ARCHIVES OF THE TURKISH SOCIETY OF CARDIOLOGY

Official journal of the TURKISH SOCIETY OF CARDIOLOGY

Clinical Outcomes of Double Kissing Culotte and Mini-Culotte Stenting in Non-Left Main Coronary Bifurcation Lesions: The OPTIMUM Trial

Sol Ana Koroner Arter Dışı Bifurkasyon Lezyonlarında Double Kissing Culotte ve Mini-Culotte Stentlemenin Klinik Sonuçları: OPTIMUM Çalışması

ABSTRACT

Objective: Culotte stenting is one of the most commonly used bifurcation stenting techniques. Double kissing mini-culotte (DKC) stenting, a modified version of culotte stenting, is currently recommended by clinical guidelines. This study aimed to compare the outcomes of DKC and mini-culotte (MC) techniques in true non-left main coronary bifurcation lesions (CBLs).

Method: A total of 200 patients with non-left main CBLs undergoing percutaneous coronary intervention were assigned to either MC stenting (n = 92) or DKC stenting (n = 108). The primary endpoint was target lesion failure (TLF), defined as a composite of cardiac death, target vessel myocardial infarction (TVMI), and target lesion revascularization (TLR) at one- and three-year follow up.

Results: The incidence of TLF was significantly lower in the DKC group at both one year [7 (7.6%) vs. 1 (0.9%), P = 0.017] and three years [18 (19.6%) vs. 6 (5.6%), P = 0.002], primarily driven by a reduction in TLR at one year [6 (6.5%) vs. 1 (0.9%), P = 0.033] and three years [13 (14.1%) vs. 5 (4.6%), P = 0.018]. Fewer patients experienced TVMI [4 (4.3%) vs. 3 (2.8%), P = 0.551] and cardiac death [5 (5.4%) vs. 1 (0.9%), P = 0.064] in the DKC group at three years.

Conclusion: In patients with true non-left main CBLs, the DKC technique was associated with a lower incidence of TLF and TLR at three years compared to the MC technique.

Keywords: Coronary bifurcation lesion, double kissing culotte, mini-culotte, mortality

ÖZET

Amaç: Culotte stentleme tekniği en sık tercih edilen koroner bifürkasyon stentleme yöntemlerden birisidir. Kılavuzlar tarafından önerilen double kissing mini-culotte (DKC) stentleme tekniği ise Culotte tekniğinin en güncel ve modifiyeli halidir. Biz çalışmamızda sol ana koroner dışı gerçek koroner bifürkasyon lezyonlarında (KBL) DKC ile mini-culotte (MC) stentlemeye karşılaştırdık.

Yöntem: Toplam 200 sol ana koroner arter dışı perkütan koroner girişim uygulanan gerçek KBL hastası MC stentleme (n=92) ve DKC (n=108) stentleme gruplarına kategorize edildi. Çalışmamızın birincil sonlanım noktası kardiyak ölüm, hedef damar miyokard enfarktüsü (TVMI) ve hedef lezyon revaskülarizasyonu (TLR) birleşik sonlanımını içeren hedef lezyon başarısızlığıdır (TLF).

Bulgular: 1 yıllık [7 (7,6%); 1 (0,9%), P = 0,017] ve 3 yıllık takiplerde [18 (19,6%); 6 (5,6%), P = 0,002] TLF sıklığı DKC grubunda daha düşüktü. Bu fark 1 yıllık [6 (6,5%); 1 (0,9%), P = 0,033] ve 3 yıllık [13 (14,1%); 5 (4,6%), P = 0,018] takiplerdeki TLR azalmasından kaynaklanmaktaydı. Ayrıca TVMI [4 (4,3%); 3 (2,8%), P = 0,551] ve kardiyak ölüm [5 (5,4%); 1 (0,9%), P = 0,064] hasta sayısı 3 yıllık takiplerde DKC grubunda daha düşüktü.

Sonuç: Sol ana koroner arter dışı gerçek KBL'lerde DKC tekniği 3 yıllık takiplerde MC'ye göre daha düşük TLF sıklığına sahiptir.

Anahtar Kelimeler: Koroner bifürkasyon lezyonu, double kissing culotte, mini culotte, mortalite

Coronary bifurcation lesion (CBL) is a particularly challenging condition for interventional cardiologists due to its complex anatomy and association with increased adverse cardiovascular outcomes. CBLs are observed in approximately

ORIGINAL ARTICLE
KLİNİK ÇALIŞMA

Serkan Kahraman
Deniz Demirci
Gökhan Demirci
Yunus Emre Erata
Mustafa Ali Yavaş
İrem Türkmen
Ahmet Yaşar Çizgici
Serkan Aslan
Hicaz Zencirkiran Agus
Ümit Bulut
Ahmet Güner
Ahmet Arif Yalçın
Ali Kemal Kalkan
Mehmet Ertürk

Department of Cardiology, University of Health Sciences, Mehmet Akif Ersoy Thoracic and Cardiovascular Surgery Center, Training and Research Hospital, Istanbul, Türkiye

Corresponding author:
Serkan Kahraman
✉ serkankahraman_86@outlook.com

Received: December 24, 2024
Accepted: March 02, 2025

Cite this article as: Kahraman S, Demirci D, Demirci G, et al. Clinical Outcomes of Double Kissing Culotte and Mini-Culotte Stenting in Non-Left Main Coronary Bifurcation Lesions: The OPTIMUM Trial. *Turk Kardiyol Dern Ars.* 2025;53(4):238-246.

