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ORIGINAL ARTICLE

Impact of the Intracoronary Rendezvous technique on coronary angioplasty for chronic total occlusion

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Abstract The Rendezvous technique, which requires bidirectional wiring, is one of the useful methods for improving the success rate of recanalization for chronic total occlusion (CTO) in the field of peripheral intervention. Recently, advanced new devices for percutaneous coronary intervention have enabled us to perform the Rendezvous technique for peripheral as well as for coronary CTO lesions. We used the Intracoronary Rendezvous technique to perform angioplasty for coronary CTO. "Intracoronary Rendezvous" means that Rendezvous was achieved within the CTO lesion. From March 2009 to November 2015, 189 patients underwent CTO angioplasty at our institute, and we treated 10 patients with the Intracoronary Rendezvous technique. This technique involves crossing the Gaia series guidewire to the contralateral Corsair microcatheter located inside the plaque of CTO lesions. The majority of the CTO sites examined were in the proximal RCA (60 %). Lesion length of the occlusion was relatively long (64.4 ± 12.2 mm). Using the biplane imaging system, we were able to control the Gaia guidewires in a specific direction. Furthermore, if the antegrade and retrograde wires can be advanced into contiguous space inside the CTO lesion, we intentionally entered either wire into the contralateral Corsair microcatheter, followed by successful CTO crossing. CTO recanalization was completed for all patients without controlled antegrade retrograde subintimal tracking (CART) or reverse CART. No major complications occurred during hospitalization. These results indicate that the Rendezvous technique, assisted by new devices and a biplane imaging system, represents one of the primary options to achieve successful coronary CTO recanalization. (249/250 words).

Keywords Rendezvous technique · Chronic coronary total occlusion · Percutaneous coronary intervention

Introduction

Recanalization of chronic total occlusion (CTO) is one of the challenging percutaneous coronary and peripheral interventions [1, 2]. Recently, the success rate of percutaneous coronary intervention (PCI) for CTO has progressively improved because of various modifications of techniques and advances in new devices [3–5]. For example, the parallel wiring technique and the retrograde approach have been applied for guidewire advancement to the distal true lumen beyond CTO lesions [4, 6]. However, depending upon the institutes involved, substantial differences in the success rates of PCI are noted in the literature, because of various CTO lesions as well as procedural complexity [7, 8]. In some cases, it is difficult to achieve successful wiring into the CTO lesion, even after the retrograde approach, including controlled antegrade retrograde subintimal tracking (CART) or reverse CART technique [9]. Therefore, novel CTO recanalization techniques are urgently required to minimize the differences in success rates among institutions.

In the peripheral CTO angioplasty procedure, the basic method used to cross the CTO lesion is an antegrade approach involving penetrating the lesion with a 0.035′,

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0.018′, or 0.014′ guidewire [10, 11]. Although this method is simple, the procedural success rate is substantially lower than that of non-CTO angioplasty [12]. The bidirectional approach, which requires antegrade and retrograde wiring systems, remarkably improves the success rate of peripheral CTO angioplasty [12, 13]. The Rendezvous method is one of the important techniques employed in the bidirectional approach that involves inserting an antegrade or retrograde guidewire into a contralateral microcatheter within the plaque of the CTO lesion. Successful execution of the Rendezvous method, followed by externalization using a 300-cm guidewire, offers us the option to cross a guidewire to the distal true lumen beyond the CTO lesion.

However, the Rendezvous method for coronary CTO angioplasty cannot be applied, because wire operability is significantly decreased under the beating heart. Recently, a novel CTO guidewire (Gaia series; Asahi Intecc, Co. Ltd, Aichi, Japan) was made available for the treatment of CTO. These guidewires exhibit favorable operability even with CTO lesions and, therefore, enable us to perform the Intracoronary Rendezvous method. In the present study, we investigated the feasibility and safety of the Intracoronary Rendezvous method inside the CTO lesion to perform coronary CTO angioplasty.

Materials and methods

Patient populations

From March 2009 to November 2015, 189 patients underwent CTO angioplasty at our institute. A flowchart of the strategies for CTO angioplasty is shown in Fig. 1. From June 2013 to November 2015, 10 of 11 patients underwent successful revascularization using the Rendezvous method, whereas the other patient was finally treated using the reverse CART technique. To examine the benefit of the Intracoronary Rendezvous method, we enrolled 11 patients who were treated using reverse CART between March 2009 and November 2015. Indications for CTO recanalization were either symptoms of angina or proven stress-induced ischemia. All patients provided written informed consent before admission to the study, which was approved by the Institutional Review Board.

