

Crimped and Collapsed: The Swiss Roll Effect and Its Role in Bifurcation Stenting Failures

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Abstract

Background: Bifurcation Percutaneous Coronary Intervention (PCI) is one of the most challenging procedures in interventional cardiology. Although established techniques like the Double Kissing (DK)-crush strategy and provisional stenting have improved results, new failure modes keep appearing.

Case Presentation: We present a 59-year-old man with type 2 diabetes who had an infero-posterior ST-Elevation Myocardial Infarction (STEMI). Coronary angiography showed a total blockage of the Left Circumflex Artery (LCX) beyond the first obtuse marginal branch. The initial stenting was complicated by no-reflow and dissection at the proximal edge, which required more stents. During attempts to rewire, the guidewire got trapped, causing a focal stent collapse. Intravascular Ultrasound (IVUS) showed an unusual spiraling inward folding of the stent struts, which we call the “Swiss Roll Effect.” This rare mechanical problem was handled with special guidewires, microcatheters, and sequential balloon dilations, followed by successful stenting from the left main to LCX.

Discussion: The Swiss Roll Effect shows a unique geometric failure pattern that is different from the previously described longitudinal or malapposition-related deformations. This case emphasizes how intravascular imaging helps to identify and fix unexpected mechanical issues during bifurcation PCI.

Conclusion: Awareness of the Swiss Roll Effect may aid operators in recognizing early signs of resistance, avoiding excessive manipulation, and adopting imaging-guided bailout strategies.

Keywords: Bifurcation stenting; Stent deformation; Intravascular ultrasound; Percutaneous coronary intervention; Stent collapse

Abbreviation List: DK-crush: Double Kissing crush technique; IVUS: Intravascular Ultrasound; LCX: Left Circumflex Artery; LM: Left Main (Coronary Artery); PCI: Percutaneous Coronary Intervention; STEMI: ST-Elevation Myocardial Infarction

Introduction

Bifurcation lesions represent one of the most technically demanding challenges in interventional cardiology, often requiring complex manipulation and advanced imaging [1]. Over time, multiple techniques have been developed to optimize outcomes, including the Double Kissing (DK)-crush and provisional stenting approaches. Randomized trials, such as the DKCRUSH-V study, have demonstrated improved outcomes with DK-crush in selected populations, especially in left main bifurcations [2]. Nevertheless, bifurcation PCI continues to be associated with procedural difficulties and higher complication rates than simpler lesions. Early experiences with two-stent strategies, particularly the crush technique, were linked to restenosis and adverse outcomes [3]. Even in the contemporary era of newer stents and refined procedural strategies, systematic reviews confirm that variability in long-term outcomes persists, underscoring the complexity of real-world practice [4]. Within this context, novel mechanical complications continue to be identified. This report presents a rare, previously undocumented failure mode during bifurcation PCI-termed the “Swiss Roll Effect”-

in which the proximal stent struts folded inward and spiraled over themselves, completely occluding the deployed segment. The case underscores the need for mechanical vigilance, imaging guidance, and adaptable procedural strategies when faced with unexpected resistance or deformation.

Case Presentation

A 59-year-old man with type 2 diabetes mellitus (left ventricular ejection fraction ~50%) presented with acute infero-posterior ST-Segment Elevation Myocardial Infarction (STEMI). He was hemodynamically stable on arrival. The electrocardiogram showed ST-segment elevation in the inferior and posterior leads, and urgent primary Percutaneous Coronary Intervention (PCI) was indicated. Coronary angiography demonstrated total occlusion of the Left Circumflex Artery (LCX) distal to the first Obtuse Marginal (OM) branch, a borderline lesion in the Left Anterior Descending artery (LAD), and no significant disease in the right coronary artery. Primary PCI was undertaken immediately. A 2.5×28mm Ultimaster Drug-Eluting Stent (DES) was deployed in the LCX main vessel at 11 atm, followed by post-dilation with a 2.75×1mm Sapphire II Non-Compliant (NC) balloon.

The procedure was complicated by a no-reflow that did not respond to intracoronary adenosine, adrenaline, or tirofiban. Proximal edge dissection was then observed and treated with a 3.0×18mm Ultimaster DES at the ostial LCX overlapping the first stent, which acutely occluded the first OM branch. During repeated rewiring aided by a Corsair 135cm microcatheter, the distal tip of a Pilot 50 guidewire became trapped at the proximal edge of the LCX stent and protruded into the Left Main (LM), deforming the

proximal stent segment. A subsequent wire inadvertently crossed through the proximal side struts of the LCX stent rather than its ostium; ballooning these side struts with a 2.0×20mm balloon produced focal crushing of the proximal LCX stent. An LAD wire was placed to secure the distal LM bifurcation and LAD. Intravascular Ultrasound (IVUS) was first advanced into the LAD to plan a bifurcation strategy and showed significant LAD ostial stenosis; a repeat IVUS run confirmed a crushed LCX stent segment with poor expansion and a retained wire fragment.

