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ROTABLATION (ROTATIONAL ATHERECTOMY) MUST KNOW PROCEDURAL ASPECTS

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Contribution
AJ conceived the idea and designed the review. Data collection and manuscript writing was done by HSK, MASA, MM, SA, and HAG. All the authors contributed equally to the submitted manuscript.

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ABSTRACT

Rotational atherectomy is a time tested, useful and effective technology when it comes to calcific coronary lesions. This tool has been a part of interventional cardiologists arsenal for a long time but now there is an increase in its demand. With increasing age and presence of comorbidities like diabetes, hypertension and renal failure the incidence of calcific lesions in coronary artery disease is increasing. This article is meant to review the basic procedural setup, principles for safety and tips and tricks. The core elements for successful and safe technique being the use of the smallest size burr needed to achieve plaque modification with burr to artery ratio of 0.6, gradual advancement in a pecking motion, rotational speed of around 140,000-180,000 RPM, decelerations of less than 5000 RPM, short ablation runs of 15-20 seconds with continuous saline, nitrate, heparin and verapamil irrigation throughout ablation and finished with a polishing run.

Keywords: Rotational atherectomy, Rotablation, calcific coronary lesions, Complex percutaneous coronary intervention (PCI)

INTRODUCTION

The first case of rotational atherectomy in human coronary arteries was performed in 1988.[1] The interest in this technology has increased over the last decade as the average life span has gone up and today's interventional cardiologist is faced with the challenge of more complex and highly calcific coronary anatomy. The concept is differential cutting or ablation of the lesion as the burr preferentially ablates hard, inelastic material, such as calcified plaque, that is less able to stretch away from the advancing burr than is healthy arterial wall. A guidewire helps to keep the burr's abrasive tip coaxial with the vessel lumen. Unlike balloon angioplasty which tends to create intimal tear and dissection facilitating lumen expansion and stent placement, rotational atherectomy yields relatively smooth luminal surface with minimal tissue injury despite heavy calcification. Rotational atherectomy when used appropriately with full understanding of do's and don'ts of the technique proves to be a very useful modality and usually converts a complex PCI into a simple one. It would not be wrong to call rotablator as interventionists best friend against calcification, which is one of the worst enemies of coronary angioplasty.[2] Rotablation is a safe procedure in experienced hands but any institution starting a new rotablator program should get a proctor and do few initial cases under expert supervision. Looking at the increasing need to use rotational atherectomy in our routine practice, we felt the need to review some of the most important, must know procedural aspects of this technology. The focus of this article will be towards the procedural aspects, which would not only increase the safety profile and success rate of the procedure but also give immense confidence to the new operators.

INDICATIONS FOR ROTABLATION

- Calcified lesions particularly if there is a length of calcification with an arc of > 270 degrees and is superficially placed.[3]
- Undilatable lesions.[4]
- Chronic total occlusions (inability to cross the CTO with hardware despite the wire passing successfully into the distal vessel).[5]
- In stent restenosis.[6]

CONTRAINDICATIONS

- Saphenous Vein Grafts.
- Angiographic presence of thrombus.
- Coronary dissections (technology literature by Boston Scientific recommends avoiding rotablation for 4 weeks to allow the dissection to heal). However there are case reports of successful rotablation, in presence of various types of dissections in desperate situations.[7]

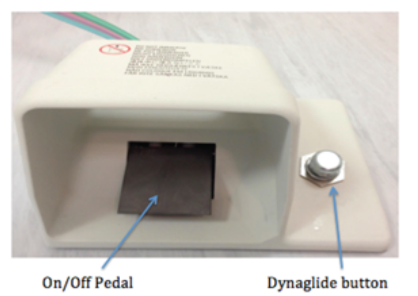
EVIDENCE BASE FOR THE USE OF ROTABLATION

There are multiple studies justifying the use of rotablation in complex coronary lesions. It is an effective treatment modality for heavily calcified diffuse disease.[5] Treating coronary lesions more than 25mm in length with rotational atherectomy does not have any negative impact on short- and long-term outcome.[7,8] Rotational atherectomy is a safe and effective technique to overcome the inability to cross a CTO with a balloon catheter[9,10] and is also associated with high procedural success and low incidence of complications in ostial coronary lesions.[11-13] There is also evidence to suggest that rotablation before stent implantation may avoid complex stenting and provide good long-term outcome in bifurcation lesions.[14,15]

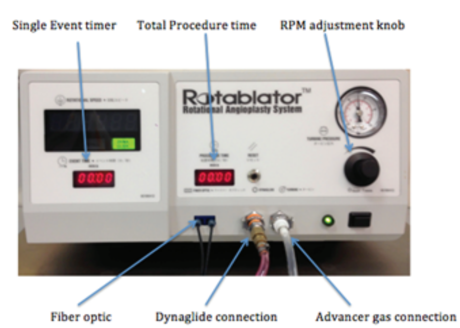
ROTABLATION SET UP

The set up consists of a console, a foot pedal, Rotalink plus, Rota wire, Gas tank (cylinder), and saline-based cocktail.