Definitions

Coronary CTO is defined as a total occlusion with complete interruption of antegrade blood flow according to the assessment using coronary angiography, a Thrombolysis in Myocardial Infarction (TIMI) flow grade of 0, and an estimated duration of occlusion >3 months. We defined technical success as the restoration of antegrade flow, with a TIMI flow grade of 3 and final residual stenosis <30 %. Major adverse cardiac events (MACE) during hospitalization included death, Q-wave MI, or recurrent angina requiring coronary revascularization (coronary artery bypass graft surgery or urgent repeat PCI).

Intracoronary Rendezvous technique

Retrograde wiring was required for CTO angioplasty to treat the Intracoronary Rendezvous group. The timing of retrograde wiring was left to the discretion of the operator. In eight patients treated using the Intracoronary Rendezvous method, retrograde wiring was performed first, and two patients underwent antegrade wiring first for approximately 20 min using a single-wire technique.

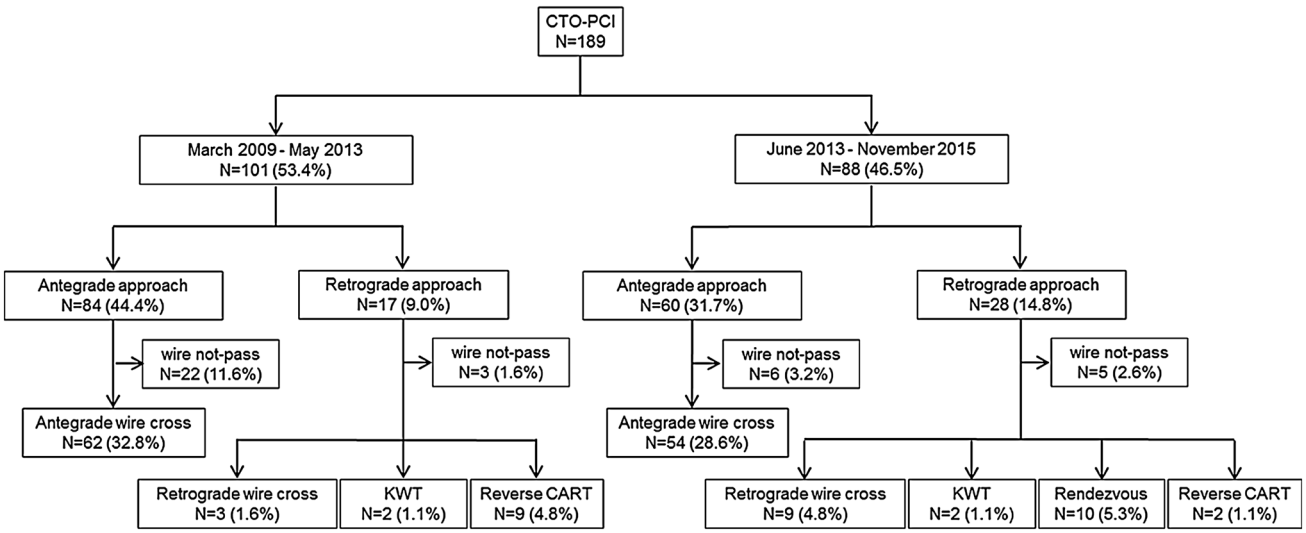

Fig. 1 Flowchart of the strategies to conduct CTO angioplasty. *CTO* chronic total occlusion, *KWT* kissing wire technique, *CART* controlled antegrade retrograde subintimal tracking

Thereafter, we attempted the retrograde approach via collateral channels. The septal or epicardial collateral channels were accessed via the contralateral patent coronary artery. Retrograde wiring was performed using a short guiding catheter (85 cm) and a microcatheter (Corsair; Asahi Intecc, Aichi, Japan). After advancing a tapered hydrophilic floppy wire (SUOH-03, Fielder XT-R; Asahi Intecc, Aichi, Japan) into the contralateral septal or epicardial artery, the wire was replaced with the Gaia second or Gaia third guidewire, which transmits excellent torque even in CTO lesions (Gaia series; Asahi Intecc, Aichi, Japan). We intentionally negotiated the Gaia series guidewires with the support of a Corsair catheter and the biplane imaging cine system. If the first Intracoronary Rendezvous attempt failed, the next step was to change the Rendezvous point or reverse the settings between the guidewires and microcatheter. After the guidewire was passed through the CTO lesion, wire pull-through was performed using a 300-cm guidewire (RG3; Asahi Intecc, Aichi, Japan), and then, predilatation was performed using a small balloon (1.5–2.0 mm). Thereafter, we used intravascular ultrasound (IVUS) to monitor the guidewire routes. Finally, all patients underwent additional ballooning and stenting. A representative example of Intracoronary Rendezvous is shown in Fig. 2, and representative IVUS images acquired after performing the Intracoronary Rendezvous method are shown in Fig. 3.