DOI: 10.5543/tkda.2025.98697

15–20% of all percutaneous coronary interventions (PCI).[1] The culotte stenting technique was first introduced by Chevalier et al.[2] in 1998 for the treatment of CBL. Since its initial description, the technique has become one of the most extensively studied approaches in clinical trials.[3-7] Studies have shown that the culotte technique is associated with lower target lesion revascularization (TLR) rates compared to the T and small protrusion (TAP) technique, and it has demonstrated better outcomes than the provisional technique in non-left main bifurcation lesions. It is now one of the most preferred strategies among interventional cardiologists.[3-5] Over the years, several modifications of the original culotte technique have been developed.[1,2,8-10] In the current stenting era, the double kissing mini-culotte (DKC) stenting technique is recommended by recent guidelines. Bench tests have shown that the DKC technique results in a shorter metal carina, fewer malapposed struts, reduced side branch (SB) ostial stenosis compared to mini-culotte (MC) stenting.[9,10] However, there is still no clinical data in the literature comparing the DKC and MC techniques. On the other hand, it has been demonstrated that the DKC technique reduces TLR and SB restenosis rates compared to T-provisional stenting.[11] The aim of this study is to compare the clinical outcomes of DKC and MC stenting techniques in true non-left main CBLs.

Materials and Methods

Study Population

This was a single-center, observational study conducted at a high-volume tertiary heart center between September 2016 and January 2021. Patients older than 18 years with de novo true bifurcation lesions (Medina 1,1,1 or 0,1,1) treated with either the DKC or MC stenting techniques were included in this study. Patients were excluded if they underwent coronary artery bypass grafting, PCI for stent restenosis, had heart failure with reduced ejection fraction (< 40%), chronic total occlusion within the bifurcation lesion, moderate to severe calcification requiring atherectomy, hematological disorders or malignancy, end-stage renal or liver disease, active bleeding, pregnancy, life expectancy of less than one year, contraindications to dual antiplatelet therapy, or presented with cardiogenic shock. Patients presenting with ST-segment elevation myocardial infarction (STEMI), as well as those treated with stepwise provisional stenting or two-stent techniques other than DKC or MC stenting, were also excluded.

Among the 1,408 PCI procedures performed for CBL during the study period, a total of 200 patients treated with either DKC or MC stenting techniques were included in the evaluation. A flow chart of the study is presented in Figure 1. The patients were divided into two groups: those treated with MC stenting (n = 92), designated as Group 1, and those treated with the DKC technique (n = 108), designated as Group 2. This study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by Istanbul Mehmet Akif Ersoy Thoracic and Cardiovascular Surgery Training and Research Hospital Scientific Research Ethics Committee (Approval Number: 2024.01-02, Date: 27.02.2024). Informed consent was waived due to the retrospective design of the study. No artificial intelligence-assisted technologies were used in the preparation of this manuscript or its contents.

ABBREVIATIONS

CABG	Coronary artery bypass grafting
CBL	Coronary bifurcation lesion
DKC	Double kissing mini-culotte
DMV	Distal main vessel
EBC	European Bifurcation Club
KBD	Kissing balloon dilatation
LMCA	Left main coronary artery
MACE	Major adverse cardiovascular events
MC	Mini-culotte
PCI	Percutaneous coronary intervention
PMV	Proximal main vessel
POT	Proximal optimization technique
SB	Side branch
ST	Stent thrombosis
STEMI	ST-segment elevation myocardial infarction
TAP	T and small protrusion
TIMI	Thrombolysis in myocardial infarction
TLF	Target lesion failure
TLR	Target lesion revascularization
TVMI	Target vessel myocardial infarction

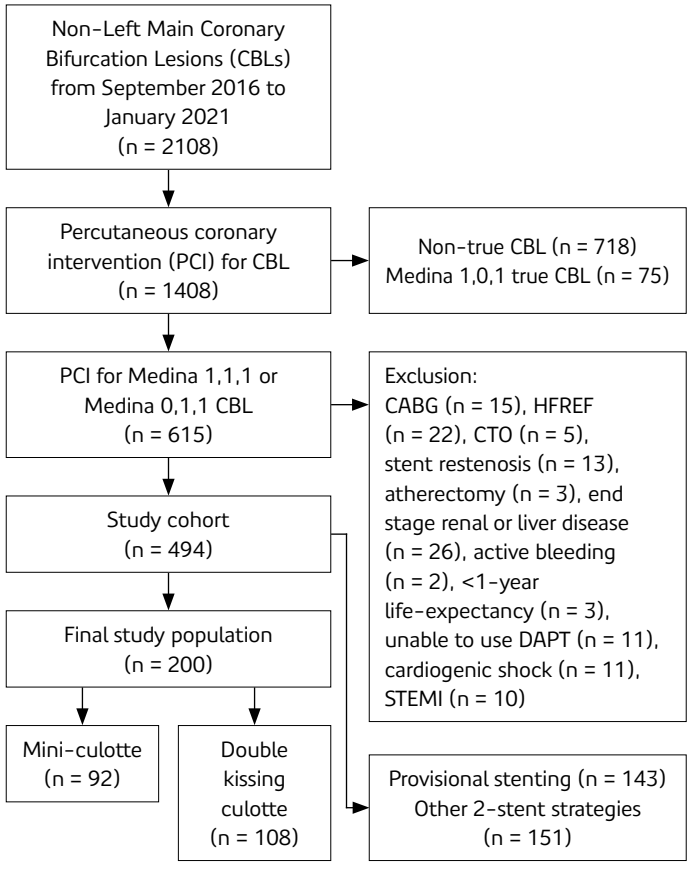

Figure 1. Flowchart of the study.

CABG, Coronary Artery Bypass Grafting; CBL, Coronary Bifurcation Lesion; DAPT, Dual Antiplatelet Therapy; HFrEF, Heart Failure with Reduced Ejection Fraction; PCI, Percutaneous Coronary Intervention; STEMI, ST-Segment Elevation Myocardial Infarction.

