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Stent geometry achieved by stepwise provisional stenting in left main trifurcation: Bench-test comparison of different side-branch intervention techniques

Short title: Provisional for left main trifurcation

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WHAT'S NEW?

This bench study highlights the feasibility of adapted provisional stenting strategies for left main coronary trifurcations, emphasizing the role of side branch rewiring and ballooning technique in shaping final stent configuration. Although differences in expansion and fenestration geometry were observed, their clinical significance remains to be established.

These findings lay the groundwork for further *in vivo* investigations, particularly using intravascular imaging, to clarify how procedural choices influence procedural and clinical outcomes in complex trifurcation percutaneous coronary intervention.

ABSTRACT

Background: Left main coronary trifurcations pose specific challenges for percutaneous coronary intervention due to complex anatomy and lack of standardized approaches.

Aims: We assess to evaluate the stent conformations achieved by different adaptations to trifurcations of stepwise provisional stenting in a bench test.

Methods: Percutaneous coronary intervention procedures were performed in silicon trifurcation models using standard equipment. After main vessel stenting and proximal optimization technique, side branch (SB) rewiring was conducted *via* same-cell (SAC) or neighbouring-cell (NEC) under optical coherence tomography guidance. SBs dilation was then performed using either simultaneous trissing or serial kissing balloon techniques. Following repeat proximal optimization technique, stent expansion and apposition were assessed with optical coherence tomography and micro-computed tomography.

Results: All 4 technique combinations were feasible and resulted in satisfactory stent expansion and apposition. Micro-computed tomography analysis showed that trissing improved expansion at the polygon of confluence compared to serial kissing (23.7 vs. 21.1 mm^2; $P = 0.043$), while SAC rewiring yielded better expansion at the distal main vessel ostium than NEC (10.3 vs. 9.6 mm^2; $P = 0.003$). Rewiring technique determined the conformation of the stent at the level of SBs take-off: NEC produced 2 stent fenestrations and SAC a single stent fenestration (with a minimal area significantly smaller than the sum of the 2 achieved by NEC: 16.4 mm^2 vs. 13.4 + 14.5 mm^2; $P = 0.019$).

Conclusions: All provisional stenting strategies tested were technically feasible for left main trifurcations. SB rewiring and ballooning technique influenced stent configuration, particularly the number and size of fenestrations, but had limited impact on overall stent expansion and apposition.

Key words: bench test, provisional stenting, side branch intervention, trifurcation

INTRODUCTION

Treatment of coronary artery disease involving the left main stem (LM) bifurcation is a major interventional challenge due to its clinical relevance and anatomical complexity. In 6%–52% of cases across ethnic groups [1], the LM divides into three branches, making percutaneous coronary intervention (PCI) particularly complex.

Various interventional strategies and stenting techniques for LM bifurcations have been extensively studied in bench models and patient populations [2, 3]. These studies provided valuable, largely concordant information on procedural aspects, technical feasibility, stent limitations, and clinical implications. Accordingly, guidelines and consensus documents offer recommendations on standardized interventional approaches during PCI in bifurcation lesions [4, 5].

However, knowledge on PCI for atherosclerosis at trifurcation level remains limited, and ballooning and stenting procedures are non-standardized [6]. Considering that LM trifurcation involves the presence of an additional branch, there is a higher likelihood of requiring predilation of one or both side branches. Given the well-established direct association between side-branch predilation and worse clinical outcomes, it is clinically relevant to identify which ballooning strategy may be more appropriate in order to minimize unnecessary device passages and procedural complexity [7].

Given the potential of bench testing to clarify stent behavior and deformation, the TRIBE (TRIfurcation BEnch) study was designed to address this gap by assessing different adaptations of stenting techniques in an LM trifurcation anatomy model. This paper reports the final results of different adaptations of stepwise provisional stenting in an LM trifurcation model.

METHODS

We designed a bench test comparison of different stent implantation techniques that can be applied trying to adapt stepwise provisional stenting to LM trifurcation.

Bench model

All procedures have been performed using commercially available latest generation drug-eluting stents (Ultimaster Nagomi, Terumo, Japan) and regular non-compliant balloons (Accuforce, Terumo, Japan) (Supplementary material, *Table S1*). Trifurcation models were produced by 3-dimensional printing and made of rubber-like elastomeric silicone (details in Supplementary material). Model was sized to have inner diameter of 5.0 mm at the level of the LM (reference vessel area of 19.6 mm^2), 3.5 mm in the left anterior descending artery (LAD) (reference vessel area 9.6 mm^2), 3.0 mm in the ramus intermedius (IM) and 3.0 mm in the left circumflex artery (LCx; reference vessel areas 7.1 mm^2 each one; Figure 1). The sizes of the 3 distal branches and the angles between distal branches were selected by approximating the average dimensions reported for LM trifurcations in men in a previous computational atlas by Medrano-Gracia et al. [8], and reflected the Finet's fractal law formula. Models were fully translucent and, accordingly, the procedures were performed under visual control.

