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Comparison of clinical significance between optical coherence tomography guided percutaneous coronary intervention and angiography-guided percutaneous coronary intervention in acute coronary syndrome of the south zone of Tamil Nadu

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ABSTRACT

Background: Intravascular optical coherence tomography (OCT) has specific features favoring its utilization in acute coronary syndrome (ACS). OCT has 100% sensitivity for detecting intraluminal thrombus compared to conventional coronary angiograms. **Aims and Objectives:** This study compares the clinical significance of OCT findings during percutaneous coronary intervention (PCI) and angiography-guided PCI in ACS patients. **Materials and Methods:** This prospective observational study was conducted in a tertiary care cardiac center at Tirunelveli Medical College Hospital and included 43 patients who had undergone both conventional and OCT-guided stenting (PCI) coronary angiograms. Their pre- and post-stenting findings of Intravascular OCT, conventional angiogram findings, and follow-up coronary angiogram findings were recorded. **Results:** The mean age of the patients was 51.61 years, with 20 (87%) males and 19 (86.4%) males in the OCT-guided PCI group. Baseline risk factors such as hypertension, smoking, and T2DM were noted. Pre-OCT showed fibrofatty plaque, plaque rupture, red thrombus, spotty calcium, mixed thrombus, and white thrombus. Post-stenting OCT results showed 13.6% Edge dissection, 9.1% Malapposition, 9.1% Red thrombus, 4.5% Tissue prolapse, and 4.5% white thrombus. Five patients had chest pain on follow-up; a check angiogram showed stent thrombosis and restenosis in four cases (17.4%), and reintervention was done. One case of early stent thrombosis expired, which is statistically significant. **Conclusion:** Intravascular OCT is a promising new and advanced technology for intra-coronary imaging due to its high resolution and dynamic range.

Key words: Optical coherence tomography; Conventional percutaneous coronary intervention; Acute coronary syndrome; Angiography

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INTRODUCTION

Coronary angiography has been the gold standard invasive imaging method for diagnosing coronary artery disease for the last three decades and guiding coronary interventional procedures. Conventional percutaneous coronary intervention (PCI) is a common and cornerstone treatment for patients with acute coronary syndromes (ACSs). Intravascular optical coherence tomography (OCT) has emerged as a newer imaging modality to evaluate the vessel microstructure in detail, which cannot be visualized in routine, conventional angiography. However, except for calcium, the penetration depth of OCT is lower than with IVUS. Now, coronary Intravascular OCT systems

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have evolved from first-generation time-domain systems to advanced second-generation frequency-domain Intravascular OCT. The latter produces images at higher frame rates with slightly deeper penetration using a short, non-occlusive flush and rapid spiral pullback.[1,2] We had the opportunity to perform the first Intravascular OCT studies in the South zone of Tamil Nadu at Tirunelveli Medical College and Hospital. In addition to research purposes, we recognized the invaluable potential of Intravascular OCT as a diagnostic technique and as an adjunctive tool for PCI to prevent stented thrombus.

The Intravascular OCT image is formed by the backscattering of emitted near-infrared light and observed cross-sectional images of the coronary vessel microstructure. Intravascular OCT images were acquired using the FD-OCT Optis system and the 6F guide-compatible Dragonfly Optis catheter. The catheter was introduced into the coronary artery via a standard 0.014-inch angioplasty guide wire after a prior injection of an intracoronary bolus of nitroglycerine. Nonocclusive flushing was performed using a continuously injected contrast medium via an automated power injector to adequately remove all blood from the imaging site. The OCT catheter was pulled back at 18 mm/s speed to guarantee sufficient time to acquire images of a 54-mm-long segment. Intravascular OCT now has unique features that favor its utilization in the setting of ACS. Intravascular OCT has 100% sensitivity in detecting intraluminal thrombus compared to conventional coronary angiograms.[3]

The method's high sensitivity in detecting thrombus can fulfill conventional angiographic limitations in differentiating thrombus from calcium and other etiologies of ambiguous angiographic radiolucency.[4]

Intravascular OCT is considered the standard gold method for fibrous cap rupture detection and vulnerable plaque and has twice the cardiac intravascular ultrasound (IVUS) sensitivity. The spatial resolution of cardiac intravascular OCT is 10–20 μm, approximately ten times greater than cardiac IVUS. An excellent contrast material between the lumen and vessel wall in cardiac intravascular OCT allows accurate lumen measurements, which helps determine the appropriate balloon or stent size.[5-8] After stenting, intravascular OCT is used to access optimal stent expansion, malapposition, tissue protrusion, edge dissection, and thrombus burden, etc.[9] OCT gives a good insight into the mechanisms of stent failure in the form of stent thrombosis.[10]

This study compares the clinical significance of OCT findings during PCI and angiography-guided PCI in ACS among patients at Tirunelveli Medical College.

