# Impact of Diabetes duration on Clinical outcome in Patients receiving Rotational Atherectomy from ROCK Registry : a multicenter, retrospective study.

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# Abstract

**Background:** There are limited data regarding the clinical impact of diabetes duration for patients with heavy calcified coronary lesions. We sought to determine the clinical impact of diabetes duration on clinical outcomes in patients with heavily calcified lesions required rotational atherectomy (RA) during percutaneous coronary intervention (PCI).

**Methods:** A total of 540 diabetic patients (583 lesions) were enrolled between January 2010 and October 2019. Patients were classified into 3 subgroups: patients with no diabetes mellitus (non-DM), shorter duration of DM (S-DM), and longer duration of DM (L-DM), of which duration was divided at 10 years. The primary outcome was target-vessel failure (TVF), a composite outcome of cardiac death, target-vessel myocardial infarction, or target-vessel revascularization.

**Results:** During 18 months of follow-up-duration, diabetes duration was significantly associated with the primary outcome. The incidence rate of TVF, primary outcome, was significantly higher in the L-DM group compared with non-DM or S-DM groups (non-DM, 30 [12.0%] vs. S-DM, 9 [13.9%] vs. L-DM, 29 [21.6%]; p=0.039). Among secondary outcomes, any repeat revascularization was frequently observed in the L-DM compared with other groups (non-DM, 19 [7.6%] vs. S-DM, 6 [9.2%] vs. L-DM, 21 [15.7%]; p=0.042). In multivariate analysis, the risk of TVF and any RR was 1.9 times and 2.4 times higher in L-DM than in non-DM, respectively.

**Conclusions:** This study was firstly demonstrated that the association between a longer DM duration and poor clinical outcomes in patients with severe calcified CAD after PCI. More careful monitoring for recurrence is needed during follow-up in those patients


# Introduction

Diabetes mellitus (DM) is a well-known risk factor for coronary artery disease (CAD) (1) and is also associated with coronary artery calcifications (CACs), greater atherosclerosis burden, and multivessel disease (2, 3), which consequently results in poor clinical outcomes following percutaneous coronary intervention (PCI) (4–6).

Because DM is a chronic, progressive disease leading to micro- or macrovessel damage (7), the duration of diabetes (DM duration) is also associated with clinical outcomes in patients with CAD (8, 9). There were several studies comparing CAD mortality and clinical outcomes following PCI, including rotational atherectomy (RA), between diabetes and non-diabetic patients (6, 10, 11). However, the clinical impact of DM duration is not well-known and there have been few studies describing the relationship between DM duration and clinical outcome after PCI, especially in heavy calcified lesions. Therefore, we sought to determine the clinical impact of DM duration on procedural, in-hospital and mid-term clinical outcomes in patients with heavy CAC lesions underwent PCI using RA.

# Methods

**Study design and population.** The study population consisted of 540 patients (583 lesions) with calcified CAD who underwent PCI using RA between January 2010 and October 2019 at 9 tertiary centers in Korea within the ROCK registry approved by the institutional review board of each hospital. Data were collected at enrolled centers using a standardized case report form to record demographic characteristics, clinical characteristics, procedural data and follow-up data. Follow-up data were collected up to 18 months based on medical records and on physician or patient interviews at the time of registry enrollment. To determine the presence and duration of diabetes, we reviewed the medical records; otherwise, they were self-reported. DM duration was calculated as the difference between age and age of onset of diabetes. Patients whose duration of diabetes was not investigated were excluded from the study.

Patients divided into three subgroups based on 10 years duration. The reason for dividing the groups at 10 years is that a type 2 DM duration of 10 years is known to be the point at which beta cell loss becomes irreversible and cannot be restored through the achievement of glycemic control (12). This process leads to high risk for the development of macro- and microvascular complications (13). In addition, we refer to previous studies in which a duration of 10 or more years predicts significant CAD, increases the risk of cardiovascular disease, and is associated with higher adverse cardiovascular events. (14). The flow chart is displayed in Fig. 1. The baseline characteristics of the study patients and clinical outcomes were compared between the three groups.

**RA procedure.** The treatment strategy, including decisions regarding burr size during the procedure, was dependent on the discretion of the attending operators. All procedures were guided by standard techniques and management. All RA procedures were performed using the Rotablator™ RA system (Boston Scientific, Marlborough, MA, USA). Antiplatelet therapy and peri-procedural anticoagulation were performed according to the accepted guidelines. During follow-up, patient management, including medical treatment, was performed in accordance with accepted guidelines and established standards of care. This study was approved by the local ethics committee of each hospital, and all patients provided written informed consent for the use of their clinical data for the registry study.