Procedural and Angiographic Evaluation

The femoral approach was the preferred strategy in nearly all patients. At the beginning of the procedure, all patients received unfractionated heparin. DKC and MC stenting techniques were performed in accordance with the most recent European Bifurcation Club (EBC) guidelines.[12] The first stent was implanted from the proximal main vessel (PMV) to the assigned side branch based on the SB reference diameter, with minimal protrusion (ideally 2-3 mm). After distal rewiring (close to the carina), a second stent was implanted from the PMV to the distal main vessel (DMV), sized according to the DMV reference diameter. The proximal optimization technique (POT) was mandatory at all stages, after the first stent implantation, after the second stent implantation, and as a final POT. Final kissing balloon dilatation (KBD) was intended for all patients. Unlike the MC technique, KBD was performed twice in the DKC technique, one of which occurred after the first stent implantation. Ideally, all patients received dual antiplatelet therapy with acetylsalicylic acid and a P2Y12 receptor inhibitor for one year (at least six months). Low-dose acetylsalicylic acid was prescribed for lifelong treatment. Second- or third-generation drug-eluting stents were used in this study, including Xience (Abbott Park, USA), Promus (Boston Scientific, Ireland), Resolute Onyx (Medtronic, USA), Firehawk (MicroPort, China) and BioMime (Meril, India).

The reference diameters of the DMV and SB, as well as the diameter stenosis of the PMV, DMV, and SB, were assessed by two independent experienced cardiologists. The bifurcation angle and lesion lengths of the main vessel and SB were also evaluated. The SYNTAX score (Synergy Between Percutaneous Coronary Intervention With TAXUS and Cardiac Surgery score) for each patient was calculated using the SYNTAX score calculator (www.syntaxscore.com). A complex bifurcation lesion was defined according to the DEFINITION criteria (Definitions and impact of complex bifurcation lesions on clinical outcomes after percutaneous coronary intervention using drug-eluting stents study) (one major criterion plus at least two minor criteria).[13] The major criterion for non-left main coronary artery (non-LMCA) bifurcation lesions was an SB lesion length ≥ 10 mm and SB diameter stenosis ≥ 90%.[13] Minor criteria included: more than mild calcification, presence of multiple lesions, bifurcation angle < 45° or > 70°, main vessel (MV) reference diameter < 2.5 mm, main vessel lesion length ≥ 25 mm, and thrombus-containing lesions.[13]

Clinical Outcomes

The primary endpoint of the study was target lesion failure (TLF), defined as a composite of cardiac death, target vessel myocardial infarction (TVMI), and ischemia-driven TLR at 1-year and 3-year follow-up. Cardiac death was defined as death without clear evidence of a non-cardiac cause. TVMI was defined as a composite of periprocedural myocardial infarction (MI) or spontaneous MI, unless there was clear evidence that the event was attributable to a non-target vessel.[14] Ischemia-driven TLR was defined as an ischemia-related revascularization of the target vessel using either repeat PCI or coronary artery bypass grafting (CABG).[14] Stent thrombosis (ST) was the secondary endpoint of the study and was defined according to the Academic Research Consortium criteria.[14]

Patient follow-up was conducted either through hospital visits or, for those unable to attend in person, via telephone at 1 month, 6 months, 1 year, and then annually until the end of the 3-year follow-up period. TLF rates at 1-year and 3-year follow-ups were evaluated in both groups.

Statistical Analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, version 22, IBM Corp., Armonk, New York, USA). Categorical variables were analyzed using Fisher's exact test or Pearson's chi-square test. The Kolmogorov-Smirnov test was used to assess the distribution of the variables. Data are presented as mean ± standard deviation (SD) for normally distributed variables, median (25^{th}-75^{th} percentiles) for non-normally distributed variables, and n (%) for categorical variables. The Mann-Whitney U test a was used for non-normally distributed variables, and the Student's t-test was used for normally distributed variables. Cox regression analysis was used to assess differences in both primary and secondary endpoints, with results reported as hazard ratios (HR) and 95% confidence intervals (CI). Long-term survival was analyzed using the Kaplan-Meier method and compared with the log-rank test. A p-value < 0.05 was considered statistically significant.

Results

A total of 2,108 patients with coronary bifurcation lesions were screened, and 1,408 PCI procedures were evaluated for CBL. Among these, 718 procedures were performed for non-true CBLs (Medina classifications 0,0,1; 0,1,0; and 1,0,0) and 75 procedures were for Medina 1,0,1 lesions. After excluding these, 615 patients with Medina 1,1,1 and 0,1,1 bifurcation lesions who underwent PCI were further evaluated. Patients were excluded from the study for the following reasons: 15 had undergone bypass grafting surgery, 22 had heart failure with reduced ejection fraction (<40%), five had chronic total occlusion within the bifurcation lesion, 13 underwent PCI for stent restenosis, three had moderate to severe calcification requiring atherectomy, 26 had end-stage renal or liver disease, two had active bleeding, three had a life expectancy of less than one year, 11 were unable to use dual antiplatelet therapy, 11 presented with cardiogenic shock, and 10 had STEMI. On the other hand, 143 patients treated with the stepwise provisional technique and 151 patients treated with other two-sent techniques were excluded. Ultimately, a total of 200 patients with non-left main true CBLs (Medina classification 1,1,1 and 0,1,1) who were treated with either DKC or MC stenting were included in the final analysis. The patients were then divided into two groups: 92 patients treated with the MC technique were categorized as Group 1, and 108 patients treated with the DKC technique were categorized as Group 2. A flowchart of the study design is presented in Figure 1.

