

REVIEW

Percutaneous Coronary Stentectomy: Redefining Stent Failure Management in the Modern Era

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ABSTRACT

Percutaneous coronary stentectomy, intentional retrieval of a fully deployed coronary stent, has evolved from anecdotal salvage to a structured interventional strategy. It addresses scenarios where a deployed stent causes ongoing complications: malapposition, longitudinal deformation, or excessive aorto-ostial protrusion leading to restenosis, thrombosis, or interference with structural heart interventions. We performed a narrative review of the published literature on intentional percutaneous coronary stent retrieval, supplemented by five illustrative cases from three academic centers representing acute, subacute, and late retrieval scenarios. Stentectomy was feasible across acute and late settings. Snare-based retrieval through guide extension catheters was the predominant approach; stents with three or fewer inter-ring connectors allowed more predictable extraction. Intravascular ultrasound was essential for procedural planning, confirmation of complete removal, and post-extraction management. Drug-coated balloons enabled metal-free revascularization after stent removal. A novel reverse hairpin-assisted snare extraction technique facilitated pre-TAVR stent retrieval in one case. The Side Flap technique and stentectomy emerged as complementary strategies for managing excessive aorto-ostial protrusion. Percutaneous coronary stentectomy is a feasible strategy for selected clinical scenarios, with intravascular imaging central to procedural planning and assessment. When performed with appropriate technique and Heart Team evaluation, it can address stent complications, restore coronary access, and enable metal-free revascularization.

1 | Introduction

Stenting aorto-ostial lesions (AOL) can be challenging and may lead to stent suboptimal stent position, longitudinal deformation, underexpansion, or excessive aorto-ostial protrusion. These mechanical complications may impair guide catheter re-engagement, preclude future coronary access, and compromise planned structural heart procedures [1]. One potential solution

is intentional stent removal (stentectomy). Stentectomy is different from stent loss, which is unintentional embolization of an undeployed or partially deployed stent, that occurs in 0.2%–8.0% of PCI procedures [2, 3]. Stentectomy, by contrast, is deliberate retrieval of a stent that has been fully deployed within the coronary artery. Stentectomy requires purpose-specific strategies, equipment, and planning [4, 5].

The clinical relevance of stentectomy has expanded substantially. Growing PCI complexity, including CTO interventions and left main bifurcation procedures, has increased the frequency of suboptimal stent results [6]. Transcatheter aortic valve replacement (TAVR) has created entirely new scenarios in which aorto-ostial stent protrusion may jeopardize future coronary access [7, 8]. Drug-coated balloon (DCB) technology allows a metal-free revascularization alternative following stent removal [9]. In selected patients, removing the stent may be more effective than attempting to fix it.

To ground the technical discussion that follows in clinical context, Table 1 summarizes the five illustrative cases, spanning acute, subacute, and late retrieval, that anchor the strategies described in this review.

2 | Conceptual Framework

2.1 | Timing and Procedural Complexity

Rather than restating the definition of stentectomy, this section focuses on the clinical settings in which it may be considered and on the factors that influence procedural difficulty. In practice, the ease of stent retrieval is strongly related to the time elapsed since implantation. Retrieval is generally more straightforward during or immediately after the index procedure, whereas delayed cases become progressively more challenging as tissue incorporation increases. Because the published experience remains limited, and because strict temporal cutoffs are not supported by histologic validation, timing is best viewed as a practical procedural consideration rather than a biologic classification.

For descriptive purposes, stentectomy may be considered acute when retrieval is attempted during or within 24 h of the index procedure, subacute when performed from 24 h to 30 days, and late when performed beyond 30 days. However, these categories should be regarded as procedural descriptors rather than histologically validated stages.

Acute stentectomy is generally the most technically favorable setting because the stent has not yet undergone meaningful endothelialization or tissue incorporation. Subacute stentectomy may be more challenging because early fibrin deposition and partial incorporation can increase traction resistance during retrieval. Late stentectomy is typically the most demanding scenario, as the stent may be embedded within neointimal tissue of variable thickness and, in some cases, associated with calcific change. Despite these challenges, successful late stentectomy has been reported even years after implantation.

2.2 | Main Clinical Indications

The principal indications for stentectomy can be grouped by the strength of the supporting evidence and organized by clinical scenario (Table 2). Two tiers are used: strong indications, in which stentectomy is the preferred or only viable solution, and situational indications, in which it is a reasonable and selective option when conventional strategies are unlikely to restore durable access. Strong indications include: (1) excessive aorto-ostial protrusion

(> 5 mm, particularly when TAVR is planned); (2) irreversible longitudinal stent deformation precluding intraluminal recrossing; and (3) impaired coronary access requiring restoration [4, 10].

Additional situational indications include suboptimal stent positioning with unfavorable anatomy for corrective restenting and selected cases in which stent removal may facilitate a metal-free revascularization strategy with DCB angioplasty. In all such settings, stentectomy should be considered a selective option reserved for cases in which conventional optimization, rewiring, side-cell strategies, or repeat stenting are unlikely to restore durable access or an acceptable mechanical result.

Because these situational decisions are inherently case-, operator-, and anatomy-specific and cannot be fully generalized, the proposed clinical algorithm (Figure 9) is intended as a condensed decision aid rather than a prescriptive rule set; the final strategy should be individualized within a Heart Team framework.

Newer-generation stent platforms with fewer inter-strut connectors are substantially more susceptible to longitudinal distortion, as demonstrated by bench testing by Leibundgut et al. Contemporary two-connector platforms, for example Synergy XD (Boston Scientific), Resolute Onyx (Medtronic), Ultimaster Nagomi (Terumo), and Coroflex Isar Neo (B. Braun), are the most prone to distortion and fragmentation, whereas three-connector designs such as Xience (Abbott), Orsiro Mission (Biotronik), and Biomatrix Alpha (Biosensors) elongate more predictably and favor intact en bloc retrieval (Table S2). Point-compression forces generate hoops-together shortening and proximal-end folding that further obstructs the lumen, supporting stent removal over iterative compression maneuvers in selected cases [11].

3 | Prevention of Aorto-Ostial Stent Complications

The best stentectomy is the one that is never required. AOLs present unique challenges to PCI: disproportionate elastic recoil, severe calcification, and asymmetric funnel-shaped geometry that promotes parallax error and geographic miss [12–15]. Several evidence-based prevention strategies substantially reduce the incidence of the complications that ultimately create stentectomy indications (Central Illustration 1).

Real-Time IVUS Guidance (RTIG) and the floating-IVUS technique prevent aorto-ostial malposition by allowing continuous ostial visualization during deployment, ensuring the proximal edge is flush with or no more than 1 mm into the aorta [16, 17]. Adjunctive options include the Wire in Aorta for Localization and Protection of the Ostium (WALPO) technique [18], dedicated positioning devices (Ostial PRO) when IVUS is unavailable, and flaring systems (Flash Ostial System) to limit aortic protrusion; a next-generation positioning system (Perfect-O) is in development [19, 20]. When only modest protrusion is present, post-hoc flaring with the Ostial Flash balloon may serve as a less invasive alternative to stentectomy in selected cases. Pre-procedural coronary CT angiography

TABLE 1 | Summary of illustrative cases.

Case	Age/Sex	Anatomy	Clinical scenario	Timing	Technique	Key imaging	Post-extraction	Outcome	Complications
1	74/M	Distal LM-LAD	Guide catheter and wire position loss during POT; failed re-cross of LM stent	Acute	Single-loop snare via 7 F GEC (Guidezilla)	IVUS: deformed stent, trapped delivery system	DCB angioplasty	Asymptomatic at 12 months; no TLR	None
2	75/F	LM protruding stent (post-LAD PCI bail-out)	Severe LM stent protrusion; non-selective LCA engagement; pre-TAVR	Late	SnareZilla (12–20 mm tri-loop via 7 F GEC)	IVUS: complete extraction confirmed	DCB angioplasty	Successful TAVR with preserved selective LCA engagement	None
3	76/F	Ostial RCA	99% ISR with 7–8 mm aorto-ostial protrusion; impossible selective engagement	Late	Side-strut fracture + one-loop snare (10 mm)	IVUS + IVL-guided re-stenting	2 overlapping DES with IVL	0% stenosis; TIMI 3 flow	None
4	77/M	Ostial RCA	4–5 mm aorto-ostial protrusion after index PCI	Subacute	Side-strut fracture + one-loop snare	IVUS: excessive protrusion; post: adequate stent expansion	IVUS-guided re-stenting	0% stenosis; TIMI 3 flow; precise ostial landing	None
5	84/M	Ostial RCA	5–7 mm protrusion; pre-TAVR access concern; CKD IV	Subacute	RASE technique (reverse hairpin + one-loop snare)	CT: 7 mm protrusion; IVUS-guided post-extraction	Balloon angioplasty only (no re-stenting)	Patent RCA; successful TAVR	None

Abbreviations: CKD = chronic kidney disease, CT = computed tomography, DCB = drug-coated balloon, DES = drug-eluting stent, GEC = guide extension catheter, ISR = in-stent restenosis, IVL = intravascular lithotripsy, IVUS = intravascular ultrasound, LAD = left anterior descending, LM = left main, PCI = percutaneous coronary intervention, POT = proximal optimization technique, RASE = Reverse hairpin assisted Avulsion and Stent Extraction, RCA = right coronary artery, TAVR = transcatheter aortic valve replacement, TIMI = Thrombolysis in Myocardial Infarction, TLR = target lesion revascularization.

