Choice of stenting strategy in true coronary artery bifurcation lesions

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Background **The optimal stenting strategy in true coronary artery bifurcation lesions has not been determined. In this study, a strategy of always stenting both the main vessel and the side branch (MV plus SB) was compared with a strategy of stenting the MV only with optional stenting of the SB. Stents used were sirolimus-eluting stents and paclitaxel-eluting stents.**

Methods **A total of 108 patients with true coronary bifurcation lesions were randomly assigned to either routine stenting with drug-eluting stents (DES) in both the branches (group MV plus SB) or provisional stenting with DES placement in the main branch and DES placement in the SB only if MV stenting alone provided inadequate results (group MV). The primary end points were major adverse cardiac events (MACE) at 8 months, including myocardial infarction, cardiac death, and stent thrombosis or target vessel revascularization by either percutaneous coronary intervention or coronary artery bypass grafting.**

Results **Angiographic follow-up revealed 28.91 ± 20.43% stenosis of the SB after provisional stenting and 18.93 ± 15.34% ($P<0.01$) after routine stenting. The corresponding binary restenosis rates were 35.2 and 14.8% ($P=0.015$). SB stents were implanted in 16.7% of patients in the provisional stenting group and 94.4% of patients in the routine stenting group. In the main branch, binary restenosis rates prebifurcation were 11.1% after provisional and 7.4% after routine stenting ($P=0.51$), whereas binary restenosis rates postbifurcation were 14.8 and 9.3% ($P=0.38$), respectively. The overall 8-month incidence of target lesion reintervention was 31.5% after provisional and 7.4% after routine stenting ($P<0.01$), and cumulative MACE were 38.9 and 11.1% ($P<0.01$), respectively.**

Conclusion **Routine stenting significantly improved the MACE outcome of percutaneous coronary intervention in true coronary bifurcation and bifurcation angle of 60 or less lesions as compared with provisional stenting.** ***Coron Artery Dis*** **21:345–351 © 2010 Wolters Kluwer Health | Lippincott Williams & Wilkins.**

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Introduction

Bifurcation lesions are frequent and occur in approximately 15% of percutaneous coronary interventions (PCIs). The technique for bifurcation stenting is evolving and has not been definitively identified. Despite the introduction of drug-eluting stents (DES), interventionalists continue to face the same question: to stent one or both of the branches? Several studies [1–3] suggest one-stent techniques with provisional side branch (SB) stenting should be the preferred strategy, but there is still a strong belief that there are many specific types of bifurcation lesions, such as lesions involving SB and bifurcation angle, and therefore patients will benefit from double stenting.

We hypothesized that a provisional stenting strategy for all bifurcation lesions is the preferred strategy. This pragmatic trial compared the clinical and angiographic outcomes of a provisional stenting strategy (stenting of the main vessel and optional stenting of the SB, MV) with a routine stenting strategy (stenting of both the main vessel and the SB, MV plus SB) in patients with true bifurcation lesions and bifurcation angle of 60 or less.

Methods

Patient selection criteria

Patients with true bifurcation lesions undergoing either the provisional stenting or routine stenting strategies at the Union Hospital, Fujian Medical University between January 2007 and January 2009 were included in the study.

Bifurcation lesion definition

Bifurcation lesions were defined according to Lefevre *et al.* [4] and could be located in the anterior descending artery and a diagonal, the circumflex artery and an obtuse marginal, the right coronary artery and posterior descending artery/posterolateral artery, or the left main stem/circumflex artery/left anterior descending artery in a right dominant system. The diameter of the MV and of the SB should be at least 2.5 and at least 2.2 mm, respectively, by visual estimate.

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Inclusion criteria

Men and women, aged 18 years or older, with stable or unstable angina pectoris or silent ischemia, and with a *de novo* coronary true and bifurcation angle of 60 or less bifurcation lesion were considered eligible for enrollment.

Exclusion criteria

Patients were excluded if one of the following was present: a myocardial infarction (MI) in the 24 h preceding treatment, life expectancy of less than 1 year, serum creatinine greater than 3.0 mg/dl, allergy to any of the drugs used (aspirin, clopidogrel, ticlopidine, sirolimus, and paclitaxel), or a left main bifurcation in a left dominant system.