**Clinical outcomes.** The primary endpoint was the target-vessel failure (TVF), defined as cardiac death, target-vessel spontaneous myocardial infarction (TVMI), or target-vessel revascularization (TVR). The secondary endpoints included all-cause death, cardiac death, any MI, TVMI, any revascularization, and TVR. Technical/procedural success, in-hospital events, or peri-procedural complication were also investigated. The definition of outcomes were same as previously published report (15).

Especially, diabetes was defined as either a previously diagnosed DM or newly diagnosed DM using the 2010 criteria of the American Diabetes Association. According to this definition, subjects with fasting glucose ≥ 126 mg/dl and/or glycated hemoglobin ≥ 6.5% and/or post-challenge glucose (glucose at 2 h after a 75 g oral glucose load) ≥ 200 mg/dl were newly diagnosed with DM. Peri-procedural MI was defined as a peak elevation of the creatine kinase-myocardial band > 10-fold above the upper reference limit within 48 hours after the procedure. Cerebrovascular accident (CVA) was defined as a focal neurological deficit of central origin lasting > 24 h, confirmed by a neurologist and imaging. Chronic

kidney disease (CKD) was defined as an estimated glomerular filtration rate < 60 mL/min/1.73 m2, as calculated using the Modification of Renal Diet (MDRD) equation from baseline serum creatinine (16). Contrast-induced nephropathy (CIN) after PCI was defined as the impairment of kidney function, measured as either a 25% increase in serum creatinine from baseline or a 0.5 mg/dL increase in absolute serum creatinine value within 48–72 hours after the procedure. All clinical events were confirmed by source documentation collected at each hospital and centrally adjudicated by an independent group of clinicians unaware of the revascularization type.

**Statistical analysis.** Continuous variables are presented as the median and interquartile range or mean ± standard deviation using Student's t-test. Categorical variables were expressed as numbers and percentages. Differences between the groups, categorized according to the DM duration, were compared using analysis of variance (ANOVA) or the Kruskal-Wallis test for continuous variables, and the chi-square test or Fisher's exact test for categorical variables as appropriate. Post hoc tests were performed using ANOVA with the Tukey method or the Kruskal-Wallis test with Bonferroni correction. Univariable and multivariable Cox regression analyses were performed to analyze the impact of DM duration on clinical outcomes. The hazard ratio (HR) and 95% confidence interval (CI) were also calculated. For multivariate analysis, confounding factors were age, sex, hyperlipidemia, CKD, dialysis, CVA, PVD, multivessel disease (MVD), Hb, total cholesterol, LDL cholesterol, HbA1c, and contrast-induced nephropathy. Event rates were estimated using Kaplan–Meier estimates in time-to-first-event analyses and were compared using the log-rank test. For subgroup analysis, Cox regression analysis was performed and visualized by forest plots. A p value < 0.05 was considered statistically significant. All statistical analyses were performed using Statistical Analysis Software (SAS, version 9.2, SAS Institute, Cary, NC, USA).

# Results

**Baseline characteristics.** Patients were divided into three groups according to the DM duration. Among a total of 583 lesions, 133 lesions of which DM duration was not investigated were excluded from the study. The remaining 450 lesions were analyzed and divided into three subgroups based on 10 years of DM duration: (1) non-DM group (251 lesions), (2) a shorter duration DM group (65 lesions) with DM duration of < 10 years (S-DM), and (3) a longer duration DM group (134 lesions) with DM duration of ≥ 10 years (L-DM).

Table 1. presents a comparison of baseline characteristics between the non-DM, S-DM, and L-DM groups. There was no significant difference demographic variables among the three groups except for proportion of gender, CKD, and history of hyperlipidemia, CVA and PVD which were more frequently observed in the diabetic groups than non-DM group. Especially, the proportions of CKD and dialysis which were known as risk factors for poor prognosis, were statistically significant and gradually increased in order of non-DM, S-DM, and L-DM (CKD, 27 [0.8%] vs. 8 [12.3%] vs. 37 [27.6%], p < 0.001; dialysis, 15 [6.0%] vs. 5 [7.7%] vs. 20 [14.9%], p = 0.012). Besides, the level of lipid profile was different between non-DM versus S-DM or L-DM, which showed significantly lower in the diabetic groups than in the non-DM group. The level of HbA1c level increased gradually according to the DM duration (5.8 ± 0.5 vs. 7.0 ± 1.3 vs. 7.6 ± 1.9, p <

0.001, respectively). MVD was lower in the no DM group than in the diabetic group, but there was no difference between the S-DM and L-DM groups (189 [75.3%] vs. 56 [86.2%] vs. 115 [85.8%], p = 0.02, respectively; Table 2).

