

## REVIEW ARTICLE OPEN ACCESS

# Rotational Atherectomy Through Guide Extension Catheters: Indications, Technique, and Limitations

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## ABSTRACT

Rotational atherectomy (RA) is an established technique for the treatment of heavily calcified coronary artery disease. Severe coronary calcification remains a frequent cause of procedural difficulty and device delivery failure during complex percutaneous coronary intervention (PCI). Delivery of the atherectomy burr to the target lesion may be particularly challenging in the presence of limited guide support, proximal vessel tortuosity, or unfavorable coronary anatomy that restricts safe access to distal calcified segments. Guide extension catheters (GECs) are widely used to enhance guide support and improve coaxial alignment during complex PCI. However, their use in combination with RA represents an advanced and selectively applied strategy that is not routinely addressed in conventional atherectomy training and is often avoided because of concerns regarding device interaction and difficulties during burr delivery and retrieval. Despite increasing anecdotal use in complex PCI, the technical principles and procedural safety considerations of performing RA through GECs remain insufficiently described in the literature. This review provides a focused technical overview of RA performed through GECs. We summarize the rationale for this approach, describe key technical considerations including device compatibility and burr advancement strategies, and discuss practical measures to minimize procedural complications. In addition, we outline clinical scenarios in which this technique may be beneficial, as well as situations where it should be avoided. Rather than advocating routine use, this review aims to define the role of guide extension-facilitated RA as a selective strategy for highly complex coronary anatomies.

## 1 | Introduction

Despite significant advances in percutaneous coronary intervention (PCI), severe coronary calcification remains a challenge for interventional cardiologists. Up to 20% of patients undergoing PCI have moderate-to-severe coronary calcification

[1]. Coronary calcification makes delivering wires, balloons, and stents difficult, limits lesion preparation with resultant stent underexpansion, and may reduce the efficacy of drug-eluting stents [2]. As such, moderate-to-severe calcification has been associated with a higher rate of major adverse cardiovascular events (MACEs) following PCI [3]. Rotational atherectomy (RA)

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is a well-established method for calcium modification and debulking [4, 5], utilizing a diamond-encrusted elliptical burr that causes “differential cutting” and preferentially ablates hard, inelastic, calcified plaque [4]. With a better understanding and development of modern atherectomy techniques, RA is increasingly used with low complication rates [6, 7]. Contemporary RA practice emphasizes the use of smaller burr sizes, short ablation runs, and careful avoidance of excessive decelerations, resulting in improved safety profiles and broader applicability, findings supported by large contemporary registries of RA [3, 8]. Nevertheless, even when RA is indicated and correctly performed, advancing the burr to the target lesion may be limited by inadequate guide support, vessel tortuosity, or proximal calcific resistance.

Guide extension catheters (GECs) have become an integral part of the interventional armamentarium for complex coronary interventions. By providing enhanced coaxial alignment, increased backup support, and deep coronary intubation, these devices facilitate the delivery of balloons and stents in anatomically challenging scenarios. Their use has expanded across a wide spectrum of complex procedures, including chronic total occlusions, distal lesions, bypass graft interventions, and heavily calcified vessels, particularly in transradial PCI where additional support is frequently required [9, 10].

The combination of RA and GECs represents a niche but increasingly reported strategy in selected cases where conventional burr delivery is not feasible. This approach may enable safe advancement of the atherectomy burr, improve procedural efficiency, limit proximal vessel disruption, and allow completion of revascularization without escalation to alternative plaque modification devices or access strategies. However, the use of guide extensions to facilitate RA is often avoided due to concerns with unfavorable equipment interaction, difficulty in delivery and retrieval of burrs, and the potential for increased complications. Nevertheless, the careful use of guide extensions in select cases may be useful, and it is important for operators to have an understanding when, why, and how these devices can be safely used with RA.

It is important to contextualize this technique within the evolving landscape of coronary calcium modification. Intravascular lithotripsy (IVL) and orbital atherectomy (OA) have emerged as effective alternatives to RA for selected calcified lesion subsets. Recent randomized evidence, including the ROTA.shock and ROLLER COASTR-EPIC22 trials, has demonstrated noninferiority of IVL compared to RA regarding minimal stent area and stent expansion [11, 12]. In a direct head-to-head comparison, the DIRO trial showed that RA achieved greater tissue modification and stent expansion than OA in heavily calcified lesions guided by optical coherence tomography [13]. However, the clinical decision to employ RA is frequently driven by factors beyond calcium modification efficacy alone, including lesion uncrossability, device availability, operator expertise, and anatomical constraints such as severe proximal tortuosity or calcific resistance. In scenarios where RA is the selected or sole available modality and standard burr delivery proves inadequate, the adjunctive use of GECs addresses a specific procedural challenge—that of burr deliverability—rather than competing with alternative calcium modification technologies.

This review serves to provide a focused technical overview of RA performed through GECs. We discuss the rationale, indications, technical and procedural considerations, limitations, and clinical scenarios in which this strategy may be appropriate or should be avoided. A better understanding of the technique will improve safety and reduce potential complications. Rather than advocating routine use, this manuscript seeks to define the role of this technique as a selective solution for highly complex coronary anatomies when standard approaches fail.

## 2 | Indications for Using GECs During RA

Successful RA depends not only on appropriate burr selection and ablation technique but also on the ability to deliver the burr safely and coaxially to the target lesion while minimizing trauma and disruption to proximal vessel structures. There are 3 key indications where guide extensions for RA may be considered.

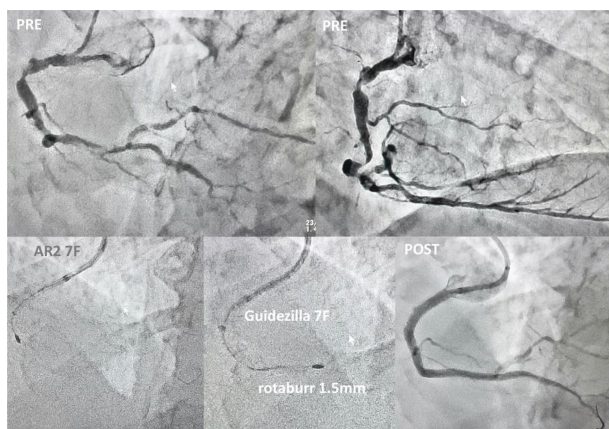
### 2.1 | Inadequate Guide Catheter Support

In complex coronary anatomies, inadequate guide catheter support represents a frequent cause of procedural failure, particularly when calcification is associated with severe tortuosity, angulated takeoff, distal lesion location, or prior surgical grafts. GECs enhance backup support by effectively shortening the distance between the guiding catheter tip and the target lesion while maintaining coaxial alignment [9, 14]. This mechanism improves force transmission during device advancement and reduces energy dissipation across proximal vessel bends. In the context of RA, these characteristics may facilitate controlled burr delivery in cases where conventional guide catheter engagement is insufficient.

From a mechanical standpoint, deep coronary intubation with a GEC stabilizes the system and minimizes guide catheter disengagement during burr advancement. This is particularly relevant when advancing small burrs through long, calcified segments or when repeated attempts at burr delivery result in guide instability. By improving alignment and support, the GEC may reduce excessive forward force and abrupt burr movements, potentially enhancing procedural control [15, 16].

