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Percutaneous coronary intervention with the staged mini culotte technique for ostial restenosis of the large side branch

Intervenção coronária percutânea com técnica mini culotte estadiada para reestenose ostial de grande ramo lateral

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ABSTRACT - Understanding the anatomy and physiology of a bifurcation is crucial in today's interventional field. The bifurcation lesion is one of the most challenging coronary conditions to treat percutaneously. Numerous interventional strategies have been investigated because of the high level of interest in these lesions, but the relatively poor procedural and long-term results. Improvements in stenting and other interventional procedures have reduced the likelihood of adverse clinical outcomes, by creating the most favorable environment for stents to do their work. Provisional stenting has been widely accepted as the initial interventional technique for coronary bifurcation lesions by the medical community for over 15 years. Restenosis of a major branch is possible after angioplasty of the main vessel using a provisional one-stent approach. Although side branch restenosis following bifurcation angioplasty is less common with modern bifurcation procedures, it still occurs in 5% of cases during angiographic follow-up for symptoms. In our case series of five patients, severe side-branch restenosis presented with recurring anginal symptoms, which required target vessel revascularization. By applying bifurcation principles, we improved the "staged mini culotte" part of the culotte bifurcation stent technique, making it more user-friendly, and reducing exposure to radiation and operating time.

Keywords: Coronary stenosis; Coronary artery diseases; Stents; Angina pectoris; Angioplasty

RESUMO - O conhecimento da anatomia e da fisiologia de uma bifurcação é essencial na área intervencionista atual. A lesão de bifurcação é uma das alterações coronárias mais desafiadoras no tratamento percutâneo. Foram investigadas muitas estratégias intervencionistas devido ao alto nível de interesse nessas lesões, mas os resultados dos procedimentos e de longo prazo foram relativamente ruins. As melhorias em implante de stents e outros procedimentos intervencionistas reduziram a probabilidade de desfechos clínicos adversos, criando o ambiente mais favorável para os stents realizarem seu trabalho. O implante de stent provisional tem sido amplamente aceito como técnica intervencionista inicial nas lesões de bifurcação coronária pela comunidade médica há mais de 15 anos. A reestenose de um grande ramo é possível após angioplastia do vaso principal utilizando uma abordagem provisional de um único stent. Embora a reestenose do ramo lateral após angioplastia de bifurcação seja menos comum nos procedimentos modernos de bifurcação, ela ainda ocorre em 5% dos casos durante o acompanhamento angiográfico baseado em sintomas. Em nossa série de casos de cinco pacientes, a reestenose grave de ramo lateral apresentou sintomas de angina recorrente, que necessitou de revascularização do vaso-alvo. Ao aplicar os princípios de bifurcação, aprimoramos a etapa do *mini culotte* estadiado da técnica *culotte* de bifurcação, tornando-a mais fácil de usar e reduzindo a exposição à radiação e o tempo de operação.

Descritores: Estenose coronária; Doença da artéria coronariana; Stents; Angina pectoris; Angioplastia

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BACKGROUND

Percutaneous coronary intervention (PCI) of bifurcation lesions is not only technically challenging, but also has higher rates of thrombosis and restenosis compared to non-bifurcation lesions.¹ Any repeat PCI or surgical bypass of any segment of the target vessel, including the target lesion, of the major intervened coronary vessel, including

side branches (SB), is considered as target vessel revascularization (TVR).² Side branch restenosis (SB-R) is a frequent problem after bifurcation angioplasty; multiple studies have shown that it occurs in 0.5 to 15% of cases, despite the use of drug-eluting stents, depending upon the method used for the evaluation.³⁻⁵ Understanding the anatomy and physiology of bifurcation is critical in modern practice. There is contradictory evidence about the opening of the SB employing different procedures, such as final kissing balloon (FKB) angioplasty, and sequential balloon dilation of the SB.^{4,6} As the use of a provisional stent alone can lead to significant SB-R, an extra procedural step, such as the proximal optimization technique (POT), should be employed to lessen this likelihood.⁷

We describe a series of five cases in which large SB-R resulted in recurrence of anginal symptoms, necessitating TVR. Based on bifurcation principles, we improved on a component of the culotte bifurcation stent technique, known as staged mini culotte, which is simple to perform and needs less time and radiation than traditional procedures.

We performed a retrospective analysis of symptomatic SB-R in five patients out of 1,022 who underwent PCI in the last 3 years (2020 to 2023). The data was analyzed to review the procedure indications, demographics, and details of previous PCI. To summarize the continuous variables, median values were calculated.

