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Application of a snare technique in retrograde chronic total occlusion percutaneous coronary intervention – a step by step practical approach and an observational study

Hsiu-Yu Fang, MD*, Wei-Chieh Lee, MD, Chih-Yuan Fang, MD, Chiung-Jen Wu, MD

Abstract

Percutaneous coronary intervention (PCI) for chronic total occlusion (CTO) has recently become popular among interventional cardiologists. CTO originating from the ostium has been one of the most difficult CTO lesions to treat with PCI for a number of reasons. Our aim was to illustrate a specific technique during retrograde CTO PCI referred to as the "snare technique."

We retrospectively examined the use of "snare technique" among 371 consecutive retrograde CTO PCIs performed at our institution between 2006 and 2015.

"Snare technique" was used in 10 patients among the 371 retrograde CTO PCIs. The baseline clinical and angiographic characteristics of patients with or without "snare technique" were similar. The "snare technique" group had significantly fewer side branches at occlusion (30.0% vs 71.2%, $P=0.01$) and a higher incidence of externalization (90% vs 25.5%, $P<0.001$). The contrast volume was significantly lower in the "snare technique" group (285.0 ± 68.5 vs 379.2 ± 144.0, $P=0.04$). The incidence of major complications, retrograde success, or final success did not differ between the groups.

The "snare technique" is safe and feasible in retrograde CTO PCI, especially in cases of difficult coronary engagement in cases such as ostial occlusion, challenging coronary anatomy, or retrograde guidewire cannot get in antegrade guiding catheter.

Abbreviations: AsAo = ascending aorta, CART = controlled antegrade and retrograde subintimal tracking, CTO = chronic total occlusion, DES = drug eluting stent, IVUS = intravascular ultrasound, LAD = left anterior descending artery, PCI = percutaneous coronary intervention, RCA = right coronary artery, TIMI = thrombolysis in myocardial infarction.

Keywords: chronic total occlusion, percutaneous coronary intervention, snare

1. Introduction

Percutaneous coronary intervention (PCI) for chronic total occlusion (CTO) has become one of the most challenging approaches for interventional cardiologists. Successful recanalization of CTO in patients with viable myocardium decreases the need for bypass surgery, reduces angina symptoms, and improves long-term survival.[1–4] PCI instruments and the techniques for CTO lesions have improved over time,[5] and excellent outcomes have been achieved in several pilot studies, especially with the combined use of drug-eluting stents (DESs).[4,6–8]

The J-CTO score is a well-established tool used to predict the likelihood of success of CTO PCI.[8,9] The J-CTO score is based on invasive angiography that includes not only the details of the lesion's characteristics, such as calcification, length, and tortuosity, but also the location of the lesion.[8,9] The SYNTAX score is a unique tool used to evaluate the severity of coronary artery disease, and also serves as a guide to decision making after coronary angiogram.[10] Several studies have also emphasized the importance of the SYNTAX score in predicting the success of CTO PCI at different locations of CTO.[11,12] Some studies have also reported that a higher SYNTAX score is correlated with the increased difficulty of ostial CTO PCI.[12]

The combined use of antegrade and retrograde approaches has markedly increased the overall success rate of CTO PCI without significant increase in the rate of major complications.[13–19] Aortocoronary dissection was one of the more common complications occurring in patients undergoing retrograde CTO PCI, especially when guiding catheter engagement was difficult.[20,21] The appropriate use of newly developed techniques and devices has raised the success rate and increased the number of cases of CTO that fall into the treatable category.[5] The "snare technique" is a well-known, effective, and minimally invasive technique used to retrieve intravascular iatrogenic foreign bodies.[22] It has recently been shown to be effective in catching the retrograde guidewire in retrograde CTO PCI, thereby avoiding aortocoronary injury by the guiding

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catheter.[23,24] Yokoi et al[25] reported using a novel homemade snare device that was safe, economical, and size-adjustable in one case of CTO PCI. The aim of our study was to evaluate the safety and efficacy of the "snare technique" in retrograde CTO PCI and to illustrate a practical step-by-step approach to using this technique by reviewing patient cases.

2. Methods

2.1. Patient population

We reviewed the procedural and clinical records and coronary angiograms of all 371 patients who underwent CTO PCI with a retrograde approach between July 2006 and July 2015 at our institution. Enrollment criteria included a documented CTO lesion defined as thrombolysis in myocardial infarction (TIMI) grade of 0 for more than 3 months and the presence of typical angina or reversible myocardial ischemia detected on a thallium stress study. The study protocol was approved by the hospital's Internal Research Board committee, and written informed consents that included a description of the specific risks were obtained from the participants.

