Early results of coronary interventions for patients with in-stent restenosis (ISR) are largely satisfactory.\textsuperscript{1,2} In this setting lack of initial angiographic success or occurrence of procedural-related complications are exceedingly rare.\textsuperscript{1,2} We report a patient presenting with old calcified ISR who experienced a pin-hole balloon rupture and peri-stent abluminal intramural hematoma during a repeated coronary intervention. Optical coherence tomography (OCT) and intravascular ultrasound (IVUS) provided unique morphological insights and facilitated identification of the calcified underlying substrate of ISR.

An 82-year-old man with a previous history of coronary surgery and interventions on the circumflex coronary (LCX) was admitted for prolonged angina, transient electrocardiographic changes on lateral leads and troponin elevation. He had a previous history of cigarette smoking, hypertension, dyslipidemia, and diabetes. The patient was treated with a drug-eluting stent (DES) for ISR. Early follow-up angiography demonstrated a small residual coiling of the stent and in-stent restenosis at the distal edge of the stent. Following for this reason a high-pressure balloon dilation of the ISR was performed resulting in a visible waist in the balloon indicating the presence of a calcified plaque. The patient was asymptomatic and discharged without further intervention.

At the follow-up visit, the patient presented with chest pain and newtroponin elevation. Coronary angiography showed a severe in-stent restenosis at the ostium of the left circumflex coronary artery (Figure 1A). A waist was noticed in the balloon during the high-pressure dilation (Figure 1B). Optical coherence tomography and intravascular ultrasound revealed a peri-stent abluminal intramural hematoma (Figure 1C). We performed prolonged low-pressure balloon inflation for a total of 30 minutes (Figure 1D).

Figure 1. (A) Coronary angiography showing severe in-stent restenosis (yellow arrow) at the ostium of the left circumflex coronary artery. (B) A waist was noticed in the balloon during high-pressure dilation (*). (C) Peri-stent abluminal hematoma (arrows) as a result of the pin-hole balloon rupture. (D) Final result after prolonged low-pressure balloon inflation. Broken arrows, stent location.
obesity, peripheral vascular disease and ischemic stroke. In 1991 he suffered an inferior myocardial infarction and received thrombolysis. In 2003 coronary angiography was performed for angina, showing severe stenosis of the left main coronary artery, total occlusion of the mid-left anterior descending artery (LAD), severe stenosis of the LCX ostium and moderate disease distal in the right coronary artery. On surgical revascularization a left internal mammary artery graft was implanted to the LAD and a saphenous vein graft to the marginal branch. In 2004 he presented again with effort angina, and angiography showed a patent mammary artery graft to the LAD but occlusion of the vein graft to the LCX. Rotational atherectomy was performed followed by sirolimus-eluting stent (3.0×23 mm, Cypher™; Cordis, Miami Lakes, FL, USA) implantation from the left main stem to the proximal LCX. Six months later he developed severe ISR that was successfully treated with cutting balloon angioplasty followed by intracoronary brachytherapy. On coronary angiography scheduled 9 months later, the results for the stent were excellent.

On the current admission physical examination was unremarkable, ST changes on lateral leads rapidly normalized and troponin rose to 4.8 ng/ml. Coronary angiography revealed severe ISR of the stent implanted 7 years previously, with severe narrowing at the ostium of the LCX (Figure 1A). After gentle, low-pressure, lesion pre-dilation with an undersized balloon (2.5×11 mm, Mercury™; Abbott Vascular, Germany), IVUS (40-Mhz transducer, Atlantis SR Pro™; Boston Scientific, Fermont CA, USA) and OCT (Dragonfly™; Light Lab Imaging, St. Jude Medical, Westford, MA, USA; Figure 2) were used to gain further insights into the composition of the tissue causing this very late ISR. Interestingly, the tissue obstructing the stent was mainly composed of calcium that protruded into the lumen, causing significant lumen compromise (minimal lumen area, 2.6 mm²; Figure 2). Severe shadowing of the struts was visualized on IVUS whereas OCT confirmed that the calcium was indeed located within the stent (Figure 2). Subsequently, a larger conventional balloon (3.0×12 mm, Apex™; Boston Scientific, Natick, MA, USA) was inflated at very high pressure (up to 24 atm) due to the presence of some residual waist of the balloon on fluoroscopy (Figure 1B). Eventually, a pin-hole balloon rupture was produced. At this moment the patient complained of transient chest pain and a large peri-stent abluminal hematoma was recognized on angiography (Figure 1C). Prolonged, low-pressure, balloon inflations were successful in obtaining a satisfactory final result with complete resolution of the peri-stent image (Figure 1D). Subsequent clinical course was uneventful.

Angiographic failures or procedure-related complications in patients undergoing repeat interventions for ISR remain very rare.1,2 The phenomenon of balloon slippage, however, may occasionally complicate these procedures and result not only in suboptimal acute results but also in poor long-term clinical and angiographic outcome.2 The use of cutting balloon angioplasty or scoring balloons has been suggested to prevent this complication.3 In contrast, many patients with ISR present with underexpanded stents.4 This problem may be a result of poor stent deployment or the presence of underlying undilatable calcified lesions.4 In the latter scenario severe stent underexpansion may be very difficult to correct despite the use of non-compliant balloons and high dilation pressures.4 This is of concern because residual stent underexpansion may trigger recurrent ISR.4 More recently, neoatherosclerosis, rather than
the classical homogeneous pattern of neointimal hyperplasia, has been described in patients with ISR. This pathological substrate tends to develop a long time after stent implantation and clinically may present either as late or very late ISR or stent thrombosis. Neoatherosclerosis is more frequently seen as a form of neoatherosclerosis. The intervention of choice in patients presenting with neoatherosclerosis remains to be defined. Likewise, the best strategy for patients with calcified ISR remains unknown. In the present patient the use of a conventional balloon in this setting was associated with dilation problems and eventually with a pin-hole balloon rupture and the peri-stent abluminal hematoma. Although edge dissections are frequently detected during interventions for ISR, particularly in patients with the “watermelon seeding” phenomenon, the best of our knowledge the occurrence of persistent hematoma has not been previously reported in these patients. Furthermore, although consequences of balloon rupture in native lesions are well established, the occurrence of this complication in patients with ISR is very rare.

The present findings suggest that in patients with old ISR the presence of neoatherosclerosis and, in particular, the presence of calcification within the stent, should be ruled out. When calcified ISR is detected on OCT, usage of non-compliant balloons would be better to prevent pin-hole balloon rupture. Salient or sharp edges of calcified tissue may cause this problem. In this setting, alternative therapies including rotational atherectomy or cutting balloon angioplasty must be also considered. We recently reported a patient with undilatable calcified ISR who experienced several episodes of balloon rupture despite the use of non-compliant balloons. Eventually rotational atherectomy was required to dilate the calcified tissue causing ISR and to obtain an optimal final result. In that patient, the combined use of OCT and IVUS was instrumental in identifying the calcified tissue within the stent and to optimize final results. Interestingly, when a new stent is implanted OCT is able to identify the presence of residual calcified tissue between the 2 stent layers. OCT is of great value in detecting dissections at the stent edge (frequently angiographically silent), and recent data suggest that these dissections may be associated with adverse clinical outcomes. OCT may also identify intra-stent dissections but its value in visualizing abluminal dissections in patients presenting with ISR remains unclear.

Fortunately, in the current patient repeated low-pressure balloon inflation was adequate to successfully address this complication. Once the complication was induced, the secondary use of rotational atherectomy was not considered to be safe. The present findings further illustrate the unique value of OCT in providing novel insights into this challenging anatomic scenario.

Disclosures
None.

References