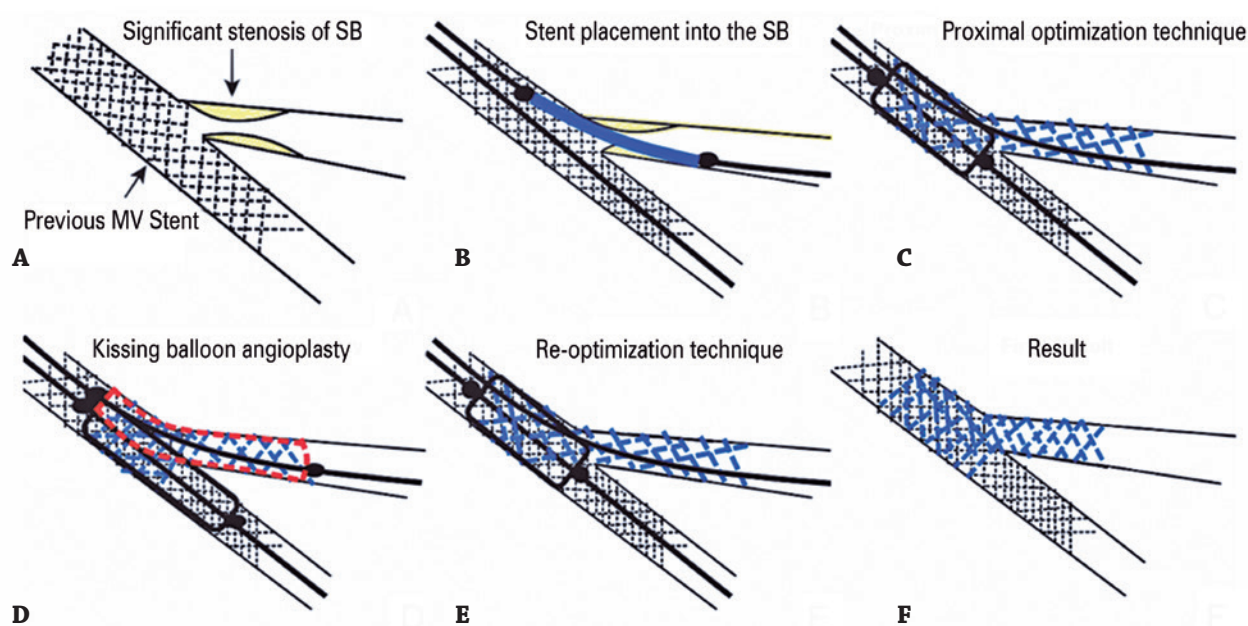
All procedures performed in studies involving human participants were in accordance with the ethical standards of the organizational and/or national research committee,

and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was not required for the participants included in the retrospective analysis of clinical data as per our organizational Ethical Committee.

The steps of the staged mini-culotte procedure are depicted in figure 1.

CASE REPORTS

In our case series, the incidence of SB-R was 0.49%. This group of five cases of TVR had a median age of 50 years. Table 1 highlights the risk factors for each patient. All cases presented with acute coronary syndrome; three patients had unstable angina, while two had non-ST-segment elevation myocardial infarction. The median ejection fraction for the group was 48%, indicating mild left ventricular dysfunction. The median time between the initial manifestation and the second intervention (TVR) in our patients was 16 months. All PCI patients underwent a transfemoral approach with a 7F guiding catheter, and a planned bifurcation strategy of the staged mini culotte. All cases had previously deployed stents in the proximal segments across the major SB, with a median length of 3x30mm, which led to 90 to 95% SB-R. In every case, bifurcation lesions of Medina class 0-0-1 were present. The median amount of contrast utilized was 70mL, and the median length of time a fluoroscopic examination took was 27 minutes (median radiation dose of 700 mGy). All five patients had favorable clinical outcomes at a median follow-up of 36 months.



Source: the authors.

SB: side branch; MV: main vessel.

Figure 1. Schematic representation of a staged mini culotte procedure.

