



## Mini-Crush Versus Double Kissing Crush in Bifurcation Percutaneous Coronary Intervention: Insights From PROGRESS-BIFURCATION Registry



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### ARTICLE INFO

#### Article History:

Received 13 August 2025

Revised 30 September 2025

Accepted 18 October 2025

There are limited data on the use of the mini-crush technique in 2-stent bifurcation percutaneous coronary intervention (PCI). Observational, multicenter (n = 7), international cohort study between 2013 and 2025, as part of the Prospective Global Registry of Percutaneous Coronary Intervention in Bifurcation Lesions (PROGRESS-BIFURCATION, NCT05100992). We evaluated procedural characteristics of patients who underwent bifurcation stenting using the mini-crush in comparison to the double kissing (DK) crush techniques. Among 2,508 bifurcation PCIs (2,284 patients), 184 (7.3%) underwent mini-crush and 257 (10.2%) DK-crush. Patients undergoing DK-crush were more likely to undergo intravascular imaging (41.9% vs 21.3%, p < 0.001). There was no difference in technical (98.4% vs 98.8%, p = 0.70) and procedural success (94.2% vs 94.9%, p = 0.77), as well as in-hospital MACE (5.0% vs 4.5%, p = 0.84). Mini-crush was associated with shorter procedural (90 [58–127] vs 107 [73–172.5] min) and fluoroscopy (24 [15.5–34.1] vs 30 [21.6–44] min) times. During a median follow-up of 754 days, as compared to DK-crush, there was a trend towards higher risk for MACE (29.8% vs 20.9%; p = 0.09) with mini-crush. Adjusted analyses with propensity score matching (aHR 1.73; 95% CI: 0.81–3.71; p = 0.14) showed no difference in MACE. In patients undergoing PCI for bifurcation lesions, the mini-crush technique had similar rates of technical and procedural success and in-hospital MACE as DK-crush and was associated with lower fluoroscopy time and procedural time. While no statistically significant differences were observed during follow-up, there was a numerical trend towards higher risk for adverse events with mini crush, and thus larger, prospective, controlled trials are needed.

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Provisional stenting is the preferred technique for most bifurcation percutaneous coronary interventions (PCI). An upfront 2-stent approach, however, may be preferred in patients with complex disease and severe side branch stenosis.<sup>1</sup> Compared with other 2-stent strategies the double kissing crush (DK-crush) technique has been validated in randomized trials and been associated with fewer major

adverse cardiac events (MACE) and target lesion failure (TLF), especially in patients with unprotected left main lesions.<sup>2–4</sup> Despite its benefits, the DK-crush technique involves multiple steps that be associated with longer procedural times, as well as higher contrast and radiation doses.<sup>5,6</sup> The mini-crush technique requires fewer steps, but clinical data supporting its efficacy and safety remain limited.<sup>7</sup> We compared procedural, in-hospital, and long-term outcomes of mini-crush vs DK-crush in bifurcation PCI in a multicenter bifurcation registry.

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## Methods

This was an observational, cohort study performed across 7 centers in the United States, Russia, and Turkey between 2013–2025 (different centers joined at different times), as part of the Prospective Global Registry of Percutaneous Coronary Intervention in Bifurcation Lesions (PROGRESS-BIFURCATION, NCT05100992). Patients undergoing 2-stent bifurcation PCI using the mini-crush technique were compared with patients treated with the DK-crush technique. The study was approved by the institutional review board of each center. [Figure 1](#) displays procedural steps of mini-crush versus DK-crush technique. The DK Crush technique begins with wiring and predilation of both the main vessel (MV) and side branch (SB), followed by deployment of the SB stent with slight protrusion into the MV. This protruding segment is then crushed using a balloon in the MV. After rewiring the SB through the crushed stent struts, the first kissing balloon inflation (KBI) is performed. The MV stent is subsequently deployed across the SB ostium, followed by proximal optimization technique (POT). A second rewiring of the SB is performed, and a second KBI is performed. The procedure concludes with a final POT.

For mini-crush technique, these steps are streamlined and very based on whether a 6-Fr or 7-Fr guide catheter is used. When using a 6-Fr guide catheter, after wiring both the MV and SB, the SB stent is deployed with minimal protrusion. A balloon positioned in the MV is then inflated to crush the protruding segment of the SB stent against the vessel wall. This is followed by deployment of the MV stent across the SB ostium. A single rewiring of the SB is performed through the MV stent struts, enabling a KBI and final POT.<sup>7</sup> When using a 7-Fr guide catheter, after wiring both the MV and SB, sequential stenting can be performed, in which the SB stent is deployed with minimal protrusion, and after removal of the stent balloon, a stent is deployed in the MV across the SB ostium. A single rewiring of the SB is performed through the MV stent struts, enabling a KBI and final POT.

