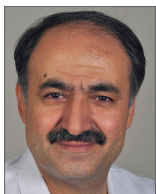


# A novel approach to treat in-stent restenosis: 6- and 12-month results using the everolimus-eluting bioresorbable vascular scaffold



Peiman Jamshidi, MD; Tobias Nyffenegger, MD; Zaid Sabti, MD; Elefteri Buset, MD; Stefan Toggweiler, MD; Richard Kobza, MD; Florim Cuculi\*, MD

Department of Cardiology, Luzerner Kantonsspital, Lucerne, Switzerland

This paper also includes supplementary data published online at: [http://www.pcronline.com/eurointervention/97th\\_issue/287](http://www.pcronline.com/eurointervention/97th_issue/287)

## KEYWORDS

- bioresorbable scaffolds
- in-stent restenosis
- scaffold thrombosis
- stent thrombosis

## Abstract

**Aims:** The treatment of in-stent restenosis (ISR) remains challenging. Small case series have described successful utilisation of bioresorbable vascular scaffolds (BVS) (Absorb; Abbott Vascular, Santa Clara, CA, USA) to treat ISR. We report our experience with this novel approach.

**Methods and results:** Patients with ISR in native coronary arteries undergoing percutaneous coronary intervention (PCI) for ISR were treated using BVS. A total of 84 ISR lesions were treated in 65 patients. The mean age was  $66\pm 11$  years, 28% had acute coronary syndrome (ACS) and 28% were diabetic. PCI was successful in all patients and all scaffolds were delivered and deployed successfully in the target lesion. All 65 patients had six-month follow-up and 49 patients had 12-month clinical follow-up. The target lesion revascularisation (TLR) rate was 3.1% at six months and 12.2% at 12 months. The mean duration from PCI to TLR was  $301\pm 148$  days. No scaffold thrombosis occurred during the study period.

**Conclusions:** This proof of concept study demonstrates that ISR treatment utilising BVS is feasible and appears to have acceptable target lesion failure rates. Prospective randomised trials are necessary to assess whether BVS are more effective than drug-eluting stents or drug-eluting balloons to treat ISR.

\*Corresponding author: Heart Centre Lucerne, Luzerner Kantonsspital, Spitalstrasse, 6000 Lucerne 16, Switzerland.  
E-mail: [florim@gmx.net](mailto:florim@gmx.net)

## Introduction

Although percutaneous coronary intervention (PCI) using drug-eluting stents (DES) has dramatically reduced the need for repeat intervention compared to bare metal stents (BMS)<sup>1</sup>, a substantial minority of patients still require reinterventions, and sometimes even coronary artery bypass grafting (CABG) needs to be considered in recurrent in-stent restenosis (ISR)<sup>2</sup>.

Drug-eluting balloons (DEB) are superior to plain old balloon angioplasty (POBA) when treating ISR<sup>3,4</sup> but new-generation everolimus-eluting stents have been shown to be more effective than DEB when treating BMS<sup>5</sup> and DES ISR<sup>6-8</sup>.

Implanting additional stent layers to treat ISR might be effective in the short term<sup>9</sup>, but the long-term consequences of more than two stent layers ("onion-skin phenomenon") are unknown<sup>6</sup>. BVS offer a more prolonged drug delivery capacity and more radial strength in the acute phase. Additionally, compared to most DEB, the Absorb BVS (Abbott Vascular, Santa Clara, CA, USA) elutes everolimus, which is believed to be more effective in fighting restenosis when compared to paclitaxel<sup>10,11</sup>. Recent case reports and small series have suggested implantation of BVS to treat ISR, which might have positive effects on neoatherosclerosis and would avoid the addition of multiple metal layers<sup>12-14</sup>.

In this report, we describe our initial experience utilising BVS to treat ISR in an all-comers population with coronary artery disease (CAD).

Editorial, see page 1451

## Methods

### STUDY POPULATION

This was an observational single-centre study which was performed at the Luzerner Kantonsspital (Lucerne, Switzerland), a centre performing 1,500 PCI/year by four operators. The Absorb BVS was introduced in July 2013 and, starting in September 2013, became optional to treat ISR. The final decision as to whether to use a DEB, DES or BVS for the treatment of ISR remained at the discretion of the interventional cardiologist. Patients with symptomatic stable CAD and those with acute coronary syndrome (ACS) were eligible to be treated using BVS. The interventional cardiology consultants agreed on the following exclusion criteria: previous stent thrombosis, restenosis in saphenous vein grafts or arterial grafts, vessel diameters <2.5 and >4.0 mm, large bifurcations requiring a two-stent strategy, and residual stenosis >50% after predilatation.

In the time period September 2013 to December 2014, a total of 84 other patients presented with ISR and were treated as follows: DES (n=62), DEB (n=14) and bypass surgery (n=8). The clinical and angiographic characteristics of these patients were largely comparable to those presented in this study.

### TYPES OF STENT WITH ISR

The following stents had been used previously in the current population:

- BMS: PRO-Kinetic (Biotronik, Berlin, Germany, n=11); MULTI-LINK VISION® (Abbott Vascular, n=3).

