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Therapeutic effect of rotational atherectomy with implantation of drug eluting stent in heavily coronary calcified patients

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Abstract

Background Rotational atherectomy (RA) could facilitate the percutaneous coronary intervention (PCI) in heavily coronary calcified patients. The effectiveness and safety of this technique needs to be further evaluated. **Methods & Results** Eighty patients who underwent RA in our center from September 2011 to June 2014 were enrolled. The mean age was 72.4 ± 10.4 years. The left ventricular ejection fraction (LVEF) was average 52.3% ± 8.48% and the estimated glomerular filtration rate was 73.2 ± 3.20 mL/min per 1.73 m^2. The coronary lesions were complex, with Syntax score 29.5 ± 9.86. The diameter of reference vessel was 3.4 ± 0.45 mm and the average diameter stenosis of target vessels was 80% ± 10%. All the patients were deployed with drug eluting stents (DES) successfully after RA. The patients were followed up for 12–18 months. Kaplan-Meier plots estimated the survival rate was 93.4% and the cumulative incidence of major adverse cardiac and cerebral events (MACCE) was 25.4%. Bleeding and procedural-related complications were quite low. COX proportional hazards model for multivariate analysis demonstrated that diabetes, LVEF and maximum pressure of postdilatation were the predictors of MACCE. **Conclusions** RA followed by implantation of DES was effective and safe for heavily coronary calcified patients. Diabetes, LVEF and maximum pressure of postdilatation were predictive for MACCE.

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1 Introduction

Coronary artery calcification (CAC) is a degenerative disease with prevalence of 35% in population. In the people older than 70 years, it occurs in more than 90% of male and more than 67% of female.[1,2] The formation of CAC is multifactorial, such as age, sex, and renal function, etc., and the pathophysiology of CAC is also complicated.[3,4] In clinical practice, CAC usually leads to severe coronary lesion and damages the compliance of the vessels, which is challenging and risky for the percutaneous coronary intervention (PCI). Rotational atherectomy (RA) was first introduced in 1987. RA could remove the calcified plaque via the rotablator, which would facilitate the PCI and improve the procedural success rate. However, the benefit and safety are always the concerns of the interventionists. Besides, the patients with heavily coronary calcified lesions usually have comorbidities. Therefore, it is worth investigating the factors that is likely to influence the prognosis of the patients after RA. In this study, eighty patients after RA followed by drug eluting stents (DES) implantation in our center were followed up to evaluate the therapeutic effect and assess the factors probably related to the prognosis.

2 Methods

2.1 Study population

The current study was aimed to evaluate the therapeutic effect of RA and assess the prognosis-related factors. Eighty patients who underwent RA in our center from September 2011 to June 2014 were enrolled in the study. The demographic characteristics, lab test results and procedural details of the patients were acquired from the database. The severity of the calcification was evaluated with angiography, sometimes facilitated by computed tomographic angiography (CTA).

2.2 Calcification grade via coronary angiography (CAG)

The severity of coronary calcification was graded by quali-

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tative CAG assessment. Severe calcification is defined as radio-opacities without cardiac motion before contrast injection. Moderate calcification is defined as densities noted only during the cardiac cycle before contrast injection.[5] Mild calcification is defined as densities noted when quite carefully.

2.3 Procedural details

All the patients were administered with loading dose of 300 mg aspirin and 300–600 mg clopidogrel and followed by maintenance dose of 100 mg aspirin and 75 mg clopidogrel once daily. After radial or femoral artery puncture, a 6F sheath was inserted. Heparin was administered with 70–100 IU/kg and tirofiban was used if necessary.

After CAG, the patients with severe calcification would undergo RA immediately. The patients with moderate severe calcification would further take intra-vascular ultrasound (IVUS) test. If the probe of IVUS was not able to get through the lesions or IVUS revealed calcified arc more than 270°, RA was also performed. The patients with mild calcification could undergo PCI routinely. However, if balloons could not be dilated adequately at the calcified lesions during PCI, RA should be carried out.