A Sion guidewire was then steered across the LCX stent with Corsair support, and predilation was performed using a 3.5×15mm Sapphire II NC balloon; however, a subsequent IVUS pass demonstrated the wire had passed behind the stent struts across a crushed proximal segment. The team elected to completely crush the compromised stent and stent across from the LM into the LCX. Still, even a low-profile 1.5mm balloon could not be advanced, and a GuideLiner could not be delivered alongside the LAD wire within the 6 F guiding catheter. While attempting to advance the Corsair, the microcatheter adhered to the LCX wire, and LCX access was lost. High-magnification fluoroscopy and IVUS then revealed a spiraling collapse of the proximal LCX stent struts-consistent with a rare geometric configuration we term the Swiss Roll Effect (see (Figure 1) for the fluoroscopic/IVUS appearances, and (Figure 2) for representative IVUS frames). Access was upsized to a 7F femoral approach. A Sion Black wire, supported by a Turnpike LP microcatheter and a GuideLiner, was advanced by tracking along the trapped wire within the rolled, crushed proximal LCX segment and into the distal LCX stent lumen, as confirmed by IVUS. The Sion Black was exchanged for a Grand Slam wire to improve support.

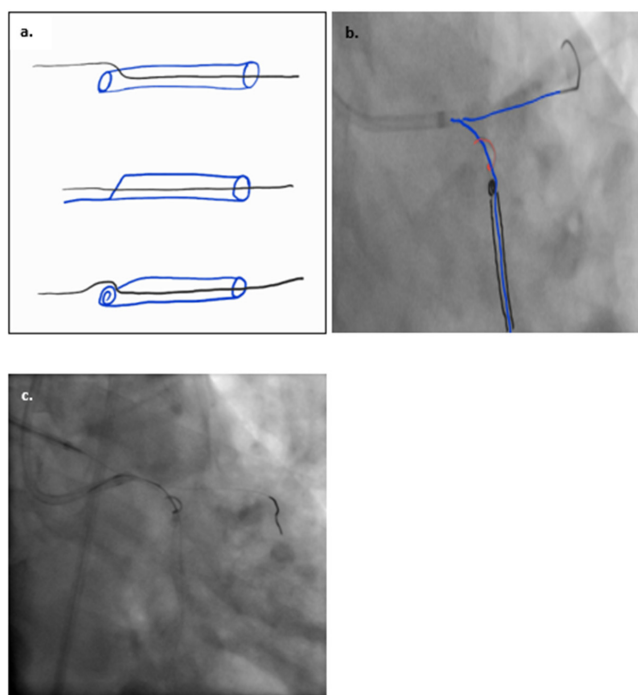


Figure 1: Diagrammatic representation of the swiss roll effect. (a) Schematic showing partial stent compression followed by repetitive manipulation (such as IVUS catheter passage) across the crushed segment. (b, c) Progressive crimping of the compressed stent into its ostium results in spiraling inward collapse, luminal obstruction, and impaired blood flow. The digital arrows highlight the site of inward folding and occlusion.

