Proximal Side Optimization: A Modification of the Double Kissing Crush Technique

Francesco Lavarra, MD

Department of Cardiology, Jilin Heart Hospital, Changchun, China

Abstract

Coronary bifurcations with significant lesions >10 mm in the side branch (SB) are likely to require two-stent treatment techniques. To date, double kissing Crush (DK-Crush) stenting has demonstrated higher rates of final kissing balloon inflation and better clinical outcomes. The technical iterations that lead to optimal clinical outcomes have been attributed to the first kissing balloon that repairs the distorted proximal segment and fully expands the orifice of the side stent. One potential caution, which relates to all Crush techniques, is the possibility of the guidewire crossing in an inappropriate position toward the Crushed SB stent. When this occurs, the SB stent may be further Crushed, leaving the ostium uncovered, which potentially negates the benefit of the Crush technique. In our experience, proximal side optimization (PSO) during DK-Crush stenting ensures stent size 'accommodation' to the larger vessel diameter in the proximal segment and better strut apposition to the wall, which is particularly important in the ostial segment. The benefits of this additional modification of the established DK-Crush technique are reduction or elimination of the risk of SB stent distortion, increase of the space of optimal wiring, and avoidance of guidewire advancement under the stent struts, even in unfavorable anatomies with extreme angulation. The author describes a step-by-step approach of a proposed PSO technique, which is easy to perform without any additional procedural time or costs.

Keywords

Two-stent technique, double kissing Crush, proximal side optimization

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Correspondence: Francesco Lavarra, Department of Cardiology, Jilin Heart Hospital, Jingyue Rd 5558, Changchun, Jilin Province 130117, China.
E: Lavarra@jlheart.org

True coronary bifurcations (Medina 1,1,1 and most of 1,0,1 and 0,1,1) with side branch (SB) diameter of >2.25 mm and lesion length of >10 mm are likely to require two-stent treatment techniques (*Figure 1A*).[1,2] The Crush technique underwent a series of technical iterations and modifications by Chen et al. before evolving into the so-called mini double kissing Crush (DK-Crush) technique.[3,4]

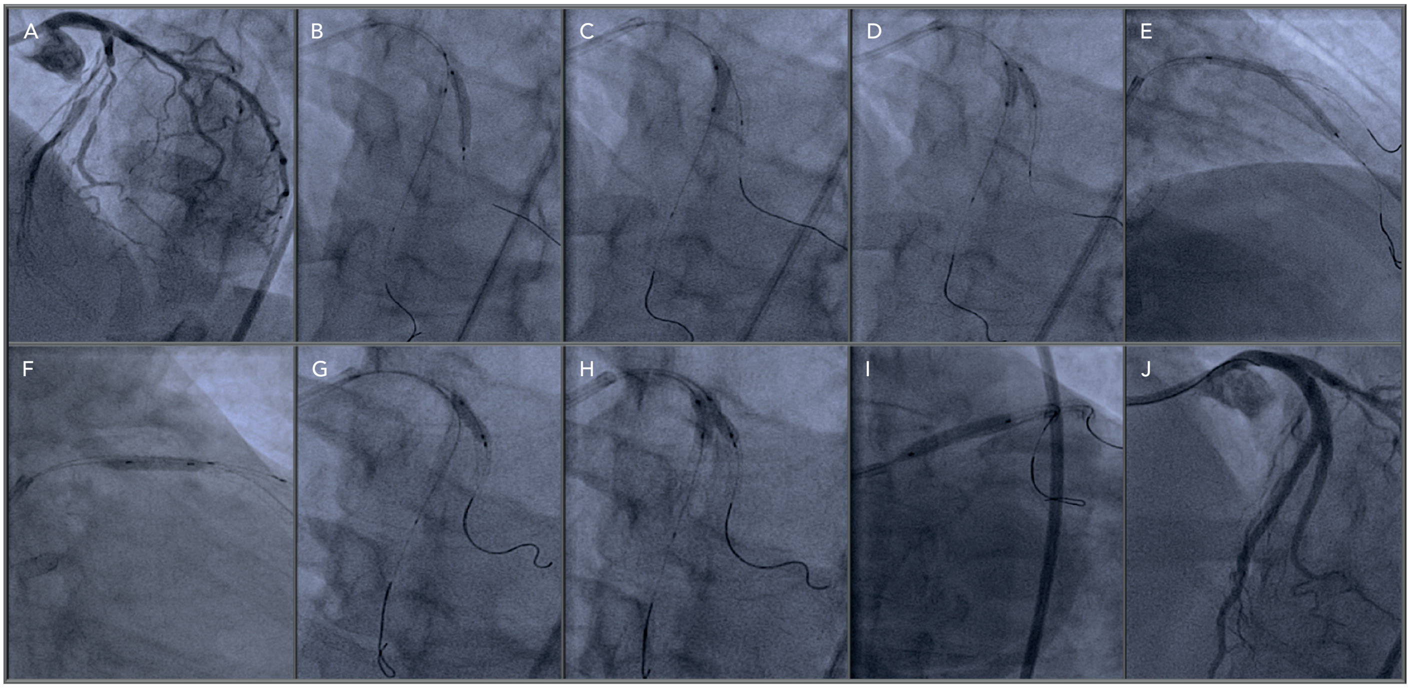
The conventional DK-Crush includes the following steps after adequate lesion preparation:

