

Microcatheter knuckle technique: A novel technique for negotiating the subintimal space during chronic total occlusion recanalization

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Abstract

Objectives: To establish if novel microcatheter knuckle technique (MKT) is feasible and efficacious in negotiating the subintimal space in difficult lesions during chronic total occlusion (CTO) percutaneous coronary intervention (PCI).

Background: CTOs remain one of the most challenging lesion subsets in PCI. Guidewire manipulation and advancement of equipment within the subintimal space is sometimes challenging and aggressive manipulation in the subintimal space is feared, because of concern of vessel disruption and perforation. Here we introduce the MKT, for negotiating the subintimal space during challenging CTO PCI.

Methods: MKT is performed by creating a wire knuckle with polymer-jacketed guidewire and positioned in the subintimal space. Subsequently, a tapered-tip, kink-resistant microcatheter is advanced towards the knuckled tip of guidewire and the guidewire is simultaneously withdrawn; creating a knuckle-shaped microcatheter tip. The MKT was considered in CTO PCIs that involved subintimal techniques where resistance to guidewire knuckle advancement was encountered. Procedures were performed between March 2013 and June 2017 at our institution.

Results: During the study period, a total of 440 CTO PCIs were performed, from which seven were treated with MKT. MKT was successful in six patients and technical success was achieved in all seven patients. The MKT was successfully performed with both the antegrade and retrograde approach.

Conclusion: We present a novel technique for negotiating the subintimal space in CTO PCI for cases where significant resistance is experienced restricting guidewire or material advancement in antegrade or retrograde dissection. The MKT appears to be efficacious complementing the CTO operator's armamentarium.

KEYWORDS

coronary artery disease, hybrid revascularization, percutaneous coronary intervention, stenting technique

1 | INTRODUCTION

Chronic total occlusions (CTO) remain one of the most challenging lesion subsets in percutaneous coronary intervention (PCI). Over the

last decade there have been significant advancements in equipment and techniques, which has led to a systematic approach to this difficult lesion subset. This has led to a remarkable increase in the success rates of CTO PCI. In addition, such innovations have been complemented by the development of dissection/re-entry techniques, which might also have contributed to improved success rates [1]. However, guidewire manipulation and advancement of equipment within the subintimal

Mauro Carlino and Ozan M. Demir contributed equally to this study, and should be regarded as joint first authors.

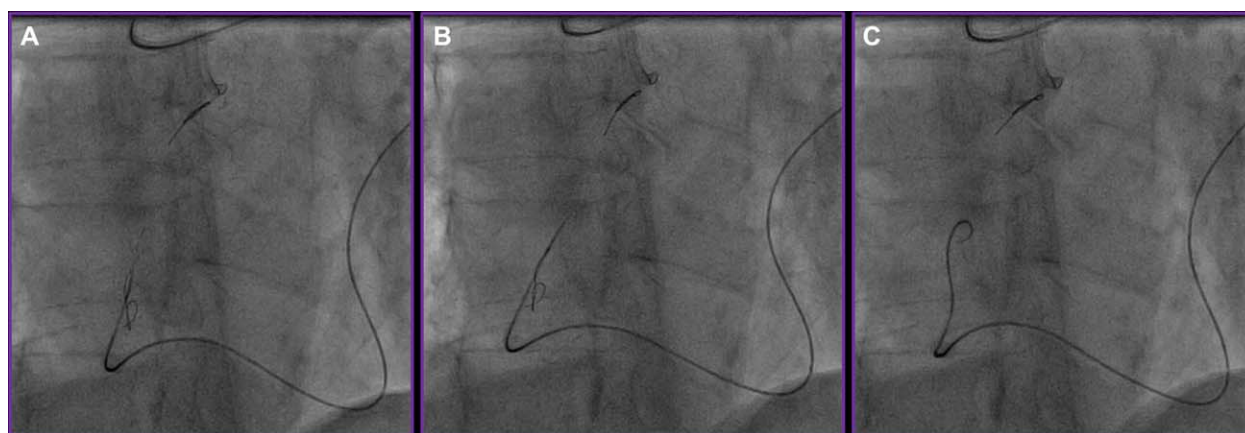


FIGURE 1 Demonstration of microcatheter knuckle technique. A, Polymer-jacketed guidewire is positioned in the subintimal space. B, Tapered-tip, kink-resistant microcatheter is advanced towards the knuckled tip of guidewire. C, Guidewire is subsequently withdrawn creating a knuckle-shaped microcatheter tip [Color figure can be viewed at wileyonlinelibrary.com]

space is sometimes challenging because of resistant fibrocalcific tissue [2]. Aggressive manipulation in the subintimal space is feared by many operators, because of concern of vessel perforation and vessel disruption.

