

Original Research

Assessment of Coronary Bifurcation Stenting using Optical Coherence Tomography

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ABSTRACT:

Background: Bifurcation Percutaneous coronary intervention is technically challenging despite improvement in techniques and devices. Side-branch occlusion occurs in about 10% of bifurcation percutaneous coronary interventions cases. We evaluated the use of OCT for PCI optimization in bifurcation lesions, using provisional one-stent and elective two-stent strategies. **Methods:** This prospective, observational study included 10 patients with 12 in coronary bifurcation lesions undergoing PCI (one-stent or two-stent strategy) who were evaluated with OCT. After stent placement, OCT was used to assess acute stent malapposition, under expansion, stent edge dissection, tissue protrusion, and micro thrombi. **Results:** The overall incidence of stent malapposition was 58.33%. It was more common with two-stent strategy (80%) compared to one-stent strategy (33.33%). The incidence of malapposition was highest in side-branch and least in distal segment of main vessel. Stent under expansion was seen in 25% of cases. Stent edge dissections, micro thrombi, tissue prolapse were noted in 16.66% of cases. OCT findings led to additional interventional steps in 33.33% of cases. **Conclusion:** OCT can be used to comprehensively assess procedural results after bifurcation stenting. The incidence of acute stent malapposition is high after stenting at bifurcation sites and is more common when the two-stent techniques are used.

Key words: Optical Coherence Tomography, Percutaneous coronary intervention, stent.

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INTRODUCTION:

Coronary bifurcation lesions constitute about 15 - 20% of total percutaneous coronary interventions (PCI).¹ Bifurcation PCI is technically challenging despite improvement in techniques and devices. Side-branch occlusion occurs in about 10% of bifurcation PCI cases.² Bifurcation lesions are associated with increased events following percutaneous coronary intervention (PCI). Factors contributing to this adverse outcome include limitations of angiography in assessment of side-branch (SB) disease severity³ and the lack of established angiographic predictors of SB patency and lumen compromise.⁴ Optical Coherence Tomography's (OCT) high spatial resolution, combined with the blood-free environment, is substantial advantages for the study of coronary stents, when compared to previous technology, like intravascular ultrasound (IVUS). A sharp delineation of the lumen contour allows for easy image interpretation and fully-automated lumen area segmentation, with virtually no observer interference.⁵

To overcome the limitations of angiography, a novel approach has been developed. The QAngioOCT 1.0 is a new software that can reconstruct the cross-sections perpendicular to the SB centerline and enable more accurate assessment of SB Ostia from MB pullbacks.⁶ We evaluated the use of OCT for PCI optimization in bifurcation lesions, using provisional one-stent and elective two-stent strategies.

MATERIALS AND METHODS:

This prospective, observational study included 10 patients with 16 in coronary bifurcation lesions undergoing PCI (one-stent or two-stent strategy) who were evaluated with OCT.

Inclusion criteria: Patients >18 years of age undergoing PCI of de-novo coronary bifurcation lesions, with main vessel diameter ranging from 2.5- 4 mm, side-branch diameter of ≥ 2 mm, treated with one or two-stent strategy.

Exclusion criteria:

Patients with:

1. Hemodynamic instability or shock
2. Baseline creatinine ≥ 2 mg/dL
3. Bleeding diathesis.
4. Coagulopathy recent stroke
5. Hypersensitivity or contraindications to contrast agent.
6. Pregnant females.
7. Coronary lesions with heavy calcification.
8. Large thrombus.
9. Total occlusion.
10. Excessive tortuosity or another stent within 10 mm of target lesion.

Baseline data such as demographic profile, clinical presentation, risk factors for coronary artery disease, electrocardiogram (ECG), 2-dimensional echocardiography, routine serum biochemistry tests, and creatine kinase MB (CKMB) were recorded in all the patients.

OCT imaging of bifurcation lesion was performed at baseline and following PCI. The rapid exchange C7 DragonFly™ OCT catheter was connected to a frequency-domain OCT system and advanced over a 0.014" coronary guide wire. Images were acquired at an automated pullback speed of 20 mm/s and a frame rate of 100 Hz during contrast flushing and were digitally stored to be analyzed offline.