- Early-generation DES: CYPHER® (Cordis, Johnson & Johnson, Fremont, CA, USA, n=15).
- Late-generation DES: XIENCE (Abbott Vascular, n=36); Orsiro (Biotronik, n=19).

## Procedure

Predilatation was performed using non-compliant balloons from SIS Medical, Winterthur, Switzerland. Either the BEO NC® (highest rated burst pressure 24 atm) or the OPN NC® (highest rated burst pressure 35 atm) was used to predilate the ISR lesion. The Absorb BVS was implanted at 12-16 atm with gradually increasing pressure (as recommended) with the intention of covering the diseased segment completely. Post-dilatation was performed using the BEO NC and OPN NC. However, in the initial months, post-dilatation was performed only in selected cases. The strategy was then changed to post-dilate all BVS.

## ANGIOGRAPHIC ANALYSIS AND OPTICAL COHERENCE TOMOGRAPHY

The angiographic pattern of ISR was classified in four categories according to Mehran et al<sup>15</sup>: focal (ISR <10 mm) diffuse (ISR >10 mm within the stent), proliferative (ISR >10 mm extending outside the stent) and occlusive (totally occluded ISR).

Quantitative angiographic analysis (QCA) was performed before (if the vessel was not completely occluded) and after BVS implantation using Xcelera software, Version 3.2.1 (Philips Healthcare, Best, The Netherlands). Measurements were taken on cineangiograms recorded after intracoronary nitroglycerine. Baseline measurements were taken with the single worst view projection and repeated in the same projection. The contrast-filled non-tapered catheter tip was used for calibration.

In selected cases optical coherence tomography (OCT) was used to guide BVS implantation. Angiographic and OCT images of a patient with ISR treated with BVS are shown in **Moving images 1-7**.

## MEDICAL THERAPY

PCI was performed using heparin (70 units/kilogram body weight) and eptifibatid was used in selected patients with ACS (at the discretion of the operator). Patients with stable CAD were discharged on aspirin and clopidogrel whilst those with ACS received ticagrelor or prasugrel in addition to aspirin. As a general rule, dual antiplatelet therapy was recommended for 12 months.

## FOLLOW-UP AND ENDPOINTS

Follow-up was performed via telephone or by clinical visits. Patients with re-occurrence of angina underwent invasive coronary angiography. The primary endpoint was a composite of target lesion revascularisation (TLR), scaffold thrombosis (ScT), myocardial infarction and death. Additionally, target vessel revascularisation (TVR) is reported.

Target lesion failure (TLF) was defined as re-occurrence of symptoms with angiographic diameter stenosis >50% at follow-up. ScT was defined according to the Academic Research Consortium definition<sup>16</sup>.

## ETHICAL CONSIDERATIONS

All patients gave informed consent to be included in this registry and to be contacted regularly for clinical follow-up. This study was part of the preparation for the AbsorbISR study (a prospective, randomised study, ClinicalTrials.gov identifier: NCT02474485) and the institutional review board gave its approval.

## Statistics

Normally distributed parameters are reported as mean and standard deviation (SD), and non-normally distributed parameters are reported as median (interquartile values). The paired and unpaired t-test was used for normally distributed parameters. A p-value <0.05 was considered significant.

## Results

Between September 2013 and December 2014, a total of 84 ISR lesions were treated in 65 patients. The baseline characteristics of the study population are shown in **Table 1**. Briefly, the mean age was 66±11 years, 28% of the patients had ACS and 26% had diabetes mellitus. Patients with stable CAD were all symptomatic with angina CCS II or more.

## LESION CHARACTERISTICS

The lesion characteristics are described in **Table 2**. The vast majority of the lesions were ISR in late-generation DES (71%). The rest were ISR lesions in early-generation DES (25%) and BMS (4%). Twenty-one lesions (29%) had two or more previous stents implanted and 17 lesions (20%) were chronic total occlusions.

**Table 1. Baseline characteristics of the study population (n=65).**

Age (years)	66.0±10.7	
Male (%)	56 (86%)	
Clinical presentation	Stable angina	47 (72%)
	Unstable angina	6 (9%)
	Non-ST-elevation myocardial infarction	11 (17%)
	ST-elevation myocardial infarction	1 (2%)
Cardiovascular risk factors	Diabetes	17 (26%)
	Hypertension	51 (79%)
	Current smoker	32 (49%)
	Hyperlipidaemia	53 (82%)
History of myocardial infarction	27 (42%)	
History of coronary artery bypass grafting	8 (12%)	
Radial approach	52 (80%)	
Periprocedural eptifibatide	6 (9%)	
Antiplatelet therapy at discharge	Aspirin	65 (100%)
	Clopidogrel	48 (74%)
	Ticagrelor	9 (14%)
	Prasugrel	8 (12%)
	Oral anticoagulation	3 (5%)

