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Simple percutaneous coronary interventions using the modification of complex coronary lesion with excimer laser☆

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ABSTRACT

Excimer laser coronary atherectomy (ELCA), a unique percutaneous coronary intervention (PCI) device, comprises a monorail-type system and is compatible with any standard 0.014-inch guidewire. ELCA is the only device that vaporizes the atherosclerotic plaques or modifies underlying plaque located underneath to a hard tissue, such as severe calcification or a stent. Therefore, ELCA differs from other coronary atherectomy devices and is useful for patients with acute coronary syndrome, chronic total occlusion or under-expanded stents. This case series reports on patients treated using ELCA to simplify complex PCI procedures. Furthermore, we review and discuss ELCA in several situations.

Contents

1. Introduction

The US Food and Drug Administration approved excimer laser coronary atherectomy (ELCA) for percutaneous coronary intervention (PCI) in 1992. ELCA utilizes a xenon-chloride excimer laser to produce bursts of ultraviolet pulses at 308 nm, which has an effective penetration depth (not >10–50 μm). A shallow absorption depth indicates that less energy is required per laser pulse to create ablation. The energy in a 308-nm photon is larger than the binding energy of some molecular bonds; this could lead directly to molecular disassociation

Abbreviations: ACS, Acute coronary syndrome; CTO, Chronic total occlusion; DCA, Directional coronary atherectomy; ELCA, Excimer laser coronary atherectomy; ISR, In-stent restenosis; LAD, Left anterior descending artery; LCX, Left circumflex artery; LMT, Left main trunk; PCI, Percutaneous coronary intervention; RA, Rotational atherectomy; RCA, Right coronary artery; TIMI, Thrombolysis in myocardial infarction.

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(photochemical effect) [1]. The large molecules of the cell, which are absorbed by the photons, heat up by exciting the vibrational modes of the macromolecules. This excitation is rapidly shared with intracellular water, which becomes transiently heated to greater than the vaporization temperature and explodes into the gas phase as steam (photothermal effect) [2]. A bubble in the liquid environment results in the free ejection of debris, which is believed to be the dominant mechanism for tissue removal for ELCA (photomechanical effect) [3]. Despite these favorable effects, ELCA at the beginning showed no benefit aside from balloon angioplasty alone with respect to the initial and long-term clinical and angiographic outcomes in PCI [4]. However, several important factors that govern successful laser application have been developed to improve the efficacy and safety of ELCA. The slow advancement rate of the laser catheter ensures an adequate absorption of the laser energy into the plaque, not the Dottering effect. One study found that intermittent laser activation (i.e., trains consisting of 5-s activation with alternating 5-s pauses) also enabled the provision of time for the dispersion of the produced gas bubbles, cooling of the target artery, and adequate coronary vasodilation [5]. The second-generation cool laser system (CVX-300, Spectranetics, Colorado Springs, CO, USA) [6], the introduction of a 0.9 mm laser catheter [7] and the saline infusion technique [8] have also led to a lower incidence in the coronary dissection rate with a higher energy density and lower heat production. Furthermore, ELCA catheters advance along a short monorail segment (30 mm) and are compatible with any standard 0.014-inch guidewire. This is a major advantage over alternative coronary atherectomy techniques requiring dedicated guidewires that are often more difficult to deliver distally [9]. In brief, ELCA is a user-friendly device compared with other coronary atherectomy devices [10]. In addition, a unique characteristic of ELCA is the modifying the plaque underneath hard tissue, such as severe calcification or stent [11]. This is beneficial in cases of chronic total occlusion (CTO) or an under-expanded stent. These features and the ease of ELCA use could simplify the complex PCI procedures. We report a series of cases in which patients have been treated using the ELCA system to simplify complex PCI procedures, and we review other case series and relevant literature.

2. Case series

2.1. Case 1

A 69-year-old man presenting with hypertension, dyslipidemia, and a current history of smoking was admitted to our institution. He was diagnosed with unstable angina with worsening exertional angina pectoris (Braunwald criteria IB1). A coronary angiography revealed severe stenosis at the left main trunk (LMT) bifurcation, Medina classification (1,0,0) (Fig. 1A–B), with a high risk of plaque shift or carina shift. Intravascular ultrasound (IVUS) revealed the eccentric plaque without much thrombus (Fig. 1C). We selected ELCA as a debulking device. Firstly, a 1.7-mm concentric catheter delivered 1000 pulses with energy settings of 45 mJ/mm^2 and 25 Hz antegradely (8 trains). Subsequently, a retrograde lasing technique was used to deliver 1600 pulses with a higher energy of 60 mJ/mm^2 and 40 Hz (8 trains), considering the aggressive debulking to a lower curvature. As the lumen gain was not satisfactory, a 1.7-mm eccentric catheter, which had a bigger effective area, was applied for further debulking with the same energy settings (Fig. 2). The laser delivered intermittent emission, using a saline flash technique, and a slow advancement rate of 0.5 mm/s for the catheter. These procedures induced no ischemia symptoms while passing the lesion. Subsequently, we successfully performed a single-stent implantation from the left anterior descending artery (LAD) to the LMT using the proximal optimization and kissing balloon techniques (Fig. 3).

2.2. Case 2

A 76-year-old man, admitted to our institution due to sudden chest compression symptoms, was diagnosed with acute coronary syndrome (ACS). A coronary angiography showed severe stenosis of the distal right coronary artery (RCA), and the plaque appeared vulnerable (Fig. 4A). The patient had a dominant RCA and severe stenosis of the LAD (Fig. 4B), indicating a high risk of distal embolization and subsequent hemodynamic collapse. A distal protection was considerable; however, many posterolateral arteries branched off distal to the culprit lesion and

