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CASE REPORT

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Additional ablation effect of low-speed rotational atherectomy following high-speed rotational atherectomy on early calcified in-stent restenosis: A case report

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Abstract
Optical frequency domain imaging-guided additional low-speed rotational atherectomy following sufficient high-speed rotational atherectomy for early calcified in-stent restenosis might be a safe and useful option for achieving additional large lumen gains and stent expansion.

KEYWORDS
drug-eluting stent, percutaneous coronary intervention, rotational atherectomy, stent restenosis

1 | INTRODUCTION

The effects of low-speed rotational atherectomy (RA) following high-speed RA for in-stent restenosis (ISR) remain unclear. We demonstrate that additional low-speed RA for calcified ISR can achieve larger lumen gains and may simultaneously exert additional effects on peri-stent tissues, leading to stent expansion.

In-stent restenosis (ISR) remains an unresolved issue even in this era of percutaneous coronary intervention (PCI) with drug-eluting stents (DES). ISR is reportedly a result of multiple factors: stent under-expansion, stent fracture, neoatherosclerosis, and calcified nodule.[1] Moreover, calcified ISR with concomitant peri-stent calcification has been reported to be an undilatable ISR.[2] Although conventional balloon angioplasty for such settings had poor prognosis, rotational atherectomy (RA) is one of the debulking options to achieve larger lumen gains.[3] However, little has been reported about whether the platform speed of RA would cause larger lumen gains in calcified ISR. Herein, we present a case in which optical frequency domain imaging (OFDI) revealed the effects of low-speed RA (LSRA) following high-speed RA (HSRA) for calcified ISR derived from severe peri-stent calcified nodule.

2 | CASE PRESENTATION

A 71-year-old man with hypertension, dyslipidemia, mild chronic kidney disease, and ischemic heart disease, presented with worsening angina pectoris. He had undergone PCI with DES implantation in the proximal circumflex artery and the proximal left anterior descending artery (LAD), 3 years and 1 year previously, respectively. Coronary angiogram confirmed an ISR of the proximal LAD. We then performed PCI using a 7-Fr guiding system via the right radial artery under OFDI guidance. Compared with the previous evaluation by intravascular ultrasound imaging (IVUS), OFDI suggested that ISR was caused by slight stent deformation due to peri-stent calcification. Additionally, it revealed that in-stent tissue might have been derived from peri-stent calcification, possibly invaded by the protrusion between stent struts (Figures 1, 2A). We performed debulking of this calcified ISR with RA at 180,000 rpm platform speed (i.e., HSRA). HSRA using a 2.0 mm burr was performed with a maximum deceleration of 5,000 rpm; HSRA was repeated six times and the burr could cross the restenosis without any further speed drop at the last two attempts of HSRA (total ablated time of HSRA: 64 s). OFDI confirmed that the minimum lumen diameter (MLD) had become 2.0 mm (Figure 2B). Abnormal findings including newly developed mal-apposed stent struts or stent fracture was not recognized, and we considered that additional ablation could be safely performed. Since the current system (7Fr) could not accommodate an RA with a burr larger than 2.0 mm, we additionally performed RA using the same burr at 120,000 rpm platform speed (i.e., LSRA) in order to obtain further acute luminal gain with the current system. After four attempts of LSRA in the MLD site with a maximum deceleration of 3,000 rpm, the burr could cross without any reduction in the burr speed (LSRA total ablated time: 37 s). OFDI revealed that the MLD had become 2.3 mm. Moreover, apparent changes were observed in the non-ISR lesion of the proximal stent: a crackle extending to the peri-stent calcification and stent mal-apposition in the middle and distal parts of the DES, respectively (Figure 2C). These findings suggested that fluctuations of the RA burr during LSRA might have exerted additional effects on the peri-stent tissue through the stent. After these sufficient debulking, balloon angioplasty with a 3.0/13-mm scoring balloon (14 atm) and a 3.5/15-mm drug-coated balloon (DCB) (7 atm) could achieve large lumen gains and optimal stent expansion. Final angiogram and OFDI showed optimal results without any coronary flow disturbance (Figure 3). Written informed consent was obtained from the patient to publish the case and any accompanying images.

3 | DISCUSSION

The incidence of ISR has decreased to 5% in the current DES era.[4] The use of OFDI can precisely evaluate the etiology of ISR. Calcified ISR, known to be undilatable, remains an unsolved issue.[2,5] Calcified ISR is reportedly a common cause of early and late ISR in patients with and without hemodialysis, respectively.[6] In this case, the possible cause of early ISR was a protruded calcified nodule from stent struts and concomitant slight stent deformation, based on comparison with the previous IVUS imaging.