Percutaneous coronary intervention technique

For the present study, various adaptations of the provisional technique [9] were applied in the LM trifurcation models by 3 expert PCI operators. All operators, independently (and blinded to the results achieved by the other colleagues) performed each technique according to a detailed study protocol in an academic training center (Gemelli Training Center, Fondazione Policlinico Gemelli IRCCS, Rome, Italy, https://www.gemellitrainingcenter.com/).

In all cases, a stent sized according to the distal main vessel reference was implanted in the LM-to-LAD artery across the side-branches (SBs) take-off (3.5 × 21 mm Ultimaster Nagomi stent). This was followed by proximal optimization using a non-compliant balloon in the proximal main vessel (i.e., LM) sized according to its reference diameter (stent segment length in the left main equal to 10 mm). Then, rewiring of the jailed SBs (i.e., IM and LCx) was performed under optical coherence tomography (OCT) guidance in the 2 following fashions:

1) double distal cell — IM and LCx were rewired through the same, most distal, stent cell according to a "same-cell" (SAC) rewiring technique;
2) distal and different non-distal (neighbour) cells — IM and LCx were rewired through different cells, namely IM through most distal cell and LCx through the first neighbouring cell according to a "neighbouring-cell" (NEC) rewiring technique.

After rewiring, SBs ballooning according to the following 2 techniques:

1) simultaneous trissing ballooning inflation technique — 3 short non-compliant balloons, sized according to distal references, were simultaneously inflated and deflated with minimal balloons overlap (maximum 8 mm) in the proximal main vessel. According to the stent manufacturer a 3.5 mm stent can reach a maximum diameter of 6.25 mm hence an area of 30 mm^2, while the sum of surface area of 3 balloons sized on the distal branches references diameters is 23.76 mm^2 (9.62 + 7.07 + 7.07 mm^2);
2) serial kissing ballooning inflations technique — kissing balloon dilations with simultaneous inflations and deflations were performed with non-compliant balloons, sized according to distal references, first in LAD and IM and then in LAD and LCx, in

each case aiming for a minimal balloon overlap (maximum 8 mm) in the proximal main vessel.

The combination of both rewiring and ballooning techniques resulted in 4 different scenarios of provisional stenting, as depicted in Figure 2. After these alternative steps, a repeat proximal optimization using a non-compliant balloon in the proximal main vessel, sized according to its reference diameter, was systematically performed. All balloons and stent inflations were performed at nominal pressure.

Optical coherence tomography

Optical coherence tomography was used to confirm the SB rewiring site and to assess the final result achieved. The applicability of 3D OCT in the bench model is limited due to the artificial vessel wall structure. Hence, guidewire position was assessed based on 2D OCT and magnified direct visualisation.

The pullback runs were, thus, carried out systematically: 1) after rewiring to verify the re-crossing spot and 2) at end of each procedure for evaluation of stent expansion, struts apposition, and distance from "floating struts" to the carina. Floating struts were intended as the portion of stent struts protruding from the carina back the polygon of confluence (POC) (Supplementary material, *Figure S1*). In case the OCT documented that stent's side-cell re-crossing was not according to the protocol, the guidewire was retracted, SB rewiring was repeated and OCT was used to confirm the achievement of the intended cell recrossing. On the opposite, final OCT was purely documentary, and the operators were not allowed to attempt correct any suboptimal result after the followed PCI protocol completion.

Pullback runs were performed with a Dragonfly™ OCT catheter (Abbott Vascular, Santa Clara, CA, US) and analyzed using a dedicated workstation (C7-XR™ OCT intravascular imaging system; Abbott Vascular). Images were recorded at 10 frames per millimetre.

Optical coherence tomography analysis was performed simultaneously in a consensual way by 2 operators. Stent expansion was defined as the minimal stent area (MSA) at the level of LM, POC, and LAD, and as the minimal stent cell opening area at the LCx and IM ostia. Apposition was analyzed in 3 main areas, namely: 1) 3 mm of the distal LM; 2) POC; and 3) 3 mm of the proximal LAD, as seen from LAD run. Malapposition of stent struts was calculated as described previously [10], graded as: 1) good apposition (no malapposition observed); 2) moderate malapposition (<200 microns); and 3) major malapposition (>200 microns).

Additionally, floating struts from the carinas were evaluated in relation both to the LAD–IM and IM–LCx carinas, and the most distant struts between the 2 were considered for analysis.

Micro-computed tomography

Micro-computed tomography (μCT) was performed using Bruker Skyscan 1276 (Billerica, MA, US) and reconstruction (cross sections) using Bruker NRecon (Billerica, MA, US) with no smoothing. Final stent deformations were visualized at a voxel resolution of 10 μm which allowed for computational stent reconstruction to obtain an isotropic voxel size of approximately 10 × 10 × 10 μm. Scanned volumes were converted into the NRRD format designed for scientific visualization and image processing using the freely available Python toolbox SimpleITK. Basic thresholding of the converted image stack, using NumeriCor Studio (NumeriCor GmbH, Graz, Austria), turned sufficient to delineate three-dimensional hexahedra-based object meshes of the stent geometries. μCT analysis was performed by the same operator (blinded to the PCI conduction) for all techniques. MSA in the LM, POC, and LAD, and minimal stent cell opening areas towards SBs ostia were quantified for all phantoms (Figure 3).