## Definitions

Bifurcation lesions were defined as coronary artery stenoses occurring adjacent to and/or involving the origin of a significant (>1.5 mm) SB. Technical success was defined as the achievement of <30% residual diameter stenosis and thrombolysis in myocardial infarction (TIMI) 3 flow in both MV and SB (when SB PCI was attempted). Procedural success was defined as the achievement of technical success without any in-hospital major adverse cardiac events (MACE). In-hospital MACE was defined as the composite of all-cause mortality, myocardial infarction (MI), urgent repeat revascularization with either PCI or coronary artery bypass graft (CABG) surgery, and cardiac tamponade requiring either pericardiocentesis or surgery prior to hospital discharge. MI was defined using the Third Universal Definition of Myocardial Infarction (type 4a MI).<sup>8</sup> Long-term MACE was defined as composite of all-cause mortality, MI, stroke, target-vessel revascularization with either PCI or CABG.

## Statistical analysis

Categorical variables were expressed as n (percentages) and were compared using the Pearson's chi-square test. Continuous variables are presented as mean  $\pm$  standard deviation or as median (interquartile range) and were compared using the independent-samples t-test for normally distributed variables and the Mann-Whitney U test for nonparametric variables, as appropriate. The effect of mini-crush technique versus DK-crush on follow-up MACE. Long-term outcomes were based on Kaplan-Meier estimates in time-to-first-event analysis with log-rank test and mixed effects Cox proportional hazard ratios (HR). HRs were adjusted for confounding. Univariable logistic regression was performed to identify variables associated with MACE; next,

variables showing statistical significance ( $p < 0.10$ ) were filtered by clinical/angiographic significance. Variables with statistical, clinical, and angiographic significance were included in the multivariable analysis.

In addition, propensity score matching analysis was also conducted to minimize potential confounding in the study outcomes. A total of 8 variables were incorporated into the analysis, including age, gender, comorbidities, left main stenosis, prevalence of acute coronary syndromes, and usage of intravascular imaging. To account for missing data, we used multiple imputation, generating and analyzing 5 imputed datasets. The propensity score matching was performed using the Within approach. Nearest neighbor matching was used with a 1:1 ratio, and covariate balance between the matched groups was evaluated through standardized differences. All statistical analyses were performed using R Statistical Software, version 4.4.0 (R Foundation for Statistical Computing, Vienna, Austria). A p-value of  $< 0.05$  was considered statistically significant.