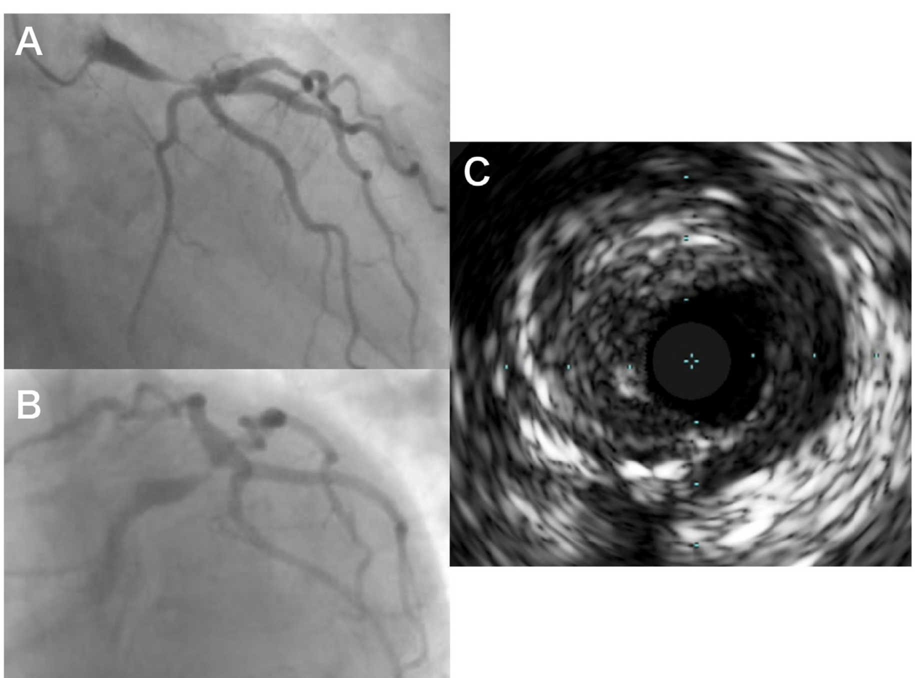

Fig. 1. The first angiography shows severe stenosis in the left main trunk bifurcation; Medina classification (1,0,0), indicating a high-risk case of plaque shift or carina shift. A: The right anterior oblique caudal view. B: The left anterior oblique caudal view. C: Intravascular ultrasound shows the eccentric plaque without much thrombus.

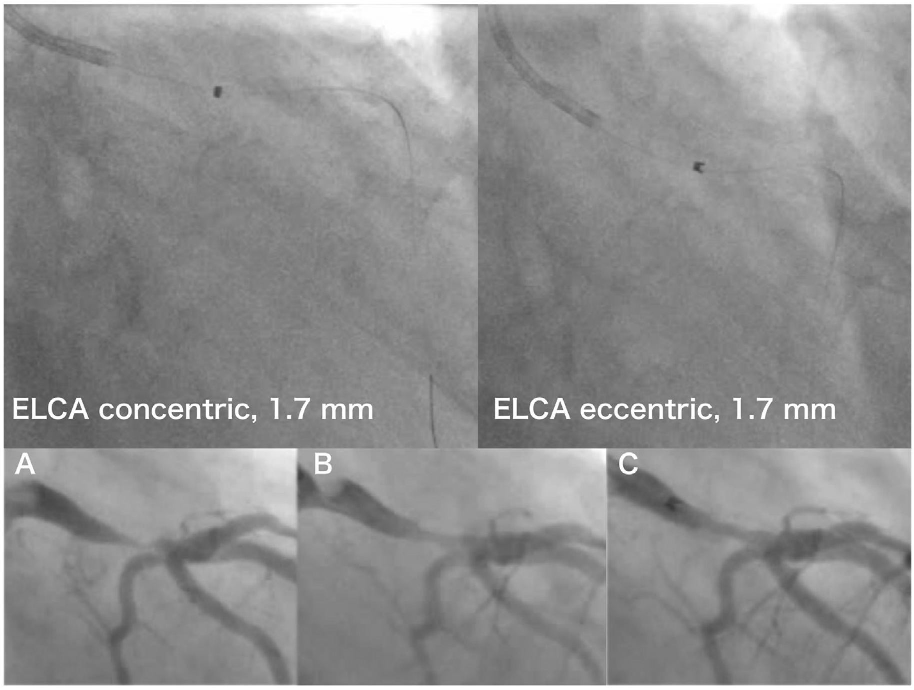

Fig. 2. Excimer laser coronary atherectomy (ELCA) 1.7 mm concentric catheter is delivered of 1000 pulses with energy settings of 45 mJ/mm^2 and 25 Hz antegradely (8 trains). Subsequently, retrograde lasing technique is delivered of 1600 pulses with higher energy of 60 mJ/mm^2 and 40 Hz (8 trains). As the lumen gain is not satisfactory, a 1.7 mm eccentric catheter, which has the bigger effective area, is applied for the purpose of further debulking with the same energy settings. A: The initial angiography. B: Angiography following the ELCA concentric 1.7 mm catheter. C: Angiography following the ELCA eccentric 1.7 mm catheter.

there was no proper place to position a distal protection device. Therefore, we applied the ELCA without a distal protection device, using a 1.4-mm concentric catheter with slow advancement (0.5 mm/s), and antegrade (45 mJ/mm^2 and 25 Hz) and retrograde (60 mJ/mm^2 and 40 Hz) lasing technique, totaling to 2850 pluses of 18 trains (Fig. 5A). Angiography following the ELCA indicated acute lumen gain without distal embolization (Fig. 5B). The optical coherence tomography (OCT) before and after ELCA demonstrated the lipid-rich plaque and the acute lumen gain, respectively (Fig. 6). A subsequent direct stent implantation completely re-vascularized the lesion without complication (Fig. 5C).

