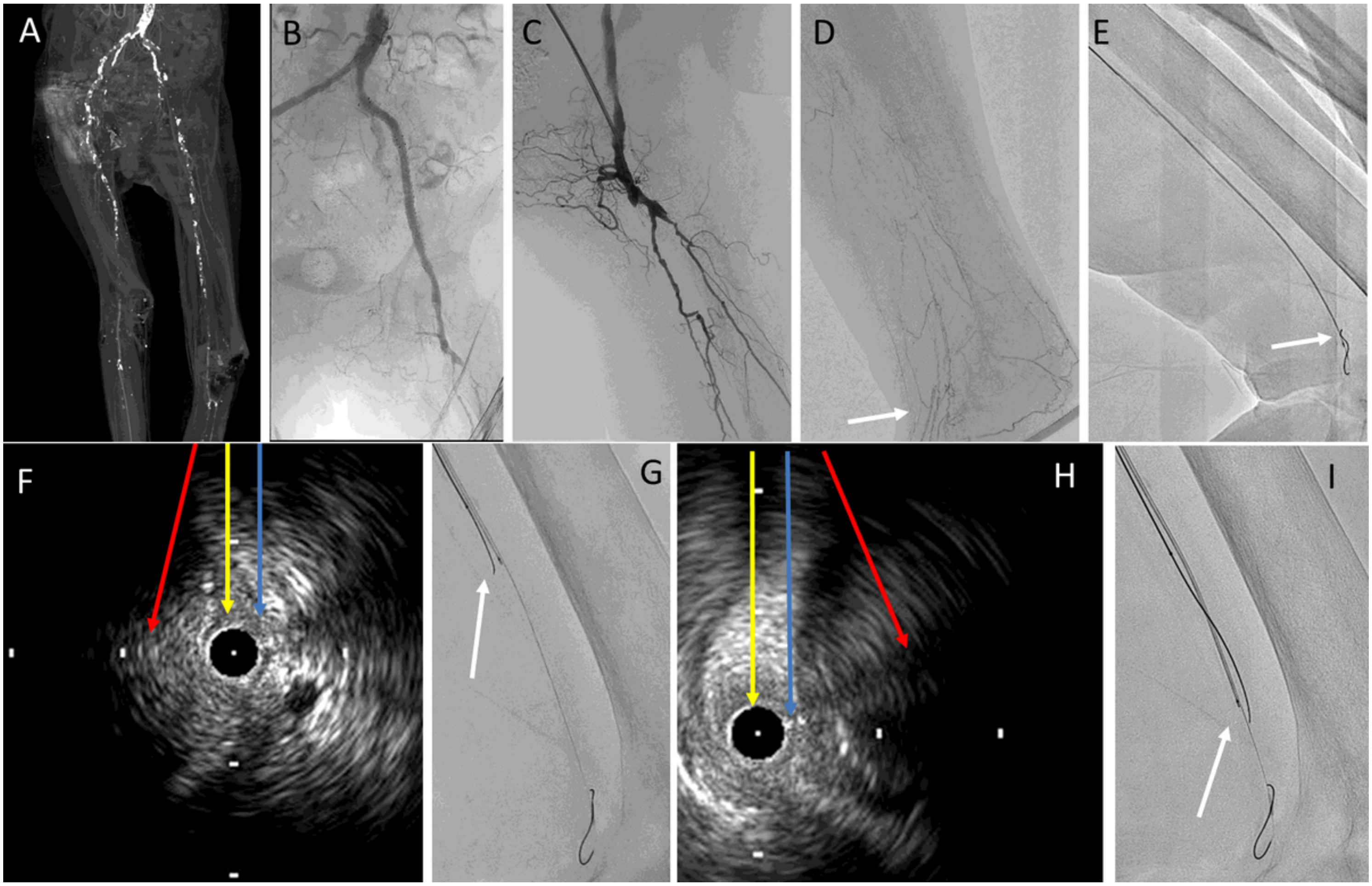

Figure 3

A Preprocedural enhanced computed tomography. B Angiography after the first endovascular therapy session for the left external iliac artery to the common femoral artery. C, D Control angiography showed total occlusion from the proximal aspect of the superficial femoral artery to the popliteal artery. The distal true lumen of the popliteal artery was minute (white arrow). E AnteOwl IVUS could be advanced to the popliteal artery (white arrow). F IVUS findings of an SFA distal lesion. The IVUS catheter was in the subintimal space. The blue arrow shows the IVUS-wire. The yellow arrow shows the IVUS transducer. The red arrow shows the direction of the target plaque to aim for. G We converted IVUS findings into an angiographic image. The IVUS-wire was on the right side, the transducer was in the center, and the second guidewire was on the left side on angiography; these findings are almost the same as the IVUS findings in F (white arrow). H IVUS findings of the popliteal artery lesion. The blue arrow shows the IVUS-wire. The yellow arrow shows the IVUS transducer. The red arrow shows the direction of the target plaque to aim for. I The IVUS-wire was in the center, the transducer was on the left side, the second guidewire was on the right side on angiography; these findings are almost the same as the IVUS findings.