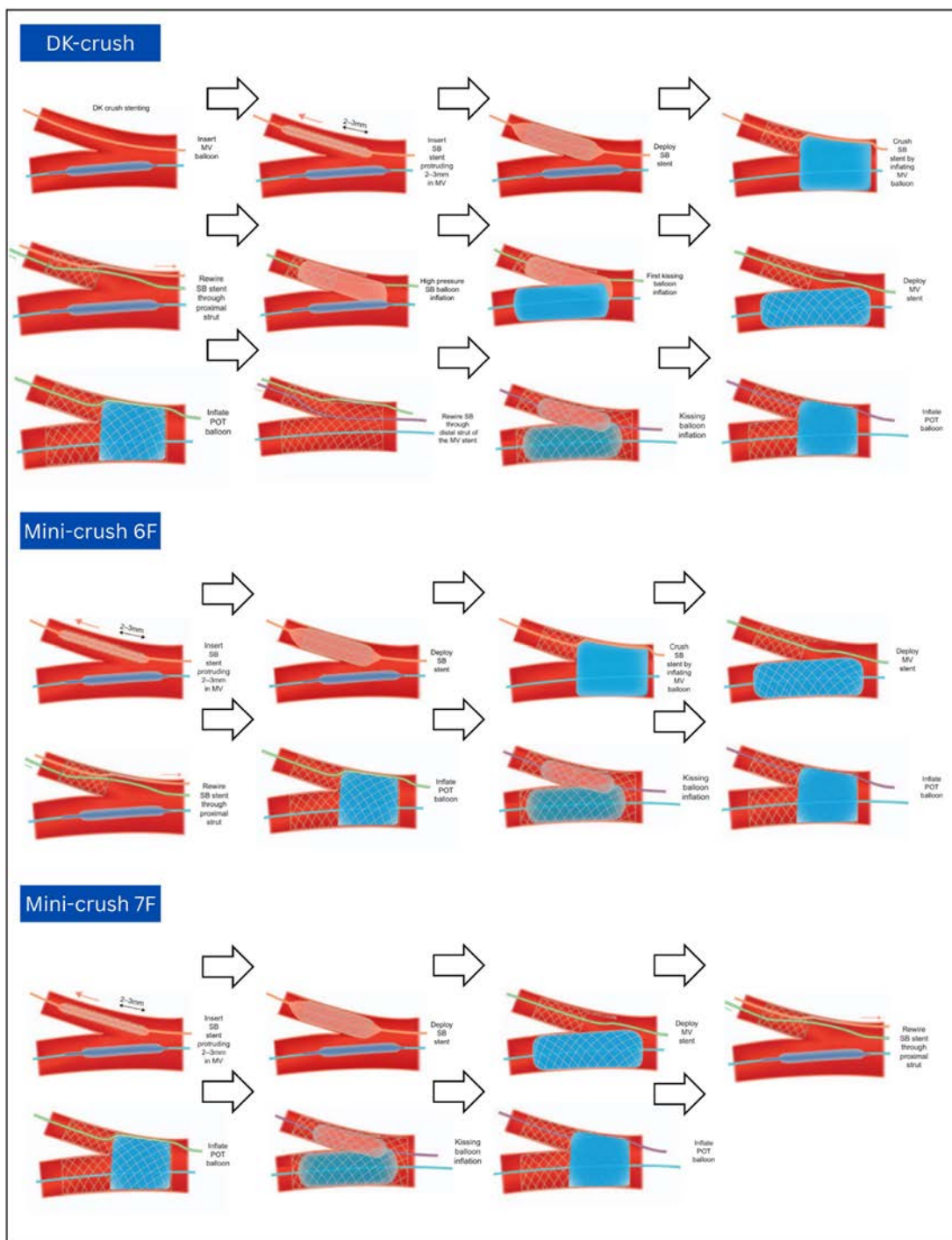
## Results

Among 2,508 bifurcation lesions treated with PCI in 2,284 patients, 184 (7.3%) used the mini-crush technique and 257 (10.2%) used the DK crush technique. Compared with patients treated with DK-crush, those treated with mini-crush had similar age ( $69.8 \pm 11.7$  vs  $68.0 \pm 12.0$ ), and proportion of men (73.9% vs 77.4%), as well as comorbidities such as hypertension, diabetes, dyslipidemia, heart failure, prior PCI, prior MI, and prior CABG ([Table 1](#)).

Compared to DK-crush, patients undergoing mini-crush stenting had a significantly higher incidence of proximal main vessel tortuosity and longer lesion lengths in both the main vessel and side branch. In addition, mini-crush was less frequently applied to left main bifurcations (25.5% vs 35.8%;  $p = 0.03$ ), underscoring a key anatomical divergence. Pretreatment intravascular imaging was utilized nearly twice as often in the DK-crush group (41.9% vs 21.3%;  $p < 0.001$ ), reflecting a more imaging-guided approach. Furthermore, final kissing balloon inflation (KBI) was performed in nearly all DK-crush cases (99.4%), compared to a significantly lower rate in the mini-crush group (86.3%;  $p < 0.001$ ). Angiographic and procedural distinctions between the study groups are detailed in [Table 2](#).

Mini-crush lesions had shorter procedural time (90 [58–127] vs 107 [73–172.5] min) and fluoroscopy time (24 [15.5–34.1] vs 30 [21.6–44] min) ([Figure 2](#)). In-hospital and procedural outcomes are described in [Table 3](#). There were no differences in technical (98.4% vs 98.8%,  $p = 0.70$ ) and procedural success (94.2% vs 94.9%,  $p = 0.77$ ) and in-hospital MACE (5.0% vs 4.5%,  $p = 0.84$ ). There was an increased incidence of dissections in the DK-crush group (0.0% vs 4.0%;  $p = 0.02$ ).