2.3. Case 3

A 75-year-old man complained about exertional chest discomfort and angiography revealed a RCA-CTO (Fig. 7). Although wire-crossing was successful in an antegrade direction, any devices such as micro-

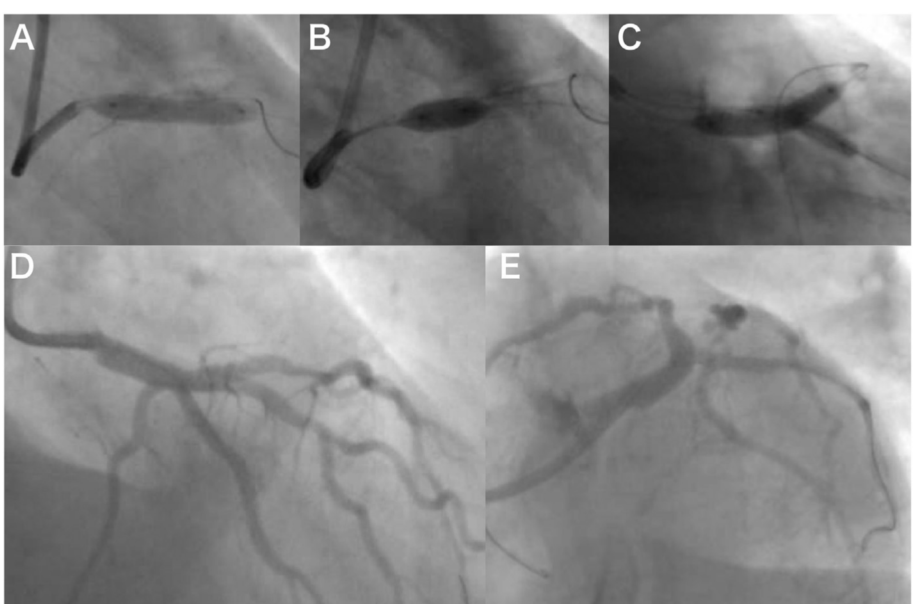

Fig. 3. Subsequent percutaneous coronary intervention. A: The direct stent implantation with a single stenting strategy. B: The proximal optimization therapy. C: The kissing balloon inflation. D: The final angiography from the right anterior oblique caudal view. E: The final angiography from the left anterior oblique caudal view.

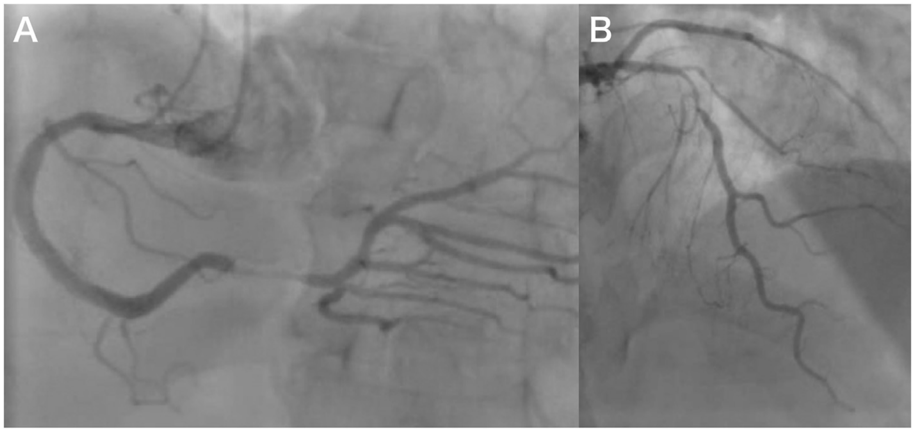

Fig. 4. A: The right coronary artery has severe stenosis with vulnerable plaque. Many posterolateral arteries branch off after the culprit lesion, limiting the location of the distal protection device. B: The left anterior descending artery also has severe stenosis, indicating a high risk of hemodynamic collapse if distal embolization of the right coronary artery occurs.

catheters, small balloons, or intravascular ultrasound could not pass the CTO lesion regardless of using the guide-extension catheter and the balloon anchoring technique. Then, the monorail-type ELCA (X-80, 0.9 mm) was delivered of 8480 pulses of 11 trains, which were the highest energy levels (80 mJ/mm^2 and 80 Hz), with antegrade and retrograde lasing in this situation. Controlling the penetration speed of 0.5 mm/s, the catheter advanced into the distal RCA smoothly (Fig. 8 A–C). After passing the ELCA, the antegrade flow was restored (Fig. 8D). Thereafter, the 2.5-mm semi-compliant balloon was able to cross the lesion and dilate, and the stents were implanted as usual (Fig. 8E).

2.4. Case 4

A 72-year-old woman, presenting with hypertension and dyslipidemia, was admitted to our institution due to stable angina pectoris. Angiography showed severe stenosis of the proximal RCA (Fig. 9A) and a direct stent implantation was performed (Fig. 9B) as angiography and intravascular ultrasound showed no calcified lesions. However, the indentation did not disappear after dilatation with rated burst pressure of the stent balloon and subsequent non-compliant balloon at 30 atm (Fig. 9C). In this situation, ELCA with contrast injection was delivered of 1600 pulses at the highest fluency and repetition rates (80 mJ/mm^2 and 80 Hz) to ablate and disrupt the underlying plaque. ELCA was positioned at the in-stent lesion without catheter advancement (Fig. 10A). Laser energy was applied 5 times for 3–5 s at each application with contrast injection. Visible vapor macro-bubbles appeared and led to a transient ST elevation. The semi-compliant balloon at standard pressure dilated the stent fully after ELCA ablation (Fig. 10B–C).

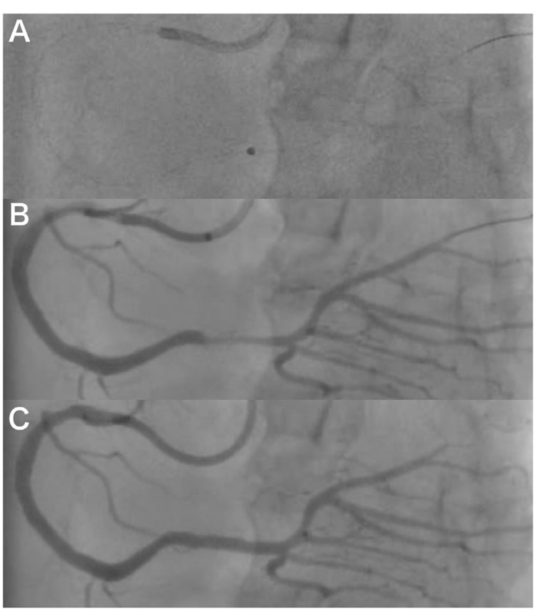

Fig. 5. A: Excimer laser coronary atherectomy (ELCA) 1.4 mm concentric catheter is delivered with slow advancement (0.5 mm/s), antegrade (45 mJ/mm^2 and 25 Hz), and retrograde (60 mJ/mm^2 and 40 Hz) lasing technique, totaling 2850 pluses of 18 trains, to reduce the plaque burden. B: Angiography following the ELCA indicates the acute lumen gain without distal embolization. C: Final angiography after direct stent implantation shows complete re-vascularization without distal embolization.