### 2.2 | Distal Location of Disease

Often, the calcific disease is located distally (Figure 1), and the delivery of a burr through a tortuous angulated but otherwise disease-free proximal vessel may result in unnecessary trauma and disruption to the proximal vessel, necessitating unnecessary treatment of proximal vessel segments. Careful delivery of a guide extension to the distal vessel may then allow safe delivery of the burr avoiding unnecessary interaction and disruption of an otherwise disease-free proximal vessel [17, 18]. This rationale is particularly relevant because, unlike balloon or stent delivery where the device traverses the vessel passively, the rotating burr actively ablates tissue during advancement. Critically, the principle of differential cutting, whereby the burr preferentially ablates hard, inelastic calcified plaque while deflecting off compliant healthy tissue, depends on coaxial alignment between the burr and the vessel lumen. When extreme tortuosity or angulation disrupts this coaxial orientation, the differential cutting mechanism is compromised, and the burr may ablate



**FIGURE 1** | Rotational atherectomy of a severely calcified and highly tortuous right coronary artery facilitated by a GEC. Baseline angiography (PRE) demonstrates extreme calcification and marked tortuosity of the right coronary artery, limiting device deliverability. Rotational atherectomy was performed using a 7-F AR2 guiding catheter in combination with a 7-F GEC to improve support and coaxial alignment. A 1.5-mm rotaburr was advanced to achieve effective plaque modification. Final angiography (POST) shows a satisfactory angiographic result with preserved flow. This case illustrates the critical role of GECs in enabling rotational atherectomy in severely tortuous coronary anatomy.

healthy arterial wall indiscriminately, significantly increasing the risk of dissection, perforation, and procedural complications. In tortuous or angulated proximal segments, unprotected burr passage may cause intimal disruption, dissection, or perforation of otherwise healthy vessel walls, potentially converting a focal distal intervention into an extensive proximal-to-distal procedure.

### 2.3 | Protection of Proximal Devices/Structures

There are certain situations where the burr needs to be protected from more proximal devices or structures. This is particularly the case when the disease is located distal to preexisting patent stents, where there is a transcatheter aortic valve replacement with cells crossing the coronary ostia or where there is a coronary side-branch protection wire proximal to atherectomy site. A carefully sized and delivered guide extension is a useful tool in these scenarios to protect interaction and disruption of these devices [16, 19].

Importantly, the use of GECs during RA should not be viewed as a means for aggressive ablation. Rather, its primary role is to enable burr delivery in anatomically hostile settings while preserving a conservative atherectomy philosophy focused on plaque modification rather than debulking. When applied judiciously, this approach may allow completion of revascularization without escalation to additional plaque modification devices or alternative access routes. Despite these potential advantages, the combined use of RA and GECs introduces specific technical constraints, including device compatibility, risk of catheter damage, burr entrapment, and vessel injury. A clear understanding of these limitations is essential before considering this strategy in clinical practice.

## 3 | Clinical Scenarios Where GEC-Protected RA May Be Useful

While the preceding section outlined the general indications for combining GECs with RA, this section describes specific anatomical and procedural scenarios encountered in clinical practice where this strategy has been applied. The use of GECs during RA should be reserved for carefully selected clinical scenarios in which conventional burr delivery is limited by anatomical or technical constraints (Table 1).

This strategy is not intended for routine use but may represent a valuable adjunct in highly complex interventions when standard support techniques fail. A decision algorithm summarizing indications and procedural workflow for GEC use during RA is provided in Figure 2.

One of the most frequent indications involves severely calcified lesions located distal to tortuous or angulated proximal vessel segments. In such anatomies, loss of guide support and suboptimal coaxial alignment may prevent advancement of even small burr sizes despite appropriate wire positioning. In these cases, deep intubation with a GEC can enhance system stability, improve force transmission, and facilitate controlled burr delivery to the target segment [15–17].

Lesions arising from challenging coronary origins, including anomalous vessels or sharply angulated takeoffs, represent another relevant scenario. Adequate guide engagement in these anatomies is often difficult to achieve without compromising stability. GECs may compensate for suboptimal guide seating by providing localized intracoronary support, enabling safe advancement of the atherectomy system [16, 17].

Distal target lesions in large epicardial vessels may also benefit from this approach. When extensive proximal calcification limits device deliverability, the GEC serves as a stabilizing platform that effectively shortens the working length of the system and improves torque transmission during burr advancement.

In highly tortuous coronary anatomy, particularly when RA is considered technically challenging or carries an increased risk of burr entrapment, the presence of a GEC already mounted within the system may provide an additional procedural safety advantage. In such situations, a preloaded GEC may serve not only as a support tool for burr delivery but also as a built-in entrapment safety net (Figure 2). When burr entrapment occurs during GEC-facilitated RA, the catheter is already in position and can be immediately advanced over the driveshaft to the entrapment site. Gentle traction on the driveshaft combined with counter-push from the GEC tip against the proximal aspect of the entrapped burr may disengage it, allowing percutaneous retrieval without surgical intervention [20–22]. This contrasts with scenarios where no GEC is preloaded: in those cases, retrieval requires partial system disassembly, including cutting the driveshaft, removing the plastic sheath, and loading a GEC onto the exposed driveshaft before advancing it to the burr [22]. The upfront presence of a GEC therefore eliminates these additional steps and provides immediate access for rescue maneuvers. Although burr entrapment remains an uncommon complication (0.5%–1%), awareness of this potential rescue role [5, 20–22] may further justify an upfront use of a GEC in selected high-risk anatomical scenarios.

**TABLE 1** | Clinical scenarios where GEC-facilitated RA may be useful.

| Clinical scenarios where guide extension–facilitated RA may be useful   |
|-------------------------------------------------------------------------|
| Severe proximal vessel tortuosity                                       |
| High-risk anatomy for burr entrapment (severe tortuosity or angulation) |
| Marked guide catheter instability                                       |
| Horizontal or ectatic ascending aorta                                   |
| Anomalous coronary origin                                               |
| Long calcified segments requiring distal burr delivery                  |
| Bypass graft PCI (SVG or LIMA)                                          |

Finally, GEC-facilitated RA may be considered as a bailout strategy in cases of burr advancement failure after appropriate lesion wiring and preparation. In such situations, this approach allows escalation of support without additional vascular access, guide catheter upsizing, or immediate conversion to alternative plaque modification devices [9, 23].