Table 1
Baseline characteristics

| | Non-DM (n = 251) | S-DM (n = 65) | L-DM (n = 134) | *p*-Value | Post-hoc* |
|---|---|---|---|---|---|
| DM duration, years | | 5(0.17–7.33) | 20(13.75-26) | | |
| Age, years | 71.8 ± 10.9 | 71.9 ± 9.7 | 70.5 ± 9.0 | 0.50 | |
| Sex | | | | 0.018 | 1 > 3 |
| Male | 164 (65.3) | 37 (56.9) | 68 (50.8) | | |
| Female | 87 (34.7) | 28 (43.1) | 66 (49.2) | | |
| Smoking | 53 (21.1) | 14 (21.5) | 26 (19.4) | 0.91 | |
| BMI | 24.18 ± 4.23 | 24.40 ± 3.26 | 24.03 ± 3.51 | 0.82 | |
| HTN | 182 (72.5) | 52 (80.0) | 106 (79.1) | 0.24 | |
| Hyperlipidemia | 95 (37.9) | 40 (61.5) | 64 (47.8) | 0.002 | 1 < 2 |
| CKD | 27 (10.8) | 8 (12.3) | 37 (27.6) | < 0.001 | 1, 2 < 3 |
| Dialysis | 15 (6.0) | 5 (7.7) | 20 (14.9) | 0.012 | 1 < 3 |
| Previous PCI | 54 (21.5) | 22 (33.9) | 38 (28.4) | 0.08 | |
| Previous CABG | 9 (3.6) | 6 (9.2) | 8 (6.0) | 0.16 | |
| Previous MI | 32 (12.8) | 8 (12.3) | 12 (9.0) | 0.53 | |
| CVA | 29 (11.6) | 16 (24.6) | 20 (14.9) | 0.028 | 1 < 2 |
| PVD | 12 (4.8) | 9 (13.9) | 16 (11.9) | 0.011 | 1 < 2, 3 |
| Chronic lung disease | 19 (7.6) | 8 (12.3) | 5 (3.7) | 0.08 | |
| Heart failure | 32 (12.8) | 16 (24.6) | 22 (16.4) | 0.06 | |
| Atrial fibrillation | 23 (9.2) | 11 (16.9) | 10 (7.5) | 0.10 | |
| Clinical diagnosis | | | | 0.66 | |
| Stable angina, | 100 (39.8) | 24 (36.9) | 58 (43.3) | | |
| Acute coronary syndrome | 151 (60.2) | 41 (63.1) | 76 (56.7) | | |
| HbA1C | 5.8 ± 0.5 | 7.0 ± 1.3 | 7.6 ± 1.9 | < 0.001 | 1 < 2 < 3 |

DM, diabetes mellitus; S-DM, shorter duration of diabetes mellitus; L-DM, longer duration of diabetes mellitus; BMI, body mass index; HTN, hypertension; CKD, chronic kidney disease; PCI, percutaneous coronary intervention; CABG, coronary artery bypass graft; MI, myocardial infarction; CVA, cerebrovascular accident; PVD, peripheral vascular disease; HbA1c, glycated hemoglobin.

| | Non-DM (n = 251) | S-DM (n = 65) | L-DM (n = 134) | *p*-Value | Post-hoc* |
|---|---|---|---|---|---|
| Total cholesterol | 152.5 ± 41.7 | 139.0 ± 37.6 | 138.1 ± 34.5 | 0.001 | 1 > 2, 3 |
| LDL cholesterol | 90.8 ± 36.2 | 73.4 ± 28.1 | 76.8 ± 30.2 | < 0.001 | 1 > 2, 3 |
| HDL cholesterol | 48.5 ± 15.3 | 43.8 ± 13.5 | 43.3 ± 14.1 | 0.003 | 1 > 2, 3 |
| Triglyceride | 118.9 ± 78.0 | 140.7 ± 70.3 | 124.1 ± 73.8 | 0.15 | |

DM, diabetes mellitus; S-DM, shorter duration of diabetes mellitus; L-DM, longer duration of diabetes mellitus; BMI, body mass index; HTN, hypertension; CKD, chronic kidney disease; PCI, percutaneous coronary intervention; CABG, coronary artery bypass graft; MI, myocardial infarction; CVA, cerebrovascular accident; PVD, peripheral vascular disease; HbA1c, glycated hemoglobin.