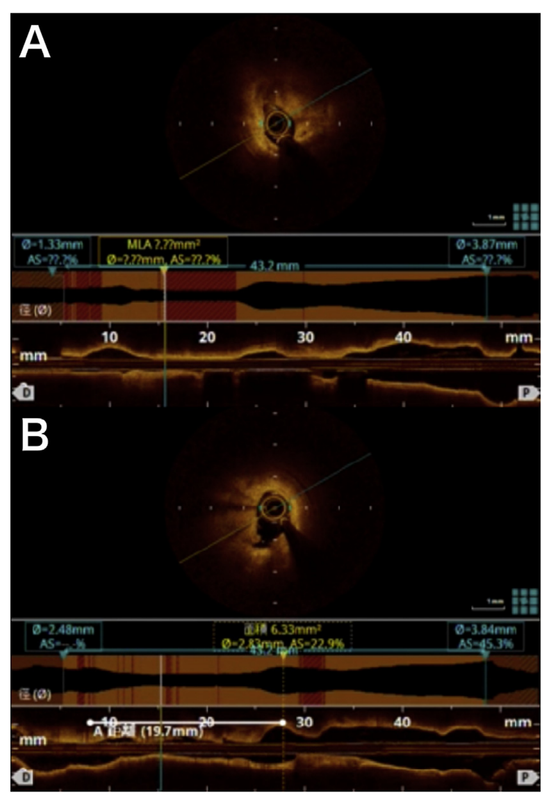

Fig. 6. Optical coherence tomography showed the lipid-rich plaque and the acute lumen gain. A: Before excimer laser coronary atherectomy. B: After excimer laser coronary atherectomy.

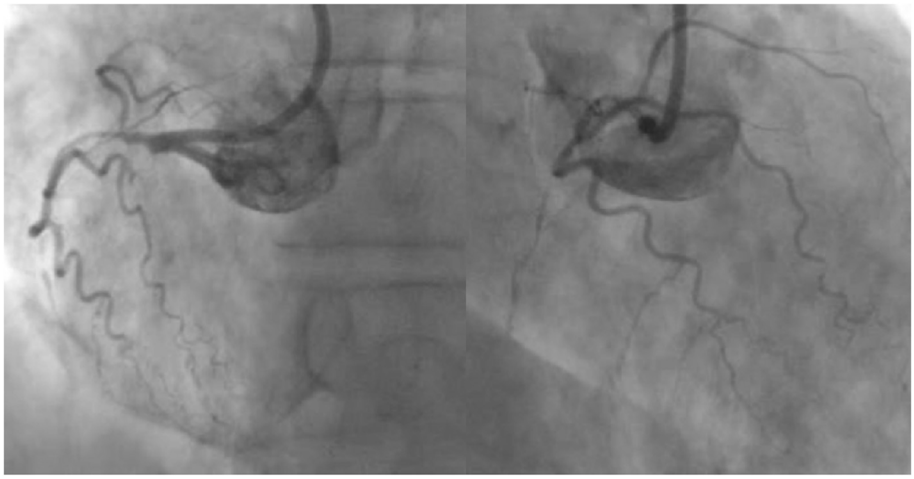

Fig. 7. Angiography reveals a chronic total occlusion of the proximal right coronary artery. The left panel is the left anterior oblique view. The right panel is the right anterior oblique caudal view.

2.5. Case 5

A 76-year-old man with old anterior myocardial infarction, hypertension, and dyslipidemia presented due to exertional angina pectoris. He had had Y stenting with bare metal stents 15 years before his current admission and in-stent restenosis (ISR) of the proximal lesion of the left circumflex (LCX) was treated by drug coated balloon a year before his current admission. His current angiography revealed the ISR of the proximal LCX (Fig. 11A). As this was his second ISR in a short duration, we applied ELCA and subsequent drug coated balloon. ELCA 1.7 mm eccentric was delivered of 3200 pulses (8 trains of 45 mJ/mm^2 and 25 Hz antegradely, and 4 trains of 60 mJ/mm^2 and 40 Hz retrogradely) to the proximal LCX with slow advancement of 0.5 mm/s (Fig. 11B–C). After ELCA, we dilated the lesion using the scoring balloon with low pressure and subsequently used the drug-coated balloon (Fig. 11D). The follow-up angiography 8 months after the ELCA session confirmed that there was no ISR at the lesion (Fig. 11E).

2.6. Case 6

A 78-year-old man was transferred to our institution due to acute myocardial infarction 6 h after chest compression onset. The emergent angiography showed the total occlusion of the proximal LAD with rich thrombus (Fig. 12A). After wire-crossing the LAD, ELCA 1.4 mm concentric was delivered of 2600 pulses (8 trains of 45 mJ/mm^2 and 25 Hz antegradely and 4 trains of 60 mJ/mm^2 and 40 Hz retrogradely, respectively) with a