In this article, we introduce the novel “microcatheter knuckle technique” (MKT), for negotiating the subintimal space during challenging CTO PCI. This technique may increase overall success rate of dissection/re-entry techniques when an arduous subintimal space is encountered.

2 | METHODS

2.1 | Technical description

MKT can be used in all cases that a knuckle wire approach is required and resistance to guidewire knuckle advancement is encountered. These situations include:

1. Antegrade dissection re-entry, to safely and quickly overcome long vessel course ambiguity to reach landing zone and in preparation for reentry;
2. Retrograde dissection reentry, to facilitate reverse Controlled Antegrade and Retrograde subintimal Tracking (reverse CART).

The MKT enlarges the subintimal space and consolidates the base of operations for further advancement of the guidewire-microcatheter knuckle unit.

MKT consists of two steps:

Step 1: A wire knuckle is created with a polymer-jacketed guidewire, e.g., Pilot 200 (Abbott Vascular, Santa Clara, California), and positioned in the subintimal space (Figure 1A) [2].

Step 2: A tapered-tip, kink-resistant microcatheter (e.g., Corsair Pro, Asahi Intecc, Nagoya, Japan; Turnpike, Turnpike LP or Turnpike Spiral, Vascular Solutions, Minneapolis, MN) is advanced towards the knuckled tip of guidewire and the guidewire is

simultaneously withdrawn; this will create a knuckle-shaped microcatheter tip (Figure 1B,C).

Supporting Information Video 1 illustrates the MKT.

A few fundamental aspects should be kept in mind for a safe and effective MKT:

1. Since the microcatheter tip is flexible it will allow adaptability for almost any size of guidewire knuckle, it is important that guidewire knuckle size is kept small to reduce the risk of vessel perforation, in case of a small side branch is engaged;
2. If significant resistance is encountered advancing the guidewire or the microcatheter, operators can perform intravascular ultrasound imaging, which can clarify the mechanism of failure and guide subsequent approach. An alternative, is represented by injection of a small amount of contrast through the microcatheter (Carlino technique [3]), which looks particularly attractive in cases where IVUS cannot be performed (e.g., inability to cross with IVUS catheter because of extensive calcification, fibrosis, or tortuosity; the retrograde approach; etc.).

2.2 | Study population

The MKT was considered in CTO PCIs that involved subintimal techniques (antegrade or retrograde dissection/re-entry). Procedures were performed between March 2013 and June 2017 at our institution. All procedures were indicated to treat angina, ischemia, or both, and were performed electively by two experienced operators [1]. All patients signed an informed consent form, approved by the local ethics committees, for procedural data collection and for the anonymous use of data for retrospective evaluation.

3 | RESULTS

During the study period, a total of 440 CTO PCIs were performed at our institution, subintimal approach was utilized in 129 (29.3%)

