

Original Article

Rotablator Utilization in Managing Complex Calcified Coronary Lesions: A Study of Immediate and Follow-Up Outcomes From an Indian Medical Center

Mohammad Maqbool Sohil¹, MD, FSCAI; Hakim Irfan Showkat^{2*}, MD, FACC; Sadaf Anwar², MBBS, Dip Card, FNIC

ABSTRACT

Background: Rotational atherectomy is an established tool in interventional cardiology for the treatment of calcified coronary lesions. The treatment of calcified lesions (in contrast to simple lesions) with percutaneous transluminal coronary angioplasty has been linked to increased procedural difficulties and a lower success rate. Although rotablation can enhance acute outcomes, the significant restenosis rate still poses a challenge.

Methods: This study aimed to assess the clinical and angiographic results of patients treated with a combination of stenting and rotablation for complicated and calcified lesions.

Results: Before coronary stenting, rotablation was consecutively performed on 106 patients. In 67% of the patients, intravascular ultrasound-guided stenting was employed. The success rate for angiography was 100%, and 96.2% of lesions had successful procedures. Two lesions (1.8%) experienced acute stent thrombosis, while 1 lesion (0.9%) experienced subacute stent thrombosis. Every patient had clinical follow-up at 1 month, 3 months, and 6.4 ± 3 months. Revascularization of the target lesion was required in 1.8% of lesions, Q-wave myocardial infarction occurred in 0.9% of lesions, and mortality was 0.9%.

Conclusions: In the present era, optimal coronary stenting after rotablation in calcified and complex lesions can be performed with a high success rate, an acceptable rate of procedural complications, and a low rate of stent thrombosis. This approach is associated with a low incidence of angiographic restenosis compared with results typically obtained with other interventional strategies in calcified and complex lesion subsets. (*Iranian Heart Journal 2025; 26(1): 16-26*)

KEYWORDS: Rotablation, Calcified lesion, NSTEMI, Left main, Bifurcation

¹ Narayana Hrudayalaya Institute, Ahmedabad India.

² Srinagar MedCity Heart Institute, Kashmir, India.

*Corresponding Author: Hakim Irfan Showkat, MD, FACC, FAPSIC; Srinagar MedCity Heart Institute, Kashmir, India.

Email: docirfanshahi512@gmail.com

Tel: +91-9990390305

Received: February 10, 2024

Accepted: August 29, 2024

The treatment of calcified and complex lesions with angioplasty in previous decades has not met expectations due to a high rate of restenosis, low success rates,

and an increased incidence of acute complications. Coronary stenting reduces the morbidity associated with acute closure and decreases angiographic restenosis when used

for discrete lesions. Nonetheless, the treatment of complex lesions, such as fibrocalcific lesions, with percutaneous transluminal coronary angioplasty (PTCA) has shown lower success rates and higher rates of acute complications, as well as clinical and angiographic restenosis, compared with PTCA treatment of simple lesions. In vivo intravascular ultrasound (IVUS) data have demonstrated that coronary calcium is a significant determinant of decreased wall compliance, leading to a high incidence of dissections when these types of lesions are treated with PTCA. Additionally, when coronary stenting is used in this context, incomplete and asymmetrical stent expansion occurs in up to 50% of cases. Achieving optimal stent expansion is crucial to decreasing the incidence of subacute stent thrombosis and eliminating the need for postprocedural anticoagulation. Rotational atherectomy (RA) is particularly useful in treating calcified lesions because it can effectively ablate calcified plaques.

METHODS

From February 2019 through March 2022, data regarding all patients who received RA treatment for calcified lesions were collected from the catheterization laboratory database for comprehensive recruitment. The relevant clinical and angiographic characteristics at the time of the index percutaneous coronary intervention (PCI), as well as the clinical follow-up outcomes, were recorded. The study protocol received approval from the Institutional Review Board.

The viewing workstation (Philips), which utilized software for quantitative analysis of angiograms, was used to measure angiographic parameters. The angiographic characterization of target lesions in the index coronary angiogram was performed by thoroughly reviewing the session cine. A stenotic left main coronary artery (LMCA)

was identified when any segment of this artery exhibited $\geq 50\%$ diameter stenosis. In the context of coronary artery disease (CAD), vessel numbers were determined by counting each of the 3 major coronary vessels that displayed $\geq 70\%$ diameter stenosis. Severe coronary artery calcification was defined as the presence of readily apparent radiopacities within the vascular walls in more than 1 projection on cine images before contrast medium injection, as detailed in the SYNTAX classification.