Study design

One hundred and eight patients met the inclusion criteria and were recruited to the study. Randomization was performed with sealed opaque envelopes assigning patients to one of the two different treatment strategies: provisional stenting (group MV) or routine stenting (group MV plus SB). In the MV plus SB group, stenting of both the MV and the SB was predominantly by application of the double-kissing (DK) crush technique [5], culotte technique [6], or T-stenting technique at the discretion of the operator. All patients recruited were followed up until August 2009.

Ethical review

The study was approved by the Ethics Committee of Fujian Medical University and conforms to the principles outlined in the Declaration of Helsinki. Ethically, a stent thrombosis rate of at least 5% in any group necessitated premature termination of the trial. All patients gave written informed consent for their participation.

Stent implantation

Patients were pretreated with aspirin (300 mg) and clopidogrel (300 mg). In the catheterization laboratory, a stat intra-arterial dose of heparin (5000–10 000 U) was administered without activating clotting time control. Low-molecular-weight heparin was administered according to hospital routine. Intracoronary trinitroglycerin was given routinely. Glycoprotein receptor antagonists were used at the discretion of the operator. After PCI, aspirin (100 mg/d) was continued indefinitely, and clopidogrel (75 mg/d) was continued for 12 months. Ticlopidine was allowed when the patient was intolerant to clopidogrel.

All stents used in this series were sirolimus-eluting stents (Cordis, Johnson & Johnson, Miami Lakes, Florida, USA) and paclitaxel-eluting stents (Boston Scientific, Natick, Massachusetts, USA). Different types of DES were not allowed in the same vessel. Both operators and patients were aware of the assigned treatment.

Angiography/stenting was performed through a radial or femoral approach with a 6 F guiding catheter used routinely. Either a 7 or 8 F catheter was used in (DK) crush technique procedures. Pretreatment by conventional balloon or cutting balloon of segments not to be covered by stent was not carried out; that is, areas close to the MV segment in the provisional stenting group and the MV plus the SB segments in the routine stenting group were not treated.

The study lesion was predilated and/or postdilated at the discretion of the operator. In the provisional stenting group, the main treatment principles were:

(1) Stenting of MV;
(2) SB dilation if there was SB flow less than thrombolysis in MI (TIMI) grade 3;
(3) SB stenting if TIMI flow grade 0 in the SB after dilation.

In the routine stenting group, the main treatment principles were stenting of both the MV and the SB by application of the DK crush technique [5], culotte technique [6], or T-stenting technique. In all cases of SB stenting, the operator was required to carry out a 'kissing balloon' dilation at the end of the procedure. Implantation of additional stents to cover the whole lesion or to cover a dissection was allowed.

Follow-up

All patients were followed up by telephone or at the clinic every month. No patients were lost to follow-up.

Definitions of vascular endpoints

Target lesion revascularization (TLR) was defined as repeat revascularization with stenosis diameter (SD) at least 50% within the stent or in the adjacent segments 5 mm distally or proximally to the stent. If separate stents were placed at either end of a target lesion, this counted as two interventions. Target vessel revascularization (TVR) was recognized as a repeat revascularization within the treated vessel. We determined the incidence of stent thrombosis according to the Academic Research Consortium criteria [7]. Stent thrombosis was defined as an acute coronary syndrome with angiographic documentation of vessel occlusion because of thrombus within or adjacent to a previously successfully stented vessel. In the absence of angiographic confirmation, either acute MI in the distribution of the treated vessel or death not clearly attributable to other causes was also considered stent thrombosis. Stent thrombosis was categorized according to the timing of the event as: early ($\leq$ 1 month after procedure) or late ($>$ 1 month).

Biochemical monitoring

Renal function

Plasma creatinine levels were assessed before, 24 h after, and 48 h after the procedure.

Cardiac biomarkers and electrocardiogram

The plasma levels of creatine kinase-MB isoenzyme (CK-MB) and troponin I were monitored before, immediately, 8 h, and 24 h after the PCI procedure. Procedure-related MI was considered if CK-MB or troponin-I increased to more than three times the upper limit of normal (ULN). In the absence of a new Q wave, CK-MB at least $3 \times$ ULN was defined as a non-Q wave MI. Development of a new Q wave in two or more contiguous electrocardiogram leads, with CK-MB at least $3 \times$ ULN, was defined as a new Q wave infarction.