TABLE 2 | Indications for percutaneous coronary stentectomy by clinical scenario and strength of indication.

Clinical Scenario	Strength of indication	Rationale	Illustrative case(s)
Excessive aorto-ostial protrusion (>5 mm), particularly when TAVR is planned	Strong	Lateral displacement or flaring cannot reliably restore an unobstructed ostium; removal re-establishes native ostial geometry and future coronary access	Cases 2, 3, 5
Irreversible longitudinal stent deformation precluding intraluminal recrossing	Strong	Deformed struts cannot be safely re-expanded or lateralized; removal is often the only route to a durable mechanical result	Case 1
Impaired coronary access requiring restoration (e.g., before structural intervention)	Strong	Guaranteed selective engagement is required for TAVR planning and future PCI	Cases 2, 5
Multilayer in-stent restenosis with ostial protrusion	Situational	Removing metal avoids compounding the ostial metal burden before re-treatment	Case 3
Suboptimal ostial positioning with anatomy unfavorable for corrective re-stenting	Situational	Re-stenting may perpetuate malposition; removal enables precise re-deployment	Case 4
Metal-free revascularization strategy (DCB-only)	Situational	Stent removal permits single-layer-free DCB treatment without adding metal	Cases 2, 5

Note: Strength of indication reflects clinical judgment, not graded evidence; the current evidence base for percutaneous stentectomy is limited to case reports and small series (Level of Evidence C). Strong = stentectomy is the preferred or only viable solution; Situational = a reasonable, selective option when conventional optimization, rewiring, side-cell strategies, or repeat stenting are unlikely to restore durable access.

Abbreviations: DCB = drug-coated balloon, PCI = percutaneous coronary intervention, TAVR = transcatheter aortic valve replacement.

defines optimal fluoroscopic angles and the true aorto-coronary junction [14, 21, 22].

At calcified aorto-ostial sites, lesion preparation with rotational or orbital atherectomy or intravascular lithotripsy improves stent expansion and reduces the malposition that later drives stentectomy [23–25]. Stent selection should favor adequate radial force and appropriate length to avoid geographic miss while minimizing aortic overhang [21]. When these preventive measures fail or a complication is already established, the remainder of this review addresses retrieval.

4 | Technical Approach to Stentectomy

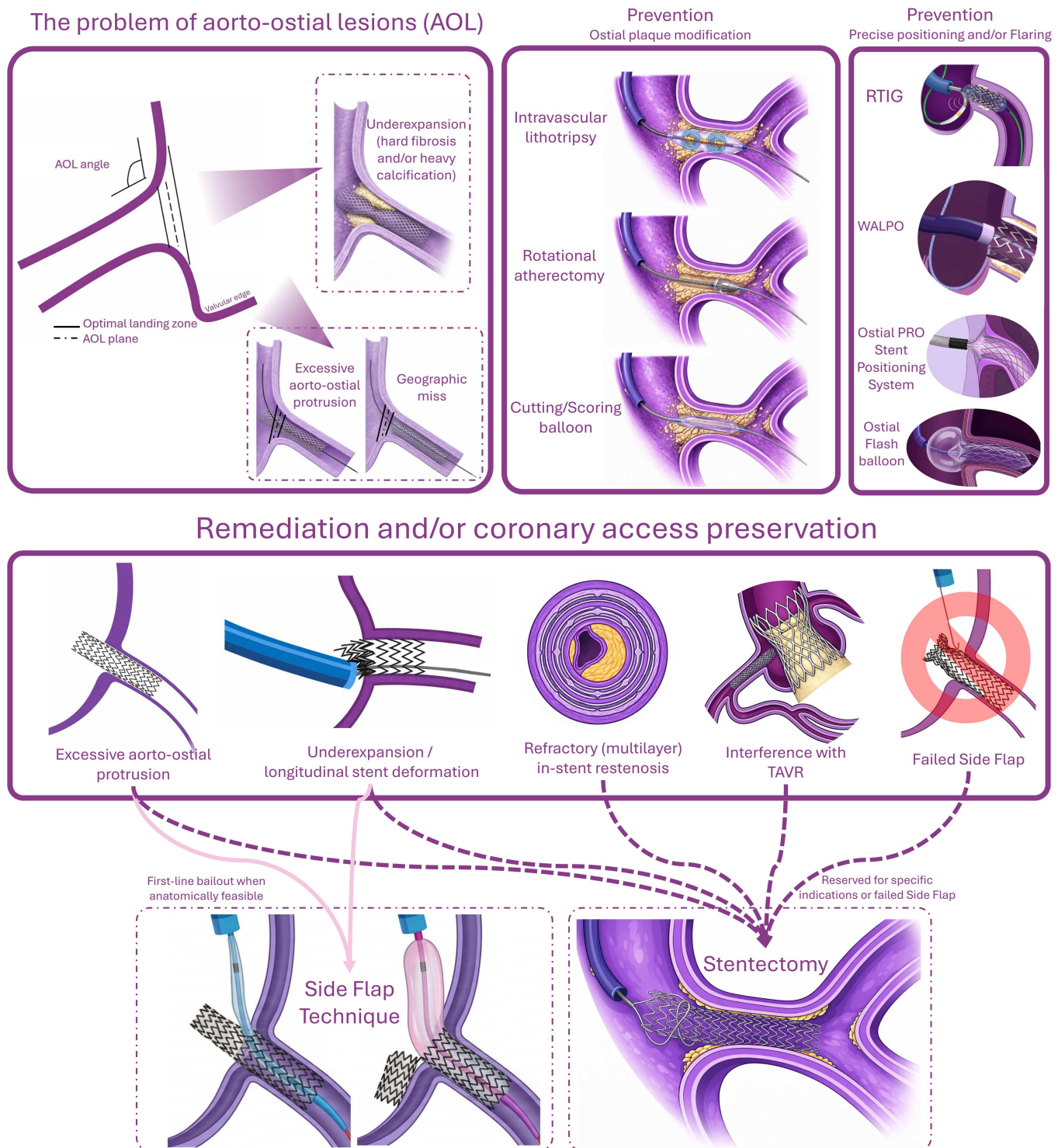
4.1 | General Principles

Pre-procedural preparation is paramount. Before any planned stentectomy, the operator should review all available prior catheterization reports, operative notes, and imaging studies to identify the stent type, manufacturer, nominal dimensions (diameter and length), date of implantation, and the clinical context of the original procedure. For the present series, these index-stent characteristics and implant contexts are summarized in Table S4. Knowledge of strut design and longitudinal stability profile directly informs retrieval strategy selection (Table S1); the more complete the prior record review, the better positioned the operator to anticipate extraction behavior and plan contingencies. When renal function permits, coronary computed tomography angiography (CCTA) should be obtained to provide precise assessment of stent protrusion length, aortic root geometry, and coronary ostial anatomy that cannot be reliably inferred from fluoroscopy alone and is particularly valuable in pre-TAVR planning and cases of suspected stent fracture. Successful stentectomy demands coaxial alignment, en

bloc retrieval, and progressive and steady, rather than abrupt and forceful, extraction. Counter-traction and balloon anchoring within or distal to the stent during snare traction facilitate progressive stent elongation and reduce peak extraction forces (Figure 1). Whenever feasible, placement of a safety guidewire should be attempted before extraction. The preferred approach is to advance this wire through a second guiding catheter using a ping-pong technique, thereby preserving coronary access outside the primary retrieval system. However, operators should recognize that the safety wire may still interact with the snare or retrieved stent construct and, in some cases, may be withdrawn en bloc during extraction. Loss of distal wire position must be included in case and bailout strategy planning and preparation. A Heart Team discussion is recommended before planned late stentectomy to assess the relative risks and benefits of both surgical and percutaneous options.

4.2 | Retrieval Techniques

Snare-based retrieval is the most widely reported approach. A snare catheter can be delivered alone or, preferably, coaxially through a guide extension catheter. Advancing a 15–25 mm one-loop snare (Medtronic, Plymouth, MN) or a 12–20 mm tri-loop snare (Merit Medical Systems, South Jordan, UT) through a 6 F/7 F guide extension catheter provides a coaxial retrieval corridor that protects the aortic wall and enables controlled withdrawal of the elongated stent into the guide extension lumen before systemic removal. Among available configurations, the combination of a guide extension with a multi-loop (tri-loop) snare, hereafter referred to as the “SnareZilla” technique (Figure 2), likely delivers the greatest traction force. In this construct the snare delivery catheter is dispensed with, the bare tri-loop snare is pre-loaded directly into the guide



CENTRAL_ILLUSTRATION 1 | Aorto-ostial lesions and protruding stents (AOL): from problem to remediation. Top panel: the problem of AOL and prevention suboptimal stenting: (left) anatomic challenges include hard fibrosis/calcification, excessive aorto-ostial stent protrusion, and geographic miss; (middle) adjunctive plaque modification (intravascular lithotripsy, rotational/orbital atherectomy, cutting/scoring balloon); (right) precise positioning and flaring strategies, RTIG, Real-Time Intravascular ultrasound (IVUS)-Guided stenting; WALPO, Wire in Aorta for Localization and Protection of Ostium; Ostial PRO (Merit Medical Systems, South Jordan, UT) stent positioning system; Ostial Flash balloon (Ostial Corporation, Palo Alto, CA). Bottom panel: remediation techniques and coronary access preservation. When excessive protrusion, underexpansion/longitudinal stent deformation, interference with transcatheter aortic valve replacement (TAVR), or refractory (multilayer) in-stent restenosis occur, two complementary bailout strategies are available. The Side Flap Technique may be considered as a stent-preserving option in anatomically suitable cases, given its favorable safety profile and avoidance of strut-vessel traction. Stentectomy is reserved for selected cases in which stent preservation is not feasible, has failed, or is unlikely to restore durable coronary access. In these cases, intravascular imaging is important for defining wire position, assessing stent incorporation and/or healing, and confirming vessel integrity and absence of residual stent material after extraction. [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1002/ccd.70815)]