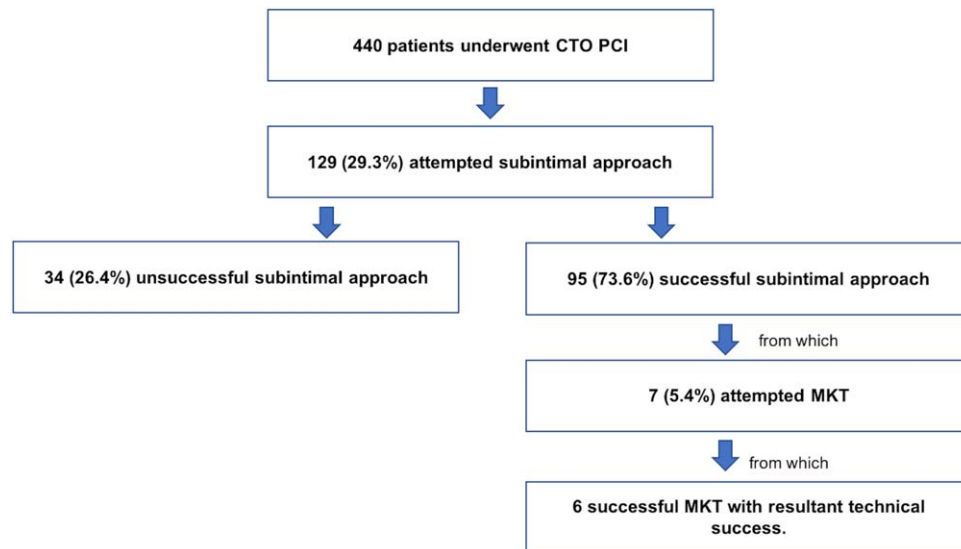


FIGURE 2 Study population flow chart. CTO, chronic total occlusion; PCI, percutaneous coronary intervention; MKT, microcatheter-knuckle technique [Color figure can be viewed at wileyonlinelibrary.com]

patients: 95 (73.6%) successful subintimal and 34 (26.4%) unsuccessful subintimal approaches. Of these subintimal approaches, MKT was attempted in seven patients (5.4%), it was successful in six (85.7%) patients, and technical success (achievement of a final stenosis <30% with thrombolysis in myocardial infarction 3 flow) was achieved in all seven patients (Figure 2).

There were no procedural complications observed. Procedural data are shown in Table 1. Here we describe two cases, one retrograde and one antegrade CTO revascularization, to provide examples of the MKT.

The first patient presented with proximal right coronary artery (RCA) CTO. The J-CTO score was 3 (length >20 mm, >45-degree bend, blunt stump). The distal RCA was supplied by retrograde

collaterals from the left circumflex artery, and the CTO landing zone was disease-free (Figure 3A). A transradial 6F XB 3.5 and a transfemoral 7F AL1 catheters were inserted. The distal cap was reached using a conventional retrograde approach; this was breached using a Miracle 3 guidewire (Asahi Intecc) and Corsair microcatheter (Asahi Intecc). As a result of significant resistance and difficulty in guidewire advancement, the Miracle 3 guidewire was changed to a Pilot 200 with knuckle shape, which was positioned into the subintimal space. However, bare knuckle wire advancement was difficult (likely because of fibrocalcific tissue). Thereafter the MKT was applied to facilitate advancement within the subintimal space (Figure 3B). Consequently, the retrograde wire could be advanced to the proximal cap and reverse

TABLE 1 Clinical and procedural characteristics of the patients treated with the Microcatheter Knuckle Technique (MKT)

Case no.	Sex	Age	CTO vessel	J-CTO score	PROGRESS-CTO score	Crossing technique	Micro-catheter	Guidewire for Knuckle	MKT Success	Procedural Success	Contrast volume (ml)	Fluoroscopy time (min)
1	M	61	Proximal RCA	3	0	Retrograde – Reverse CART	Corsair	Sion Black	No	Yes	550	130
2	M	54	Ostial RCA	5	2	Antegrade – STAR	Turnpike LP	Pilot 200	Yes	Yes	500	103
3	M	72	Proximal RCA	4	0	Retrograde – Reverse CART	Corsair	Pilot 200	Yes	Yes	270	53
4	M	64	Ostial RCA	3	2	Retrograde – Reverse CART	Corsair	Pilot 200	Yes	Yes	600	68
5	M	68	Proximal RCA	3	1	Retrograde – Reverse CART	Corsair	Pilot 200	Yes	Yes	400	49
6	M	57	Proximal RCA	3	1	Retrograde – Reverse CART	Corsair	Pilot 200	Yes	Yes	485	55
7	M	66	Proximal LCx	1	2	Retrograde – Reverse CART	Corsair	Sion Black	Yes	Yes	280	101

*RCA, right coronary artery; LCx, Left circumflex artery; CART, Controlled Antegrade and Retrograde subintimal Tracking; STAR, subintimal tracking and reentry.