Study end points

The primary end points were major adverse cardiac events (MACE) at 8 months, including MI, cardiac death, and stent thrombosis or TVR by either PCI or coronary artery bypass grafting. Secondary end points included binary angiographic restenosis and late loss of vessel diameter in the MV and SB after 8 months.

Quantitative angiographic analysis and angiographic follow-up

Angiographic follow-up was performed at 8 months unless clinically indicated earlier. Quantitative angiographic parameters were calculated for the target lesion before and after the procedure and at the time of angiographic follow-up using dedicated software (Qangio XA, version 7.0, Medis, Leiden, the Netherlands). TLR or TVR was determined based on angiographic results and patients' symptoms. Views were matched for preprocedural, postprocedural, and at 8-month review. Vessels involved in the bifurcation lesions were divided into three segments: prebifurcation segment of the MV (pre-MV), postbifurcation segment of the MV (post-MV), and the SB. Pre-MV segment included the stented segment and the segment 5-mm proximal to the stent; the post-MV segment and the SB also included the stented segment and the segment 5-mm distal to the stent, as appropriate. In addition, the bifurcation angle was measured using this analysis system. The bifurcation angle was defined as the angle between the axis of the MV and the axis of the SB at its origin. Measurement is complicated by the need to ensure that rotation and foreshortening effects do not reduce the apparent bifurcation angle.

Angiographic success was defined as residual stenosis less than 30% with TIMI flow grade 3 in both of the branches. Procedural success was defined as the achievement of angiographic success in the absence of any in-hospital MACE. In-stent restenosis was defined as SD greater than 50% within the stented segment. In-segment restenosis was defined as SD greater than 50% either within the stented segment or within the 5 mm proximal or distal to the stent edges.

All events were classified and adjudicated by two observers in the Core Laboratory of the Fujian Institute of Coronary Artery Disease who were not involved in the follow-up process. Clinical data entry and quantitative coronary angiography were double-checked by a trained study member.

Statistical analysis

Basing on our clinical practice, we expected a primary end-point event rate of 35% in the MV plus SB group. A power calculation assuming $\alpha = 5\%$, and power = 80%, and a two-sided χ^2 test was carried out. This resulted in an estimate that to detect a reduction in the primary end-point rate to 15%, 40 patients would be needed in each group. To allow for patients lost to follow-up, it was decided to recruit 108 patients to the study.

Continuous variables were expressed as mean ± standard deviation and compared using P–P plot and analysis of variance. Categorical variables were evaluated with the χ^2 or Fisher's exact test. Time-to-event data were analyzed with the Kaplan–Meier method and the log-rank test. A P value less than 0.05 was considered statistically significant. All data were analyzed with SPSS version 11.5 (SPSS Inc., Chicago, Illinois, USA).

Results

Baseline characteristics

The two groups were well balanced with regard to baseline clinical characteristics and risk factors (Table 1).

Lesions and procedural characteristics

Procedural data are shown in Table 2. The index lesions were similarly distributed in the left anterior descending artery, circumflex artery, and right coronary artery in the two groups. There was also no significant difference between the two groups with respect to type of bifurcation, vessel size, or severity of stenosis as assessed by the operator. Calcification and lesion thrombus was not significantly different between the groups. The procedure time, fluoroscopy time, and contrast volume used in the routine stenting group were significantly greater than in the provisional stenting group. There was no difference in the final rate of 'kissing' stents and the stent type between the two groups. In the routine stenting group,

Table 1 Baseline clinical characteristics

	Provisional stenting ($n=54$)	Routine stenting ($n=54$)	P value
Age (years)	60.59 ± 7.45	59.20 ± 7.17	0.33
Male (%)	45 (83.3)	41 (75.9)	0.34
Diabetes mellitus (%)	10 (18.5)	7 (13)	0.43
Hypertension (%)	49 (90.7)	45 (83.3)	0.25
Current smoker (%)	16 (29.6)	13 (24.1)	0.52
LDL-cholesterol (mg/dl)	142.65 ± 18.36	140.89 ± 15.31	0.59
Previous MI (%)	12 (22.2)	10 (18.5)	0.63
History of PCI (%)	13 (24.1)	13 (24.1)	1.00
History of CABG (%)	5 (9.3)	4 (7.4)	0.73
Ejection fraction (mg/dl)	55.63 ± 6.37	57.11 ± 5.87	0.21
Unstable angina pectoris (%)	23 (42.6)	22 (40.7)	0.85

CABG, coronary artery bypass grafting; LDL, low-density lipoprotein; MI, myocardial infarction; PCI, percutaneous coronary intervention.

