



Short communication

Benefits of final proximal optimization technique (POT) in provisional stenting

François Dérimay^{a,*}, Gilles Rioufol^a, Guillaume Cellier^a, Géraud Souteyrand^b, Gérard Finet^a

^a Department of Interventional Cardiology, Cardiovascular Hospital and Claude Bernard University and INSERM Unit 1060 CARMEN, Lyon, France

^b Cardiology Department, Clermont-Ferrand University Hospital Center, Clermont-Ferrand, France

ARTICLE INFO

Article history:

Received 20 May 2018

Received in revised form 16 July 2018

Accepted 10 September 2018

Available online 13 September 2018

Keywords:

Bench

Coronary bifurcation

POT

Provisional stenting

ABSTRACT

Aims: Initial proximal optimization technique (POT) in provisional stenting improves global malapposition, side-branch (SB) obstruction (SBO) and conservation of arterial circularity. The specific mechanical effects of a final POT sequence concluding the main provisional stenting techniques, on the other hand, are unknown.

Methods and results: Synergy™ stents were implanted on fractal coronary bifurcation bench models using the main provisional stenting techniques ($n = 5$ per group): kissing-balloon inflation (KBI), snuggle, and rePOT (initial POT + SB inflation + final POT). Final results were quantified on 2D and 3D OCT before and after final POT. Whichever the technique, final POT significantly decreased global malapposition (from $7.6 \pm 5.3\%$ to $2.2 \pm 2.5\%$, $p < 0.05$) and proximal elliptic deformation (from 1.15 ± 0.07 to 1.09 ± 0.04 , $p < 0.05$), without impact on SBO (from $11.5 \pm 9.6\%$ to $12.9 \pm 10.6\%$, NS). However, final POT failed to completely correct the elliptic deformation induced by balloon juxtaposition during the KBI and snuggle techniques, with final elliptic ratios of 1.11 ± 0.03 and 1.11 ± 0.04 respectively, significantly higher than with the complete rePOT sequence: 1.05 ± 0.02 ($p < 0.05$).

Conclusions: Like initial POT, final POT is recommended whatever the provisional stenting technique used. However, final POT fails to completely correct all proximal elliptic deformation associated with “kissing-like” techniques, in contrast to results with the rePOT sequence.

© 2018 Elsevier B.V. All rights reserved.

1. Introduction

Provisional stenting of coronary bifurcations must take account of three major issues: malapposition in the mother vessel (MoV), due to fractal geometry; side-branch (SB) obstruction (SBO) by the stent; and conservation of vessel integrity. Recently, a new sequence, “rePOT” [2–3], experimentally and clinically demonstrated superiority over other strategies, including kissing-balloon inflation (KBI). The proximal optimization technique (POT) is central to rePOT, which associates initial POT + SB inflation + final POT [2]. Benefit of initial POT for malapposition and SBO was clearly demonstrated [2–3], but that of a final POT remains to be proven, especially concerning proximal side-effects after KBI [2].

Abbreviations: MoV, mother vessel; SB, side branch; SBO, side-branch obstruction; KBI, kissing-balloon inflation; POT, proximal optimization technique; EBC, European Bifurcation Club; SAR, stent/artery ratio; POC, polygon of confluence.

* Corresponding author at: Fédération de Cardiologie Médicale, Hôpital Cardiologique Lyon-Monchat, 69394 Lyon Cedex03, France.

E-mail address: fdirimay@hotmail.fr (F. Dérimay).

2. Methods

2.1. Experimental protocol

Synergy™ stents 3.5×20 mm@14 atm (Boston Scientific, MA, USA) were implanted at in fractal bifurcation bench models [2,3] (Segula Technologies, Saint-Priest, France). Bench diameters were: MoV = 4.1 mm, main branch = 3.35 mm and SB = 2.8 mm. All sequences ($n = 5$ /groups) began by an initial POT with a compliant balloon Maverick™ (Boston Scientific) 4.0×9 mm@18 atm then rewiring in the SB through the distal cell [4]. Three provisional stenting techniques were used (Fig. 1): i) KBI (with non-compliant balloons Trek™ (Abbott Vascular) 3.0×15 mm@12 atm and 3.5×20 mm@12 atm), ii) Snuggle (same balloons as KBI) and iii) rePOT (SB inflation alone with a compliant balloon Maverick™ 3.0×15 mm@12 atm) [2]. Snuggle was a technique used to reduce the balloons juxtaposition by positioning the two proximal radio opaque markers of each balloons 2 mm before the polygon of confluence (POC) entry (Fig. 1). All sequences were concluded by a final POT. Stent and balloon sizes and inflation pressures were adapted following European Bifurcation Club (EBC) recommendations [1], to achieve distal and proximal stent artery/ratio (SAR) of 1.0–1.1.