- stenting the SB (with 1–2 mm protrusion in the main branch (MB);
- removal of SB wire and balloon and MB balloon Crush;
- proximal wiring of SB access through the Crushed stent and first kissing balloon inflation (KBI);
- main vessel stenting;
- first proximal optimization technique (POT);
- SB rewiring access and strut dilation;
- final KBI; and
- final POT (*Figure 1*).

The main difference between classic and DK-Crush is the use of the first KBI after balloon Crush of the implanted SB stent. Therefore, after MB stenting, one layer of metal struts remains at the ostial SB to cross through, which facilitates the second KBI. Contrary to the provisional SB stenting approach, where guidewire recrossing is suggested to be performed through the distal cells, the first recrossing of the SB during DK-Crush should be carried out through the most proximal cell to avoid malapposition of the SB stent at the carina.[4] Compared to the provisional treatment, DK-Crush is superior to the classic Crush and Culotte strategies, because it leads to higher rates of successfully performed final KBI and to lower target lesion revascularizations (repeat interventions), as shown in the DK-CRUSH I, II, III, and V studies.[5–8] This led to a class II recommendation for DK-Crush to be used as a treatment option for distal left main bifurcations in the European Association for Cardio-Thoracic Surgery/European Society of Cardiology guidelines.[9]

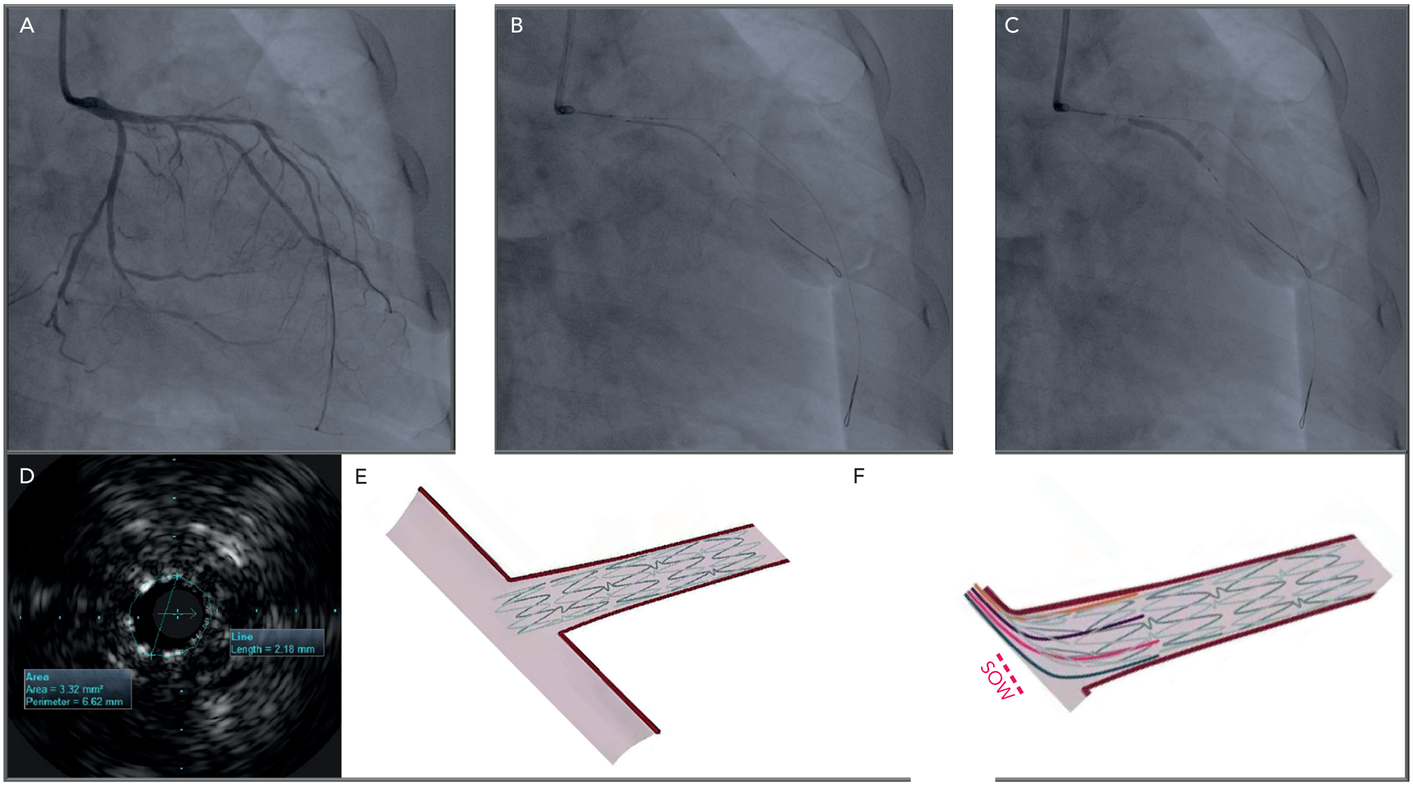
All Crush techniques have the limitation of the inappropriate guidewire crossing in the Crushed SB stent. When this occurs, the SB stent may be further Crushed, leaving the ostium uncovered. Furthermore, it yields difficult SB rewiring after MB stent deployment, and potentially negates