Table 2
Baseline angiographic characteristics and procedural details.

| | Non-DM (n = 251 lesions) | S-DM (n = 65 lesions) | L-DM (n = 134 lesions) | *p*-Value |
|---|---|---|---|---|
| Lesion classification | | | | 0.22 |
| B1, n (%) | 11 (4.4) | 1 (1.5) | 4 (3.0) | |
| B2, n (%) | 23 (9.2) | 2 (3.1) | 16 (11.9) | |
| C, n (%) | 217 (86.5) | 62 (95.4) | 114 (85.1) | |
| MVD, n (%) | 189 (75.3) | 56 (86.2) | 115 (85.8) | 0.02 |
| CTO, n (%) | 34 (13.6) | 4 (6.2) | 17 (12.7) | 0.26 |
| Pre EF | 54.80 ± 13.08 | 52.98 ± 13.24 | 51.90 ± 14.77 | 0.13 |
| Procedure time, min | 83.03 ± 49.32 | 82.10 ± 40.84 | 74.39 ± 55.24 | 0.26 |
| Mean stent diameter, mm | 3.01 ± 0.38 | 3.01 ± 0.39 | 2.96 ± 0.38 | 0.38 |
| Total number of stent | 2.35 ± 1.15 | 2.19 ± 1.03 | 2.55 ± 1.26 | 0.11 |
| Total stent length, mm | 67.09 ± 32.72 | 60.31 ± 28.42 | 72.18 ± 39.17 | 0.08 |
| Number of burr, mm | 1.19 ± 0.45 | 1.25 ± 0.44 | 1.15 ± 0.36 | 0.32 |
| Technical success, n (%) | 243 (96.8) | 61 (93.9) | 128 (95.5) | 0.52 |
| Procedure success, n (%) | 233 (92.8) | 60 (92.3) | 131 (97.8) | 0.11 |

DM, diabetes mellitus; S-DM, shorter duration of diabetes mellitus; L-DM, longer duration of diabetes mellitus; MVD, multivessel disease; CTO, chronic total occlusion; EF, ejection fraction.

**Procedural details, in-hospital events and procedure complications.** Procedural details including procedure time, mean stent diameter, total stent length, and technical/procedure success rates were similar among the three groups (Table 2). The incidence rates of in-hospital MACCEs were also similar among the three groups (Table 3). However, CIN occurred more frequently in the L-DM group compared with non-DM or S-DM group.

Table 3
In-hospital major adverse cardiac and cerebral events and procedural complications.

| | Non-DM (n = 251) | S-DM (n = 65) | L-DM (n = 134) | *p*-Value |
|---|---|---|---|---|
| In-hospital MACCEs | 35 (13.9) | 5 (7.7) | 15 (11.2) | 0.36 |
| In-hospital death | 6 (2.4) | 1 (1.5) | 4 (3.0) | 0.82 |
| Urgent revascularization | 4 (1.6) | 0 (0.0) | 4 (3.0) | 0.31 |
| In-hospital stroke | 2 (0.8) | 0 (0.0) | 0 (0.0) | 0.45 |
| Peri-procedure MI | 26 (10.4) | 5 (7.7) | 8 (6.0) | 0.33 |
| Procedural Complications | | | | |
| Severe coronary dissection* | 35 (13.9) | 10 (15.4) | 19 (14.2) | 0.96 |
| Temporary pacemaker during procedure | 7 (2.8) | 5 (7.7) | 5 (3.7) | 0.18 |
| Coronary perforation | 6 (2.4) | 1 (1.5) | 1 (0.8) | 0.50 |
| Contrast-Induced Nephropathy | 4 (1.6) | 0 (0.0) | 7 (5.2) | 0.035 |
| In-hospital bleeding | 11 (4.4) | 6 (9.2) | 8 (6.0) | 0.31 |

*Type D, E, or F defined from The National Heart, Lung, and Blood Institute (NHLBI) classification system.

MACCE, major adverse cardiac and cerebral event; MI, myocardial infarction.

**Mid-term clinical outcomes.** During median follow-up duration of 18 months, the incidence rate of TVF, primary outcome, was significantly higher in the L-DM group compared with non-DM or S-DM groups (non-DM, 30 [12.0%] vs. S-DM, 9 [13.9%] vs. L-DM, 29 [21.6%]; p = 0.039). Among secondary outcomes, any repeat revascularization was frequently observed in the L-DM compared with other groups (non-DM, 19 [7.6%] vs. S-DM, 6 [9.2%] vs. L-DM, 21 [15.7%]; p = 0.042 (Table 4) (Fig. 2). In multivariate analysis, L-DM group showed significantly poorer clinical outcomes than non-DM group in terms of TVF and RR (TVF: hazard ratio [HR] 1.86, 95% confidence interval [CI] 1.04–3.34, p = 0.037; RR: HR 2.40, 95% CI 1.17–4.89, p = 0.017), while S-DM group did not show statistical significance (TVF: HR 1.04, 95% CI 0.45–2.44, p = 0.92; RR: HR 1.27, 95% CI 0.47–3.46, p = 0.64).