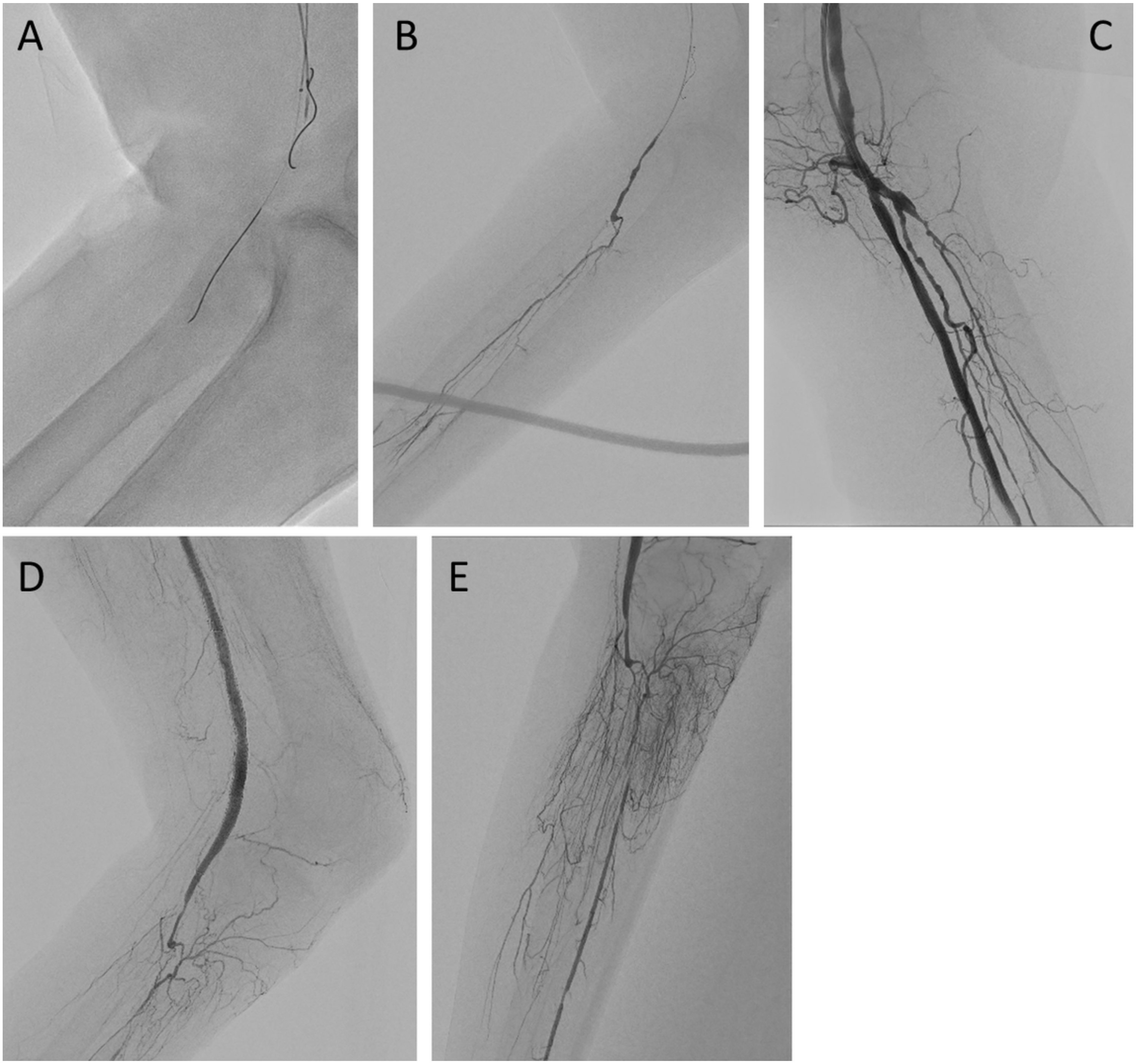

Figure 4

A, B A guidewire could be passed to the CTO lesion. We confirmed using tip injection with micro catheter. C-E Final angiography shows that the lumen from the SFA to the popliteal artery was well opened.