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Comparison of the device performance between the conventional guide extension catheter and the soft guide extension catheter☆

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ABSTRACT

Background: The guide extension catheter is frequently used in current percutaneous coronary intervention, and the GuideLiner (Vascular Solutions Inc., Minneapolis, MN) has been the standard guide extension catheter. Recently, the Guideplus (Nipro, Osaka, Japan) has emerged as a new guide extension catheter. The aim of the present study was to compare device performance between the Guideplus and GuideLiner.

Methods: We compared the purpose of guide extension catheter and the device unsuccessful rate between the Guideplus and GuideLiner. We classified the purpose of guide extension catheter into 4 categories: (1) to advance devices into the target lesion, (2) to engage guide catheter into the ostium, (3) to support the small profile balloon crossing the CTO or 99% stenosis that the microcatheter could not cross, and (4) others.

Results: Ninety-two lesions were classified as the Guideplus group, whereas 103 lesions were classified as the GuideLiner group. The purpose of guide extension catheter was significantly different between the 2 groups ($P < 0.001$). The Guideplus was frequently used to support the small profile balloon crossing the CTO or 99% stenosis (20.7%), whereas the GuideLiner was not used (0%). The device unsuccessful rate was significantly less in the Guideplus (8.7%) than in the GuideLiner (20.4%) ($P = 0.022$).

Conclusions: The purpose of guide extension catheter was significantly different between the Guideplus and GuideLiner. The Guideplus was more frequently used to support the small profile balloon crossing the CTO or 99% stenosis. The device unsuccessful rate was less in the Guideplus, which may suggest the better performance as the guide extension catheter.

Introduction

Current percutaneous coronary intervention (PCI) is applicable to more complex lesions such as tortuous, diffuse, calcified or totally occluded lesions, partly because of the development of devices such as drug-eluting stents or small profile balloons, and techniques such as "mother in child" technique [1–3]. The mother in child technique using 5 Fr straight tip catheter was useful for complex lesions [4], but the insertion of straight tip catheter into guide catheter was not simple. As the emergence of guide extension catheter such as GuideLiner (Vascular Solutions Inc., Minneapolis, MN) has made mother in child technique simpler, the GuideLiner is more frequently used as "child" than the straight tip catheter in current complex PCI [5–8].

Although the GuideLiner has dramatically simplified the mother in child technique, the GuideLiner has some limitations. For example, anchor ballooning is essential to advance the GuideLiner in most cases [9, 10]. Recently, the Guideplus (Nipro, Osaka, Japan), which is a soft guide extension catheter [11], was launched. The Guideplus does not require anchor ballooning in most cases, because of its softness and hydrophilic coating. Thus, the Guideplus may have better performance as "child" as compared to the GuideLiner. However, the direct comparison of device performance has not been investigated between the GuideLiner and Guideplus. The aim of the present study was to compare device performance between the Guideplus and GuideLiner in clinical setting.

1. Methods

1.1. Study lesions

From our catheter laboratory records, we identified lesions that underwent PCI using GuideLiner or Guideplus from May 2014 to December 2017. During the study period, interventional cardiologists in

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our medical center used GuideLiner or Guideplus by the following 3 reasons: (1) To advance devices including stent, balloon, or intravascular ultrasound (IVUS) catheter into the target lesion (Fig. 1 for Guideplus, Fig. 2 for GuideLiner). (2) To engage guide catheter into the ostium of coronary artery (Fig. 3 for Guideplus, Fig. 4 for GuideLiner). (3) To support the small profile balloon (1.0 or 1.5 diameter) crossing the CTO (or 99% stenosis) lesion that the microcatheter could not cross (Fig. 5). Other reasons for using GuideLiner or Guideplus were aspiration, removal of devices, capture of retrograde guidewire in reverse controlled antegrade and retrograde subintimal tracking (CART) technique and super selective injection.

During the study period (May 2014 to December 2017), a consecutive 196 lesions were treated by using either Guideplus or GuideLiner. Of 196 lesions, the Guideplus was used in 93 lesions, whereas the GuideLiner was used in 104 lesions. One lesion was treated by using both Guideplus and GuideLiner, and was excluded from the present study. Thus, a total of 92 lesions were classified as the Guideplus group, whereas a total of 103 lesions were classified as the GuideLiner group. We compared the clinical, angiographic and procedural characteristics between the Guideplus and GuideLiner groups. We also compared the purpose of the guide extension catheter and the device unsuccessful rate between the 2 groups. This study was approved by the institutional review board and written informed consent was waived, because of the retrospective study design.

1.2. PCI procedures

PCI was performed with standard conventional techniques. The choice of components such as guide wire, balloon, and stent was left at the discretion of the interventional cardiologists. The choice of guide extension catheter was also left at the discretion of the interventional cardiologists, but the Guideplus was not available before February 2017. An IVUS was routinely used for almost all lesions in our medical center, partly because the government reimbursement system covers the cost of IVUS in Japan.