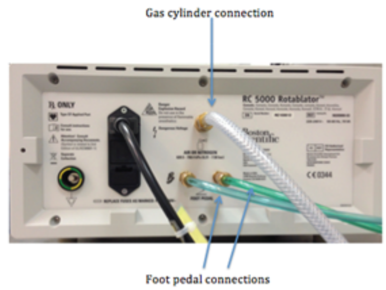
The foot pedal (Figure 1) is connected to the console with 3 tubing's. The pink tube is attached to the dynaglide port in front of the console (Figure 2) whereas the blue and green tubes are attached to the back of console into the ports labeled foot pedal (Figure 3).



{FIGURE 1-FOOT PEDAL}

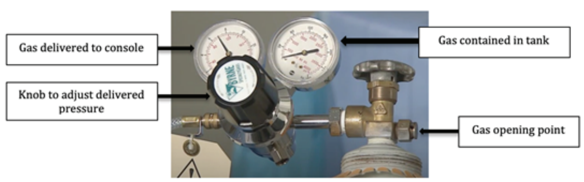


{FIGURE 2-CONSOLE FRONT}



{FIGURE 3-CONSOLE BACK}

Next task is to connect the console to the air supply. The dual stage regulator (Mickey mouse gauge) (Figure 4) is already attached to the tank (cylinder). One end of the braided tube is attached to the regulator and the other end to the gas port at the back of the console (Figure 3). The gas (air or nitrogen) levels in the tank and amount delivered for rotablation are checked, as explained later under the heading of air supply set up.



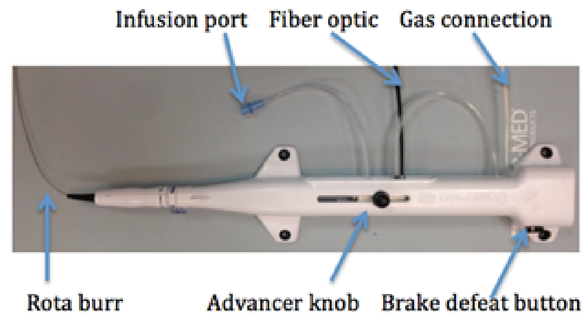
{FIGURE 4: Mickey Mouse gas gauge}

(Figure 4 adopted from Boston Scientific teaching material)

A cocktail of 500ml Normal Saline containing Verapamil 5 mg, Nitrates 5mg and Heparin 5000 units is prepared.[9] This fluid bag is kept under 200mmHg pressure with a BP cuff, to achieve continuous high flow irrigation throughout the procedure. This cocktail is important to prevent too much heat generation in the coronaries causing thermal injury, as well as helping with vasodilation to help reduce coronary spasm and slow flow occurring due to embolization of debris.

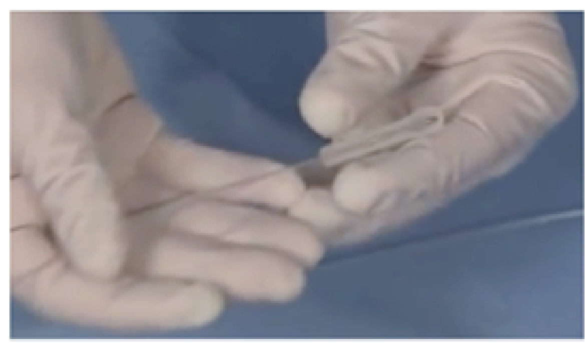
The rota wire is then advanced across the lesion and advancer is prepared. The advancer (Figure 5 is opened and its fiber optic cable (black) is connected to the front of the console (Figure 2). The gas connector of the advancer is attached to the front of console (Figure 2). The saline infusion port of the advancer is joined to the IV tubing of saline cocktail.