Importantly, the presence of favorable anatomy alone does not mandate the use of a GEC. This technique should be considered only after careful assessment of lesion morphology, vessel size, procedural risk, and patient tolerance and should be performed exclusively by operators experienced in both RA and GEC

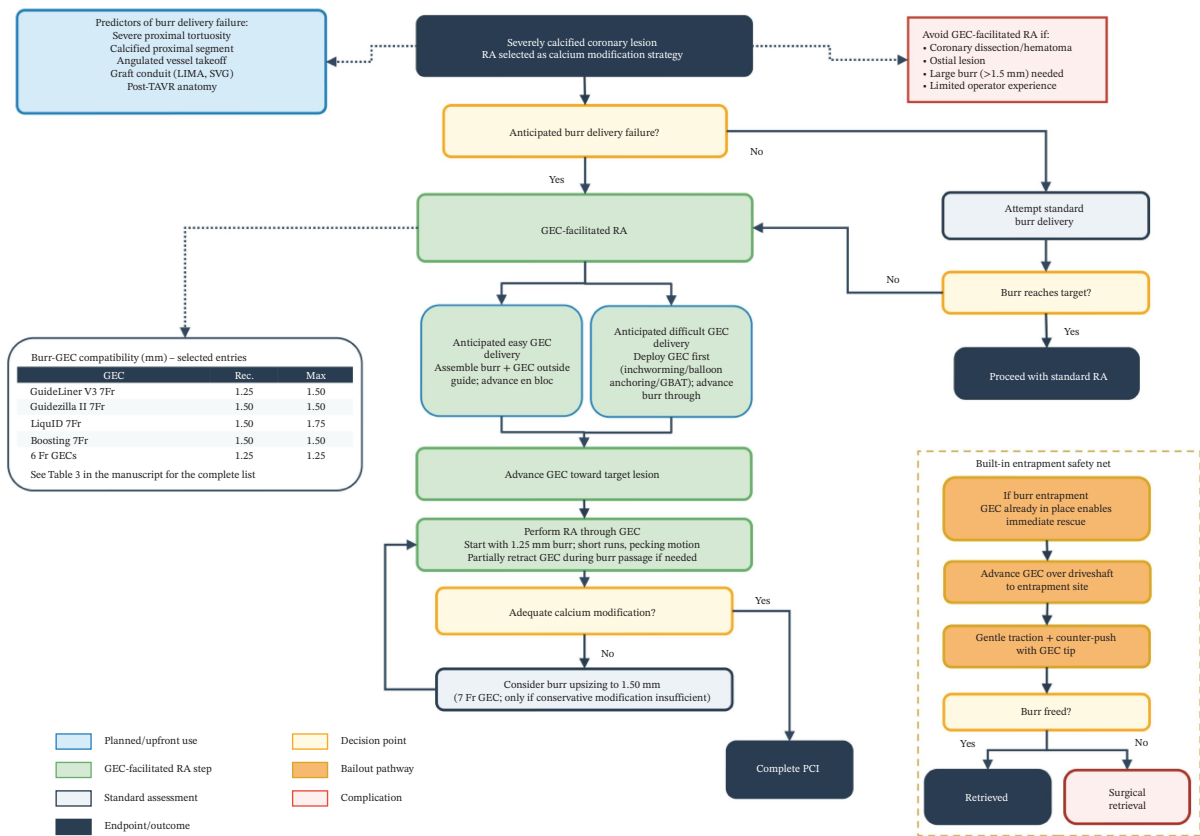
handling. Table 2 compiles published case reports illustrating the use of RA conducted through, or facilitated by, GECs.

4 | Representative Clinical Applications

4.1 | RA Burr Delivery to a Distal Lesion While Protecting Proximal Coronary Anatomy

The anatomical location of calcific plaque varies considerably among patients, and severe proximal vessel tortuosity in the presence of a distal heavily calcified lesion may adversely affect device deliverability and procedural safety. Although deep intubation of the guiding catheter may facilitate distal advancement of the RA burr [16, 17, 23], this strategy is frequently associated with increased procedural risk and limited stability. In most cases, the use of a mother-in-child GEC represents a low-risk and more controlled alternative to overcome proximal tortuosity and improve guide catheter support.

Beyond complex proximal anatomy, additional scenarios in which protection of the proximal vessel is desirable include the presence of acute proximal vessel dissection or previously implanted stents, particularly recently deployed stents with an increased risk of burr entrapment or significant vessel injury. In these settings, the GEC may act as a protective conduit, shielding the proximal segment from direct interaction with the rotating burr while enabling controlled atherectomy of the distal lesion (Figure 3).



**FIGURE 2** | Decision algorithm for GEC use during rotational atherectomy. The algorithm addresses both planned/upfront GEC deployment (when burr delivery failure is anticipated based on anatomical predictors) and standard delivery with bailout GEC use when the burr fails to reach the target lesion. A separate pathway covers burr entrapment and driveshaft fracture management.

**TABLE 2** | Published reports of rotational atherectomy with GECs.

| Author                                 | Year | Journal                    | Study type  | Indication/context                                               | Outcome                                 | GCE used                                   | Burr (mm) |
|----------------------------------------|------|----------------------------|-------------|------------------------------------------------------------------|-----------------------------------------|--------------------------------------------|-----------|
| <i>Intentional/planned use</i>         |      |                            |             |                                                                  |                                         |                                            |           |
| Ogita et al.                           | 2018 | Case Rep Cardiol           | Case report | Anomalous RCA with angulated calcified lesion                    | Successful RA with mother-and-child     | Dio thrombus aspiration catheter (Goodman) | 1.5       |
| Pellicano et al.                       | 2018 | BMC Cardiovasc Disord      | Case report | Calcified SVG; sequential RA and Guidezilla delivery             | Successful RA and stenting via radial   | Guidezilla 6F (BSC)                        | 1.25, 1.5 |
| Kobayashi et al.                       | 2020 | SAGE Open Med Case Rep     | Case report | In-stent calcified RCA; RA + OA through 7-Fr GEC                 | Successful RA and OA with GEC support   | GCE 7F (unspecified)                       | 1.5       |
| Pawlowski et al.                       | 2020 | Adv Interv Cardiol         | Case report | Distal RCA calcification; GEC-facilitated RA                     | Successful RA and stenting              | GuideLiner 7F (Teleflex)                   | 1.25      |
| Illescas et al.                        | 2020 | Eur Heart J Case Rep       | Case report | RA through RIMA graft post-TAVI with Guidezilla                  | Successful RA through native graft      | Guidezilla (BSC)                           | 1.25      |
| Kato et al.                            | 2021 | BMC Cardiovasc Disord      | Case report | Calcified tortuous LAD; GEC to prevent proximal overcutting      | Successful RA with proximal protection  | Guidezilla II 7F (BSC)                     | 1.5       |
| Derbas et al.                          | 2021 | JACC Cardiovasc Interv     | Case report | RA through LIMA graft using GEC                                  | Successful RA and stenting              | Guidezilla II 7F (BSC)                     | 1.5       |
| Pawlowski et al.                       | 2021 | Adv Interv Cardiol         | Bench study | Compatibility testing of 4 GECs (6Fr/7Fr) with 1.25/1.5-mm burrs | 7-Fr GECs reliably accommodate RA burrs | GL/Guidon/GZ/Telescope 6F + 7F             | 1.25, 1.5 |
| <i>Bailout/complication management</i> |      |                            |             |                                                                  |                                         |                                            |           |
| Cunnington and Eged                    | 2012 | Catheter Cardiovasc Interv | Case report | Burr entrapment retrieval using GuideLiner                       | Successful percutaneous retrieval       | GuideLiner 7F (Teleflex)                   | 1.25      |
| Sakakura et al.                        | 2017 | JACC Cardiovasc Interv     | Case report | Entrapped burr retrieval using soft GEC                          | Successful percutaneous retrieval       | Guideplus (Nipro)                          | 1.25      |
| Wainstein et al.                       | 2021 | PCRonline                  | Case report | Burr entrapment retrieval using GEC in 4 steps                   | Successful stepwise retrieval           | GCE (unspecified)                          | N/R       |
| Toba et al.                            | 2023 | Cardiovasc Interv Ther     | Case report | Entrapped burr retrieval using GEC and Rotawire spring-tip       | Successful percutaneous retrieval       | GCE (unspecified)                          | 1.75      |
| Nguyen et al.                          | 2024 | Cureus                     | Case report | Burr entrapment; ping-pong and mother-in-child retrieval         | Successful retrieval                    | Heartrail ST01 5F (Terumo)*                | 1.25      |
| Kobayashi et al.                       | 2024 | Case Rep Cardiol           | Case report | Driveshaft fracture; child-in-mother GEC retrieval               | Successful nonsurgical retrieval        | Guideplus (Nipro)                          | 1.5       |