Statistical analysis

All analyses were performed using IBM SPSS Statistics (IBM Corp., Armonk, NY, US), in a blinded fashion by an operator not involved in OCT and μCT image analysis. Continuous variables are reported as mean (standard deviation [SD]), and categorical variables as number (%). Data distribution was assessed for normality using the Shapiro–Wilk test. As the 4 experimental scenarios represented independent bench-test experiments, overall comparisons among the four scenarios were performed using analysis of variance. Prespecified pairwise comparisons between two independent groups were performed to assess the effect of rewiring technique (NEC vs. SAC) and ballooning strategy (simultaneous trissing vs. serial kissing). For continuous variables, comparisons were conducted using the unpaired Student's t-test (including stent apposition categories reported as mean [SD] of percentages). All tests were 2-sided, and a *P*-value <0.05 was considered statistically significant. Inter-operator agreement for OCT- and μCT-derived quantitative measurements was evaluated using the intraclass correlation coefficient. A 2-way mixed-effects model with absolute agreement was applied.

RESULTS

Procedural overview

A total of 12 bench procedures were performed using four combinations of the different rewiring and SBs ballooning techniques (Figure 2), namely:

- scenario 1: NEC rewiring followed by simultaneous trissing ballooning inflation technique (n = 3);
- scenario 2: SAC rewiring followed by simultaneous trissing ballooning inflation technique (n = 3);
- scenario 3: NEC rewiring followed by serial kissing ballooning inflations technique (n = 3);
- scenario 4: SAC rewiring followed by serial kissing ballooning inflations technique (n = 3).

All procedures were successfully completed, as well as OCT runs which were analyzed for each bench test. In total, 492 OCT frames were analyzed, with measurements obtained from 2340 individual struts.

Stent expansion

Overall, stent expansion was satisfactory across all stented segments. Indeed, at OCT, the mean MSA was 18.1 mm^2 in the LM, 22.2 mm^2 in the POC and 8.2 mm^2 in the LAD. This translated into a relative stent expansion, compared to the reference vessel area, of 92.3% in the LM, 113% in the POC, and 85% in the LAD. Similar results were observed at µCT: the mean MSA was 19.9 mm^2 in the LM, 22.4 mm^2 in the POC and 9.9 mm^2 in the LAD, resulting in relative stent expansions of 101%, 114%, and 103% respectively.

Overall, no significant differences in stent expansion were observed at OCT among the various rewiring and ballooning techniques (Table 1). On the opposite, comparing the different rewiring and ballooning techniques, µCT showed slight but significant larger MSA values in the POC with the simultaneous trissing versus serial kissing ballooning inflations (23.7 vs. 21.1 mm^2; $P = 0.043$) (Table 2). Moreover, a larger µCT MSA was found also in LAD with SAC vs. NEC rewiring (10.3 vs. 9.6 mm^2; $P = 0.003$).

When comparing the 4 scenarios, the combination of SAC rewiring and simultaneous trissing ballooning inflation (scenario 2) demonstrated higher OCT MSA values at the POC site (Supplementary material, *Table S2*) and the combination of SAC rewiring and serial kissing ballooning inflation (scenario 4) demonstrated higher µCT MSA values in the LAD (Supplementary material, *Table S3*). Of note, visual assessment of the 3D reconstructed uCT did not show any strut fracture.

Stent geometry: cell fenestration toward the side branches

Micro-CT images clearly documented that the rewiring technique, independently on the ballooning technique, induced 2, completely different, stent conformations. Indeed, as seen in Figure 3, NEC rewiring induced 2 distinct stent cell opening areas (towards each SB ostium, with a mean minimal area of 13.4 [1.8] mm^2 for LCx and 14.5 [1.4] mm^2 for IM) while SAC induced aa single stent cell opening area (towards both SBs ostia, with a mean minimal area of 16.4 [2.1] mm^2, and located in the POC). Of note, such configurations might be appreciated by 3-dimensional OCT. The single cell opening towards both SBs obtained by SAC was smaller than the sum of the 2 cell opening areas created by the NEC rewiring (16.4 [2.1] mm^2 vs. 27.9 [1.9] mm^2; $P = 0.019$) (Graphical abstract).

Malapposition

Table 3 reports the OCT apposition analyses showing an overall good apposition for the implanted stents. Major malapposition was not observed in the LM and LAD, while it involved 20% of the stent struts at the POC ($P < 0.001$). As shown in Table 3, apposition was independent by rewiring and ballooning techniques. Similarly, no significant difference in malapposition was observed across the four scenarios (Supplementary material, *Table S4*).