Follow-up data were available for 124 patients in the mini-crush group (89.2%) and 148 patients in the DK-crush group (74.7%). During a median follow-up of 754 days, as compared to DK-crush, there was a nonstatistically significant, trend towards higher in risk of MACE with mini-crush (29.8% vs 20.9%; HR 1.57; 95% CI 0.96–2.55;  $p = 0.07$ ; [Figure 3](#)), in large part due to a numerically higher rate of all-cause mortality (20.2% vs 12.2%;  $p = 0.07$ ), myocardial infarction (4.8% vs 4.1%;  $p = 0.75$ ), stroke (2.4% vs 1.4%;  $p = 0.66$ ), and target-vessel revascularization (6.5% vs 8.1%;  $p = 0.60$ ) compared with the DK-crush group ([Table 4](#)). These results remained consistent after adjusting for confounding variables using propensity score matching. After propensity score matching, adjusting for age, sex, intravascular imaging usage, 99 patients were retained in the mini-crush group and 95 in the DK-crush group. The table presenting adjusted baseline characteristics is provided in [Supplementary Table 1](#). Both stenting techniques demonstrated comparable rates of follow-up MACE (aHR 1.73; 95% CI: 0.81–3.71;  $p = 0.14$ ).



**Figure 1.** Procedural steps of mini-crush versus DK-crush techniques.

A sensitivity analysis examining temporal trends in DK-crush procedures—comparing the early registry period (2013–2018) to the later years (2019–2025)—is presented in [Supplementary Tables 2 through 9](#). Overall, the findings were consistent with the primary analysis. Notably, the majority of mini-crush cases (68.5%) were performed in the more recent years. However, intravascular imaging was infrequently used in these old mini-crush cases (3.8%), compared to its use in other recent cases (27.2%). Additionally, the prevalence of left main disease within the DK-crush cohort was primarily influenced by cases from the earlier years, rather than those performed more recently.

## Discussion

In patients undergoing 2-stent bifurcation PCI compared with DK-crush, the mini-crush technique was associated with (1) shorter procedural and fluoroscopy times, (2) lower contrast volume, (3) comparable in-hospital outcomes, and (4) a higher, though nonsignificant, incidence of adverse events during long-term follow-up.

Numerous randomized controlled trials have shown superiority of the DK-crush technique for complex bifurcations. DK-crush has been linked to lower rates of long-term target-vessel revascularization and major adverse cardiovascular events (MACE).<sup>2–4</sup> Findings from the

**Table 1**  
Comparison of baseline clinical characteristics of patients who underwent bifurcation PCI using the DK-crush versus the mini-crush techniques

Variables	DK crush (n = 198)	Mini-crush (n = 139)	p-value
Age (years)	68.02 ± 11.98	69.79 ± 11.66	0.222
Gender, male	77.4% (151)	73.9% (102)	0.459
BMI	29.80 ± 5.68	28.97 ± 5.95	0.180
Diabetes mellitus	36.2% (71)	42.8% (59)	0.228
Hypertension	75.0% (147)	76.8% (106)	0.704
Dyslipidemia	81.1% (159)	88.4% (122)	0.073
Smoking, current	22.7% (45)	22.3% (31)	0.927
Left ventricular ejection fraction (%)	52.26 ± 13.14	51.85 ± 12.24	0.446
Family history of CAD	15.6% (30)	18.4% (25)	0.510
Heart failure	26.3% (51)	23.4% (32)	0.545
Prior PCI	44.9% (88)	50.7% (69)	0.295
Prior MI	34.0% (66)	40.4% (55)	0.234
Cerebrovascular disease	13.8% (27)	10.9% (15)	0.420
Peripheral arterial disease	10.3% (20)	14.5% (20)	0.241
CAD presentation			0.226
Stable angina	35.6% (69)	33.8% (45)	
Unstable angina	20.1% (39)	11.3% (15)	
NSTEMI	26.8% (52)	33.8% (45)	
STEMI	8.2% (16)	12.8% (17)	
No symptoms	8.8% (17)	7.5% (10)	
Nonischemic symptoms	0.5% (1)	0.8% (1)	
Baseline creatinine (mg/dL)	1.00 [0.85, 1.20]	0.97 [0.81, 1.21]	0.863

CAD = coronary artery disease; CABG = coronary artery bypass graft; MI = myocardial infarction; NSTEMI = non-ST segment elevation myocardial infarction; PCI = percutaneous coronary intervention; STEMI = ST segment elevation myocardial infarction.

Double Kissing Crush V trial (DKCRUSH-V) and the long-term follow-up of the Double Kissing Crush II (DKCRUSH-II) trial highlight its effectiveness, particularly in treating complex lesions such as left main bifurcation.<sup>3,9</sup> A network meta-analysis that included 22 randomized controlled trials (RCTs) provided direct and indirect evidence supporting DK-crush and mini-crush over provisional and other 2-stent techniques.<sup>10</sup> However, direct comparisons between these 2 techniques are limited.