Statistical analysis

Continuous variables are presented as the mean ± standard deviation (SD) or as median and interquartile ranges (IQR), and categorical variables are presented as numerals and percentages. The unpaired Student's *t* test and Mann–Whitney tests for normally and asymmetrically distributed data, respectively, were used to analyze the differences between continuous variables. The Chi-squared or Fisher's exact test was used to analyze the categorical variables.

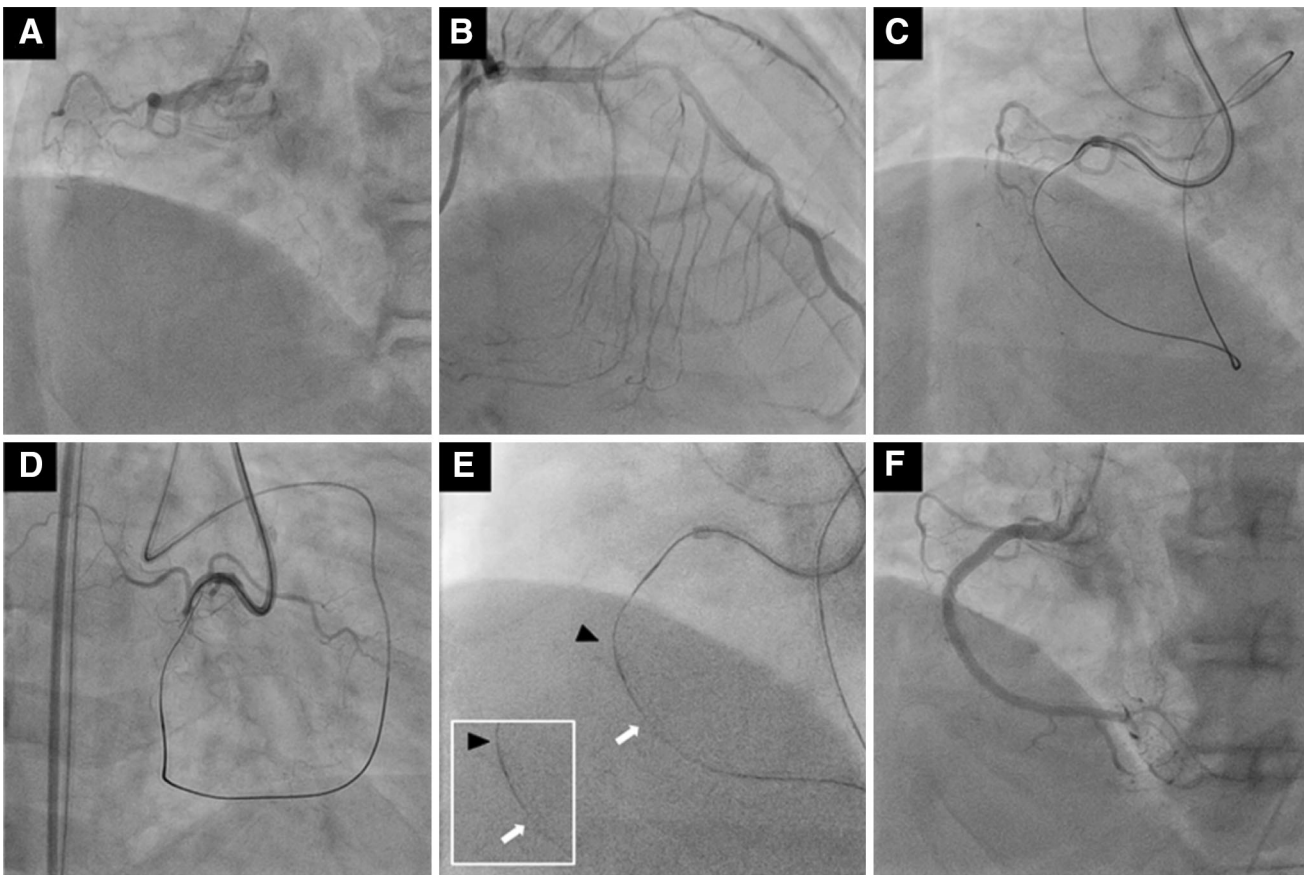

Fig. 2 A representative case of the Intracoronary Rendezvous method. **a** The right coronary artery was completely occluded from the proximal region. **b** The collateral channel is shown from the left anterior descending artery through the septal artery to the distal part of the right coronary artery. **c**, **d** From antegrade and retrograde perspectives, the Gaia second guidewire with the Corsair microcatheter was advanced and crossed inside the CTO (*C* LAO view, *D* RAO view). **e** The Rendezvous technique was completed via an antegrade Gaia second guidewire into a retrograde Corsair microcatheter (*white arrow* antegrade Gaia second wire, *arrowhead* retrograde Corsair microcatheter). **f** Balloon dilatation of the CTO site followed by stent implantation was then performed with a good outcome

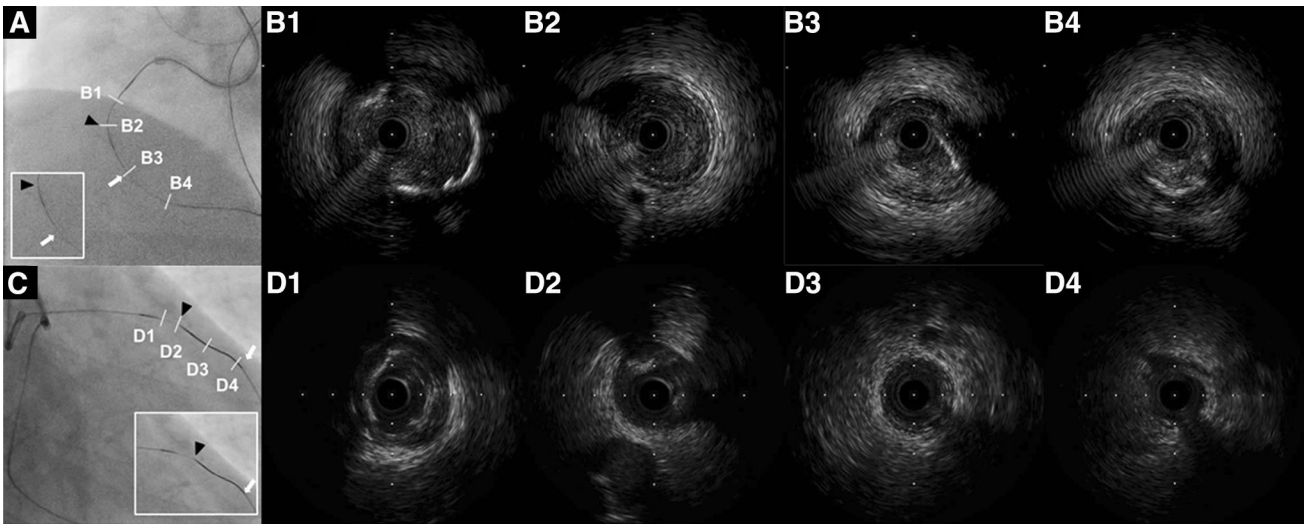

