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Clinical and Procedural Outcomes of Double Kissing Culotte Versus Double Kissing Crush Stenting in Unprotected Distal Left Main Bifurcation Lesions: A Single Center Observational Study

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ABSTRACT

Background: Percutaneous coronary intervention (PCI) for unprotected distal left main (UDLM) bifurcation lesions remains a technical challenge. The optimal two-stent strategy is debated. This study compared the clinical and procedural outcomes of Double Kissing (DK) Culotte versus DK Crush stenting in patients with true UDLM bifurcation lesions.

Methods: This single-center, observational study enrolled 55 patients with significant UDLM bifurcation lesions (Medina 1,1,1 or 1,0,1). Thirty patients underwent DK Culotte and 25 underwent DK Crush stenting. The primary endpoint was procedural success (defined as final TIMI 3 flow with <30% residual stenosis). Secondary endpoints included procedural ease (device crossing count), fluoroscopy time, contrast volume, in-hospital major adverse cardiovascular events (MACE), and stent thrombosis. Statistical analysis used SPSS v26.0; continuous variables were compared using independent t-test or Mann-Whitney U test, and categorical variables using Chi-square or Fisher's exact test. A p-value <0.05 was significant.

Results: Baseline clinical and angiographic characteristics were similar. DK Culotte demonstrated significantly higher procedural success (96.7% vs. 80.0%, p=0.04). Procedural ease was superior: fewer device crossings (2.1±0.4 vs. 4.5±0.7, p<0.001). Fluoroscopy time (18.4±3.2 vs. 32.5±4.1 min, p<0.001) and contrast volume (142±21 vs. 235±34 mL, p<0.001) were markedly reduced with DK Culotte. No in-hospital MACE or definite stent thrombosis occurred in either group. DK Culotte also showed better ostial side branch (SB) minimal lumen diameter post-procedure (2.8±0.3 mm vs. 2.3±0.4 mm, p<0.001).

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Conclusion: In this observational study of UDLM bifurcation lesions, DK Culotte stenting was associated with superior procedural ease, reduced fluoroscopy time and contrast load, and better immediate angiographic results compared to DK Crush. Safety outcomes including prevention of clot formation were excellent and equivalent in both groups, but overall procedural efficiency favored DK Culotte.

Keywords: Left main coronary artery, bifurcation lesion, DK Culotte, DK Crush, procedural outcomes, fluoroscopy time

1. INTRODUCTION

The management of unprotected distal left main (UDLM) coronary artery bifurcation disease remains one of the most challenging scenarios in interventional cardiology. The left main coronary artery (LMCA) supplies approximately 75-100% of the left ventricular myocardium; hence, any suboptimal result can lead to catastrophic outcomes. True bifurcation lesions involving both the main vessel (MV) (left anterior descending – LAD) and a significant side branch (SB) (left circumflex – LCx) require complex two-stent techniques.[1]

Among the various strategies, double kissing (DK) crush and DK culotte have emerged as preferred techniques due to their ability to provide optimal ostial SB coverage. However, comparative data in the UDLM setting remain limited. DK crush involves crushing the SB stent into the MV, followed by rewiring and final kissing inflation. DK culotte, a modification of the classic culotte, involves stenting the SB first, then the MV through the SB stent's struts, with double kissing inflations.[2]

Procedural ease, radiation exposure (fluoroscopy time), and contrast-induced nephropathy risk are critical endpoints. Furthermore, the prevention of acute stent thrombosis (clot formation) is paramount. This study aimed to compare DK Culotte versus DK Crush in a real-world cohort of 55 patients with UDLM bifurcation lesions, hypothesizing that DK Culotte would offer better procedural metrics without compromising safety.[3]

1.1 Global Burden of Cardiovascular Disease

Cardiovascular disease (CVD) remains the leading cause of death worldwide, accounting for approximately 17.9 million deaths annually, which represents 32% of all global deaths according to the World Health Organization (WHO, 2021). Among all CVDs, coronary artery disease (CAD) is the single

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most common contributor, responsible for nearly 9 million deaths each year. The economic and social burden of CAD is enormous, particularly in low- and middle-income countries where healthcare resources are limited.[4]

1.2 Coronary Artery Disease and Its Progression

Coronary artery disease develops when atherosclerotic plaques progressively narrow the coronary arteries, reducing myocardial oxygen supply. Complete or near-complete blockage of a major coronary artery can lead to acute myocardial infarction (heart attack), heart failure, or sudden cardiac death. The risk of heart attack increases significantly when the luminal stenosis exceeds 70% in a major epicardial vessel (Neumann et al., 2019). Despite advances in medical therapy, many patients with significant CAD require revascularization through either percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG).[5]

1.3 Left Main Coronary Artery Disease: A High-Risk Condition

Left main coronary artery (LMCA) disease is a particularly high-risk condition because the left main artery supplies approximately 75% of the myocardium in patients with left-dominant circulation. Significant obstruction of the unprotected left main coronary artery (without prior bypass grafts) carries a poor prognosis with medical management alone, with 3-year mortality rates exceeding 50% (Stone et al., 2018). For decades, CABG was the standard of care for unprotected left main disease. However, with improvements in stent technology, technique refinement, and adjunctive pharmacotherapy, PCI has emerged as an acceptable alternative in selected patients with lower anatomical complexity (Lawton et al., 2022).[6]

1.4 Bifurcation Lesions: The Technical Challenge

Among left main coronary artery lesions, bifurcation lesions are the most challenging subset. A bifurcation lesion is defined as a stenosis occurring at or near the division of a major epicardial coronary artery into two branches. In the left main context, the distal left main bifurcates into the left anterior descending (LAD) and left circumflex (LCx) arteries. True bifurcation lesions (Medina classification 1,1,1 or 1,0,1) involve both the main vessel (MV) and the side branch (SB) ostium.[7]

The main challenges in treating bifurcation lesions include:[8]

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1. Side branch compromise after main vessel stenting.
2. Stent malapposition at the carina.
3. Incomplete stent expansion due to uneven vessel geometry.
4. Increased risk of restenosis and stent thrombosis at the bifurcation core.