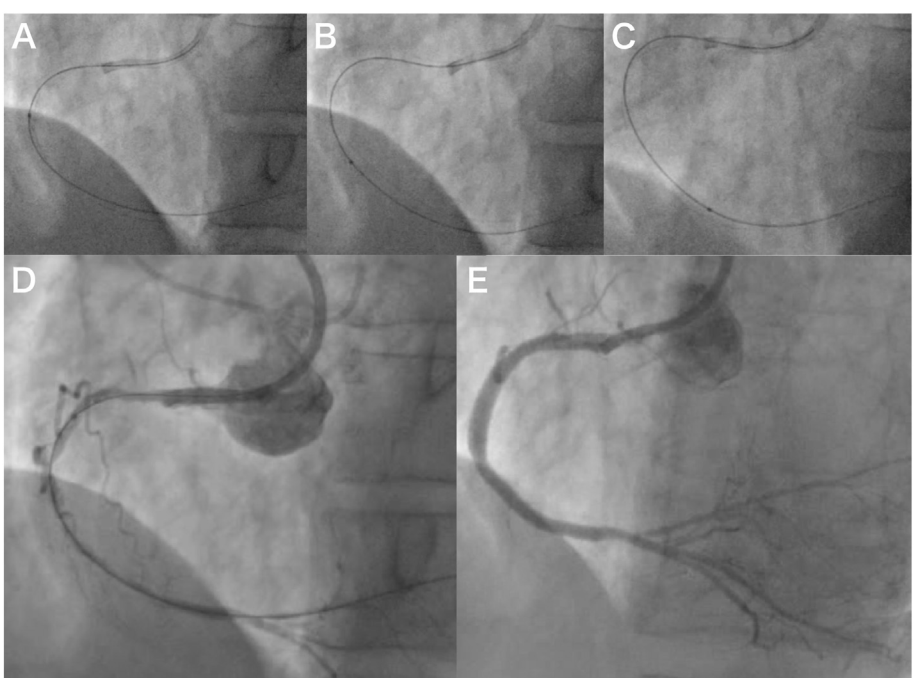

Fig. 8. Any thin devices including micro-catheter, small balloons, or intravascular ultrasound, supported by the guide-extension catheter and the balloon anchoring technique, after the success of the antegrade wire-crossing. A–C: Excimer laser coronary atherectomy (ELCA, X-80, 0.9 mm) delivered of 8480 pulses of 11 trains at the highest fluency and repetition rates (80 mJ/mm^2 and 80 Hz). The ELCA advances to the distal right coronary artery smoothly with a controlled penetration speed of 0.5 mm/s. D: The antegrade flow is restored after passing the ELCA. E: Final angiography after crossing the used 2.5 mm semi-compliant balloon and deploying the stents as usual.

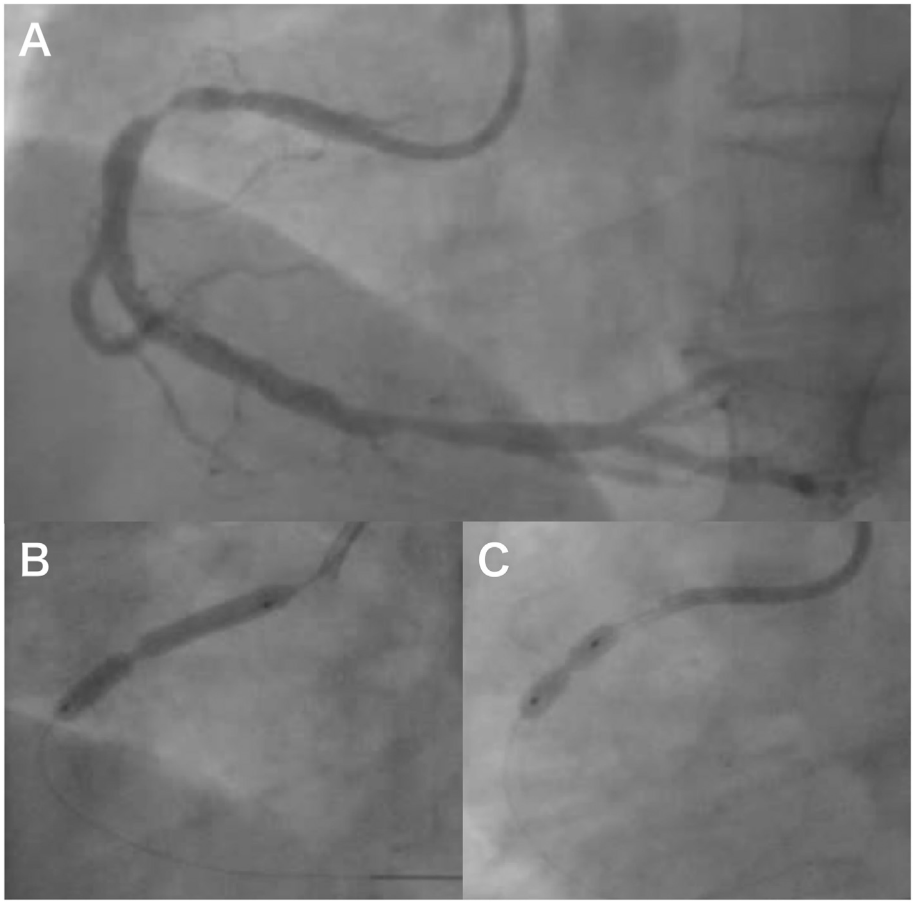

Fig. 9. A: The initial angiography shows severe stenosis of the proximal right coronary artery. The intravascular sound reveals the fibrous plaque. B: Direct stent implantation is performed and the balloon indentation remains with rated burst pressure. C: The balloon indentation also remains after non-compliant balloon inflation at 30 atm.

slow advancement of 0.5 mm/s; this markedly decreased the thrombus and led to a grade 3 Thrombolysis in Myocardial Infarction (TIMI) score (Fig. 12B–C). Finally, direct stent implantation and adjunctive balloon dilatation to proximal stent completely revascularized the LAD (Fig. 12D).