Fig. 3 Representative IVUS images acquired after performing the Intracoronay Rendezvous method. **a** Example 1; the Intracoronary Rendezvous method was performed in the middle RCA (white arrow: antegrade Gaia second wire, arrowhead: retrograde Corsair microcatheter). **b** IVUS findings (at points *B1–B4*). The guidewire was located in the true lumen from *B1* to *B4*. **c** Example 2; the Intracoronary Rendezvous method was performed in the middle LAD (white arrow: antegrade Gaia second wire, arrowhead: retrograde Corsair microcatheter). **d** IVUS findings (at points *D1–D4*). The guidewire was located in the true lumen from points *D1* to *D4*

P values <0.05 were considered statistically significant. Statistical analysis was performed using SPSS statistics 20 (IBM Corp, Armonk, NY, USA).

Results

Baseline patient clinical characteristics

We enrolled 21 patients with CTO lesions (Intracoronary Rendezvous group: $n = 10$, reverse CART group: $n = 11$). The baseline clinical characteristics of the patients are shown in Table 1. In the Intracoronary Rendezvous group, the mean age of the 10 male patients was 65.0 ± 10.7 years. There was a high incidence of history of myocardial infarction (70 %). The high prevalence of dyslipidemia and diabetes mellitus among our patients was consistent with that reported by a previous study [7]. The left ventricular ejection fraction was slightly decreased in our patients (51.4 ± 9.0 %).