The primary option for bypass surgery was coronary artery bypass grafting (CABG) due to LMCA lesions and high SYNTAX scores, which was a strict indication. Following the completion of angiograms, patients and their families were informed of the advantages and disadvantages of PCI and CABG. After the consideration of multiple factors and patient preferences, the final decision to proceed with PCI was made. This study included all patients who provided signed informed consent and underwent PCI with subsequent rotablation.

The Rotablator RA system, manufactured by Boston Scientific Corporation in Natick, MA, USA, was utilized for this study. As per routine protocol, a 1.25–1.75 mm burr RA catheter and a RotaWire floppy guidewire (Boston Scientific Corporation, Natick, MA, USA) were connected to the console to power the device, and a water source was used to cool the system according to the prescribed guidelines. Prior to the procedure, patients already on antiplatelet therapy were administered 150 mg of aspirin and 75 mg of clopidogrel. To ensure an activated clotting time of > 300 seconds, intra-arterial heparin was administered immediately before the intervention. As part of the routine RA process, a cocktail infusion containing verapamil, heparin, and nitroglycerin was delivered intracoronarily. Burr runs lasted 10 seconds or less to prevent burr deceleration. Elective temporary right ventricular pacing was performed in a small number of cases.

The decision to conduct RA-PCI was based on the operator's prior knowledge of significantly calcified coronary lesions. Following the lesion was successfully crossed with a 0.014-inch guidewire, a 0.09-inch RotaWire floppy guidewire was advanced through a microcatheter to replace the initial guidewire. Angiographic success with thrombolysis in myocardial infarction (TIMI) grade III flow was defined by a residual stenosis of < 20%. Procedural success was determined as the achievement of angiographic success without experiencing in-hospital major adverse cardiac events (MACE), encompassing all-cause mortality, myocardial infarction (MI), and repeat revascularization. MACE occurrences were included in the complication assessment. Clinical success was defined as successful discharge without any in-hospital complications. Target lesion revascularization (TLR) was defined as repeat revascularization for restenosis exceeding 50% within the target segment. Target vessel revascularization (TVR) encompassed any repeat revascularization that occurred within the treated vessel. Following the procedure, patients underwent routine monitoring for cardiac biomarkers such as creatine kinase (CK), creatine kinase-MB (CK-MB), and troponin-I. Myonecrosis was identified when CK-MB or troponin-I levels were 3 times higher than their respective baseline levels. Clinical follow-up was carried out through scheduled follow-up visits at 1, 3, 6, and 12 months post-procedure. For patients unable to attend in-person follow-ups, telephonic conversations were conducted to gather relevant information and assess their progress.

Statistical Analysis

The collected data were compiled and entered into a spreadsheet using Microsoft Excel. The data were then exported to the data editor of SPSS version 20.0 (SPSS Inc, Chicago, Illinois, USA) for further analysis. Continuous variables were represented as

means \pm standard deviations, while categorical variables were summarized as frequencies and percentages.

RESULTS

A total of 106 patients were enrolled in this study for the final analysis. The baseline characteristics of the patients are presented in Table 1. The mean age of the patients was 61.8 ± 8.78 years, ranging from 38 to 76 years. Moreover, 32% of the patients had diabetes mellitus, and 0.9% had chronic kidney disease. Additionally, 1.8% of patients had a history of prior CABG, 6.6% had prior PCI, and 10.3% had experienced a recent (within 4 weeks) MI. The mean SYNTAX score was 26.2 ± 8.69 .