The baseline clinical and demographic characteristics of the patients are shown in Table 1. The mean age in the MC group was 62 ± 10.2 years, while it was 63.3 ± 8.6 years in the DKC group. The proportion of female patients was 25.0% in the MC group and 22.2% in the DKC group. In the MC group, 42 patients (45.7%) presented with stable angina pectoris, compared to 45 patients (44.6%) in the DKC group.

Table 1. Baseline Clinical and Laboratory Characteristics of the Patients

	Mini-Culotte (n = 92)	DK Culotte (n = 108)	P
Age (years)	62 ± 10.2	63.6 ± 8.6	0.230
Gender (female), n (%)	23 (25.0)	24 (22.2)	0.644
Hemoglobin (g/dL)	13.82 ± 1.71	13.46 ± 1.65	0.129
Thrombocyte count (×10³/mm³)	245.5 (206–291.5)	244 (202.5–284.5)	0.928
Leukocyte count (×10³/mm³)	8.27 (6.97–10.61)	8.30 (6.56–10.0)	0.233
Creatinine (mg/dL)	0.86 (0.71–1.0)	0.85 (0.77–1.0)	0.783
Total cholesterol (mg/dL)	190.7 ± 54	187.5 ± 55.5	0.697
LDL cholesterol (mg/dL)	116.5 ± 45.7	116.9 ± 44.6	0.957
HDL cholesterol (mg/dL)	42 (36–50)	44 (38–52)	0.266
Triglycerides (mg/dL)	151 (103–201)	155 (125–206)	0.038
Glucose (mg/dL)	115 (98.5–180)	113 (91–150.5)	0.108
Diabetes mellitus, n (%)	41 (44.6)	50 (46.3)	0.806
Hypertension, n (%)	50 (54.3)	68 (63.0)	0.217
Smoking, n (%)	30 (32.6)	39 (36.1)	0.604
Previous PCI, n (%)	19 (20.7)	27 (25.0)	0.466
Atrial fibrillation, n (%)	4 (4.3)	6 (5.6)	0.478
Oral anticoagulation, n (%)	5 (5.4)	6 (5.6)	0.970
Beta-blocker use, n (%)	87 (94.6)	99 (91.7)	0.423
ACEI/ARB use, n (%)	82 (89.1)	97 (89.8)	0.875
Statin use, n (%)	90 (97.8)	106 (98.1)	0.627
Calcium channel blocker use, n (%)	17 (18.5)	23 (21.3)	0.619
Clinical presentation, n (%)			0.878
Stable	42 (45.7)	45 (44.6)	
USAP/NSTEMI	50 (54.3)	56 (55.4)	
Left ventricular ejection fraction (%)	52.5 ± 9.8	52.2 ± 8.0	0.853

ACEI, Angiotensin-Converting Enzyme Inhibitor; ARB, Angiotensin Receptor Blocker; DK, Double Kissing; HDL, High-Density Lipoprotein; LDL, Low-Density Lipoprotein; NSTEMI, Non-ST-Segment Elevation Myocardial Infarction; PCI, Percutaneous Coronary Intervention; USAP, Unstable Angina Pectoris.

Angiographic Features

Lesion characteristics are summarized in Table 2. There were no differences between the groups in terms of the culprit vessel, proximal and distal MV stenosis ratio, SB stenosis ratio, MV proximal, MV distal, and SB diameters, MV and SB stent diameters and lengths, bifurcation angle, severity of coronary artery disease, SYNTAX score, incidence of complex bifurcation lesions, presence of MV and SB calcification, or pre-procedural thrombolysis in myocardial infarction (TIMI) blood flow in the MV and SB.

There was also no difference in terms of culprit vessels between the groups. The SB lesion length was higher in the DKC group (16.3 ± 4.7 vs. 18.4 ± 3.9, P < 0.001), while the MV lesion length was higher in the MC group (25.89 ± 6.67 vs. 23.49 ± 8.76, P = 0.033). There were no significant differences regarding guiding catheter size, arterial access, acute SB occlusion, emergent CABG, glycoprotein IIb/IIIa inhibitor usage, or procedural time. Acute side branch occlusion occurred in three patients (3.3%) in the MC group compared to none (0%) in the DKC group (P = 0.096). Emergent coronary artery bypass grafting was required in only one patient (1.1%) in the MC group and none (0%) in the DKC group (P = 0.460). The incidence of final kissing balloon dilatation (FKBD) was higher in the DKC group [87 (94.6%) vs. 108 (100.0%), P = 0.019].

Clinical Endpoints

The incidence of TLF, a composite outcome of TLR, TVMI, and cardiac death, at one year [7 (7.6%) vs. 1 (0.9%), P = 0.017] and three years [18 (19.6%) vs. 6 (5.6%), P = 0.002] was significantly lower in the DKC technique compared to the MC technique. This difference was mainly driven by the TLR at both one year [6 (6.5%) vs. 1 (0.9%), P = 0.033] and three years [13 (14.1%) vs. 5 (4.6%), P = 0.018] (Figure 2). Although the number of patients with TVMI [4 (4.3%) vs. 3 (2.8%), P = 0.551] and cardiac death [5 (5.4%) vs. 1 (0.9%), P = 0.064] was also lower in the DKC group at three years, these differences were not statistically significant. The incidence of definite ST, as a secondary endpoint, was similar in both groups at one year and three years (Table 3).