According to the diameter of reference vessel, RA usually began with 1.25 mm or 1.5 mm rotablation burr (Boston Scientific). The rotational speed was set at 150,000–200,000 r/min, avoiding deceleration of more than 50,000 r/min during the procedure. If the adequate dilatation of balloons was not able to perform after the initial rotablation, the procedure would be carried out once more with the same burr or with a new burr of bigger size. The drug eluting stents were implanted after successful RA. All the procedures were completed by experienced interventionists.

2.4 Definition of endpoint and follow-up

All the patients were followed up by clinical visit or telephone call. Primary endpoint was all-cause death. Secondary endpoint was major adverse cardiac and cerebral events (MACCE), which composite of cardiac death, non-fatal myocardial infarction, recurrence of angina, worsening of heart failure, target vessel revascularization (TVR) or target lesion revascularization (TLR), and non-fatal ischemic stroke.

Cardiac death referred to the death due to cardiac diseases such as myocardial infarction, arrhythmia, and heart failure. Any death that was not clearly non-cardiac was also regarded as cardiac death. The diagnostic criteria of myocardial infarction should accord with the 3rd universal definition of ESC/AHA/ACCF.[6] Angina referred to reversible chest pain caused by ischemia accompanied with dynamic ST-T alteration on ECG. Worsening of heart failure referred to typical symptoms of heart failure which needed intravenous diuretics or inotropic agent. Ischemic stroke referred to cerebral ischemic lesion accompanied with new onset focal neurological deficit which was not reversible within 24 h. TVR was defined as a repeated procedure of the target vessel, either PCI or coronary artery bypass grafting (CABG). TLR was defined as revascularization of the stents implanted as well as 5 mm proximal or distal to the stents. The hemorrhagic complication was classified to mild, moderate and severe bleeding according to GUSTO study.[7]

2.5 Statistical analysis

The statistical analysis was performed with STATA (version 11.0). Continuous variables of normal distribution were presented as mean ± SD and were compared using *t*-test between two groups, while those of skewed distribution were presented as median and interquartile range (IQR) and were compared using Wilcoxon rank-sum test between the two groups. Categorical variables were presented with frequencies and percentage and were compared with χ^2 test or Fisher exact test between two groups. The survival rate and the cumulative incidence of MACCE were estimated with Kaplan-Meier plots. Univariate and multivariate regression was performed with COX proportional hazards model. The factors with $P < 0.2$ in the univariate regression would construct the multivariate model. The backward stepwise was used to remove the covariates with $P \geq 0.1$.

3 Results

3.1 Clinical characteristics of the patients

The patients were average 72.4 ± 10.4 years, including 65% male and 35% female. 13.8% of the patients presented with acute myocardial infarction and 65% of them presented with unstable angina. A few patients (7.5%) had prior myocardial infarction before RA. Left ventricular ejection fraction (LVEF) was preserved at average 52.3% ± 8.48%. Meanwhile, estimated glomerular filtration rate (eGFR) was average 73.2 ± 3.20 mL/min per 1.73 m^2 (Table 1).

3.2 Details of the procedure

The procedural time was average 95.9 ± 29.94 min. The syntax score was average 29.5 ± 9.86, which suggested that most of the coronary lesions were complex. The diameter of reference vessel was 3.4 ± 0.45 mm and the average diameter stenosis of target vessels was 80% ± 10%. 67.5% of the target vessels were left anterior descending artery (LAD). Left circumflex artery (LCX) and right coronary artery (RCA) accounted for 7.5% and 10%, respectively. The

Table 1. The demographics and clinical characteristics of the patients (*n* = 80).