The overall maximum floating strut distance from the carinas was 2.2 (0.8) mm. No significant differences were identified among the different techniques (Supplementary material, *Table S5*). Excellent inter-operator reproducibility was observed, with intraclass correlation coefficient values exceeding 0.90 for all analyzed variables.

DISCUSSION

Percutaneous coronary intervention represents a valuable revascularization strategy for patients with unprotected LM lesions, and its optimization remains a key topic. A substantial proportion of patients with LM disease have trifurcated anatomy, which poses technical challenges for PCI, as reflected by higher SYNTAX scores [11]. We therefore evaluated the impact of different rewiring sites and ballooning techniques used during stepwise provisional stenting in LM trifurcation bench models.

The main findings can be summarized as follows:

1. Using contemporary drug-eluting stents, stepwise provisional stenting — with various rewiring and ballooning strategies — achieved good adaptation of the LM–LAD stent to the complex trifurcation anatomy.

2. Stent expansion and apposition in the LM–LAD were largely independent of the specific rewiring and ballooning technique, with only minor variations observed.
3. The pattern of side-cell expansion after ballooning was strongly influenced by the rewiring site.

Although limited by its mechanistic design, this study provides novel insights that may help standardize LM trifurcation PCI.

Bench testing and PCI simulations are essential to understanding stent deformation. This study is the first bench test assessing how rewiring and ballooning during stepwise provisional stenting affect LM trifurcation geometry. Despite being a non-clinical investigation, it has several strengths:

- the bench model was anatomically realistic, based on prior studies;
- procedures were performed by experienced interventional cardiologists from 2 academic groups in a dedicated simulation center;
- last-generation drug-eluting stents and clinically used devices (guidewires, balloons) were employed;
- OCT guidance — known to improve bifurcation outcomes [12] — was systematically used;
- results were evaluated using multimodal imaging (OCT and μCT), both gold standards for stent geometry assessment.

As stepwise provisional is the most widely adopted bifurcation technique and can extend to trifurcations [13], we explored different strategies to treat side branches (IM and LCx) after LM–LAD stenting and proximal optimization. In the model, both side branches were accessible either through the same distal stent cell or through adjacent cells. Side-branch dilation was performed either with simultaneous triple balloon inflation or sequential double kissing (LAD–IM, then LAD–LCx). While rewiring site has not been previously addressed in trifurcation PCI, both ballooning approaches are known and involve specific challenges, including the need for larger guiding catheters, potential proximal overstretch, and asymmetrical plaque or carina shift.

Stent expansion and apposition

Overall, the results of the present study demonstrate that the investigated combinations of rewiring and ballooning techniques provided satisfactory stent expansion and apposition. Regarding stent expansion, both OCT and μCT showed the achievement of >80% expansion in the different stent segments in all tests. Some minor differences between the techniques were noted — in particular — by μCT (probably due to its superior resolution and measurement precision capability compared with OCT). In particular, a significantly greater stent expansion in the POC with trissing as compared with serial kissing. This finding (generated by simultaneous inflation of 3 balloons in the POC area) was somehow expected and is corroborated by OCT measurements, where the combination of SAC rewiring and simultaneous trissing ballooning achieved the highest MSA at POC. Furthermore, a significant MSA increase in LAD was documented by μCT (but not OCT) with SAC rewiring. The explanations for this finding are less intuitive. It can be speculated that the double distal rewiring of SAC minimizes metallic strut crowding around the LAD ostium.

Regarding stent strut apposition, no significant differences were observed between the 2 different rewiring and ballooning techniques. Indeed, optimal apposition was observed in both LM and LAD segments, while some occurrence (20%) of major malapposition was noticed for some struts at the POC, where the vessel transition from LM to the 3 daughter vessels pushes the mechanical stress of the stent platform over its limits.

In vivo, malapposed struts may alter local shear stress conditions, potentially promoting delayed endothelialization, peri-strut low-flow zones, or an exaggerated neointimal response. However, the actual clinical impact of such malapposition remains uncertain, particularly because physiologic vessel motion, and vascular healing, may mitigate the extent or persistence of the phenomenon observed on the bench.

Impact of rewiring site on the pattern of side-cell(s) expansion

Rewiring site is known to guide the geometric deformation of the stents in bifurcation interventions where the achievement of distal rewiring is known to warrant better stent configurations [14]. In the setting of trifurcations, rewiring might theoretically be achieved through the same, more distal, cell like in bifurcations, or through 2 different cells with the aim of “adapting” the stent configuration to the 2 original SB’s ostia. In this study we clearly documented that SAC (followed by either trissing or serial kissing) yields to a stent configuration like that of bifurcation provisional stenting. Indeed, despite the presence of 2 SBs, only a single stent cell is opened at the level of distal LM toward both the IM and LCx, replicating a bifurcation-like conformation. On the opposite, with NEC, the different tracks of the 2 guidewires through adjacent distal and non-distal stent cells, generate 2 separate stent cell openings — one for each SB (Graphical abstract). Furthermore, some metal (the stent ring between the 2 neighbour cells crossed by the wires) is displaced in the carina between the IM and LCx. Of note, the sum of the areas achieved after ballooning on top of NEC, is larger than that of the big, single, cell created dilating the SBs after SAC. Yet, in both cases, absolute values of these openings were reassuring with respect to maintaining adequate blood flow to both SBs. Indeed, the single large opening obtained with SAC was 14.5 mm^2 (more than double the combined IM and LCX nominal ostial areas) and the 2 openings achieved with NEC were 13.4 mm^2 and 16.4 mm^2 each (both exceeding the nominal ostial dimensions of the individual SBs).