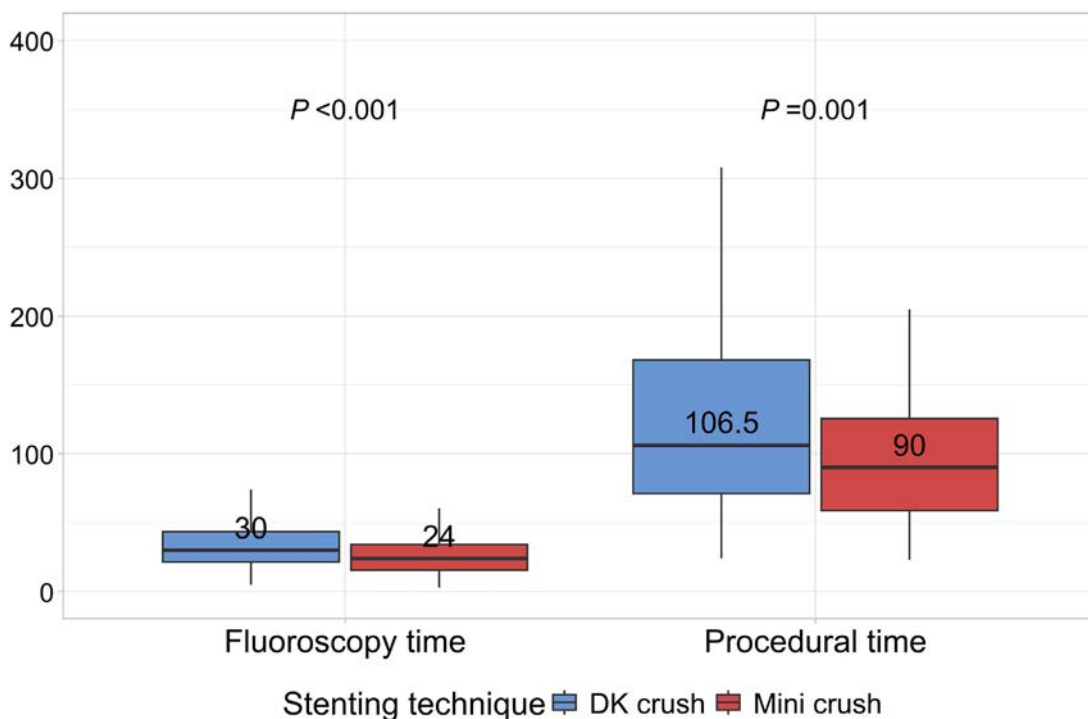
Despite the strong clinical evidence supporting DK-crush and its inclusion in class 1A guideline recommendations, this technique is technically demanding.<sup>11</sup> DK-crush involves multiple procedural steps, contributing to longer procedural time and higher contrast utilization, as demonstrated in our study. In the DK-crush technique, SB stenting involves a long stent protrusion, which is fully crushed before MV stenting. Following MV stent deployment, the SB is rewired for a second kissing balloon inflation. The mini-crush technique, however, involves SB stenting with shorter stent protrusion directly followed by MV stent placement and final kissing balloon inflation, making it simpler and requiring fewer steps (Figure 3).<sup>7,12</sup> Intravascular imaging was more frequently utilized in the DK-crush group for procedural guidance. This trend may be attributed to potential variability among operators since the final technique was left to their discretion, and the higher prevalence of left main bifurcation lesions treated with DK-crush compared with mini-crush (25.5% vs 35.8%;  $p = 0.03$ ). In complex lesions, including bifurcation PCIs, randomized controlled trials have demonstrated that intravascular imaging reduces target vessel failure compared with angiography-guided PCI.<sup>13–17</sup>

In our study, when compared with the guideline-recommended DK-crush, mini-crush was associated with similar procedural and in-hospital complications and long-term outcomes, but shorter procedural time and lower contrast utilization. Notably, the DK-crush group demonstrated a higher incidence of coronary dissection, which may be partially attributed to the increased procedural complexity inherent to the technique as well as higher lesion complexity. Similar

**Table 2**  
Angiographic characteristics of patients who underwent bifurcation PCI using the DK-crush versus the mini-crush technique