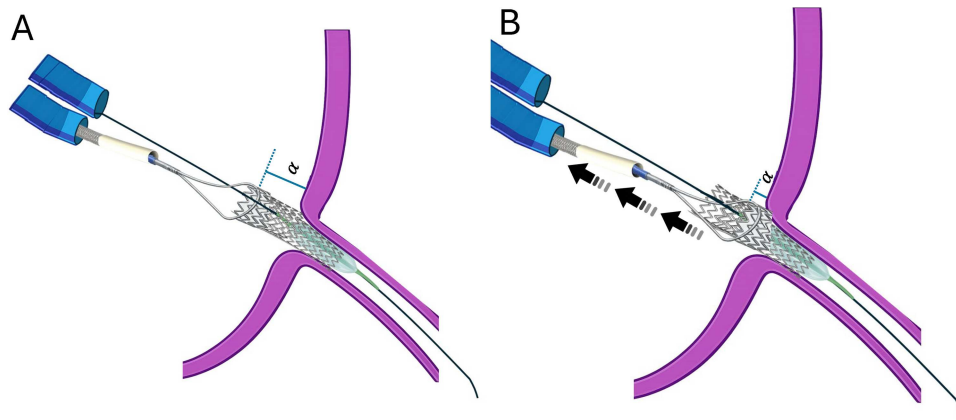


FIGURE 1 | Balloon trapping-assisted snaring technique. Illustration of the balloon-trapping maneuver combined with snaring through a guide extension catheter during percutaneous stentectomy. A semi-compliant balloon is inflated at nominal pressure within or adjacent to the target stent to anchor it against the vessel wall while a snare advanced through the guide extension catheter captures the proximal stent edge. The annotated alpha (α) distance corresponds to the axial separation between the snare-capture point and the ostium: the shorter the alpha distance, the larger the volume of stent engaged by the snare, the greater the coaxial traction force transmitted to the captured segment, and the higher the probability of complete en bloc stent retrieval. (Panel A) large α distance, snare capture far from the ostium engages only a short proximal portion of the stent, reducing traction efficiency and increasing the risk of snare slippage or release during external pull; this is a suboptimal configuration. (Panel B) small α distance, snare capture close to the ostium engages a larger volume of stent and maximizes coaxial traction, favoring complete extraction. The operator should therefore aim for the smallest achievable α distance, grasping the stent as close to the ostium as possible. [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1002/ccd.70815)]

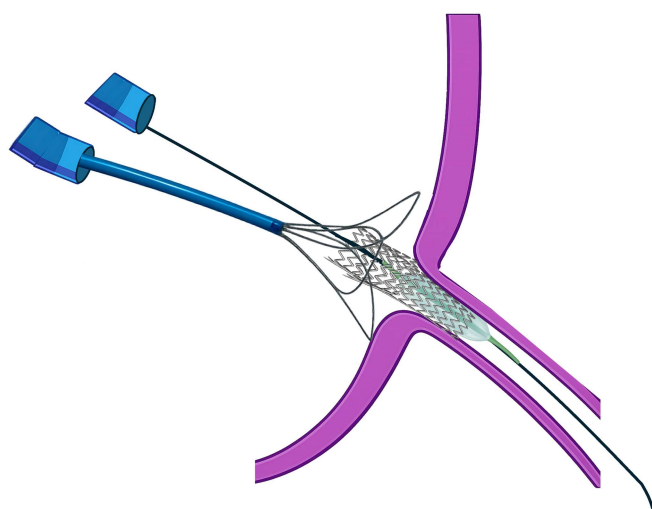


FIGURE 2 | “SnareZilla” configuration: guide extension catheter combined with a tri-loop snare. Illustration of the SnareZilla construct, a multi-loop (tri-loop) snare pre-loaded directly into a guide extension catheter and advanced en bloc through the guiding catheter to the target zone, dispensing with the dedicated snare delivery catheter. The three independent loops distribute grip circumferentially around the stent edge and engage struts at multiple points, while the large-lumen guide extension provides coaxial support, facilitates device manipulation, and accommodates the retrieved specimen for controlled en bloc withdrawal. This represents the most efficient configuration for percutaneous coronary stentectomy, offering the greatest coaxial traction force and minimizing snare slippage during external pull. The superiority of the tri-loop design is conferred by its three-dimensional geometry: the three nitinol loops are deployed in orthogonal planes, forming a true 360° capture basket that remains coaxial with the vessel lumen regardless of target orientation, a geometric advantage unavailable to planar single-loop snares. [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1002/ccd.70815)]

extension catheter, and the assembly is advanced en bloc through the guiding catheter to the target zone. This simplified coaxial arrangement maximizes force transmission as the three independent loops distribute grip circumferentially around the stent edge and engage struts at multiple points, reducing slippage during external pull, while the large-lumen guide extension facilitates device manipulation and accommodates the retrieved specimen for controlled en bloc withdrawal [7, 10]. Multi-loop systems (e.g., 12–20 mm tri-loop snare) provide a larger capture surface for longer stents and are particularly suited for late stentectomy. A novel self-expanding basket catheter fabricated from double-layer nitinol achieved 100% procedural success in a preliminary series of six patients with stent dislodgement, including one case with complete guidewire loss, and may also be applicable to stentectomy [26].

Balloon trapping is an important adjunct technique: a balloon inflated within or adjacent to the stent anchors it during external traction, reducing the risk of proximal stent migration. Combined approaches, simultaneous snaring, balloon anchoring, and guide extension support, are advised in complex cases, particularly for late or multi-stent extractions [7].

4.3 | Equipment Requirements

A 7 F or 8 F guiding catheter is recommended to accommodate the retrieval system and the elongated stent during withdrawal. A 6 F or 7 F guide extension catheter (e.g., GuideLiner, Teleflex, Wayne, PA; Guidezilla II, Boston Scientific, Marlborough, MA; Telescope, Medtronic, Minneapolis, MN) is the single most important adjunct, providing coaxial support and a protected extraction corridor. Soft polymer jacketed guidewires are preferred for coronary crossing, ideally advanced as a looped J-tip configuration, as this increases the likelihood of entering the

true stent lumen rather than passing through or in-and-out of side struts. Non-compliant balloons enable counter-traction; DCBs may be available in selected cases for post-extraction treatment. Dual-lumen microcatheters facilitate selective wiring in deformed stents. Key equipment categories are summarized in Table S1 [4, 27].

4.4 | Role of Intravascular Imaging

IVUS plays a central role throughout the stentectomy procedure (Figure 3). Pre-extraction assessment confirms guidewire position within the true stent lumen, quantifies stent-tissue incorporation, and identifies calcification that may increase extraction resistance. Post-extraction IVUS confirms complete retrieval by excluding residual metallic fragments, assesses intimal disruption, measures residual lumen, and determines the appropriate post-extraction strategy: conservative management, non-compliant balloon or DCB angioplasty, or additional stenting [1, 7, 10]. Failure to confirm complete extraction by imaging risks unrecognized stent remnants that may precipitate thrombosis or lead to access complications at future re-interventions.

4.5 | Influence of Stent Design on Retrieval Mechanics

The structural design of the target stent critically determines extraction behavior (Table S2). Hwang et al. demonstrated that platforms with three inter-ring connectors elongate uniformly and narrow predictably during extraction, enabling en bloc retrieval through a guide extension catheter [10]. Leibundgut et al. corroborated these findings across contemporary drug-eluting stent platforms, demonstrating that stents with fewer connectors exhibit substantially higher susceptibility to longitudinal distortion but also more predictable elongation patterns favorable for extraction [2, 7, 21]. High-connector stent platforms may fragment rather than elongate, increasing the risk of distal embolization and incomplete retrieval. Knowledge of the target stent platform is therefore an essential component of pre-procedural planning.