Table 1. Clinical and procedural details of patients who underwent staged mini culotte

	Case 1	Case 2	Case 3	Case 4	Case 5
Age, years/sex	45/F	50/M	65/M	48/F	55/M
Previous diagnosis	Unstable Angina	Unstable Angina	Old IWMI Post CABG Patent LIMA to LAD and occluded SVG to RCA	NSTEMI	AWMI
Risk factors	HTN	HTN, DM	HTN, DM	HTN, DM	Smoker
LVEF (%)	50	45	48	49	46
Previous MV	Proximal segment of the LAD	Proximal segment of the LAD	Proximal segment of the split RCA to PLB	Proximal segment of the LCx	Ostio-proximal segment of the LAD
Previous stent size, mm/ type of stent	3.5x23/SES	3x33/SES	3.0x48, 2.75x33/ EES	2.75x23/EES	3x30/EES
Time since the prior intervention	12-months	16-months	18-months	24-months	12-months
Present diagnosis	NSTEMI – rest/effort angina for last 4 days	Unstable angina – recent onset effort angina for last 15 days	Unstable angina – rest angina for last 20 days	NSTEMI – rest/effort angina for last 15 days	Unstable angina – recent onset effort angina
SB involved	90% stenosis of the ostial segment of first large diagonal branch	95% stenosis of the ostial segment of first large diagonal branch	90% stenosis of the ostial segment of the large PDA	90% stenosis of the ostial segment of the large first OM branch	90% stenosis of the ostial proximal segment of first large diagonal branch
Guide catheter	7F EBU	7F EBU	7F JR	7F EBU	7F EBU
Stent size, mm	3x18	2.5x22	3x26	2.5x22	2.25x26
Type of stent	ZES	ZES	ZES	ZES	ZES
POT/re-POT, mm	3.5x12	3x12	3.5x12	2.75x12	3x12
FKB, mm	3x12 (LAD) 3x 12 (LAD -diagonal)	2.75x12 (LAD) 2.5x15 (LAD-diagonal)	3x12 (RCA-PDA) 3x 12 (RCA-PLB)	2.5x12 (LCx) 2.5x12 (LCx-OM1)	2.75x12 (LAD) 2.5x12 (LAD-diagonal)
Contrast volume, mL	65	75	80	70	50
Fluoroscopy time, minutes	18	22	35	30	27
Radiation dose, mGy	550	600	800	740	700
Follow-up duration, months	60	36	48	36	22

F: female; M: male; IWMI: inferior wall myocardial infarction; CABG: coronary artery bypass graft; LIMA: left internal mammary artery; LAD: left anterior descending artery; SVG: saphenous venous graft; RCA: right coronary artery; NSTEMI: non-ST-elevation myocardial infarction; AWMI: anterior wall myocardial infarction; HTN: hypertension; DM: diabetes mellitus; LVEF: left ventricular ejection fraction; MV: main vessel; PLB: posterior lateral branch; LCx: left circumflex artery; SES: sirolimus-eluting stent; EES: everolimus-eluting stent; SB: side branch; PDA: posterior descending artery; OM: obtuse marginal; EBU: extra backup; ZES: zotarolimus-eluting stent; FKB: final kissing balloon.

Table 1 depicts the procedural details of each case (Figures 2 and 3).

DISCUSSION

Side branch restenosis was identified in 27 (5.25%) of the 514 patients who had 8-month angiograms available when Roh et al. compared standard final kissing inflation (FKI) *versus* a leave-alone approach, following the provisional single-stent strategy for bifurcations.⁵ The incidence rate in our study was lower (0.49%), because we relied on symptoms to diagnose SB-R rather than follow-up angiography. When proper bifurcation angioplasty techniques are not followed in interventional practice, we frequently

encounter ostial SB-R across the main vessel (MV) stent.⁸ There is no proper technique described in the literature for the SB-R following the provisional single-stent strategy. Depending on whether or not additional stenting was required, either the culotte stenting or T-stenting and minimum protrusion (TAP) method has been used to treat SB-R.

Culotte is a well-known two-stent technique, in which both stents in the MV have a common overlap, which prevents the ostium from being missed, which might happen in other techniques, such as T or TAP. Initiated with MV stenting, as previously reported by Chevalier et al., the original culotte technique ensures complete bifurcation coverage at the cost of an overabundance of metal at the