Table 1: Demographic Characteristics of the Studied Patients

Variables	Number	Percentage	
Age, y	< 50	11	10.4
	50-59	28	26.4
	60-69	46	43.4
	≥ 70	21	19.8
	Mean \pm SD (range)	61.8 \pm 8.7 (38-76)	
Sex	Male	75	70.8
	Female	31	29.2
Comorbidities		Number	Percentage
Diabetes mellitus		34	32.0
Hypertension		29	27.3
Chronic kidney disease		1	0.9
Epilepsy		1	0.9
Dyslipidemia		31	29.2
Past medical History			
Previous stroke		0	0.0
Previous myocardial infarction		8	7.5
Previous percutaneous coronary intervention		7	6.6
Previous coronary artery bypass grafting		2	1.8
Presentation			
Chest pain on exertion		79	74.5
Dyspnea on exertion		32	30.2
Acute coronary syndrome		11	10.3

The angiographic success rate was 100%, with RA burrs successfully delivered to the

target lesions in all patients. No major procedural complications were reported. The overall procedural characteristics of the patients are presented in Tables 2, 3, 4, 5,

and 6. On average, 1 ± 0.5 RA burrs were used per patient, with a final burr size of 1.6 ± 0.2 mm (Fig. 1).

Table 2: Distribution as per Diagnosis

Diagnosis		Number	Percentage
Coronary artery disease	Single-vessel disease	10	9.4
	Double-vessel disease	48	45.3
	Triple-vessel disease	48	45.3
Left Ventricular Ejection Fraction		Number	Percentage
< 40		3	2.8
40-50		56	52.8
> 50		47	44.3
Approach			
Radial approach		100	94.3
Femoral approach		6	5.7

Table 3: Lesion Characteristics

Lesion Characteristics	Number	Percentage
Left main coronary artery stenosis	12	11.3
Single-vessel disease	10	9.4
Double-vessel disease	28	26.4
Triple-vessel disease	38	35.8
Calcified bifurcation	18	16.9
Syntax Score		
< 22	32	30.2
22-32	39	36.8
> 32	35	33.0
Total	106	100

mean \pm SD (range) = 26.2 ± 8.69 (7–47)

Table 4: Number of Lesions Treated With Rotational Atherectomy

Number of Lesions	Number	
1	25	
2	35	
≥ 3	26	
Total	173	
Lesions Treated With Rotational Atherectomy		
Lesions Treated	Number	Percentage
Left main coronary artery	12	6.9
Left anterior descending artery	72	41.6
Circumflex artery	27	15.6
Right coronary artery	44	25.4
Calcified bifurcation treated with rotational atherectomy	18	10.4

Table 5: Burr Characteristics

Sheath Caliber		Number	Percentage
Burr size	1.25	34	32.1
	1.50	65	61.3
	1.75	7	6.6
Burr speed	1.4 rpm	1	0.9
	1.5 rpm	4	3.8
	1.6 rpm	2	1.9
	1.7 rpm	94	88.7
	1.8 rpm	3	2.8
	1.9 rpm	2	1.9

Table 6: Stent Procedural Characteristics

Stent Characteristics		Number	Percentage
DES implantation	LAD	42	39.6
	RCA	20	18.8
	LCX	14	13.2
	LMCA	12	11.3
	Bifurcation	18	16.9
No. of stents	1	55	51.9
	2	41	38.7
	3	10	9.4
Total stent length (mm)	24-48	43	40.6
	48-72	32	30.2
	72-96	25	23.5
	96-120	4	3.8
	≥ 120	2	1.8

DES: drug-eluting stent, LAD: left main coronary artery, RCA, right coronary artery, LCX: left circumflex artery, LMCA: left main coronary artery