1.3. Definition

The diagnosis of acute myocardial infarction (AMI) required the following criteria: symptom consistent with AMI, elevated cardiac enzyme including Troponin T, Troponin I, and/or creatinine kinase (at least 2-folds increase from normal upper limit), and ST-segment elevation (ST-elevation myocardial infarction) or depression (non ST-elevation myocardial infarction) in electrocardiograms compatible with AMI [12,13]. Chronic total occlusion (CTO) was defined as total occlusion with complete interruption of antegrade blood flow as assessed by coronary arteriography and with an estimated duration of occlusion of ≥3 months [14]. We divides the lesions into 2 groups, Type B2/C or not, according to American Heart Association/American College of Cardiology (AHA/ACC) lesion type classification [15]. We classified the purpose of guide extension catheter into 4 categories: (1) to advance devices into the target lesion, (2) to engage guide catheter into the ostium, (3) to support the small profile balloon crossing the CTO or 99% stenosis that the microcatheter could not cross, and (4) others. Device unsuccess was defined as that the guide extension catheter could not work for the above specific purposes. For example, when the guide extension catheter was used for the purpose of advancing the stent, the stent did not reach the target lesion.

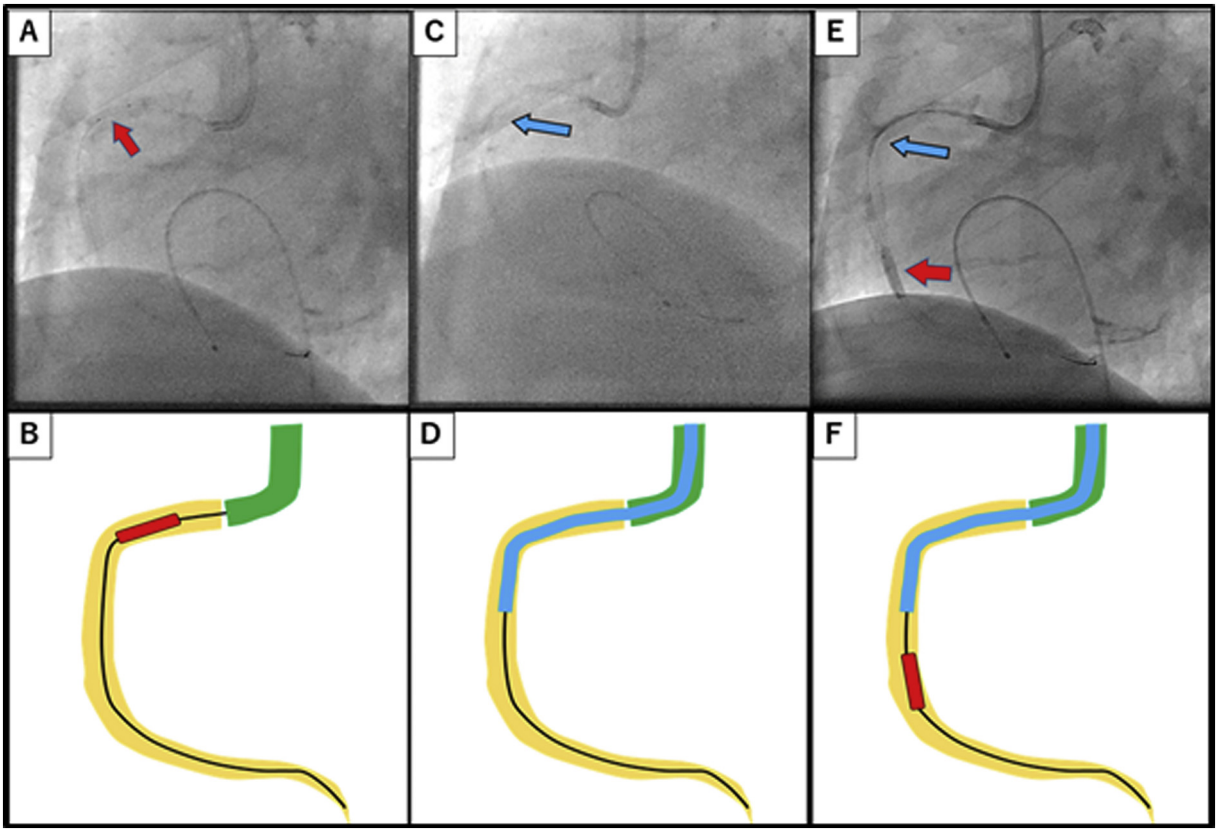

Fig. 1. The representative procedure of the Guideplus to advance the balloon into the target lesion. A: We could not advance the balloon (red arrow) until the target lesion. B: The illustration of panel A. C: We inserted the Guideplus (blue arrow) into the middle segment of the right coronary artery. D: The illustration of panel C. E: We could advance and inflated the balloon (red arrow) via the Guideplus (blue arrow). F: The illustration of panel E.