4.6 | Procedural Risks

Coronary dissection is the most common complication, occurring to varying degrees in most extraction cases. Mild,

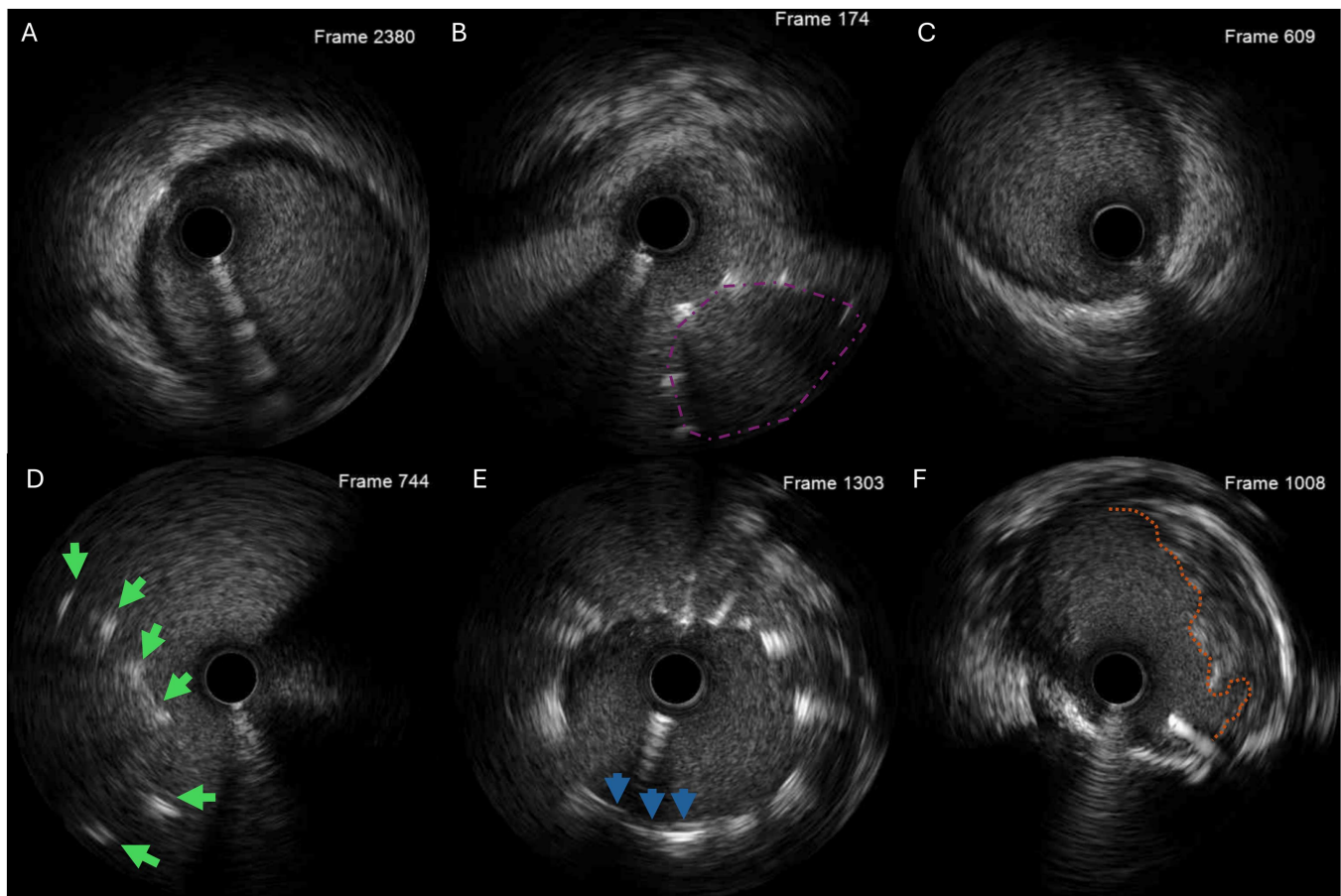


FIGURE 3 | IVUS findings during acute (A–C) and late (D–F) stentectomy. Representative intravascular ultrasound images demonstrating: (A) Baseline IVUS demonstrating a normal left main coronary artery; (B) IVUS confirming extra-stent guidewire position, with the dashed purple contour outlining the stent structure; (C) Post-extraction IVUS showing preserved left main anatomy without significant residual dissection; (D) IVUS demonstrating marked aorto-ostial stent protrusion into the aortic lumen, with green arrows highlighting protruding stent struts; (E) IVUS of a chronically implanted stent with complete neointimal coverage of the struts (blue arrows); (F) Post-stentectomy IVUS showing intimal dissection (orange dashed contour) with preserved luminal area and TIMI 3 flow after drug-coated balloon angioplasty. [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

non-flow-limiting dissections are typically managed conservatively or with DCB; more severe complications may arise if distal wire position is lost during stent retrieval. Vessel perforation, though rare, may occur with excessive traction forces; covered stents and pericardiocentesis equipment must be immediately available. In left main or last-remaining-vessel stentectomy, where acute vessel closure may precipitate hemodynamic collapse, standby mechanical circulatory support should also be considered. Distal embolization of metallic debris is minimized by en bloc retrieval via guide extension catheters. Aortic wall trauma during stent withdrawal is mitigated by the guide extension corridor. Loss of vascular access, requiring sheath removal or surgical cutdown, has been reported in heavily calcified ostial cases [7, 11].

In the present series, no vessel perforation and no flow-limiting left main or coronary dissection requiring bailout stenting, covered-stent implantation, pericardiocentesis, or surgical rescue occurred; the dissections encountered were non-flow-limiting and were managed conservatively or with DCB angioplasty. Follow-up at the extraction site was favorable within available surveillance: Case 1 remained asymptomatic without target-lesion revascularization at 12 months, and Cases 3–5 demonstrated patent vessels with TIMI 3 flow (follow-up up to 12 months). Case 2 is instructive for long-term surveillance: at 7 months, severe in-stent restenosis developed at the retained metallic stent sites (ostial left circumflex and left anterior descending), whereas the left main stentectomy site treated with DCB alone remained widely patent; the patient subsequently died of refractory cardiogenic shock unrelated to the extraction site [28]. Restenosis at drug-coated-balloon-treated stentectomy sites was therefore not observed within available

follow-up, although systematic long-term data remain limited and are a priority for future registries.

5 | Illustrative Clinical Cases

Five cases illustrate the clinical range of stentectomy: acute retrieval after delivery-system loss (Case 1); retrieval of a protruding stent before structural heart intervention (Cases 2 and 5); and staged retrieval for aorto-ostial complications (Cases 3 and 4) (Table 1).

5.1 | Case 1: Acute Stentectomy for Left Main Stent Deformation

A 74-year-old man with unstable angina underwent LM-LAD stenting (4.0×38 mm DES) followed by a second ostial LM DES. During POT the patient coughed, with loss of guide catheter and wire position; subsequent re-crossing attempts produced longitudinal stent deformation. Acute stentectomy was performed using a single-loop snare through a 7 F Guidezilla, retrieving the deformed stent en bloc with the delivery system. Post-extraction IVUS confirmed LM integrity; DCB angioplasty achieved an optimal result. The patient remained asymptomatic at 12 months (Figure 4, Video S1) [29, 30].

5.2 | Case 2: Late Stentectomy of a Protruding Left Main Stent Before TAVR

A 75-year-old woman with severe aortic stenosis (EF 32%, eGFR 18) presented with NSTEMI. Angiography revealed a fully deployed stent protruding from the ostial LM into the aorta

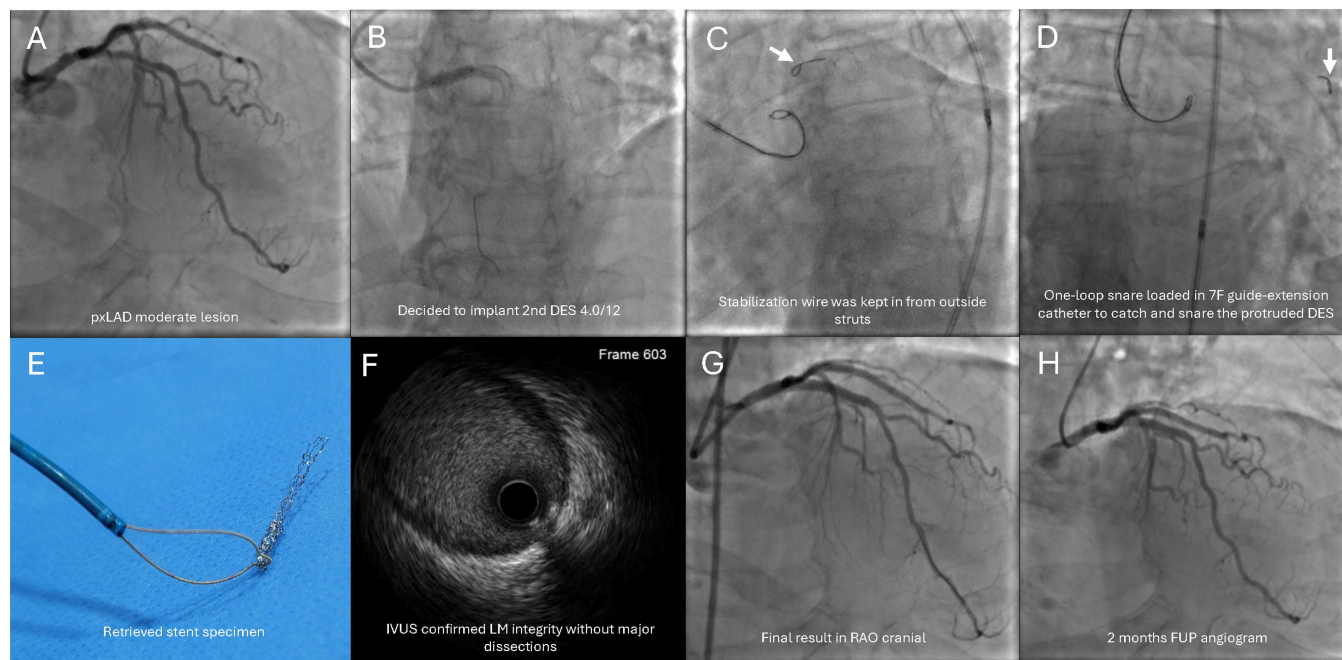


FIGURE 4 | Case 1. Acute stentectomy of a deformed left main stent. (A) Baseline angiography; (B) Second DES implantation at LM ostium; (C) Stabilization guidewire maintained outside stent struts (white arrow indicates safety wire in the coronary artery); (D) Single-loop snare via 7 F GEC capturing the protruding stent (white arrow indicates safety wire); (E) En bloc retrieval; (F) Post-extraction IVUS confirming LM integrity; (G) Final result after DCB angioplasty; (H) 2-month follow-up. [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1002/ccd.70815)]

(implanted 5 years prior as bail-out), precluding selective engagement, plus severe calcified LCx disease in a left-dominant system. After Heart Team discussion, a staged approach was planned: PCI with IABP support, stentectomy, then TAVR. The LCx was stented first (3.5 × 24 mm DES) to secure the dominant vessel. The protruding LM stent was then retrieved en bloc using a 12–20 mm tri-loop snare via 7 F GEC (SnareZilla technique). IVUS confirmed complete extraction; DCB angioplasty was applied to the LM-LAD. TAVR was subsequently performed with preserved LCA engagement (Figure 5, Video S2). This case has been reported separately in detail [28–30].