In a subgroup analysis, the incidence of TLF was evaluated in patients with complex CBL. Complex bifurcation lesions were identified in 60 patients who underwent PCI in the MC group and

Table 2. Angiographic and Procedural Characteristics

	Mini-Culotte (n = 92)	DK Culotte (n = 108)	P
Culprit vessel, n (%)			0.966
LAD	60 (65.2)	72 (66.7)	
CXA	29 (31.5)	33 (30.6)	
RCA	3 (3.3)	3 (2.8)	
MV proximal stenosis (%)	69.6 ± 14.7	66.6 ± 18.9	0.207
MV distal stenosis (%)	72.9 ± 13.1	73.5 ± 13.7	0.761
SB stenosis (%)	88.8 ± 5.8	87.6 ± 7.3	0.195
MV reference vessel diameter (mm)	3.01 ± 0.32	2.98 ± 0.26	0.528
SB reference vessel diameter (mm)	2.87 ± 0.26	2.84 ± 0.23	0.393
MV stent length (mm)	26.9 ± 6.7	25.3 ± 8.3	0.143
SB stent length (mm)	21.2 ± 5.3	21.9 ± 6.5	0.425
Bifurcation angle (°)	60 (51–66)	61 (51–66)	0.640
Multivessel disease, n (%)	41 (44.6)	62 (57.4)	0.070
SYNTAX score	16.1 ± 4.6	16.5 ± 4.8	0.603
Complex bifurcation, n (%)	60 (65.2)	74 (68.5)	0.621
MV lesion length (mm)	25.89 ± 6.67	23.49 ± 8.76	0.033
SB lesion length (mm)	16.3 ± 4.7	18.4 ± 3.9	<0.001
Calcification MV, n (%)	5 (5.4)	8 (7.4)	0.573
Calcification SB, n (%)	5 (5.4)	3 (2.8)	0.276
Guiding catheter size, n (%)			0.096
6F	3 (3.3)	0 (0)	
7F	89 (96.7)	108 (100)	
Arterial access, n (%)			0.460
Femoral	91 (98.9)	108 (100)	
Radial	1 (1.1)	0 (0)	
MV predilatation, n (%)	63 (68.5)	75 (69.4)	0.883
SB predilatation, n (%)	35 (38.0)	47 (43.5)	0.433
Final kissing balloon, n (%)	87 (94.6)	108 (100)	0.019
POT, n (%)	89 (96.7)	104 (96.3)	0.588
Procedural time (minutes)	33 (14–53)	28 (13–53)	0.723

CXA, Circumflex Artery; DK, Double Kissing; LAD, Left Anterior Descending Artery; MV, Main Vessel; POT, Proximal Optimization Technique; RCA, Right Coronary Artery; SB, Side Branch.

74 patients who underwent PCI in the DKC group. The incidence of TLF at one year [6 (10.0%) vs. 0 (0%), P = 0.005] and at three years [15 (25.0%) vs. 3 (4.1%), P < 0.001] was significantly lower in the DKC group compared to the MC group. Similarly, the incidence of TLR at one year [5 (8.3%) vs. 0 (0%), P = 0.012] and at three years [11 (18.3%) vs. 2 (2.7%), P = 0.002] was also significantly lower in the DKC group. TVMI was lower in the DKC group at the three-year follow-up [4 (6.7%) vs. 0 (0%), P = 0.025]. On the other hand, the incidence of definite ST, as the secondary endpoint, was similar between the two groups at both one-year and three-year follow-ups (Table 4).

Discussion

In this study, we compared the incidence of TLF between the MC and DKC techniques. The incidence of TLF at both one-year and three-year follow-up were lower in the DKC group compared to the MC group, primarily driven by the TLR. Additionally, the number of patients with TVMI and cardiac death was lower in the DKC group. Furthermore, in patients with complex bifurcation lesions, the three-year TLF rate was also lower in the DKC group, primarily driven by TLR.

The culotte technique was first introduced by Chevalier et al. in 1998.[2] Using this novel approach, 50 patients were treated with a 94% procedural success rate. However, late outcomes revealed a target vessel revascularization (TVR) rate of 12.5%, even when final KBD was performed. Since its initial description, the culotte technique has become one of the most popular bifurcation strategies among interventional cardiologists. It is also the most frequently studied bifurcation technique in both