2.2. Definitions

CTO was defined as previously described. The duration of occlusion was estimated based on the history of angina, a history of myocardial infarct in the same territory, or previous angiography. The retrograde approach was defined as the introduction of the guidewire into the collateral channels, and retrograde success was defined as successful guidewire connection to the target CTO vessel distal to the lesion. A CTO lesion length was measured using 3 methods: from the proximal occlusion to the distal retrograde filling from contralateral collaterals using a dual injection technique, from the start of filling of bridging collaterals to the distal vessel reconstruction, or from the length of the lesion visible after the guidewire crossing. Severe calcification of a CTO lesion was considered to be present if multiple persistent opacifications of the coronary wall were visible in more than 1 projection and surrounded the complete lumen of the coronary artery at the site of the lesion. Severe tortuosity was defined if there were one or more bends of 90° or greater, or 3 or more bends of 45° to 90° proximal to the diseased segment. The success of the technique was defined as successful guidewire and balloon crossing with a residual stenosis $<50\%$ and a TIMI flow grade of 3. The final success of the procedure was defined as successful guidewire and balloon crossing, with or without final stenting, the presence of a final TIMI 3 flow, and a residual diameter stenosis of $<30\%$ without the occurrence of in-hospital major adverse cardiac event.

2.3. Coronary angiogram and intravascular ultrasound (IVUS) interpretation

Angiographic findings of the CTO lesion, CTO stumps, CTO lesion length, collaterals, and the degree of calcification were assessed. The results of all coronary angiograms and IVUSs were independently interpreted by a cardiologist who was blinded to the procedure.

2.4. Procedures and protocols

2.4.1. Selection of guiding catheter. A 6-Fr Ikari IL 3.5 guiding catheter (Terumo, Tokyo, Japan) or a 6-Fr Kimny Mini-radial guiding catheter (Boston Scientific, Grove, MN) was primarily used for the antegrade approach. A 7-Fr BL 3.5–4 or AL 1–2 short guiding catheter (Terumo) or an EBU 3.75–4 (Medtronic) was specifically selected for each patient for the retrograde approach with or without a sheathless approach. After successful engagement of both guiding catheters, a second bolus of 5000 IU of heparin was administered through the catheters.

2.4.2. Bilateral simultaneous coronary injections. At least 2 perpendicular projections with a biplane cine-machine were obtained, and the most proper view for the CTO intervention was selected by using simultaneous bilateral coronary injections.

2.4.3. Selection of guidewire. The guidewire used in the antegrade approach was selected by the operator after baseline coronary angiography was performed. The frequently used guidewires ranged from those with usual stiffness such as the Runthrough Floppy wires (Terumo, Japan), hydrophilic wires such as Pilot (Abbott, Abbott Park, IL), Sion wires (Blue, Black; Asahi, Japan), or Fielder wires (FC, XT, or XT-A; Asahi), and stiff guidewires such as Miracle (3, 4.5, 6, 12 gm; Asahi), Ultimate Bros 3 (Asahi), Conquest (9, 12, or 20/8 gm; Asahi), or Gaia (1, 2, 3; Asahi). The guidewire selected was later placed at the proximal cap of the CTO site with a 1.8-Fr microcatheter (Finecross or Corsair; Terumo). The guidewires used for the retrograde approach were Fielder-FC, Sion, Fielder-XT, and Fielder-XT-R (Asahi). They were supported with a microcatheter or an over-the-wire balloon (Ryujin 1.25×10 mm, 135 cm, or 150 cm; Terumo, Japan).

2.4.4. Retrograde and antegrade approaches. The retrograde approach was typically selected because of a failed antegrade approach (that had been performed previously or during the same procedure) and/or the presence of an unfavorable anatomy for antegrade wiring. The retrograde routes included septal channel collaterals, epicardial collaterals, saphenous vein grafts, and the left internal mammary artery. Collateral selection was made with further super-selective contrast injection through the microcatheter into the collaterals. Fielder FC, Sion, Fielder XT, or Fielder XT-R guidewires (Asahi) were carefully passed through the collaterals in a stepwise manner. After the guidewire was successfully advanced into the distal part of the CTO vessel, retrograde wiring was attempted with stiff wires such as with Miracle 3–6 gm, Ultimate Bros 3, Conquest-pro 9–12 gm, or Gaia wires followed by a gradual step-up in the wire-tip strength. Different retrograde methods included: the kissing wire technique, the controlled antegrade and retrograde subintimal tracking (CART) technique, and the reverse CART technique or knuckle wire technique. These techniques were used alone or in combination. After the retrograde wire had passed the occluded segment, it was manipulated into the antegrade guiding catheter, either for balloon anchoring or for externalization of the wire, by changing the original 190 cm wire into a 300 cm long wire through the microcatheter or using the Rendevou technique.

2.4.5. Snare technique. When the antegrade guiding catheter had difficulty engaging and the retrograde guidewire can pass the CTO segment into the ascending aorta (AsAo), the "snare technique" was initiated. The "snare technique" is illustrated in Figs. 1 to 3.

Upper panel of Fig. 1 illustrates the general concept of "snare technique." When the retrograde guidewire successfully passes the CTO segment to AsAo, a snare device such as 3-loop En Snare (Merit Medical Systems, South Jordan, Utah) or home-made