Aims and objectives

The aim of this study is to compare the clinical significance of optical coherence tomography (OCT) findings during percutaneous coronary intervention (PCI) and angiography-guided PCI in patients with Acute Coronary Syndrome (ACS).

MATERIALS AND METHODS

This prospective observational study was conducted at the Department of Cardiology, Tirunelveli Medical College and Hospital, for 2 years.

All cases admitted to the cardiology department of Tirunelveli Medical College Hospital are under the inclusion criteria during study periods.

Inclusion criteria

Age >18 years, male and female, patients willing to give written informed consent, all ACS patients who underwent OCT, and some randomly chosen patients who underwent conventional PCI during the study period were included.

Exclusion criteria

Uncontrolled blood sugar, cardiogenic shock, ventricular septal rupture, other life-threatening complications, sepsis, post-covid sequelae, and primary life-threatening conditions were excluded.

Forty-five patients who had undergone coronary angiograms, both conventional and OCT-guided stenting (PCI), were selected for the study. Their pre- and post-stenting findings of Intravascular OCT, conventional angiogram findings, and follow-up coronary angiogram findings were recorded.

Potential patients were identified by the treating Cardiologist in the ICCU. Patients who met the eligibility criteria were registered for the study. Written informed consent was obtained from all subjects before initiating any study-specific procedures. Procedures performed as part of the subject's routine clinical management and obtained before signing the informed consent may be utilized for screening or baseline purposes, provided the procedure was performed within the timeframe specified in the protocol.

Demographics, including age, sex, address, diagnosis (ACS), risk factors (T2DM, Smoker, SHT, etc.), coronary angiogram reports, check coronary angiogram reports, conventional and OCT-guided PCI reports, outcomes, and follow-up were recorded.

Data entry was done in Microsoft Excel, and statistical analysis was done using SPSS version 23. A $P<0.05$ was considered statistically significant, and all statistical tests were two-sided. Categorical variables are presented as numbers (percentages) and were compared by the Chi-squared test. Continuous variables are presented as the mean±standard deviation and were compared between groups by t-test or analysis of variance, as appropriate.

RESULTS

In the conventional PCI group, the mean age was 51.61 years, and in the OCT guide PCI group, the mean age was 56.27 years, which is statistically insignificant (P=0.095).

Among both studies, the majority of the patients were male. Among the conventional PCI group, 20 (87%) were males, 3 (13%) were females, and in the OCT-guided PCI group, 19 (86.4%) were males and 3 (13.6%) were females.

Baseline risk factors like hypertension (one vs. one case) (4.3% vs. 4.5%), smoking (17 vs. 15 cases) (74% vs. 68.2%), and T2DM (7 vs. 8 cases) (34.7% vs. 36%) were noted in conventional and OCT-guided PCI groups. Association with Smoking (17 vs. 15) (74% vs. 68.2%) was more common in our patients.

In the Conventional PCI group, Out of 23 patients, the majority had undergone PCI to left anterior descending (LAD)-13 (56.5%), followed by PCI to left circumflex artery (LCX)-2 (8.7%), and PCI to LAD and LCX-1 (4.3%). In the OCT-guided PCI group, Out of 22 patients, the majority had undergone OCT-guided PCI to LAD-15 (68.2%), followed by PCI to LCX-2 (9.1%), PCI to left main (LM) to LAD-1 (4.5%), PCI to RAMUS-1 (4.5%), PCI to right coronary artery-2 (9.1%), and deferred PCI 1 (4.5%).