3. Discussion

ELCA has been used as a debulking or lesion-modification device in Japan. ELCA is much easier to maneuver than representative debulking

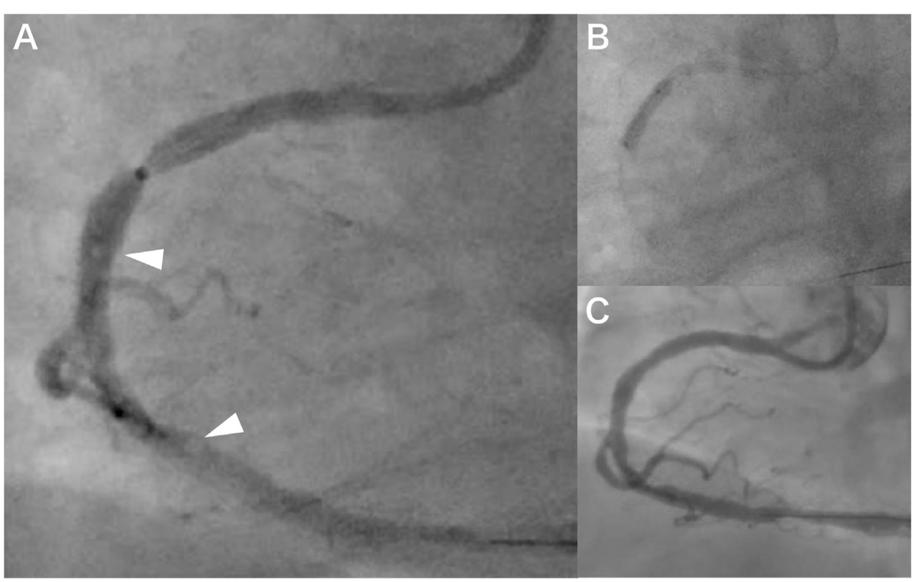

Fig. 10. A: Excimer laser coronary atherectomy (ELCA, X-80, 0.9 mm) with contrast injection is delivered of 1600 pulses at the highest fluency and repetition rates (80 mJ/mm^2 and 80 Hz) to ablate and disrupt the underneath plaque. An ELCA is positioned in the in-stent lesion without advancement. Laser energy is applied 5 trains at 3 to 5 s each with a contrast injection. The white arrowheads indicate the visible vapor macro-bubbles, which lead to the transient ST elevation. B: The semi-compliant balloon at standard pressure dilates the stent fully after ELCA ablation. C: The final angiography.

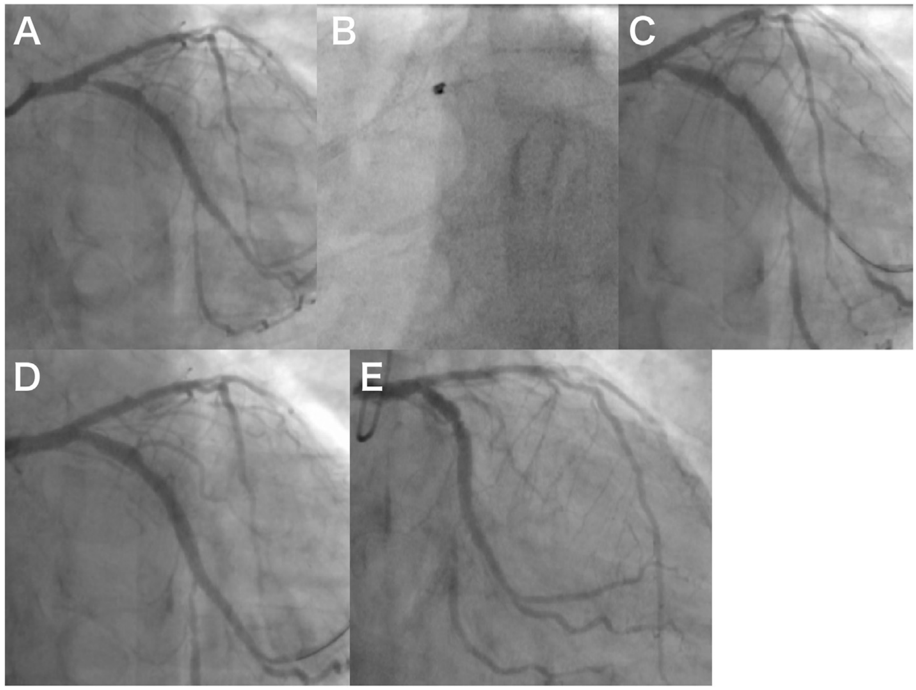

Fig. 11. A: The initial angiography shows the in-stent restenosis of the proximal left circumflex artery (LCX). B: Excimer laser coronary atherectomy (ELCA) 1.7 mm eccentric catheter is delivered of 3200 pulses (8 trains of 45 mJ/mm^2 and 25 Hz antegradely, and 4 trains of 60 mJ/mm^2 and 40 Hz retrogradely) to the proximal LCX with slow advancement of 0.5 mm/s. C: The angiography after ELCA indicates the acute lumen gain. D: The final angiography after the dilatation of drug coated balloon. E: The follow-up angiography 8 months after the current percutaneous coronary intervention with ELCA.

devices, such as rotational atherectomy (RA) and directional coronary atherectomy (DCA), because of its compatibility with general 0.014-inch guidewires and 6–7 Fr guiding catheters, and its monorail-type system. In addition, its unique mechanisms modify the plaque morphology, even if it was located underneath hard tissue, such as severe calcification or a stent. This user-friendly devices could simplify the complex PCI practice.

The first case was a bifurcation PCI. Side branch occlusion is one of the most serious complications of main vessel stenting, and carina and plaque shifts have been reported to be due to side branch occlusion [12,13]. One intravascular ultrasound study showed that carina shift significantly correlated with plaque volume of the distal main vessel [14]. Therefore, a debulking strategy in bifurcation lesions could decrease the incidence of side branch occlusion and simplify the stenting strategy. However, an aggressive debulking strategy has risks such as vessel perforation, dissection, or distal embolization. Moreover, RA and DCA, which are representative debulking devices in Japan, have several limitations. RA could result in distal emboli especially in ACS cases, and requires a specific wire. Furthermore, DCA needs an 8-Fr guiding catheter and can induce ischemia due to its thickness and the length of the procedure time. ELCA is a simpler debulking device than DCA and RA, having a rapid-exchange system and requiring no additional sheath size-up or dedicated wire exchange. The application of ELCA contributes to lowering the threshold of an aggressive debulking strategy, reducing side branch occlusion, and avoiding a complex stent strategy such as the two-stent technique. Table 1 showed the comparisons of characteristics using the debulking device in ELCA, RA, and DCA.