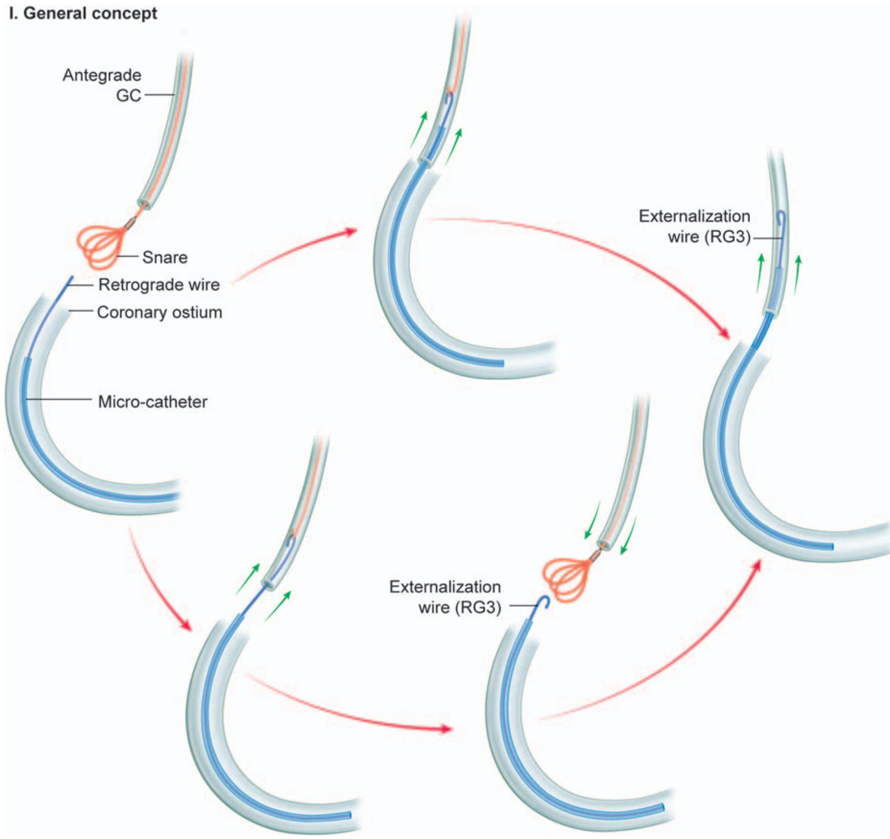

Figure 1. The general concept behind the "snare technique." The upper panel demonstrated the retrograde microcatheter advancement after it has snared the retrograde wire. The lower panel demonstrates the release of the snare outside of the antegrade guiding catheter after snaring the retrograde wire. Externalization is performed after introducing an RG3 guidewire.

snare catches the retrograde guidewire as an "anchor effect" to facilitate the retrograde microcatheter passing the CTO segment into the antegrade guiding catheter. After the microcatheter is inserted into the antegrade guiding catheter, the snare is released inside the guiding catheter and the retrograde guidewire is changed to a 300 cm RG 3 guidewire (Asahi), and externalization is then performed. In lower panel of Fig. 1, when the retrograde guidewire successfully passes the CTO segment to AsAo, a snare device can catch the retrograde guidewire also as an "anchor effect" to facilitate retrograde microcatheter pass the CTO segment outside the antegrade guiding catheter. Then the retrograde guidewire can be released in the AsAo. Then, a 300 cm RG 3 guidewire can float in the AsAo with the microcatheter and can then be caught again by the snare device, thus facilitating externalization avoiding releasing problem inside antegrade guiding catheter.

Both upper and lower panel of Fig. 2 illustrate solutions to situations in which it was difficult to release the snare inside the antegrade guiding catheter. The upper panel showed the snare device slowly pulls out the initial retrograde guidewire under the protection of the microcatheter without damaging the collaterals. If there is still resistance when pulling out the retrograde guidewire, the extension wire (Asahi) can be used to slowly push the end of the initial retrograde guidewire as a "Pull and Push" method. The lower panel showed using an another balloon to anchor inside the antegrade guiding catheter at the floppy part of the retrograde guidewire and facilitating snare to release.

Figure 3 demonstrated solutions when the retrograde microcatheter cannot pass the CTO segment even after snaring catches the retrograde wire with an "anchor effect." The retrograde guidewire is changed to a 300 cm RG3 guidewire, passed the CTO segment where it can be caught by the snare to facilitate externalization.

2.4.6. Final balloon angioplasty and stenting. Stepwise balloon angioplasty was performed through the antegrade or retrograde routes, and an antegrade soft-tip wire was subsequently advanced into the distal portion of the occluded vessel along with the retrograde wire, or by using a "Crusade" (Kaneka, Corp) multifunction probing catheter. An IVUS of the occluded vessel was later performed to prepare for stenting. If all of the retrograde methods failed, an antegrade approach using a stiffer wire or the parallel-wire technique was then attempted as a last resort. Rotablator was considered if the lesion could not be crossed with the balloon or balloon popping could not be achieved. After successful balloon dilatation, either bare-metal stents (BMS) or DESs were deployed based on the patient's preference.

2.4.7. Medications. Patients were pretreated with oral aspirin (100 mg/day) and a loading dose of clopidogrel (300 or 600 mg) 4 to 12 hours before the procedure. A postprocedure dose of clopidogrel (300 mg) was administered, and then 75 mg/day was prescribed for at least 9 months following implantation of a DES or at least 3 months after BMS deployment.