Table 2 Baseline angiographic and procedural characteristics

	Provisional stenting ($n=54$)	Routine stenting ($n=54$)	*P* value
Lesions locations (%)			
LAD-D1	45 (83.3)	43 (79.6)	0.62
LCX-OM	5 (9.3)	6 (11.1)	0.75
RCA	4 (7.4)	5 (9.3)	1.00
Medina classification (%)			
111	26 (48.1)	23 (42.6)	0.56
101	9 (16.7)	13 (24.1)	0.34
011	19 (35.2)	18 (33.3)	0.84
Lesions characteristics (%)			
Calcification	14 (25.9)	15 (27.8)	0.83
Thrombus	5 (9.3)	4 (7.4)	1.00
Restenosis	0	0	1
CTO	0	1 (1.9)	1.00
GPIIb/IIIa inhibitors (%)	7 (13)	5 (9.3)	0.54
Cross over (%)	9 (16.7)	3 (5.6)	0.07
Final kissing (%)	51 (94.4)	49 (90.7)	0.71
Lesion length (mm)			
Main branch	23.76 ± 2.58	23.56 ± 2.13	0.66
Side branch	12.91 ± 3.12	12.69 ± 2.75	0.70
Stent type (%)			
SES	35 (64.8)	31 (57.4)	0.43
Nominal final balloon size (mm)			
Main branch	3.55 ± 0.22	3.52 ± 0.14	0.47
Side branch	2.87 ± 0.19	2.87 ± 0.13	0.86
Maximal inflation pressure (atm)			
Main branch	15.28 ± 1.81	14.85 ± 1.51	0.19
Side branch	13.19 ± 1.87	12.81 ± 1.75	0.29
Contrast volume (ml)	288.89 ± 113.58	398.70 ± 71.24	0.00
Procedure time (min)	55.74 ± 16.17	71.37 ± 18.04	0.00
Fluoroscopy time (min)	15.13 ± 4.03	17.78 ± 4.62	<0.01

CTO, chronic total occlusion; GP, glycoprotein; LAD-D1, left anterior descending artery and diagonal branch; LCX-OM, left circumflex artery and obtuse marginal branch; RCA, right coronary artery; SES, sirolimus-eluting stents.

Table 3 Quantitative angiographic analysis analysis of the prebifurcation main vessel segment

	Provisional stenting ($n=54$)	Routine stenting ($n=54$)	*P* value
Baseline			
Reference diameter (mm)	3.98 ± 0.43	3.94 ± 0.44	0.66
MLD (mm)	1.65 ± 0.40	1.60 ± 0.35	0.50
Diameter stenosis (%)	60.00 ± 8.29	59.92 ± 7.67	0.96
Post-PCI			
Reference diameter (mm)	4.01 ± 0.41	3.99 ± 0.42	0.80
MLD (mm)	3.57 ± 0.55	3.51 ± 0.41	0.55
Diameter stenosis (%)	14.25 ± 3.86	13.14 ± 5.81	0.24
Acute gain (mm)	1.92 ± 0.53	1.91 ± 0.44	0.92
8-month follow-up			
Reference diameter (mm)	3.98 ± 0.43	3.93 ± 0.43	0.52
MLD (mm)	3.12 ± 0.66	3.09 ± 0.57	0.79
Diameter stenosis (%)	24.69 ± 10.32	22.73 ± 10.44	0.33
Late loss (mm)	0.44 ± 0.26	0.42 ± 0.34	0.68
Restenosis (%)	6 (11.1)	4 (7.4)	0.51

MLD, minimum lumen diameter; PCI, percutaneous coronary intervention.

the bifurcation technique used was the DK crush technique in 65%, the culotte technique in 25%, and other techniques in 10% of patients.

Quantitative angiographic analysis

Pre-MV quantitative angiographic analysis is shown in Table 3. The baseline reference vessel diameter (RVD) was not significantly different between the groups. There were no significant differences in acute gain, minimum lumen diameter (MLD), late loss, or SD.