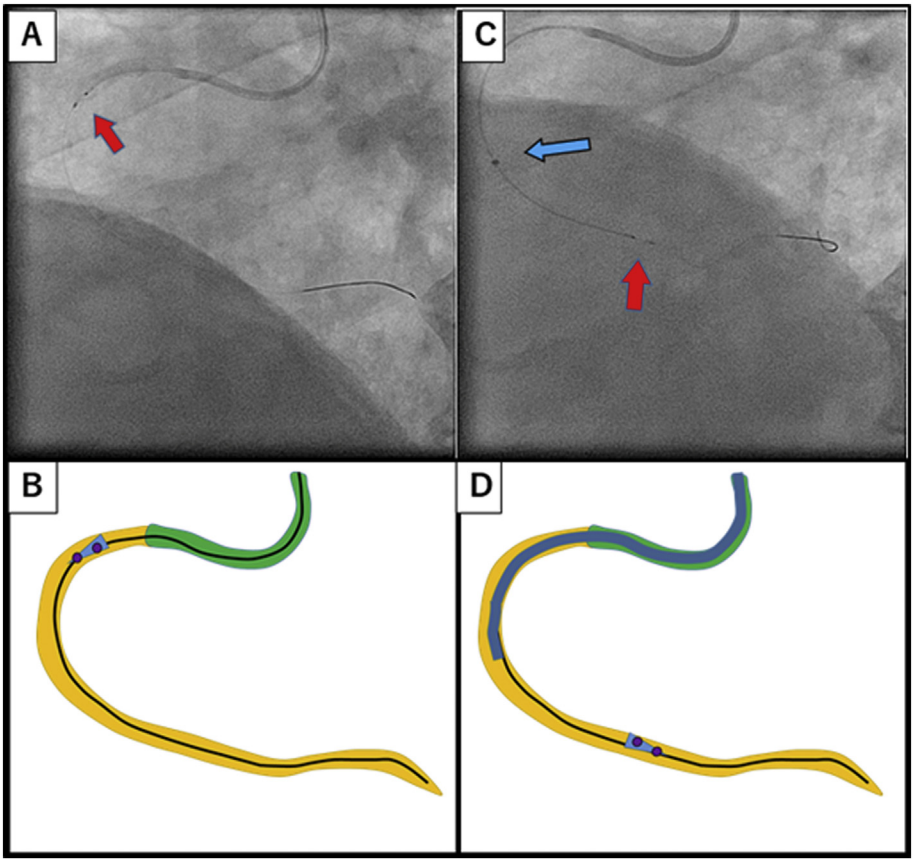

Fig. 2. The representative procedure of the GuideLiner to advance the intravascular ultrasound (IVUS) into the target lesion. A: We could not advance the IVUS catheter (red arrow) until the target lesion. B: The illustration of panel A. C: We could advance the IVUS catheter (red arrow) via the GuideLiner (blue arrow). D: The illustration of panel C.

1.4. Statistical analysis

Data are expressed as mean ± SD or percentage. Categorical variables are presented as numbers (percentage) and compared with a Pearson's χ^2 test or Fisher's exact-test. The Kolmogorov–Smirnov test was performed to determine if the continuous variables were normally distributed. Normally distributed continuous variables were compared between the groups using an unpaired Student *t*-test. Otherwise, continuous variables were compared using a Mann–Whitney *U* test. All analysis was performed using statistical software, SPSS18.0/Windows (SPSS, Chicago, IL).

2. Result

Table 1 shows the comparison of patient characteristics between the 2 groups. Most of clinical characteristics were comparable between the 2 groups. The prevalence of PCI to the culprit of STEMI was less in the Guideplus group (9.8%) than in the GuideLiner group (25.2%).

Table 2 shows the comparison of lesion and procedural characteristics between the 2 groups. PCI to the right coronary artery was less frequently performed in the Guideplus group (57.6%) than in the GuideLiner group (72.8%). PCI to CTO was more frequently performed in the Guideplus group (29.3%) than in the GuideLiner group (14.6%) ($P = 0.012$).

Table 3 shows the comparison of purpose of guide extension catheter and device unsuccessful rate between the 2 groups. The purpose of guide extension catheter was significantly different between the 2 groups ($P < 0.001$). The Guideplus was used to support the small profile balloon crossing the CTO or 99% stenosis that the microcatheter could not cross in 19 lesions (20.7%), whereas the GuideLiner was not used for this purpose. Other purposes of guide extension catheter were capture of retrograde guidewire in reverse CART technique (2 lesions in the Guideplus group, 3 lesions in the GuideLiner group), thrombus aspiration (1 lesion in the Guideplus group, 2 lesions in the GuideLiner group), bailout from entrapped device (1 lesion in the Guideplus group [11], 1 lesion in the GuideLiner group) and selective angiography (1 lesion in the Guideplus group). The device unsuccessful rate was significantly less in the Guideplus group (8.7%) than in the GuideLiner group (20.4%) ($P = 0.022$).