Possible implications of the findings for the technical selections during LM trifurcation PCI

At present, the procedural implications of these novel findings have still to be established. Yet, it may be speculated that when atherosclerotic plaque is confined to the LM without major SBs ostial involvement, an approach with SAC rewiring combined with trissing inflation could optimize expansion and create a single side stent fenestration able to warrant enough room for flow preservation and device advancement in the IM and LCx territories. However, this may come at the expense of lower metal scaffolding in lateral part of the POC as well as around SB ostia. In contrast, when disease extends into the POC and the SBs, a NEC rewiring strategy may be preferable to achieve 2 distinct stent cell openings and better scaffold towards the SBs.

Study limitations

The above considerations remain speculative. Future clinical studies, involving real patients with atherosclerotic trifurcations, are necessary to determine whether the favourable mechanistic parameters observed in these bench tests will have procedural and clinical impact.

Additionally, the Ultimaster Nagomi 3.5 mm stent platform offers one of the highest expansion capacities among current stents, both in terms of maximum stent diameter and maximal cell expansion diameter. Therefore, the results presented in the manuscript may not be directly applicable to other stent platforms.

CONCLUSIONS

During the practice of stepwise provisional for LM trifurcations, despite the anatomic challenges offered by the presence of multiple branches, the post-PCI stent configuration achieved might warrant good stent expansion and apposition. The stent configuration achieved are influenced by SB rewiring and ballooning technique selections that may create a single or a couple of stent fenestrations, but have minor impact on stent apposition and expansion.

Supplementary material

Supplementary material is available at https://journals.viamedica.pl/polish_heart_journal.

Article information

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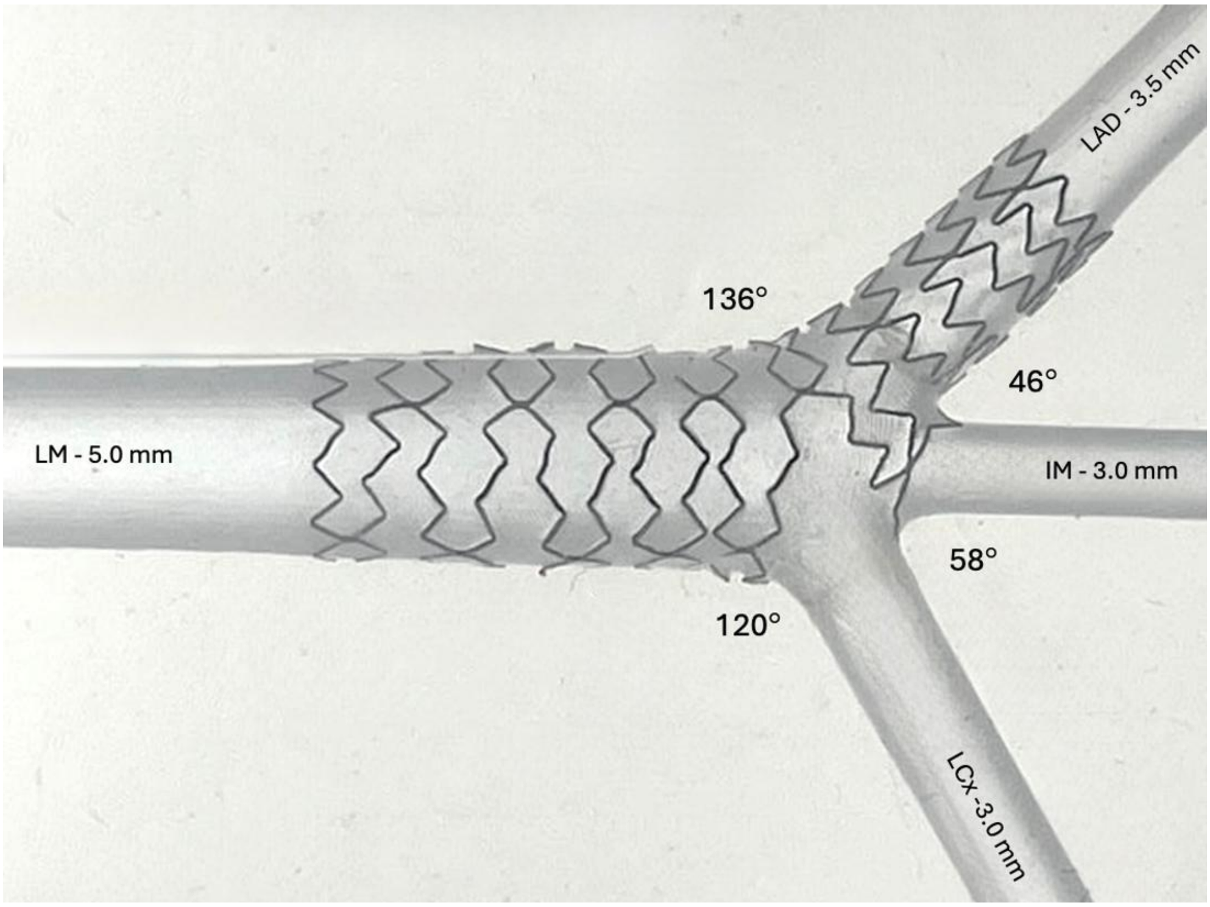