5.3 | Case 3: Intentional Stent Fracture and Retrieval for Refractory ISR

A 76-year-old woman with prior RCA stenting presented with NSTEMI and 99% ostial ISR with ostial stent underexpansion (due to underlying calcium) and 7–8 mm of aorto-ostial protrusion from the index procedure, precluding selective Guide catheter engagement. Via trans-strut balloon access, serial inflations produced intentional stent fracture; a 10 mm one-loop snare retrieved the fragment en bloc. IVUS-guided IVL and re-stenting with high radial strength DES achieved 0% residual stenosis with TIMI 3 flow (Figure 6).

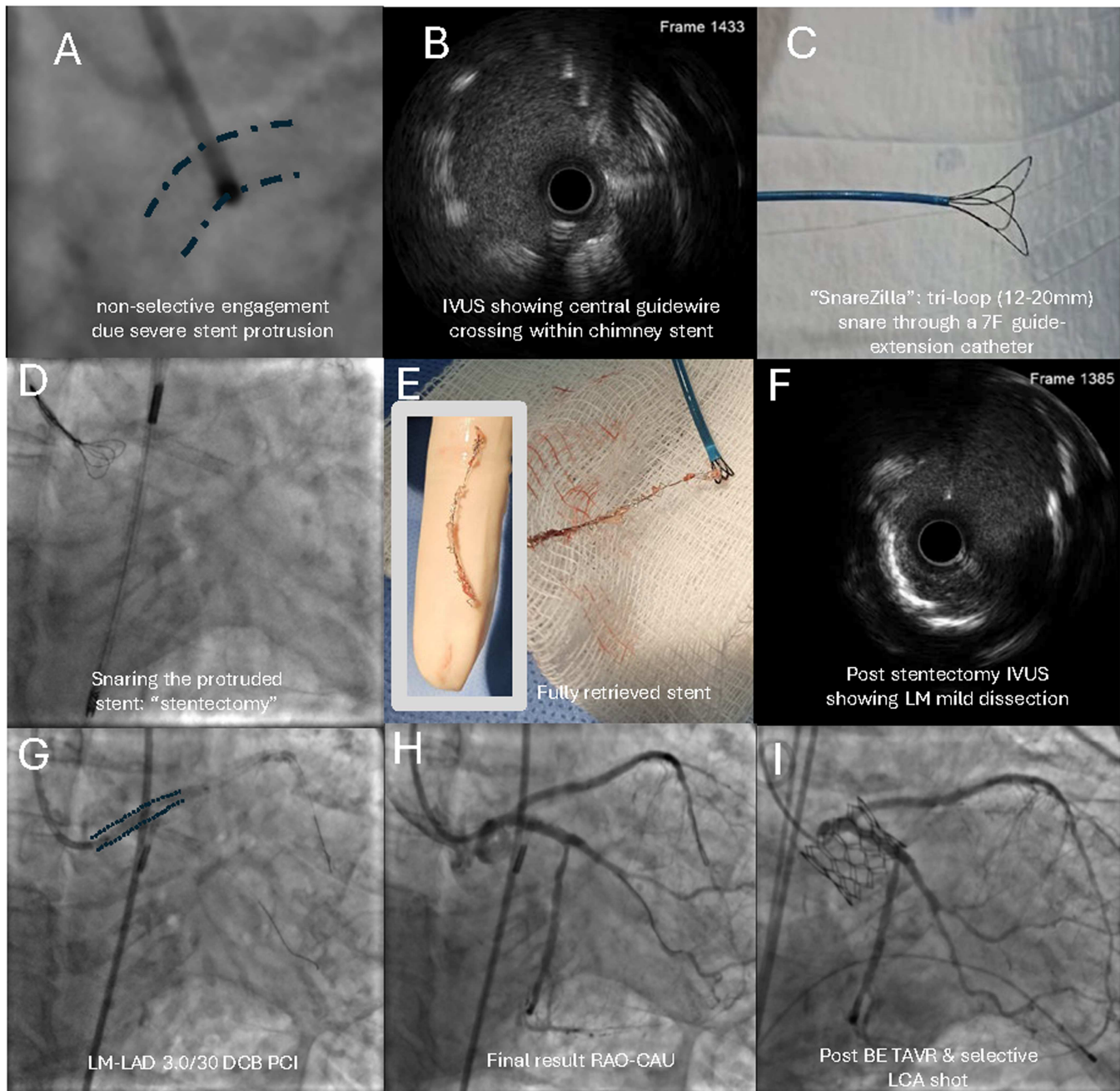


FIGURE 5 | Case 2. Snare-assisted stentectomy of a protruding LM stent before TAVR. (A) Non-selective LCA engagement; (B) IVUS confirming guidewire within protruding stent lumen; (C) SnareZilla capturing the stent; (D) En bloc retrieval; (E) Retrieved specimen; (F) Post-extraction IVUS; (G) DCB angioplasty of LM-LAD; (H) Final angiography; (I) Post-TAVR angiography with restored selective LCA engagement. [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

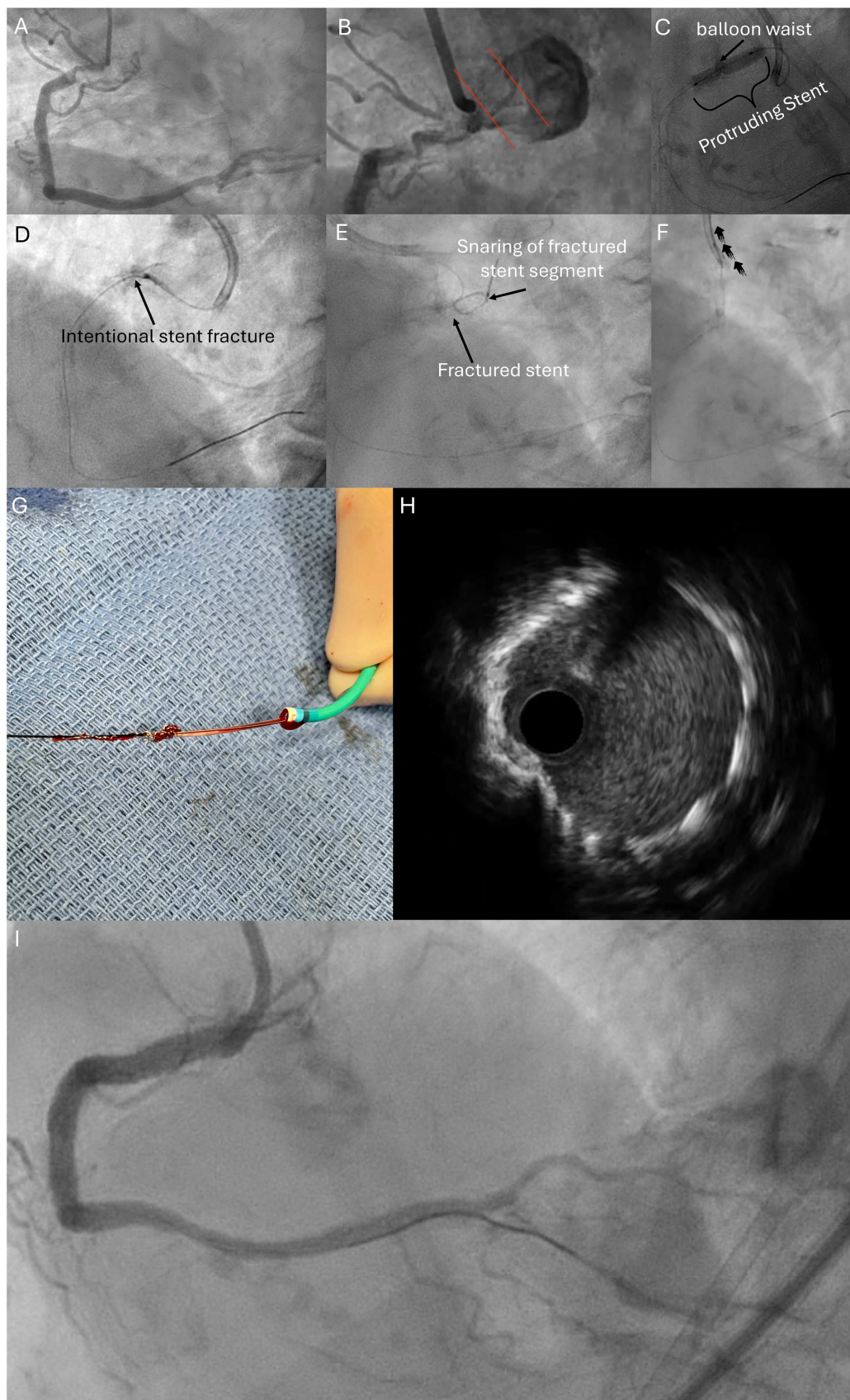


FIGURE 6 | Case 3. Intentional stent fracture and retrieval for aorto-ostial RCA ISR. (A) Baseline angiography; (B) 99% ISR with stent underexpansion at the ostium and aortic protrusion; (C) Trans-strut balloon access; (D) Intentional fracture; (E) Fluoroscopic view; (F) Snare capture and en bloc retrieval; (G) Retrieved specimen; (H) Post-IVL/re-stenting IVUS; (I) Final angiography with TIMI 3 flow. [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1002/ccd.70815)]

5.4 | Case 4: Staged Retrieval of a Protruding Aorto-Ostial RCA Stent

A 77-year-old man underwent IVUS-guided ostial RCA PCI with 4–5 mm of residual stent protrusion. Recognizing the suboptimal result, the operator planned staged retrieval. Weeks later, trans-strut balloon fracture and one-loop snare extraction were performed; IVUS-guided re-stenting (4.0 × 38 mm DES) confirmed precise ostial landing and TIMI 3 flow (Figure 7, Video S3).