3. Discussion

The present study included 195 lesions, which were divided into 92 lesions using the Guideplus and 103 lesions using the GuideLiner. The purpose of guide extension catheter was significantly different between the Guideplus and GuideLiner groups. Particularly, one-fifth of Guideplus cases were used to support the small profile balloon crossing the CTO or 99% stenosis that the microcatheter could not cross, whereas there were no GuideLiner cases that were used for that purpose. The device unsuccessful rate was less in the Guideplus group than in the GuideLiner group, which may suggest the better performance as the guide extension catheter in the Guideplus than in the GuideLiner. Currently, several types of guide extension catheter are available in the field of PCI. To the best of our knowledge, the present study is a first study to compare different types of guide extension catheters.

The difference of purpose of guide extension catheter between the 2 groups was mainly derived from that the one-fifth of Guideplus cases were used to support the small profile balloon crossing the CTO or

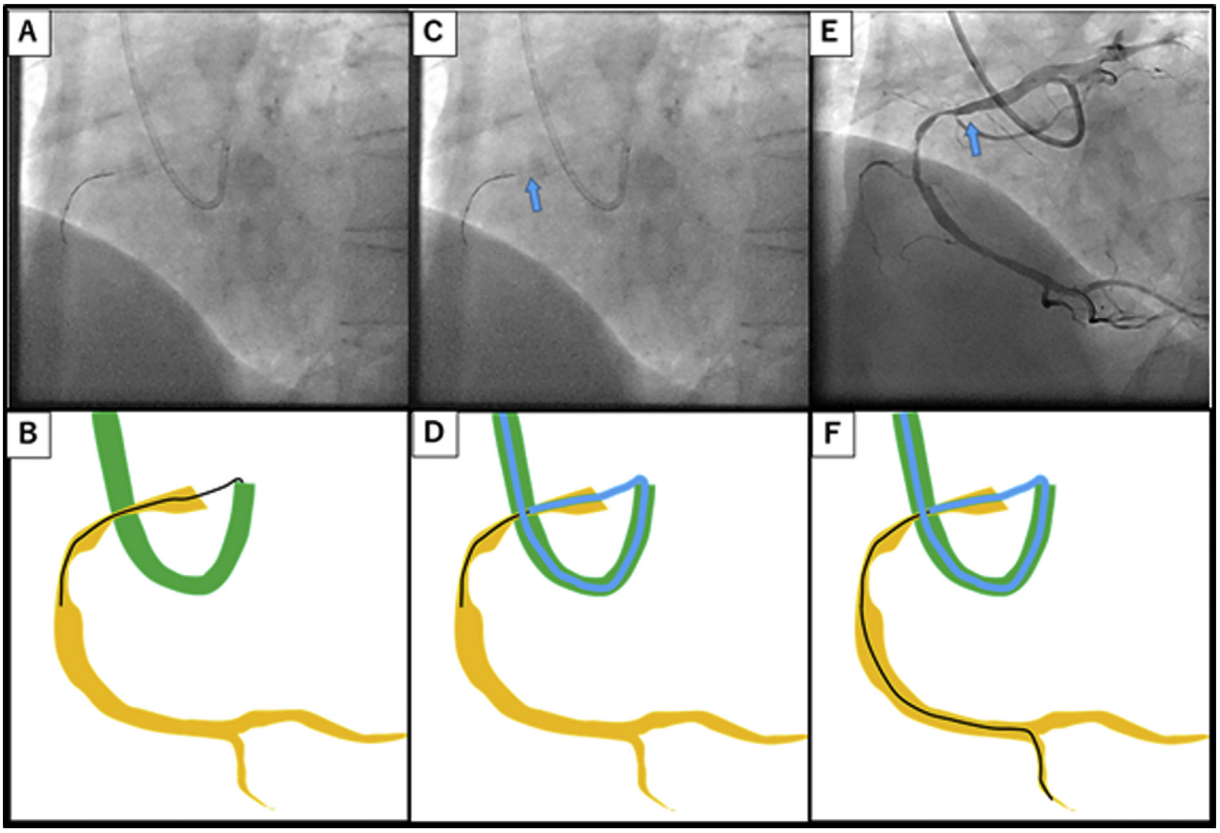

Fig. 3. The representative procedure of the Guideplus to engage the guide catheter into the ostium of coronary artery. A: We could not insert the guide catheter into the right coronary artery, but inserted the guidewire. B: The illustration of panel A. C: We advanced the Guideplus (blue arrow) into the right coronary artery. D: The illustration of panel C. E: We could advance the guidewire beyond the lesion, and could perform angiography via the Guideplus. F: The illustration of panel E.

99% stenosis that the microcatheter could not cross, while no GuideLiner cases were used for that purpose. We should explain why only the Guideplus was used for that purpose. In CTO PCI, to advance the microcatheter such as the Corsair microcatheter (Asahi Intecc, Nagoya, Japan) beyond the CTO lesion following the guidewire crossing is the essential step for the successful procedure [16]. Thus, if the microcatheter cannot cross the CTO lesion, every effort would be made to strengthen back-up force. The GuideLiner was also used as an adjunctive tool in PCI for balloon uncrossable CTO [17]. However, the anchor balloon technique, which is often required to advance the GuideLiner to the lesion, would not be possible for balloon uncrossable CTO. On the other hand, since the Guideplus does not require the anchor balloon in most cases, we can advance the Guideplus until the just proximal of the CTO lesion without anchor balloon technique. Therefore, we preferred using the Guideplus for that specific purpose.