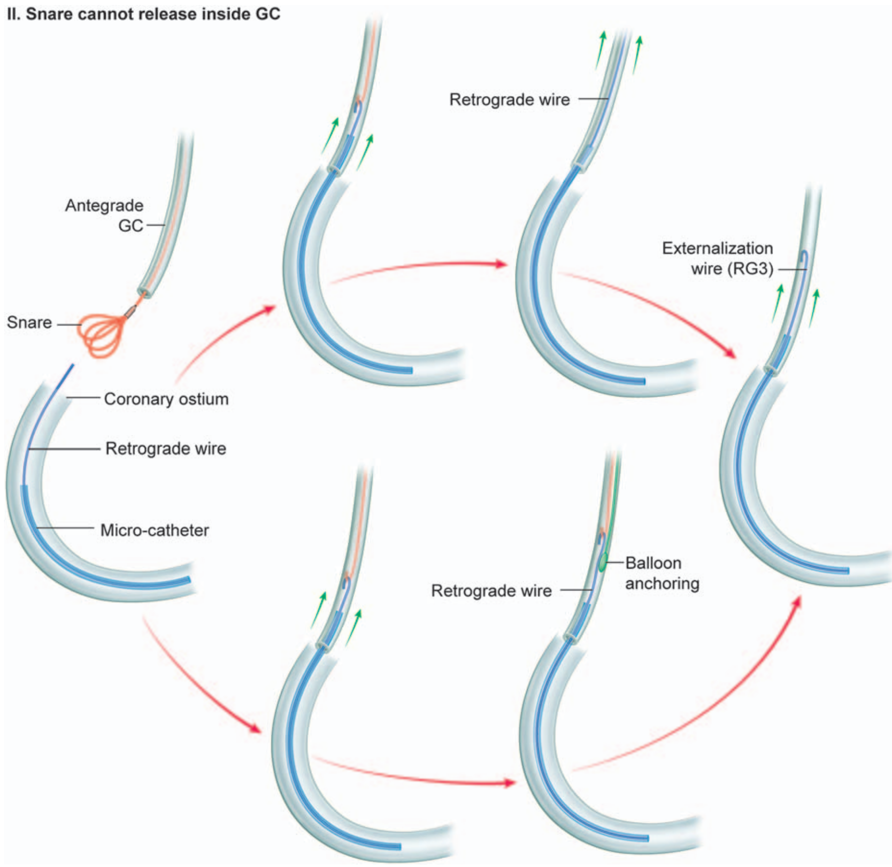

Figure 2. The situation in which the snare cannot be released inside antegrade guiding catheter. The upper panel illustrates the "pull and push" technique for removing the retrograde wire from antegrade guiding catheter. The lower panel illustrates the "balloon anchor" technique for releasing the retrograde guidewire inside of the antegrade guiding catheter. Externalization is performed after introducing a RG3 guidewire.

2.5. Statistical analysis

Continuous variables are reported as the mean ± standard deviation, while categorical variables are reported as frequencies. Continuous variables were compared between groups by a 2-tail *t* test. Categorical variables were compared between groups by the Chi-square test and Fisher exact test. A *P*-value of <0.05 was considered statistically significant. Statistical analysis was performed using SPSS version 16.0 software (SPSS, Chicago, IL).

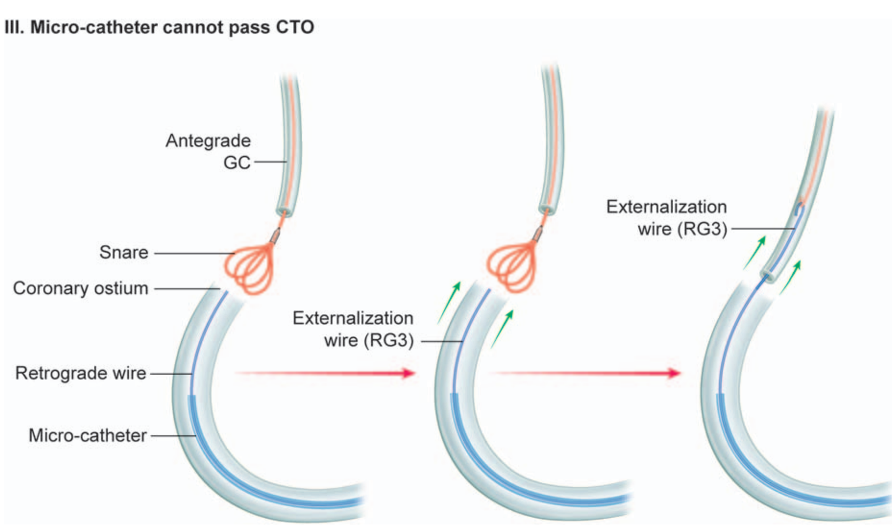

Figure 3. The microcatheter cannot pass the chronic total occlusion (CTO) segment after snaring. The only solution is to introduce the microcatheter into the plaque of the CTO and change to the RG3 guidewire to pass the CTO segment. Externalization is performed after advancing the RG3 guidewire.