5.5 | Case 5: The RASE Technique—Reverse Hairpin Assisted Avulsion and Stent Extraction Before TAVR

An 84-year-old man with CKD IV, prior LIMA-LAD bypass, LM-LCx stents, and severe aortic stenosis underwent ostial RCA PCI, but 5–7 mm of stent protrusion remained, and wire loss prevented follow-on optimization. CT confirmed ~7 mm protrusion threatening TAVR delivery. Via bifemoral access, a 20 mm one-loop snare was pre-positioned in the aortic root. Trans-strut balloon fracture was performed, then a reverse hairpin maneuver redirected a polymer-jacketed wire retrogradely through the stent lumen and into the aorta, creating a controlled extraction rail. The snare captured the fractured stent segment, and the entire assembly was withdrawn as a single unit through the guide catheter (RASE technique, Reverse hairpin-assisted Avulsion and Stent Extraction). This approach adapts the hairpin-trap concept originally described by Brilakis et al. [31] for intentional fracture-extraction with continuous wire control, mitigating embolization risk. However, depending on the degree of

wire-stent intertwining, en bloc retrieval of both components may still occur with this construct. IVUS-guided balloon angioplasty achieved an optimal result without re-stenting; TAVR was subsequently performed without complication (Figure 8; Animation S1). This case has been reported separately in detail [32].

6 | Discussion

Five clinical scenarios drove stentectomy in our cohort: pre-TAVR coronary access restoration; preservation of access for future interventions; mechanical stent failure presenting as ACS; rescue after failed complex PCI; and metal-free revascularization with DCBs after stent removal (Table 1).

Across the prior published experience synthesized in Table 4, procedural success rates have been consistently high, yet complications, although uncommon, are not negligible. The four-patient series by Ragosta et al. reported no complications with snare-based, IVUS-guided aorto-ostial retrieval, but their accompanying literature review identified isolated cases of acute coronary closure and dissection among earlier, less systematically performed extractions [7]. This series is also notable for 2 extractions involving stents implanted > 5 years prior, supporting the feasibility of very-late stentectomy. In the largest retrieval cohort to date, Brilakis et al. documented an acute closure rate of approximately 1% with no retrieval-related deaths among 97 stent-loss events over a decade, with bleeding and emergency CABG confined to a small subset [33]. The absence of periprocedural complications in our five-patient series is therefore consistent with this trajectory of improving safety

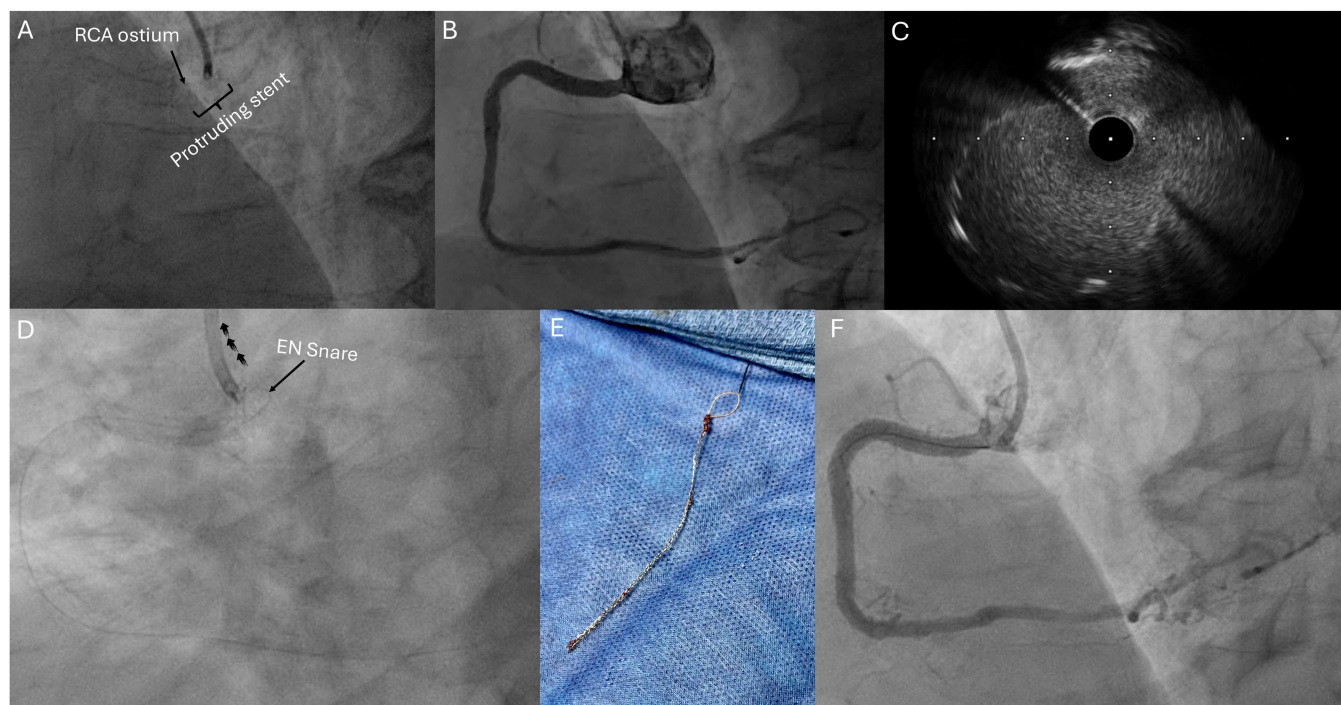


FIGURE 7 | Case 4. Staged retrieval of protruding aorto-ostial RCA stent. (A) Non-selective angiography confirming protrusion; (B) Guide catheter positioning; (C) IVUS confirming excessive protrusion; (D) Snare capture; (E) Retrieved specimen; (F) Final angiography after re-stenting. [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