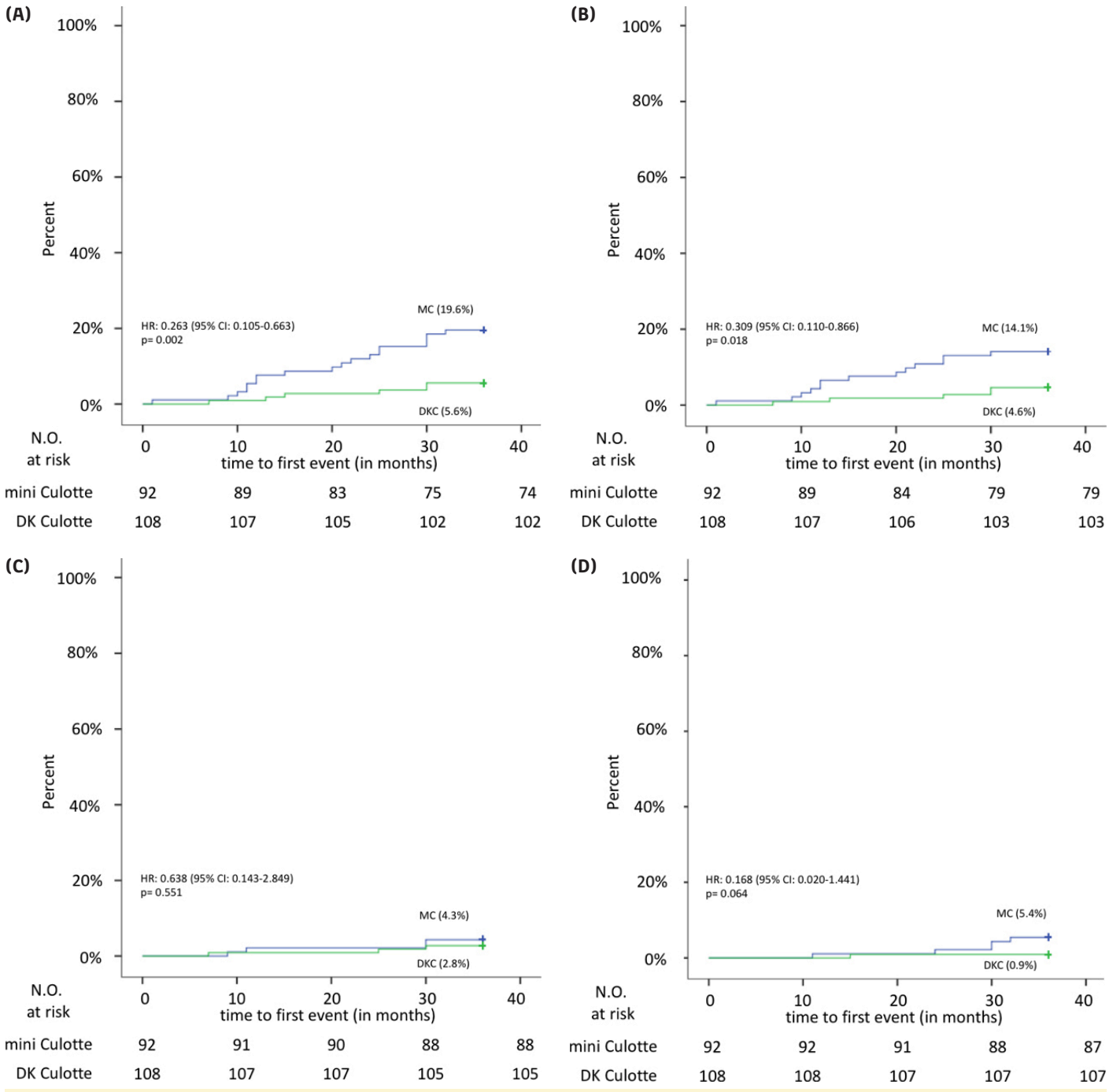

Figure 2. Kaplan-Meier survival analysis comparing mini-culotte (MC) and double kissing culotte (DKC) stenting techniques in terms of: (A) Target lesion failure (TLF), (B) Target lesion revascularization (TLR), (C) Target vessel myocardial infarction (TVMI), (D) Cardiac death.

randomized trials and observational studies. Over the years, several modifications have been developed to optimize stent apposition, reduce metallic neocarina and double metallic layers, and improve clinical outcomes. The mini-culotte technique has been evaluated in several trials. In the Bifurcations Bad Krozingen (BBK) II trial, the culotte technique was compared with TAP stenting in 300 patients.[3] At the nine-month angiographic follow-up, the culotte technique demonstrated a lower maximal percent diameter stenosis compared to TAP, which served as the trial's primary endpoint. Additionally, the one-year incidence of TLF (a composite of cardiac death, TVMI, and TLR) was lower in the culotte group, with an incidence of 6.7% compared to 12% in the TAP group. In the Nordic-Baltic Bifurcation Study IV, a provisional strategy (218 patients) was compared to a two-stent strategy (228 patients) in patients with CBL.[4] The culotte technique was initially recommended in the two-stent strategy arm. At the 24-month follow-up, the incidence of major adverse cardiovascular events (MACE)

Table 3. Clinical Outcomes of All Patients

	Mini-Culotte (n = 92)	DK Culotte (n = 108)	Hazard Ratio (95% CI)	P
1-Year outcomes				
TLF, n (%)	7 (7.6)	1 (0.9)	0.119 (0.015–0.969)	0.017
TLR, n (%)	6 (6.5)	1 (0.9)	0.140 (0.017–1.159)	0.033
Target vessel MI, n (%)	2 (2.2)	1 (0.9)	0.427 (0.039–4.709)	0.474
Cardiac death, n (%)	1 (1.1)	0 (0)	0.013 (0–13,551)	0.279
Secondary endpoint, n (%)				
Definite stent thrombosis, n (%)	1 (1.1)	0 (0)	0.013 (0–13,551)	0.279
3-Year outcomes				
TLF, n (%)	18 (19.6)	6 (5.6)	0.263 (0.105–0.663)	0.002
TLR, n (%)	13 (14.1)	5 (4.6)	0.309 (0.110–0.866)	0.018
Target vessel MI, n (%)	4 (4.3)	3 (2.8)	0.638 (0.143–2.849)	0.551
Cardiac death, n (%)	5 (5.4)	1 (0.9)	0.168 (0.020–1.441)	0.064
Secondary endpoint, n (%)				
Definite stent thrombosis, n (%)	1 (1.1)	1 (0.9)	0.847 (0.053–13.5)	0.907

DK, Double Kissing; MI, Myocardial Infarction; TLF, Target Lesion Failure; TLR, Target Lesion Revascularization.

Table 4. Clinical Outcomes of Patients with Complex Bifurcation Lesions

	Mini-Culotte (n = 60)	DK Culotte (n = 74)	Hazard Ratio (95% CI)	P
1-Year outcomes				
TLF, n (%)	6 (10.0)	0 (0)	0.012 (0–9.019)	0.005
TLR, n (%)	5 (8.3)	0 (0)	0.012 (0–17.064)	0.012
Target vessel MI, n (%)	2 (3.3)	0 (0)	0.012 (0–1175)	0.115
Cardiac death, n (%)	1 (1.7)	0 (0)	0.012 (0–136,577)	0.267
Secondary endpoint, n (%)				
Definite stent thrombosis, n (%)	1 (1.7)	0 (0)	0.012 (0–136,577)	0.267
3-Year outcomes				
TLF, n (%)	15 (25.0)	3 (4.1)	0.146 (0.042–0.503)	<0.001
TLR, n (%)	11 (18.3)	2 (2.7)	0.135 (0.030–0.610)	0.002
Target vessel MI, n (%)	4 (6.7)	0 (0)	0.012 (0–40.442)	0.025
Cardiac death, n (%)	4 (6.7)	1 (1.4)	0.200 (0.022–1.792)	0.109
Secondary Endpoint, n (%)				
Definite stent thrombosis, n (%)	1 (1.7)	1 (1.4)	0.804 (0.050–12.855)	0.877