Abbreviations: GEC, guide extension catheter; N/R, not reported.

\*Heartrail ST01 (Terumo) is a classic over-the-wire mother-and-child catheter, not a modern rapid-exchange guide extension catheter.

## 4.2 | RA Burr Delivery While Protecting Transcatheter Aortic Valve Struts

With the expansion of transcatheter aortic valve replacement indications from exclusively high-risk patients to those at moderate and low surgical risk and with a progressive reduction in the age threshold for treatment, an increasing number of patients with calcified coronary artery disease present for coronary intervention following TAVR implantation. Coronary intervention after implantation of most balloon-expandable TAVR prostheses is generally feasible without major modifications in guiding catheter engagement or procedural technique.

In contrast, some self-expanding valve platforms significantly alter access to the coronary ostia, often requiring alternative guide catheter selection and advanced support strategies. In this context, GECs are frequently recommended to facilitate safe device delivery through or between valve struts into the coronary artery. When heavily calcified coronary lesions coexist, RA may be indicated. Because the atherectomy burr carries a risk of entrapment on TAVR struts, the use of a GEC can secure the transition point [19] between the guiding system and the coronary artery, improving procedural safety and control (Figure 4).

## 4.3 | RA Burr Delivery While Protecting a Side Branch Workhorse Wire

Bifurcation disease requiring treatment of both branches does not preclude the presence of severe coronary calcification. In scenarios where RA cannot be avoided, the operator faces limited options. Treating the limb requiring calcium modification first over a single wire increases the risk of side branch compromise due to plaque shift or dissection, potentially resulting in loss of access to the secondary vessel.

There are, however, situations in which calcium modification must be performed in the main branch distal to an important bifurcation while maintaining wire access to the side branch, such as in the presence of a dissection flap or critical disease in the side branch. Anecdotally, protection of the side branch wire using a microcatheter placed via a ping-pong guide configuration has been described [22]. Alternatively, a GEC can be used for this purpose.

Using one guiding catheter disengaged from the coronary ostium, a workhorse wire may be left in the side branch, while a second guiding catheter equipped with a Rotawire and GEC is advanced deeply up to or beyond the bifurcation. This configuration allows protection of the side branch wire from direct interaction with the rotating burr during atherectomy of the main branch (Figure 5(C,D)).

## 5 | Technical Considerations and Procedural Principles

When RA is performed through a GEC, meticulous attention to technical details is essential to minimize procedural risk and ensure predictable system behavior. This strategy imposes constraints that differ from conventional atherectomy and should therefore be approached with a conservative, deliberate, and safety-oriented mindset.

## 5.1 | Burr Size Selection and Atherectomy Philosophy

Contemporary RA has evolved from an aggressive debulking strategy to a plaque modification approach aimed at facilitating balloon dilatation and optimal stent expansion, an evolution that is particularly relevant when atherectomy is performed through GECs [3, 25].

Small burr sizes are strongly preferred in this setting. Burrs ranging from 1.25 to 1.5 mm are generally sufficient to achieve effective plaque modification while maintaining acceptable deliverability and safety margins. Larger burrs increase friction within the GEC, reduce maneuverability, and may amplify the risk of catheter damage or burr entrapment [3, 20].

The procedural objective should remain plaque modification rather than aggressive debulking. Short ablation runs, gentle pecking motion, and strict avoidance of excessive rotational decelerations are critical. The use of a GEC does not justify deviation from contemporary low-intensity atherectomy principles [3].

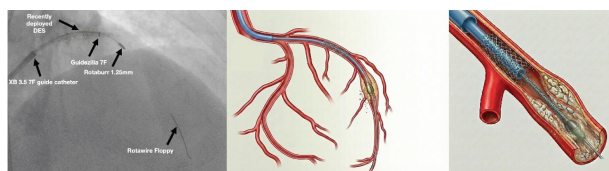
## 5.2 | GEC Compatibility and Positioning

GECs represent the modern evolution of the classical mother-and-child technique, in which a smaller catheter was advanced coaxially through a larger guiding catheter to achieve deep coronary intubation. Contemporary rapid-exchange GECs offer several practical advantages over the original 5-in-6 French approach, including monorail design, lower crossing profile, improved trackability, and dedicated compatibility with interventional platforms. Nevertheless, the classical mother-and-child technique may remain a viable alternative when modern GECs are unavailable.

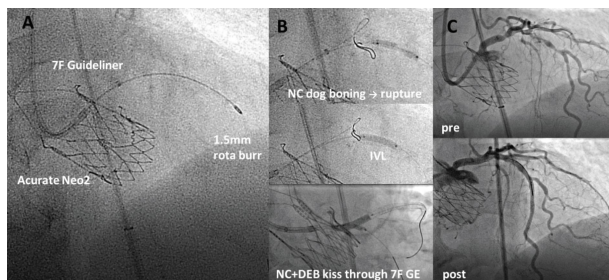
Device compatibility is a key determinant of procedural feasibility. Inner lumen diameter, transition zone geometry, and shaft rigidity must be carefully evaluated before attempting RA through a GEC (Table 3). In general, 7-French GECs provide adequate clearance for RA burrs, whereas most 6-French devices do not accommodate even the smallest 1.25-mm burr with a safe margin. When compatibility data are unavailable or a new device combination is being used for the first time, an *ex vivo* bench test—advancing the burr through the guide extension collar outside the patient—is a simple and recommended approach to verify unobstructed passage before intravascular deployment (Figure 6).

The GEC should be advanced gradually and positioned proximal to the target lesion. Adjunctive maneuvers such as balloon anchoring, the inchworm technique, or initial optimization of guide catheter support may be required to facilitate safe delivery to the target segment [27]. Excessively deep intubation increases the risk of vessel trauma, ischemia, and catheter deformation; the goal is to achieve sufficient coaxial alignment and backup support without compromising coronary flow or vessel integrity.