The reason for the lower device unsuccessful rate in the Guideplus should be discussed. The unique characteristic of the Guideplus is its softness [11] (Fig. 6). The Guideplus may advance with little resistance in the tortuous coronary artery, because of its softness and hydrophilic coating. As the anchor balloon technique is unnecessary in most Guideplus cases, it is possible for the Guideplus to engage guide catheter in the anomalous origin of coronary artery, as long as the guidewire advance into the coronary artery. Moreover, the small profile of Guideplus (the maximum outer diameter: 1.65 mm) might decrease the friction between the Guideplus and coronary vessel wall, while the GuideLiner also has a small profile type (the maximum outer diameter: 1.64 mm for 5.5 Fr type).

We should mention the weakness of Guideplus. The visibility under fluoroscopy is poorer in the Guideplus than in the GuideLiner. For example, the tip of GuideLiner is clearly visible without contrast media (Fig. 2C), while the tip of Guideplus is less visible without contrast media (Fig. 1C, Fig. 3C). Although the Guideplus might pursue crossability with sacrificing visibility, poor visibility would increase the risk of unanticipated errors in PCI. While we have not experienced any complications related to the poor visibility of Guideplus, stent deployment within the Guideplus is a possible complication. Furthermore, the Guideplus does not have size variation (only 6 Fr), while the GuideLiner has 3 size variations (5.5 Fr, 6 Fr and 7 Fr). Therefore, we cannot advance some large profile devices via the Guideplus.

4. Study limitations

The present study has the following limitations. Because this study was a single-center retrospective observational study, there is a risk of selection bias. Especially, since the Guideplus was launched after the GuideLiner, we started to use the Guideplus at later study period (from February 2017). Furthermore, most operators in our catheter laboratory preferred to try the Guideplus rather than the GuideLiner after the launch of the Guideplus, which could be a selection bias. We defined device unsuccess as that the guide extension catheter could not work for the intended purposes of each operator. However, we did not have specific protocol when or how we use the guide extension catheter. For example, some interventional cardiologists prefer to use the guide extension catheter before the buddy wire technique, whereas other interventional cardiologists may prefer to try the buddy wire technique before the guide extension catheter. Thus, there would be an operator bias. As the study population was relatively small, the statistical analysis has an inherent risk of beta error [18].

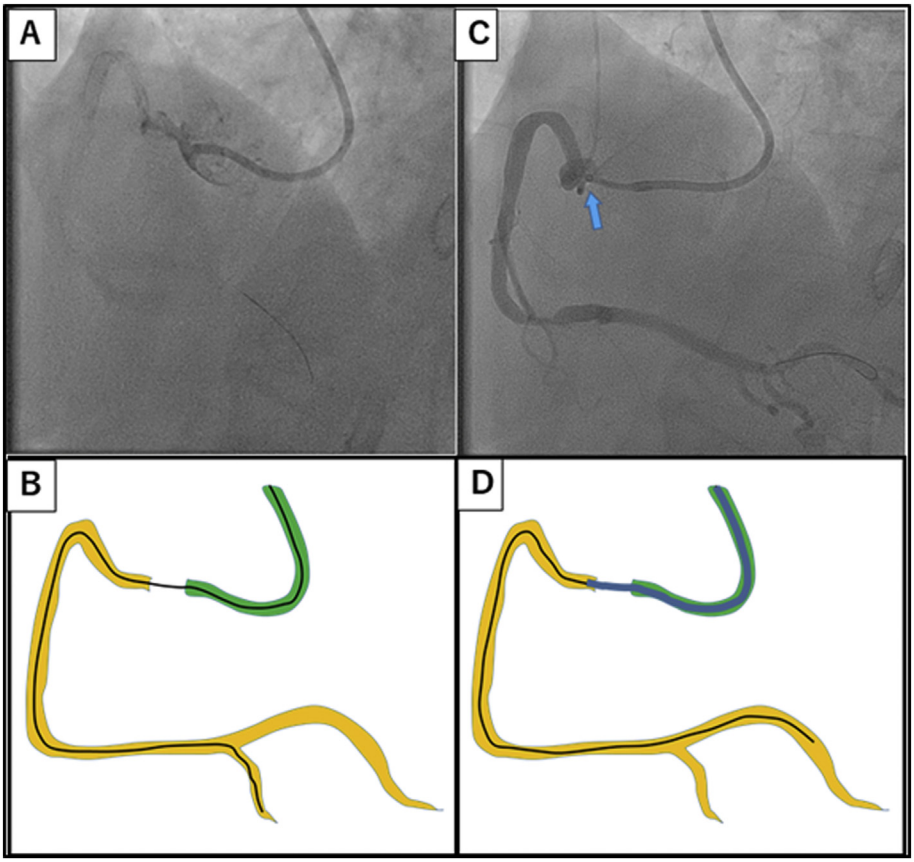

Fig. 4. The representative procedure of the GuidLiner to engage the guide catheter into the ostium of coronary artery. A: We could not insert the guide catheter into the right coronary artery, but inserted the guidewire. B: The illustration of panel A. C: We could advance the GuideLiner (blue arrow) into the ostium of right coronary artery, and could perform coronary angiography via the GuideLiner. D: The illustration of panel C.