Figure 1. Three-dimensional printed silicon model with dimensions of proximal main branch (LM), distal main branch (LAD) and side branches (ramus IM and LCx). Inner diameters: LM = 5.0 mm, LAD = 3.5 mm, IM and LCx = 3.0 mm each. Angulations: LM–LAD = 136°; LAD–IM = 46°; IM–CX = 58°; CX–LM = 120°

Abbreviations: IM, intermedius; LAD, left anterior descending artery; LCx, left circumflex; LM, left main

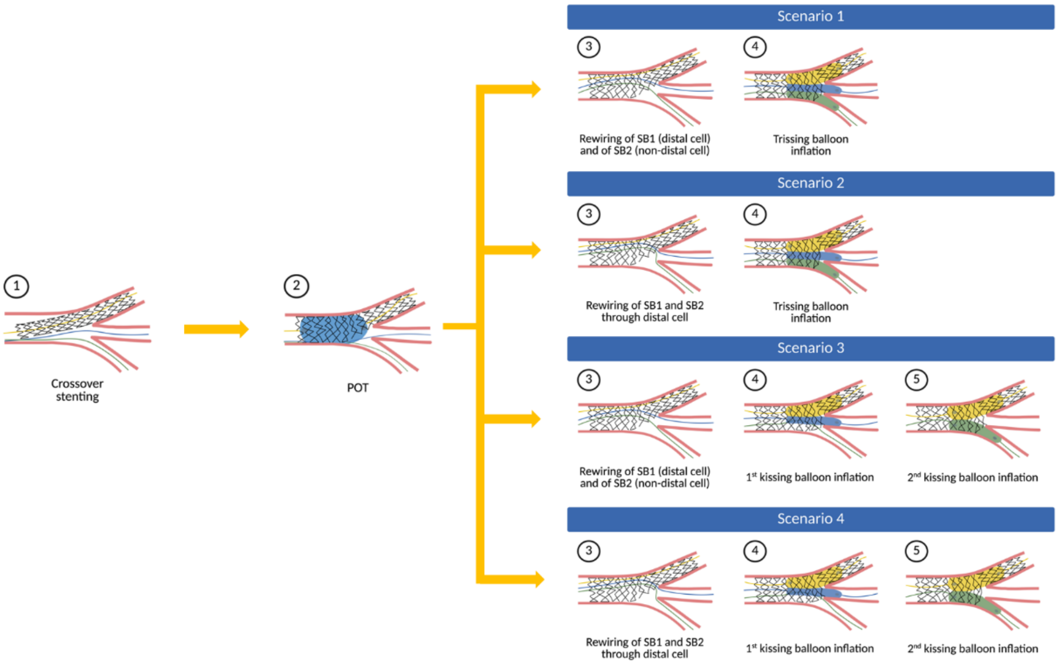


Figure 2. Step-by-step description of the 4 different provisional strategies tested. 1 — cross stenting in the LM-to-LAD. 2 — POT using a NC balloon in the proximal main vessel (i.e., LM). Scenario 1: 3 — rewiring of the IM through most distal cell and the LCx through the first neighbouring cell (neighbouring cell rewiring), 4 — 3 short NC balloons, simultaneously inflated in SBs (simultaneous trissing ballooning inflation technique). Scenario 2: 3 — rewiring of the jailed SBs (i.e., IM and LCx) through the same, most distal, stent cell (same cell rewiring). 4 — Simultaneous trissing ballooning inflation. Scenario 3: 3 — neighbouring cell rewiring, 4 — kissing balloon dilations, first in LAD and IM 5-then in LAD and LCx (serial kissing ballooning inflations technique). Scenario 4: 3 — same cell rewiring, 4–5 — serial kissing ballooning inflations technique

Abbreviations: NC, non-compliant; POT, proximal optimization; SB, side branch; other — see Figure 1