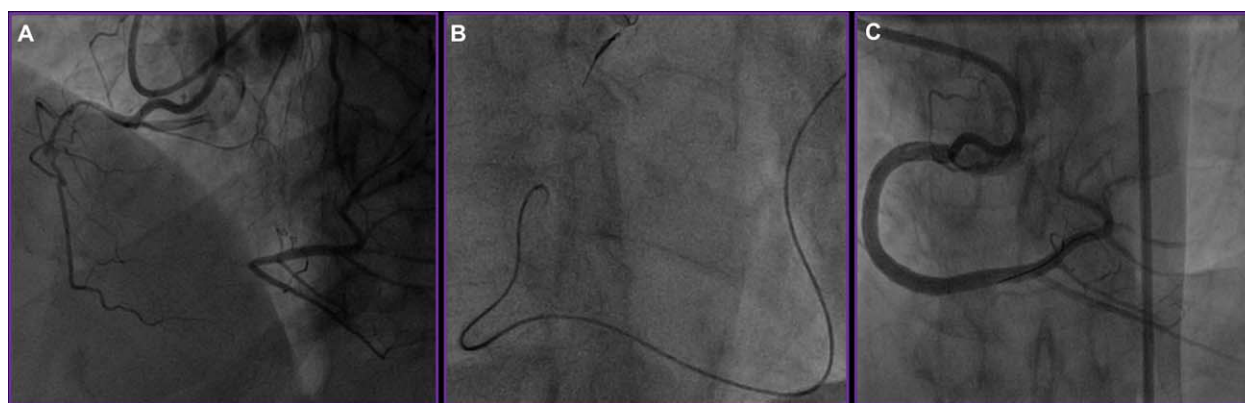


FIGURE 3 Illustrative case of microcatheter knuckle technique using retrograde approach. A, Coronary angiogram demonstrating proximal right coronary artery occlusion with distal vessel supplied by retrograde collaterals from the left circumflex artery. B, Fluoroscopy demonstrating microcatheter knuckle technique. C, Final coronary angiogram demonstrating excellent result [Color figure can be viewed at wileyonlinelibrary.com]

CART was performed. The procedure was then carried out as per standard practice, and three drug-eluting stents were implanted, with excellent final result (Figure 3C).

The second patient presented with ostial RCA CTO, involving three stents in the mid-to-distal segment. The distal vessel was supplied by septal collaterals from the left anterior descending artery (Figure 4A). The J-CTO score was 5. A transradial 6F XB 3.5 and a transfemoral 7F JR4 catheters were inserted. The proximal cap was passed using a Confianza Pro guidewire (Asahi Intecc) and a Turnpike LP microcatheter (Vascular Solutions). Following navigation in the subintimal space, it was impossible to engage the occluded stents in a within-stent fashion (likely because of stent undersizing). Therefore, the decision was made to perform subadventitial crossing around the occluded stents [4]. Significant resistance was experienced within the subintimal space (likely because of the close proximity with metallic stent struts) and the wire could not be advanced any further. Therefore, a Pilot 200 guidewire with a knuckle-shaped tip was advanced into the subintimal space, subsequently applying the MKT to facilitate

guidewire manipulation within the subintimal space (Figure 4B). Consequently, the guidewire-microcatheter unit could be advanced through the vessel, which was followed by subintimal tracking and reentry (STAR). The vessel (including the occluded stents) was then predilated and six drug-eluting stents were implanted with good final result (Figure 4C) [5].

4 | DISCUSSION

In this article, we have described the MKT, a novel CTO PCI technique that aims at complementing the CTO operator's toolkit. It can be utilized in both antegrade and retrograde approaches that require negotiation of a challenging subintimal space. MKT enlarges the subintimal space and consolidates the base of operations for further advancement of the guidewire-microcatheter unit. In our experience, the MKT was not associated with any procedural complication and facilitated successful negotiation of the subintimal space in six out seven patients and consequently allowed successful completion of the procedure.