The distal gripper is gently removed from the burr {(Figure 6). The burr is back loaded on the rota wire and is kept advancing till the wire appears from the back end of the advancer. Brake defeat button on the advancer (Figure 5) is kept pressed during this maneuver. The provided wire clip torquer is attached to the rota wire end.



{FIGURE 5- ADVANCER}

If the physician fails to remove the distal gripper before moving the advancer knob, the drive shaft coil could be kinked and this may result in difficulty loading the burr onto the rota wire. When using a rotablator advancer and a Rota burr (provided separately), the operator should connect them prior to removing the distal gripper. The rota burr



{FIGURE 6-Gripper on burr}

should be tested before inserting into the guide catheter.

PRE PROCEDURE TEST

- Drip: Continuous saline drip under pressure. Ensure fluid coming out from distal tip of burr catheter.
- Rotate: Adjust burr speed (RPM's) in rota mode to around 150000.
- Advancer: Move the burr to and fro with advancer knob.
- Wire: Confirm wire tip position, avoiding a small branch (small risk of perforation) and check brake system.

ACT should be checked every 20 minutes and kept around 300 seconds throughout the procedure to avoid thrombosis.

AIR SUPPLY SET UP

Cylinder tanks of compressed gas (air or nitrogen) or surgical room air (central hospital supply) can be used.

- **American system:**

  One dial of the Mickey Mouse gauge shows gas contained in the tank (minimum 500PSI/3447.5 KPA per case) and the other dial shows the gas being delivered to the console (90/620.55Kpa-110 PSI/758.45 KPA).

- **British system:**

  Full cylinder will have more than 100 bars. If <30 Bars do not proceed and change the gas cylinder. Delivery pressure should be kept at 7 Bars by rotating the black knob on Mickey Mouse gauge set (Figure 4).

Must make sure before starting every case that the gas opening point is open otherwise the gauges may show the last readings and as there is no further flow of air into the system the burr may run for a few seconds consuming the remaining air in the Mickey mouse head and the tubing and then stop. Hence it is important to test the burr outside the body.

GUIDE CATHETER

Tight fitting burr in the guide catheter can lead to poor opacification. Guide catheter should give good support and should be able to accommodate possible final burr size (Table 1).

Table 1: Guide catheter size, compatibility and maximum burr size

Guide catheter size	Burr size (mm) compatibility	Max burr size (mm)
6F	1.25,1.5	1.75(internal guide diameter 1.8mm)
7F	1.25,1.5	1.75
8F	1.25,1.5,1.75,2.0,2.15	2.25

ROTA WIRE

The Rota wire is 325cm long and has a relatively broad tip (0.014”), which is 22mm long. This is wider than the rest of the wire that is 0.009” wide and ensures that the distal tip of the wire cannot enter the burr. The operator must therefore ensure that the Rota wire tip is well ahead of the lesion and will not come into contact with the rotating burr. Keep the wire tip in the main artery or a big branch. For all cases, use floppy rota wire except aorto-ostial lesions, where extra support rota wire may be used. A wire clip torquer is applied at all times to prevent the wire from spinning. The brake (black button on advancer) must be kept pressed to move the wire.

The Rota wire is very delicate and must not be kinked, however it can be difficult to manipulate in challenging anatomy. A solution to this can be to wire the coronary with a standard angioplasty wire and then advance an over the wire (OTW) balloon or micro catheter into the distal vessel in order to exchange to the Rota wire.

ADVANCER KNOB AND BURR ADVANCEMENT

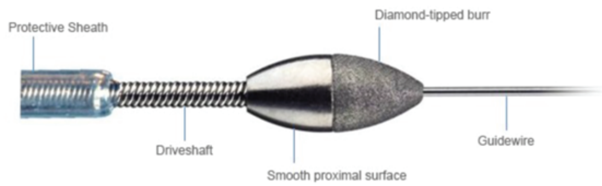
The advancer knob should be kept locked in a central position while introducing the burr into the catheter. Advance the burr while holding the wire coming out of the advancer. A strong tug may have to be kept on the wire while keeping an eye on the guide catheter (which may otherwise tend to back out) and the distal wire tip. When the burr has reached proximal to the lesion, release burr tension by unlocking the advancer knob and pulling it back. Now keep the knob in full back position, ready to burr.

Another way to advance the rota burr is to activate dynaglide mode, keep the brake defeat button on the advancer pressed and without holding the wire, simply keep advancing the rota burr in the guide catheter till the burr reaches proximal to the lesion. Deactivate dynaglide mode.