**Table 2. Lesion characteristics of the study population (n=84).**

Culprit vessel	LAD	27 (32%)
	LCX	12 (14%)
	RCA	45 (54%)
Type of in-stent restenosis	Focal	20 (24%)
	Diffuse	21 (25%)
	Proliferative	26 (31%)
	Occlusive	17 (20%)
Type of restenosed stent	BMS	3 (4%)
	First-generation DES (CYPHER, TAXUS)	21 (25%)
	Second-generation DES (XIENCE, Orsiro)	60 (71%)
Layers of stents	One	63 (75%)
	Two	18 (21%)
	Three or more	3 (4%)
History of DEB treatment		6 (7%)
Moderate to severe calcification		58 (69%)
Aorto-ostial location of the lesion		1 (1%)
Chronic total occlusion (>3 months)		17 (20%)
Optical coherence tomography guidance		15 (18%)
Lesion preparation	Predilatation	84 (100%)
	Normal non-compliant balloon	24 (29%)
	Super non-compliant balloon (OPN NC)	60 (71%)
	Predilatation balloon diameter (mm)	3.1±0.4
	Predilatation pressure (atm)	26.1±7.2
Absorb BVS characteristics	Total scaffolds implanted	95
	Scaffold diameter (mm)	3.1±0.4
	Scaffold length (mm)	24.6±5.1
	Scaffold deployment pressure (atm)	15.2±1.9
	Post-dilatation	42/84 (50%)
	Maximal post-dilatation pressure (atm)	27.0±7.8

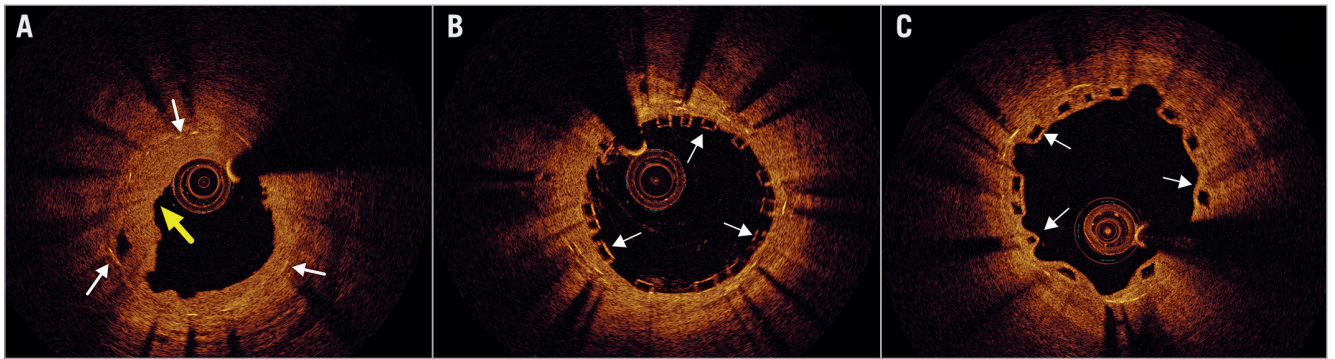
Predilatation was performed in all lesions and in all lesions a non-compliant balloon was used and inflated at high pressures, reaching a mean inflation pressure of 26±7 atm.

Procedure success was 100%, no major acute complication occurred and all scaffolds could be deployed to the target lesion. A total of 95 scaffolds were implanted with a mean diameter of 3.1±0.4 mm and a mean length of 24.6±5.1 mm. Mean deployment pressure was 15.2±1.8 atm and post-dilatation was performed in 42/84 lesions (50%). Mean post-dilatation pressure was 27.0±7.8 atm.