3. Results

3.1. Patient baseline clinical, angiographic characteristics, and procedure outcomes

Table 1 demonstrates that baseline clinical characteristics of the study patients and a comparison of the procedure with versus without the "snare technique." The mean age of the patients was 60.9±11.6 years, and 89.9% were male. Two of the most frequent underlying risk factors for coronary artery disease were hypertension (91.9%) and hyperlipidemia (61.5%). The mean left ventricular ejection fraction was 55.0%±10.9% with no significant difference between the groups. The target vessel in this group of patients was the right coronary artery (RCA) (66.3%). In total, there were 175 patients (41.2%) who had previously failed PCI, and 42 patients (11.3%) who were undergoing CTO PCI with an ad hoc procedure. There was no significant difference in basic angiographic characteristics, namely severe calcification, severe tortuosity, and stump morphology, between with versus without "snare technique" groups. The "snare technique" group had significantly fewer side branches at occlusion (30.0% vs 71.2%, $P=0.01$) due to the specific angiographic findings. That means most of the "snare technique" was used only in ostial lesion, anomalous origin, or aorto-ostial dissection happened. There was no difference in the use of additional techniques such as CART, the kissing wire technique and IVUS-guided PCI between the groups who underwent retrograde PCI. The "snare

Table 1

Baseline clinical, angiographic and procedural characteristic of the study patients, classified according to use snare technique during CTO intervention.

	Overall (n=371)	With Snare (n=10)	Without Snare (n=361)	*P*
Clinical characteristics				
Age, years	60.9±11.6	58.9±15.9	60.9±11.5	0.583
Male, %	333 (89.9)	9 (90)	324 (89.8)	1.000
Hypertension, %	341 (91.9)	8 (80)	333 (92.2)	0.190
Hyperlipidemia, %	228 (61.5)	8 (80)	220 (60.9)	0.328
Diabetes mellitus, %	151 (40.7)	5 (50)	146 (40.4)	0.536
History of MI, %	143 (38.5)	5 (50)	140 (38.8)	0.521
History of coronary artery bypasses graft surgery, %	33 (8.9)	2 (20)	31 (8.6)	0.220
LVEF, %	55.0±10.9	55.5±14.9	55.0±10.8	0.893
Angiographic characteristics				
CTO target vessel				
Right coronary artery, %	246 (66.3)	6 (60)	240 (66.5)	0.738
Left anterior descending artery, %	148 (39.9)	3 (30)	145 (40.2)	0.746
Left circumflex artery, (%)	51 (13.7)	1 (10)	50 (13.9)	1.000
Prior failed attempt CTO PCI, %	175 (41.2)	5 (50)	171 (47.4)	1.000
Ad hoc CTO PCI, %	42 (11.3)	3 (30)	37 (10.2)	0.082
Severe calcification, %	52 (14.0)	2 (20)	50 (13.9)	0.637
Severe tortuosity, %	42 (11.3)	1 (10)	41 (11.4)	1.000
Tapper stump, %	42 (11.3)	1 (10)	41 (11.4)	1.000
Blunt stump, %	262 (70.6)	5 (50)	257 (71.2)	0.166
No stump, %	67 (18.1)	4 (40)	63 (17.5)	0.086
Side branch at occlusion, %	260 (70.1)	3 (30)	257 (71.2)	0.010
Procedure techniques				
CART, %	36 (9.7)	1 (10)	35 (9.7)	1.000
Reverse CART, %	143 (38.5)	1 (10)	142 (39.3)	0.096
Kissing wire technique, %	259 (69.8)	6 (60)	253 (70.1)	0.497
Externalization, %	101 (27.2)	9 (90)	92 (25.5)	<0.001
IVUS guide PCI, %	226 (60.9)	9 (90)	217 (60.1)	0.096
Procedure outcomes				
Retrograde success, %	301 (81.1)	10 (100)	291 (80.6)	0.219
Technique success, %	355 (95.7)	10 (100)	345 (95.6)	1.000
Final success, %	330 (88.9)	9 (90)	327 (90.6)	1.000
Total procedure time, minutes	165.0±59.4	162.7±38.0	165.0±59.9	0.902
Total fluoroscopic time, minutes	76.1±32.3	74.4±19.6	76.2±32.6	0.867
Total contrast volume, mL	376.6±143.2	285.0±68.5	379.2±144.0	0.040
Major complications				
Cardiac tamponade, %	10 (2.7)	0 (0)	10 (2.8)	1.000
Emergent PCI, %	2 (0.5)	0 (0)	2 (0.6)	1.000
Emergent CABG, %	0 (0)	0 (0)	0 (0)	1.000
GI bleeding, %	7 (1.9)	0 (0)	7 (1.9)	1.000
CIN, %	11 (3.0)	0 (0)	11 (3.0)	1.000
Aortic dissection, %	6 (1.6)	0 (0)	6 (1.7)	1.000
Donor vessel dissection, %	7 (1.9)	0 (0)	5 (1.4)	1.000
Coronary perforation no need coil or cover stent, %	39 (10.5)	1 (10)	38 (10.5)	1.000
Coronary perforation need coil or covered stent, %	13 (3.5)	1 (10)	12 (3.6)	0.303

Data are presented as mean±SD or number (%) of patients. CABG=coronary artery bypass graft, CIN=contrast induced nephropathy, CTO=chronic total occlusion, GI=gastrointestinal, IVUS=intravascular ultrasound, LVEF=left ventricle ejection fraction, MI=myocardial infarction, PCI=percutaneous coronary intervention, SD=standard deviation.

Table 2

The detailed technical differences between the 10 patients.