Table 4
Clinical outcomes.

| | Non-DM (n = 251) | S-DM (n = 65) | L-DM (n = 134) | *p*-Value |
|---|---|---|---|---|
| TVF, n (%) | 30 (12.0) | 9 (13.9) | 29 (21.6) | 0.039 |
| All cause death, n (%) | 19 (7.6) | 8 (12.3) | 12 (9.0) | 0.48 |
| Cardiac death, n (%) | 14 (5.6) | 5 (7.7) | 12 (9.0) | 0.44 |
| Any myocardial infarction, n (%) | 10 (4.0) | 0 (0.0) | 5 (3.7) | 0.27 |
| Target-vessel MI, n (%) | 6 (2.4) | 0 (0.0) | 3 (2.2) | 0.46 |
| Any repeat revascularization, n (%) | 19 (7.6) | 6 (9.2) | 21 (15.7) | 0.042 |
| TVR, n (%) | 15 (6.0) | 4 (6.2) | 17 (12.7) | 0.06 |
| TVF, target vessel failure; MI, myocardial infarction: TVR, target vessel revascularization | | | | |

Table 5
Univariable and Multivariable Cox Regression analysis of Clinical outcomes

| | | Univariable | | | Multivariable | | |
|---|---|---|---|---|---|---|---|
| | | HR | 95% CI | p-value | HR | 95% CI | p-value |
| Target vessel failure | No DM | 1.00 | | | 1.00 | | |
| | S-DM | 1.13 | 0.54–2.38 | 0.75 | 1.04 | 0.45–2.44 | 0.92 |
| | L-DM | 1.85 | 1.11–3.01 | 0.018 | 1.86 | 1.04–3.34 | 0.037 |
| All cause death | No DM | 1.00 | | | 1.00 | | |
| | S-DM | 1.55 | 0.68–3.54 | 0.30 | 0.77 | 0.25–2.35 | 0.65 |
| | L-DM | 1.18 | 0.57–2.43 | 0.66 | 0.98 | 0.44–2.21 | 0.97 |
| Cardiac death | No DM | 1.00 | | | 1.00 | | |
| | S-DM | 1.32 | 0.47–3.66 | 0.60 | 0.66 | 0.16–2.67 | 0.56 |
| | L-DM | 1.60 | 0.74–3.46 | 0.23 | 1.67 | 0.69–4.04 | 0.26 |
| Myocardial infarction | No DM | 1.00 | | | 1.00 | | |
| | S-DM | - | - | - | - | - | - |
| | L-DM | 0.91 | 0.31–2.67 | 0.87 | 0.85 | 0.23–3.21 | 0.81 |
| Target vessel MI | No DM | 1.00 | | | 1.00 | | |
| | S-DM | - | - | - | - | - | - |
| | L-DM | 0.92 | 0.23–3.69 | 0.91 | 0.82 | 0.12–5.12 | 0.85 |
| Any revascularization | No DM | 1.00 | | | 1.00 | | |
| | S-DM | 1.22 | 0.49–3.05 | 0.68 | 1.27 | 0.47–3.46 | 0.64 |
| | L-DM | 2.20 | 1.18–4.10 | 0.013 | 2.40 | 1.17–4.89 | 0.017 |
| TVR | No DM | 1.00 | | | 1.00 | | |
| | S-DM | 1.01 | 0.33–3.03 | 0.99 | 0.87 | 0.26–2.98 | 0.83 |
| | L-DM | 2.21 | 1.10–4.43 | 0.025 | 2.16 | 0.94–4.94 | 0.07 |
| ** adjusted by age, sex, hyperlipidemia, CKD, dialysis, CVA, PVD, MVD, Hb, Total cholesterol, LDL cholesterol, HDL cholesterol, Hba1c, Contrast-induced nephropathy | | | | | | | |
| HR, hazard ratio; CI, confidence interval; MI, myocardial infarction: TVR, target vessel revascularization | | | | | | | |

In subgroup analysis comparing the primary outcome for non-DM and L-DM groups, the sex difference was observed that the relative risk of TVF was higher in the L-DM group compared with the non-DM group

in females which was not observed in males ($p_{interaction}$=0.033). However, there was no risk difference in the subgroups with CKD, dialysis, or lesions of chronic total occlusion (Fig. 3).