2.2. OCT analysis

2D- and 3D-OCT analysis (Lunawave™ OFDI system, Terumo, Belgium) before and after final POT quantified lumen area (mm^2) and mean (D_{mean}), maximum (D_{max}) and minimum diameter (D_{min}). Areas of interest comprised: 1) proximal MoV after first 5 mm; 2) POC entry; and 3) main branch. Ellipticity ratio was calculated as $D_{\text{max}}/D_{\text{min}}$ (1.0 = perfect circularity). After millimetric cross-sectional stent analysis, global

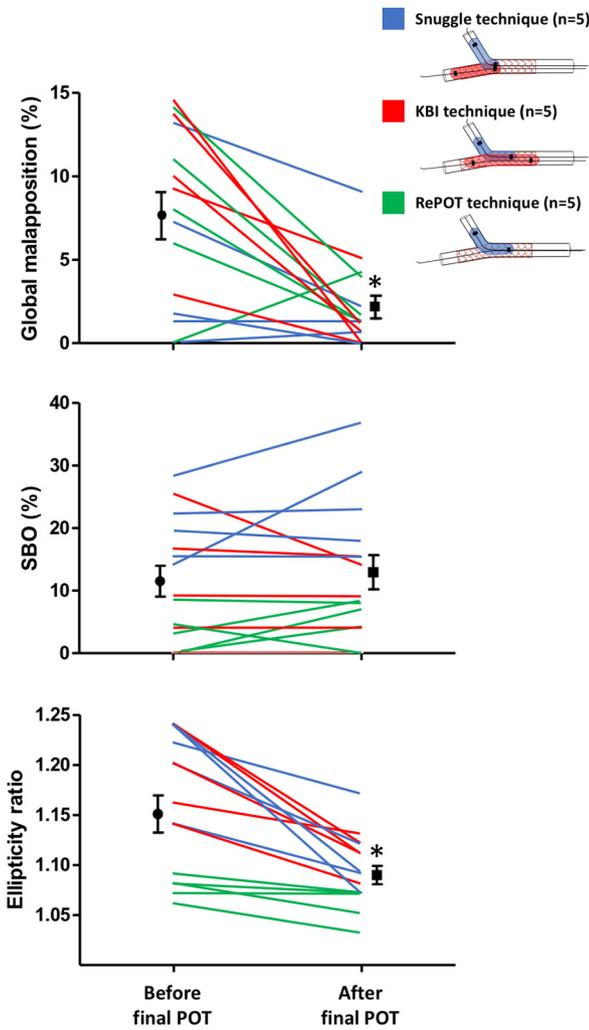


Fig. 1. Main final POT effects in three provisional stenting techniques. * $p < 0.05$ vs. before final POT. Ellipticity ratio was measured at polygon of confluence entry. KBI: kissing-balloon inflation; POT: proximal optimization technique; SBO: side-branch obstruction.

Table 1
Mechanical results of final POT after KBI, snuggle and rePOT techniques.