Figure 1: Conventional Double Kissing Crush Steps



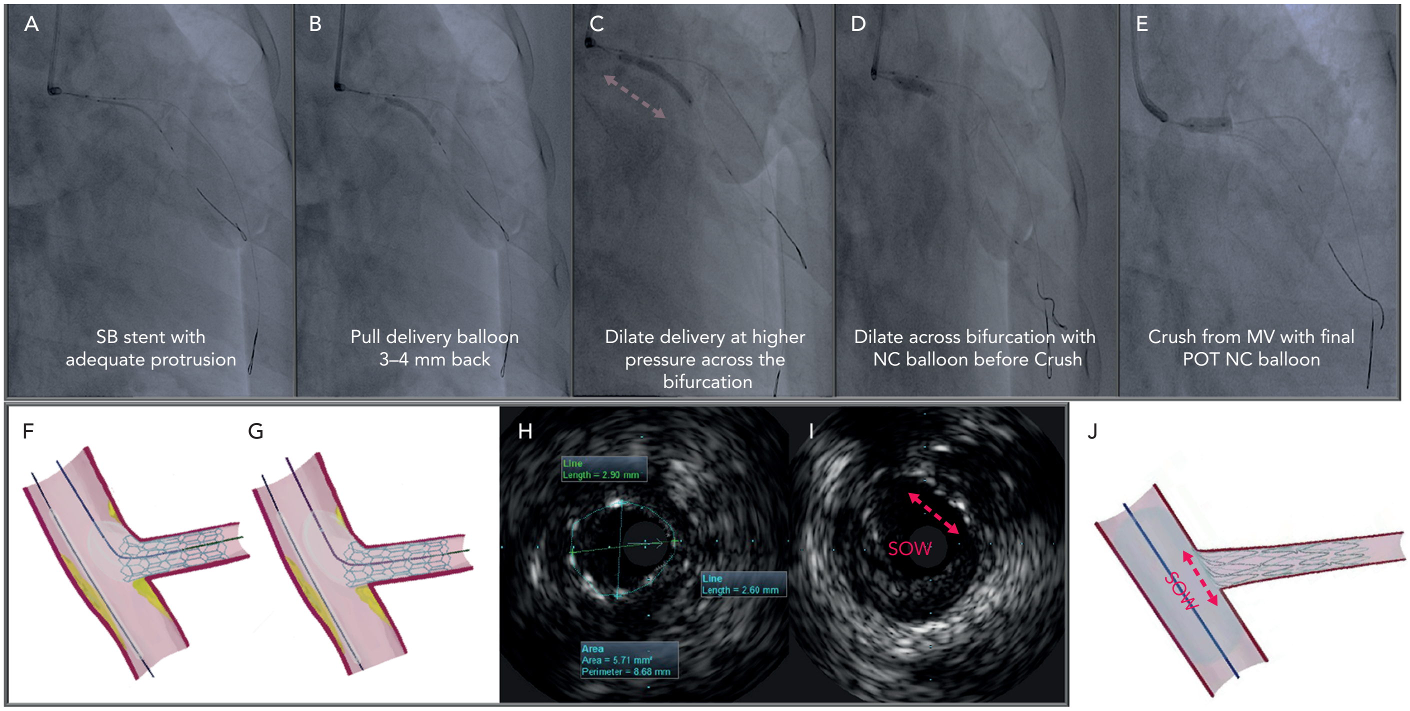
A: Baseline angiography showing true bifurcation lesion of mid left anterior descending artery (LAD-D1; Medina 1,1,1). B: Side branch (SB) stenting with 1–2 mm stent protrusion in the main vessel (MV). C: Main branch balloon Crush. D: Proximal wiring of SB access through the Crushed stent and first kissing balloon inflation (KBI). E: MV stenting. F: First proximal optimization technique (POT). G: SB proximal rewire access and strut dilation. H: Second KBI. I: Final POT. J: Final angiography. KBI = kissing balloon inflation; MV = main vessel; POT = proximal optimization technique; SB = side branch.