A large-scale network meta-analysis found that PCI with additional everolimus-eluting stent or with DCB angioplasty

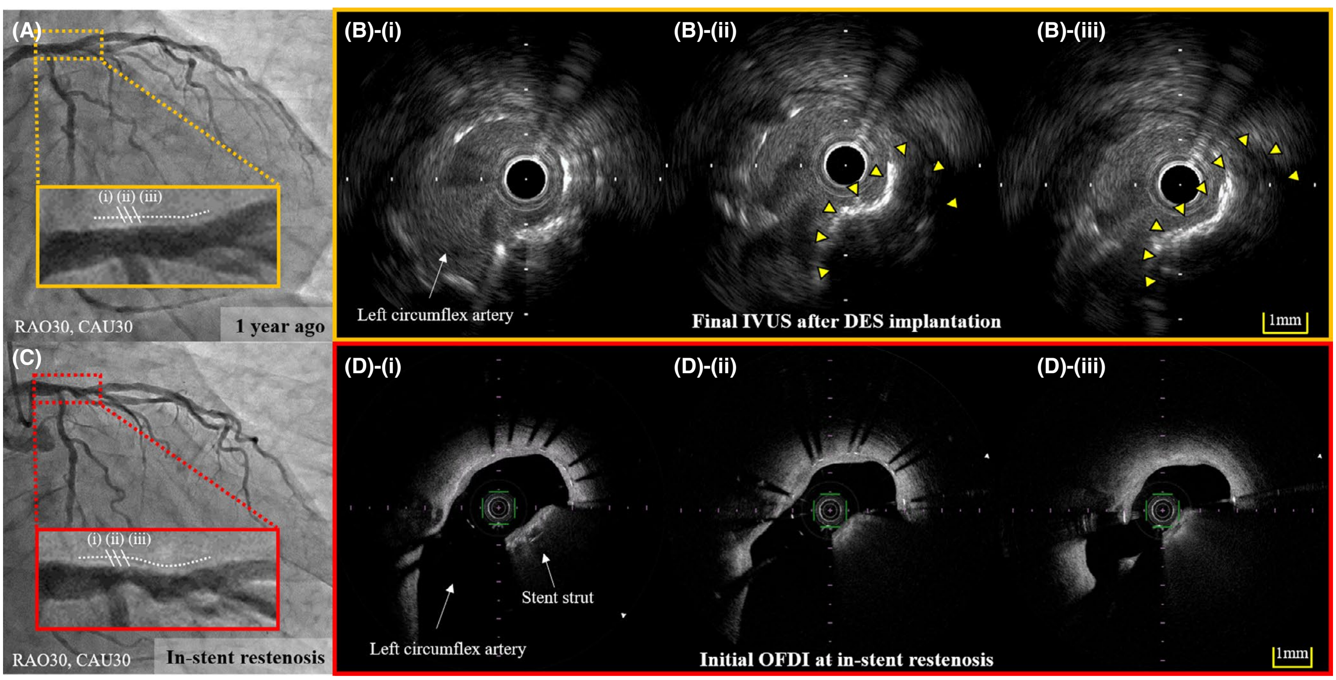

FIGURE 1 Coronary angiogram and intracoronary imaging. (A, B) Coronary angiogram (A), and intravascular ultrasound imaging (B) at the end of the percutaneous coronary intervention 1 year ago. Coronary angiogram (C), and optical frequency domain imaging (D) at the timing of in-stent restenosis