Table 4 Quantitative angiographic analysis of the postbifurcation main vessel segment

	Provisional stenting ($n=54$)	Routine stenting ($n=54$)	*P* value
Baseline			
Reference diameter (mm)	3.91 ± 0.55	3.82 ± 0.52	0.41
MLD (mm)	1.45 ± 0.25	1.43 ± 0.23	0.69
Diameter stenosis (%)	62.93 ± 4.10	62.47 ± 4.48	0.58
Post-PCI			
Reference diameter (mm)	4.02 ± 0.50	3.95 ± 0.53	0.50
MLD (mm)	3.43 ± 0.54	3.35 ± 0.51	0.41
Diameter stenosis (%)	14.83 ± 4.95	15.12 ± 5.23	0.77
Acute gain (mm)	1.97 ± 0.41	1.94 ± 0.45	0.74
Follow-up			
Reference diameter (mm)	3.94 ± 0.50	3.91 ± 0.51	0.78
MLD (mm)	3.24 ± 0.68	3.14 ± 0.66	0.46
Diameter stenosis (%)	18.25 ± 12.15	19.88 ± 13.01	0.50
Late loss (mm)	0.19 ± 0.35	0.19 ± 0.34	0.89
Restenosis (%)	8(14.8)	5(9.3)	0.38

MLD, minimum lumen diameter; PCI, percutaneous coronary intervention.

Table 5 Quantitative angiographic analysis of the side branch

	Provisional stenting ($n=54$)	Routine stenting ($n=54$)	*P* value
Baseline			
Reference diameter (mm)	2.82 ± 0.25	2.79 ± 0.17	0.53
MLD (mm)	0.85 ± 0.16	0.84 ± 0.14	0.52
Diameter stenosis (%)	69.72 ± 5.28	70.13 ± 4.63	0.68
Post-PCI			
Reference diameter (mm)	2.89 ± 0.27	2.87 ± 0.16	0.57
MLD (mm)	2.37 ± 0.40	2.42 ± 0.18	0.40
Diameter stenosis (%)	17.92 ± 10.81	15.38 ± 6.18	0.14
Acute gain (mm)	1.49 ± 0.37	1.59 ± 0.18	0.07
8-month follow-up			
Reference diameter (mm)	2.82 ± 0.27	2.80 ± 0.16	0.66
MLD (mm)	2.00 ± 0.59	2.26 ± 0.41	<0.01
Diameter stenosis (%)	28.91 ± 20.43	18.93 ± 15.34	<0.01
Late loss (mm)	0.38 ± 0.44	0.16 ± 0.32	<0.01
Restenosis (%)	19 (35.2)	8 (14.8)	0.015

MLD, minimum lumen diameter; PCI, percutaneous coronary intervention.

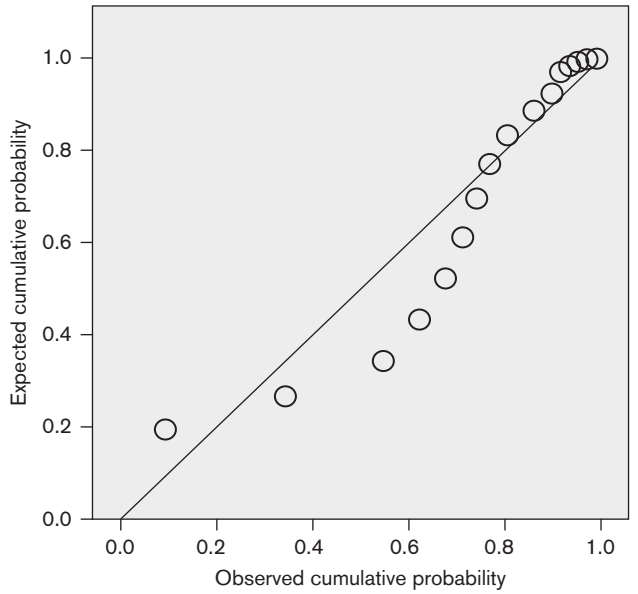
Post-MV is shown in Table 4. As in the pre-MV segment, no difference in RVD between the two groups was detected throughout the follow-up period, and no difference was found in acute gain, late loss, or MLD (Table 4).