Age, yrs	72.4 ± 10.4
Male	52 (65%)
Hypertension	69 (86.3%)
Diabetes	26 (32.5%)
Ischemic stroke	24 (30%)
Smoke	32 (40%)
Ischemic cardiomyopathy	10 (12.5%)
Family history of coronary heart isease	15 (18.8%)
History of myocardial infarction	6 (7.5%)
Acute myocardial infarction	11 (13.8%)
Unstable angina	52 (65%)
TC, mmol/L	3.64 (3.15–4.25)
TG, mmol/L	1.23 (0.91–1.82)
LDL-C, mmol/L	1.88 (1.45–2.35)
HDL-C, mmol/L	0.92 (0.81–1.14)
LVEF, %	52.3% ± 8.48%
eGFR, mL/min per $1.73m^2$	73.2 ± 3.20

Data are presented as mean ± SD, *n* (%) or median (IQR). eGFR: estimated glomerular filtration rate; HDL-C: high density lipoprotein cholesterol; IQR: interquartile range; LDL-C: low density lipoprotein cholesterol; LVEF: left ventricular ejection fraction; TC: total cholesterol; TG: triglyceride.

bifurcation lesion in distal segment of left main artery (LM), in other words LM-LAD and/or LM-LCX, accounted for 15%. Incidence of procedural-related complications was low (Table 2).

3.3 Follow-up results

All the patients were followed up for 12–18 months by clinical visit or phone call and angiography follow-up were available for 52 patients (65%). Five patients died and seventeen cases of MACCE occurred (Table 3). Recurrence of angina occurred in four patients and were identified no significant in-stent restenosis with angiography. Six patients were identified in-stent restenosis more than 50% but without ischemic symptom. The survival rate was 93.4% and the cumulative incidence of MACCE was 25.4% estimated by Kaplan-Meier plots respectively (Figures 1 & 2).

Five patients (6.25%) suffered from bleeding complication. One of them suffered from cerebral hemorrhage eight months after procedure. He discontinued clopidogrel and fortunately recovered without any sequela. The others were mild bleeding complication (Table 3).

3.4 Comparison between patients with and without MACCE

We divided patient cohort to MACCE group and MACCE-free group. The clinical characteristics and procedural parameters were compared between two groups. It

Table 2. The interventional therapy of the patients (*n* = 80).

Procedural time, min	95.9 ± 29.94
Syntax score	29.5 ± 9.86
Target vessel	
LAD	54 (67.5%)
LCX	6 (7.5%)
RCA	8 (10%)
LM-LAD and/or LM-LCX	12 (15%)
Bifurcation	14 (17.5%)
Diameter of reference vessel, mm	3.4 ± 0.45
Minimum luminal diameter, mm	0.6 ± 0.27
Diameter of stenosis	80% ± 10%
Maximum diameter of predilatation balloon, mm	2.5 (2−2.5)
Maximum diameter of postdilatation balloon, mm	3.3 ± 0.48
Maximun pressure of predilatation, atm	14 (12−16)
Maximun pressure of postdilatation, atm	17.9 ± 2.87
Burr size, mm	1.5 ± 0.13
Rotablation speed, × 10000 r/min	17.9 ± 1.32
Assessment with IVUS	26 (32.5%)
Diameter of stents, mm	3.2 ± 0.43
Length of stents, mm	51 (29−66)
Stent category	
Sirolimus eluting stent	45 (56.2%)
Everolimus eluting stent	31 (38.8%)
Zotarolimus eluting stent	4 (5.0%)
Completely revascularization	36 (45%)
Coronary dissection	4 (4.8%)
Perforation	1 (1.2%)
Entrapment of burr	2 (2.4%)

Data are presented as mean ± SD, median (IQR) or *n* (%). IVUS: intra-vascular ultrasound; LAD: left anterior descending artery; LCX: left circumflex artery; RCA: right coronary artery; LM: left main artery.

Table 3. Endpoint of the patients (*n* = 80).

All-cause death	5 (6.25%)
MACCE	17 (21.25%)
Cardiac death	3 (3.75%)
TLR	4 (5.0%)
TVR	1 (1.25%)
Worsening of heart failure	3 (3.75%)
Recurrence of angina	4 (5.0%)
Ischemic stroke	2 (2.5%)
Severe bleeding complication	
Cerebral hemorrhage	1 (1.25%)
Mild bleeding complication	4 (5.0%)
Hemoptysis	1 (1.25%)
Petechia	2 (2.5%)
Epistaxis	1 (1.25%)

Data are presented as *n* (%). MACCE: major adverse cardiac and cerebral events; TLR: target lesion revascularization; TVR: target vessel revascularization.