Baseline lesion and procedural characteristics

Baseline lesion and procedural characteristics are shown in Table 2. In the Intracoronary Rendezvous group, the majority of occlusion sites were in the proximal RCA (60 %), and all lesions had mild to moderate calcification. Most lesions revealed abrupt stumps. Septal collateral channels were most frequently used to approach the occluded lesions, and epicardial channels were used in only one case. A majority (40 %) of Rendezvous lesions was in the middle RCA. Antegrade wiring to the retrograde Corsair catheter was performed for four patients, whereas retrograde wiring to the antegrade Corsair catheter was used for the others. The guidewires of the Gaia series, including Gaia second and Gaia third guidewires, were used in the Intracoronary Rendezvous method along with the Corsair catheter. The stent type, number of stents implanted, and stent deployment pressure are presented in Table 2. The amount of contrast volume was significantly smaller in the Intracoronary Rendezvous group than in the reverse CART group. Although no significant difference in the total fluoroscopic time was noted between the two groups, the procedure time was shorter in the Intracoronary Rendezvous group than in the reverse CART group. No deaths occurred in either group during the procedures, and there were no severe complications including coronary perforation or MACE during hospitalization.

IVUS findings

Representative IVUS images of the Rendezvous group (Fig. 3) show that the guidewire was located in the intraplaque from the proximal to the distal CTO lesions of the nine patients in the Intracoronary Rendezvous group. In another patient who underwent the Intracoronary Rendezvous method, the antegrade guidewire was first entered into the subintimal lumen, which was made with previous attempt. Therefore, we reinserted the antegrade guidewire from the proximal channel of the CTO with the IVUS guide and performed re-Rendezvous inside the CTO lesion.

Lesion and procedural characteristics

An individual lesion and procedural characteristics in the Intracoronary Rendezvous group are shown in Table 3. The bilateral transfemoral approach (TFA) was administered to four patients, and the TFA and one transradial approach (TRA) was administered to six patients. The majority of the guiding catheters used for the antegrade approach was 7 Fr, for the retrograde approach was 6 Fr, respectively. For patients administered the 7-Fr TFA and 8-Fr TFA, vascular closure devices, ExoSeal (Cordis Corporation, Fremont, CA, USA) and Perclose ProGlide (Abbott Vascular, Abbott Park, IL, USA) were used for hemostasis, respectively. For patients administered TRA, a 6-Fr sheath or 5-Fr and 6-Fr Glidesheath Slenders were used, and the TR-band (Terumo, Tokyo, Japan) was used to maintain hemostasis. All closures were technically successful (successful device deployment) without major complications.

Discussion

To our knowledge, the present study is the first report to demonstrate series of successful coronary CTO recanalization using the Intracoronary Rendezvous technique inside the CTO lesion. Techniques for CTO-PCI appear well established because of the retrograde approach, including the CART technique and new devices [3, 7, 14, 15]. However, it is not always easy to advance a guidewire from the false to true lumen even using the CART technique [9], indicating the importance of developing other methods for coronary CTO angioplasty.

The Rendezvous method is one of the techniques used to treat long-segment CTO of the peripheral artery [13]. The traditional Rendezvous method involves inserting the antegrade or retrograde guidewire into a contralateral microcatheter in the CTO lesion [13]. This technique significantly increased the procedural success rate of CTO angioplasty in the peripheral [12]. The Rendezvous method requires no subintimal dissection and re-entry techniques. This method, therefore represents an ideal recanalization technique with true-to-true lumen crossing in CTO lesions. However, in coronary CTO lesions, it is very difficult to advance a conventional guidewire to a contralateral microcatheter because of its insufficient operability. Therefore, subintimal dissection and re-entry techniques, including CART and reverse CART, are recommended by most operators as a second- or third-line strategy after the failure of conventional antegrade or retrograde crossing attempts [4, 6, 14, 15].