| | KBI technique (n = 5) | | Snuggle technique (n = 5) | | rePOT technique (n = 5) | |
|-------------------------------|-----------------------|-----------------|---------------------------|-----------------|-------------------------|-----------------|
| | Before final POT | After final POT | Before final POT | After final POT | Before final POT | After final POT |
| Proximal mother vessel | | | | | | |
| D _{mean} (mm) | 4.19 ± 0.09 | 4.27 ± 0.04* | 4.20 ± 0.01 | 4.22 ± 0.03 | 4.18 ± 0.06 | 4.18 ± 0.05 |
| D _{max} (mm) | 4.35 ± 0.18 | 4.47 ± 0.11* | 4.27 ± 0.04 | 4.28 ± 0.13 | 4.25 ± 0.05 | 4.25 ± 0.05 |
| D _{min} (mm) | 4.02 ± 0.02 | 4.10 ± 0.06 | 4.14 ± 0.02 | 4.10 ± 0.07 | 4.09 ± 0.09 | 4.10 ± 0.07 |
| Area | 13.78 ± 0.58 | 14.33 ± 0.46 | 13.85 ± 0.10 | 13.82 ± 0.41 | 13.70 ± 0.35 | 13.70 ± 0.36 |
| Ellipticity ratio | 1.08 ± 0.05 | 1.09 ± 0.03* | 1.03 ± 0.02 | 1.04 ± 0.03 | 1.04 ± 0.02 | 1.04 ± 0.01 |
| SAR | 1.04 ± 0.02 | 1.06 ± 0.02 | 1.03 ± 0.02 | 1.03 ± 0.02 | 1.03 ± 0.02 | 1.03 ± 0.01 |
| POC entry | | | | | | |
| D _{mean} (mm) | 4.24 ± 0.02 | 4.26 ± 0.08* | 4.13 ± 0.04 | 4.15 ± 0.03 | 4.10 ± 0.02 | 4.12 ± 0.06 |
| D _{max} (mm) | 4.66 ± 0.07 | 4.47 ± 0.07* | 4.40 ± 0.10 | 4.36 ± 0.07* | 4.25 ± 0.03 | 4.22 ± 0.06 |
| D _{min} (mm) | 3.83 ± 0.06 | 4.04 ± 0.12 | 3.80 ± 0.11 | 3.95 ± 0.09 | 3.96 ± 0.05 | 4.01 ± 0.08 |
| Area | 14.22 ± 0.13 | 14.26 ± 0.50* | 13.41 ± 0.27 | 13.56 ± 0.17 | 13.19 ± 0.16 | 13.34 ± 0.39 |
| Ellipticity ratio | 1.22 ± 0.04 | 1.11 ± 0.03* | 1.16 ± 0.05 | 1.11 ± 0.04* | 1.07 ± 0.01 | 1.05 ± 0.02 |
| SAR | 1.05 ± 0.02 | 1.01 ± 0.01 | 1.01 ± 0.02 | 1.01 ± 0.01 | 1.01 ± 0.01 | 1.01 ± 0.02 |
| Main branch | | | | | | |
| D _{mean} (mm) | 3.49 ± 0.05 | 3.45 ± 0.06 | 3.49 ± 0.05 | 3.54 ± 0.03 | 3.47 ± 0.05 | 3.47 ± 0.05 |
| Ellipticity ratio | 1.05 ± 0.02 | 1.03 ± 0.01 | 1.05 ± 0.02 | 1.03 ± 0.02 | 1.03 ± 0.01 | 1.04 ± 0.02 |
| SAR | 1.06 ± 0.06 | 1.05 ± 0.04 | 1.06 ± 0.06 | 1.06 ± 0.02 | 1.06 ± 0.02 | 1.06 ± 0.03 |
| Global malapposition (%) | 10.3 ± 4.6 | 1.4 ± 2.1 | 4.8 ± 5.5 | 2.6 ± 3.7 | 7.9 ± 4.6 | 2.6 ± 1.5 |
| SBO (%) | 9.1 ± 7.2 | 8.9 ± 6.9 | 22.1 ± 5.5 | 24.3 ± 9.1* | 3.3 ± 3.6 | 5.6 ± 3.5 |
| Fractal ratio | 0.65 ± 0.02 | 0.66 ± 0.01 | 0.65 ± 0.01 | 0.65 ± 0.00 | 0.65 ± 0.01 | 0.65 ± 0.01 |

Values are expressed as mean ± SD. No significant difference between before and after final POT. KBI: kissing-balloon inflation, POT: proximal optimization technique, D: diameter, SAR: stent/artery ratio, POC: polygon of confluence, SBO: side-branch obstruction.

* $p < 0.05$ vs. final complete rePOT technique.

malapposition (threshold: 110 μm) was calculated as percentage malapposed/total struts. Final SBO was calculated by planimetry as: $(A1/A2) \times 100\%$ (A1 = total strut area in ostium; A2 = total ostium area) [2].

2.3. Statistical analysis

Quantitative variables were expressed as mean ± SD. Quantitative effects were compared on Mann-Whitney and Wilcoxon tests, on GraphPad Prism 5 software (GraphPad Software, CA, USA). The significance threshold was $p < 0.05$.