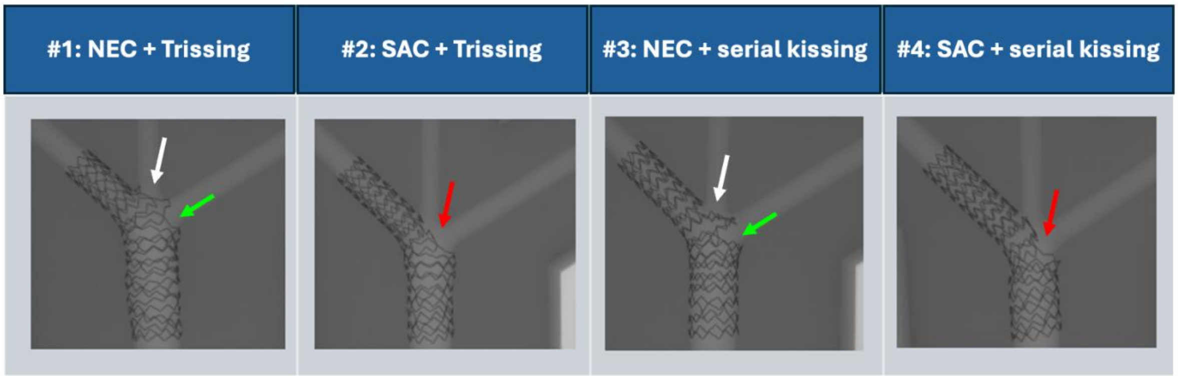
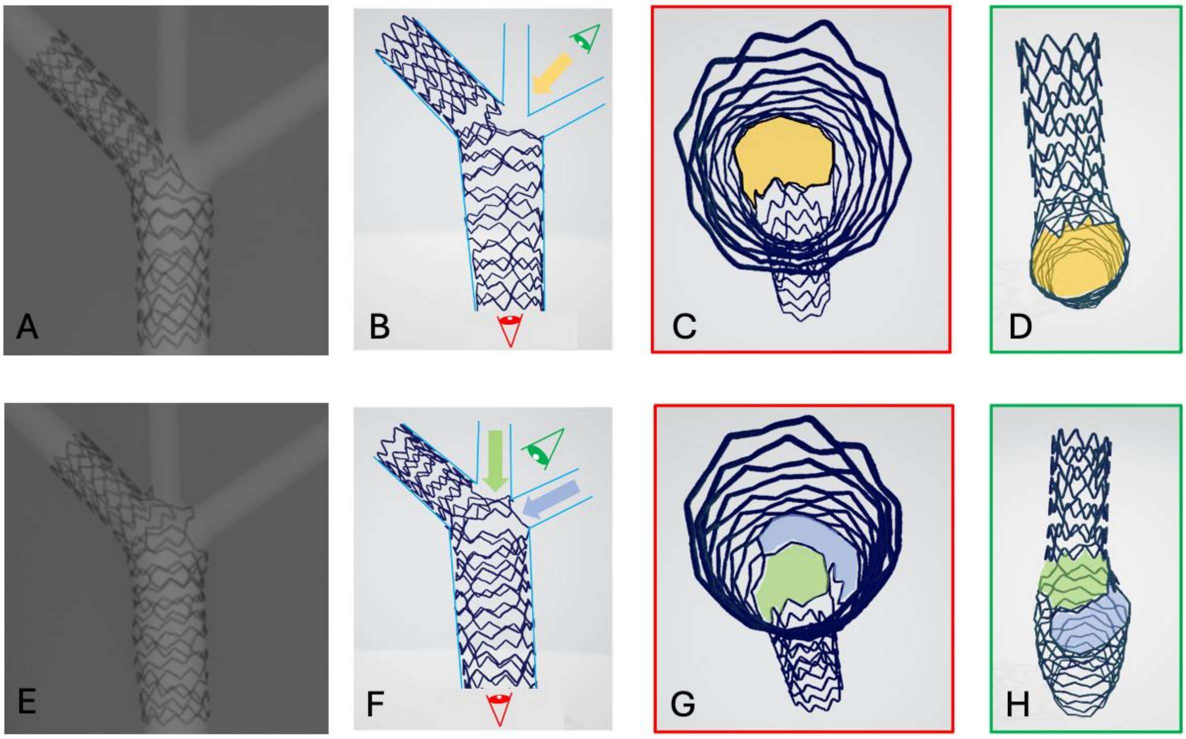


Figure 3. Micro computed tomography. 2D-reconstruction analysis focusing on stent area at distal main branch, proximal main branch and cell opening area towards side branches. White arrows indicate first fenestration towards ramus intermedius, green arrows the second fenestration towards circumflex. Red arrows indicate the single fenestration towards both side branches

Abbreviations: NEC, neighbouring-cell; SAC, same-cell



Graphical abstract: Impact of stepwise provisional stenting variations on side-cell(s) created according to rewiring technique in trifurcation left main models. The single, wide, ostium created with same cell rewiring as appreciated at μCT (**A.** 2D-reconstruction; **B–D.** 3D-reconstruction from different views). The two ostia created with neighboring cells rewiring as appreciated at μCT (**E.** 2D-reconstruction; **F–H.** 3D-reconstruction from different views)

