CORONARY ROTATIONAL ATHERECTOMY (ROTABLATION)

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I BIOPHYSICAL MECHANISM (DIAMOND-COATED DIFFERENTIAL CUTTING)

- **The Device System (Rotablator / RotaPro):** Consists of an olive-shaped, nickel-plated brass/stainless-steel **elliptical burr (sizes 1.25, 1.50, 1.75, 2.00, 2.15, and 2.25 mm)** coated on its **anterior (distal) half** with **2,000 to 3,000 microscopic diamond crystals** (20 microns in size, exposing 5 microns) driven by a helical drive shaft and compressed gas turbine over a specialized **0.009-inch stainless-steel RotaWire** (with a 0.014-inch radiopaque platinum spring tip).
- **Two Fundamental Physical Principles:**
  - **Differential Cutting:** Rotating at **140,000 to 160,000 RPM**, the diamond burr selectively pulverizes **hard, inelastic calcified or fibrotic plaque** while **compliant, elastic normal arterial wall tissue deflects safely away** from the spinning burr.
  - **Orthogonal Displacement of Friction:** At rotational speeds exceeding 60,000 RPM, longitudinal sliding friction between the catheter and guidewire/vessel wall is virtually eliminated, allowing smooth forward advancement through tortuous segments.
  - **Microparticle Clearance:** Ablated calcium is ground into **microparticles smaller than 5 micrometers** (smaller than erythrocytes, which are 7 to 8 micrometers), which pass harmlessly through the coronary capillary bed to be phagocytosed by the reticuloendothelial system (liver, spleen, and lungs).

II CLINICAL INDICATIONS

- **Balloon-Uncrossable or Microcatheter-Uncrossable Calcified Lesions (Primary Gold-Standard Indication):** Severely calcified pinhole stenoses or chronic total occlusions where the wire crosses into the distal true lumen, but no balloon (even a 1.0-mm balloon) or microcatheter can advance across the lesion.
- **Balloon-Undilatable Calcified Lesions:** Lesions where a balloon crosses but fails to expand (“dog-boning”) despite high-pressure inflation (>20 atm) or when OCT/IVUS shows a superficial calcium arc >270–360 degrees.
- **Calcified Aorto-Ostial Lesions (Ostial RCA or Ostial LM/LAD/LCx):** Prevents balloon slippage (**“watermelon-seeding”**) and reduces ostial elastic recoil.
- **Calcified Nodules:** Debulks eruptive, protruding calcified nodules that resist balloon expansion.

III COMPLICATIONS AND SPECIFIC PREVENTION PROTOCOLS

- **Slow-Flow and No-Reflow Phenomenon (2% to 5%):**
  - **Mechanism:** Excessive microparticle debris load, microcavitation bubbles, platelet aggregation, and microvascular vasospasm caused by oversized burrs, aggressive pushing, or **rotational speed decelerations exceeding 5,000 RPM** (which generate large >10–20 micron particles and frictional thermal injury).
  - **Prevention and Treatment:** Strictly follow the **"Modern Optimal Rotablation Technique"**—use a **conservative burr-to-artery ratio of 0.5 to 0.6** (a **1.5-mm burr** suffices for most vessels), a gentle **to-and-fro "pecking" motion**, short ablation runs (**<15 to 20 seconds**), rotational speed **140,000 to 160,000 RPM** (avoiding >180,000 RPM, which increases platelet activation), **zero decelerations >5,000 RPM**, and continuous pressurized **flush solution** (heparinized saline +/- nitroglycerin/verapamil); treat established no-reflow with intracoronary **Adenosine, Verapamil, or Sodium Nitroprusside**.
  - **Burr Entrapment ("Kokeshi Phenomenon" — <0.5% to 1%, Catastrophic Emergency):**
  - **Mechanism:** Because the **proximal (posterior) half of the burr is smooth and NOT diamond-coated**, the burr can only ablate **forward**. If the operator pushes the burr forcefully across an unablated tight calcified ring during a deceleration ("ledging"), the burr pops distal to the lesion and **cannot be pulled back**.
  - **Stepwise Percutaneous Bailout (Before Calling Surgery):** Never apply excessive traction that avulses the coronary artery! (1) Advance a **second guidewire** (via the same or a ping-pong second guide catheter) past the trapped burr and **inflate a small (1.5–2.0 mm) angioplasty balloon directly adjacent to the trapped burr** to crack the calcium collar and free the burr; (2) Deep-seat a **"mother-and-child" guide extension catheter (GuideLiner / Guidezilla)** right up to the burr tip for focused counter-traction; or (3) Cut off the proximal advancer handle near the sheath and advance a snare or diagnostic catheter over the exposed drive shaft to the burr.
  - **Guidewire Fracture / Transection:**
  - **Mechanism:** Grinding the burr repeatedly at a sharp angulation (>60 degrees) or keeping the spinning burr stationary at one spot wears through the 0.009-inch RotaWire, or accidentally leaving the burr on the **radiopaque 0.014-inch spring tip**.
  - **Coronary Perforation (1% to 2%):** Highest risk in severely eccentric, angulated (>60–90 degree) lesions (due to **"wire bias"** pushing the burr into the outer or inner curve) or when burr-to-artery ratio exceeds 0.7.
  - **Transient Bradycardia and High-Grade AV Block:** Common during rotablation of a **dominant Right Coronary Artery (RCA)** or **dominant Left Circumflex** due to micro-embolization/microcavitation into the AV nodal artery; prevented with intravenous **Atropine or Aminophylline** or temporary pacing (increasingly performed via **pacing over the coronary guidewire** rather than a femoral venous pacemaker).