3. Results

Final POT decreased global malapposition from $7.6 \pm 5.3\%$ to $2.2 \pm 2.5\%$ ($p < 0.05$) and elliptic deformation from 1.15 ± 0.07 to 1.09 ± 0.04 ($p < 0.05$), without effect on SBO ($11.5 \pm 9.6\%$ to $12.9 \pm 10.6\%$; $p = \text{NS}$) (Fig. 1). Table 1 presents final POT effects according to technique: KBI, Snuggle and rePOT.

4. Discussion

This study is the first to quantify mechanical effects of final POT after KBI, Snuggle and rePOT provisional stenting techniques. Experimentally, final POT significantly improved global malapposition and ellipticity ratio, without effect on final SBO. However, it failed to fully correct proximal elliptic deformation and overstretch at POC entry induced by balloon juxtaposition in KBI and Snuggle, compared to perfect results with rePOT.

4.1. Impact of final POT according to provisional stenting technique

Final POT provided benefit whichever technique was used, but especially when elliptic deformation or global malapposition were significant, as in KBI and Snuggle. Like initial POT [1–3], final POT appears mandatory in whatever provisional stenting technique, to correct i) malapposition induced during SB opening by stent strut attraction facing the carina, and ii) elliptic deformation due to balloon juxtaposition. However, as demonstrated by Foin et al. [5], proximal ellipticity correction after final POT is incomplete in balloon juxtaposition techniques (KBI or snuggle), especially compared to rePOT.

4.2. Mini-kissing or “Snuggle” technique

Given the deleterious effect of proximal balloon juxtaposition in KBI [2], the “Snuggle” technique, with shorter juxtaposition balloon, was imagined (Fig. 1). Despite limited juxtaposition, elliptical deformation at POC entry remained greater, like with KBI, than with rePOT. Surprisingly, Snuggle induced greater SBO than rePOT or KBI ($22.1 \pm 5.5\%$, $5.6 \pm 3.5\%$ and $9.1 \pm 7.2\%$, respectively), perhaps by strut attraction from main vessel to SB due to balloon slippage during inflation.

4.3. Limitations

The main limitation of this study lay in the use of healthy bifurcation bench model which couldn't quantify a potential carina shifting. However, this non-pathological character didn't impact on the ellipticity ratio and malapposition final results.

5. Conclusion

Experimentally, final POT after provisional stenting (KBI, Snuggle, rePOT) improved global malapposition and ellipticity ratio. So final POT, like initial POT, seems recommended in provisional stenting, to improve final results whatever the technique used. However, it failed to completely correct elliptical deformation induced by balloon

juxtaposition (Snuggle and KBI) unlike in the simpler rePOT sequence. Finally, the Snuggle, imagined to limit the elliptical deformation induced by KBI, was complicated by a greater final SBO.

Conflict of interest

All authors have no disclosures to report. Synergy™ was provided by *Boston Scientific*, unconditionally.

References

- [1] J.F. Lassen, F. Burzotta, A.P. Banning, et al., Percutaneous coronary intervention for the left main stem and other bifurcation lesions. The 12th consensus document from the European Bifurcation Club, *EuroIntervention* 13 (13) (2018) 1540–1553.
- [2] G. Finet, F. Dérîmay, P. Motreff, et al., Comparative analysis of sequential proximal optimizing technique versus kissing balloon inflation technique in provisional bifurcation stenting: fractal coronary bifurcation bench test, *J. Am. Coll. Cardiol. Interv.* 8 (10) (2015) 1308–1317.
- [3] F. Dérîmay, G. Finet, G. Souteyrand, et al., Benefit of a new provisional stenting strategy: the re-proximal optimisation technique. The rePOT clinical study, *EuroIntervention* 14 (3) (2018) e325–e332.
- [4] N. Foin, R. Torii, E. Alegria, et al., Location of side branch access critically affects results in bifurcation stenting: insights from bench modeling and computational flow simulation, *Int. J. Cardiol.* 168 (4) (2013) 3623–3628.
- [5] N. Foin, G.G. Secco, L. Ghilencea, R. Krams, C. Di Mario, Final proximal post-dilatation is necessary after kissing balloon in bifurcation stenting, *EuroIntervention* 7 (5) (2011) 597–604.