Patient number	CTO location	Reason	Snare type	Snare success	Unable release	Management	Complications
1	Ostial RCA	Anomalous	Official	Yes	Yes	Balloon anchor	–
2	Proximal LAD	Retrograde GW cannot get in Antegrade GC	Official	Yes	No	–	–
3	Proximal RCA	Coronary dissection	Official	Yes	No	–	–
4	Proximal LCX	Retrograde GW cannot get in Antegrade GC	Official	Yes	Yes	Pull and push	–
5	Ostial LAD	Ostial lesion	Official	Yes	Yes	Balloon anchor	Perforation need coil
6	Proximal RCA	Anomalous	Official	Yes	Yes	Pull and push	Aborted
7	Ostial RCA	Ostial lesion	Official	Yes	No	–	Tiny septal hematoma
8	Ostial LM	Ostial lesion	Home-made	Yes	Yes	Pull and push	–
9	Proximal RCA	Anomalous	Home-made	Yes	No	–	–
10	Ostial RCA	Ostial lesion	Balloon-assist	Yes	No	–	–

CTO = chronic total occlusion, GC = guiding catheter, GW = guide-wire, LAD = left anterior descending artery, LCX = left circumflex artery, LM = left main artery, RCA = right coronary artery.

technique" group had a lower incidence of reverse CART (10.0% vs 39.3%, $P=0.096$) without statistically significant. The "snare technique" group also had a higher incidence of externalization (90% vs 25.5%, $P<0.001$). Procedure outcomes, which included retrograde success, technique success, and final success, did not differ between the groups. The contrast volume was significantly lower in the "snare technique" group (285.0 ± 68.5 vs 379.2 ± 144.0, $P=0.04$). The incidence of major complications, such as cardiac tamponade, emergent PCI, emergent coronary artery bypass graft, gastrointestinal bleeding, contrast-induced nephropathy, aortic dissection, donor vessel dissection, and coronary perforation with or without the need for a covered stent, did not differ between the groups.

3.2. Case series illustration

Table 2 illustrates the detailed technical differences between the 10 cases. The "snare technique" was used in cases of ostial lesions (4/10), anomalous coronary arteries (3/10), guidewire and guiding catheter mismatch (2/10), and coronary dissection (1/10). In 5 patients, failed release inside the guiding catheter necessitated using a balloon-anchor or pull-push method. Patient number 5 experienced an epicardial collateral perforation that required a coil to seal it. The procedure for patient number 6 was aborted due to poor patient cooperation and the presence of delirium after sedation.

3.3. Case illustration 1 (patient number 7)

A 60-year-old man with a history of hypertension, diabetes, and hyperlipidemia presented with angina pectoris and inferior inducible ischemia (Fig. 4). His coronary angiogram showed triple vessel disease with ostial RCA CTO and retrograde collaterals from septal branches (Fig. 4A). He had failed the antegrade approach twice, resulting in an ostial RCA dissection and difficult engagement. A primary retrograde approach was attempted with a Sion (Asahi) guidewire from the septal collaterals to the posterior descending artery. The Finecross

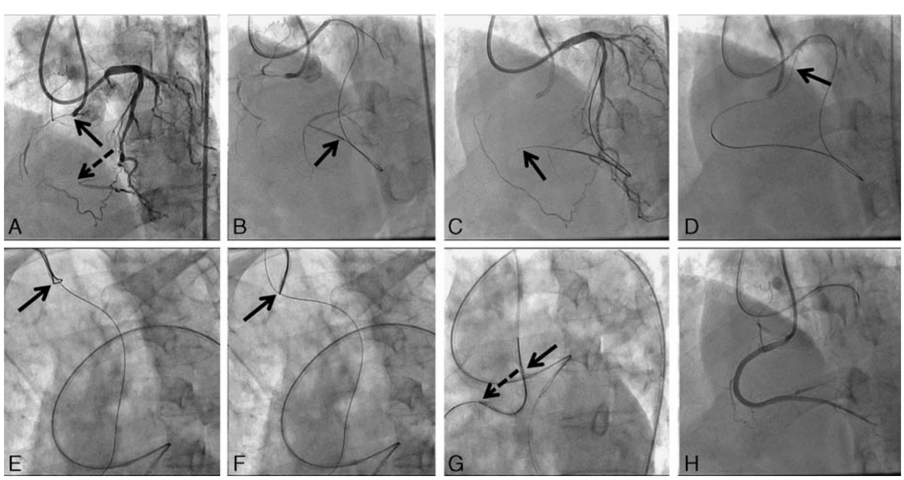

Figure 4. In patient number 7, (A) contralateral injection demonstrated an ostial RCA CTO with retrograde collaterals from the septal branches. The ostial RCA was engaged with a pressure damp (black arrow) and retrograde collaterals filled up to the PDA (black dot arrow). (B) A Sion wire was successfully inserted into the PDA with the support of Finecross and Corsair (black arrow) microcatheters through the septal collaterals. (C) A Gaia-2 (black arrow) wire was used to pass the 2 segment CTO. (D) A Gaia-2 (black arrow) wire was advanced into the ascending aorta (E) and (F) an EN snare (black arrow) was used to catch the retrograde Gaia-2 wire. (G) Using the "snare technique" (black arrow), the antegrade guiding catheter is advanced to the ostium of the RCA (black dot arrow). (H) Final angiogram of RCA. CTO = chronic total occlusion, PDA = posterior descending artery, RCA = right coronary artery.