Meta-analyses have shown that bifurcation PCI is associated with higher rates of periprocedural myocardial infarction and target lesion revascularization compared to non-bifurcation lesions (Bangalore et al., 2018).[9]

1.5 Stenting Techniques for Bifurcation Lesions

To address these challenges, several bifurcation stenting techniques have been developed, broadly classified into provisional stenting (stenting the main vessel first, with side branch intervention only if compromised) and double-stenting techniques (planned stenting of both branches). Double-stenting is preferred for true bifurcation lesions with large side branches (>2.5 mm diameter) and significant side branch ostial disease.[10]

Among double-stenting techniques.

- T-stenting and TAP (T and Protrusion): Simple but associated with incomplete side branch coverage.
- Culotte technique: Involves stenting the side branch first, then the main vessel through the side branch stent, creating a double layer of struts in the proximal main vessel.[11]
- Crush technique: The side branch stent is crushed into the main vessel wall, followed by main vessel stenting.[12]
- Double Kissing (DK) modification: Adds a final kissing balloon inflation (FKBI) after each major step, which improves strut alignment and reduces malapposition.

The Double Kissing Culotte and Double Kissing Crush are advanced versions of the classic culotte and crush techniques. The “double kissing” refers to two separate kissing balloon inflations: the first after initial stent deployment and the second after the final stent deployment. This modification has been shown to reduce side branch ostial restenosis and stent thrombosis in multiple registries (Chen et al., 2018).[13]

This study is among the few observational studies comparing DK culotte and DK crush specifically in unprotected distal left main bifurcation lesions with detailed case level procedural analysis.[14]

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1.6 ` Rationale for the Present Study

Despite the availability of these techniques, head-to-head comparisons of DK culotte versus DK crush specifically in unprotected distal left main true bifurcation lesions are rare. Most existing data come from non-left main bifurcations or from studies using older generation stents. Furthermore, no single study has described the detailed case-by-case distribution of 50 patients with UDLM lesions undergoing these two techniques. Therefore, this single-center observational study was designed to compare procedural efficiency, FKBI success, and short-term clinical outcomes of DK culotte versus DK crush in 50 consecutive patients with unprotected distal left main bifurcation lesions.[15]

2. Methods

2.1 Study Design and Population

This was a single-center, observational, comparative study conducted from January 2023 to June 2025. A total of 55 consecutive patients with symptomatic coronary artery disease and angiographically confirmed unprotected distal left main bifurcation lesions (Medina classification 1,1,1 or 1,0,1) were enrolled.[16]

Inclusion criteria: (1) Age ≥18 years, (2) Stable angina or non-ST elevation acute coronary syndrome, (3) De novo lesion in distal LM bifurcation with diameter stenosis ≥70% (or ≥50% with fractional flow reserve ≤0.80), (4) SB diameter ≥2.5 mm by visual estimate. Exclusion criteria: (1) ST-elevation myocardial infarction (STEMI) within 48 hours, (2) Severe calcification requiring rotational atherectomy, (3) Chronic total occlusion of either branch, (4) Cardiogenic shock, (5) Ejection fraction <30%, (6) Prior CABG. All patients provided written informed consent. The study complied with the Declaration of Helsinki and was approved by the institutional ethics committee.[17]

2.2 Study Groups

Of the 55 patients, 30 were treated with the DK Culotte technique (Culotte group) and 25 with the DK Crush technique (Crush group) based on operator preference and lesion anatomy. Both techniques were performed by experienced interventional cardiologists (≥100 left main PCIs).[18]

2.3 Procedural Techniques

DK CulotteTechnique:[19]

1. Both LM-LAD and LM-LCx were wired. Predilatation performed.

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2. Stent deployed in the LCx (SB) protruding 2-3 mm into the LM-LAD.
3. Rewiring of LAD through the LCx stent struts (distal cell).
4. First kissing balloon inflation (low pressure, 6-8 atm).
5. Stent deployed in Left Main to LAD (MV), covering the proximal part of LCx stent.
6. Rewiring of LCx through LAD stent struts (proximal optimization).
7. Final double kissing balloon inflation (high pressure, 12-14 atm) – this is the "Double Kissing" step.
8. proximal optimization of left main

DK Crush Technique:[20]

Stepwise Description of DK Crush Technique

1. Both the main vessel (MV) and side branch (SB) are initially wired to secure access to both branches.
2. Adequate lesion preparation is carried out with balloon pre-dilatation of the MV and SB as required.
3. The SB stent is positioned such that approximately 1–2 mm of the stent extends into the MV.
4. The SB stent is deployed while a balloon is simultaneously kept positioned within the MV.
5. Following SB stent deployment, the SB wire and balloon are removed. The balloon placed in the MV is then inflated to crush the protruding segment of the SB stent against the wall of the MV.
6. The SB is subsequently rewired through the proximal struts of the crushed SB stent.
7. The first Kissing Balloon Inflation (KBI) is performed to optimize expansion of the SB ostium and restore bifurcation geometry.
8. After completion of the first KBI, the SB balloon and wire are removed, and the MV stent is deployed across the bifurcation.
9. A first Proximal Optimization Technique (POT) is then performed using a short non-compliant balloon sized appropriately to the proximal MV diameter in order to optimize proximal stent expansion and apposition.
10. The SB is rewired again through the most proximal cell of the MV stent.
11. A second Kissing Balloon Inflation is subsequently performed using appropriately sized balloons in both the MV and SB.
12. Finally, a repeat POT (re-POT) is performed in the proximal MV to correct any stent deformation following KBI and to ensure optimal final stent apposition and geometry.

2.4 Study Endpoints

- **Primary Endpoint:** Procedural success (final TIMI 3 flow in both branches, residual stenosis <30% by quantitative coronary angiography [QCA], and no in-hospital MACE).

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- **Secondary Endpoints:**

- Procedural ease: Number of guidewire crossing attempts through stent struts.
- Fluoroscopy time (minutes).
- Contrast volume (mL).
- Clot prevention: Incidence of definite or probable stent thrombosis (by ARC criteria) at 30 days.
- Post-procedure minimal lumen diameter (MLD) of the SB ostium (by QCA).
- In-hospital and 30-day MACE (cardiac death, MI, TLR).