In the Conventional PCI group, Out of 23 patients, the majority had AWMI-12 (52.2%), followed by IPWMI-6 (26.1%), IWMI-2 (8.7%), Unstable angina-2 (8.7%), and IPLWMI-1 (4.3%). In the OCT-guided PCI group, Out of 22 patients, the majority had AWMI-12 (54.5%), followed by IPWMI-4 (18.2%), Unstable angina-4 (18.2%), IPLWMI-1 (4.5%), and IWMI-1 (4.5%).

Among the conventional PCI group, ten patients (43.5%) needed pre-dilatation before PCI, and 12 patients (52.2%) needed post-dilatation after PCI. In the OCT-guided PCI group, six patients (27.3%) needed pre-dilatation before PCI, and ten patients (45.5%) needed post-dilatation after PCI (Table 1).

In OCT guided PCI group, Pre OCT showed Fibro fatty plaque in 13 (59.1%), Plaque rupture in 5 (22.7%), Red thrombus in 4 (18.2%), Spotty calcium in 4 (18.2%), Mixed thrombus in 2 (9.1%) white thrombus in 1 (4.5%). Post-stenting OCT results showed 3 (13.6%) Edge dissection, 2 (9.1%) Malapposition, 2 (9.1%) Red thrombus, and 1 (4.5%) Tissue prolapse, 1 (4.5%) white thrombus (Table 2).

Table 1: The demographics and baseline characteristics of the patients

Variables	Group				P-value
	Conventional PCI (%)		OCT guided PCI (%)		
Mean age	51.61	8.86	56.27	9.26	0.095
Sex					
Female	3	13.0	3	13.6	0.953
Male	20	87.0	19	86.4	
Coronary Angio					
LAD	13	56.5	17	77.3	0.259
LAD and LCX	1	4.3	0	0.0	
LCX	2	8.7	2	9.1	
RAMAS	0	0.0	1	4.5	
RCA	7	30.4	2	9.1	
PCI					
Deferred	0	0.0	1	4.5	0.33
LAD	13	56.5	15	68.2	
LAD and LCX	1	4.3	0	0.0	
LCX	2	8.7	2	9.1	
LM to LAD	0	0.0	1	4.5	
RAMUS	0	0.0	1	4.5	
RCA	7	30.4	2	9.1	
Diagnosis					
AWMI	12	52.2	12	54.5	0.848
IPLWMI	1	4.3	1	4.5	
IPWMI	6	26.1	4	18.2	
IWMI	2	8.7	1	4.5	
Unstable Angina	2	8.7	4	18.2	
Pre-dilation					
No	13	56.5	16	72.7	0.256
Yes	10	43.5	6	27.3	
Post-dilatation					
No	11	47.8	12	54.5	0.652
Yes	12	52.2	10	45.5	

LAD: Left anterior descending artery, LCX: Left circumflex artery, RCA: Right coronary artery, LM: Left main artery, PCI: Percutaneous coronary intervention, OCT: Optical coherence tomography, AWMI: Anterior wall myocardial infarction, IPLWMI: Inferoposterolateral wall myocardial infarction, IPWMI: Inferoposterior wall myocardial infarction, IWMI: Inferolateral wall myocardial infarction

Table 2: Pre- and post-OCT finding

Variables	Frequency	Percentage
Pre-OCT		
Spotty calcium	4	18.2
Red thrombus	4	18.2
White thrombus	1	4.5
Mixed	2	9.1
Fibrofatty plaque	13	59.1
Plaque rupture	5	22.7
Post-OCT		
Red thrombus	2	9.1
White thrombus	1	4.5
Tissue prolapse	1	4.5
Edge dissection	3	13.6
Malapposition	2	9.1

OCT: Optical coherence tomography

On follow-up, all 22 patients in the OCT-guided PCI group had no complaints and No stent thrombosis. Five patients had chest pain in the conventional PCI group on follow-up, and a check angiogram was done. Check CAG showed stent thrombosis and restenosis in 4 cases (17.4%), and reintervention was done. Among the above four stent thrombosis cases, three patients presented with early and one with late stent thrombosis. Among the 4 cases, one early stent thrombosis patient expired, which is statistically significant (p=0.020) (Table 3 and Figures 1-6).