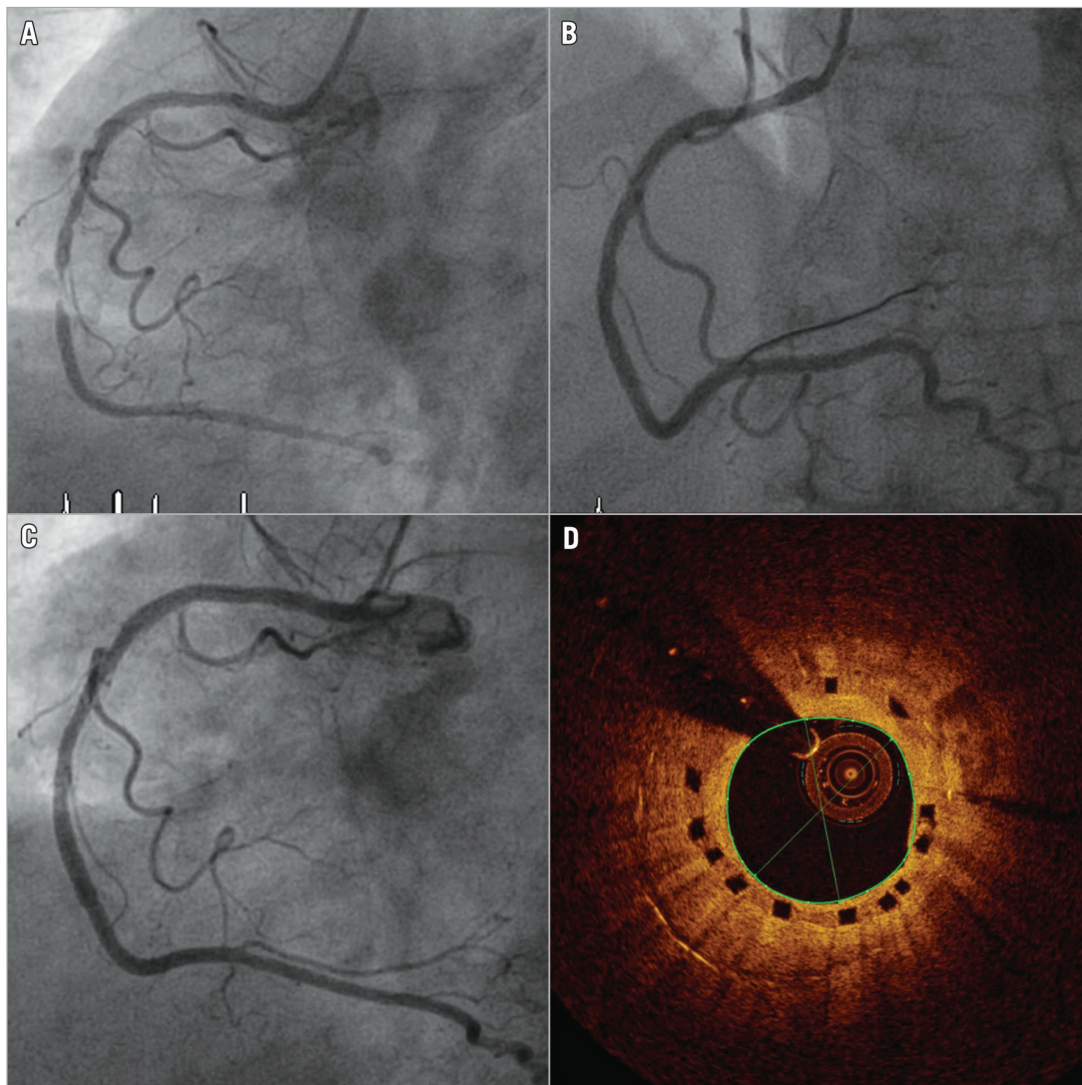
OCT was used in 15/84 lesions (18%). Post-dilatation pressure was similar in patients where OCT was used to guide the procedure (n=12) as compared to those in whom OCT was not used (n=27): 26.6±5.4 atm vs. 27.4±8.5 atm (p=0.77).

**Figure 1** depicts the use of OCT to guide the procedure and to demonstrate endothelialisation of the scaffold at six months. **Figure 2** demonstrates a patient with target lesion failure.

The results of the QCA analysis are shown in **Table 3**. Mean lesion length was 21.86±9.72 mm and the diameter stenosis reduced from 72.1±17.4% to 23.0±8.4% (p<0.001).



**Figure 1.** Optical coherence tomography images of a patient with in-stent restenosis treated with Absorb BVS. A) Baseline: optical coherence tomography demonstrates intimal hyperplasia covering a previously implanted drug-eluting stent (arrows). B) After BVS implantation: an Absorb BVS has been implanted achieving a good result with good scaffold expansion and apposition. C) At 6 months post PCI: the scaffold is covered by thin neointima but no in-stent restenosis is seen.



**Figure 2.** Angiographic and optical coherence tomography images in one of the patients with target lesion failure. A) Severe ISR in a 66-year-old woman previously treated with metallic, new-generation DES. B) The mid and proximal RCA was treated with two 3.0×28 mm Absorb BVS deployed at 14 atm. No post-dilatation was performed. C) The patient complained of angina 14 months after treatment and a moderate ISR was observed angiographically. D) Undersizing and underdeployment of the scaffold can be seen on optical coherence tomography. Intimal hyperplasia is mild-moderate. The mean diameter on the frame shown is 1.8 mm with an area of 2.55 mm<sup>2</sup>.

**Table 3. Quantitative coronary angiography analysis of the study population (n=84).**

	Before BVS	After BVS	p-value
Lesion length (mm)	21.86±9.72		
Minimal luminal diameter (mm)	1.09±0.48	2.63±0.47	<0.001
Reference vessel diameter (mm)	3.18±0.55	3.44±0.52	<0.001
Diameter stenosis (%)	72.1±17.4	23.0±8.4	<0.001

**PERIPROCEDURAL AND IN-HOSPITAL OUTCOMES**

PCI was successful in all patients and all scaffolds were delivered and deployed successfully in the target lesion. No deaths, scaffold thrombosis or repeat revascularisation occurred during the hospitalisation.

**LONG-TERM OUTCOMES**

Follow-up was performed in all 65 patients at six months and in 49/65 patients (75%) at 12 months (**Table 4**). The primary outcome, which consisted of a composite endpoint of TLR, ScT, myocardial infarction and death, was reached in 9/49 patients (18.4%) at 12 months.

Two patients died during follow-up: one was a 75-year-old diabetic lady who presumably died due to severe pulmonary embolism seven months post-procedure. The second patient was a 68-year-old man who died of severe pulmonary fibrosis 10 months post-procedure. No scaffold thrombosis occurred during follow-up. The TLR rate was 3.1% at six months and 12.2% at 12 months. The narratives of the patients experiencing TLR are summarised in **Table 5**. The lesions where BVS implantation failed were either occlusive (4/6) or proliferative (2/6), and only 2/6 lesions were post-dilated. Angiographic and OCT images of a patient with TLF are shown in **Figure 2**.