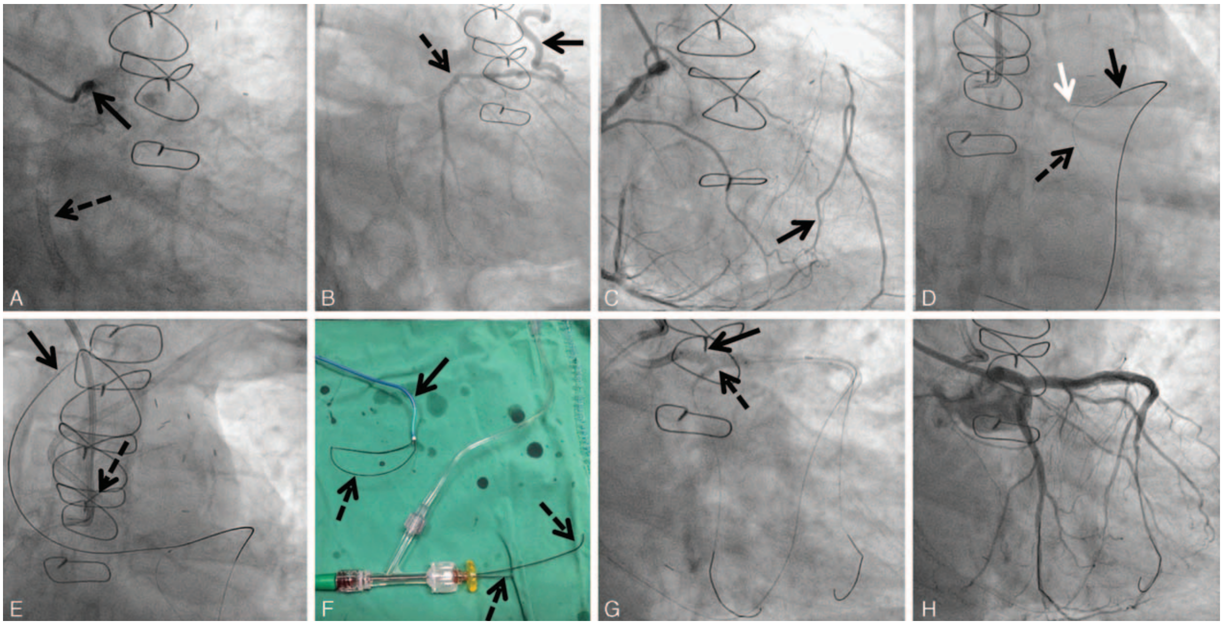

Figure 5. In patient number 8, (A) a baseline angiogram showed LM ostium CTO (black arrow) with a previous RCA stent (black dot arrow). (B) The angiogram from LIMA (black arrow) to the 2nd diagonal branch, which filled with contrast back to the proximal LAD, distal LM (black dot arrow), and LCX. (C) A retrograde angiogram showed septal collaterals (black arrow) filled with contrast to the proximal LAD. (D) A Sion wire was successfully passed to the proximal LAD (black arrow) through the septal collaterals and to the distal LCX (black dot arrow). After retrograde balloon dilatation, a Crusade catheter (black arrow) was advanced to the proximal LAD facilitating retrograde guidewire puncture with Conquest Pro 12 (white arrow). (E) The Conquest Pro 12 (black arrow) guidewire was successfully advanced into the ascending aorta and the antegrade guiding catheter (black dot arrow) was parked inside of the ascending aorta in preparation for the "snare technique". (F) A Terumo 0.025 inch 260 cm hydrophilic wire (black dot arrow) (Terumo, Japan) was used for the "home-made snare" that was placed inside the antegrade guiding catheter (black arrow). (G) The final kissing technique with a 3.0 (black dot arrow) and 3.5 balloon (black arrow) was performed through the antegrade and retrograde routes. (H) Final angiogram of LM, LAD, and LCX. CTO = chronic total occlusion, LAD = left anterior descending artery, LCX = left circumflex artery, LIMA = left internal mammary artery, LM = left main artery, RCA = right coronary artery.

microcatheter (Asahi) could not easily pass the septal collaterals and was replaced by a Corsair microcatheter (Asahi) that eventually successfully passed to the posterior descending artery. Figure 4B shows the contralateral injection through the Corsair microcatheter. The CTO was successfully passed using a Gaia-2 guidewire (Asahi) (Fig. 4C) that was directly inserted into the AsAo (Fig. 4D). An EN snare (Merit Medical Systems, South Jordan, Utah) was used to catch the retrograde guidewire (Fig. 4 E and F), and the antegrade guiding catheter, 6French AL1, was able to engage the ostium of the RCA (Fig. 4G). After externalization and balloon dilatation, 3 DES Xience Xpedition (2.5×38 mm, 3.0×38 mm, and 3.25×15 mm) (Abbott, Santa Clara, CA, USA) were deployed from the distal to the ostial RCA. The final angiogram showed good results (Fig. 4H).