Variables	DK crush (n = 257)	Mini-crush (n = 184)	p-value
LM stenosis (%)	20.00 [0.00, 70.00]	0.00 [0.00, 50.00]	0.002
Proximal LAD stenosis (%)	80.00 [50.00, 90.00]	80.00 [60.00, 90.00]	0.407
Mid–distal LAD, diagonal stenosis (%)	80.00 [60.00, 90.00]	80.00 [60.00, 90.00]	0.717
CIRC, OM, LPDA, LPL branches stenosis (%)	80.00 [30.00, 90.00]	70.00 [30.00, 90.00]	0.026
RCA, RPDA, RPL branches stenosis (%)	60.00 [20.00, 99.00]	50.00 [0.00, 90.00]	0.098
Ostial lesion (within 5 mm of aortocoronary ostium)	13.9% (34)	14.0% (25)	0.992
Proximal main vessel LMCA	35.8% (92)	25.5% (47)	0.137
LAD	41.6% (107)	48.9% (90)	
RCA	9.7% (25)	10.9% (20)	
Circumflex	12.1% (31)	14.7% (27)	
Bypass graft	0.8% (2)	0.0% (0)	
Proximal main vessel diameter (mm)	3.50 [3.30, 4.00]	3.50 [3.25, 4.00]	0.913
Proximal main vessel lesion length (mm)	8.00 [5.00, 10.00]	10.00 [5.00, 15.00]	0.005
Proximal main vessel diameter stenosis (%)	70.00 [50.00, 90.00]	80.00 [60.00, 90.00]	0.539
Distal main vessel diameter (mm)	3.00 [3.00, 3.50]	3.00 [2.75, 3.50]	0.112
Distal main vessel lesion length (mm)	10.00 [7.00, 20.00]	15.00 [8.00, 20.00]	0.078
Proximal main vessel tortuosity			< 0.001
Straight (< 70 degrees, 1 Bend)	66.9% (172)	52.7% (97)	
Slight (>70 degrees, 1 Bend)	21.4% (55)	37.5% (69)	
Moderate (2 Bends >70 degrees or 1 Bend >90 degrees)	8.6% (22)	9.8% (18)	
Severe (2 Bends >90 degrees or 1 Bend >120 degrees)	3.1% (8)	0.0% (0)	
Side branch diameter (mm)	2.75 [2.50, 3.00]	2.50 [2.50, 3.00]	0.471
Side branch lesion length (mm)	10.00 [5.00, 15.00]	12.00 [8.00, 20.00]	< 0.001
Distal main vessel diameter stenosis (%)	80.00 [70.00, 90.00]	80.00 [70.00, 90.00]	0.983
Calcification			0.109
None	22.2% (57)	31.0% (57)	
Mild (Spots)	26.1% (67)	22.8% (42)	
Moderate (≤50% reference lesion diameter)	26.1% (67)	19.0% (35)	
Severe (>50% reference lesion diameter)	25.7% (66)	27.2% (50)	
Medina classification			0.327
1,1,1	65.4% (168)	74.5% (137)	
1,1,0	9.7% (25)	6.5% (12)	
1,0,1	5.4% (14)	4.3% (8)	
0,1,1	12.1% (31)	10.3% (19)	
1,0,0	0.8% (2)	1.6% (3)	
0,1,0	3.1% (8)	1.1% (2)	
0,0,1	3.5% (9)	1.6% (3)	
Side branch diameter stenosis (%)	80.00 [70.00, 90.00]	80.00 [80.00, 90.00]	0.226
Pretreatment IVUS/OCT Technical success	41.9% (106) 98.8% (254)	21.3% (39) 98.4% (181)	< 0.001 0.697

CIRC = circumflex; IQR = interquartile range; IVUS = intravascular ultrasound; LAD = left anterior descending; LM = left main; LPDA = left posterior descending artery; LPL = left posterolateral; OCT = optical coherence tomography; OM = obtuse marginal; RCA = right coronary artery; RPDA = right posterior descending artery; RPL = right posterolateral.



**Figure 2.** Box plots of procedural outcomes of mini-crush versus DK-crush techniques.

findings were observed in the EVOLUTE-CRUSH registry, which included 269 patients.<sup>18</sup> Compared with DK-crush, mini-crush was associated with shorter procedural times, lower equipment utilization, and comparable in-hospital and long-term outcomes after a mean follow-up of  $31.1 \pm 10$  months.<sup>18</sup> Using latest drug-eluting stent platforms, mini-crush may be as effective as DK-crush with

respect to short-term outcomes and involve lower technical complexity.

Despite comparable procedural and in-hospital outcomes, the mini-crush technique was associated with a numerically higher incidence of follow-up MACE. Although this difference did not reach statistical significance after propensity score matching, it may reflect underlying differences in lesion complexity as well as target-lesion failure that may have gone undetected due to limited statistical power, and residual confounding. This protective effect of DK-crush in follow-up MACE suggests that the lack of statistical significance should not imply a lack of clinical difference. Additional contributing factors may include the more frequent use of intravascular imaging and KBI in the DK Crush group, which could be associated with improved long-term outcomes.