# Discussion

The major findings from the present analysis are as follows: (1) patients with longer DM duration, especially more than 10 years, showed poorer clinical outcomes in terms of TVF and RR than non-diabetic patients or those with shorter DM duration even after revascularization; (2) a long DM duration did not affect the procedural details, in-hospital and procedural outcomes except for CIN during PCI using RA.

This is the first study to examine the associations between DM duration and clinical outcomes in a Korean population with CAD. Our registry is the largest, all-comer, multi-center registry, including CAD patients with advanced atherosclerosis in Korea. All patients received PCI with drug-eluting stents (DESs), especially 2nd generation DES, except for one patient with 1st generation DES, which reflect the current revascularization strategy for significant CAD (17, 18).

Also, all patients underwent RA during PCI, which meant that majority of patients in this study population might have significant CAD lesions with severe calcification. Using this registry, our study showed the novel results which demonstrated the clinical impact of DM duration on clinical outcomes in advanced CAD after revascularization. Indeed, there have been several studies demonstrating poor clinical outcome of DM duration in CAD patients (8, 19). However, those studies were designed as cohort or epidemiological studies with relatively healthy patients, while the majority of patients in this study received treatment at tertiary or specialized cardiology centers, and may have more severe disease compared with community-treated patients. Therefore, this study has strengths over prior studies that have examined the relation between DM duration and clinical outcomes in revascularized CAD patients with advanced atherosclerosis and calcification.

It is well-known that DM is an independent predictor of adverse clinical outcome in CAD patients after revascularization (5, 6). Our study also showed that patients with a longer duration (≥ 10 years) of DM showed poorer clinical outcomes regarding TVF and RR than non-DM and shorter duration DM (< 10 years) groups. The risk of TVF and any revascularization was 1.863 times and 2.395 times higher in L-DM than in non-DM, respectively. The plausible mechanisms are as follows: (1) CAD severity and the extent atherosclerosis is getting worse during prolonged diabetes (2, 3). (2) DM duration had a strong correlation with the nature of unfavorable coronary artery lesions. Vulnerable plaque including lipid-rich plaque and thin cap fibroatheroma and plaque rupture were frequently observed in long DM duration (10 ≥ year) group compared to shorter duration DM or non-DM group (20, 21). (3) CAC can be promoted by multifocal factors of the hormonal and physiological abnormalities associated with DM, including oxidative stress, endothelial dysfunction, and increased inflammatory cytokine production (22, 23). These changes were enhanced by prolonged DM with poor glycemic control (24), leading to adverse procedural complications and long-term clinical outcomes (25–27).

However, the incidence rate of clinical outcome in shorter DM duration group was numerically higher but did not achieve statistically significance compared to non-DM group in this study. In our registry, duration of S-DM group was relatively short (median 5 [IQR 0.17–7.33] years), including 20 (30.8%) patients were diagnosed as DM within 1 year. Therefore, S-DM group may include diabetic patients without complications. Even though the presence of DM itself is associated with poor clinical outcomes as mentioned above (5, 6), adverse clinical events are usually prevented by revascularization with optimization, which is already known for an important protective predictor (28). Several previous studies have shown in line with this result in patients with CAD (29, 30).

Our study showed a similar results regarding to the procedural details, in-hospital and procedural outcomes except for CIN. CIN occurred more frequently in the longer DM duration group. Prolonged DM is associated with microvascular complication including microalbuminuria (19, 31, 32). In this context, we could understand that CKD was frequently observed in the L-DM group. This would be a plausible explanation of difference in CIN occurrence after procedure.

Operators are usually more careful for patients with diffuse narrowing CAD during RA and worry about distal embolization, leading to flow compromising and peri-procedure MI. Because DM may affect the coronary vessel more diffusely narrowing including capillaries (33) and longer DM duration reduces myocardial blood flow in remote myocardium (34), diabetic patients would have more chance to suffer peri-procedure MI. However, the incidence rates of peri-procedure MI were similar among the three groups in our study. According to the results, one of our message is that, we may not be hesitate RA even in longer duration of diabetic patients in terms of slow or no reflow.

In subgroup analysis, the present study was in agreement with several previous studies that showed that the relative risk of vascular disease associated with DM was substantially higher in women than men (35, 36). Although the mechanisms were not fully identified, it may be associated with hormonal and storage patterns of adipose tissue differences (37, 38).

**Study limitation**. This study was based on a nonrandomized registry with inherent methodological limitations. Thus there is a possibility of selection bias. Second, the number of study participants and events was relatively small, limiting the statistical power of our multivariate analysis. Third, the proportion of S-DM group was relatively small (14%). Therefore, caution is necessary when interpretating our results.