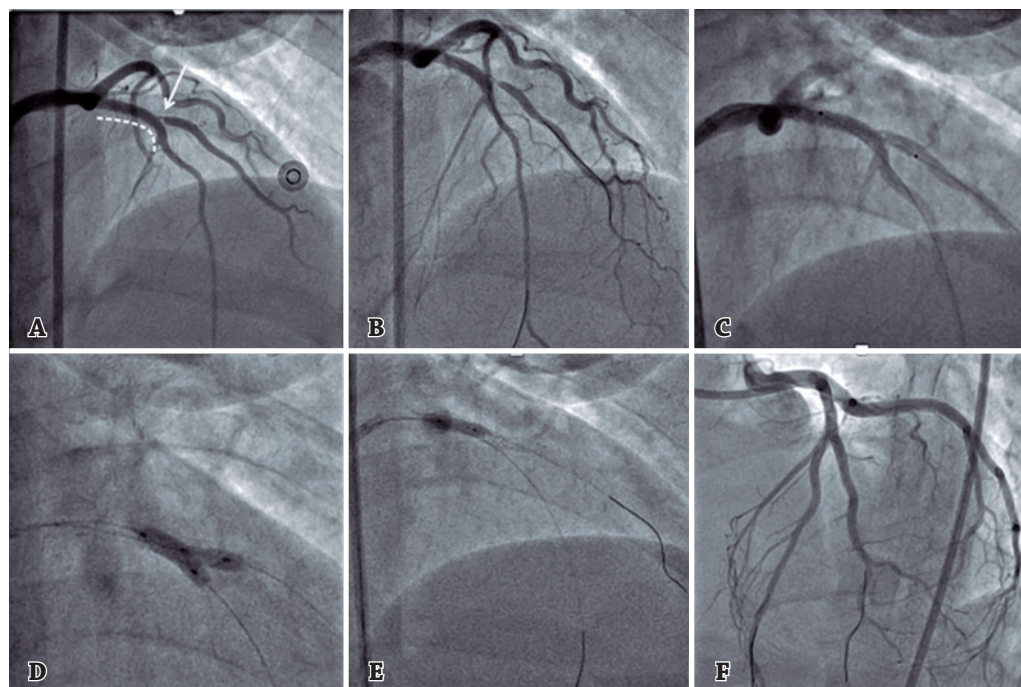


Figure 2. (A to F): Coronary angiography of case 1 demonstrated critical restenosis (95%) of the first diagonal side branch (white arrow) across the patent previous stent (sirolimus-eluting stent; 3x33mm) across the proximal segment of the left anterior descending artery (main vessel, curved white dashed line, A). After previous dilation using a compliant balloon (2x10mm at 2 atm, B), the drug-eluting stent (zotarolimus-eluting stent; 3x18mm) deployed partially across the previous main vessel stent into the side branch (C) at 12 atm. The proximal optimization technique using a non-compliant balloon (3.5x12mm at 12 atm) was done followed by final kissing balloon angioplasty, using two non-compliant balloons – left anterior descending artery (3x12mm), and left anterior descending artery to diagonal side branch (3x12mm) at sequentially at higher pressures (at 20 atm, D), followed by simultaneously at nominal pressures (at 12 atm). The proximal optimization technique was done using a 3.5x12mm non-compliant balloon placed before neo carina at nominal pressure (E). The final angiography showed that the side branch had substantially enlarged, and that there was a well-formed neo carina with Thrombolysis in Myocardial Infarction 3 flow (F).

proximal end.⁹ In the inverted/reverse culotte technique, which is a two-stent strategy to treat, the most angular branch, typically the SB is pre-dilated, and a stent is implanted throughout its length. Next, the SB stent is dilated while the MV is re-wired through its struts. The MV receives a second stent, which is inserted and enlarged there, followed by FKB.¹⁰

Our illustrated cases developed significant symptoms because of the presence of a significant ostial SB stenosis. Our method, which we called “staged mini culotte”, is used when the MV and SB are of relatively similar sizes, and is indicated for patients with a provisional single-stent strategy for the bifurcation lesion, who developed delayed or late clinical symptoms due to ostial SB-R. We labeled it a staged procedure since part of the culotte stenting was performed after an interval while the MV stent was endothelialized, and a mini culotte technique because the SB stent partially overlapped the previous MV stent.

It is a simple procedure with less radiation exposure and a better long-term outcome. The advantage of our technique is that the SB ostium is nearly completely covered by

this method, and it works for any angle of bifurcation. Our method may prove to be an effective tactic for treating restenosis of a modestly inclined SB at locations where it will have less of an impact on the MV than T-stenting, and a lesser metallic carina than the TAP method. However, the methodology works best with a narrow-angle bifurcation, in which the two branches are of roughly equal size. The main disadvantage of our technique is that it results in a double-stent layer at the carina and the proximal region of the bifurcation; however, the MV stent is already endothelialized and only partial overlapping is performed, which reduces restenosis rates.