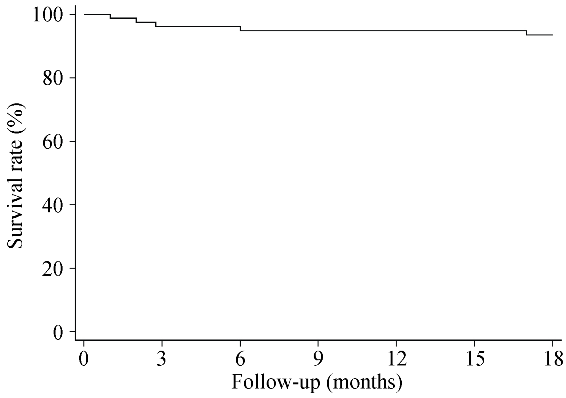

Figure 1. The survival rate during follow-up period.

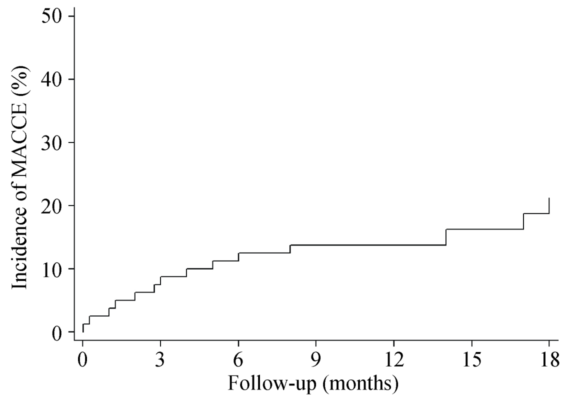

Figure 2. The cumulative incidence of MACCE during follow-up period. MACCE: major adverse cardiac and cerebral events.

demonstrated that the LVEF in MACCE group was significantly lower than that in MACCE-free group (P = 0.04), while there were no significant differences in other indexes between two groups (Table 4).

3.5 COX proportional hazards model for regression analysis

The results of univariate and multivariate regression analysis for MACCE were shown in Table 5. Diabetes increased the risk of MACCE, whereas LVEF and maximum pressure of post-dilatation were the protective factors.

4 Discussion

Coronary heavy calcification is more likely to cause the failure of stent deployment. It has been reported that the incidence of failure in deploying DES was 5.8% at severe calcified lesions, while the incidence of failure was 1.8% in non-calcified lesions.[5] RA is able to reduce the calcified plaque and decrease the rigidity of the calcified artery wall via the diamond-encrusted burr.[8] This technique has ever been widely used in PCI. However, the use has fallen to 3%–5% in recent years,[9] probably due to the concerns about the effect and safety.

Table 4. Clinical and procedural characteristics between two groups.