Table 3: Check CAG follow-up between groups

Follow-up	Group				P-value
	Conventional PCI		OCT guided PCI		
Check CAG					
Nil complaints	18	78.3%	22	100.0%	0.020
C/o chest pain	5	21.7%	0	0.0%	

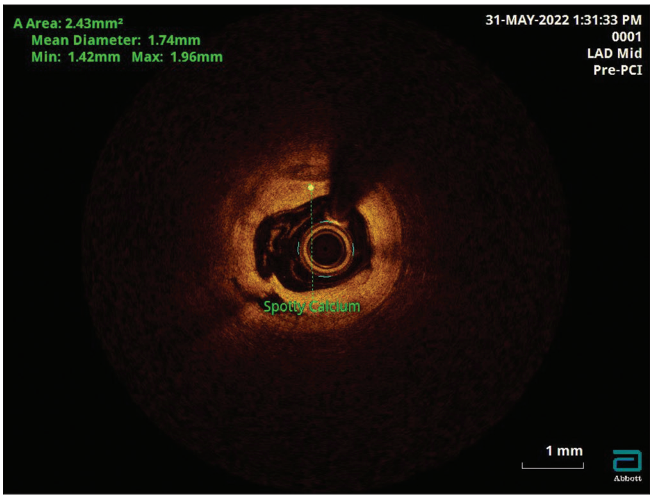

Figure 1: Optical coherence tomography image of spotty calcium (arrow) at the site of an acute coronary syndrome culprit lesion

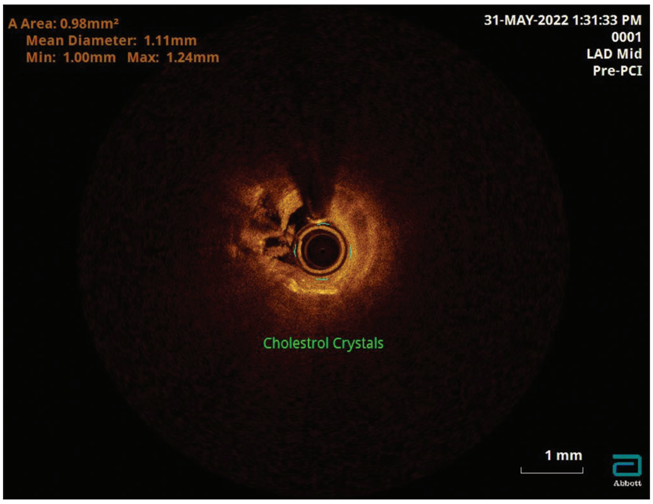

Figure 2: Optical coherence tomography image of cholesterol crystals (arrow) at the site of an acute coronary syndrome culprit lesion

DISCUSSION

This study was the first to compare the clinical significance between OCT-guided PCI and angiography-guided PCI in ACS in the south zone of Tamil Nadu. It has the following implications: OCT can be safely performed to guide routine PCI, and OCT discloses additional procedural issues not recognized by conventional angiography in most unselected patients undergoing PCI, leading to further interventions in a third of them. In this Prospective observational study, OCT guidance on top of angiography was associated with significant clinical benefits.

Over the last 30 years, significant advancements have been made in PCI, decreasing early complications and improving long-term outcomes.[11] However, despite these advancements, the imaging approaches utilized for PCI have remained relatively unchanged since their introduction

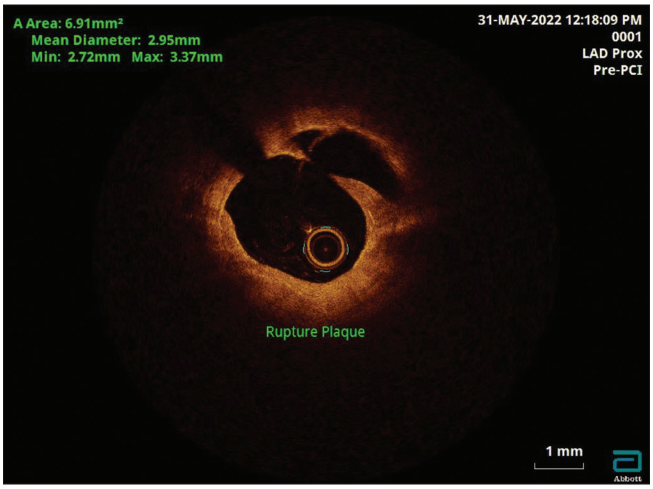

Figure 3: Optical coherence tomography image of ruptured plaque (arrows) with a thin fibrous cap at the site of an acute coronary syndrome culprit lesion