Alternative strategies for enhanced coaxial support during RA have been described without the use of dedicated GECs. Latsios et al. reported extra-deep intubation of a 6-French Judkins Right guiding catheter into the right coronary artery to facilitate burr advancement through an angulated calcified segment. Although this approach achieves the same objective of enhanced coaxial



**FIGURE 3** | Proximal drug-eluting stent protection during rotational atherectomy. Rotational atherectomy performed with a 1.25-mm burr advanced through a guide catheter extension using the mother-and-child technique. The guide extension catheter (Guidezilla II 7F, Boston Scientific) is deeply intubated to shield a recently implanted proximal drug-eluting stent, allowing safe plaque modification of the distal calcified segment while minimizing the risk of burr–stent interaction.



**FIGURE 4** | Increased support and TAVR strut protection. (A) Rotational atherectomy of LM and LAD with 1.5-mm burr performed through 7-F EBU 3.0 and 7-F GuideLiner V3 (Teleflex) while protecting TAVR struts and improving support for device delivery. (B) Despite upfront rotational atherectomy, NC balloon did not expand sufficiently and ruptured. GEC-facilitated intravascular lithotripsy (Shockwave, US) [24] delivery and inflation led to full expansion and sequential stenting of LAD and provisional LM stenting (DEB to CX and Kiss DEB balloon in CX and final POT). (C) Top—preprocedural anatomy; bottom—postprocedural result.

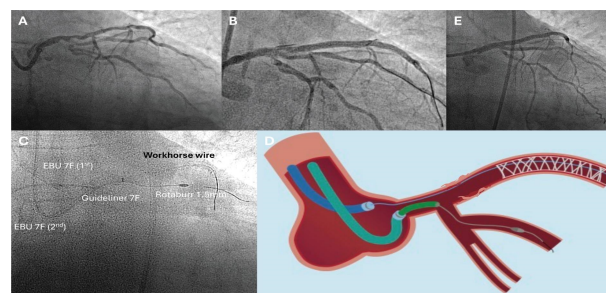
support, it carries a distinct risk of vessel trauma from deep intubation and should be weighed against the more standardized profile of contemporary GECs.

### 5.3 | Practical Workflow for En Bloc GEC–Burr Assembly

A practical and reproducible workflow for en bloc GEC–burr assembly, corresponding to the anticipated easy delivery pathway in the decision algorithm (Figure 2), includes four sequential steps (Figure 7): first, the Rotawire is positioned distally past the target lesion under fluoroscopic guidance. Second, the GEC is threaded onto the burr shaft outside the guiding catheter. Third, the Rotawire is passed through the burr lumen and advancer while the GEC remains mounted on the shaft. Fourth, the entire assembled system is advanced en bloc over the Rotawire, through the hemostatic Y-connector and guiding catheter, until the GEC reaches a position proximal to the lesion. This sequence minimizes interaction at the transition zone, facilitates controlled delivery, and enhances procedural safety.

### 5.4 | Burr Advancement and System Control

Advancement of the burr within or adjacent to a GEC requires precise system control. In contemporary practice, reliance on automated low-speed advancement modes such as Dynaglide for



**FIGURE 5** | Workhorse wire protection of a major side branch using ping-pong technique with GEC. Workhorse wire protection of a major side branch using the ping-pong guiding catheter technique with a GEC. A complex case involving tortuous, heavily calcified OM1 and OM2 disease required sequential rotablation with a 1.25-mm burr, followed by further calcium modification with noncompliant balloons, IVL, and OPN. (A) Baseline angiography demonstrating severe calcification of the left circumflex and obtuse marginal branches. (B) During attempted stent delivery to OM1, the stent was lost due to distal napkin-ring calcification. After successful stent retrieval, the ostial LAD was dissected causing LAD ischemia; urgent LAD rotational atherectomy with a 1.5-mm burr was performed and the vessel stented, restoring TIMI 3 flow (not shown). (C) Fluoroscopic detail of the ping-pong technique: the first EBU 7-F guiding catheter (1st) maintains a workhorse wire in the dissected ostial LAD, while the second EBU 7-F guiding catheter (2nd) containing a 7-F GEC (GuideLiner) with a 1.5-mm rotaburr on a RotaFloppy wire is advanced into the distal OM1. The GEC successfully shields the LAD workhorse wire from direct contact with the rotating burr. (D) Schematic illustration of the mechanism: the GEC creates a protective conduit that isolates the rotaburr from the side branch workhorse wire at the bifurcation level, preventing wire damage and maintaining side branch access. (E) Final angiographic result after completion of OM1 rotablation, stenting, and DK Crush of the left main bifurcation.

burr progression within the GEC is inconsistent and should not be considered routine. Many operators favor controlled manual advancement with the burr stopped, followed by conventional atherectomy runs once the burr is positioned distal to the extension catheter tip.

Continuous fluoroscopic monitoring is essential during this phase. Any resistance, unexpected motion, or loss of tactile feedback during burr advancement should prompt immediate reassessment rather than forceful progression. Mechanical interaction between the Rotawire and the GEC shaft, including wire–catheter twisting, may significantly increase friction and impede burr advancement [9, 23] (Figure 8).

As illustrated in Figure 8, torsional coupling between the Rotawire and the shaft of the GEC may result in wire wrapping, increased friction, and loss of coaxial alignment. This phenomenon frequently manifests as resistance at the collar of the GEC, impairing burr advancement despite adequate lumen size compatibility.

In such situations, gentle controlled rotation of the GEC hub under fluoroscopic guidance may help unwind the wire–shaft interaction, restore coaxial alignment, and facilitate smooth burr advancement. This maneuver should be performed cautiously, avoiding excessive torque, and only in the absence of resistance suggestive of burr entrapment or catheter deformation.

**TABLE 3** | List of guide catheter extensions with published internal diameters and recommended as well as largest possible rotational atherectomy burr sizes.