The novel Gaia series, specially designed for treating CTO lesions, was approved for use in late 2013 [16]. The Gaia series of guidewires (Gaia first, Gaia second and Gaia third) possess specific properties that allow them to move in specific directions, even within CTO lesions. Thus, we

Table 1 Baseline clinical characteristics

Variables	Reverse CART ($n = 11$)	Rendezvous ($n = 10$)	P value
Age (years)	63.8 ± 11.7	65.0 ± 10.7	0.81
Male/female	10/0	10/0	1.00
Risk factors, *n* (%)			
Hypertension	8 (73)	8 (80)	0.55
Dyslipidemia	7 (64)	7 (70)	0.56
Diabetes mellitus	3 (27)	4 (40)	0.44
Current smoker	2 (18)	4 (40)	0.27
Hemodialysis	2 (18)	0 (0)	0.26
History of MI, *n* (%)	5 (45)	7 (70)	0.25
Prior PCI, *n* (%)	9 (82)	9 (90)	0.54
History of CABG, *n* (%)	2 (18)	0 (0)	0.26
Clinical diagnosis, *n* (%)			
Stable angina	11 (100)	8 (80)	0.21
Silent myocardial ischemia	0 (0)	2 (20)	
LVEF, %	51.6 ± 11.0	51.4 ± 9.0	0.97
Number of diseased arteries, *n* (%)			
Single vessel	6 (55)	8 (80)	0.22
Double vessel	5 (45)	2 (20)	

Results are expressed as the mean ± SD

MI myocardial infarction, *PCI* percutaneous coronary intervention, *CABG* coronary artery bypass graft, *LVEF* left ventricular ejection fraction, *CART* controlled antegrade retrograde subintimal tracking

Table 2 Baseline lesion and procedural characteristics

Variables	Reverse CART ($n = 11$)	Rendezvous ($n = 10$)	P value
Target lesion, *n* (%)			
Proximal RCA	3 (27)	6 (60)	0.002
Middle RCA	5 (45)	1 (10)	
Distal RCA	1 (9)	2 (20)	
Proximal LAD	2 (18)	0 (0)	
Middle LAD	0 (0)	1 (10)	
TIMI flow			
0	11 (100)	10 (100)	>0.99
Rentrop grade			
1	1 (9)	1 (10)	0.74
2	10 (91)	9 (90)	
3	0 (0)	0 (0)	
Calcification, *n* (%)	6 (55)	10 (100)	0.09
Proximal stump type, *n* (%)			
Tapered	6 (55)	2 (20)	0.12
Abrupt	5 (45)	8 (80)	
Distal stump type, *n* (%)			
Tapered	9 (82)	9 (90)	0.67
Convex	2 (18)	1 (10)	
Side branch at occlusion, *n* (%)	8 (73)	4 (40)	0.14
Bridging collateral, *n* (%)	3 (27)	4 (40)	0.44
Occlusion length, mm	50.3 ± 19.4	64.4 ± 12.2	0.07
Reference diameter (proximal only), mm	3.1 ± 0.3	3.0 ± 0.4	0.64
Timing of retrograde wiring, *n* (%)			
Retrograde earlier than antegrade	7 (64)	8 (80)	0.37
Immediately after failed antegrade	4 (36)	2 (20)	
Used retrograde route, *n* (%)			
Septal route	8 (73)	9 (90)	0.33
Epicardial route	3 (27)	1 (10)	
Rendezvous lesion, *n* (%)			
Proximal RCA	NA	2 (20)	NA
Middle RCA	NA	4 (40)	
Distal RCA	NA	3 (30)	
Middle LAD	NA	1 (10)	
Rendezvous direction, *n* (%)			
Antegrade wire to retrograde MC	NA	4 (40)	NA
Retrograde wire to antegrade MC	NA	6 (60)	
Wires used for Rendezvous to MC, *n* (%)			
Gaia second guidewire	NA	8 (80)	NA
Gaia third guidewire	NA	2 (20)	
MC used for Rendezvous, *n* (%)			
Corsair	NA	10 (100)	NA
Stent type, *n* (%)			
Cypher Select	3 (27)	0 (0)	<0.01
Taxus Liberte	1 (9)	0 (0)	
Xience V	3 (27)	0 (0)	
Xience Xpedition	0 (0)	4 (40)	
Xience Alpine	1 (9)	1 (10)	
Promus Element	2 (18)	0 (0)	
Resolute Integrity	0 (0)	1 (10)	
Nobori	1 (9)	4 (40)	
Number of stents implanted	2.9 ± 0.3	2.7 ± 0.5	0.23