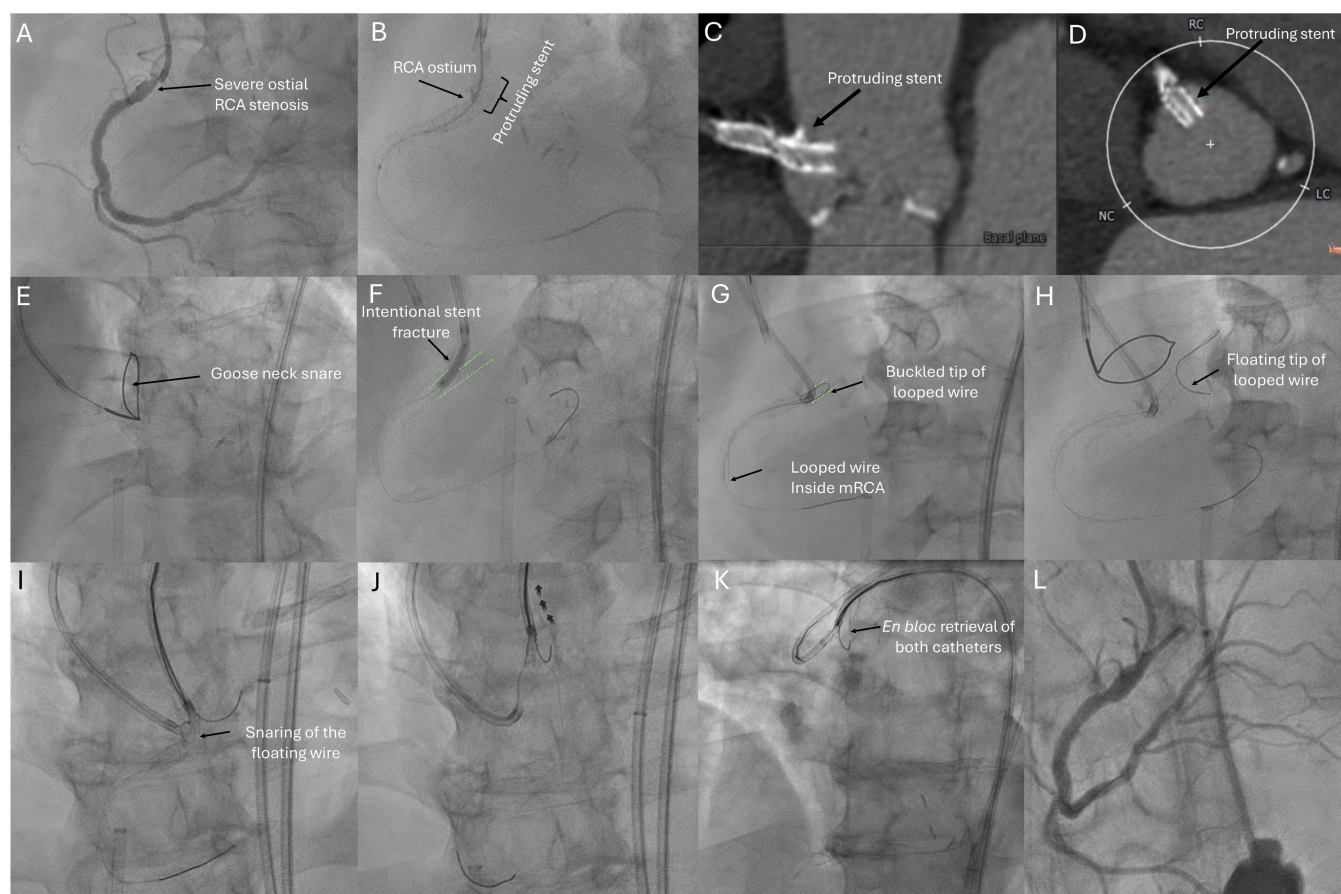


FIGURE 8 | Case 5. The RASE Technique for pre-TAVR aorto-ostial RCA stent retrieval. (A) Baseline angiography; (B) Stent protrusion post-index PCI; (C-D) CT angiography confirming ~7 mm protrusion; (E) Pre-positioned snare; (F) Intentional fracture; (G) Reverse hairpin maneuver; (H) Wire externalized into aorta; (I) Snare capturing the RASE construct; (J) Controlled traction; (K) Stent segment retrieval; (L) Final angiography confirming patent ostial RCA. [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1002/ccd.70815)]

as pre-procedure planning, imaging integration, guide-extension support, and technique standardization have matured, while acknowledging that the total number of cases reported in the literature remains modest and that risk is not zero.

Several principles emerge from this collective experience. Patient selection and Heart Team involvement are essential, accounting for temporal classification, stent design, coronary anatomy, operator experience, and surgical backup. Stentectomy should never be a reflex response to a suboptimal angiographic result. IVUS guidance is essential, as angiography alone may not reveal wire position, apposition, or residual protrusion. Stent design influences extraction in ways not apparent from fluoroscopy: platforms with fewer connectors elongate more predictably but deform more easily, while high-connector platforms resist elongation but may fragment under traction.

The stentectomy learning curve is steep, requiring mastery of snare manipulation, guide extension, counter-traction, and imaging under adverse hemodynamics. Early experience at high-volume centers with available and pre-notified surgical backup is strongly advised. Stentectomy should be viewed as one option within a broader bailout spectrum that includes

balloon optimization, additional stenting, the Side Flap technique, and DLC-facilitated wiring, rather than as a universal solution [4].

6.1 | Reconciling the Side Flap Technique and Stentectomy: Complementary Strategies in a Unified Toolkit

The comprehensive evaluation by Leibundgut et al. is a major contribution to managing excessive aorto-ostial stent protrusion [21]. Their systematic mechanical testing definitively demonstrates that longitudinal crushing strategies, direct guide catheter pushback, anchor-assisted push, balloon-assisted pushback, and telescoping ring-by-ring maneuvers, while seemingly attractive, are mechanically unreliable and frequently produce severe stent deformation or malapposition rather than the intended controlled foreshortening. Iterative crushing should be avoided with meaningful overhang. The Side Flap technique rewires and dilates a side cell, laterally displacing the protruding segment and creating a stable neo-lumen across contemporary stent platforms. A step-by-step schematic of the Side Flap technique is provided in Figure S2. In their clinical experience, the Side Flap technique achieved high procedural

success without technique-related adverse events (to include stent fragment embolization) on follow-up. Nonetheless, when the displaced flap remains large or the stent platform is structurally compromised, there is a theoretical risk of stent fragment embolization during or after Side Flap deployment; in such scenarios, combining Side Flap with targeted snare retrieval of the displaced flap (as performed in two of the three RCA cases in the present series) provides an additional margin of safety.

Contemporary stentectomy mitigates the failure modes of bare snare-pull described on the bench through IVUS guidance, coaxial guide-extension support, controlled fracture via serial side-strut balloon inflations, and snare capture close to the ostium (SnareZilla and RASE constructs). Stent length and chronicity interact multiplicatively; longer, more incorporated stents may exceed the usable lumen of guide-extension catheters and frequently mandate intentional segmental fracture rather than en bloc withdrawal (Table S3).

Side Flap and stentectomy are complementary strategies suited to specific failure modes (Table 3). Given its favorable safety profile and reproducibility, the Side Flap technique may be considered an initial stent-preserving option in anatomically suitable cases, regardless of stent age. Stentectomy is preferred when TAVR planning requires an unobstructed ostium (since lateral metal displacement does not restore re-engagement), in multilayer ISR substrate, with critical longitudinal deformation or delivery-system loss,

when the protruding segment exceeds 7 mm, when Side Flap is contraindicated or has failed, or when a metal-free DCB strategy is pursued.

7 | Proposed Clinical Algorithm

A 7-step algorithm summarizes the workflow (Figure 9): confirm stent complication; assess severity and consider Side Flap first-line unless contraindicated (Table 3); classify temporally as acute (≤ 24 h), subacute (24 h to 30 day), or late (> 30 day) as procedural descriptors of expected tissue incorporation; obtain pre-procedural CT angiography when feasible (mainly for planned late stentectomy); select access, guiding catheter, guide extension, snare, and IVUS; perform IVUS-guided extraction with post-extraction assessment; and defer in heavy calcification, absent surgical backup, or unfavorable anatomy.

8 | Limitations

The existing literature on intentional stentectomy is limited to case reports and small series with heterogeneous approaches, precluding systematic analysis. The absence of randomized controlled trial data prevents definitive conclusions regarding patient selection criteria, long-term outcomes, or comparisons with alternative management strategies. Reporting bias likely overestimates success. Prospective registries and standardized reporting are needed to define the true risk-benefit profile.

TABLE 3 | Selecting between side flap technique and stentectomy for excessive aorto-ostial stent protrusion.

Clinical scenario	Side flap preferred	Stentectomy preferred	Rationale
Isolated moderate-excessive protrusion; stable patient; intact stent platform; no TAVR planned	Yes	—	Less invasive; preserves stent platform; high reproducibility on bench and clinical data (albeit with theoretical risk of embolization)
Protrusion with planned TAVR or other structural intervention	—	Yes	Lateral displacement of stent metal does not eliminate the obstacle to coronary re-engagement after valve deployment
Multilayer in-stent restenosis with ostial protrusion	—	Yes	Adding flap-displaced metal compounds the ostial metal burden in an already restenotic segment
Critical longitudinal deformation, acute delivery-system loss, or other structural stent failure	—	Yes	Side Flap presupposes a structurally intact stent; deformed stents cannot be safely lateralized
Long protrusion (> 5 mm)	—	Yes	Protrusion exceeding 5 mm is defined as excessive (Leibundgut et al.); even successful lateralization leaves a clinically significant residual lateral flap
Side-cell anatomy inaccessible or Side Flap attempt failed	—	Yes	Bailout extraction restores ostial geometry
Metal-free revascularization with DCB pursued	—	Yes	Stentectomy enables single-layer-free DCB-based treatment without adding metal

Abbreviations: DCB = drug-coated balloon, TAVR = transcatheter aortic valve replacement.

TABLE 4 | Published experience with percutaneous coronary stent retrieval.

Author, year	Journal	Study type (N)	Clinical setting	Extraction technique	Imaging guidance	Success	Complications	Follow-up
Brilakis, 2005	Catheter Cardiovasc Interv	Retrospective cohort (97 events/38 retrievals)	Stent loss during PCI (1994-2004)	Small-balloon technique, snare, forceps	Fluoroscopy (1994-2004 cohort)	Retrieval ~86%; overall clinical success ~96%	Acute closure ~1%; no retrieval-related deaths; bleeding/emergent CABG in small subset	In-hospital cohort analysis
Brilakis, 2011	Catheter Cardiovasc Interv	Case report (1)	Lost stent/intracoronary equipment retrieval	Hairpin-trap wire technique	Fluoroscopy	1/1 (100%)	None	Not reported
Hwang, 2016	Korean Circ J	Bench + case report (1)	Fully deployed stent requiring extraction	Snare pull; documented uniform elongation (3-connector) vs. fragmentation (2-connector)	Bench + fluoroscopy	1/1 (100%)	None	Not reported
Ragosta, 2021	Catheter Cardiovasc Interv	Case series (4)	Aorto-ostial stent malposition (RCA/LM)	One-loop snare via GEC	IVUS	4/4 (100%)	None in series; isolated acute closure/dissection in prior literature	Up to 5 yr
Hussain, 2022	J Cardiol Cases	Case report (1)	Fully deployed stent explantation	Coaxial snare retrieval	Fluoroscopy	1/1 (100%)	None	Not reported
Han, 2024	BMC Cardiovasc Disord	Case series (6)	Stent dislodgement during PCI	Self-expanding nitinol basket catheter	Fluoroscopy	6/6 (100%)	No adverse events	Short-term
Singh, 2025	Cardiovasc Revasc Med	Case report (1)	Ostial RCA protrusion (8-10 mm) with severe ISR	Snare retrieval under OCT guidance; avoided CABG	OCT	1/1 (100%)	None	Symptom resolution
Current series	Catheter Cardiovasc Interv (this study)	Case series (5)	LM, aorto-ostial RCA protrusion, pre-TAVR access, stent deformation	Snare + GEC; side-strut fracture; RASE technique; IVUS/IVL-guided	IVUS (all 5 cases); IVL in 1	5/5 (100%)	None	Up to 12 months

Note: Complications are periprocedural unless otherwise specified.