| Guide catheter extension          | Size (Fr) | OD (mm) | ID (mm) | Maximum recommended burr size (mm) | Maximum possible burr size (mm) |
|-----------------------------------|-----------|---------|---------|------------------------------------|---------------------------------|
| Boosting (QXMedical)              | 5.5       | 1.63    | 1.32    | 1.25                               | 1.25                            |
|                                   | 6         | 1.73    | 1.45    | 1.25                               | 1.25                            |
|                                   | 7         | 1.91    | 1.60    | 1.50                               | 1.50                            |
|                                   | 8         | 2.18    | 1.82    | 1.50                               | 1.75                            |
| GuideLiner V3 (Teleflex)          | 5.5       | 1.64    | 1.30    | NA <sup>†</sup>                    | 1.25 <sup>‡</sup>               |
|                                   | 6.0       | 1.70    | 1.42    | 1.25                               | 1.25                            |
|                                   | 7.0       | 1.90    | 1.57    | 1.25                               | 1.50                            |
|                                   | 8.0       | 2.13    | 1.80    | 1.50                               | 1.75                            |
| Guideplus (Nipro)                 | 6         | 1.76    | 1.33    | NA <sup>†</sup>                    | 1.25 <sup>‡</sup>               |
| Guidezilla II (Boston Scientific) | 6         | 1.70    | 1.45    | 1.25                               | 1.25                            |
|                                   | 7         | 1.85    | 1.60    | 1.50                               | 1.50                            |
|                                   | 8         | 2.11    | 1.83    | 1.50                               | 1.75                            |
| Guidion Hydro (IMDS)              | 6         | 1.70    | 1.42    | 1.25                               | 1.25                            |
|                                   | 7         | 1.90    | 1.57    | 1.25                               | 1.50                            |
|                                   | 8         | 2.13    | 1.80    | 1.50                               | 1.75                            |
| Hikyaku (Kaneka)                  | 6         | 1.75    | 1.48    | 1.25                               | 1.25                            |
| LiquID (Seigla Medical)           | 6F LP     | 1.73*   | 1.29    | NA                                 | NA                              |
|                                   | 6         | 1.73    | 1.55    | 1.25                               | 1.50                            |
|                                   | 7         | 1.88    | 1.80    | 1.50                               | 1.75                            |
| Telescope (Medtronic)             | 6         | 1.71    | 1.42    | 1.25 <sup>‡</sup>                  | 1.25 <sup>‡</sup>               |
|                                   | 7         | 1.90    | 1.57    | 1.25                               | 1.50                            |
| Expressman (APT Medical)          | 4         | 1.42    | 1.27    | 1.25                               | 1.25                            |
|                                   | 5         | 1.70    | 1.47    | 1.25                               | 1.25                            |
|                                   | 6         | 1.98    | 1.68    | 1.5                                | 1.50                            |

Note: Adapted and extended from Kato et al. [18] and Kovacic [26]. "Recommendation" is at least 0.1 mm smaller burr than the ID of the GEC catheter.

\*Proximal outer diameter; distal segment outer diameter is 1.47 mm.

<sup>†</sup>Nominal internal diameter does not meet the 0.1-mm clearance margin relative to the 1.25-mm burr; not recommended for rotational atherectomy.

<sup>‡</sup>Despite adequate nominal internal diameter, bench testing by Pawłowski et al. [19] demonstrated inability to advance a 1.25-mm burr through the Telescope 6F.

Alternatively, complete withdrawal of the entire system followed by stepwise reassembly and reintroduction of the Rotawire, subsequent advancement of the GEC, and final burr delivery over a properly aligned system represents a safe and reproducible corrective strategy.

A recently proposed best-practice technique recommends that, during insertion of the GCE, forceps be attached to the proximal plastic end of the hypotube and secured in a stable position (e.g., beneath a damp cloth). This approach is intended to prevent

unintended rotation of the GCE around the coronary guidewire and the consequent intertwining of the gear.

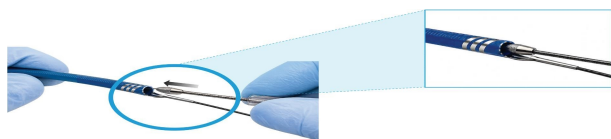
## 5.5 | Transition From Atherectomy to Device Delivery

After completion of atherectomy, the GEC may continue to serve as a delivery platform for balloons and stents. However, careful reassessment of catheter position is mandatory. Partial or complete withdrawal of the GEC prior to balloon dilation or stent delivery may be necessary to reduce friction, avoid device deformation, and minimize the risk of distal embolization or vessel injury.

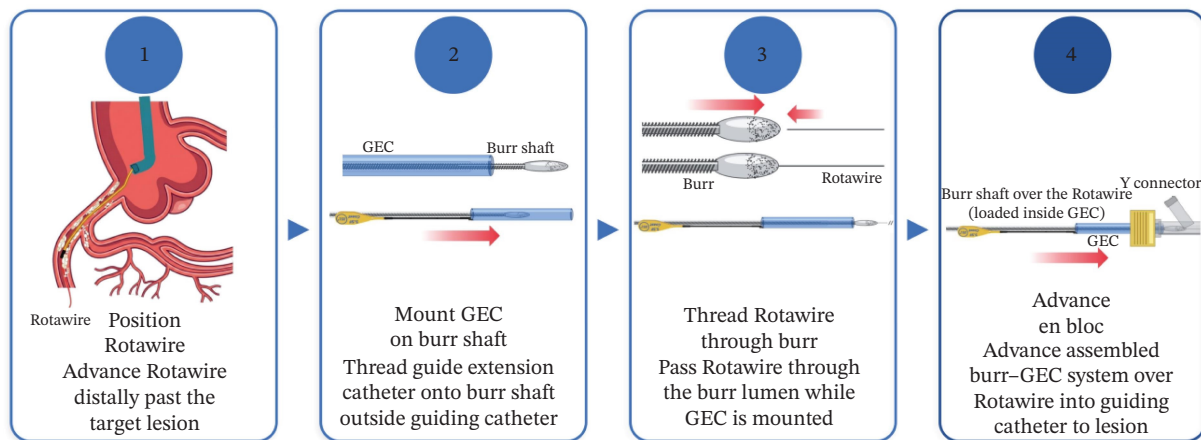
Throughout the procedure, the operator should maintain a low threshold to abandon the GEC strategy if resistance increases or complications arise. Flexibility, early de-escalation, and willingness to reset the system are hallmarks of safe application of this technique.

## 6 | Potential Risks and Limitations

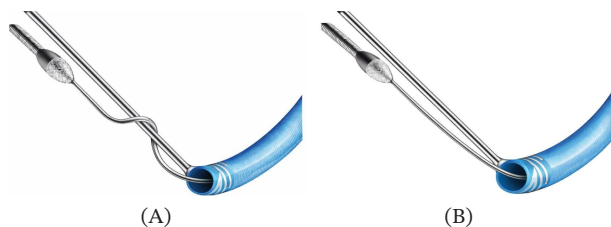
The combination of RA and GECs introduces specific risks that extend beyond those associated with either technique alone. Awareness of these limitations is essential to prevent complications and to guide appropriate case selection.



**FIGURE 6** | Ex vivo compatibility test. A 1.25-mm rotational atherectomy burr is advanced through the collar of a 7-French Guidezilla II GEC (Boston Scientific) to verify unobstructed passage before intravascular use. This bench test is recommended whenever the operator is unfamiliar with a specific burr–catheter combination or when new devices are being used for the first time. Magnified view (inset) shows the burr traversing the guide extension collar.



**FIGURE 7** | Practical workflow for en bloc GEC–burr assembly during rotational atherectomy. Step-by-step illustration of the en bloc assembly technique. (1) The Rotawire is advanced distally past the target lesion. (2) The GEC is threaded onto the burr shaft outside the guiding catheter. (3) The Rotawire is passed through the burr lumen and advancer while the GEC remains mounted. (4) The entire assembly is advanced en bloc through the hemostatic Y-connector and guiding catheter to the target lesion. This en bloc assembly minimizes interaction at the transition zone, facilitates controlled delivery, and enhances procedural safety.