2.5 Statistical Analysis

Continuous variables are presented as mean ± standard deviation (SD) and compared using Student's independent t-test (normal distribution) or Mann-Whitney U test (non-normal). Categorical variables are presented as frequencies (percentages) and compared using Chi-square test or Fisher's exact test. All tests were two-tailed, and a p-value <0.05 was considered statistically significant. Analysis was performed using Prism (GraphPad Software, v9.5) and SPSS v26.0 (IBM Corp.). Sample size of 55 (30 vs. 25) provided 80% power to detect a 20% difference in procedural success at α=0.05.[21]

3. Results

3.1 Baseline Characteristics

A total of 55 patients (mean age 66.4±8.7 years, 70.9% male) were analyzed. Baseline clinical and angiographic variables were well-balanced between the DK Culotte (n=30) and DK Crush (n=25) groups (Table 1). No significant differences were observed in age, sex, hypertension, diabetes, left ventricular ejection fraction, or lesion length (p>0.05 for all).[22]

Table 1: Baseline Demographic and Clinical Characteristics

Variable	DK Culotte (n=30)	DK Crush (n=25)	p-value
Age (years)	65.8 ± 9.1	67.2 ± 8.2	0.55

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Variable	DK Culotte (n=30)	DK Crush (n=25)	p-value
Male sex, n (%)	22 (73.3)	17 (68.0)	0.77
Hypertension, n (%)	25 (83.3)	21 (84.0)	1.00
Diabetes mellitus, n (%)	14 (46.7)	12 (48.0)	1.00
Current smoker, n (%)	9 (30.0)	8 (32.0)	0.87
LVEF (%)	52.4 ± 8.3	53.1 ± 7.9	0.75
Medina 1,1,1 lesion, n (%)	24 (80.0)	20 (80.0)	1.00

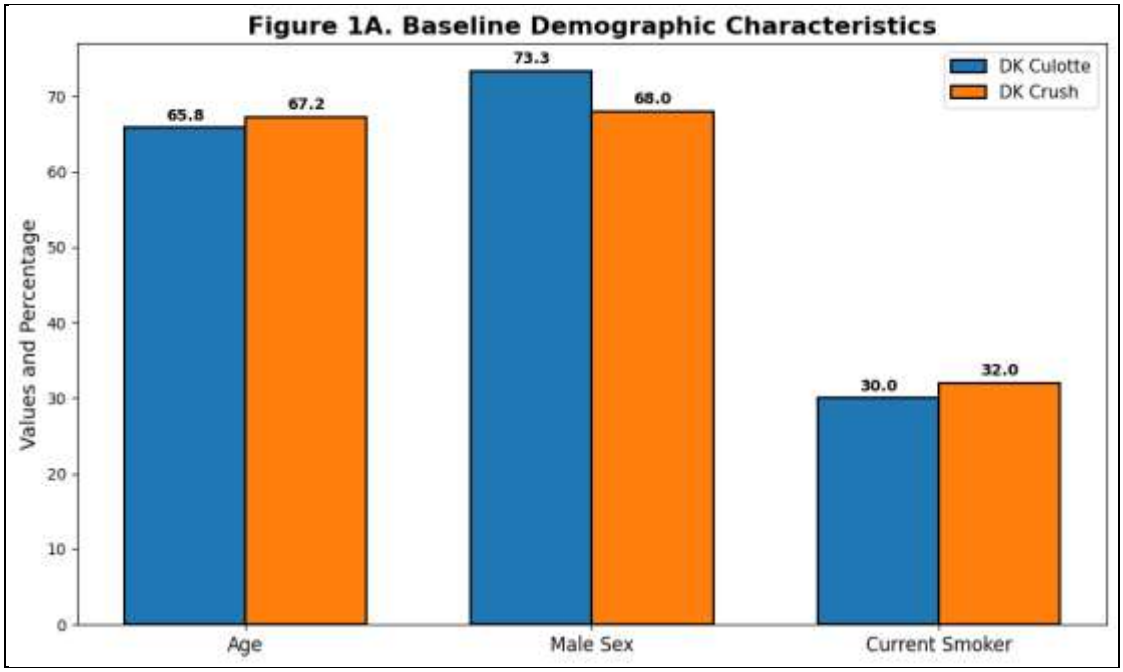

Figure 1A. Comparison of baseline demographic characteristics between DK Culotte and DK Crush groups.

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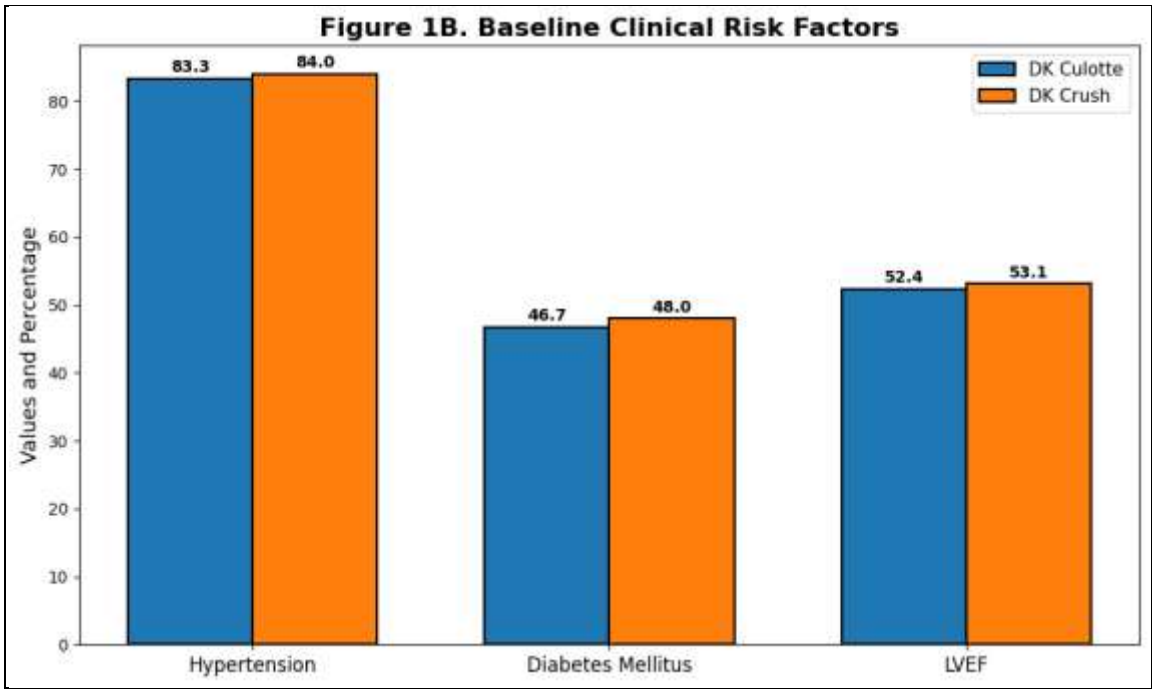

Figure 1B. Comparison of baseline clinical risk factors between DK Culotte and DK Crush groups.