**Discussion**

To the best of our knowledge, this is the first study to report outcomes in patients with ISR in metallic stents treated with Absorb BVS. Given the fact that we treated a relatively complex

**Table 4. Summary of outcomes.**

Follow-up	6 months N=65	1 year N=49
Primary endpoint		
Myocardial infarction	1/65 (1.5%)	1/49 (2.0%)
Death	1/65 (1.5%)	2/49 (4.1%)
Scaffold thrombosis (ScT)	0 (0%)	0 (0%)
Target lesion revascularisation (TLR)	2/65 (3.1%)	6/49 (12.2%)
Target vessel revascularisation (TVR)	3/65 (4.6%)	9/49 (18.4%)
Mean duration: PCI to TLR (days)	301±148	
Repeat coronary angiography	21/65 (32%)	
Clinically driven	13/65 (15.4%)	
Planned at index PCI	8/58 (12.3%)	

population with a high proportion of diabetes (26%) and with complex lesion characteristics (only 24% had focal ISR, 20% had chronic total in-stent occlusions and 21% already had two layers of metallic stents), we believe that our results are encouraging.

Although the use of new-generation DES has markedly improved PCI outcomes<sup>17</sup>, a minority of patients treated with DES will still develop ISR. These patients are difficult to treat and prone to adverse outcomes<sup>2</sup>. Current guidelines recommend DES implantation in patients with BMS or DES ISR, but the prospect of adding additional stent layers is not appealing for all patients, especially those who already have two layers of stent struts<sup>18</sup>.

The ISAR-DESIRE 3 was a randomised study comparing paclitaxel-eluting balloons (PEB) vs. paclitaxel-eluting stents (PES) vs. balloon angioplasty in patients with ISR in a limus stent<sup>19</sup>. The TLR rate at one year was 13.5% in the PES group and 22.1% in the PEB group, which indicates that the TLR rate of 12.2% in our complex population compares well to PES and might be superior to PEB.

The recently published ABSORB II randomised study demonstrated similar one-year results between patients treated with the Absorb BVS and those treated using XIENCE<sup>20</sup>, confirming that BVS can compete with well-established metallic stents. Our small pilot study takes the discussion about the daily use of BVS to the next level and indicates that even challenging lesions can be

**Table 5. Summary of patients with target lesion revascularisation.**

Age	Clinical setting at implant.	Clinical setting at TLR	Diabetes	Type of ISR before BVS	BVS dimensions	Post-dilation
49	NSTEMI	Unstable angina	NO	Occlusive	2.5×28 mm 3.0×28 mm	NO
67	Stable angina	Stable angina	NO	Proliferative	3.0×28 mm	YES
69	Stable angina	Stable angina	NO	Occlusive	3.0×28 mm 3.5×28 mm 3.5×28 mm	NO
63	Stable angina	Stable angina	NO	Occlusive	2.5×28 mm 2.5×18 mm	YES
66	Stable angina	Stable angina	YES	Occlusive	3.0×28 mm 3.0×28 mm	NO
77	NSTEMI	NSTEMI	YES	Proliferative	3.0×28 mm 3.0×28 mm 3.0×18 mm	NO

treated. Importantly, in our study all lesions were prepared using non-compliant balloons, as it is well known that underexpansion of stents is a common mechanism inducing ISR and/or stent thrombosis<sup>21-23</sup>. Underexpansion can be dramatic and is not always discernible angiographically<sup>24</sup>. Since we did not routinely use intravascular imaging to guide the procedure, we regularly performed aggressive predilatation to achieve maximal stent expansion and facilitate BVS deployment.

In the early days of BVS use (2013/early 2014), we were very cautious with post-dilatation of scaffolds, which explains why only half of the lesions were post-dilated. With increasing use of intravascular imaging (especially OCT) in our daily practice, we noticed that better scaffold expansion could be reached with post-dilatation. Additionally, on OCT imaging of patients experiencing early scaffold thrombosis, we observed that underexpansion was very frequent and thus we are currently routinely performing aggressive post-dilatation of BVS using the OPN NC balloon at very high pressures (30-40 atm).

Our approach is supported by the small study of Rivero et al, in which 15 patients with ISR were treated using BVS and OCT guidance<sup>14</sup>. The authors were able to achieve good final expansion by performing high-pressure pre- and post-dilatation of the lesions. In one patient, underexpansion could not be corrected despite aggressive pre- and post-dilatation and this patient sustained subacute scaffold thrombosis.

The OPN NC is a highly non-compliant, twin-layer balloon with a rated burst pressure of 35 atm<sup>25,26</sup>. The 3.0 mm balloon only expands to 3.38 mm at 35 atm and prevents overexpansion of the 3.0 mm scaffold, which has an expansion limit of 3.5 mm.

As can be appreciated from **Table 2**, post-dilatation is currently being performed with high pressure (mean 27±8 atm) in order to reach maximal BVS expansion. Of note, post-dilatation was not performed in 4/6 patients with TLF and this probably resulted in underexpansion of BVS (**Figure 2**). Routine use of OCT to guide the procedure has the potential to improve outcomes, although this needs to be demonstrated in a prospective study.