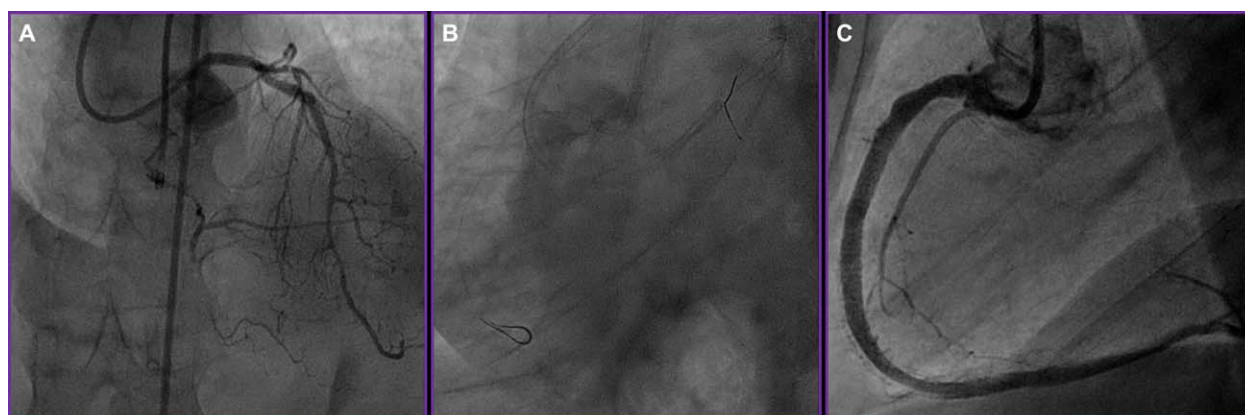


FIGURE 4 Illustrative case of microcatheter knuckle technique using antegrade approach. A, Coronary angiogram demonstrating ostial right coronary artery occlusion with distal vessel supplied by septal collaterals from the left anterior descending artery. B, Fluoroscopy of microcatheter knuckle technique. C, Final coronary angiogram demonstrating excellent result [Color figure can be viewed at wileyonlinelibrary.com]

There are alternative techniques that can be considered when significant resistance is experienced in negotiating the subintimal space. External crush [6] involves advancing a second guidewire with a different subintimal path compared with the first, and performing balloon dilatation in order to modify plaque compliance from “outside”. This technique requires additional maneuvers, compared with MKT (which can be performed immediately, after knuckle wire failure to advance), which increases procedural time and might lead to displacement of the first guidewire during microcatheter manipulation. However, they can only be performed antegradely (as opposed to the MKT) and may increase risk of vessel perforation.

There are some caveats related to the use of MKT. First, knuckle characteristics (size, wire) will determine the initial progression of the wire that will subsequently be utilized for knuckling the microcatheter. Therefore, it might be advisable that a wire with sufficient strength to negotiate a hostile subintimal space (e.g., Pilot 200) is chosen. Also, too small a knuckle can potentially engage in small side branches, which should be avoided. To increase the penetration force of the knuckle, MKT can be combined with the so-called “power knuckle”, in which the microcatheter is anchored in place by inflating a balloon proximal to its tip; then, the wire knuckle is advanced, the balloon is deflated, and MKT is performed as previously described. In addition, the choice of microcatheter is essential: this should be tapered and kink-resistant (either braided or dual-coil) as other kinds of microcatheters will kink and encounter difficulty in advancing in such a way in the subintimal space. In our experience, we have used the Corsair and Turnpike LP microcatheters, which fulfil criteria to performing MKT.

Although we did not experience any MKT-related complications, we speculate that this technique can be associated with vessel perforation, should the wire/microcatheter knuckle be advanced into a small side branch hence it is important that guidewire knuckle size is kept small to reduce the risk of vessel perforation. For this reason, it is imperative to clarify knuckle position with regards to expected vessel course in multiple fluoroscopic projections. In case a side branch is engaged, the knuckle should be withdrawn, and wire redirection should be performed. Another possible complication is microcatheter entanglement into the occlusion with subsequent inability to remove it or to remove the wire. To avoid this possibility, only a kink-resistant microcatheter should be employed.

In addition, should significant resistance be encountered advancing the guidewire or the microcatheter, operators can perform intravascular ultrasound imaging or injection of a small amount of contrast through the microcatheter to clarify vessel architecture. Despite these putative limitations, the MKT was not associated with any procedural complications and appears to be an effective technique to be employed when a conventional wire knuckle encounters difficulty advancing in the subintimal space, either antegradely or retrogradely.

5 | CONCLUSION

We present a novel technique for negotiating the subintimal space in CTO PCI for cases where significant resistance is experienced

restricting guidewire or material advancement in antegrade or retrograde dissection. The MKT appears efficacious complementing the CTO operator's armamentarium.

CONFLICT OF INTEREST

Nothing to report

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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