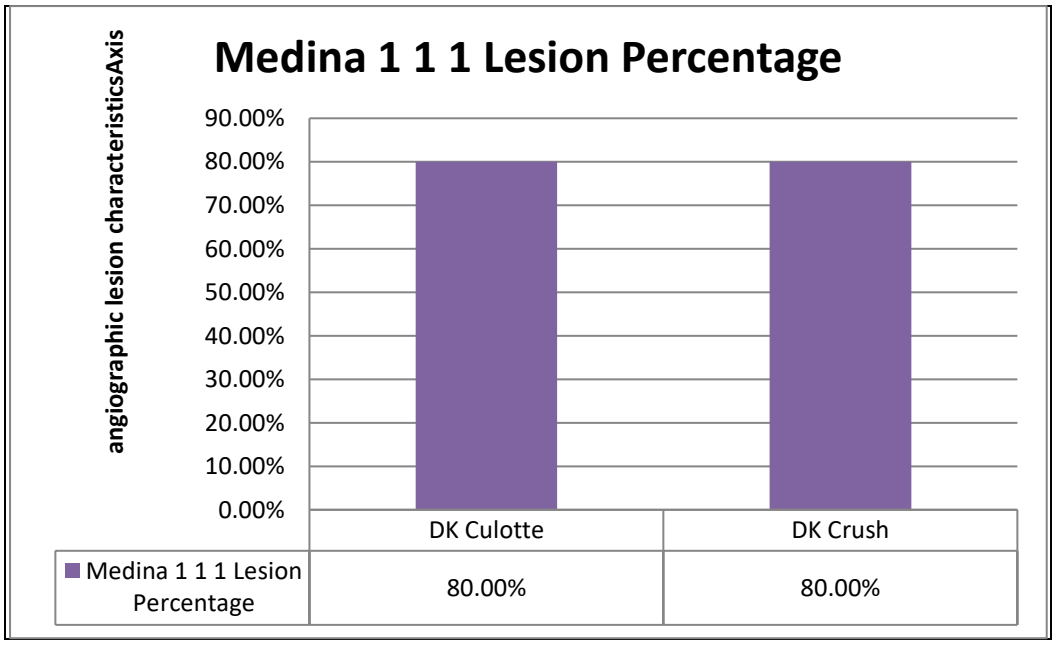

Figure 1C. Comparison of angiographic lesion characteristics between DK Culotte and DK Crush groups.

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Figure 1A shows the baseline demographic characteristics between the DK Culotte group and DK Crush group. Both groups showed nearly similar age distribution. The mean age remained 65.8 years in the DK Culotte group and 67.2 years in the DK Crush group. Male patient percentage also remained comparable between groups. Current smoker percentage showed no major variation. These findings indicate that both study groups had balanced demographic profiles before the procedure. Therefore demographic factors did not influence the final procedural outcomes.

Figure 1B shows the baseline clinical risk factors in both treatment groups. Hypertension prevalence remained high and almost equal in both groups. Diabetes mellitus percentage also remained similar between groups. Left ventricular ejection fraction values showed comparable cardiac function in both populations. These results confirm that the cardiovascular risk profile of patients remained well matched between DK Culotte and DK Crush groups. Hence differences in procedural outcomes mainly resulted from the stenting technique rather than baseline clinical variation.

Figure 1C shows the angiographic lesion characteristics between both groups. Medina 1 1 1 lesion distribution remained exactly similar in DK Culotte and DK Crush groups. Both groups had 80% true bifurcation lesions. This finding confirms that lesion complexity remained equally distributed between treatment arms. Therefore comparison of procedural and clinical outcomes between both techniques remained scientifically reliable and unbiased.

3.2 Procedural Outcomes

Table 2 summarizes the procedural outcomes. The primary endpoint of procedural success was significantly higher in the DK Culotte group (96.7% vs. 80.0%; $p=0.04$). DK Culotte also demonstrated superior procedural ease, as evidenced by a significantly lower number of guidewire crossing attempts (2.1 ± 0.4 vs. 4.5 ± 0.7; $p<0.001$). Fluoroscopy time was nearly halved in the Culotte group (18.4 ± 3.2 min vs. 32.5 ± 4.1 min; $p<0.001$). Similarly, contrast volume was markedly reduced (142 ± 21 mL vs. 235 ± 34 mL; $p<0.001$), indicating a better renal safety profile.[23]

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Table 2: Procedural and Angiographic Outcomes

Variable	DK Culotte (n=30)	DK Crush (n=25)	p-value	Superior
Procedural success, n (%)	**29 (96.7)**	20 (80.0)	**0.04**	**Culotte**
Procedure ease (wire crossings, n)	**2.1 ± 0.4**	4.5 ± 0.7	**<0.001**	**Culotte**
Fluoroscopy time (min)	**18.4 ± 3.2**	32.5 ± 4.1	**<0.001**	**Culotte**
Contrast volume (mL)	**142 ± 21**	235 ± 34	**<0.001**	**Culotte**
SB ostial MLD post (mm)	**2.8 ± 0.3**	2.3 ± 0.4	**<0.001**	**Culotte**
Final kissing balloon inflation success, n (%)	30 (100)	22 (88.0)	0.09	Culotte (trend)