Figure 2: Limitations of the Conventional Double Kissing Crush



A: Baseline angiography showing bifurcation lesion of the left anterior descending artery and first diagonal artery. B: Stent positioning. C: Stent deployment. D: Intravascular ultrasound pullback from the side branch immediately after deployment, showing reduced stent minimal luminal cross-sectional area due to stent underexpansion in the ostial position. E: Graphic representation showing the risk of stent underexpansion and malapposition to the artery wall in the ostial segment of the side branch. F: Graphic representation showing the risk of reduced SOW due to stent underexpansion. SOW = space of optimal wiring.

Figure 3: Proximal Side Optimization Modification of Double Kissing Crush Steps



A: Stent positioning in the side branch (SB). B: Stent implantation in the SB with adequate protrusion in the main vessel (MV), as conventional Crush and not as mini Crush. C: The delivery balloon is pulled halfway back into the MV, and higher than nominal pressure (12–14 atm) is applied for inflation. D: High-pressure post-dilatation with a non-compliant balloon (0.25–0.5 mm larger in diameter) is done across the bifurcation. E: Non-compliant balloon intended for final proximal optimization technique is used to Crush the SB stent from the MV. F: Graphic representation of stent implantation in the SB with adequate protrusion in the MV (as conventional Crush and not as mini Crush). G: Graphic representation of proximal side optimization (PSO); the delivery balloon is pulled halfway back into the MV, and higher than nominal pressure (12–14 atm) is applied for inflation. H: Intravascular ultrasound pullback from the SB before stent Crush shows increased minimal stent area and apposition to the vessel wall in the ostial segment. I: Intravascular ultrasound pullback from the MV after SB stent Crush shows increased space for optimal rewiring, eliminating the need for proximal strut rewiring. J: Graphic representation showing increased SOW (red line) after complete PSO modification. MV = main vessel; NC = non-compliant; POT = proximal optimization technique; PSO = proximal side optimization; SB = side branch; SOW = space of optimal wiring.

the benefit of the Crush technique, leaving the SB ostium uncovered (*Figures 2A–2D*). KBI may maximize SB access, but is unlikely to optimize SB stent apposition in the para-ostial segment.

The Proximal Side Optimization Technique

We suggest a small modification to the established DK-Crush technique proposed by Chen et al.,[4] which we call the proximal side optimization (PSO) technique. As the SB stent is sized based on the distal reference SB diameter, in long lesions there will be a definite size mismatch with the ostial SB diameter, thus it should be positioned and deployed with adequate protrusion in the MB (as conventional Crush and not as mini Crush; *Figures 3A and 3B*). In this way, the segment of SB stent is reliably Crushed and completely bent in only one direction in front of the SB, leaving one single layer of the stent struts to be further crossed by the guidewire and opened by the SB balloon (*Figure 3H*). The delivery balloon needs to be pulled back partially in the MB and deployed at a higher pressure (usually 4–6 atm above 'nominal' pressure; *Figure 3C*). Subsequently, high-pressure dilatation with a non-compliant balloon (0.25–0.5 mm greater in size, or if intravascular ultrasound or optical coherence tomography is used, according to the dimensions of the proximal SB) is performed (*Figure 3D*). The SB stent is then Crushed from the MB using a big, short, high-pressure balloon designed for final POT (*Figure 3E*). The rest of the procedure follows the standard DK-Crush technique previously described.