DK, Double Kissing; MI, Myocardial Infarction; TLF, Target Lesion Failure; TLR, Target Lesion Revascularization.

was lower in the two-stent group (12.9% vs. 8.4%), primarily driven by TVR (10.5% vs. 6.6%) and MI (5.1% vs. 3.1%). In the European Bifurcation Coronary Two (EBC TWO) trial, 200 patients with large-caliber true CBLs (SB diameter ≥ 2.5 mm) were treated with either a provisional strategy (103 patients) or the culotte technique (97 patients).[5] There was no significant difference in MACE between the two groups at the 12-month follow-up. However, the number of patients with TVR (2.9% vs. 1.0%) and cardiac death (2.0% vs. 1.1%) was lower in the culotte group. The culotte technique has also been studied in left main coronary artery (LMCA) bifurcation trials. In the EBC MAIN trial (European Bifurcation Club Left Main), 467 patients with true left main stem bifurcation lesions were evaluated.[7] Of these, 230 patients were treated with a provisional strategy, while 237 received a two-stent strategy (culotte 53%, double kissing [DK] crush 5%, and T-stenting with protrusion [TP] 33%). There was no significant difference in terms of MACE, defined as a composite of TLR, death, and MI. In light of the foregoing data, the culotte stenting technique has proven to be both a feasible and safe method for the treatment of CBL.

Additionally, in the DKCRUSH-III trial (Double Kissing Crush III), the outcomes of culotte and DK crush stenting were compared in patients with distal left main bifurcation lesions.[6] A total of 419 patients were evaluated in this study: 210 patients in the DK crush group and 209 patients in the culotte group. There were no significant differences in terms of cardiac death and MI between the groups; however, the incidence of TVR was higher in the culotte stenting group (4.3% vs. 11.0%) at the 12-month follow-up, primarily driven by SB ostial restenosis. This result is not particularly surprising, as the study compared the conventional culotte method with the more advanced DK crush technique, which was performed according to EBC recommendations and in line with modern PCI standards. In addition to comparing different stenting techniques, this study also highlights the importance of minimizing stent protrusion and performing KBD.

The importance of double kissing balloon dilatation has also been demonstrated in bench studies. The morphologic characteristics of the mini-culotte and DK mini-culotte techniques were investigated by Hu et al.[9] In this study, DKC and MC techniques were compared using two different silicone bifurcation models. The DKC technique showed reduced metallic neocarina length, lower side branch ostial stenosis, and less stent malapposition on the side opposite the SB ostium. These parameters were assessed using micro-computed tomography. As a result, the DKC technique was associated with a shorter metal carina length, fewer malapposed struts, and reduced SB ostial stenosis compared to the mini-culotte technique. Toth et al.[10] also demonstrated the importance of DK balloon dilatation in the culotte stenting technique using a bench model. In this study, the DKC technique was compared with both the MC and DK crush techniques. The overall rates of moderate (200-500 μm) and significant (> 500 μm) malapposition were lower in the DKC group compared to both culotte and DK crush techniques. The lower malapposition rate of DK-culotte compared to DK crush was primarily due to malapposition in the proximal main branch (MB). In a study by Fan et al.,[11] DKC stenting was compared with T-provisional stenting in the treatment of true CBL. A total of 223 patients were treated using either DKC (91 patients, 92 lesions) or T-provisional (132 patients, 135 lesions) stenting techniques. The primary endpoint was MACE, defined as a composite of cardiac death, MI, and TVR at one-year follow-up. The incidence of MACE (4.55% vs. 13.6%, P = 0.127) and TLR (1.52% vs. 12.12%, P = 0.033) was lower in the DKC group compared to T-provisional stenting. The SB stenosis rate was also lower in the DKC group (5.6% vs. 22.4%, P = 0.014). A recent study also demonstrated that the DKC technique had a lower incidence of TLF compared to the DK crush technique (3.0% vs. 10.9%, P = 0.028) in non-left main CBL at one-year follow-up.[15] These findings support the notion that DKC offers better outcomes than MC, particularly in terms of MV stent placement and SB ostial stenosis. As a result, DKC has become a routinely recommended technique in clinical guidelines, considered superior to MC.[12,16] In this context, it would not be surprising to find that the clinical outcomes of DKC stenting outperform those of MC. However, large-scale randomized trials are still needed to guide future investigations.

Limitations

The primary limitation of this study was its small sample size. While DKC appeared to be a more effective strategy than MC in terms of TLF and TLR at three years, the lower incidence of TVMI and cardiac mortality in the DKC group did not reach statistical significance. Large-scale, randomized trials are needed to compare DKC and MC stenting techniques and to address this limitation. Additionally, due to the non-randomized design of the study, there were limited but notable differences in some demographic and angiographic parameters between the groups. Notably, although the SB lesion length and the incidence of complex CBLs were higher in the DKC group, the better clinical outcomes with the DKC technique make its advantage even more evident. Lastly, both second- and third-generation stents were used across both groups. Design differences between second- and third-generation stents may affect the clinical outcomes of the techniques. However, since the distribution of stent types was similar between the two groups, we believe this is unlikely to have impacted the study results.

Conclusion

In true CBLs, the DKC technique was associated with a lower incidence of TLF and TLR compared to the MC technique at one-year and three-year follow-up. There were no differences in cardiac death or TVMI between the DKC and MC techniques at either one or three years.