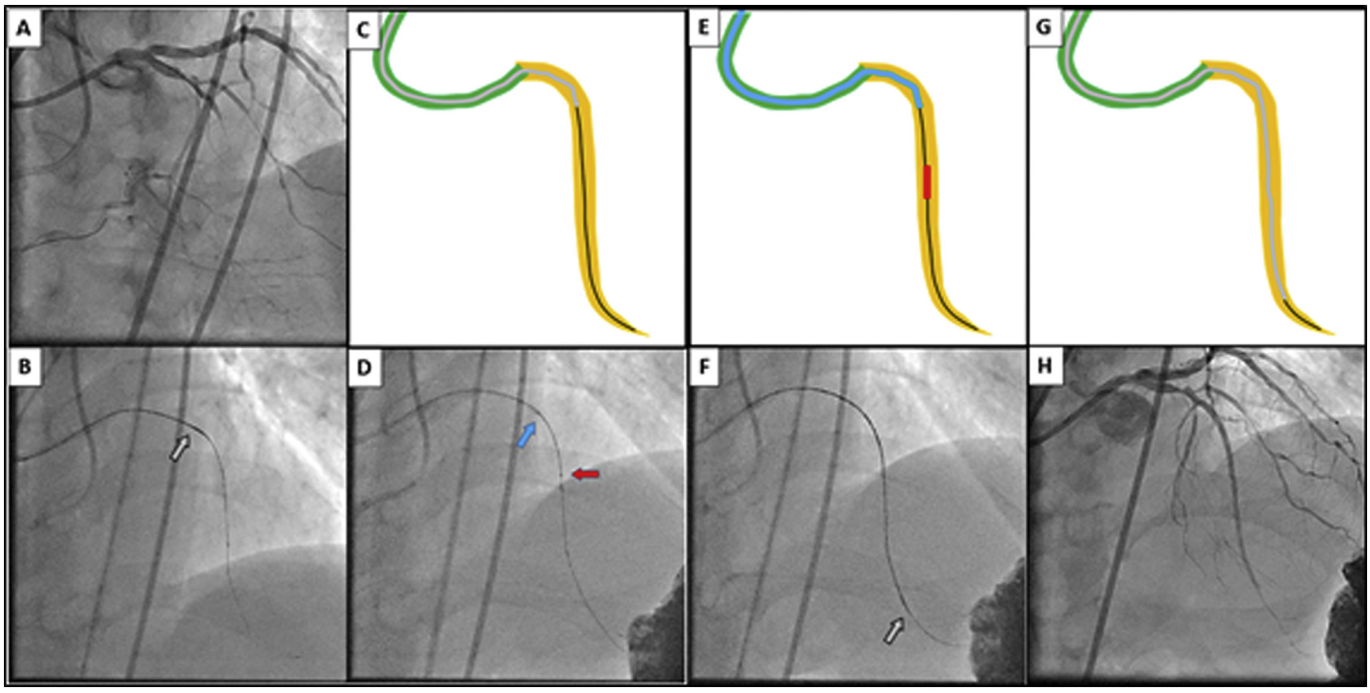

Fig. 5. The representative procedure of the Guideplus to support the small profile balloon crossing the chronic total occlusion (CTO) lesion. A: Coronary angiography shows CTO of the middle of left anterior descending artery. B: Although the guidewire crossed the CTO lesion, we could not advance the Corsair microcatheter beyond the CTO lesion. C: The illustration of panel B. D: We could advance the 1.0 mm balloon (red arrow) with support of the Guideplus (blue arrow). E: The illustration of panel D. F: We could advance the Corsair microcatheter beyond the CTO lesion. G: The illustration of panel F. H: Final angiogram.

Table 1
Comparison of clinical characteristics between the Guideplus and GuideLiner groups.

