Coronary artery bifurcation lesions constitute a complex subgroup that are encountered in 15–20 % of all percutaneous coronary interventions (PCI).1–5 Compared with simple lesions, bifurcations have been associated with lower procedural success rates, higher adverse event rates, longer procedures, and worse angiographic and clinical outcomes.1,3,5–12 The less favourable outcomes associated with bifurcation treatment compared with non-bifurcation lesions may in part result from the inability of current devices and techniques to adequately scaffold and preserve the side branch (SB) ostium, which is a common location of restenosis.1,3,5–13

Stenting using drug-eluting stents (DES) is currently the default approach to bifurcation PCI, due to their superior angiographic and clinical outcomes as compared with bare metal stents (BMS). Refinement of the various techniques used high-pressure stent deployment or post-dilatation, kissing balloon inflation), better selection of lesions to be treated with a two-stent technique, and deferral of treatment of SB ostial lesions with an angiographically suboptimal result after main branch (MB) stenting but functionally non-significant, have led to even better outcomes, narrowing the gap with non-bifurcation PCI.1,3,5–12 Bifurcation PCI with DES is associated with a higher stent thrombosis (ST).1,2,15–19 Contemporary randomised studies have shown that routine stenting of both branches offers no benefit over stenting of the MB only, with provisional stenting of the SB, making the provisional strategy the preferred approach.

Achievement of an optimal proximal MB stent expansion and apposition, using the proximal optimisation technique (POT), prevents the wire from passing outside the proximal MB stent during wire exchange. If the result in the SB is satisfactory,1,2,17–19 the procedure is complete. In case the result in the SB is suboptimal, rewire the SB and a final kissing inflation (FKI) can then be performed with moderate pressure in the SB. If the result in the SB is still suboptimal (>75 % residual stenosis and/or Thrombolysis in Myocardial Infarction [TIMI] flow <3, fractional flow reserve [FFR] <0.75, flow-limiting dissection, abrupt vessel closure) proceed with SB stenting (T-stent, T And Protrusion or culotte techniques).1,4,20–22

Two-stent Techniques
A two-stent strategy as intention-to-treat should be considered in true bifurcations (Medina 1.1.1, 1.0.1 and 0.1.1)23–25 when a significant SB is involved (>2.5 mm, large amount of myocardium subtended, disease extending >5 mm from the ostium).14

Culotte, Crush and Simultaneous Kissing Stent
Culotte and crush techniques have been designed to provide complete scaffolding of the SB and the MB. These techniques are usually employed for a large SB (>2.5 mm) with relatively low take off angles. In the culotte technique, a first stent is deployed in one of the branches, usually across the most angulated of the two, which most often is the SB. The second branch is then rewired through the strut of the first stent and dilated with a non-compliant balloon. The second stent is implanted followed by FKI.1,3,8

In contrast, using the crush technique, a stent is first positioned in the SB and retracted to protrude in the MB (>5 mm in the classical crush or 1–2 mm in mini-crush). The protruding portion of the SB stent is then crushed against the wall by deployment of the MB stent or dilatation with a non-compliant (NC) balloon. The procedure needs to be completed with the rewiring of the SB and FKI post-dilatation. This complex technique requires more steps than the culotte technique, and has more limited anatomical applications, explaining why the crush technique is almost
never used nowadays. Another technique for complex bifurcation treatment is the simultaneous kissing stent (SKS) technique. Both SB and MB stent are deployed either simultaneously or sequentially to form a double-barrel stent with a neocarina in the MB. Such a technique has the advantage of not requiring recrossing of the stent, but the SKS technique raises concerns over potential risk of stent thrombosis induced by the long double neocarina in the MB.

T-stenting and the T And Protrusion Technique

In the classical T-stenting technique, a stent is implanted in the SB up to the SB ostium. A second stent is then deployed in the MB and the procedure is completed by FKI. It is a popular approach for wide angle (>70°) T-shaped bifurcation because it provides coverage of the SB with minimal stent protrusion in the MB. A popular adaptation of the T-stenting that offers good strut coverage at the expense of a predictable increase of malapposition of the ostium is the T And Protrusion (TAP) technique. The SB stent is advanced and left with a minimal protrusion (1–2 mm) in the MB.

Dedicated Stents for Bifurcations

The ideal stent for bifurcations should be easy to use, intuitive or under clinical investigation.

Optical Coherence Tomography Guidance

Optical coherence tomography (OCT) is a high resolution intravascular imaging tool used to assess coronary lesions and evaluate the results after stenting. In bifurcated lesions, it is particularly helpful in guiding several steps. For example, immediate automated online detection of the lumen area after pullback will assist in the rapid assessment of the vessel morphology and minimum lumen area (Lightlab C7, St. Jude Medical, St. Paul, Minnesota, US). This may be particularly useful for guidance of interventions in bifurcations, where knowing the reference diameter of the vessel distal and proximal to the SB is critical in correctly sizing the diameter and length both of the stent and post-dilatation balloon.

In addition, the recent development of OCT with online three-dimensional (3D) reconstruction allows the operator to obtain a 3D visualisation of the lesion and to plan a strategy accordingly. Initial experience of using 3D OCT reconstruction has revealed how 3D images may provide a unique tool for guidance during complex intervention in bifurcation, and potentially improve stenting results.

SB ostium restenosis still remains the Achilles heel of bifurcation stenting. Opening the stent strut at the SB ostium is considered critical to avoid coverage with neointimal tissue and risk of stent thrombosis. Several parameters affect SB opening during bifurcation stenting, for example the platform design and the size of the balloon. To efficiently open a stent at the SB ostium, current recommendations suggest attempting to recross the wire through the most distal cell of the MB stent to achieve optimal scaffolding of the SB ostium and avoid leaving unopposed struts near the carina. It can, however, be difficult in practice to ensure that the SB has not been accessed through a proximal cell. Thus it becomes possible for the interventionist to check that crossing to the SB is satisfactory and one can further anticipate the result after balloon dilation or implantation of a second stent and final kissing-balloon inflation. Finally, OCT visualisation of the distal and proximal edges of the stent will rule out the presence of dissections, undetectable by angiography alone.

Conclusions

Bifurcational PCI are complex procedures leading to high rates of malapposed struts. OCT is a high resolution intravascular imaging tool that allows accurate assessment during bifurcational stenting, guiding interventional cardiologists to better procedural results. Future generations of OCT equipment will include several technological advances that may further enhance the capabilities of this imaging method.