**FIGURE 8** | Interaction between the Rotawire and the GEC shaft. This figure illustrates a major technical challenge of rotational atherectomy performed through a GEC, namely, the interaction between the Rotawire and the shaft of the extension catheter. (A) Unfavorable configuration in which torsional coupling causes the Rotawire to wrap around the GEC shaft, resulting in increased friction, loss of coaxial alignment, and mechanical interference at the catheter collar, thereby impeding burr advancement. (B) Favorable configuration after correction of the wire–shaft interaction, with resolution of the twist and restoration of coaxial alignment. In this configuration, smooth burr advancement is achieved. Correction may be accomplished either by gentle controlled rotation of the GEC hub under fluoroscopic guidance to unwind the wire–shaft interface or by complete system withdrawal and stepwise reassembly, with reintroduction of the Rotawire, subsequent advancement of the GEC, and final burr delivery over a properly aligned system.

Mechanical interaction between the rotating burr and the GEC represents a primary concern. Friction within the catheter lumen may impair burr control, increase resistance during advancement or retrieval, and predispose to burr entrapment. This risk is amplified when larger burr sizes are used, when catheter alignment is suboptimal, or when excessive forward force is applied [9, 20, 21, 23].

GEC deformation or structural damage has been reported, particularly at the transition zone between the hypotube and the distal polymer segment [28]. This complication may result from repeated device passage, forceful manipulation, or attempts to

advance the burr across this junction in the presence of resistance or suboptimal coaxial alignment. Assembly of the burr and GEC outside the guiding catheter, followed by *en bloc* advancement, minimizes mechanical stress at the transition zone and should be favored over forceful burr progression within the GEC lumen, thereby preserving catheter integrity and procedural safety.

Coronary ischemia related to deep intubation constitutes another important limitation. Prolonged or excessive advancement of the GEC may transiently obstruct antegrade coronary flow [15], particularly in vessels supplying large myocardial territories or in the presence of limited collateral circulation. This risk is further amplified during RA runs, when distal perfusion is already compromised. Accordingly, intubation depth and duration should be carefully limited, and whenever feasible, the GEC should be partially retracted into the guiding catheter during active burr passage. This approach may reduce ischemic burden and mitigate the risk of slow-flow or no-reflow phenomena, underscoring the importance of continuous clinical and electrocardiographic monitoring throughout the procedure.

Vessel injury remains a relevant concern, especially in fragile conduits such as bypass grafts or in vessels with severe tortuosity. Although GECs may improve coaxiality, their advancement itself can provoke dissection or spasm if not carefully controlled. This is particularly pertinent during RA, where vessel compliance is already reduced by heavy calcification.

Finally, the technique requires a high level of operator experience and tactile sensitivity. Subtle changes in resistance or system behavior may precede serious complications. Operators unfamiliar with the nuances of GEC manipulation or RA dynamics may be at increased risk of adverse events when combining these tools.

Taken together, these limitations reinforce the concept that RA through GECs should be reserved for carefully selected cases and performed only by experienced operators in centers equipped to manage potential complications.

## 7 | Technique Description: Practical Considerations, Tips, and Pitfalls

RA performed through a GEC presents specific challenges that differ from conventional atherectomy techniques and require careful procedural planning.

### 7.1 | GEC Inner Diameter and Burr Compatibility

The internal diameter of GECs is inherently smaller than that of standard guiding catheters. An overview of the internal diameters of commonly used GECs is provided in Table 3. As a practical rule of thumb, the burr diameter should be approximately 0.1 mm smaller than the internal diameter of the GEC in use. This principle allows the combination of most 6-Fr GECs with a 1.25-mm burr.

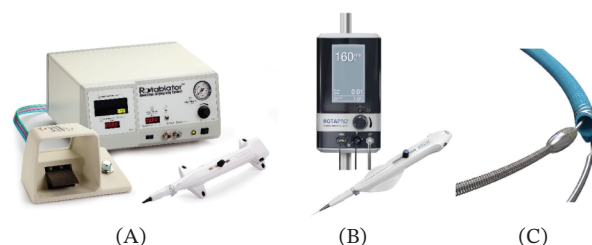
However, published data on the routine use of RA through 6-Fr GECs remain limited. Bench testing by Pawlowski et al. evaluated four commonly used GECs and demonstrated that safe advancement of a 1.25-mm burr on Dynaglide was only consistently achievable with the Guidion catheter, despite its nominally smaller listed internal diameter. In contrast, when 7-Fr GECs were tested, both 1.25-mm and 1.5-mm burrs were advanced without difficulty across all evaluated devices. It should be noted that these bench data primarily reflect burr advancement performed entirely within the GEC lumen. In clinical practice, alternative 6-Fr GECs may still be safely used with a 1.25-mm burr when the burr–GEC assembly is performed outside the guiding catheter, followed by en bloc advancement of the system. This strategy minimizes friction at the transition zone and underscores the importance of system assembly technique in addition to nominal internal diameter specifications.

This apparent discrepancy between nominal internal diameter and successful burr advancement likely reflects the contribution of the plastic Rotablator shaft sleeve, which measures approximately 1.45–1.5 mm in diameter and increases mechanical interaction between the burr system and the GEC. Consequently, with current technology, the use of RA through GECs smaller than 7 Fr is likely to remain a niche strategy best avoided in routine practice.

Conversely, 7-Fr GECs reliably accommodate 1.25-mm burrs. For 1.5-mm burrs, devices such as Guidezilla II, Boosting, or LiquiD may offer improved compatibility due to their larger internal diameters, although prior bench testing and anecdotal experience also support the use of 1.5-mm burrs through other 7-Fr GECs, including GuideLiner V3 (Table 3). GECs incorporating trapping balloons are not recommended for use during RA.

### 7.2 | RA System Generation: Practical Implications

Important technical differences exist between the legacy Rotablator system and the newer RotaPro system (Boston Scientific), as illustrated in Figure 9(A,B) [4]. In our experience, the legacy Rotablator system permits advancement of the burr within the guiding catheter alongside the GEC shaft, with or without Dynaglide activation. In contrast, the RotaPro system does not allow burr advancement on Dynaglide within the catheter when a GEC shaft is present. Manual advancement without Dynaglide is usually successful.



**FIGURE 9** | (A) Legacy Rotablator™ rotational atherectomy system. (B) RotaPro™ rotational atherectomy system (image provided courtesy of Boston Scientific. ©2023 Boston Scientific Corporation or its affiliates. All rights reserved). (C) Illustration of a 1.25-mm rotational atherectomy burr entering the proximal collar (transition segment) of a 7-Fr GEC.

This behavior may be related to the electronic feedback system of the RotaPro platform, which appears to detect the metallic GEC shaft adjacent to the burr and may trigger premature burr stall within the guiding catheter. As device software and hardware continue to evolve, operators are advised to remain aware of system-specific behavior and to seek updated manufacturer guidance when uncertainty arises.

Occasionally, resistance may be encountered when the burr reaches the transition zone between the metallic hypotube and the proximal polymer segment (“collar”) of the GEC (Figure 9(C)). Although brief Dynaglide activation has been proposed to facilitate passage at this junction, its use within the guide extension lumen should be discouraged. Dynaglide activation in this setting may increase uncontrolled mechanical interaction between the rotating burr system and the catheter wall, thereby predisposing to inner lumen damage or structural deformation. A safer and more controlled strategy is to assemble the burr and GEC outside the guiding catheter and advance the system en bloc, which minimizes mechanical stress at the transition zone and avoids forced advancement within the GEC.