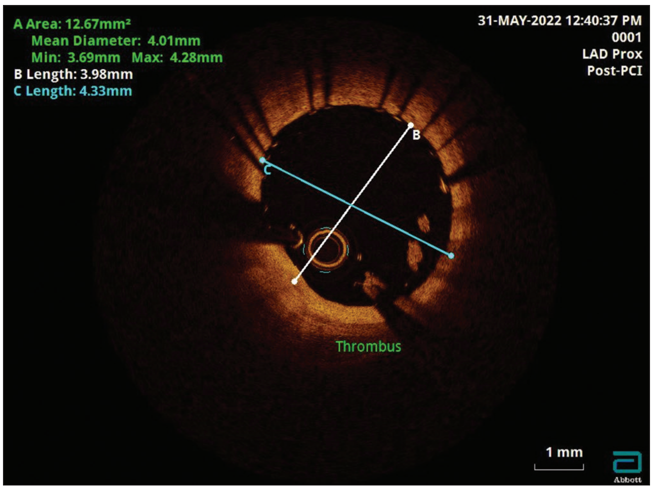

Figure 4: Optical coherence tomography image shows a red thrombus (arrows) with the drug-eluting stent

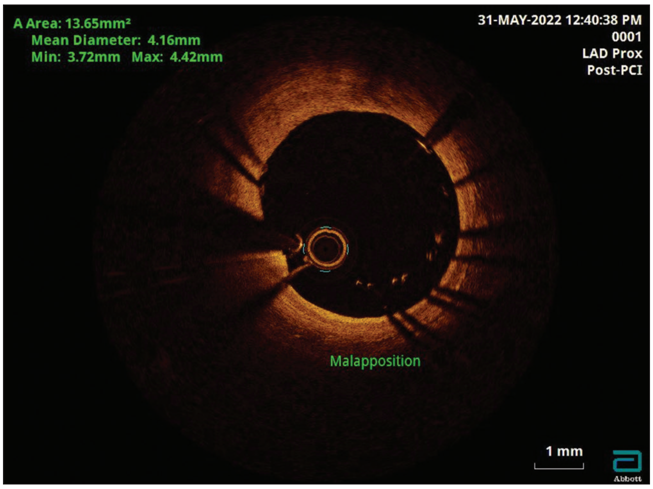

Figure 5: Optical coherence tomography image shows incomplete stent apposition (arrows) with the drug-eluting stent

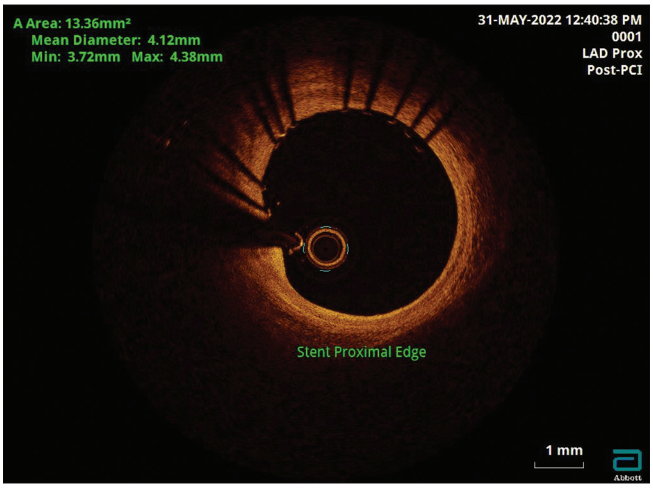

Figure 6: Optical coherence tomography image shows stent proximal edge dissection (arrows) with the drug-eluting stent

by Andreas Gruntzig over 40 years ago.[12] Although the limitations of angiography for guiding coronary procedures are well documented, it remains the primary imaging modality used for most PCI cases.[13]