The publication of high ScT rates in the GHOST-EU registry has raised concerns regarding the safety of the Absorb BVS<sup>27</sup>. We observed no ScT in this small population and this is reassuring.

In summary, this small, exploratory study indicates that BVS are efficient in treating ISR. The results of this registry are in line with the results of the DEB arm from the RIBS IV trial, which demonstrated a rate of freedom from TLR of 87% at one year. However, as mentioned above, the study population reported in this manuscript was more complex, including long lesions and chronic stent occlusions.

We are currently performing a prospective randomised study comparing BVS vs. DEB to treat ISR at our centre (AbsorbISR). This study includes OCT guidance of the procedure and angiographic and OCT follow-up at nine months. If our encouraging results in this retrospective study are confirmed in prospective and randomised trials, the Absorb BVS can become an alternative to DES or DEB for patients presenting with ISR.

## Limitations

This was a relatively small population of patients treated with this novel approach. Although we treated a relatively complex population, selection bias might still have played a role. OCT guidance of the intervention and angiographic follow-up were available for a minority of patients. Our report must be considered a pilot project, and further studies are needed before BVS treatment for ISR can become clinical routine.

## Conclusions

This study demonstrates that BVS can be safely used to treat ISR in metallic stents. Event rates are low in this small study of complex patients. The proof that BVS are a good option to treat ISR will have to be established in a prospective randomised study.

### Impact on daily practice

ISR in metallic stents is not uncommon in daily practice and currently DEB or DES can be used to treat it. Both DEB and DES have their limitations and we evaluated whether BVS could be a good option to be used in this situation. The results of this study are encouraging as we demonstrate that BVS are safe to treat ISR in metallic DES. Importantly, good pre- and post-dilatation needs to be performed in order to achieve maximal scaffold expansion and full apposition. The importance of post-dilatation is highlighted in **Moving images 5-7**.

## Conflict of interest statement

P. Jamshidi, R. Kobza and F. Cuculi have received an institutional, unrestricted research grant from Abbott Vascular. P. Jamshidi and F. Cuculi have received lecture fees from Abbott Vascular. The other authors have no conflicts of interest to declare.

## References

1. Stefanini GG, Holmes DR Jr. Drug-eluting coronary-artery stents. *N Engl J Med*. 2013;368:254-65.
2. Maluenda G, Ben-Dor I, Gaglia MA Jr, Wakabayashi K, Mahmoudi M, Sardi G, Laynez-Carnicero A, Torguson R, Xue Z, Margulies AD, Suddath WO, Kent KM, Bernardo NL, Satler LF, Pichard AD, Waksman R. Clinical outcomes and treatment after drug-eluting stent failure: the absence of traditional risk factors for in-stent restenosis. *Circ Cardiovasc Interv*. 2012;5:12-9.
3. Scheller B, Hehrlein C, Bocksch W, Rutsch W, Haghgi D, Dietz U, Bohm M, Speck U. Treatment of coronary in-stent restenosis with a paclitaxel-coated balloon catheter. *N Engl J Med*. 2006;355:2113-24.
4. Rittger H, Brachmann J, Sinha AM, Waliszewski M, Ohlow M, Brugger A, Thiele H, Birkemeyer R, Kurowski V, Breithardt OA, Schmidt M, Zimmermann S, Lonke S, von Cranach M, Nguyen TV, Daniel WG, Wöhrle J. A randomized, multicenter, single-blinded trial comparing paclitaxel-coated balloon angioplasty with plain balloon angioplasty in drug-eluting stent restenosis: the PEPCAD-DES study. *J Am Coll Cardiol*. 2012;59:1377-82.