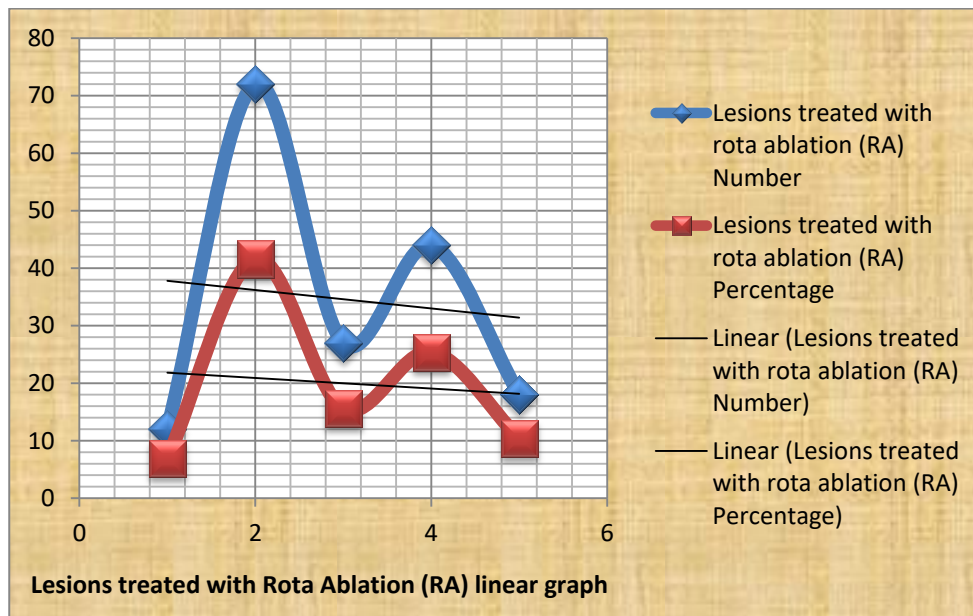


Figure 1: The linear graph shows lesions treated with rota ablation.

Out of the 106 patients, 79% presented with multiple-vessel disease. The average number of diseased vessels per patient was 1.5 ± 0.6 . The left anterior descending artery (LAD) and the right coronary artery (RCA) were the most frequently involved (67.0%), followed by the LMCA in 6.9% of patients. Additionally, 10.4% of patients had bifurcation lesions. On average, 1 ± 0.5 rota burrs were used per patient, with a final burr size of 1.6 ± 0.2 mm and an artery-burr ratio of 0.6 ± 0.1 . For all 18 bifurcation lesions, a 2-stent strategy was employed. IVUS-guided procedures were used to treat 67.0% of the lesions. The average number of stents deployed in each lesion was 1.7 ± 0.5 , with an average total stent length of 56.5 ± 24.6 mm per lesion. Further, 18 patients (10.4%) received additional stents for the treatment of non-rotablated lesions during the primary procedure. Intra-aortic balloon pump (IABP)-assisted procedures were performed on 8 patients (7.5%) who experienced

cardiogenic shock, hypotension, or intractable ventricular tachycardia during the procedure. During hospitalization, 1 patient, a 79-year-old elderly man, expired due to extensive MI and cardiogenic shock. The overall procedural success rate was 96.2%. At the 12-month follow-up, the incidence of out-of-hospital MACE was 1.8% (Table 7). Clinically driven coronary angiographic follow-up was conducted on 23 patients (21.6%), with 2 patients (1.8%) requiring TLR due to ischemia. PCI was successfully employed to treat all cases, and no CABG was necessary. Among patients who underwent angiographic follow-up, no coronary aneurysms were found in the stented segments. Acute stent thrombosis was observed in 1 patient (0.9%) during hospitalization, which necessitated revascularization with stents, using a total stent length of 66 mm for the LMCA-LAD/LMCA-left circumflex artery bifurcation lesion (Fig. 2).

Table 7: Clinical Outcome of the Studied Patients

Clinical Outcomes	In-Hospital		Follow-Up	
	Number	Percentage	Number	Percentage
Clinical success	102	96.2	-	-
Major adverse cardiac events	0	0	2	1.8
Death	0	0	1	0.9
Q-wave myocardial infarction	0	0	1	0.9
Non-Q-wave myocardial infarction	0	0.0	0	0
Target lesion revascularization	0	0	2	1.8
Target vessel revascularization	0	0.0	0	0