3.4. Case illustration 2 (patient number 8)

A 71-year-old man with a history of hypertension and diabetes presented with unstable angina and anteroseptal inducible myocardial ischemia. He had a history of a previous myocardial infarction and had undergone coronary bypass surgery 22 years prior to this presentation. His coronary angiogram showed the RCA in stent restenosis, a patent left internal mammary artery to the 2nd diagonal branch with left main artery CTO at the ostium (Fig. 5A and B). Because a previous antegrade attempt had failed, a primary retrograde approach was attempted with a Sion guidewire (Asahi) through the septal collaterals to the proximal left anterior descending artery (LAD) (Fig. 5C). The Sion guidewire (Asahi) successfully passed the septal collaterals to the proximal LAD and distal left circumflex artery. The antegrade approach was performed using a Gaia-3 guidewire (Asahi) but could not be advanced further. Balloon dilatation was performed at the mid to proximal LAD through septal collaterals, allowing passage of a Crusade catheter (Kaneka, Japan). The Sion wire was placed at the distal left circumflex artery and, using the Crusade catheter, a Conquest Pro 12 (Asahi) used for retrograde punctures (Fig. 5D). The Conquest Pro 12 was successfully inserted into the AsAo and snared by a "home-made snare" (Fig. 5E and F). After externalization and balloon dilatation, 3 DES (Resolute 3.0×38 mm, 3.5×38 mm, and 4.0×18 mm)

Table 3

The comparison between different types of snares.

	Price	Availability	Handle	Preparation	Unable to release
Official snares (EN snare, loop snare . . . etc.)	Expensive	Not easy	Easy	Fast	Yes
Home-made snares	Cheap	Easy	Need practice	Slow	Yes
Balloon-assisted snares	Cheap	Easy	Need practice	Slow	Yes

(Medtronic, Minneapolis, MN, USA) were deployed from the mid-LAD to left main artery ostium. After completion of the kissing technique, the final angiogram showed good results (Fig. 5G and H).

3.5. Comparison between different types of snares

Table 3 describes the 3 different types of snares. Official snares have the advantage of being easy to handle and quick to prepare. However, they are expensive and are not always available in the catheterization lab. Home-made snares and balloon-assisted snares are inexpensive, incur no additional costs, and are readily available in every catheterization lab. However, they are difficult to handle requiring a substantial amount of practice and are slow to prepare. All 3 types of snares are potentially difficult to release inside the guiding catheters.

4. Discussion

In recent years, the retrograde approach has been shown to improve the success rate of CTO PCI.[13–19] Several newly developed methods such as the "kissing guidewire technique," "landmark technique," "CART technique," "reverse CART technique," or "knuckle wire technique" have also been described in previous studies.[13–19] When CTO PCI was faced with the problem of difficult coronary engagement in cases such those involving ostial occlusion, challenging coronary anatomy, or retrograde guidewire cannot get in antegrade guiding catheter, implementation of the "snare technique" was instrumental in achieving final success.[25]

Official snares such as the EN snare (Merit Medical Systems) and the Amplatz GooseNeck Snare (Covidien, Medtronic, Minneapolis, MN) have been the most commonly used snares for foreign body retrieval. The home-made snare is widely used in our institute for interventions such as aortic valvuloplasty[26] and central vein angioplasty.[27] The use of the self-made balloon-assisted snare in CTO PCI has also been reported[25] and was shown to be inexpensive, safe, and size-adjustable. In our case studies, all of the different snare devices in CTO PCI were used, and their advantages and disadvantages compared. To our knowledge, this is the first publication to describe a step-by-step approach to retrograde CTO PCI using official or home-made snares.

The "snare technique" has 3 main strengths. First, for patients whose coronary anatomy makes engagement difficult, snares facilitate passing the guiding catheter to the ostium of totally occluded coronary arteries. Second, for retrograde CTO PCI, the "snare technique" allows for great "anchor effect" of the retrograde guidewire, thus enabling the operator to overcome difficulties in retrograde microcatheter advancement. Third, if the home-made or balloon-assisted snare devices were used more frequently, CTO PCI would likely become economically more feasible. Nonetheless, the "snare technique" can only provide solutions to difficulties encountered with specific CTO lesions.

There are 3 main weaknesses associated with the "snare technique." First, more experience is needed with using this technique to successfully catch a floating guidewire in the AsAo. Adjusting the loop of the home-made snare is a difficult skill to master in the beginning, but can improve with practice. Second, releasing the snare inside of the guiding catheter is relatively difficult, though it is more easily accomplished with the home-made or balloon-assisted snare than with official snares. Our illustrations demonstrate methods that can be employed when snare devices cannot be released. Third, the "snare technique" can easily deform the retrograde and externalization guidewires. Deformity of the retrograde guidewire prevents the operator from pulling it back after the microcatheter has been placed inside the antegrade guiding catheter. This problem can only be solved by pulling and pushing the retrograde guidewire through the collaterals so that it can be externalized. When the externalization guidewire is deformed, back-end ballooning after externalization may be limited. This problem can be solved by cutting part of the externalized guidewire. However, at the completion of the procedure, the externalized guidewire should be withdrawn under microcatheter protection to avoid damaging the collaterals.

5. Conclusions

The snare technique is safe and feasible in retrograde CTO PCI, especially in cases of difficult coronary engagement such as ostial occlusion, challenging coronary anatomy, or retrograde guidewire cannot get in antegrade guiding catheter.

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