The second case was a patient diagnosed with ACS. Advantages for ELCA in ACS are rapid thrombus removal with vaporization of procoagulant reactants [15], a reduced risk of distal embolization, and the debulking of underlying plaque [16]. Moreover, ELCA has shown an inhibitory effect on platelet aggregation, namely, the “Stunned Platelet Phenomenon” [17]. The CARMEL multicenter registry showed that ELCA increased the TIMI grade from 1.2 to 2.8, and decreased

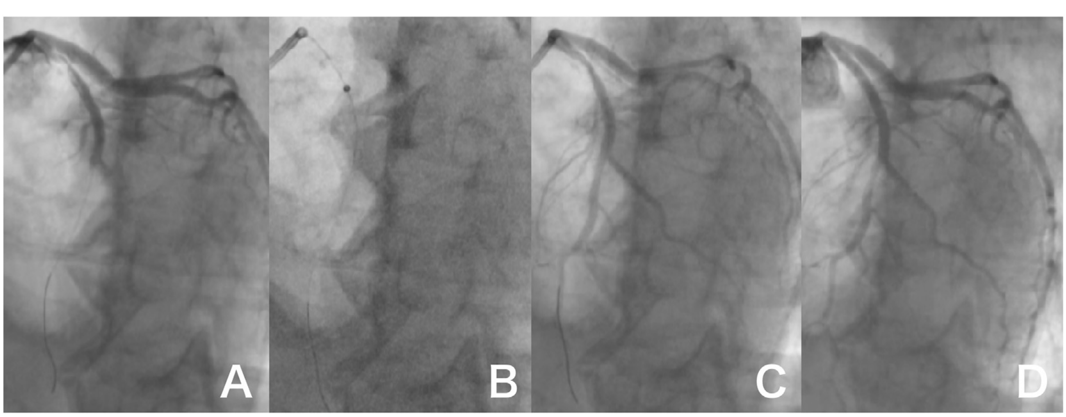

Fig. 12. A: The initial angiography shows the total occlusion of the left anterior descending artery with much thrombus. B: Excimer laser coronary atherectomy (ELCA) 1.4 mm concentric catheter is delivered of 2600 pulses (8 trains of 45 mJ/mm^2 and 25 Hz antegradely and 4 trains of 60 mJ/mm^2 and 40 Hz retrogradely) with slow advancement of 0.5 mm/s is performed. C: The angiography after ELCA indicates the decreased thrombus and grade 3 of Thrombolysis in Myocardial Infarction score. D: The final angiography after direct stent implantation.

Table 1
Comparison of characteristics using debulking devices in ELCA, RA, and DCA.

	ELCA	RA	DCA
Trade name	CVX-300 cardiovascular laser Excimer system (Spectranetics, CO, USA)	Rota Link PLUS (Boston Scientific, MA, USA)	ATHEROCUT (NIPRO, Osaka, Japan)
Mechanism	Photochemical Photothermal Photomechanical	Mechanical (rotational, difference cut)	Mechanical (directional cut)
Size variation	0.9 mm, 1.4 mm 1.7 mm (concentric, eccentric) 2.0 mm (concentric, eccentric)	1.25, 1.50, 1.75, 2.00, 2.15 2.25, 2.38, 2.50 mm	S (3.0–3.4 mm) M (3.5–3.9 mm) L (4.0–4.4 mm)
Wire compatibility	Any 0.014″ wire Any 0.018″ wire (2.0 mm eccentric)	Rota Wire (dedicated 0.010″ wire) (micro-catheter often needed)	Support type 0.014″ wire (micro-catheter often needed)
Sheath compatibility	6 Fr (0.9 mm, 1.4 mm) 7 Fr (1.7 mm), 8 Fr (2.0 mm)	6 Fr (1.25–1.50 mm) 7 Fr (1.75–2.15 mm) 8 Fr (2.25–2.50 mm)	8 Fr
Adjustment methods	Fluency, repetition rate	Rotational frequency	Balloon inflation
Deliverability	Excellent (0.9 mm) Modest (others), especially in hard/calcified lesions	Good in hard/calcified lesion Size-up strategy often needed	Poor
Main purpose	Debulking (soft plaque) Suppression platelet activity Penetration of CTO entry Improving balloon inflation (prior/posterior stent implantation)	Debulking (hard/calcified plaque) Improving balloon inflation (prior to stent implantation)	Debulking (soft plaque)
Appropriate lesion	ACS, CTO, ISR, SVG Non-dilatable lesion	Calcified lesion Non-dilatable lesion	Proximal lesion Eccentric lesion
Inappropriate lesion	Severe calcified lesion	ACS	ACS
Expected complication	Vessel perforation/dissection Slow flow	Vessel perforation/dissection Slow flow	Vessel perforation/dissection Device induced ischemia
Easiness to handle	Easy	Considerable experience required	Considerable experience required

ACS: acute coronary syndrome, CTO: chronic total occlusion, DCA: directional coronary atherectomy, ELCA: excimer laser coronary atherectomy, ISR: in-stent restenosis, RA: rotational atherectomy, SVG: saphenous vein graft.

angiographic stenosis from 83% to 52% in ACS patients [18]. In a subgroup study of the CARMEL study that analyzed patients whose saphenous vein graft was the infarct related vessel, notably, there was no case of distal embolization and the transient no reflow phenomenon without insertion of distal protection devices occurred in 3% of the patients [19]. The following issues were noted: 1) considerable plaque burden, 2) no place to position the distal protection device, 3) the right dominant anatomy, and 4) the existence of the lesion in the left coronary artery. Therefore, the slow flow complication had to be avoided. An elective mechanical support device such as intra-aortic balloon pumping provided one option; however, it is relatively invasive. ELCA was applied in the expectation of reducing the plaque and thrombus burden. This lesion-modification technique can reduce the possible risk of complications and be effective for ACS cases unsuitable for distal protection.