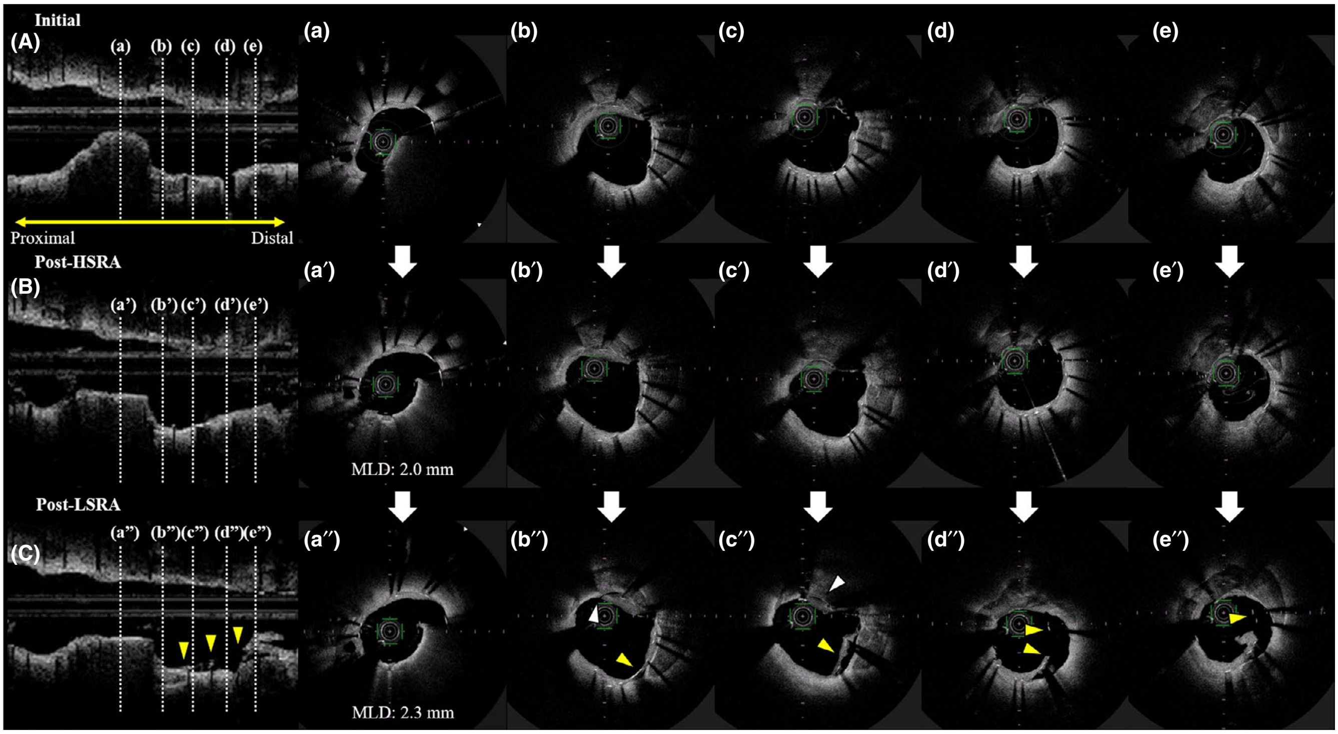

FIGURE 2 Optical frequency domain imaging during percutaneous coronary intervention. Comparison of optical frequency domain imaging at (A) pre-percutaneous coronary intervention, (B) post-high-speed rotational atherectomy, and (C) post-low-speed rotational atherectomy. (a–e), (a'–e'), (a"–e") Comparison of the cross-sectional image at each site of the in-stent lesion (white and yellow arrows refer to a crackle of peri-stent calcification and mal-apposed strut, respectively). HSRA, high-speed rotational atherectomy; LSRA, low-speed rotational atherectomy; MLD, minimum lumen diameter

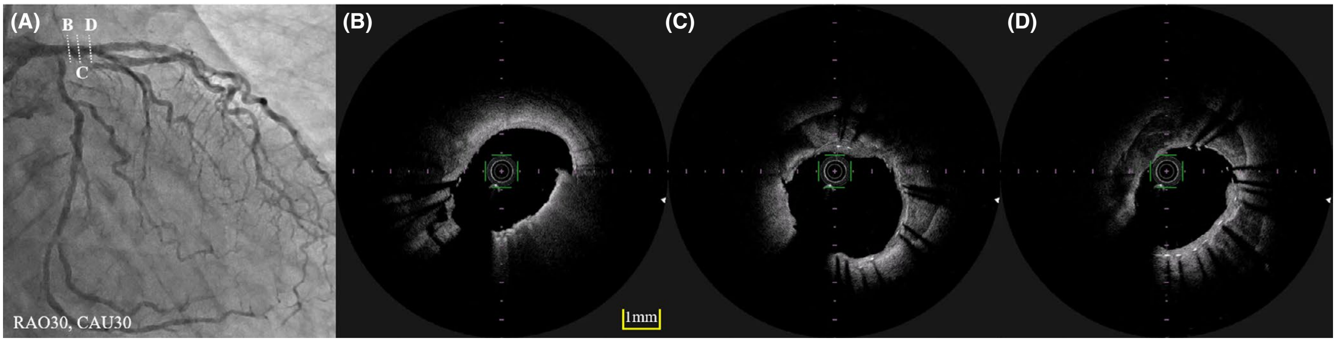

FIGURE 3 Final imaging. (A) Final coronary angiogram. (B-D) Final optical frequency domain imaging at the minimum lumen diameter (B), the site of peri-stent crackles (C), and the site of newly formed mal-apposed struts (D)