Table 2 continued

Variables	Reverse CART ($n = 11$)	Rendezvous ($n = 10$)	P value
Stent deployment pressure (atm)	15.1 ± 3.5	15.1 ± 3.5	0.99
Contrast volume (ml)	296.8 ± 31.7	234.5 ± 78.0	0.03
Total fluoroscopic time (min)	147.1 ± 46.7	124.5 ± 63.7	0.36
Procedure time (min)	253.7 ± 68.1	197.0 ± 88.6	0.07

Results are expressed as the mean ± SD

RCA right coronary artery, *LAD* left anterior descending artery, *TIMI* thrombolysis in myocardial infarction, *MC* microcatheter, *CART* controlled antegrade retrograde subintimal tracking, *NA* not applicable

Table 3 Individual lesion and procedural characteristics of patients treated with the Rendezvous method

Patient no.	Age (years)/sex	Target vessel (segment)	Approach site/size of GC		Contrast volume (ml)	Total fluoroscopic time (min)	Procedure time (min)
			Antegrade approach	Retrograde approach			
1	64/M	RCA (1)	Right TFA/8 Fr	Left TFA/7 Fr	290	97	130
2	84/M	RCA (1)	Right TFA/8 Fr	Left TFA/7 Fr	170	63	103
3	50/M	RCA (1)	Right TFA/7 Fr	Left TRA/6 Fr	190	125	162
4	61/M	LAD (7)	Right TFA/8 Fr	Left TFA/7 Fr	290	102	170
5	71/M	RCA (1)	Right TFA/7 Fr	Left TRA/6 Fr	270	262	385
6	54/M	RCA (1)	Right TFA/7 Fr	Left TFA/6 Fr	170	75	153
7	58/M	RCA (2)	Right TFA/7 Fr	Left TRA/6 Fr	160	165	262
8	59/M	RCA (3)	Right TFA/7 Fr	Left TRA/6 Fr	405	132	287
9	74/M	RCA (1)	Right TFA/7 Fr	Left TRA/6 Fr	200	84	121
10	75/M	RCA (3)	Right TFA/7 Fr	Left TRA/6 Fr	200	141	198

GC guiding catheter, *RCA* right coronary artery, *LAD* left anterior descending artery, *TFA* transfemoral approach, *TRA* transradial approach

are able to advance the Gaia series wire in almost any direction guided by biplane imaging. Furthermore, Corsair microcatheter, which has the features of a microcatheter and a support catheter, improves the ability to manipulate guidewires in a CTO lesion without channel dilation [3]. These new devices and the biplane imaging system provide us with the option of administering the Intracoronary Rendezvous technique to patients with coronary CTO, if we can advance the antegrade and retrograde guidewires into the contiguous space of intimal plaque or subintimal tissue in a CTO lesion.

The major advantage of the Intracoronary Rendezvous method is its potential for successful crossing of the CTO when the Rendezvous method succeeds. The externalization procedures are sometimes laborious and lengthy [17]. Furthermore, in some cases, it is difficult to advance the retrograde microcatheter beyond the CTO lesion because of heavy calcium deposits. Our Intracoronary Rendezvous method enables instant retrograde guidewire advancement into the antegrade guiding catheter, without effort to exchange the Gaia guidewire for a floppy guidewire, or introduce child-catheter deeply inside CTO lesion. In the present study, the procedure time required to treat tended to be shorter in the Intracoronary Rendezvous group than in the reverse CART group. Rathore et al. [18] reported that the procedure time of CTO-PCI with CART technique performed in a Japanese high-volume center is 213.6 ± 78 min, which is comparable with our procedure time for the Intracoronary Rendezvous group. Rathore et al. demonstrated that the total contrast volume used is 321.32 ± 137.77 ml in the CTO-PCI with IVUS-guided reverse CART [19]. In the present study, the contrast volume use was significantly smaller in the Intracoronary Rendezvous group than in the reverse CART group, and six of 10 patients were successfully treated with the Intracoronary Rendezvous method using <200 ml contrast medium. These results indicate that Intracoronary Rendezvous method could save time and contrast medium compared with PCI employing the reverse CART technique.

However, compared to the peripheral artery, the coronary artery bends or twists with a beating heart. Therefore,

application of the Rendezvous method must be confirmed before and during the PCI. First, the Rendezvous point is better when it is as linear as possible. Using the biplane imaging system allowed us to select a linear section of the coronary CTO lesion. Second, the length of the CTO lesion is an important factor. Similar to the peripheral Rendezvous method, a long coronary CTO lesion is better suited than a short CTO lesion for the Intracoronary Rendezvous method, because multiple Rendezvous points can be selected in a long CTO lesion. Third, the stability of a Corsair microcatheter within the CTO lesion is mandatory to accomplish the Intracoronary Rendezvous under the beating heart. Therefore, the Intracoronary Rendezvous method is not feasible in the CTO lesion with a large subintimal space created using a knuckle wire technique or predilatation including the CART technique.