Ethics Committee Approval: Ethics committee approval was obtained from Istanbul Mehmet Akif Ersoy Thoracic and Cardiovascular Surgery Training and Research Hospital Scientific Research Ethics Committee (Approval Number: 2024.01-02, Date: 27.02.2024).

Informed Consent: Informed consent was waived due to the retrospective design of the study.

Conflict of Interest: The authors have no conflicts of interest to declare.

Funding: The authors declared that this study received no financial support.

Use of AI for Writing Assistance: No artificial intelligence-assisted technologies were used in the preparation of this manuscript or its contents.

Author Contributions: Concept –S.K., A.K.K., M.E.; Design – S.K., D.D., Y.E.E., M.A.Y., İ.T., A.K.K., M.E.; Supervision – S.K., M.E.; Data Collection and/or Processing - S.K., G.D., Y.E.E., M.A.Y., A.Y.Ç., S.A., H.Z.A., Ü.B., A.G., A.A.Y.; Analysis and/or Interpretation - S.K., G.D., Y.E.E., M.A.Y., A.Y.Ç., S.A., H.Z.A., Ü.B., A.G., A.K.K.; Literature Review – S.K., D.D., G.D., A.A.Y., A.K.K., M.E.; Writing – S.K.; Critical Review – S.K., M.E.

Peer-review: Externally peer-reviewed.

References

1. Burzotta F, Lassen JF, Lefèvre T, et al. Percutaneous coronary intervention for bifurcation coronary lesions: The 15th consensus document from the European Bifurcation Club. *EuroIntervention*. 2021;16(16):1307-1317. [CrossRef]
2. Chevalier B, Glatt B, Royer T, Guyon P. Placement of coronary stents in bifurcation lesions by the "culotte" technique. *Am J Cardiol*. 1998;82(8):943-949. [CrossRef]
3. Ferenc M, Gick M, Comberg T, et al. Culotte stenting vs. TAP stenting for treatment of de-novo coronary bifurcation lesions with the need for side-branch stenting: The Bifurcations Bad Krozingen (BBK) II angiographic trial. *Eur Heart J*. 2016;37(45):3399-3405. [CrossRef]

4. Kumsars I, Holm NR, Niemelä M, et al. Randomised comparison of provisional side branch stenting versus a two-stent strategy for treatment of true coronary bifurcation lesions involving a large side branch: The Nordic-Baltic Bifurcation Study IV. *Open Heart*. 2020;7(1):e000947. [CrossRef]
5. Hildick-Smith D, Behan MW, Lassen JF, et al. The EBC TWO study (European Bifurcation Coronary TWO): A randomized comparison of provisional T-stenting versus a systematic 2 stent culotte strategy in large caliber true bifurcations. *Circ Cardiovasc Interv*. 2016;9(9):e003643. [CrossRef]
6. Chen SL, Xu B, Han YL, et al. Comparison of double kissing crush versus Culotte stenting for unprotected distal left main bifurcation lesions: Results from a multicenter, randomized, prospective DKCRUSH-III study. *J Am Coll Cardiol*. 2013;61(14):1482-1488. [CrossRef]
7. Hildick-Smith D, Egred M, Banning A, et al. The European bifurcation club Left Main Coronary Stent study: A randomized comparison of stepwise provisional vs. systematic dual stenting strategies (EBC MAIN). *Eur Heart J*. 2021;42(37):3829-3839. [CrossRef]
8. Kahraman S, Çizgici AY, Ertürk M. A novel coronary bifurcation stenting technique: Double kissing nano-culotte stenting. *Anatol J Cardiol*. 2023;27(2):113-116. [CrossRef]
9. Hu F, Tu S, Cai W, et al. Double kissing mini-culotte versus mini-culotte stenting: Insights from micro-computed tomographic imaging of bench testing. *EuroIntervention*. 2019;15(5):465-472. [CrossRef]
10. Toth GG, Sasi V, Franco D, et al. Double-kissing culotte technique for coronary bifurcation stenting. *EuroIntervention*. 2020;16(9):e724-e733. [CrossRef]
11. Fan L, Chen L, Luo Y, et al. DK mini-culotte stenting in the treatment of true coronary bifurcation lesions: A propensity score matching comparison with T-provisional stenting. *Heart Vessels*. 2016;31(3):308-321. [CrossRef]
12. Lassen JF, Albiero R, Johnson TW, et al. Treatment of coronary bifurcation lesions, part II: Implanting two stents. The 16th expert consensus document of the European Bifurcation Club. *EuroIntervention*. 2022;18(6):457-470. [CrossRef]
13. Chen SL, Sheiban I, Xu B, et al. Impact of the complexity of bifurcation lesions treated with drug-eluting stents: The DEFINITION study (Definitions and impact of complEx biFurcation leslons on clinical outcomes after percutaNeous coronary IntervenTIOn using drug-eluting steNts). *JACC Cardiovasc Interv*. 2014;7(11):1266-1276.
14. Lunardi M, Louvard Y, Lefèvre T, et al. Definitions and standardized endpoints for treatment of coronary bifurcations. *EuroIntervention*. 2023;19(10):e807-e831. [CrossRef]
15. Kahraman S, Cizgici AY, Guner A, et al. clinical outcomes of double-kissing crush or double-kissing culotte in nonleft main bifurcation lesions: The ROUTE trial. *Circ Cardiovasc Interv*. 2024;17(11):e014616. [CrossRef]
16. Kahraman S, Güner A, Çizgici AY, Ertürk M. Current evidence and future perspective for coronary bifurcation stenting. *Turk Kardiyol Dern Ars*. 2022;50(8):595-609.