5. Alfonso F, Perez-Vizcayno MJ, Cardenas A, Garcia Del Blanco B, Seidelberger B, Iniguez A, Gomez-Recio M, Masotti M, Velazquez MT, Sanchis J, Garcia-Touchard A, Zueco J, Bethencourt A, Melgares R, Cequier A, Dominguez A, Mainar V, Lopez-Minguez JR, Moreu J, Marti V, Moreno R, Jimenez-Quevedo P, Gonzalo N, Fernandez C, Macaya C; RIBS V Study Investigators under the auspices of the Working Group on Interventional Cardiology of the Spanish Society of Cardiology. A randomized comparison of drug-eluting balloon versus everolimus-eluting stent in patients with bare-metal stent-in-stent restenosis: the RIBS V Clinical Trial (Restenosis Intra-stent of Bare Metal Stents: paclitaxel-eluting balloon vs. everolimus-eluting stent). *J Am Coll Cardiol.* 2014;63:1378-86.
6. Alfonso F, Byrne RA, Rivero F, Kastrati A. Current treatment of in-stent restenosis. *J Am Coll Cardiol.* 2014;63:2659-73.
7. Alfonso F, Perez-Vizcayno MJ, Cardenas A, Garcia Del Blanco B, Garcia-Touchard A, Lopez-Minguez JR, Rivero F, Masotti M, Zueco J, Cequier A, Moris C, Fernandez-Ortiz A, Escaned J, Jimenez-Quevedo P, Gonzalo N, Fernandez C, Macaya C; Restenosis Intra-stent: drug-eluting Balloon vs. everolimus-eluting Stent (RIBS IV) Study Investigators (under the auspices of the Working Group on Interventional Cardiology of the Spanish Society of Cardiology). Rationale and design of the RIBS IV randomised clinical trial (drug-eluting balloons versus everolimus-eluting stents for patients with drug-eluting stent restenosis). *EuroIntervention.* 2015;11:336-42.
8. Alfonso F, Pérez-Vizcayno MJ, Cárdenas A, García del Blanco B, García-Touchard A, López-Minguez JR, Benedicto A, Masotti M, Zueco J, Iñiguez A, Velázquez M, Moreno R, Mainar V, Domínguez A, Pomar F, Melgares R, Rivero F, Jiménez-Quevedo P, Gonzalo N, Fernández C, Macaya C; RIBS IV Study Investigators (under auspices of Interventional Cardiology Working Group of Spanish Society of Cardiology). A Prospective Randomized Trial of Drug-Eluting Balloons Versus Everolimus-Eluting Stents in Patients With In-Stent Restenosis of Drug-Eluting Stents: The RIBS IV Randomized Clinical Trial. *J Am Coll Cardiol.* 2015;66:23-33.
9. Alfonso F, Garcia J, Perez-Vizcayno MJ, Hernando L, Hernandez R, Escaned J, Jimenez-Quevedo P, Banuelos C, Macaya C. New stent implantation for recurrences after stenting for in-stent restenosis: implications of a third metal layer in human coronary arteries. *J Am Coll Cardiol.* 2009;54:1036-8.
10. Tamburino C, Latib A, van Geuns RJ, Sabate M, Mehilli J, Gori T, Achenbach S, Alvarez MP, Nef H, Lesiak M, Di Mario C, Colombo A, Naber CK, Caramanno G, Capranzano P, Brugaletta S, Geraci S, Araszkiwicz A, Mattesini A, Pyxaras SA, Rzeszutko L, Depukat R, Diletti R, Boone E, Capodanno D, Dudek D. Contemporary practice and technical aspects in coronary intervention with bioresorbable scaffolds: a European perspective. *EuroIntervention.* 2015;11:45-52.
11. Kubo S, Kadota K, Otsuru S, Hasegawa D, Habara S, Tada T, Tanaka H, Fuku Y, Katoh H, Goto T, Mitsudo K. Everolimus-eluting stent implantation versus repeat paclitaxel-coated balloon angioplasty for recurrent in-stent restenosis lesion caused by paclitaxel-coated balloon failure. *EuroIntervention.* 2015;10:e1-8.
12. Alfonso F, Nuccio J, Cuevas C, Cardenas A, Gonzalo N, Jimenez-Quevedo P. Treatment of coronary in-stent restenosis with bioabsorbable vascular scaffolds. *J Am Coll Cardiol.* 2014;63:2875.
13. Deora S, Shah S, Pancholy S, Patel T. Bioresorbable vascular scaffold for coronary in-stent restenosis: a novel concept. *Indian Heart J.* 2014;66:459-61.
14. Rivero F, Bastante T, Cuesta J, Benedicto A, Restrepo JA, Alfonso F. Treatment of in-stent restenosis with bioresorbable vascular scaffolds: optical coherence tomography insights. *Can J Cardiol.* 2015;31:255-9.
15. Mehran R, Dangas G, Abizaid AS, Mintz GS, Lansky AJ, Satler LF, Pichard AD, Kent KM, Stone GW, Leon MB. Angiographic patterns of in-stent restenosis: classification and implications for long-term outcome. *Circulation.* 1999;100:1872-8.
16. Cutlip DE, Windecker S, Mehran R, Boam A, Cohen DJ, van Es GA, Steg PG, Morel MA, Mauri L, Vranckx P, McFadden E, Lansky A, Hamon M, Krucoff MW, Serruys PW; Academic Research Consortium. Clinical end points in coronary stent trials: a case for standardized definitions. *Circulation.* 2007;115:2344-51.
17. Pilgrim T, Heg D, Roffi M, Tuller D, Muller O, Vuilliomenet A, Cook S, Weilenmann D, Kaiser C, Jamshidi P, Fahrni T, Moschovitis A, Noble S, Eberli FR, Wenaweser P, Jüni P, Windecker S. Ultrathin strut biodegradable polymer sirolimus-eluting stent versus durable polymer everolimus-eluting stent for percutaneous coronary revascularisation (BIOSCIENCE): a randomised, single-blind, non-inferiority trial. *Lancet.* 2014;384:2111-22.
18. Authors/Task Force members, Windecker S, Kolh P, Alfonso F, Collet JP, Cremer J, Falk V, Filippatos G, Hamm C, Head SJ, Jüni P, Kappetein AP, Kastrati A, Knuuti J, Landmesser U, Laufer G, Neumann FJ, Richter DJ, Schauerte P, Sousa Uva M, Stefanini GG, Taggart DP, Torracca L, Valgimigli M, Wijns W, Witkowski A. 2014 ESC/EACTS Guidelines on myocardial revascularization: The Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS) Developed with the special contribution of the European Association of Percutaneous Cardiovascular Interventions (EAPCI). *EuroIntervention.* 2015;10:1024-94.
19. Byrne RA, Neumann FJ, Mehilli J, Piniček S, Wolff B, Tiroch K, Schulz S, Fusaro M, Ott I, Ibrahim T, Hausleiter J, Valina C, Pache J, Laugwitz KL, Massberg S, Kastrati A; ISAR-DESIRE 3 investigators. Paclitaxel-eluting balloons, paclitaxel-eluting stents, and balloon angioplasty in patients with restenosis after implantation of a drug-eluting stent (ISAR-DESIRE 3): a randomised, open-label trial. *Lancet.* 2013;381:461-7.
20. Serruys PW, Chevalier B, Dudek D, Cequier A, Carrie D, Iniguez A, Dominici M, van der Schaaf RJ, Haude M, Wasungu L, Veldhof S, Peng L, Staehr P, Grundeken MJ, Ishibashi Y, Garcia-Garcia HM, Onuma Y. A bioresorbable everolimus-eluting scaffold

