Cardiovascular Intervention and Therapeutics (2021) 36:20–22
https://doi.org/10.1007/s12928-020-00731-w

INVITED REVIEW ARTICLE

Contemporary coronary drug-eluting and coated stents: a mini-review

Yuichi Saito[1] · **Yoshio Kobayashi**[1]

Received: 29 October 2020 / Accepted: 30 October 2020 / Published online: 10 November 2020

Abstract
Percutaneous coronary intervention has become a standard-of-care procedure in patients with acute and chronic coronary syndromes, in which coronary stent technology is commonly used. In this mini-review article, we summarize the characteristics of contemporary coronary drug-eluting and coated stents.

Keywords Drug-eluting stent · Drug-coated stent · Percutaneous coronary intervention

The introduction of drug-eluting stents (DES) into the armamentarium of percutaneous coronary intervention (PCI) has reduced in-stent restenosis. Currently, PCI with DES has become a standard-of-care procedure in patients with acute and chronic coronary syndromes. Table 1 lists the features of contemporary stents. The first-generation DES were made of stainless steel, while contemporary DES mainly consist of different kind of alloys such as cobalt chromium and platinum chromium. In the current generation DES, thinner struts are employed than in the first-generation DES (> 130 μm) with preserved radial strength and radio opacity. The lower strut thickness is believed to be associated with better stent-related outcomes including target lesion revascularization, myocardial infarction, and stent thrombosis [1, 2]. The number of links (connectors) between hoops has an impact on stent flexibility, deliverability and conformability, and possibly clinical events [2]. Current generation DES include both durable and biodegradable polymer-coated stents, and the lifelong presence of durable polymer is reported to be related to chronic inflammation and neoatherosclerosis [3]. To overcome this potential limitation of durable polymer, biodegradable polymer DES have been developed. To date, numerous clinical trials have shown the safety of biodegradable polymer DES compared with durable polymer DES, but their clinical benefit is unclear [4, 5]. DES polymer is applied to the surface circumferentially or only at the abluminal side. Limiting the polymer to the abluminal aspect of the stent reduces total polymer burden, although whether this technology leads to better clinical outcomes is also unknown. Different immunosuppressive and anti-cancer agents are used as anti-restenotic drugs in DES to inhibit smooth muscle proliferation. There is a stent that has an additional circumferential layer of anti-CD 34 antibodies on the stent struts on top of the polymer to capture circulating endothelial progenitor cells, conceptually leading to better endothelial healing. However, the clinical evidence is limited [6]. Beyond polymer-based DES, polymer-free DES and a drug-coated coronary stent have been emerged. With no polymer, abluminally coated probucol regulates the release of sirolimus in the former, while the latter has the microstructured abluminal surface in which an anti-restenotic drug is directly applied.

Coronary stent technologies have evolved enormously in the past 2 decades from bare metal stents to contemporary DES, achieving safer and more effective devices for all patient and lesion subsets undergoing PCI. However, short- and long-term stent-related adverse events continue to accrue even in PCI with contemporary DES [7]. In the future, the use of novel technologies may provide better clinical outcomes.

✉ Yuichi Saito
saitoyuichi1984@gmail.com

[1] Department of Cardiovascular Medicine, Chiba University Graduate School of Medicine, 1-8-1 Inohana, Chuo-ku, Chiba 260-8677, Japan

Table 1 Drug-eluting and coated stents

Stents	Manufacture	Strut material	Strut thickness (μm)	Number of links	Polymer	Polymer type	Polymer thickness (μm)	Coating method	Absorption time (m)	Drug	Drug elution time (m)	Stent diameter (mm)	Stent length (mm)
DES													
XIENCE Sky point	Abbott	CoCr (L605)	81	3	PVDF–HFP	Durable	4.7–7.8[a]	Circumferential	–	Everolimus	4	2.25–4.0	8–38
XIENCE Xpedition 48	Abbott	CoCr (L605)	81	3	PVDF–HFP	Durable	4.7–7.8[a]	Circumferential	–	Everolimus	4	2.5–3.5	48
Orsiro	BIOTRONIK	CoCr (L605)	60 or 80[b]	3	PLLA	Bioresorbable	3.5–7.4	Circumferential	15	Sirolimus	3	2.25–4.0	13–40
Synergy XD	Boston Scientific	PtCr	74	2[c]	PLGA	Bioresorbable	4	Abluminal	3–4	Everolimus	3	2.25–4.0	8–48
Resolute Onyx	Medtronic	CoCr with Pt-Ir	81 or 91[d]	NA[e]	BioLinx[f]	Durable	6	Circumferential	–	Zotarolimus	6	2.0–4.0	8–38
COMBO Plus	OrbusNeich	Stainless steel (316L)	87	2	PLGA block co-polymer[g]	Bioresorbable	≤5	Abluminal	3	Sirolimus	1	2.5–3.5	9–33
Ultimaster Tansei	Terumo	CoCr (L605)	80	2	PDLLA–PCL	Bioresorbable	≤15	Abluminal	3–4	Sirolimus	3	2.25–4.0	9–38
Polymer-free DES													
Coroflex ISAR Neo	B.Braun Melsungen AG	CoCr (L605)	55 or 65 [h]	3	NA[i]	–	4[i]	Abluminal[i]	–	Sirolimus	3	2.25–4.0	9–38
Drug coated stent													
BioFreedom	Biosensors	Stainless steel (316L)	114 or 120	2 or 3 [k]	–	–	–	Abluminal[l]	–	Biolimus A9	1	2.5–4.0	14–36