Table 1. OCT derived stent expansion by rewiring and ballooning techniques

Variables	**Overall**	**NEC rewiring**	**SAC rewiring**	***P*-value**
LM				
MSA, mm^2	18.08 (1.17)	18.17 (1.03)	17.99 (1.39)	0.80
D_{min}, mm	4.58 (0.17)	4.59 (0.16)	4.58 (0.20)	0.89
D_{max}, mm	5.06 (0.22)	5.10 (0.25)	5.01 (0.21)	0.51
POC				
MSA, mm^2	22.2 (1.1)	21.2 (3.0)	23.2 (1.1)	0.16
D_{min}, mm	3.9 (0.1)	3.9 (0.2)	3.8 (0.4)	0.47
D_{max}, mm	7.3 (0.6)	6.9 (1.2)	7.7 (0.8)	0.24
LAD				
MSA, mm^2	8.20 (0.60)	8.05 (0.74)	8.35 (0.45)	0.41
D_{min}, mm	3.14 (0.13)	3.12 (0.17)	3.16 (0.08)	0.66
D_{max}, mm	3.35 (0.16)	3.32 (0.20)	3.39 (0.11)	0.46
LCx stent cell opening				
MSA, mm^2	6.68 (0.27)	6.69 (0.22)	6.68 (0.33)	0.93
D_{min}, mm	2.77 (0.09)	2.77 (0.10)	2.77 (0.09)	0.98
D_{max}, mm	3.13 (0.09)	3.14 (0.06)	3.11 (0.11)	0.60
IM stent cell opening				
MSA, mm^2	4.42 (0.44)	4.46 (0.36)	4.39 (0.53)	0.81
D_{min}, mm	2.25 (0.14)	2.26 (0.13)	2.23 (0.16)	0.72
D_{max}, mm	2.50 (0.13)	2.52 (0.12)	2.48 (0.15)	0.70

All reported values represent mean (standard deviation)

Abbreviations: D_{max}, maximum diameter; D_{min}, minimum diameter; IM, ramus intermedius; LAD, left anterior descending artery; LCx, left circumflex; LM, left main; MSA, minimum stent area; NEC, neighbor cells; POC, polygon of confluence; SAC, same cells; SEI, stent eccentricity index

Table 2. μCT derived stent expansion by rewiring and ballooning techniques

Variables	Overall	NEC rewiring	SAC rewiring	*P*-value	Trissing inflation	Serial kissing inflations	*P*-value
LM							
MSA, mm^2	19.90 (0.76)	19.36 (0.94)	20.43 (1.97)	0.26	19.40 (1.16)	20.40 (1.87)	0.29
POC							
MSA, mm^2	22.42 (0.63)	21.97 (2.46)	22.86 (2.35)	0.54	23.74 (2.26)	21.09 (1.65)	0.043
LAD							
MSA, mm^2	9.96 (0.54)	9.57 (0.36)	10.34 (0.34)	0.003	9.81 (0.51)	10.11 (0.54)	0.34
SB1 stent cell opening							
MSA, mm^2	15.50 (1.33)	14.50 (1.44)	16.43 (2.09)	0.09	14.71 (2.17)	14.29 (0.61)	0.35
SB2 stent cell opening							
MSA, mm^2	13.43 (1.83)	13.43 (1.83)	-	-	14.56 (1.42)	12.30 (1.57)	0.14

All reported values represent mean (standard deviation)

Abbreviations: SB, side branch; other — see Table 1

Table 3. OCT derived stent apposition by rewiring and ballooning techniques

Variables	Overall	NEC rewiring	SAC rewiring	*P*-value	Trissing inflation	Serial kissing inflations	*P*-value
LM							
Well apposed, %	96 (5)	97 (4)	95 (5)	0.41	96 (5)	96 (5)	0.82

Moderate malapposition, %	4 (5)	3 (4)	5 (5)	0.40	4 (5)	3 (4)	0.81
Major malapposition, %	0 (1)	0 (1)	0 (1)	0.79	1 (1)	0 (1)	0.79
POC							
Well apposed, %	72 (12)	76 (6)	69 (16)	0.37	70 (1)	74 (14)	0.71
Moderate malapposition, %	8 (6)	8 (3)	8 (8)	0.98	5 (3)	10 (7)	0.15
Major malapposition, %	20 (12)	16 (8)	23 (14)	0.34	24 (13)	16 (8)	0.27
LAD							
Well apposed, %	97 (7)	95 (9)	99 (3)	0.39	94 (9)	100 (0)	0.12
Moderate malapposition, %	3 (6)	4 (8)	1 (3)	0.46	6 (8)	0 (0)	0.13
Major malapposition, %	0 (1)	1 (1)	0 (0)	0.15	1 (0)	0 (0.)	0.15

All reported values represent mean (standard deviation) of the percentage of stent struts per bench experiment. A value of 0 (0) indicates that no struts belonging to the correspondence category were observed in any experiment within that scenario

Abbreviations: see Table 1