# Conclusions

This study was firstly demonstrated that the association between a longer DM duration (≧ 10 years) and poor clinical outcomes in patients with severe calcified CAD lesions after PCI, especially in terms of TVF and RR. We should be more careful for recurrence during follow-up in those patients.

# Abbreviations

CAD
coronary artery disease
DM
diabetes mellitus
RA
rotational atherectomy
PCI
percutaneous coronary intervention
MACCE
major adverse cardiac and cerebral event(s)
TVF
target-vessel failure
MI
myocardial infarction
TVR
target-vessel revascularization
TLR
target-lesion revascularization
ST
stent thrombosis.

# Declarations


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### Author's contributions

Jin Jung contributed to the study design, data analysis and wrote the manuscript. Sung-Ho Her and Kyusup Lee contributed to the data acquisition, data analysis, reviewed and edited the intellectual content as a corresponding author. Ji-Hoon Jung contributed to the data analysis. Ki-Dong You, Keon-Woong Moon, Donggyu Moon, Su Nam Lee, Won Young Jang, Ik Jun Choi, Jae Hwan Lee, Jang Hoon Lee, Sang Rok Lee, Seung-Whan Lee, Kyeong Ho Yun and Hyun-Jong Lee contributed to the data acquisition. All authors gave approval for this final version to be published. All authors approved the final manuscript.


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All authors have nothing to disclose.


### Availability of data and materials

The datasets used during the current study are available from the corresponding author on reasonable request.

### Ethics approval and consent to participate

This study was performed in accordance with the Declaration of Helsinki. All patients provided written informed consent. 9 tertiary centers were approved by the institutional review board of each hospital

### Consent for publication

Not applicable

### Competing interests

The authors declare that they have no competing interests

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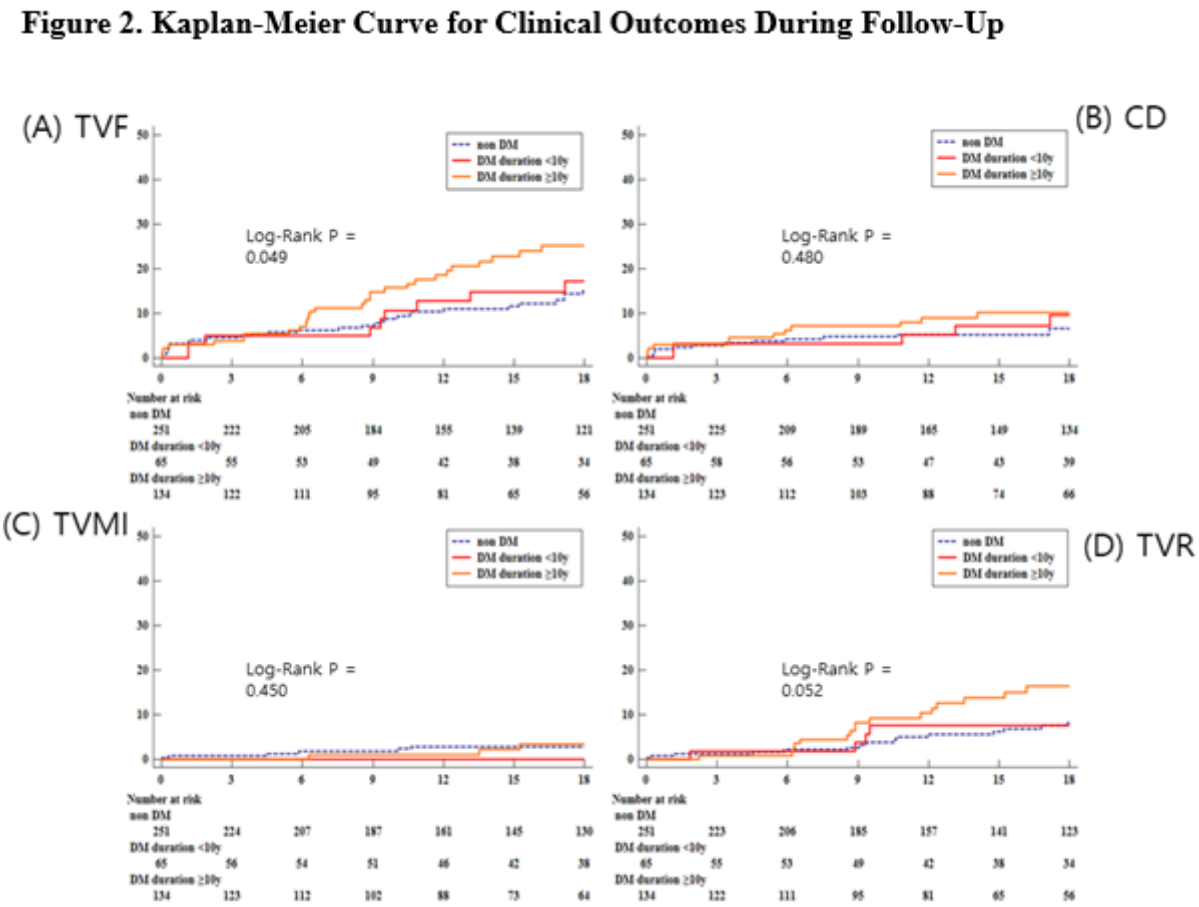
# Figures