The kissing wire technique (KWT) is often used as a suitable technique during the bidirectional approach [14]. However, if the antegrade and retrograde guidewires are located in a different intraplaque channel, the retrograde channel must be intentionally punctured by the antegrade wire to cross the CTO. This procedure is often difficult and unpromising. Actually, Muramatsu et al. reported that the success rate of KWT was approximately 70 % [8]. This difficulty may be overcome using the Intracoronary Rendezvous method. The Gaia series guidewire fixed in the intraplaque by the Corsair allows us to intentionally penetrate the intimal membrane separating the antegrade and retrograde channels. In the present study, the success rate of Intracoronary Rendezvous methods was approximately 90 % since June 2013. Furthermore, in almost all cases, IVUS revealed that the guidewires crossed through the true or intraplaque of the CTO lesion. These results indicate that the Intracoronary Rendezvous method is a promising option for CTO crossing.

Muramatsu et al. reported the Rendezvous method for patients with CTO after failure of the reverse CART techniques [9]. They succeeded by inserting an antegrade Conquest guidewire into the retrograde Corsair catheter in the coronary CTO lesion. However, we found that the Conquest guidewire was too stiff to move in specific directions within the CTO lesion and, therefore, used the Gaia series of guidewires, which have a more appropriate level of penetration and manipulation for performing the coronary Rendezvous technique inside the CTO lesion. Furthermore, Kim and Mitsudo et al. reported a method employing microcatheters aligned in a guide catheter followed by an antegrade guidewire that is pulled into a retrograde microcatheter [20]. Although the authors referred to this method as "the Bridges or Rendezvous technique," this method differs from our Intracoronary Rendezvous technique, because our technique advanced the guidewire into an antegrade or retrograde microcatheter inside the CTO lesion. Therefore, our Intracoronary Rendezvous method did not require CART or reverse CART. Subintimal dissection and re-entry techniques, including CART and reverse CART, potentially involve a side-branch occlusion. Thus, these techniques cannot be applied to left anterior descending coronary artery (LAD) with major side branches. The Intracoronary Rendezvous method, in which the guidewire can cross into the true lumen, was applicable to LAD CTO lesions without concern for side-branch occlusions.

Shorrock et al. reported that the frequency of aortocoronary dissection occurrence is 1.8 % (6/336 patients) during PCI for CTO [21]. Most aortocoronary dissections occurred in patients undergoing retrograde PCI for CTO using an excessively large guiding catheter. Furthermore, access site management after sheath removal is of utmost importance, because significant morbidity is associated with access-related complications [22]. In the present study, the Intracoronary Rendezvous method was routinely accomplished using 7-Fr/6-Fr PCI systems, in which the risk of catheter-induced ostial injury was not increased during externalization. Furthermore, major bleeding after the TFA did not occur when the vascular closure devices were operated with care. These results indicate that our Rendezvous method is safe. Recently, Yoshimachi et al. reported that the Glidesheath Slender (GSS) (Terumo, Tokyo, Japan) is safe for transradial intervention [23]. GSS is a new dedicated transradial sheath with a thinner wall and hydrophilic coating. The 6-Fr GSS combines an inner diameter compatible with the 6-Fr guiding catheter with an outer diameter close to that of the 5-Fr sheath. The use of GSS for TRA may provide a less-invasive Intracoronary Rendezvous method in the future.

The present study has two main limitations as follows: The study was conducted at a single center and included a small number of patients. Because our study represents a highly selective series of patients and an experienced operator, the results may not be applicable to less experienced operators. Second, this study investigated the feasibility, safety and immediate success rate of the Intracoronary Rendezvous technique. However, it is too soon to evaluate the intermediate and long-term results.

Conclusions

The present study is the first report that the Intracoronary Rendezvous technique can be used as one of the primary options for the percutaneous treatment of CTO of the coronary artery. The Intracoronary Rendezvous technique, assisted by the Gaia series of guidewires, in combination with a Corsair microcatheter and a biplane imaging system, facilitated the current highly successful retrograde approach.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional Research Committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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