Contemporary coronary DES and a drug-coated stent used in Japan are listed. Different stent sizes may be available outside Japan

CoCr cobalt–chromium, *DES* drug-eluting stents, *NA* not applicable, *PCL* poly(e-caprolactone), *PDLLA* poly-D, L-lactic acid, *PLGA* poly-lactic co-glycolic acid, *PLLA* poly-L-lactic acid, *PtCr* platinum–chromium, *Pt-Ir* platinum–iridium, *PVDF-HFP* co-polymer of vinylidene fluoride and hexafluoropropylene

[a]4.7 and 7.8 μm on the abluminal and luminal sides

[b]60 μm for 2.25–3.0 mm stents and 80 μm for 3.5–4.0 mm stents

[c]Proximal two segments have 4 (2.25–3.5 mm) or 5 (4.0 mm) links

[d]81 μm for 2.0–4.0 mm stents and 91 μm for 4.5–5.0 mm (not available in Japan) stents

[e]Every 4th crown laser fused (every 5th crown fused in the 2.75 and 3.0 mm platforms). Approximately 1.5 links for 2.0–3.0 mm stents and approximately 2.5 links for 3.5–4.0 mm stents

[f]A blend of the Medtronic proprietary components (a hydrophobic C10 polymer, a hydrophilic C19 polymer, and water-soluble polyvinyl pyrrolidinone)

[g]An additional circumferential layer of anti-CD 34 antibodies is applied on the stent struts on top of the polymer to capture circulating endothelial progenitor cells

[h]55 μm for 2.25–3.0 mm stents and 65 μm for 3.5–4.0 mm stents

[i]Probucol (abluminal coating) mimics the function of a polymer by retarding the release of sirolimus

[j]114 μm for 3.5–4.0 mm stents and 120 μm for 2.5–3.0 mm stents

[k]2 links for 2.5–3.0 mm stents and 3 links for 3.5–4.0 mm stents

[l]Biolimus A9 is directly coated to the micro-structured abluminal surface with no polymer

Funding None.

Compliance with ethical standards

Conflict of interest Yuichi Saito reports nothing to disclose. Yoshio Kobayashi reports research grants from Abbott Medical Japan, Japan Lifeline, and Terumo, and honoraria from Abbott Medical Japan, Boston Scientific, and Terumo.

References

1. Bangalore S, Toklu B, Patel N, Feit F, Stone GW. Newer-generation ultrathin strut drug-eluting stents versus older second-generation thicker strut drug-eluting stents for coronary artery disease. Circulation. 2018;138:2216–26.
2. Iannaccone M, Gatti P, Barbero U, Bassignana A, Gallo D, de Benedictis M, et al. Impact of strut thickness and number of crown and connectors on clinical outcomes on patients treated with second-generation drug eluting stent. Catheter Cardiovasc Interv. 2019. https://doi.org/10.1002/ccd.28228.
3. Nakazawa G, Shinke T, Ijichi T, Matsumoto D, Otake H, Torii S, et al. Comparison of vascular response between durable and biodegradable polymer-based drug-eluting stents in a porcine coronary artery model. EuroIntervention. 2014;10:717–23.
4. El-Hayek G, Bangalore S, Casso Dominguez A, Devireddy C, Jaber W, Kumar G, et al. Meta-analysis of randomized clinical trials comparing biodegradable polymer drug-eluting stent to second-generation durable polymer drug-eluting stents. JACC Cardiovasc Interv. 2017;10:462–73.
5. Kobayashi T, Sotomi Y, Suzuki S, Suwannasom P, Nakatani S, Morino Y, et al. Five-year clinical efficacy and safety of contemporary thin-strut biodegradable polymer versus durable polymer drug-eluting stents: a systematic review and meta-analysis of 9 randomized controlled trials. Cardiovasc Interv Ther. 2020;35:250–8.
6. Saito S, Krucoff MW, Nakamura S, Mehran R, Maehara A, Al-Khalidi HR, et al. Japan-United States of America Harmonized Assessment by Randomized Multicentre Study of OrbusNEich's Combo StEnt (Japan-USA HARMONEE) study: primary results of the pivotal registration study of combined endothelial progenitor cell capture and drug-eluting stent in patients with ischaemic coronary disease and non-ST-elevation acute coronary syndrome. Eur Heart J. 2018;39:2460–8.
7. Madhavan MV, Kirtane AJ, Redfors B, Généreux P, Ben-Yehuda O, Palmerini T, et al. Stent-related adverse events >1 year after percutaneous coronary intervention. J Am Coll Cardiol. 2020;75:590–604.