Comparison Parameter	Rotational Atherectomy (Rotablator / RotaPro)	Orbital Atherectomy (Diamondback 360)	Intravascular Lithotripsy (IVL)
Ablation / Fracture Direction	**Forward ONLY** (distal half of burr is diamond-coated)	**Bi-directional** (both forward & backward)	Circumferential balloon at 4 atm
Sizing Mechanism	Fixed burr sizes (**1.25 to 2.25 mm**); target **burr/artery ratio 0.5–0.6**	Single **1.25 mm eccentric crown**; orbit expands with RPM (80k vs. 120k)	1:1 balloon sizing (**2.5 to 4.0 mm**)
Guidewire System	Dedicated **0.009" RotaWire** (Floppy or Extra-Support)	Dedicated **0.012"/0.014" ViperWire**	Any standard **0.014" workhorse wire** (+ allows SB wire)
Uncrossable Pinhole Lesions	**1st-Choice Gold Standard**	Second choice (nosecone needs space)	Cannot cross until channel is opened
Deep Medial Calcium	Does not reach deep medial calcium	Does not reach deep medial calcium	**1st-Choice** (fractures deep & superficial calcium)

IV CONTEMPORARY PARADIGM: SMALL-BURR MODIFICATION AND "ROTATRIPSY"

- **Shift from "Aggressive Debulking" to "Plaque Modification" (STRATAS & CARAT Trials):** Landmark randomized trials (**STRATAS and CARAT**) proved that **small burrs (burr-to-artery ratio <=0.7, typically 0.5 to 0.6)** achieve identical procedural and angiographic success compared to large aggressive burrs (>0.7) while **causing fewer angiographic complications and less slow-flow** (CARAT: roughly half the complication rate).
- **The "RotaTripsy" Synergy:** In contemporary complex PCI, Rotational Atherectomy is no longer expected to debulk the entire vessel diameter; instead, a small **1.25-mm or 1.50-mm burr** is used as a **"front-end channel opener"** for an uncrossable lesion, followed by **Intravascular Lithotripsy (IVL)** or a non-compliant/cutting balloon to fracture the remaining deep circumferential calcium ring prior to OCT/IVUS-guided DES deployment.

KEY REFERENCES

- **Abdel-Wahab M, Toelg R, Byrne RA, et al. (PREPARE-CALC Investigators):** High-Speed Rotational Atherectomy Versus Modified Balloons Prior to Drug-Eluting Stent Implantation in Severely Calcified Coronary Lesions, *Circulation: Cardiovascular Interventions*, 2018.
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- **Whitlow PL, Bass TA, Kipperman RM, et al. (STRATAS Investigators) & Safian RD, et al. (CARAT Investigators):** Small vs. large burr-to-artery ratio trials in rotational atherectomy, *American Journal of Cardiology / Catheterization and Cardiovascular Interventions*, 2001.