versus a metallic everolimus-eluting stent for ischaemic heart disease caused by de-novo native coronary artery lesions (ABSORB II): an interim 1-year analysis of clinical and procedural secondary outcomes from a randomised controlled trial. *Lancet*. 2015;385:43-54.

21. Blackman DJ, Porto I, Shirodaria C, Channon KM, Banning AP. Usefulness of high-pressure post-dilatation to optimize deployment of drug-eluting stents for the treatment of diffuse in-stent coronary restenosis. *Am J Cardiol*. 2004;94:922-5.

22. Kim SW, Mintz GS, Escolar E, Ohlmann P, Pregowski J, Tyczynski P, Hassani SE, Pichard AD, Satler LF, Kent KM, Suddath WO, Waksman R, Weissman NJ. An intravascular ultrasound analysis of the mechanisms of restenosis comparing drug-eluting stents with brachytherapy. *Am J Cardiol*. 2006;97:1292-8.

23. Doi H, Maehara A, Mintz GS, Yu A, Wang H, Mandinov L, Popma JJ, Ellis SG, Grube E, Dawkins KD, Weissman NJ, Turco MA, Ormiston JA, Stone GW. Impact of post-intervention minimal stent area on 9-month follow-up patency of paclitaxel-eluting stents: an integrated intravascular ultrasound analysis from the TAXUS IV, V, and VI and TAXUS ATLAS Workhorse, Long Lesion, and Direct Stent Trials. *JACC Cardiovasc Interv*. 2009;2:1269-75.

24. Bermejo J, Botas J, Garcia E, Elizaga J, Osende J, Soriano J, Abeytua M, Delcan JL. Mechanisms of residual lumen stenosis after high-pressure stent implantation: a quantitative coronary angiography and intravascular ultrasound study. *Circulation*. 1998;98:112-8.

25. Raja Y, Routledge HC, Doshi SN. A noncompliant, high pressure balloon to manage undilatable coronary lesions. *Catheter Cardiovasc Interv*. 2010;75:1067-73.

26. Diaz JF, Gomez-Menchero A, Cardenal R, Sanchez-Gonzalez C, Sanghvi A. Extremely high-pressure dilation with a new noncompliant balloon. *Tex Heart Inst J*. 2012;39:635-8.

27. Capodanno D, Gori T, Nef H, Latib A, Mehilli J, Lesiak M, Caramanno G, Naber C, Di Mario C, Colombo A, Capranzano P, Wiebe J, Araszkiwicz A, Geraci S, Pyxaras S, Mattesini A,

Naganuma T, Munzel T, Tamburino C. Percutaneous coronary intervention with everolimus-eluting bioresorbable vascular scaffolds in routine clinical practice: early and midterm outcomes from the European multicentre GHOST-EU registry. *EuroIntervention*. 2015;10:1144-53.

## Supplementary data

The case of a 57-year-old man with ISR in the mid and distal LAD is shown. This gentleman underwent OCT-guided treatment with implantation of two Absorb BVS.

**Moving image 1.** Severe ISR in the mid and distal LAD.

**Moving image 2.** A 2.5×15 mm OPN balloon at 30 atm was used to predilate the ISR lesions. Residual stenosis is seen despite high-pressure predilatation.

**Moving image 3.** A 2.5×28 mm Absorb is implanted in the distal part at 12 atm and prolonged proximally with a 3.0×23 mm Absorb at 14 atm (minimal overlap).

**Moving image 4.** After aggressive post-dilatation with a 3.0×20 mm OPN balloon at 35 atm, a much better expansion of the scaffold can be observed.

**Moving image 5.** OCT recording of the distal and mid LAD is shown after predilation with a 2.5×15 mm OPN balloon at 30 atm.

**Moving image 6.** OCT recording of the distal LAD after the implantation of a 2.5×28 mm Absorb at 12 atm. Underexpansion can be seen.

**Moving image 7.** After aggressive post-dilatation with a 3.0×20 mm OPN balloon at 35 atm, a much better expansion of the scaffold can be observed.

The supplementary data are published online at:

<http://www.pcronline.com/>

[eurointervention/97th\\_issue/287](http://eurointervention/97th_issue/287)

