Distal embolization of coronary calcified nodule after rotational atherectomy

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Abstract
A 62-year-old man with effort angina underwent percutaneous coronary intervention in our hospital. The target lesion was severely calcified at the mid part of the right coronary artery. Pre-procedural intravascular imaging and optical frequency domain imaging showed a calcified nodule at the lesion. We performed rotational atherectomy with a 2.0 mm burr and observed an increase in the lumen area; however, a large amount of calcified nodule persisted. We decided to perform rotational atherectomy with a burr size of 2.25 mm; however, distal embolization of the calcified nodule occurred. We failed to retrieve the embolus; hence, we performed balloon dilatation with a 2.0 mm balloon, which was successfully performed. Yet, the lesion with the embolus immediately recoiled. Finally, a drug-eluting stent was implanted in both the distal lesion with the embolus and the lesion with the calcified nodule. Final coronary angiography showed good results. We confirmed good stent expansion and that calcified nodule was compressed outside the stent. Atherectomy of a calcified nodule is effective at achieving sufficient stent expansion and reducing the risk of vessel perforation. However, we experienced distal embolization of the calcified nodule at the time of rotational atherectomy and so distal embolization should be considered at the time of treatment of calcified nodule.

Keywords
Calcified nodule, rotational atherectomy, distal embolization, optical frequency domain imaging, optical coherence tomography

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Introduction
Under-expansion of a stent is one cause of eventual stent failure. Moreover, the amount of calcium at a target lesion site is associated with stent expansion.1,2 Calcified nodules (CNs) protrude into the lumen and occupy large amounts of the lumen. Therefore, atherectomy of CNs is an important strategy for achieving sufficient stent expansion and reducing the risk of vessel perforation. In this study, we reported a case of distal embolization of the CN after rotational atherectomy (RA).

Case report
A 62-year-old man with effort chest pain was admitted to our hospital for percutaneous coronary intervention (PCI). His coronary risk factors included hypertension and diabetes mellitus. Coronary angiography revealed tight stenosis with severe calcification at the mid part of the right coronary artery (Figure 1(a) and (b)). We performed PCI via the right femoral artery using an 8-Fr guiding catheter. Optical frequency domain imaging (OFDI; Lunawave; Terumo Corporation, Tokyo, Japan) indicated the presence of a high-backscattering protruding mass with an irregular luminal surface and signal attenuation (Figure 1(c)). Meanwhile, intravascular ultrasound (IVUS; Atlantis;
Boston Scientific Corporation, Natick, MA, USA) indicated the appearance of a protruding mass with a superficial hyperechoic signal accompanied by acoustic shadowing (Figure 1(d)). From these findings, we diagnosed this lesion as a CN. We performed lesion modification by RA with a 2.0 mm burr after implantation of temporary pacing (Figure 2(a)). After RA, although coronary angiography revealed no change, OFDI showed an increase in the minimum lumen area by ablation of the CN by RA (Figure 2(b) and (c)). However, the total amount of CN was still large and the risk of coronary perforation with balloon dilation or stent implantation remained. Therefore, we performed additional RA with a larger burr size (2.25 mm) (Figure 3(a)). After RA, the CN was found to have disappeared on coronary angiography (Figure 3(b)), and OFDI showed lumen area that was larger than expected area by the burr size of RA (Figure 3(c)). However, distal embolization of the ablated nodule occurred, and the patient developed chest pain with slight ST elevation on the inferior leads (Figure 4(a)). We performed IVUS and identified loose clots containing some calcification (Figure 4(b)). We unsuccessfully attempted embolus retrieval using three entangled wires and a thrombectomy catheter. Finally, balloon dilation using a 2.0-mm-diameter balloon successfully expanded the lesion without indentation. Yet, coronary angiography after balloon dilation revealed recoil of the lesion (Figure 4(c) and (d)). We implanted a 2.25-mm drug-eluting stent and achieved good stent expansion (Figure 4(e)). After stenting, IVUS showed full stent expansion and a compressed embolus outside the stent (Figure 4(f)). Then, we implanted a drug-eluting stent with 3.5 mm diameter at the site of the CN lesion. Final coronary angiography

**Figure 1.** Coronary angiography at the (a) left anterior oblique artery (40°) revealing tight stenosis with severe calcification at the mid-RCA (arrow) and (b) right anterior oblique artery (30°) revealing tight stenosis with severe calcification at the mid-RCA (arrow). (c) OFDI demonstrated the presence of irregular surfaced protruding masses with signal attenuation (arrows). (d) IVUS demonstrated the presence of protruding masses with superficial hyperechoic signal accompanied by acoustic shadowing (arrows).
revealed a good result without any distal embolization and OFDI revealed good stent expansion of the lesion with CN (Figure 5(a) and (b)).

Figure 2. (a) RA with a 2.0 mm burr. (b) Coronary angiography after the RA with a 2.0 mm burr. CN persisted, as indicated by coronary angiography (arrow). (c) OFDI indicated an increase in the lumen area. CN was well ablated by RA with a 2.0 mm burr (arrows).

Figure 3. (a) RA with a 2.25 mm burr. (b) CN disappeared after RA with a 2.25 mm burr by coronary angiography (arrow). (c) OFDI indicated a much larger lumen area compared to the burr size for RA.

Discussion
Stent implantation on CN sometimes leads to stent under-expansion and vessel perforation due to the overstretching of a healthy vessel wall. Therefore, clinicians should debulk the CN before stenting. As shown in our case, however, distal embolization of the CN after RA can occur and, to the
best of our knowledge, this report is the first report regarding distal embolization of CN after RA. Although the etiology of CN is not fully understood, it has been reported that there is a thin fibrous cap over the nodule. Moreover, histopathological studies of fibrin deposits with a disrupted surface fibrous cap and an overlying thrombus have been observed.4,5 In

Figure 4. (a) Coronary angiography indicated embolization of CN at the distal part of the RCA (arrow). (b) IVUS revealed an embolus with some calcification in a healthy small vessel. (c) Balloon angioplasty with a 2.0 mm balloon was performed. (d) Stenosis persisted after balloon angioplasty, as indicated by coronary angiography (arrow). (e) Coronary angiography showed no residual stenosis after stenting with a 2.25 mm stent. (f) IVUS after stenting revealed sufficient circle stent expansion.

Figure 5. (a) Final coronary angiography revealed good results. (b) Final OFDI demonstrated good stent expansion and compressed CN outside the stent (arrows).
addition, Higuma et al. demonstrated that CN was one cause of ST-elevated myocardial infarction, with a recorded prevalence of 8.0%. As these studies suggest, CN is speculated to have unstable features and a heterogeneous hardness. Therefore, embolization of CN can occur after both RA and balloon angioplasty. The volume of the embolus can also vary; hence, a larger size embolus may induce critical ST-elevated myocardial infarction. Although it is difficult to prevent complete distal embolization of CN, clinicians must be mindful of this complication during PCI for CN.

Conclusion
We experienced a case of distal embolization of CN after RA. A reduction in the amount of CN by RA leads to sufficient stent expansion; however, distal embolization of CN can occur due to its heterogeneity. Thus, clinicians must be mindful of this complication during PCI for CN.

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