Our study has limitations. PROGRESS-BIFURCATION is an observational registry, with all inherent limitations. Despite adjustments through propensity score matching, the potential for reporting bias and residual confounding remains. Factors such as operator experience, technical proficiency, and unreported angiographic characteristics may have influenced procedural outcomes but were not fully accounted for in the analysis. Although baseline characteristics were broadly comparable between groups, the DK-crush cohort demonstrated more frequent use of intravascular imaging and a higher prevalence of left main bifurcation lesions. These differences suggest potential selection bias, as operators may have preferentially applied the DK-crush technique to anatomically complex or high-risk lesions. There was no independent adjudication of clinical events or core laboratory assessment of angiograms to verify adherence to procedural techniques. All procedures were performed at centers with experienced PCI operators, limiting generalizability to less experienced centers. Procedural differences in mini-crush stenting between 6-Fr and 7-Fr guide catheters could not be assessed due to insufficient reported data. Large-scale, controlled randomized trials using standardized modern PCI techniques are needed to compare mini-crush versus DK-crush in bifurcation lesions.

**Table 3**

In-hospital and procedural outcomes of patients undergoing bifurcation PCI with the DK-crush versus the mini-crush technique

Variables	DK crush (n = 198)	Mini-crush (n = 139)	p-value
Procedural success	94.9% (188)	94.2% (131)	0.777
MACE	4.5% (9)	5.0% (7)	0.835
AKI	2.3% (4)	4.0% (5)	0.498
Death	1.0% (2)	1.4% (2)	> 0.999
Acute MI	0.5% (1)	2.9% (4)	0.164
Repeat PCI	2.0% (4)	1.4% (2)	> 0.999
Stroke	0.5% (1)	0.7% (1)	> 0.999
Emergency CABG	0.5% (1)	0.0% (0)	> 0.999
Bleeding	0.5% (1)	0.0% (0)	> 0.999
Side branch occlusion	0.0% (0)	0.0% (0)	> 0.999
Equipment loss	0.5% (1)	0.0% (0)	> 0.999
Pericardiocentesis	0.0% (0)	0.0% (0)	> 0.999
Perforation	1.0% (2)	0.7% (1)	> 0.999
Dissection	4.0% (8)	0.0% (0)	0.023
Thrombus	0.5% (1)	0.0% (0)	> 0.999
Tamponade	0.0% (0)	0.0% (0)	> 0.999
Contrast volume, ml	190 (140, 260)	200 (127.50, 260)	0.737
Fluoroscopy time	30.05 (21.60, 44.00)	24.00 (15.50, 34.10)	< 0.001
Air Kerma radiation dose (Gray)	1.80 (1.07, 2.80)	1.85 (0.93, 2.96)	0.749
Procedure time	107.00 (73.00, 172.47)	90.00 (58.00, 127.00)	0.001

AKI = Acute kidney injury; CABG = coronary artery bypass graft; MACE = major adverse cardiac events; MI = myocardial infarction; PCI = percutaneous coronary intervention.