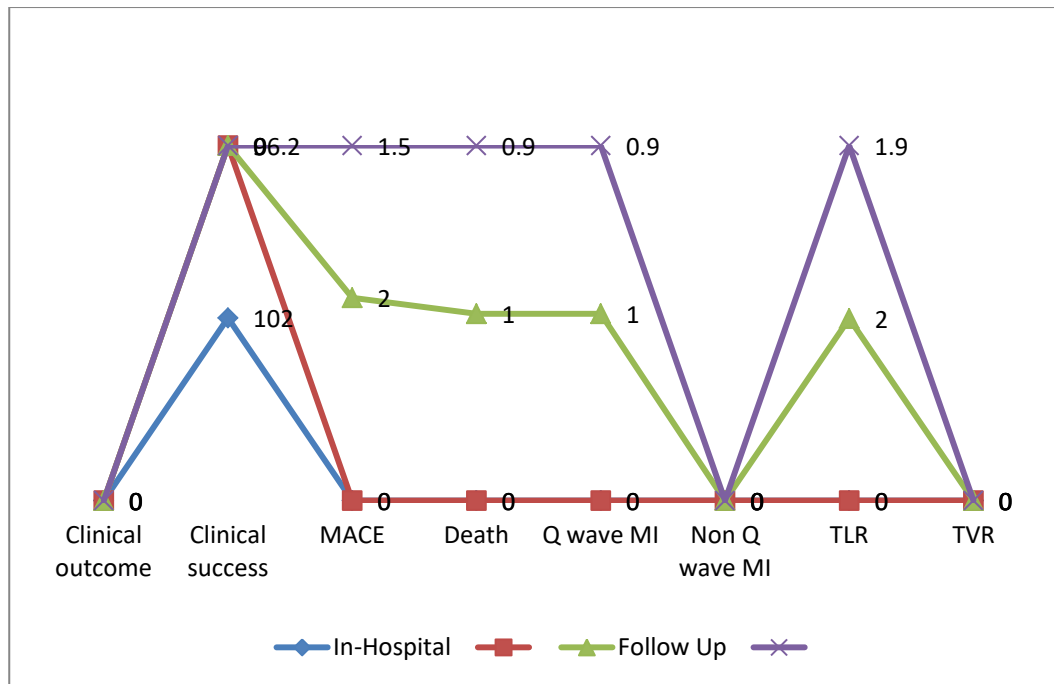


Figure 2: The graph displays the clinical outcomes during hospitalization and follow-up periods.

DISCUSSION

We commonly encounter coronary calcifications, which may be a component of systemic vessel calcinosis.¹ Calcified coronary lesions are frequently linked to an increased risk of restenosis and TLR.² RA has emerged as an essential alternative treatment option for patients with calcified lesions. Although RA was initially developed approximately 30 years ago, isolated RA was initially abandoned due to high complication rates.³ Nevertheless, in the era of the drug-eluting stent (DES), RA has reemerged, as it is now associated with significantly reduced restenosis rates and low complication rates.⁴ Traditionally, RA has been viewed as an elective procedure, and it was more widely performed as a secondary treatment following unsuccessful conventional angioplasty. Recently, however, RA has become increasingly utilized as an upfront procedure in routine practice.

The present study demonstrates notably low complication rates, with successful management of complicated procedures using

RA. The DES has become widely used in contemporary practice due to its efficacy in reducing restenosis and MACE following PCI.⁶ The angiographic and clinical advantages of the DES, along with recent advancements in novel techniques and approaches, have encouraged the increased use of PCI for treating highly complex lesions and high-risk patients.⁷ Treating highly calcified lesions with the DES presents distinct challenges, including inadequate DES deployment, potentially increasing the risk of stent thrombosis; extensive DES manipulation, which may result in damage to the stent's polymer coating; and stent delivery failure. Heavily calcified lesions pose a potential risk for insufficient drug diffusion to the arterial wall.⁸ The presence of calcified lesions in the stent delivery pathway has been shown to significantly impact restenosis following the implantation of sirolimus-eluting stents. Conventional PCI requires the achievement of adequate debulking due to the presence of calcifications. It is expected that positive outcomes will be observed following the deployment and utilization of the DES.⁹ In

calcified lesions, if rotablation is not employed, the DES may be insufficient to prevent restenosis.¹⁰ In our study, multiple rota burrs were necessary for all patients, resulting in a 100% angiographic success rate. Notably, no major procedural complications were reported. The overall procedure success rate was 96.2%, with 1 patient mortality during hospitalization due to extensive MI with cardiogenic shock, which was determined to be unrelated to the procedure itself.