Associated risk factors like hypertension (one vs. one case) (4.3% vs. 4.5%), smoking (17 vs. 15 cases) (74% vs. 68.2%), and T2DM (7 vs. 8 cases) (34.7% vs. 36%) in conventional and OCT-guided PCI were noted in our study. Association with smoking (17 vs. 15) (74% vs. 68.2%) was more common in our patients, but in a study by Iftikhar et al., at the Institute of Cardiology, Rawalpindi, Pakistan, Diabetes mellitus was the most commonly associated risk factor.[14]

Our study aimed to assess the feasibility of using OCT to evaluate the nature of the atherosclerotic process in various coronary syndromes in native coronary arteries and to identify other processes that may require further interventions after stent placement.[15] The results of this study provide additional insight into the pathophysiology of coronary plaques and highlight the limitations of stent optimization when relying solely on coronary angiogram-guided PCI.[16] There was a trend toward fibrofatty plaque in 13 (59.1%), Plaque rupture in 5 (22.7%), Red thrombus in 4 (18.2%), Spotty calcium in 4 (18.2%), Mixed thrombus in 2 (9.1%), and white thrombus in 1 (4.5%) in ACSs. These findings indicate that lipids are the main component of a vulnerable plaque. The fibrous cap may be a prerequisite for rupturing a plaque leading to ACS. A study conducted by Mizukoshi et al., reported that the frequency of plaque rupture (43% vs. 13% vs. 71%, $P<0.001$) and plaque erosion (32% vs. 7% vs. 8%, $P=0.003$) was significantly different among the types of UAP in Braunwald classes I, II, and III, TCFA (72%, 50%, and 20% in AMI, UAP, and stable AP, respectively).[17]

This study provides statistical inferences on the benefit of angiographic plus OCT-guidance versus angiographic guidance alone. We found that OCT can be safely and effectively performed whenever needed, thanks to the current low-profile probe and the non-occlusive technique.[18] Moreover, we showed that OCT opens a real Pandora's box of potentially severe procedural issues that are altogether missed by angiography, including 3 (13.6%) Edge dissection, 2 (9.1%) malapposition, 2 (9.1%) red thrombus, 1 (4.5%) tissue prolapse, and 1 (4.5%) white thrombus. Based on post-OCT findings, additional post-dilatation was undertaken in 9.1% of patients with malapposition; rich, potent dual anti-platelet drugs for at least 1 year for white thrombus; glycoprotein IIb/IIIa inhibitors, mainly Tirofiban injection for red thrombus; and conservative management for edge dissection, which resulted in nil complications during follow-up.

According to Iftikhar et al.'s study, 32 (47.7%) patients received post-dilatation, 11 patients (16.4%) required additional stent placements, and 6 (8.9%) patients underwent thrombus aspiration based on post-OCT findings.[14] The Does OCT Optimize Results of Stenting trial revealed that OCT is significantly more effective than angiography in identifying stent under expansion (42% vs. 10.8%), incomplete lesion coverage (20% vs. 17%), edge dissection (37.5% vs. 4%), and stent malapposition (which is not visible under fluoroscopy alone) in 32% of patients undergoing OCT.[19]

In cases of stent failure, OCT-guided intracoronary imaging is highly recommended, as it helps identify the underlying mechanism causing stent thrombosis and aids in determining the most appropriate treatment. Results from a study showed that in the conventional PCI group, stent failure with stent thrombosis was observed in four cases, and the primary markers for early stent thrombosis were underexpansion and edge dissection. For late stent thrombosis, markers included expansion, late acquired stent malapposition, and neoatherosclerosis. A personalized treatment strategy that addresses the specific failure mechanism is suggested, such as post-dilatation for malapposition or underexpansion, implantation of an additional drug-eluting stent for neoatherosclerosis, and dual potent anti-platelet drugs for stent thrombosis.[20]

Limitations of the study

Small sample size, single-center study, observational design, selection bias, lack of blinding, limited follow-up, and limited external validity.

CONCLUSION

Intravascular OCT is a cutting-edge technology for intracoronary imaging that provides high-resolution and broad dynamic range details about the morphology of coronary plaque and a better understanding of ACS and stent microstructures. Post-stent placement, OCT is a useful tool in assessing optimal stent expansion, malapposition, tissue prolapse, edge dissection, red and white thrombus, and estimating thrombus burden and the need for reintervention. With its ability to assess optimization techniques during and after stent placement, OCT-guided PCI is deemed superior to conventional angiography-alone-guided PCI.

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