Before PCI, OCT pullbacks of both the main vessel and the side-branch were acquired in all patients. Reference vessel diameters (proximal and distal main vessel and side-branch), minimal luminal diameter, percentage diameter stenosis, and lesion length were calculated. PCI was done using either the provisional one-stent strategy or elective two stent strategy based on the operator's discretion. Standard angioplasty techniques including post-dilatation, final kissing balloon inflation and proximal optimization technique (POT) were used in each case to achieve optimal angiographic results. After stent placement, OCT catheter pullback was performed in all the 14 main vessels and the 6 side-branches which were stented. Post-PCI OCT imaging of the side branch was not performed in those with the single-stent strategy. All patients received FDA-approved Xience Everolimus-eluting stent. All patients had a clinical follow-up for 6-months following discharge.

RESULTS: The overall incidence of stent malapposition was 58.33%. It was more common with two-stent strategy (80%) compared to one-stent strategy (33.33%). The incidence of malapposition was highest in side-branch and least in distal segment of main vessel. Stent under expansion was seen in 25% of cases. Stent edge dissections, micro thrombi, tissue prolapse were noted in 16.66% of cases. OCT findings led to additional interventional steps in 33.33% of cases.

Table 1: General characteristics

Variable		Number of patients/ mean
Mean age		65±11.2
Sex	Males	9 (75%)
	Females	3(25%)
Risk Factors	Hypertension	7 (58.33%)
	Diabetes mellitus	1(8.33%)
	Hypercholesterolemia	4 (33.33%)
	Family history of cardiovascular disease	3(25%)
	Active smoking	3(25%)
	Previous percutaneous coronary intervention	2 (16.66%)
Clinical Presentation	MI	3(25%)
	Unstable angina	1 (8.33%)
	Stable angina	8 (66.66%)

Table 2: Stent malapposition observed with OCT.

Vessel segment	N	Malapposition
Main vessel	12	8 (66.66%)
Distal segment	12	2 (16.66%)
Proximal Segment	12	5 (41.66%)
Bifurcation Segment	12	5 (41.66%)
Side branch	5	4 (80%)
Overall	12	7(58.33%)
Bifurcation PCI Technique		
Provisional one-stent	9	4(33.33%)
Elective two-stent	5	4(80%)

DISCUSSION:

Stent malapposition is a frequent OCT finding in bifurcation lesions. Its incidence varies from 40 - 80% with provisional one-stent technique and is higher with two-stent technique.⁷⁻⁹ We observed it in 58.33% of cases. Four out of 9 (33.33%) patients with provisional one-stent technique and 4 out of 5 (80%) patients with two-stent technique had malapposition in the present study.

The incidence of malapposition was highest in side-branch and least in distal segment of main vessel. Stent under expansion was seen in 25% of cases. Stent edge dissections, micro thrombi, tissue prolapse were noted in 16.66% of cases. OCT findings led to additional interventional steps in 33.33% of cases.

Similar findings were reported in a study by Burzotta F et al¹⁰ using provisional stenting strategy.

Simply reporting the presence or absence of malapposition does not give any information on the extent of the problem. In this regard, more recent studies report percentage malapposed struts ("Malapposition burden") in each segment after a strut level analysis.⁷ We observed that the bifurcation segment showed the highest percentage of malapposed struts (3%) followed by the proximal segment (1.6%) whereas the distal segment showed the least (0.2%). In the side-branch, 1.5% struts were malapposed. A study of 12 patients using provisional strategy, Sgueglia GA et al⁷ reported that the proximal and bifurcation segments (4.5% combined) show the highest percentage of malapposed struts.

OCT is a fundamental tool in the interventional cardiologist's arsenal for the treatment of complex coronary lesions such as bifurcation lesions. Indeed, OCT provides valuable additional information compared with angiography and IVUS that can guide the operator at each step of the PCI – from the planning of the appropriate revascularisation strategy to the assessment of final results.¹¹

In quiet a short time, OCT has become the standard imaging modality for stent analysis in the research environment. It is also not difficult to predict that the penetration of this modality in the clinical setting will rapidly increase. As a light-based technology, OCT will continue to quickly evolve, and hardware and software development will make the method even more attractive for stent assessment.¹² Further studies with larger number of patients are required to confirm the role of OCT in the optimization of bifurcation PCI and its clinical significance.

CONCLUSIONS:

OCT can be used to comprehensively assess procedural results after bifurcation stenting. The incidence of acute stent malapposition is high after stenting at bifurcation sites and is more common when the two-stent techniques are used.

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