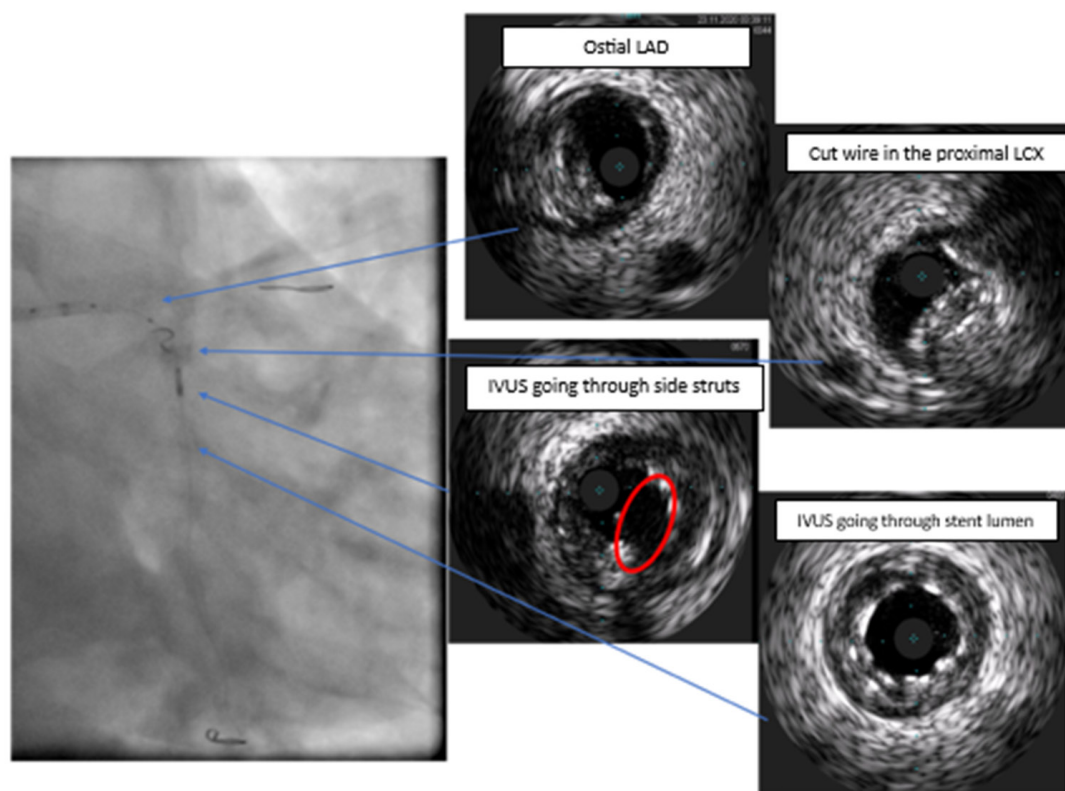


Figure 2: IVUS imaging of the swiss roll effect. Intravascular Ultrasound (IVUS) images showing spiraling collapse of stent struts at the proximal LCX. The digital arrows mark the inward folding and luminal obstruction at the side branch ostium, consistent with the Swiss Roll Effect.

Sequential NC balloon dilations (1.5mm to 2.0mm to 3.5mm) achieved progressive re-expansion of the deformed segment. After complete crushing of the compromised stent, a 4.0×28mm Xience Alpine DES was deployed from the LM to the LCX, overlapping the distal LCX stent. Proximal Optimization Technique (POT) was performed using a 5.0×10mm Sapphire II NC balloon inflated up to 28 atm, followed by LAD rewiring and first kissing-balloon inflation with 3.5×15mm (LAD) and 4.0×15mm (LCX) NC balloons. The LM-LAD was then stented with a 3.5×38mm Resolute Onyx DES at 14atm, followed by a second POT, LCX rewiring, a second kissing inflation, and final POT (balloon sizes as above). Final IVUS runs from the LCX and LAD to the LM confirmed well-apposed, well-expanded stents, and final angiography showed TIMI III flow. The patient tolerated the procedure without further complications, was discharged on dual antiplatelet therapy with guideline-directed medical therapy, and remained asymptomatic at one-month follow-up with preserved left ventricular function and no evidence of recurrent ischemia.

Discussion

Bifurcation PCI is among the most technically demanding procedures in interventional cardiology due to anatomical variation, flow dynamics, and the potential for mechanical complications. Despite advancements in bifurcation strategies-including the DK-crush and culotte techniques-real-world cases still present unanticipated failure modes that require procedural flexibility and

imaging support [2,4]. One such rare event, which we describe in this case, is a spiraling collapse of part of the stent struts into the remaining part of the deployed stent, here termed the Swiss Roll Effect. Unlike longitudinal stent deformation or malapposition, the Swiss Roll Effect represents a geometric inward folding of the stent that mimics a tightly rolled scroll, completely occluding the vessel lumen. This occurred after multiple balloonings through side struts following stent crushing and repeated introduction of previously inflated balloons and the IVUS catheter. IVUS played a critical role in identifying the pattern and guiding the strategy for complex management of the situation [5]. The complication emphasizes the importance of recognizing mechanical resistance during device advancement as a potential early sign of structural instability. Operators must be cautious when manipulating wires through crushed segments, particularly in bifurcation zones with overlapping stent layers. Ballooning through side struts, although sometimes necessary, should be performed only after imaging confirmation of true lumen continuity [1].

Despite the severity of the mechanical distortion in this case, successful recanalization was achieved through a combination of targeted guidewire passage, microcatheter manipulation, and sequential balloon dilations. This stepwise mechanical strategy ultimately restored vessel patency, enabling LM-to-LCX stenting with optimal expansion and apposition [3]. The Swiss Roll Effect may be understood as the end result of layered mechanical trauma: initial stent compromise, balloon-induced distortion, and repeated

intraluminal stress. Although rare, it reinforces several procedural principles: the need for early imaging, conservative manipulation within unstable segments, and vigilance for novel mechanical failure patterns not yet widely recognized [6,7]. This case also highlights the role of IVUS not just in lesion assessment but in real-time problem-solving during complex PCI. Its utility extended beyond sizing and apposition evaluation to actual mechanical diagnosis, reinforcing its importance in contemporary bifurcation strategy [5,7].

Conclusion

The Swiss Roll Effect represents a novel geometric complication during bifurcation PCI, characterized by a spiraling collapse of stent struts and complete luminal obstruction. This case demonstrates that, despite the severity of such deformation, successful recanalization was possible through strategic use of intravascular imaging, specialized wiring, and sequential ballooning. Awareness of procedural resistance, early recognition of structural failure, and adaptability in technique are essential for overcoming rare but significant mechanical challenges in complex coronary interventions.

Conflict of Interest Disclosure

The authors declare that there are no conflicts of interest to disclose. No benefits from commercial sources were received, and

there are no personal or professional relationships that could be perceived as influencing the work presented in this research.

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