### Figure 1

### Study Population Flow Chart

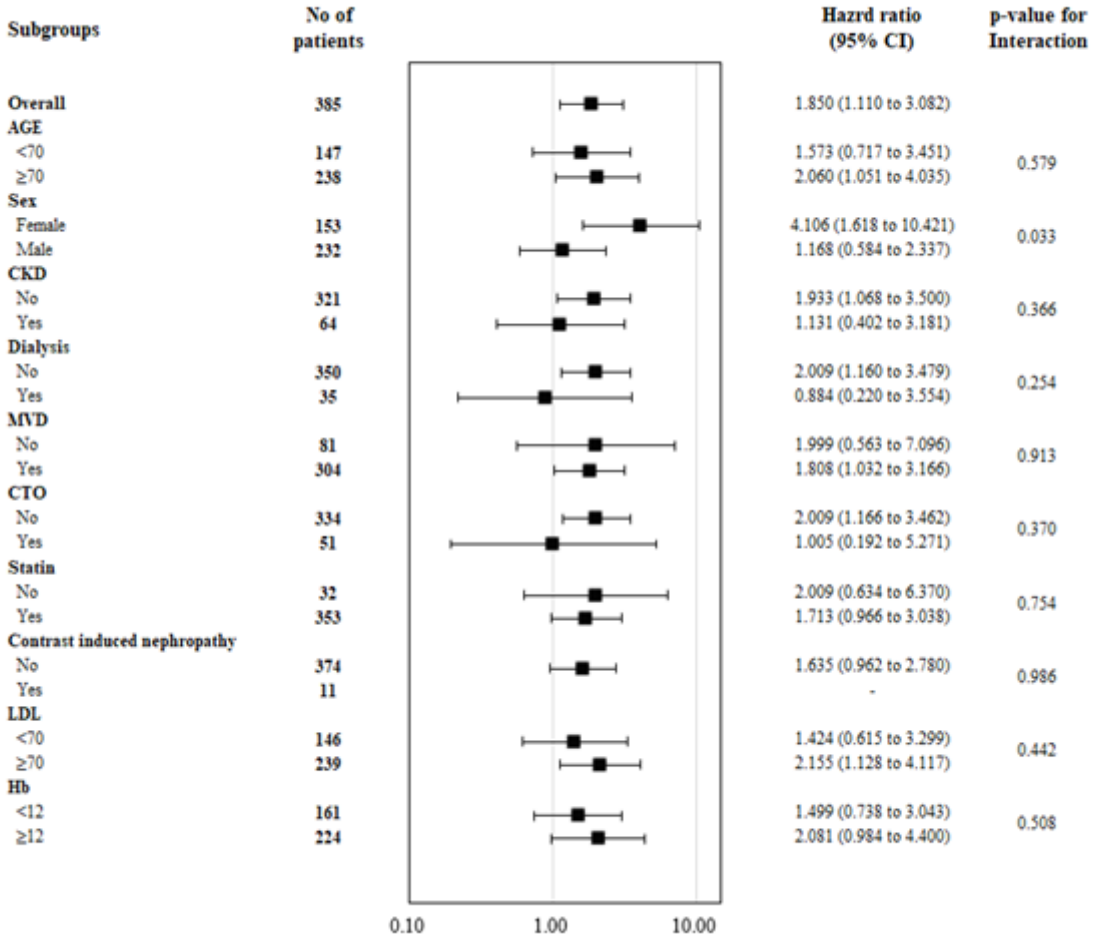



### Figure 2

### Kaplan-Meier Curve for Clinical Outcomes During Follow-Up

(A) Target vessel failure (B) Cardiac death (C) Target vessel myocardial infarction (D) Target vessel revascularization

**Figure 3. Subgroup Analysis Comparing the Target vessel failure of Non DM and Long duration DM**




## Figure 3

## Subgroup Analysis Comparing the Target vessel failure of Non DM and Long duration DM