	MACCE *n* = 17	MACCE-free *n* = 63	*P*-value
Age, yrs	72.5 ± 2.40	72.3 ± 1.30	0.96
Male	13 (76.5%)	39 (61.9%)	0.39
Acute myocardial infarction	3 (17.6%)	8 (12.7%)	0.69
Unstable angina	12 (70.6%)	40 (63.5%)	0.59
TC, mmol/L	4.07 (3.36–4.40)	3.53 (3.12–4.24)	0.52
TG, mmol/L	1.77 (1.00–2.17)	1.1 (0.90–1.70)	0.15
LDL-C, mmol/L	2.28 (1.84–2.36)	1.77 (1.34–2.34)	0.20
HDL-C, mmol/L	0.88 (0.81–1.01)	0.96 (0.80–1.20)	0.18
LVEF, %	48.6% ± 1.90%	53.3% ± 1.06%	0.04
eGFR, mL/min per 1.73m^2	66.7 ± 6.17	75.1 ± 3.69	0.28
Syntax score	32.9 ± 2.40	28.5 ± 1.23	0.11
Target vessel			0.72
LAD	10 (62.5%)	44 (68.8%)	
LCX	2 (12.5%)	4 (6.2%)	
RCA	1 (6.2%)	7 (10.9%)	
LM-LAD and/or LM-LCX	3 (18.8%)	9 (14.1%)	
Bifurcation	5 (29.4%)	9 (14.1%)	0.15
Diameter of reference vessel, mm	3.29 ± 0.11	3.49 ± 0.06	0.11
Minimum luminal diameter, mm	0.67 ± 0.05	0.62 ± 0.04	0.54
Diameter of stenosis, %	79% ± 1.5%	82% ± 1.0%	0.24
Maximum diameter of predilatation balloon, mm	2.5 (2–2.5)	2.5 (2–2.5)	0.41
Maximum diameter of postdilatation balloon, mm	3.1 ± 0.14	3.3 ± 0.06	0.23
Maximun pressure of predilatation, atm	15 (14–16)	14 (12–16)	0.36
Maximun pressure of postdilatation, atm	17.0 ± 1.00	18.0 ± 0.3	0.13
Burr size, mm	1.4 ± 0.03	1.5 ± 0.02	0.16
Rotablation speed, × 10000 r/min	17.6 ± 0.34	18.0 ± 0.16	0.40
Assessment with IVUS	4 (23.5%)	22 (34.9%)	0.56
Diameter of stents, mm	3.1 ± 0.12	3.3 ± 0.05	0.10
Length of stents, mm	46 (29–89)	51 (36–66)	0.87
Stent category			0.91
Sirolimus eluting stent	9 (52.9%)	36 (57.1%)	
Everolimus eluting stent,	7 (41.2%)	24 (38.1%)	
Zotarolimus eluting stent	1 (5.9%)	3 (4.8%)	
Completely revascularization	6 (35.3%)	30 (47.6%)	0.42
Coronary dissection	1(5.9%)	3 (4.8%)	1.00
Perforation	0	1 (1.6%)	1.00
Entrapment of burr	0	2 (3.2%)	1.00

Data are presented as mean ± SD, median (IQR) or *n* (%). HDL-C: high density lipoprotein cholesterol; IVUS: intravascular ultrasound; IQR: interquartile range; LAD: left anterior descending artery; LCX: left circumflex artery; LDL-C: low density lipoprotein cholesterol; LM: left main artery; TC: total cholesterol; TG: triglyceride; RCA: right coronary artery.

Table 5. COX proportional hazards model of MACCE.

	Hazard ratio	Standard error	*P* value	95% CI
Univariate regression				
Diabetes	2.51	1.22	0.059	0.97–6.51
Ischemic stroke	2.12	1.03	0.123	0.82–5.51
Ischemic cardiomyopathy	3.31	1.94	0.04	1.05–10.43
LVEF	0.94	0.03	0.033	0.90–0.99
eGFR	0.98	0.01	0.042	0.96–0.99
Diameter of stent	0.27	0.19	0.058	0.07–1.05
Maximum pressure of post-dilatation	0.87	0.06	0.035	0.76–0.99
Multivariate regression				
Diabetes	3.74	2.04	0.015	1.29–10.89
LVEF	0.93	0.03	0.01	0.88–0.98
Maximum pressure of post-dilatation	0.77	0.06	0.001	0.66–0.90

eGFR: estimated glomerular filtration rate; LVEF: left ventricular ejection fraction; MACCE: major adverse cardiac and cerebral events.