The third case involved a patient with crossable-wire CTO; however, the device was uncrossable. In this relatively common situation, the majority of internationalists would apply an RA. Given the micro-catheter could also not cross the lesion, a dedicated 0.009-inch guidewire would have had to be controlled as a bare wire, and this was not a promising procedure. Wire externalization using a bidirectional approach could be a further option to strengthen the back-up force and to deliver the devices. However, promising collateral arteries, additional time, contrast, radiation exposure, and extra devices would have been required. ELCA had a great advantage here. No extra devices, preparation, or risk hedges were required. This type of procedure only entailed pushing the monorail-type laser catheter, and this was much simpler. For calcified lesion, ELCA executes the localized atheroablation [20] and changes vessel compliance [21]. ELCA can create a channel through the CTO, which allows a balloon or micro-catheter to pass the tough lesion [6]. Therefore, ELCA is used in selected patients with CTO where a balloon would not pass despite a guidewire in the distal lumen [22]. Fernandez et al. demonstrated the efficiency of ELCA in CTO PCIs. Of all the CTO cases, the procedure success rate was 91% (with ELCA-only successful in 76.1% of cases, after RA failure in 6.8% of cases, and in combination with RA in 8.6% of cases). They advocated for the RASER technique, which is a combination of the ELCA and RA procedures. In a non-dilatable lesion following RA, ELCA can ablate the softer tissue within the calcified lesion to dilate completely. In addition, for cases where a micro-catheter for exchanging a dedicated rota-wire cannot pass the lesion, ELCA could modify the entry of the CTO to pass the micro-catheter or screw in the CTO entry for bare wire exchanging. An ELCA X-80, 0.9-mm catheter is not used as a debulking device, but rather as a penetration and lesion-modifying device. It provides maximum fluency and repetition rates to modify hard tissue.

The fourth case involved an under-expanded stent situation. Clearly, vessel preparation prior to stent implantation is important; however, unexpected under-expanded stent deployment sometimes occurs due to underestimation of a severely fibrotic lesion. Stent under-expansion is an important risk factor for in-stent restenosis [23] and stent thrombosis [24]. Since the saline flushing technique reduced the risk of coronary dissection induced through high-pressure waves, high energy induced using ELCA with a contrast injection could harm the vessels. However, the ELLEMENT study confirmed the feasibility of ELCA with a contrast injection to dilate the under-expanded stent lesions [25]. Laser-assisted stent dilatation was 96.4% successful in cases with a relatively low rate of complication including procedural myocardial infarction (7.1%), transient slow-flow (3.6%), ST elevation (3.6%), and target-lesion restenosis (6.7%). RA could be considered an alternative. However, stent debris often leads to a deteriorated slow-flow phenomenon. Limiting the usage within the in-stent lesion, ELCA may be safer than RA as a means of resolving under-expanded stents resistant to high-pressure balloon inflation.

The fifth case was a refractory ISR patient. Despite the fact that the drug-eluting stents significantly reduced the ISR, complications remain a main problem associated with PCI. The drug-eluting balloon is one hopeful solution to ISR when compared with conventional balloons; however, the target lesion revascularization rate was still high (19.4% vs. 36.8%, $p = 0.046$) [26]. Although intravascular ultrasound cased data documented effective ablation of neointimal tissue and adjunct balloon angioplasty extrudes neointimal tissue out of the stent and also further expands the stent [27], follow-up data showed a high incidence of recurrent restenosis in patients with up to 68% ISR in 6 months [28]. However, Lee et al. recently showed that PCI for ISR with ELCA was associated with a larger final minimum lumen area and a previously implanted stent area rather than with non-ELCA (median 4.76 mm^2, interquartile ranges [3.25, 5.58] vs, 3.46 mm^2 [2.80, 4.13], $p < 0.01$ and 6.15 mm^2 [4.83, 7.09] vs. 4.65 mm^2 [3.84, 5.40], $p < 0.01$, respectively) [29]. ELCA could break the vicious circle, modifying the calcium-plaque located underneath stents and facilitating better expansion of the previously implanted stent.

The sixth case presented the handling of thrombus using ELCA. ELCA vaporizes the atherosclerotic plaques and thrombotic material by photomechanical and photothermal processes [30]. Laser activation generates acoustic shock waves, which mechanically break and dissolve fibrin fibers, a major constituent of thrombus [31], and suppresses platelet aggregation [17]. The resultant debris particles also are <10 μm in diameter with a minimal risk of distal embolization [10]. In addition, exposure to excimer laser energy produced a dose-dependent suppression of platelet aggregation and force development (stunned platelet phenomenon). The percentage of CD 43 (glycoprotein IIb/IIIa)-positive platelets significantly increased with exposure to laser energy [17]. However, the expression level did not exceed 0.5% of whole cells, so that the extent of suppression on the circulating platelets is unknown and ELCA is not a substitute for heparin or glycoprotein IIb/IIIa antagonists. Therefore, routine anticoagulation-preparation is also required.

Based on the above cases, Table 2 summarized the contemporary clinical/angiographic indications and the contribution to simple PCI of ELCA.

4. Conclusion

The ELCA simplify the complex PCIs by modification of the complex coronary lesions.

Table 2
Contemporary clinical/angiographic indications and the contributions to simple PCI of ELCA.

Clinical indication	Purpose of ELCA	Contribution to simple PCI
Acute coronary syndrome Acute myocardial syndrome	Vaporize the thrombus Reduce the risk of distal embolization Suppress the platelet aggregation	Avoid the distal protection devices
Chronic total occlusion	Modify the hard plaque Pass the devices through the CTO	Avoid the wire exchange for the RA
Stent under-expansion	Modify the hard plaque underneath to the stents Make the implanted stent area larger	The unique methodology
In-stent restenosis	Reduce the plaque burden Modify the hard plaque underneath to the stents Make the implanted stent area larger	Suppress the frequent PCI to ISR
Saphenous vein graft	Vaporize the thrombus Debulk the neointimal hyperplasia Reduce the risk of distal embolization	Avoid the distal protection devices
Bifurcation lesion	Debulk the plaque of carina Reduce the risk of side branch occlusion	Avoid the complex stenting Substitute the other debulking devices
Calcified lesion	Modify the calcified plaque Modify the hard plaque underneath to the calcium Improve the balloon reaction	Substitute the RA

CTO: chronic total occlusion, ELCA: excimer laser coronary atherectomy, ISR: in-stent restenosis, PCI: percutaneous coronary intervention, RA: rotational atherectomy.

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