Drug-coated balloon therapy is another option for SB-R treatment, albeit it is not entirely event-free. In 2022, Lee et al. published the results of 1,545 patients with 1,688 in-stent restenosis lesions, from 2009 to 2017, in a multicenter observational registry of patients treated with drug-coated balloon. They reported 8.9% of patients had target lesion failure, and 7.1% had TLR at 12 months.¹¹ Long-term follow-up in our cases shows the risk of events after stent insertion across the SB is minimal.

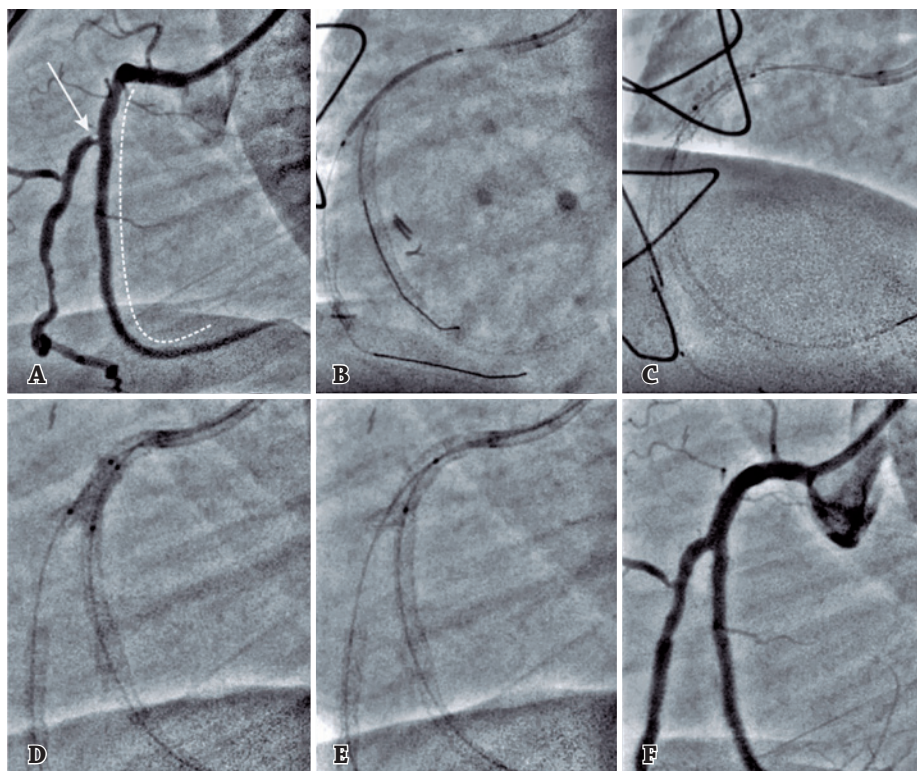


Figure 3. (A to F) Coronary angiography of case 3 revealed significant restenosis (90%) of the large posterior descending artery (side branch, posterior descending artery; solid white arrow) across the previous two long overlapped drug-eluting stents (main vessel everolimus-eluting stents; proximal stent: 3x48mm; curved dashed white line) (A) of the dominant split (early bifurcation) right coronary artery in a post coronary bypass graft surgery, whose saphenous vein graft was occluded. The zotarolimus-eluting stent (3x26mm) was deployed across the previous stent in the main vessel into the side branch (B), followed by proximal optimization technique using 3.5x12mm non-compliant balloon at 12 atm (C). The final kissing balloon angioplasty using two non-compliant balloons (3x12mm) sequentially at high pressures (at 18 to 20 atm) followed by 10 atm (D). The proximal optimization technique was done using the same 3.5x12mm non-compliant balloon at 12 atm (E). The final angiography showed a well-formed neo carina with Thrombolysis in Myocardial Infarction 3 flow to the side branch (F).

The main limitations of our case series were the small sample size and the lack of imaging technology. Due to the promising results of this preliminary intervention, we are considering expanding to a larger case registry.

Staged mini culotte is a convenient and inexpensive method for dealing with SB-R. Reducing SB-R occurrence necessitates careful consideration of how best to implement a bifurcation strategy in our practice.

SOURCE OF FINANCING

None.

CONFLICTS OF INTEREST

The authors declare there are no conflicts of interest.

CONTRIBUTION OF AUTHORS

Conception and design of the study: PJ; data collection: GK; data interpretation: PJ; text writing: PJ; approval of the final version to be published: PJ and GK.

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