A retrospective study included one hundred and two patients, who were followed up for 15 months. The endpoint events identified the effectiveness and safety of RA,[10] which included incidence of stent thrombosis (2.9%), cardiac mortality (4.9%), TLR (8.8%) and myocardial infarction (3.9%). In our study, there was much lower incidence of cardiac death, TVR/TLR and stent thrombosis during the comparable follow-up period. Of note, two cases TLR were driven by stent thrombosis, whereas the other two cases of TLR and one case of TVR were driven by stent restenosis. Calcified lesions are more prone to stent thrombosis and restenosis mainly due to the mechanisms as follows: (1) the polymer on the stents is vulnerable during the delivery of the stents through the calcified lesions, which further compromises the preventive effect on in-stent restenosis; (2) malapposition of the stents probably delays the reendothelialization, which is likely to lead stent thrombosis; and (3) calcified plaque would affect the release of the drug on the stents.[11] So to speak, PCI of calcified lesion would be faced with higher incidence of TVR or TLR theoretically. Several studies published in recent years reported that the incidence of TVR/TLR after RA was 4.9%–11.8%.[10,12–14] Nevertheless, it has been demonstrated that there was similar incidence of TVR between RA plus DES group and DES-only group within six months after procedure.[15]

Numerous studies have focused on the identification of the likely predictors in complex PCI. In the current study, COX proportional hazards model was applied to this task. Consequently, diabetes, LVEF and maximum pressure of postdilatation were significant predictors for MACCE. This result was partly consistent with the previous studies.[12,16] It has been widely accepted that age were important predictors in PCI. Interestingly, it was removed by univariate and multivariate regression analysis of MACCE, which probably due to TLR/TVR less relevant to age. Besides, LVEF and eGFR are also well known as the predictors of PCI. However, the significant predictive role of eGFR shown in univariate analysis was diminished in multivariate analysis. Further analysis revealed that eGFR was in linear correlation with LVEF. This relationship made LVEF more powerful in prediction of the endpoint events, which further masked the predictive role of eGFR. Diabetes has been an accepted risk factors of stent thrombosis and restenosis.[17,18] It was no wonder that diabetes was the predictors of MACCE after RA, mainly because TLR and TVR were the components of MACCE and furthermore TLR/TVR events accounts for more than thirty percent of the MACCE in the current study.

Different from the previous study,[16] Syntax score was not the predictor of MACCE, which was possibly due to the reasons as follows: (1) the sample size was relative small and the follow-up period was not long enough; (2) second, most of the patients with multivessels disease underwent elective PCI of the other coronary artery lesions, which would alleviate ischemic condition. Third, a few patients with heavily coronary calcified were underwent CABG or chose conservative therapy due to the bad condition. On the contrary, the maximum pressure of postdilatation became a predictor of MACCE, the significance of which was not shown in the previous study.[12] It was reported that underexpansion and malapposition of stents are most prevalent in early stent thrombosis.[19] In the current study, the patients with stent thrombosis were all assessed with IVUS during the revascularization procedure and the underexpansion of stents was indentified. Adequate postdilatation would enlarge the minimum lumen diameter, which would lower the incidence of stent thrombosis.

There are some limitations in our study. This study was retrospective without control group, presenting with single center experiences. Nonetheless, the sample size was a bit of small and the long-term outcome of RA was not yet evaluated. Although the univariate and mulitvariate analysis could adjust confounding factors, there were yet factors unexplained for the endpoint events due to the intrinsic shortcomings of current study, such as selection biases. It was also identified that different platform of stents would influence the endpoint, such as stent thrombosis, TLR/TVR, restenosis.[20,21] However, we did not record the information of the stent platform, which disabled the analysis of the impact of the first and second generation stent on the prognosis in calcified coronary lesions.

References

1 Baber U, Kini AS, Sharma SK. Stenting of complex lesions: An overview. *Nat Rev Cardiol* 2010; 7: 485–496.

2 Wong ND, Kouwabunpat D, Vo AN, *et al*. Coronary calcium and atherosclerosis by ultrafast computed tomography in asymptomatic men and women: Relation to age and risk factors. *Am Heart J* 1994; 127: 422–430.

3 Demer LL, Tintut Y. Vascular calcification: Pathobiology of a multifaceted disease. *Circulation* 2008; 117: 2938–2948.

4 Johnson RC, Leopold JA, Loscalzo J. Vascular calcification: Pathobiological mechanisms and clinical implications. *Circ Res* 2006; 99: 1044–1059.