In our experience, the PSO leads to more reliable and considerably easier rewiring of the Crushed stent, most often increasing the area of optimal rewiring (space of optimal wiring, which is smaller before PSO, as with conventional DK-Crush [*Figure 2F*], and much larger after PSO [*Figures 3I and 3J*]), and by using the original workhorse soft-tipped guidewire in almost all of the cases. Notably, our modification excludes the necessity to rewire through the most proximal strut, which is discouraged in PSO to avoid the need to pass more layers of stents Crushed there. Similarly, in most cases, after first rewiring we utilize the same non-compliant balloon previously used for high-pressure SB stent post-dilatation to perform the KBI.

Conclusion

The PSO modification ensures stent size 'accommodation' to the larger vessel diameter in the proximal segment and better strut apposition to the wall, which are particularly important in the ostial segment where size mismatch between proximal and distal SB dimensions in long lesions is greater (*Figure 2E*). It can be helpful in all Crush techniques and also in other stent techniques, such as T and protrusion (TAP) and Culotte.

Further serial clinical studies of optical coherence tomography, and bench tests of micro-CT and flow dynamics, need to be performed to demonstrate whether this iteration leads to optimal flow conditions in the carina, further reducing revascularization rates triggered by the restenotic process in the SB ostium. ■

1. Kim HY, Doh JH, Lim HS, et al. Identification of coronary artery side branch supplying myocardial mass that may benefit from revascularization. *JACC Cardiovasc Interv* 2017;27;10:571–81. https://doi.org/10.1016/j.jcin.2016.11.033; PMID: 28259665.
2. Burzotta F, Lassen JF, Banning AP, et al. Percutaneous coronary intervention in left main coronary artery disease: the 13th consensus document from the European Bifurcation Club. *EuroIntervention* 2018;14:112–20. https://doi.org/10.4244/EIJ-D-18-00357; PMID: 29786539.
3. Colombo A, Stankovic G, Orlic D, et al. Modified T-stenting technique with Crushing for bifurcation lesions: immediate results and 30-day outcome. *Catheter Cardiovasc Interv* 2003;60:145–51. https://doi.org/10.1002/ccd.10622; PMID: 14517916.
4. Chen SL, Zhang JJ, Ye F, et al. DK Crush (double-kissing and double-Crush) technique for treatment of true coronary bifurcation lesions: illustration and comparison with classic Crush. *J Invasive Cardiol* 2008;18:223–6. PMID: 17404406.
5. Chen SL, Zhang JJ, Ye F, et al. Study comparing the double kissing (DK) Crush with classical Crush for the treatment of coronary bifurcation lesions: the DKCRUSH-1 Bifurcation Study with drug-eluting stents. *Eur J Clin Invest* 2008;38:361–71. https://doi.org/10.1111/j.1365-2362.2008.01949.x; PMID: 18489398.
6. Chen SL, Santoso T, Zhang JJ et al. A randomized clinical study comparing double kissing (DK) Crush with provisional stenting for treatment of coronary bifurcation lesions: the results from the DKCRUSH-II trial. *J Am Coll Cardiol* 2011;57:914–20. https://doi.org/10.1016/j.jacc.2010.10.023; PMID: 21329837.
7. 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;61:1482–8. https://doi.org/10.1016/j.jacc.2013.01.023; PMID: 23490040.
8. Chen SL, Zhang JJ, Han Y, et al. Double kissing Crush versus provisional stenting for left main distal bifurcation lesions: DKCRUSH-V randomized trial. *J Am Coll Cardiol* 2017;70:2605–17. https://doi.org/10.1016/j.jacc.2017.09.1066; PMID: 29096915.
9. Neumann FJ, Sousa-Uva M, Ahlsson A, et al. ESC/EACTS guidelines on myocardial revascularization. *Eur Heart J* 2019;40:87–165. https://doi.org/10.1093/eurheartj/ehy855; PMID: 30615155.