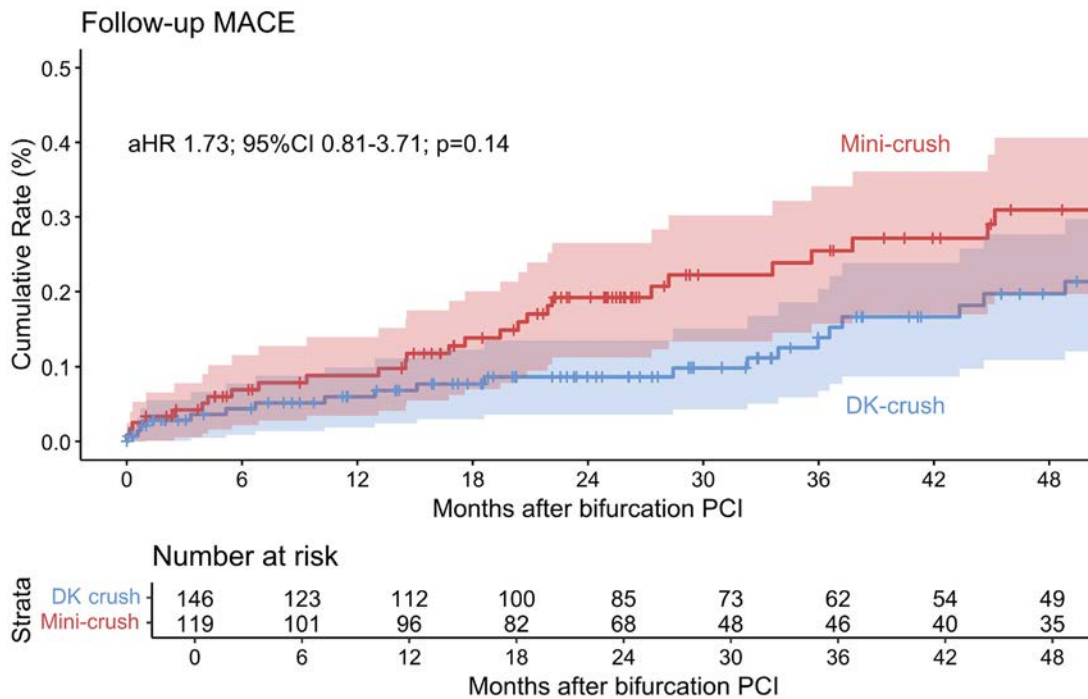


Figure 3. Long-term MACE of after bifurcation stenting using the mini-crush versus the DK-crush technique.

Table 4  
Follow-up outcomes of patients undergoing bifurcation PCI with the DK-crush vs the mini-crush technique

Variables	DK crush (n = 148)	Mini-crush (n = 124)	p-value
Follow-up MACE	20.9% (31)	29.8% (37)	0.092
CABG	3.4% (5)	0.8% (1)	0.225
Death	12.2% (18)	20.2% (25)	0.072
Stroke	1.4% (2)	2.4% (3)	0.662
Spontaneous MI	4.1% (6)	4.8% (6)	0.754
Follow-up target vessel revascularization	8.1% (12)	6.5% (8)	0.602

CABG = coronary artery bypass graft; MACE = major adverse cardiac events; MI = myocardial infarction.

Conclusion

As compared with DK-crush, the mini-crush technique had similar rates of procedural complications, in-hospital MACE, and long-term outcomes but required less contrast volume, fluoroscopy time, and procedural time. While no statistically significant differences were observed during follow-up, there was a numerical trend towards higher risk for adverse events with mini crush, potentially due to confounding factors including patient selection and variation in procedural techniques such as the use of intravascular imaging, and thus large-scale, prospective, controlled trials are needed to compare these techniques.

Declaration of competing interest

Dr. Sandoval reports the following disclosures: Abbott (consultant, advisory board, speaker), CathWorks (consultant, speaker), Cleerly (speaker, research grant), GE Healthcare (consultant, advisory board), HeartFlow (consultant, speaker), Medtronic (speaker), Philips (consultant, advisory board, speaker), Roche Diagnostics (consultant, advisory board, speaker), and Zoll (advisory board); owner, Systole

LLC. He is an Associate Editor for JACC Advances. He and others hold patent 20210401347.

Dr Brilakis has received consulting/speaker honoraria from Abbott Vascular, American Heart Association (associate editor Circulation), Biotronik, Boston Scientific, Cardiovascular Innovations Foundation (Board of Directors), Cordis, CSI, Elsevier, GE Healthcare, Haemonetics, IMDS, Medtronic, SIS Medical, Teleflex, and Orbus Neich; research support: Boston Scientific, GE Healthcare; owner, Hippocrates LLC; shareholder: Cleerly Health, LifeLens Technologies, Inc, MHI Ventures, Stallion Medical, TrueVue Inc.

All other authors declare that they have no relationships relevant to the contents of this paper to disclose.

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### Acknowledgments

The authors are grateful for the philanthropic support of our generous Anonymous donors(2), and the philanthropic support of Drs. Mary Ann and Donald A Sens; Mr. Raymond Ames and Ms. Barbara Thorndike; Frank J and Eleanor A. Maslowski Charitable Trust; Joseph F and Mary M Fleischhacker Family Foundation; Mrs. Diane and Dr. Cline Hickok; Mrs. Marilyn and Mr. William Ryerse; Mr. Greg and Mrs. Rhoda Olsen; Mrs. Wilma and Mr. Dale Johnson; Mrs. Charlotte and Mr. Jerry Golinvaux Family Fund; the Roehl Family Foundation; the Joseph Durda Foundation. The generous gifts of these donors to the Minneapolis Heart Institute Foundation's Science Center for Coronary Artery Disease (CCAD) helped support this research project.

### Supplementary materials

Supplementary material associated with this article can be found in the online version at <https://doi.org/10.1016/j.amjcard.2025.10.024>.

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