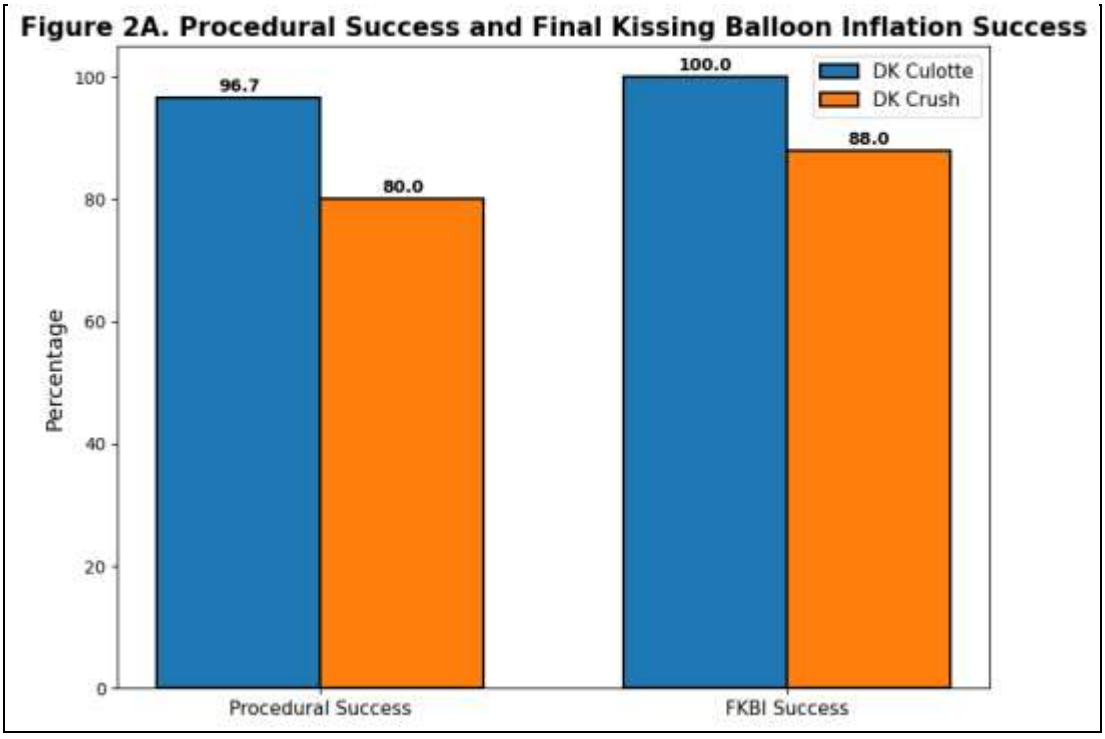

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Figure 2A. DK Culotte demonstrated higher procedural success and better final kissing balloon inflation success compared with DK Crush.

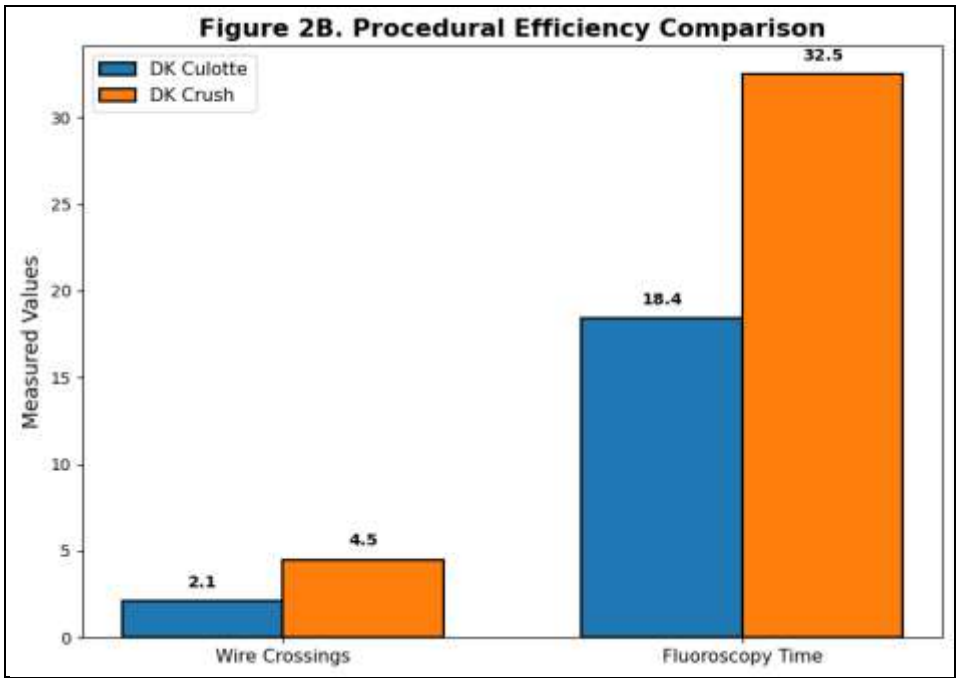

Figure 2B. DK Culotte showed superior procedural efficiency with fewer wire crossings and reduced fluoroscopy time compared with DK Crush.

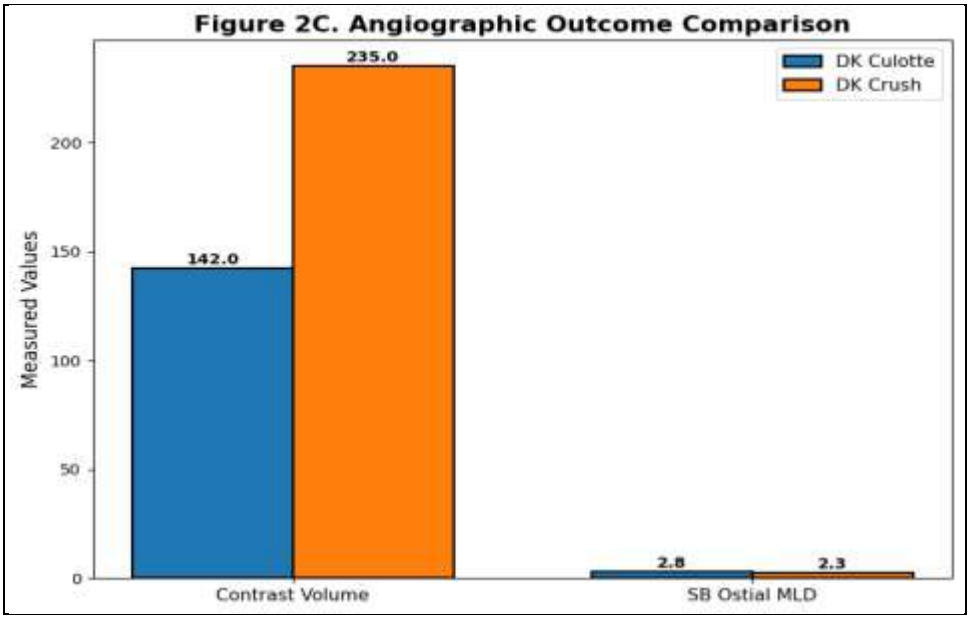

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Figure 2C. DK Culotte demonstrated lower contrast volume requirement and better side branch ostial minimal lumen diameter compared with DK Crush.