SB analysis data are shown in Table 5. No difference in RVD was found between the two groups. There were no differences in MLD or SD at baseline and post-PCI in treatment groups. However, MLD and SD at follow-up in the routine stenting group were significantly better than in the provisional stenting group. Furthermore, the late loss in the SB was significantly higher in the provisional stenting group than in the routine stenting group (0.38 ± 0.44 vs. 0.16 ± 0.32 mm, $P < 0.01$), with a resultant greater restenosis rate (35.2 vs. 14.8%, $P = 0.015$). A P–P plot of late loss of SB in follow-up (MV group and MV plus SB group) is shown in Figs 1 and 2.

Clinical outcome

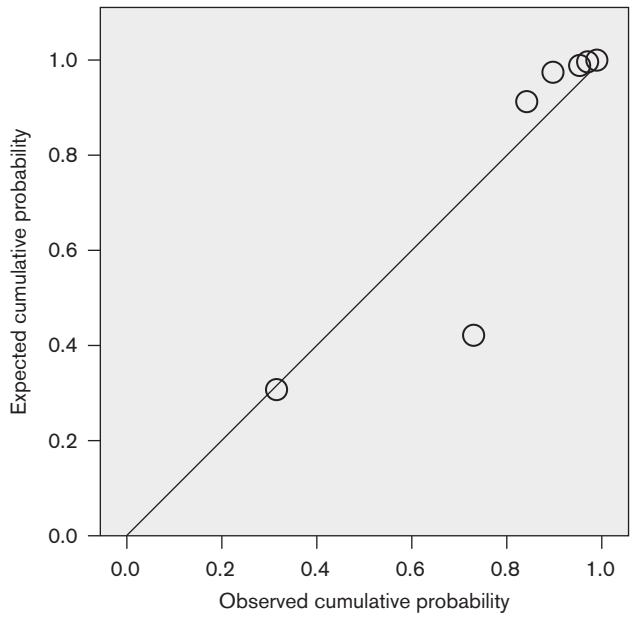
The cumulative event rate for the primary end point of MACE (cardiac death, MI, TVR, or stent thrombosis) in-hospital and after 8 months of follow-up is shown in Table 6 and Fig. 3. There was no significant difference

Fig. 1



Nomal P–P plot of late loss in follow-up (main vessel group).

Fig. 2



Nomal P–P plot of late loss in follow-up (main vessel plus side branch group).

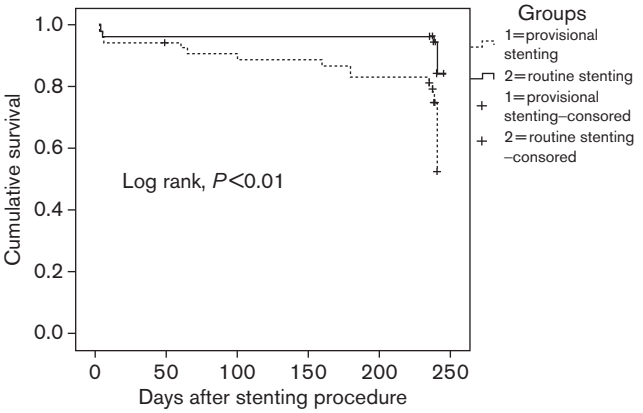
in the in-hospital MACE rate between the two groups. However, TLR and TVR in the provisional stenting group after 8 months were significantly higher than in the routine stenting group, with a resultant greater cumulative MACE (38.9 vs. 11.1%, $P < 0.01$), and by the Kaplan–Meier method, the cumulative survival rates free from MACE after an 8-month follow-up were significantly different between the two groups ($P < 0.01$).

Table 6 MACE in-hospital and at 8-month

	Provisional stenting ($n=54$)	Routine stenting ($n=54$)	*P* value
In-hospital MACE (%)	4 (7.4)	2 (3.7)	0.67
Cardiac death	0	0	1
Myocardial infarction	1 (1.9)	1 (1.9)	0.48
Target lesion revascularization	1 (1.9)	0	1
Target vessel revascularization	2 (3.7)	1 (1.9)	1
Stent thrombosis	0	0	1
Cumulative MACE at 8-month (%)	21 (38.9)	6 (11.1)	<0.01
Cardiac death	1 (1.9)	0	1
Myocardial infarction	0	0	1
Target lesion revascularization	17 (31.5)	4 (7.4)	<0.01
Target vessel revascularization	16 (29.6)	4 (7.4)	<0.01
Stent thrombosis	1 (1.9)	0	1

MACE, major adverse cardiac events.