Abbreviations: CABG = coronary artery bypass grafting, CT = computed tomography, GEC = guide extension catheter, ISR = in-stent restenosis, IVL = intravascular lithotripsy, IVUS = intravascular ultrasound, LM = left main, OCT = optical coherence tomography, PCI = percutaneous coronary intervention, RASE = Reverse hairpin-assisted Avulsion and Stent Extraction, RCA = right coronary artery, TAVR = transcatheter aortic valve replacement.

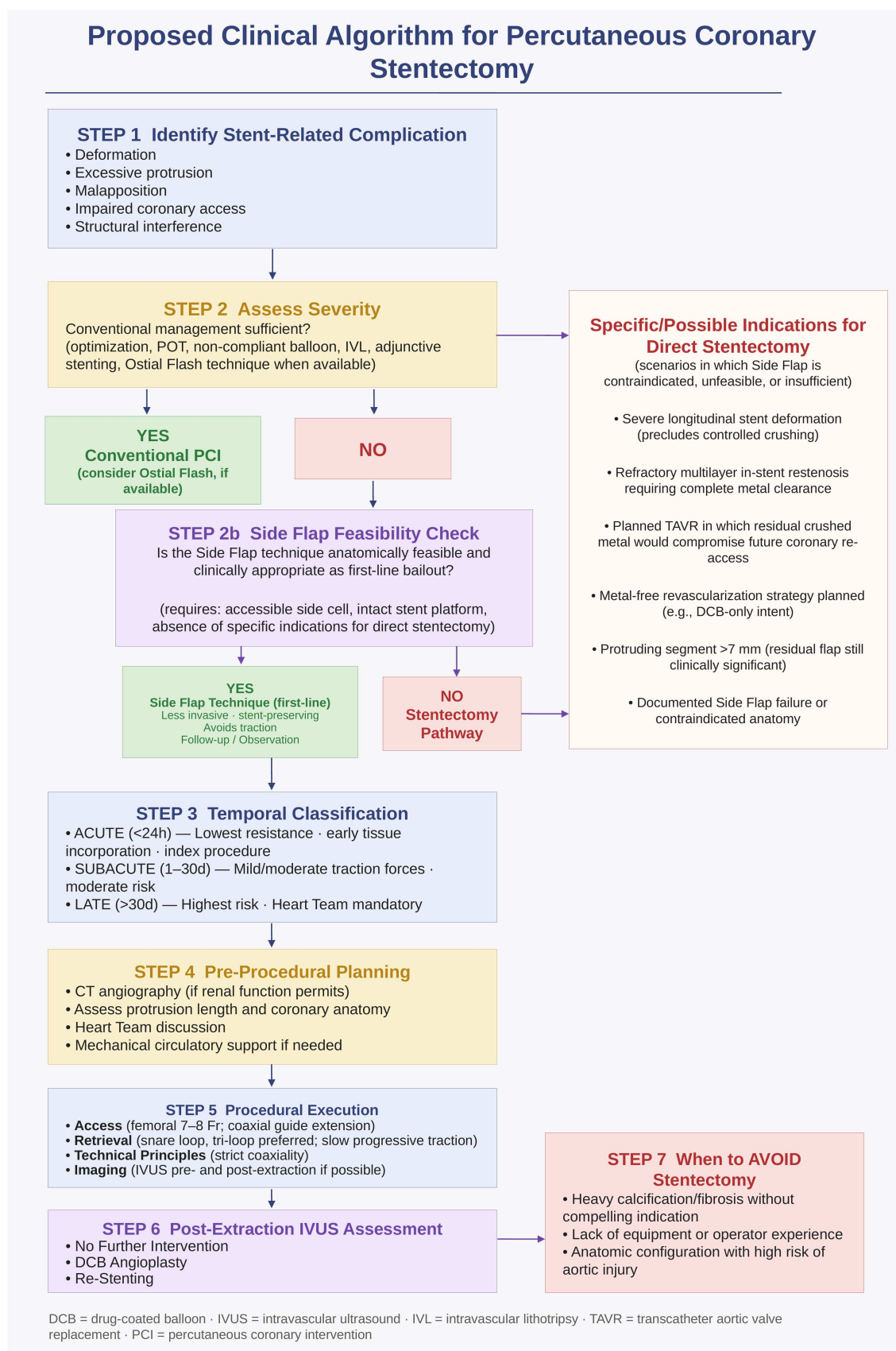


FIGURE 9 | Proposed clinical algorithm for percutaneous coronary stentectomy. The algorithm integrates clinical indication, temporal descriptor (acute/subacute/late), stent design assessment, imaging evaluation, procedural strategy selection, technical execution, and post-extraction management. DCB = drug-coated balloon; IVUS = intravascular ultrasound; LM = left main; TAVR = transcatheter aortic valve replacement. [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

9 | Conclusions

Percutaneous coronary stentectomy is a feasible, image-guided option for mechanical stent failure or clinically important aorto-ostial protrusion. In experienced centers with Heart Team involvement, systematic intravascular imaging, and operator expertise in snare-based retrieval, it may help restore coronary access, manage selected stent-related complications, and facilitate metal-free revascularization in carefully chosen anatomies. Given the steep learning curve, stentectomy should be undertaken only by, or under the direct proctorship of, operators with substantial experience in snare-based retrieval and complex aorto-ostial intervention; it is not a procedure for the occasional or inexperienced operator to attempt without an experienced hand at the table. Prospective registries and standardized reporting are needed to better define patient selection, procedural safety, and long-term outcomes.

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Ethics Statement

Ethics committee approval was not required for this technical review with illustrative cases, in accordance with institutional policies.

Consent

Written informed consent was obtained from all patients for publication of their clinical data and accompanying images.

Conflicts of Interest

The authors declare no conflicts of interest.

Artificial Intelligence Disclosure

The authors used a large language model (Claude, Anthropic) to assist with language editing, reference formatting, and manuscript organization. All scientific content, clinical data, interpretations, and conclusions are the sole responsibility of the authors, who reviewed and verified all text prior to submission.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request. De-identified procedural images and clinical details may be shared subject to institutional policies and patient consent.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.

Figure S2: Step-by-step schematic of the Side Flap technique for excessive aorto-ostial stent protrusion, shown in a sagittal view of the aorta at the level of the coronary ostium. (A) An aorto-ostial stent protrudes from the coronary ostium into the aortic lumen, obstructing coaxial re-engagement. (B) A polymer-jacketed guidewire is advanced through the side struts of the protruding segment into the true coronary lumen. (C) An uninflated balloon is tracked over the wire across the stent struts. (D) Balloon inflation opens the struts (the Side Flap itself), laterally displacing the protruding segment. (E) Aggressive high-pressure non-compliant (NC) balloon post-dilation at the ostium ensures complete strut opening, restoring a coaxial neo-lumen. NC = non-compliant.

Supplementary Animation S1: The RASE Technique (Reverse hairpin Assisted Avulsion and Stent Extraction). Sequential panel animation illustrating the RASE technique for percutaneous aorto-ostial stent retrieval. The sequence begins with trans-strut crossing, where a guidewire is advanced through the side struts of the protruding stent segment and the cells are dilated with a semi-compliant balloon to promote intentional stent fracture. Using a dual-lumen microcatheter to deliver a hairpin-shaped wire (not depicted, only the wire trajectory is shown), the guidewire is redirected back through the stent body, forming a loop that is exteriorized proximally through the stent architecture into the aorta. The externalized hairpin loop is then captured by a tri-loop snare positioned at the right coronary ostium, securing the construct under bilateral wire tension. Finally, the entire assembly, wire hairpin and fractured stent, is withdrawn as a single unit; the stent is typically advanced into and retrieved through the snare catheter, restoring a stent-free ostium.

Supporting File 1: ccd70815-sup-0003-SuppAnimation_S1_RASE_Technique.mp4

Supporting File 2: ccd70815-sup-0004-Supplementary_Material_Stentectomy_2026_04_18.docx

Table S1: Device Toolbox for Aorto-Ostial Interventions and Percutaneous Coronary Stentectomy.

Table S2: Contemporary Drug-Eluting Stent Platforms: Connector Architecture and Implications for Stentectomy.

Table S3: Predictors of Procedural Difficulty in Percutaneous Coronary Stentectomy.

Table S4: Index Stent Characteristics and Implant Context for the Five Illustrative Cases

Video S1: Case 1: Acute stentectomy of a deformed left main stent. Fluoroscopic recording showing snare capture and en bloc retrieval of the deformed stent through the guide extension catheter.

Video S2: Case 2: Late stentectomy of a protruding left main stent before TAVR. Fluoroscopic recording demonstrating SnareZilla-assisted capture and controlled extraction of the chronically implanted stent.

Video S3: Case 4: Staged retrieval of a protruding aorto-ostial RCA stent. Fluoroscopic recording showing trans-strut balloon fracture, snare capture, and extraction of the protruding stent segment.