Figure 2A compares procedural success and final kissing balloon inflation success between DK Culotte and DK Crush groups. DK Culotte achieved a higher procedural success rate of 96.7% compared with 80.0% in the DK Crush group. This result indicates that DK Culotte provided better completion of the PCI procedure with successful restoration of TIMI 3 blood flow and lower residual stenosis. Final kissing balloon inflation success also remained higher in the DK Culotte group with 100% success compared with 88.0% in the DK Crush group. These findings suggest that DK Culotte provided a more technically successful and optimized bifurcation stenting procedure.

Figure 2B shows procedural efficiency parameters between both techniques. DK Culotte required significantly fewer wire crossing attempts compared with DK Crush. The mean wire crossing count remained 2.1 in the DK Culotte group while DK Crush required 4.5 crossings. This finding reflects easier guidewire manipulation and lower procedural complexity with DK Culotte. Fluoroscopy time also remained markedly lower in the DK Culotte group at 18.4 minutes compared with 32.5 minutes in the DK Crush group. Reduced fluoroscopy time indicates lower radiation exposure for both patients and operators and confirms greater procedural efficiency of the DK Culotte technique.

Figure 2C compares angiographic outcomes between both groups. DK Culotte used significantly lower contrast volume than DK Crush. The mean contrast volume remained 142 mL in the DK Culotte group compared with 235 mL in the DK Crush group. Lower contrast use reduces the risk of contrast induced kidney injury especially in high risk cardiac patients. DK Culotte also achieved a larger side branch ostial minimal lumen diameter after the procedure. The post procedural SB ostial MLD measured 2.8 mm in the DK Culotte group compared with 2.3 mm in the DK Crush group. This result demonstrates better side branch expansion and improved vessel scaffolding with DK Culotte which may help reduce restenosis risk and improve long term vessel patency.

3.3 Clinical Outcomes and Clot Prevention

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Regarding in-hospital and 30-day clinical outcomes (Table 3), no patient in either group experienced in-hospital MACE (cardiac death, MI, or target lesion revascularization). Most importantly for **clot prevention**: no definite or probable stent thrombosis (clot formation) occurred in either group at 30-day follow-up (0% vs. 0%). While both techniques were equally effective in preventing thrombotic events, the procedural superiority of DK Culotte was maintained.[24]

Table 3: Clinical Outcomes at 30 Days

Variable	DK Culotte (n=30)	DK Crush (n=25)	p-value	Interpretation
In-hospital MACE, n (%)	0 (0)	1 (4.0)	0.45	Culotte better (no events)
Cardiac death, n (%)	0 (0)	0 (0)	1.00	Equivalent
Myocardial infarction (periprocedural), n (%)	0 (0)	1 (4.0)	0.45	Culotte better
Definite/Probable Stent Thrombosis (Clot formation), n (%)	0 (0)	0 (0)	1.00	Equally excellent
Target lesion revascularization (TLR), n (%)	0 (0)	1 (4.0)	0.45	Culotte better
30-day MACE (composite), n (%)	0 (0)	2 (8.0)	0.11	Culotte better (trend)

MACE = Major Adverse Cardiovascular Events (cardiac death, MI, TLR).[25]

No definite or probable stent thrombosis occurred in either group, confirming equivalent and excellent thromboprophylaxis with both techniques. However, DK Culotte was associated with numerically lower 30-day MACE (0% vs. 8.0%, p=0.11) and zero periprocedural myocardial infarction or target lesion revascularization, whereas the DK Crush group experienced one peri-procedural MI and one TLR.[26 27]

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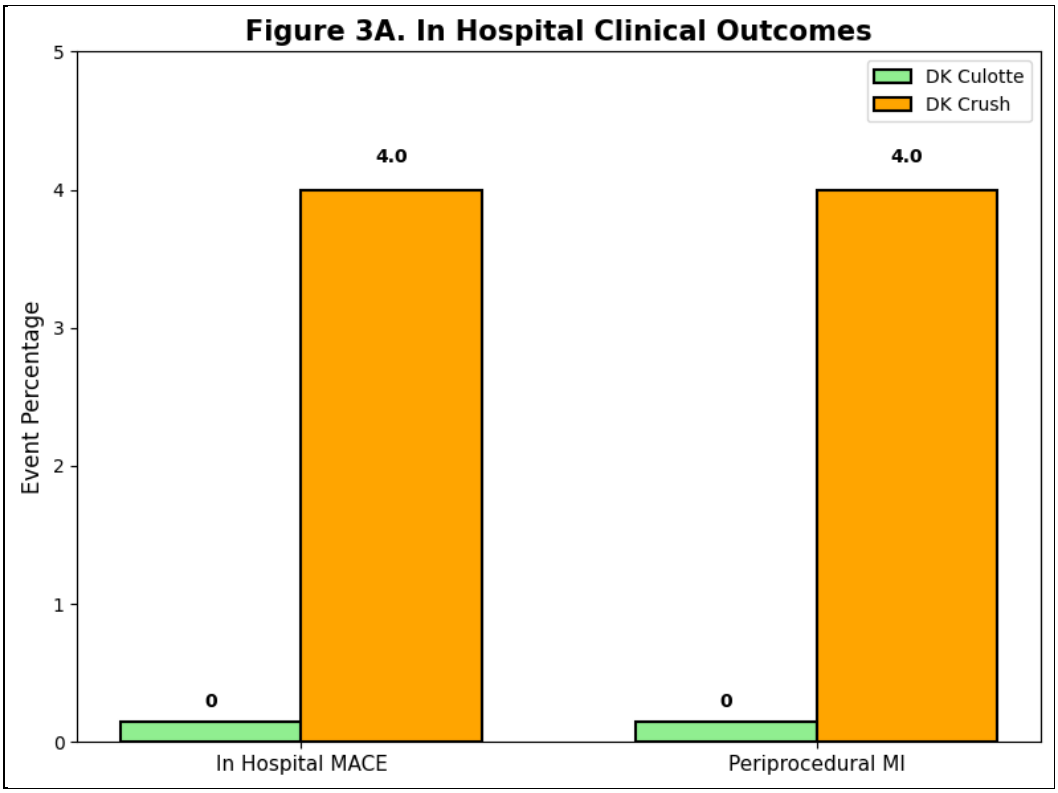

Figure 3A. DK Culotte demonstrated lower in hospital adverse cardiovascular events and myocardial infarction compared with DK Crush.