Fig. 3



Comparison of survival rate-free from major adverse cardiac events between provisional stenting and routine stenting groups.

In addition, there were two MIs in the area supplied by the bifurcation treated: one in the routine stenting group at day 4 and one in the provisional stenting group at day 3. In both the groups, one patient developed a late stent thrombosis during follow-up. One patient assigned to the provisional stenting group died of a sudden death at day 49 in a patient without a SB stent.

Discussion

Our pragmatic clinical interventional trial of treatment of true coronary bifurcation lesions with DES compared the clinical and angiographic outcome of routine stenting with that of provisional stenting. As our key result, we found that the SB outcome in this trial was opposite to earlier studies. Specifically:

(1) Late loss and restenosis were significantly lower in the SB of the routine stenting group in the 8-month follow-up period.

(2) A significant difference was shown in SB TLR, TVR, and cumulative MACE at 8 months in the two treatment groups.

Earlier studies have shown that restenosis mechanisms differ substantially between plain balloon angioplasty and stent placement. After stent placement, neointima formation accounts for more than 90% of the lumen loss, whereas after plain balloon angioplasty the contribution of neointima formation to restenosis is less than 30% [8–10]. With plain balloon angioplasty, remodeling because of elastic recoil and late vessel shrinkage are the predominant mechanisms of postprocedural lumen loss [8,9]. DES inhibits postprocedural neointima proliferation and has shown promise for the treatment of coronary lesions, with significant reductions in restenosis rates [11]. Stent placement reduces elastic recoil and late vessel shrinkage, with consequent significant improvement of procedural success rate in bifurcation lesions (main branch $> 95\%$ and SB $> 88\%$) [12]. A possible explanation is that DES in the SB inhibits neointima formation, and reduces elastic recoil and late vessel shrinkage. This has led to the extraordinarily low late SB loss, which we observed in our routine stenting group.

We began our study shortly after the results of the NORDIC Bifurcation Study were published. NORDIC included 413 patients randomly assigned to stenting of both the MV and the SB or stenting of the MV only, with optional stenting of the SB. In contravention to our findings, the MLD and late lumen loss of the SB in NORDIC was significantly higher in the group assigned to routine stenting of the SB compared with the group assigned to optional SB stenting only. However, NORDIC did not detect any significant difference between the two study arms in its primary end point of MACE, but it is possible that in NORDIC, patients had a variety of lesion types and locations. Furthermore, it is notable that restenosis rates in both main branch and SB in NORDIC were significantly lower than those in our study. This may be explained by differences in the risk profiles of our study cohorts. Dzavik *et al.* [13] reported that bifurcation angle, an important measure of cardiac anatomy, correlated well with outcomes immediately after PCI and at long-term follow-up. A measurement of bifurcation angle can predict the risk of SB occlusion after stenting in main branch, the smaller the angle the greater the risk of occlusion. Our study differed from NORDIC, because we only treated patients with true bifurcation lesions with bifurcation angle of 60 or less between the MV and SB.

Consistent with earlier studies, we found no significant difference in quantitative angiographic analysis of main branch, cardiac death, MI, stent thrombosis, and need for in-hospital TVR between the provisional and routine coronary bifurcation stenting strategies. However, the routine stenting strategy was associated with increased procedure and fluoroscopy times, and greater contrast volume used, which is related to the complexity of the surgery.

Bifurcation lesions represent one of the remaining challenges in interventional cardiology. It is not yet clear whether the optimal treatment strategy is routine or provisional SB stenting; the latter being the simpler and most frequently used strategy [14–16]. Although several studies [1–3] suggest that a one-stent technique with provisional SB stenting is superior, it was not applied in all types of patients. We believe the criteria for SB stenting for patients with true bifurcation lesions and bifurcation angle of 60 or less should be reconsidered. Furthermore, we believe it would be reasonable to carry out SB stenting if the diameter of SB is greater than 2.2 mm in a true bifurcation lesion.

The principal limitations of this trial include its open study design, and the limited number of patients, which might introduce bias. In addition, there was not a completely uniform approach with regard to the stenting technique.

In conclusion, routine stenting significantly improved MACE outcome of PCI of true coronary bifurcation lesions as compared with provisional stenting.

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