Chiang et al¹¹ reported that the 100% angiographic success rate in their study might be attributed to the use of multiple burrs per lesion, allowing for more comprehensive lesion remodeling. Five patients (7.4%) experienced in-hospital mortality, although none of these deaths was procedure-related; instead, they were all associated with underlying severe MI or ischemia resulting in cardiogenic shock. These 5 patients exhibited severely complex coronary vessel disease, and their PCI complexity was very high, involving multi-vessel PCI and 2-stent LMCA bifurcation stents. Still, the DES with RA can be meticulously performed in the current era with minimal procedural complications. In our study, the complex nature of the lesions and the associated risk factors were evident, with an average of 1.7 ± 0.5 stents implanted per lesion and a total stent length of 56.5 ± 24.6 mm per lesion. Chiang et al¹² also reported on the complexity of the treated lesions, highlighting the use of the 2-stent technique in 36% of patients with true bifurcation lesions and an average final stent length of 47 ± 23 mm.

In our study, 7.5% of patients required IABP-assisted procedures due to cardiogenic shock or intractable ventricular tachycardia. Chiang et al¹³ reported that 20.6% of patients (7 out of 34) necessitated IABP-assisted surgeries during RA in their study. In our study, the incidence of MACE during a mean follow-up

period of 12 months was 1.5%. Clinically driven coronary angiography was performed on 23 patients (21.6%) based on their symptoms, and TLR was required in 2 patients (1.5%) due to ischemia. Patel et al¹³ demonstrated in a monocentric, retrospective study involving younger patients that the utilization of IVUS for PCI on coronary ostial lesions was linked to significantly lower MACE rates (19% vs 38%; $P = 0.004$). In the study by Chiang et al,¹⁴ MACE occurred in 16.1% of patients, all of which involved TLR or TVR. The rates of recurrent angina and MI during follow-up were low (3.3%), and the overall MACE rate was 11.3%. Remarkably, no MACE incidents were reported during hospitalization.

In a previous study involving patients with severely calcified lesions who underwent DES implantation, lesion preparation using RA, a modified balloon, or a super high-pressure balloon yielded comparable stent expansion results.¹⁵ In addition, a super high-pressure balloon led to less stent eccentricity, while RA was linked to a higher frequency of strategy success. Our study also supports these findings, indicating that RA is the most effective technique for managing highly calcified lesions, as it results in fewer procedural complications and improved long-term outcomes. Significantly, we observed no instances of the slow/no-reflow phenomenon in our study. This phenomenon is perhaps the most dangerous, consistent, preventable, and operator-dependent complication of RA.

In a recent RA study conducted during the DES era, slow flow/no-reflow rates showed a significant reduction from 15% to 0.0%,¹⁶ 2.6%,^{17, 18} and 19% to 28%.¹⁹ Slow flow/no-reflow is characterized by an acute decrease or obstruction in the clearance of contrast agent, resulting from microvascular embolism caused by atherosclerotic debris and associated thrombi, platelet activation, and the release of vasoactive mediators.

CONCLUSIONS

In cases of calcified and complex lesions, coronary stenting performed after rotablation can be accomplished with a low incidence of stent thrombosis, manageable procedural complications, and a high success rate. This approach was associated with a low incidence of angiographic restenosis in subgroups of calcified and complex lesions, compared with outcomes typically achieved with other interventional methods. Even high-risk bifurcation lesions, such as LMCA bifurcation, and lesions with heavy calcium load were meticulously treated, resulting in very low procedural complications and a low incidence of restenosis.

Declarations

Ethics approval and consent to participate: The study received approval from the Ethics Committee of Narayana Hrudayalaya in Ahmedabad. Written consent was obtained from all participants.

Consent for publication: Written informed consent was acquired.

Availability of data and material: The data presented in the present study can be provided upon reasonable request.

Conflict of interest: The authors declare no competing interests.

Funding: No funding was received for this study.

Authors' contributions: MMS was responsible for primary data collection, HIS handled data interpretation and the research project, and SA managed the review of work and compilation.