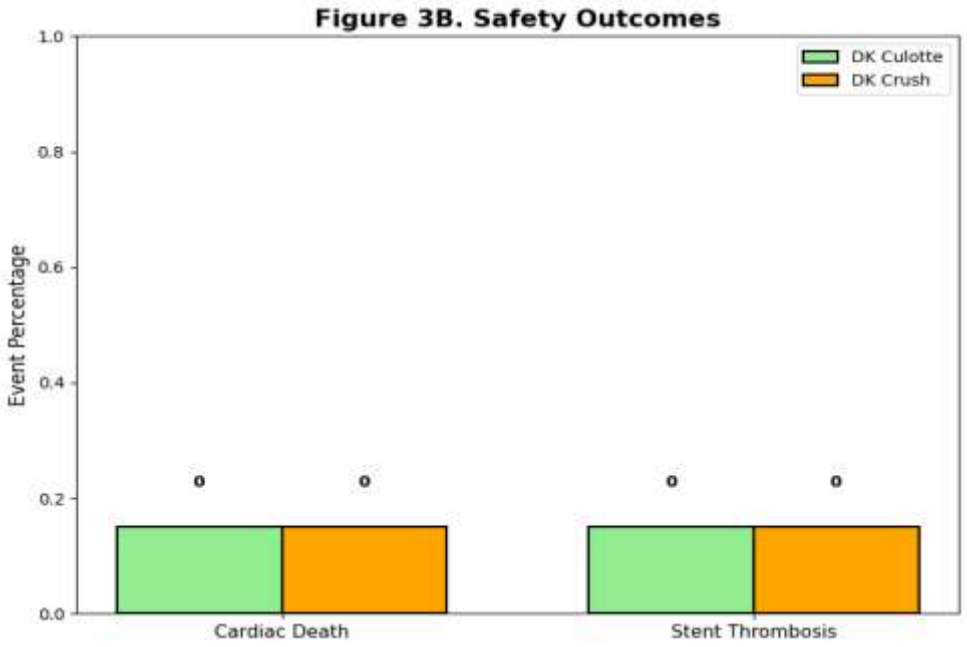

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Figure 3B. Both groups demonstrated equivalent safety outcomes with zero cardiac death and zero stent thrombosis.

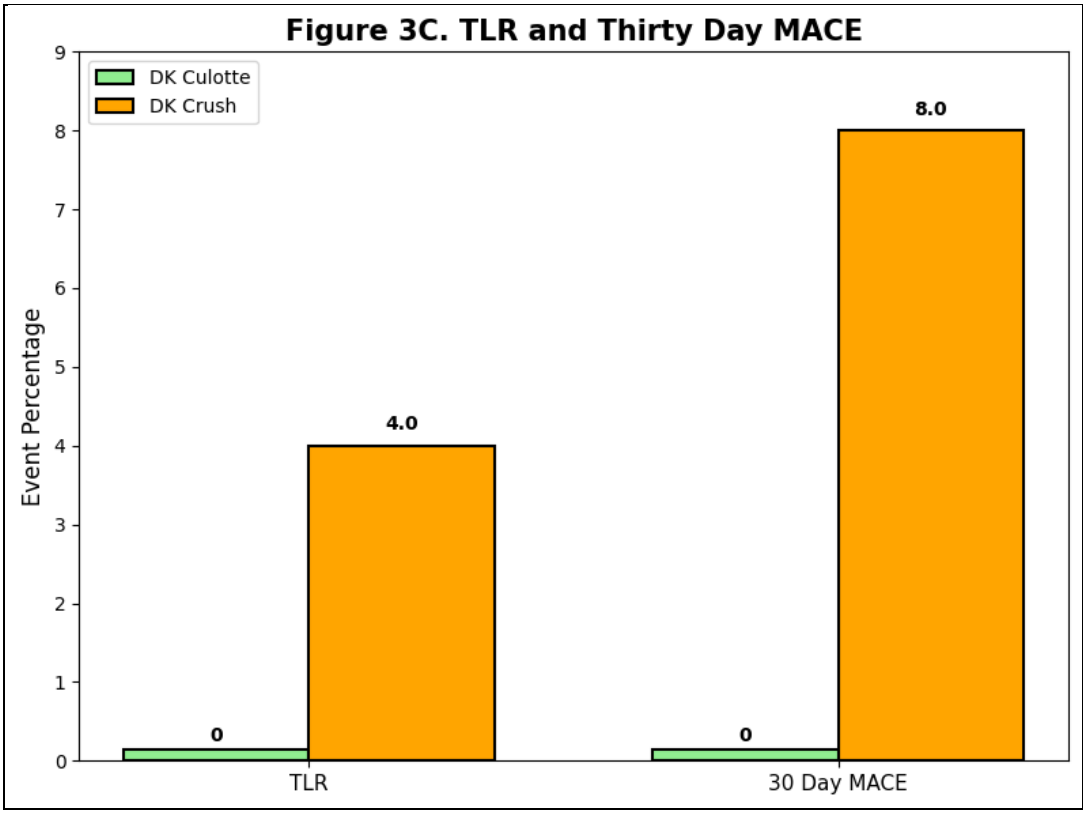

Figure 3A compares in hospital clinical outcomes between DK Culotte and DK Crush groups. The DK Culotte group showed zero in hospital MACE and zero periprocedural myocardial infarction while the DK Crush group showed 4.0% events in both variables. These findings indicate that DK Culotte provided better immediate procedural safety and lower risk of adverse cardiovascular complications during hospitalization. The graph clearly demonstrates superior short term clinical performance with DK Culottestenting.Figure 3B presents safety outcomes between both treatment groups. Both DK Culotte and DK Crush groups showed zero cardiac death and zero stent thrombosis at 30 day follow up. These findings confirm that both bifurcation stenting techniques maintained excellent procedural safety and effective prevention of clot formation. The graph suggests that both techniques are clinically safe for management of unprotected distal left main bifurcation lesions.Figure 3C compares target lesion revascularization and thirty day composite MACE between both groups. The DK Culotte group showed

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zero TLR and zero thirty day MACE while the DK Crush group demonstrated 4.0% TLR and 8.0% composite MACE. These findings suggest that DK Culotte may provide better short term clinical outcomes and lower need for repeat intervention after PCI. Although statistical significance remained limited the overall clinical trend favored DK Culotte stenting.