5 Moussa I, Ellis SG, Jones M, *et al*. Impact of coronary culprit lesion calcium in patients undergoing paclitaxel-eluting stent implantation (a TAXUS-IV substudy). *Am J Cardiol* 2005; 96: 1242–1247.

6 Thygesen K, Alpert JS, Jaffe AS, *et al*. Third universal definition of myocardial infarction. *J Am Coll Cardiol* 2012; 60: 1581–1598.

7 An international randomized trial comparing four thrombolytic strategies for acute myocardial infarction. The GUSTO investigators. *N Engl J Med* 1993; 329: 673–682.

8 Tomey MI, Kini AS, Sharma SK. Current status of rotational atherectomy. *JACC Cardiovasc Interv* 2014; 7: 345–353.

9 Mota P, Pereira H. Facts on rotational atherectomy for coronary artery disease: Multicentric registry. Presented at EuroPCR, Paris, France, May 21, 2013.

10 Benezet J, Diaz de la Llera LS, Cubero JM, *et al*. Drug-eluting stents following rotational atherectomy for heavily calcified coronary lesions: Long-term clinical outcomes. *J Invasive Cardiol* 2011; 23: 28–32.

11 Tran T, Brown M, Lasala J. An evidence-based approach to the use of rotational and directional coronary atherectomy in the era of drug-eluting stents: when does it make sense? *Catheter Cardiovasc Interv* 2008; 72: 650–662.

12 Abdel-Wahab M, Baev R, Dieker P, *et al*. Long-term clinical outcome of rotational atherectomy followed by drug-eluting stent implantation in complex calcified coronary lesions. *Catheter Cardiovasc Interv* 2013; 81: 285–291.

13 Naito R, Sakakura K, Wada H, *et al*. Comparison of long-term clinical outcomes between sirolimus-eluting stents and paclitaxel-eluting stents following rotational atherectomy. *Int Heart J* 2012; 53: 149–153.

14 Mangiacapra F, Heyndrickx GR, Puymirat E, *et al*. Comparison of drug-eluting versus bare-metal stents after rotational atherectomy for the treatment of calcified coronary lesions. *Int J Cardiol* 2012; 154: 373–376.

15 Clavijo LC, Steinberg DH, Torguson R, *et al*. Sirolimus-eluting stents and calcified coronary lesions: clinical outcomes of patients treated with and without rotational atherectomy. *Catheter Cardiovasc Interv* 2006; 68: 873–878.

16 Pyxaras SA, Mangiacapra F, Wijns W, *et al*. ACEF and clinical SYNTAX score in the risk stratification of patients with heavily calcified coronary stenosis undergoing rotational atherectomy with stent implantation. *Catheter Cardiovasc Interv* 2014; 83: 1067–1073.

17 Park DW, Flaherty JD, Davidson CJ, *et al*. Prognostic influence of diabetes mellitus on long-term clinical outcomes and stent thrombosis after drug-eluting stent implantation in Asian patients. *Am J Cardiol* 2009; 103: 646–652.

18 Kassimis G, De Maria GL, Patel N, *et al*. Evolution of coronary stents in patients with diabetes: Are clinical outcomes still improving? *Expert Rev Cardiovasc Ther* 2014; 12: 997–1003.

19 Ong DS, Jang IK. Causes, assessment, and treatment of stent thrombosis-intravascular imaging insights. *Nat Rev Cardiol* 2015; 12: 325–336.

20 Onuma Y, Tanimoto S, Ruygrok P, *et al*. Efficacy of everolimus eluting stent implantation in patients with calcified coronary culprit lesions: Two-year angiographic and three-year clinical results from the SPIRIT II study. *Catheter Cardiovasc Interv* 2010; 76: 634–642.

21 Dangas GD, Serruys PW, Kereiakes DJ, *et al*. Meta-analysis of everolimus-eluting versus paclitaxel-eluting stents in coronary artery disease: Final 3-year results of the SPIRIT clinical trials program (clinical evaluation of the Xience V everolimus eluting coronary stent system in the treatment of patients with De Novo native coronary artery lesions). *JACC Cardiovasc Interv* 2013; 6: 914–922.