REFERENCES

1. Nonin S, Iwata S, Sugioka K, et al. Plaque surface irregularity and calcification length within carotid plaque predict secondary events in patients with coronary artery disease. *Atherosclerosis*. 2017; 256:29–34. [PubMed] [Google Scholar]
2. Moses JW, Carlier S, Moussa I. Lesion preparation prior to stenting. *Rev Cardiovasc Med*. 2004; 5(suppl 2):16–21. [PubMed] [Google Scholar]
3. Reifart N, Vandormael M, Krajcar M, et al. Randomized comparison of angioplasty of complex coronary lesions at a single center. Excimer Laser, Rotational Atherectomy, and Balloon Angioplasty Comparison (ERBAC) Study. *Circulation*. 1997; 96:91–8. [PubMed] [Google Scholar]
4. 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; 53:149–53. [PubMed] [Google Scholar]
5. Benezet J, Díaz 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. [PubMed] [Google Scholar]
6. Ramsdale DR, Rao A, Asghar O, Ramsdale KA, McKay E. Late outcomes after drug-eluting stent implantation in “real-world” clinical practice. *J Invasive Cardiol* 2008; 20:493e500.
7. Sharma SK. Update in management of coronary bifurcation lesions in the drug-eluting stent era. *Indian Heart J* 2006; 58:108e19.
8. Sousa JE, Serruys PW, Costa MA. New frontiers in cardiology: drugeluting stents: Part I. *Circulation* 2003; 107:2274e9.
9. Furuichi S, Sangiorgi GM, Godino C, Airoidi F, Montorfano M, Chieffo A, et al. Rotational atherectomy followed by drug-eluting stent implantation in calcified coronary lesions. *EuroIntervention* 2009; 5:370e4.

10. Kuriyama N, Kobayashi Y, Yamaguchi M, Shibata Y. Usefulness of rotational atherectomy in preventing polymer damage of everolimus-eluting stent in calcified coronary artery. *JACC Cardiovasc Interv* 2011; 4:588e9.
11. Meng-Hsiu Chiang, Wen-Lieng Lee, Cheng-Rong Tsao et al. The use and clinical outcomes of rotablation in challenging cases in the drug-eluting stent era. *Journal of the Chinese Medical Association* 76 (2013) 71-77.
12. Chiang MH, Yi HT, Tsao CR, Chang WC, Su CS, Liu TJ, Liang KW, Ting CT, Lee WL. Rotablation in the treatment of high-risk patients with heavily calcified left-main coronary lesions. *J Geriatr Cardiol*. 2013 Sep; 10(3):217-25. doi: 10.3969/j.issn.1671-5411.2013.03.009. PMID: 24133507; PMCID: PMC3796693
13. Y. Patel, J. P. Depta, J. S. Patel et al., "Impact of intravascular ultrasound on the long-term clinical outcomes in the treatment of coronary ostial lesions," *Catheterization and Cardiovascular Interventions*, vol. 87, no. 2, pp. 232–240, 2016.
14. Mezilis N, Dardas P, Ninios V, et al. et al. Rotablation in the drug eluting era: immediate and long-term results from a single center experience. *J Interv Cardiol*. 2010; 23:249–253.
15. Tobias Rheude, Sean Fitzgerald, Abdelhakim Allali, Kambis Mashayekhi, Tommaso Gori, Florim Cuculi et al. Rotational Atherectomy or Balloon-Based Techniques to Prepare Severely Calcified Coronary Lesions. *J Am Coll Cardiol Interv*. 2022 Sep, 15 (18) 1864–1874.
16. Hanna GP, Yhip P, Fujise K, Schroth GW, Rosales OR, Anderson HV, Smalling RW. Intracoronary adenosine administered during rotational atherectomy of complex lesions in native coronary arteries reduces the incidence of no-reflow phenomenon. *Catheter Cardiovasc Interv*. 1999; 48:275–278
17. Tomey MI, Kini AS, Sharma SK. Current status of rotational atherectomy. *JACC Cardiovasc Interv*. 2014; 7:345–353. doi:10.1016/j.jcin.2013.12.196
18. Abdel-Wahab M, Richardt G, Joachim Büttner H, Toelg R, Geist V, Meinertz T, Schofer J, King L, Neumann FJ, Khattab AA. High-speed rotational atherectomy before paclitaxel-eluting stent implantation in complex calcified coronary lesions: the randomized ROTAXUS (Rotational Atherectomy Prior to Taxus Stent Treatment for Complex Native Coronary Artery Disease) trial. *JACC Cardiovasc Interv*. 2013; 6:10–19. doi: 10.1016/j.jcin.2012.07.017
19. Kawamoto H, Latib A, Ruparelia N, Ielasi A, D'Ascenzo F, Pennacchi M, Sardella G, Garbo R, Meliga E, Moretti C, Rossi ML, Presbitero P, Magri CJ, Nakamura S, Colombo A, Boccuzzi GG. In-hospital and midterm clinical outcomes of rotational atherectomy followed by stent implantation: the ROTATE multicentre registry. *EuroIntervention*. 2016; 12:1448–1456. doi:10.4244/EIJ-D-16-00386 Crossref Google Scholar Go back to content
20. Abdel-Wahab M, Baev R, Dieker P, Kassner G, Khattab AA, Toelg R, Sulimov D, Geist V, Richardt G. 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. doi:10.1002/ccd.24367 Crossref Medline Google Scholar
21. Naito R, Sakakura K, Wada H, Funayama H, Sugawara Y, Kubo N, Ako J, Momomura S. Comparison of long-term clinical outcomes between sirolimus-eluting stents and paclitaxel-eluting stents following rotational atherectomy. *Int Heart J*. 2012; 53:149–153. Crossref Google Scholar
22. Benezet J, Díaz de la Llera LS, Cubero JM, Villa M, Fernández-Quero M, Sánchez-González A. Drug-eluting stents following rotational atherectomy for heavily calcified coronary lesions: long-term clinical outcomes. *J Invasive Cardiol*. 2011; 23:28–32. Google Scholar
23. Dardas P, Mezilis N, Ninios V, Tsikaderis D, Theofilogiannakos EK, Lampropoulos S. The use of rotational atherectomy and drug-eluting stents in the treatment of heavily calcified coronary lesions. *Hellenic J Cardiol*. 2011; 52:399–406. Google Scholar