	All ($n = 195$)	Guideplus group ($n = 92$)	GuideLiner group ($n = 103$)	P value
Age, years (years)	72.5 ± 9.78	72.9 ± 9.34	72.2 ± 10.2	0.464
Female sex, n (%)	39 (20.0)	22 (23.9)	17 (16.5)	0.197
Body mass index (kg/m^2)	24.0 ± 3.58	23.7 ± 3.25	24.2 ± 3.84	0.322
Hypertension, n (%)	179 (91.8)	85 (92.4)	94 (91.3)	0.774
Diabetes mellitus, n (%)	101 (51.8)	44 (47.8)	57 (55.3)	0.295
Dyslipidemia, n (%)	164 (84.1)	78 (84.8)	86 (83.5)	0.806
Smoking, n (%)	138 (70.8)	67 (72.8)	71 (68.9)	0.551
History of previous myocardial infarction, n (%)	38 (19.5)	15 (16.3)	23 (22.3)	0.289
History of previous PCI, n (%)	96 (49.2)	51 (55.4)	45 (43.7)	0.101
History of previous CABG, n (%)	18 (9.2)	6 (6.5)	12 (11.7)	0.217
Chronic renal failure on hemodialysis, n (%)	35 (17.9)	16 (17.4)	19 (18.4)	0.848
Target lesion characteristics				0.017
PCI to the culprit of non-AMI, n (%)	126 (64.6)	64 (69.6)	62 (60.2)	
PCI to the culprit of NSTEMI, n (%)	34 (17.4)	19 (20.7)	15 (14.6)	
PCI to the culprit of STEMI, n (%)	35 (17.9)	9 (9.8)	26 (25.2)	

Abbreviations: PCI = percutaneous coronary intervention, CABG = coronary artery bypass grafting, AMI = acute myocardial infarction, NSTEMI = non ST-elevation myocardial infarction, STEMI = ST-elevation myocardial infarction

Table 2
The comparison of lesion and procedural characteristics between the Guideplus and GuideLiner groups.

	All (n = 195)	Guideplus group (n = 92)	GuideLiner group ($n = 103$)	P value
Target vessel				0.042
Right coronary artery, n (%)	128 (65.6)	53 (57.6)	75 (72.8)	
LM or LAD, n (%)	43 (22.1)	26 (28.3)	17 (16.5)	
Left circumflex artery, n (%)	22 (11.3)	13 (14.1)	9 (8.7)	
Saphenous vain graft, n (%)	2 (1.0)	0 (0)	2 (1.9)	
Type B2/C, n (%)	176 (90.3)	86 (93.5)	90 (87.4)	0.152
Access site				0.670
Radial artery, n (%)	65 (33.3)	31 (33.7)	34 (33.0)	
Femoral artery, n (%)	116 (59.5)	56 (60.9)	60 (58.3)	
Brachial artery, n (%)	14 (7.2)	5 (5.4)	9 (8.7)	
Procedure to the culprit lesion				0.126
Bare metal stent, n (%)	8 (4.1)	3 (3.3)	5 (4.9)	
Drug eluting stent, n (%)	161 (82.6)	79 (85.9)	82 (79.6)	
Drug coated balloon, n (%)	16 (8.2)	9 (9.8)	7 (6.8)	
DES + DCB, n (%)	1 (0.5)	0 (0.0)	1 (1.0)	
Plain old balloon angioplasty only, n (%)	9 (4.6)	1 (1.1)	8 (7.8)	
PCI to chronic total occlusion, n (%)	42 (21.5)	27 (29.3)	15 (14.6)	0.012

Abbreviations: LM = left main, LAD = left anterior descending, DES = drug eluting stent, DCB = drug coated balloon

5. Conclusion

The purpose of guide extension catheter was significantly different between the Guideplus and GuideLiner. As compared to the GuideLiner, the Guideplus was more frequently used to support the small profile balloon crossing the CTO or 99% stenosis that the microcatheter could not cross. Although the visibility under fluoroscopy is poorer in the Guideplus than in the GuideLiner, the device unsuccessful rate was less in the Guideplus, which may suggest the better performance as the guide extension catheter.

Acknowledgements

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Disclosures

Dr. Sakakura has received speaking honoraria from Abbott Vascular, Boston Scientific, Medtronic Cardiovascular, Terumo, OrbusNeich, Japan

Table 3
The comparison of purpose of guide extension catheter and device unsuccess between the Guideplus and GuideLiner groups.

	All (n = 195)	Guideplus group (n = 92)	GuideLiner group (n = 103)	P value
Purpose of guide extension catheter				<0.001
To advance devices into the target lesion, n (%)	135 (69.2)	53 (57.6)	82 (79.6)	
To engage guide catheter into the ostium, n (%)	30 (15.4)	15 (16.3)	15 (14.6)	
To support the small profile balloon crossing the CTO or 99% stenosis that the microcatheter could not cross, n (%)	19 (9.7)	19 (20.7)	0 (0)	
Others, n (%)	11 (5.6)	5 (5.4)	6 (5.8)	
Device unsuccessful rate, n (%)	29 (14.9)	8 (8.7)	21 (20.4)	0.022

Abbreviations: CTO = chronic total occlusion

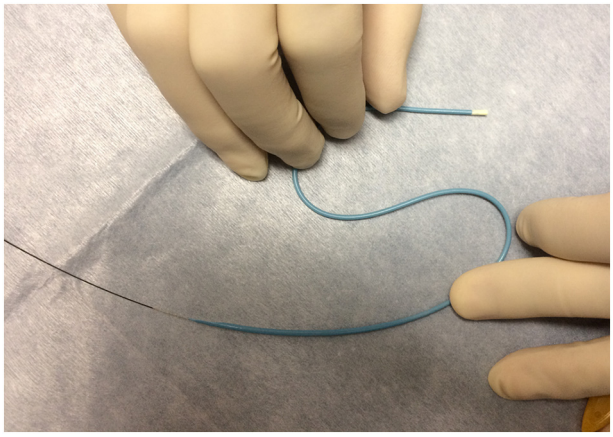

Fig. 6. The picture of the Guideplus. The softness is a clear characteristics of the Guideplus.