showed favorable results for treating ISR.[7] Moreover, because adequate lesion modification before these procedures is crucial, subsequent interventions (except for balloon angioplasty) to increase lumen diameter should be considered, especially in calcified ISRs. Studies show that procedures, such as RA, orbital atherectomy, intravascular lithotripsy, and excimer laser with contrast, are effective for treating calcified ISR.[8–10] However, except for RA, these indications are still off-label and limited in Japan.

Several trials were conducted to evaluate if RA followed by balloon angioplasty would provide a more favorable outcome than angioplasty alone to treat ISR.[11,12] In cases where ISR is due to stent under-expansion, RA is typically not beneficial, whereas, RA has been reported to reduce intimal hyperplasia and is considered appropriate in other ISR cases.[13] However, a recent multicenter study showed that RA for unexpanded calcified ISR is one of the effective options to achieve optimal results.[3] Although RA for unexpanded calcified ISR is still controversial, we hypothesized that RA would effectively remove the intimal hyperplasia of ISR, and that RA followed by additional angioplasty with adequate balloon dilatation pressure would result in optimal stent expansion. In addition, adjuvant DCB angioplasty is more effective for reducing target lesion revascularization compared with balloon angioplasty alone.[14]

Rotational atherectomy for native coronary calcified lesions is performed in the recommended range of 140,000–190,000 rpm; LSRA, defined as RA with a platform speed <140,000, has also been performed by some experts to acquire additional lumen gains.[15] Several reports showed that LSRA can achieve larger lumen gains in native coronary calcified lesions than HSRA.[16,17] In contrast, a retrospective study showed that LSRA did not demonstrate additional merits after sufficient HSRA.[18] These prior studies included a small sample size, and the debulking effect of LSRA remains controversial. Moreover, the mechanism and effect of LSRA on calcified ISR have not been fully investigated. To the best of our knowledge, this is the first report using OFDI to precisely evaluate whether additional LSRA after sufficient HSRA contributes to achieving larger lumen gain in a patient with calcified ISR. Although the total ablation time in LSRA following HSRA was longer than in HSRA alone, a previous study using an *in vitro* calcified model suggested that the potential mechanism for achieving larger lumen gain is the greater motion bias caused by burr deflection in LSRA rather than that in HSRA; the additional LSRA is expected to achieve further ablation effect.[16] Though the total ablation time was extended by the additional LSRA, we performed them after the confirmation of no further reduction of burr speed of HSRA. We determined that this additional effect by LSRA was derived from itself in our case.

Additionally, we could observe the adjunct effects of LSRA on peri-stent tissue owing to the conduction of vibration through the stent. However, we should be aware of possible complications such as burr entrapment and coronary perforation in cases with abnormal findings, including newly developed mal-apposed stent struts and stent fracture detected by intracoronary imaging. In this case, we assumed that additional RA might lead to burr entrapment, based on the OFDI findings of newly developed stent mal-apposition, and we discontinued the RA procedure. OFDI with a high resolution might be useful to avoid these RA-related complications. Therefore, additional LSRA may not be regular method. This procedure would be recommended after the precise evaluation of stent conditions after HSRA with intracoronary imaging. On observing abnormal findings after HSRA, performing balloon angioplasty without additional LSRA would be recommended. Large-scale randomized-controlled studies are needed to investigate ablation effects of LSRA following HSRA on calcified ISR.

4 | CONCLUSION

Optical frequency domain imaging-guided additional LSRA following sufficient HSRA for calcified ISR might be a safe and useful option for achieving additional large lumen gains and stent expansion. However, in cases where abnormal findings are revealed by OFDI, additional LSRA may not be recommended to avoid potential complication of RA.

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CONFLICTS OF INTERESTS

All authors declare that they have no conflict of interest.

AUTHOR CONTRIBUTIONS

TH and HY: mainly conducted the study, analyzed the data, and wrote the initial draft of the manuscript. TS, HK, and TT: contributed to engaging technical support and supervised the study.

ETHICAL APPROVAL

This study was approved by the appropriate ethics review board, and this manuscript has not been published elsewhere.

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