24. Garcia de Lara J, Pinar E, Ramon Gimeno J, Hurtado JA, Lacunza J, Valdesuso R, Valdes Chavarri M. Percutaneous coronary intervention in heavily calcified lesions using rotational atherectomy and paclitaxel-eluting stents: outcomes at one year. *Rev Esp Cardiol.* 2010; 63:107–110. Google Scholar
25. Rathore S, Matsuo H, Terashima M, Kinoshita Y, Kimura M, Tsuchikane E, Nasu K, Ehara M, Asakura Y, Katoh O, Suzuki T. Rotational atherectomy for fibro-calcific coronary artery disease in drug eluting stent era: procedural outcomes and angiographic follow-up results. *Catheter Cardiovasc Interv.* 2010; 75:919–927. doi: 10.1002/ccd.22437 Medline Google Scholar
26. Vaquerizo B, Serra A, Miranda F, Triano JL, Sierra G, Delgado G, Puentes A, Mojal S, Brugera J. Aggressive plaque modification with rotational atherectomy and/or cutting balloon before drug-eluting stent implantation for the treatment of calcified coronary lesions. *J Interv Cardiol.* 2010; 23:240–248. doi:10.1111/j.1540-8183.2010.00547.x Crossref Medline Google Scholar
27. Furuichi S, Sangiorgi GM, Godino C, Airolidi F, Montorfano M, Chieffo A, Michev I, Carlino M, Colombo A. Rotational atherectomy followed by drug-eluting stent implantation in calcified coronary lesions. *EuroIntervention.* 2009; 5:370–374. Crossref Google Scholar
28. Clavijo LC, Steinberg DH, Torguson R, Kuchulakanti PK, Chu WW, Fournadjiev J, Satler LF, Kent KM, Suddath WO, Waksman R, Pichard AD. Sirolimus-eluting stents and calcified coronary lesions: clinical outcomes of patients treated with and without rotational atherectomy. *Catheter Cardiovasc Interv.* 2006; 68:873–878. doi:10.1002/ccd.20615
29. Ary KA, Barward P, Bahl A, Sharma Y, Gupta H. Rotablation in complex ACS versus Non-ACS patients: Prospective follow up study from tertiary care centre in North India. *Indian Heart J.* 2022 Nov-Dec; 74(6):510-512. doi:10.1016/j.ihj.2022.11.008. Epub 2022 Nov 24. PMID: 36435206; PMCID: PMC9773281.