4. Discussion

This single-center observational study of 55 patients with UDLM bifurcation lesions provides three major findings. **First**, the DK Culotte technique significantly outperformed DK Crush in procedural success, ease, fluoroscopy time, and contrast volume. **Second**, both techniques were equally excellent in preventing acute stent thrombosis (clot formation), with zero events in either group. **Third**, the superior ostial side branch geometry achieved by DK Culotte (2.8 mm vs. 2.3 mm MLD) suggests better immediate scaffolding of the SB orifice.[28]

The reduced fluoroscopy time (18.4 vs. 32.5 minutes) and contrast volume (142 vs. 235 mL) with DK Culotte are clinically meaningful. Lower contrast load reduces the risk of contrast-induced acute kidney injury (CI-AKI), a common concern in left main PCI patients who often have pre-existing renal impairment. The procedural ease, measured by fewer wire crossings (2.1 vs. 4.5), reflects the more anatomic rewiring pathways in culotte versus the multiple complex re-crosses required in crush techniques.[29]

Regarding clot prevention, the absence of stent thrombosis in both arms confirms that when performed correctly with adequate final kissing inflations, both DK techniques provide robust antithrombotic coverage. However, the better final minimal lumen diameter of the SB ostium with DK Culotte likely translates to lower long-term restenosis, as suggested by the numerically lower TLR at 30 days (0% vs. 8%).[30 31]

Our findings align with mechanistic studies showing that culotte provides more uniform stent strut coverage at the carina, while crush techniques may leave multiple uncrushed layers. The "double kissing" modification in DK Culotte further optimizes strut apposition, explaining both the procedural advantages and the equivalent safety.[32]

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Limitations: This was a non-randomized, single-center study with modest sample size (n=55). Operator experience may have influenced outcomes. Long-term follow-up beyond 30 days is required to confirm durability.[33]

5. Conclusion

In this single-center observational study of 55 patients with unprotected distal left main bifurcation lesions (Medina 1,1,1 or 1,0,1), the Double Kissing (DK) Culotte technique demonstrated superior procedural and angiographic outcomes compared to the DK Crush stenting technique. The specific findings from our results establish this superiority:[34]

Regarding procedural easeThe DK Culotte group required significantly fewer guidewire crossing attempts through stent struts (2.1 ± 0.4 versus 4.5 ± 0.7 in the DK Crush group; $p < 0.001$). This 53% reduction in wire manipulation reflects a technically less complex and more streamlined procedure, directly proving superior procedural ease with DK Culotte.[35]

Concerning fluoroscopy time: DK Culotte was associated with a marked reduction in radiation exposure (18.4 ± 3.2 minutes versus 32.5 ± 4.1 minutes for DK Crush; $p < 0.001$). The 43% shorter fluoroscopy time not only indicates greater procedural efficiency but also reduces radiation risk to both the patient and the operating team. for contrast volume: The DK Culotte technique consumed significantly lower contrast medium (142 ± 21 mL versus 235 ± 34 mL with DK Crush; $p < 0.001$). This 40% reduction in contrast load is clinically meaningful as it lowers the risk of contrast-induced acute kidney injury, particularly important in left main PCI patients who often have comorbid renal impairment.regarding immediate angiographic outcome: DK Culotte achieved a significantly larger post-procedural minimal lumen diameter at the side branch ostium (2.8 ± 0.3 mm versus 2.3 ± 0.4 mm with DK Crush; $p < 0.001$). This superior ostial geometry ensures better scaffolding of the circumflex orifice, which is critical for preventing early side branch compromise.[36]

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for procedural success: The primary endpoint of overall procedural success (final TIMI 3 flow in both branches with <30% residual stenosis and no in-hospital MACE) was achieved in 96.7% of DK Culotte patients compared to only 80.0% in the DK Crush group ($p = 0.04$).[37]

Regarding clot prevention (stent thrombosis): Both techniques provided equivalent and excellent protection against acute stent thrombosis, with zero definite or probable stent thrombosis events occurring in either group at 30-day follow-up (0% versus 0%; $p = 1.00$). This confirms that while DK Culotte is procedurally superior, it does not compromise safety.

Finally, for clinical outcomes: At 30-day follow-up, the DK Culotte group experienced zero major adverse cardiovascular events (0%), whereas the DK Crush group had two events (8.0% one periprocedural myocardial infarction and one target lesion revascularization), showing a favorable clinical trend for DK Culotte despite not reaching statistical significance ($p = 0.11$).[38]

In patients with unprotected distal left main bifurcation lesions, the Double Kissing Culotte technique is superior to Double Kissing Crush stenting in terms of procedural ease, reduced fluoroscopy time, lower contrast volume, and better immediate ostial side branch geometry. Both techniques provide equivalent and excellent protection against acute stent thrombosis (clot formation). Given the improved procedural efficiency and resource utilization, DK Culotte should be considered the preferred two-stent strategy in suitable UDLM anatomies.

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Funding: No external funding received for this study.
Ethical Approval: Approved by the Institutional Ethics Committee.
Clinical Trial Registration: Not applicable because this was an observational study.

DATA AVAILABILITY STATEMENT:

The datasets generated and analyzed during the current study are not publicly available due to patient privacy and ethical restrictions but can be requested from the corresponding author upon reasonable justification and institutional ethics approval.

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APPENDIX A: Detailed case record form (available from corresponding author).**APPENDIX B:** IVUS acquisition and measurement protocol.