## 8 | When This Strategy Should Be Avoided

Clear recognition of scenarios in which RA through a GEC should be avoided is essential to ensure procedural safety and appropriate technique selection. Severe calcification alone does not justify this approach, and indiscriminate use may expose patients to unnecessary procedural risk.

This strategy should be avoided in lesions associated with angiographic evidence of coronary dissection, intramural hematoma, or significant vessel injury. In such settings, advancement of a GEC may propagate the dissection plane or compromise distal flow, while RA may further exacerbate vessel trauma.

The presence of previously implanted stents warrants particular caution but should not be considered an absolute contraindication. Performing RA through a GEC within or immediately adjacent to a recently implanted stent carries a risk of stent deformation, strut interaction, or device entrapment and should generally be avoided. However, in selected scenarios, a GEC may be deliberately used to protect a proximal, newly implanted stent while enabling atherectomy of a severely calcified lesion located distal to the stent. In these cases, meticulous technique, conservative burr sizing, and continuous fluoroscopic monitoring

are mandatory, and the potential risks must be carefully weighed against anticipated procedural benefits.

Ostial lesions represent another unfavorable anatomical substrate. Deep intubation with a GEC at or near the coronary ostium may be mechanically unstable and may compromise burr control, increasing the risk of catheter-induced injury or incomplete plaque modification. Alternative support strategies or atherectomy modalities should be considered in this context.

This technique should also be avoided when adequate lesion modification requires large burr sizes. Escalation to larger burrs within a GEC is associated with increased friction, reduced rotational efficiency, and diminished system predictability, thereby increasing the risk of mechanical complications.

Finally, limited operator experience represents an important exclusion criterion. The combined use of RA and GECs requires familiarity with both devices and the ability to promptly recognize early warning signs of adverse interactions. In centers with limited atherectomy volume or operator experience, alternative plaque modification strategies may offer a safer and more reproducible approach.

Defining these boundaries is fundamental to preserving the role of this technique as a selective solution for highly complex cases rather than a routine procedural option.

## 9 | Limitations and Future Perspectives

As device technology and lesion preparation strategies continue to evolve, the role of RA in contemporary practice is being progressively refined. Advances in plaque modification modalities and balloon technologies have expanded the therapeutic options for heavily calcified lesions, including the introduction of IVL as an alternative calcium modification strategy [24]. Nevertheless, limitations related to device deliverability, vessel tortuosity, and complex anatomy persist, ensuring that RA remains relevant in carefully selected clinical scenarios.

The evidence supporting RA performed through GECs is primarily derived from case reports, small observational series, and cumulative expert experience. Robust comparative or randomized data are lacking, and this technique should therefore not be considered a routine strategy for the treatment of calcified coronary lesions. Rather, it represents an advanced procedural option reserved for specific anatomical challenges and for operators with substantial experience in complex coronary intervention.

This manuscript is intended as a narrative expert review and technical perspective based on published case reports, bench data, and cumulative procedural experience. As such, it does not provide outcome-based validation or comparative effectiveness analyses in relation to conventional atherectomy strategies. In addition, the use of GECs during RA remains off label, underscoring the importance of careful patient selection, meticulous attention to device compatibility, and strict adherence to established safety principles.

Future developments in GEC design may further improve the safety and predictability of this approach. Importantly, currently available RA systems and GECs were developed independently and were not originally engineered for combined use. As a result,

burr profile dimensions may approach the internal lumen limits of certain guide extension platforms, which can influence deliverability and device interaction. Future device development may focus on improving compatibility between atherectomy systems and GECs, including optimized burr profiles, modified nosecone geometries, or dedicated delivery platforms specifically designed for this technique.

Innovations such as optimized inner lumen geometry, refined transition zones, enhanced flexibility, and increased radiopacity may reduce friction, improve mechanical control, and mitigate risks associated with combined device use. Parallel advances in intravascular imaging are also likely to contribute to more precise lesion characterization and improved identification of cases in which RA through a GEC is likely to be beneficial or unnecessary, reinforcing a conservative, lesion-specific strategy.

Beyond catheter-related innovations, continued evolution of atherectomy systems themselves may further expand the applicability of rotational techniques in complex anatomies. One potential conceptual advance is the development of burr designs incorporating diamond coating on both the leading and trailing edges, enabling bidirectional plaque modification during forward advancement and controlled withdrawal. Such a configuration could theoretically improve plaque modification efficiency in tortuous or angulated segments, enhance burr control during retrieval, and reduce dependence on adjunctive support devices such as GECs in selected cases.

Given the technical and highly specialized nature of this approach, future evidence is likely to remain limited to case series, technical reports, and expert-driven analyses rather than randomized comparisons. In this context, transparent reporting of both procedural success and complications will be essential to inform safe clinical practice. International collaborative registries aggregating larger datasets from experienced centers would provide a more robust evidence base for this technique, enabling standardized reporting of procedural characteristics, device interactions, success rates, and complication patterns across diverse clinical settings and preventing inappropriate extrapolation of this technique beyond its intended scope.

In summary, within the context of contemporary complex PCI, GECs may serve as valuable adjunctive tools during RA when used with a clear understanding of their benefits and limitations. These devices are effective facilitators of burr delivery and system support. However, they should not be regarded as conduits for active ablation. GECs are support tools rather than ablation chambers. Adherence to this principle is essential to preserve procedural safety and to avoid inappropriate or hazardous application of this technique.

## 10 | Key Points

GECs address a specific procedural challenge during RA: burr deliverability in anatomically hostile coronary anatomies, including severe tortuosity, calcified proximal segments, angulated takeoffs, and graft conduits.

This technique should be considered either as a planned (upfront) strategy when anatomical predictors of burr delivery failure are identified or as a bailout approach when standard delivery attempts prove inadequate.

Device compatibility is critical: 7-Fr GECs reliably accommodate 1.25- and 1.50-mm burrs, whereas 6-Fr devices are limited to 1.25-mm burrs and should be used with caution.

GECs are support tools for burr delivery, not conduits for active ablation. Conservative atherectomy principles, including small burr sizes, short runs, and pecking motion, must be strictly maintained.

Operators should be aware that a prepositioned GEC may serve a dual role: facilitating burr delivery and providing a potential retrieval mechanism in case of burr entrapment.

## 11 | Conclusions

RA performed through GECs represents a highly selective technical strategy designed to overcome burr delivery failure in complex coronary anatomies. Its primary value lies in facilitating plaque modification in situations where conventional support is inadequate and alternative strategies are limited or undesirable.

This approach should not be regarded as routine nor as a substitute for contemporary plaque modification technologies [9]. When applied, it must adhere to conservative atherectomy principles, strict attention to device compatibility, and careful limitation of GEC advancement.

In experienced hands and appropriately selected cases, RA through GECs may enable procedural completion while avoiding escalation to more invasive or resource-intensive strategies. Defining clear indications, technical boundaries, and limitations is essential to preserving the safety and credibility of this approach within modern interventional practice.

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## Conflicts of Interest

The authors declare no conflicts of interest.

## Data Availability Statement

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

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