Lifeline (Sales of GuideLiner in Japan) and NIPRO (Guideplus); has served as a proctor for Rotablator for Boston Scientific; and has served as a consultant for Abbott Vascular and Boston Scientific. Prof. Fujita served as a consultant for Mehergen Group Holdings, Inc.

References

[1] Tanabe M, Kodama K, Asada K, Kunitomo T. Lesion characteristics and procedural outcomes of re-attempted percutaneous coronary interventions for chronic total occlusion. Heart Vessels 2017. https://doi.org/10.1007/s00380-017-1091-3.

[2] Oreglia JA, Garbo R, Gagnor A, Gasparini GL. Dual lumen microcatheters for complex percutaneous coronary interventions. Cardiovasc Revasc Med 2017. https://doi.org/10.1016/j.carrev.2017.09.016.

[3] Chen CY, Huang YY, Tang L, Hu XQ, Fang ZF, Zhou SH. Guidezilla extension catheter for percutaneous interventional therapy of complex lesions via a transradial approach: case series from a single-center experience. Cardiol J 2017. https://doi.org/10.5603/CJ.a2017.0122.

[4] Hayashida K, Louvard Y, Lefevre T. Transradial complex coronary interventions using a five-in-six system. Catheter Cardiovasc Interv 2011;77:63–8.

[5] Cunnington M, Egred M. GuideLiner, a child-in-a-mother catheter for successful retrieval of an entrapped rotablator burr. Catheter Cardiovasc Interv 2012;79:271–3.

[6] Numasawa Y, Motoda H, Yamazaki H, Kuno T, Kodaira M, Fujisawa T. Use of the GuideLiner catheter for aspiration thrombectomy in a patient with ST-elevation myocardial infarction with a large intracoronary thrombus. Cardiovasc Interv Ther 2016;31:164–9.

[7] Kodaira M, Numasawa Y. Successful percutaneous coil embolization of a severely tortuous coronary artery fistula using the mother-child-grandchild technique via a GuideLiner catheter. SAGE Open Medical Case Reports, 5. ; 2017 [2050313x16672382].

[8] Sharma D, Shah A, Osten M, et al. Efficacy and safety of the GuideLiner mother-in-child guide catheter extension in percutaneous coronary intervention. J Interv Cardiol 2017;30:46–55.

[9] Matsumoto M, Tamanaha Y, Tsurumaki Y, Nakamura T. GuideLiner catheter use for percutaneous intervention involving anomalous origin of a single coronary trunk arising from the ascending aorta. Case Rep Cardiol 2016;2016:8790347.

[10] Repanas TI, Christopoulos G, Brilakis ES. "Candy cane" guide catheter extension for stent delivery. J Invasive Cardiol 2015;27:E169–70.

[11] Sakakura K, Taniguchi Y, Tsukui T, Yamamoto K, Momomura SI, Fujita H. Successful removal of an entrapped rotational Atherectomy Burr using a soft guide extension catheter. JACC Cardiovasc Interv 2017;10:e227-e9.

[12] Watanabe Y, Sakakura K, Taniguchi Y, et al. Determinants of in-hospital death in acute myocardial infarction with triple vessel disease. Int Heart J 2016;57:697–704.

[13] Tsukui T, Sakakura K, Taniguchi Y, et al. Determinants of short and long door-to-balloon time in current primary percutaneous coronary interventions. Heart Vessels 2017. https://doi.org/10.1007/s00380-017-1089-x.

[14] Teramoto T, Tsuchikane E, Matsuo H, et al. Initial success rate of percutaneous coronary intervention for chronic total occlusion in a native coronary artery is decreased in patients who underwent previous coronary artery bypass graft surgery. JACC Cardiovasc Interv 2014;7:39–46.

[15] Ellis SG, Vandormael MG, Cowley MJ, et al. Coronary morphologic and clinical determinants of procedural outcome with angioplasty for multivessel coronary disease. Implications for patient selection. Multivessel angioplasty prognosis study group. Circulation 1990;82:1193–202.

[16] Godino C, Sharp AS, Carlino M, Colombo A. Crossing CTOs-the tips, tricks, and specialist kit that can mean the difference between success and failure. Catheter Cardiovasc Interv 2009;74:1019–46.

[17] Kovacic JC, Sharma AB, Roy S, et al. GuideLiner mother-and-child guide catheter extension: a simple adjunctive tool in PCI for balloon uncrossable chronic total occlusions. J Interv Cardiol 2013;26:343–50.

[18] Brown CG, Kelen GD, Ashton JJ, Werman HA. The beta error and sample size determination in clinical trials in emergency medicine. Ann Emerg Med 1987;16:183–7.