Advance the burr back and forth, moving forward only when there is light resistance. With the advancer knob, the rota burr can be advanced a maximum of 9cm (range of ablation). For multiple lesions, ablate the proximal lesion (9cm range) and again park burr proximal to the ablated lesion. Now activate the burr again and advance whole burr sheath as a unit while maintaining a tug on wire. Park it as distally as required, but proximal to the second lesion for rotablation and another 9 cm of ablation can be done distally.

BURR SELECTION

The elliptical shaped brass burr is nickel coated and has 2000-3000 microscopic diamond crystals on the distal edge. The proximal surface of the burr is smooth and non-cutting (Figure 7). The 1.25mm burr is much less of an ellipse than other burr sizes this means that it can potentially get stuck so should not be used to rotablate through stent struts. In this situation a minimum of 1.5mm burr should be used.



{FIGURE 7: Rotablator burr}
(Figure 7 adopted from Boston Scientific teaching material)

Plaque is ablated into micro particles less than 5 microns (smaller than red blood cells). These particles pass through the coronary microcirculation and are picked up by reticuloendothelial system. Rota burrs come in various sizes, 1.25, 1.5, 1.75, 2.0, 2.15, 2.25, 2.38 and 2.50mm.

A special relationship exists between the degree of platelet aggregation and burr speeds.[10]

- Rota speed <135,000 RPM----Chances of burr lodging.
- Rota speed >180,000 RPM----Increased platelet activation and thrombotic complications.

Therefore, rotational speed is kept around 150000-160000 RPM to avoid complications. Dynaglide cuts the RPM's in half and is used mainly to withdraw the burr out of the guide catheter.

Always test the burr on the wire before entering the catheter and adjust the RPM's by rotating the black knob on front of the console (Figure 2). Also test the free movement of the burr by moving the advancer knob back and forth.

Each run should not be more than 15-20 seconds. If revs keep dropping by >5000 RPM, downsize the burr. Excessive drops in speed and aggressive advancement of the burr are related to potential thermal injury.[16] In the STRATAS trial deceleration of more than 5000 rpm from baseline for more than 5 seconds was associated with an increase in CK-MB elevation.[17]

It is preferable to use a step-up approach for burr size selection. Begin with a small burr. Aim for a final burr-artery ratio of 0.6. This is known as a "lesion modification" strategy, as opposed to a more aggressive "debulking" strategy.[18] A single 1.5mm burr suffices for most vessels <3mm in diameter and a 1.75mm burr for vessels >3mm in diameter. Larger burrs may be required for aorto-ostial lesions or larger vessels in which smaller sized burrs may not make physical contact with the plaque.

Neutralize guidewire tension. Make sure that the tension of the system is "unloaded" before ablation. This is to avoid wire bias, inadvertent sidewall burring, and the burr "jumping" forward into the lesion Upsize the burr in 0.25mm increments. The aim is plaque modification and not plaque debulking, so for the majority of procedures upsizing the burr may not be required. You are not aiming to remove all the calcium, just make the lesion more pliable. Most procedures are performed with a 1.25mm or 1.5mm burr to start off with depending on the severity and tortuosity of the lesion. Ablation should be finished with one polishing run with no RPM drop.

In the presence of extreme tortuosity or angulation, long segments of severe diffuse disease, or inability to pass microcatheter across the lesion, a step up approach starting with 1.25mm burr with subsequent upsizing with use of more supportive guide catheters may be required.

TROUBLESHOOTING:

If the burr does not cross the lesion after several passes, options are to decrease the burr size and/or increase the guide catheter support. If this does not work then try increasing burr speed. Perseverance while remaining within the safety limits is the key to success. If a burr is stuck in guide catheter, then most likely there is a kink in the catheter.

After completion of successful ablation, one approach could be to use the same rota wire to take a balloon into the lesion and try inflation. Another approach is to remove the burr from the catheter and park a workhorse wire parallel to the Rota wire. A non-compliant balloon (smaller than vessel size) is inflated at nominal pressure on the workhorse wire to determine if there is any residual dog boning. If present, consideration should be given to further ablation with a larger size burr.

Dynaglide (Green light on console) (Figure 2): is mainly used while removing the burr but now there is an increased trend to also advance the burr in the catheter up to the lesion (although not recommended by Bostobn Scientific). If required, rota mode can also be used to remove burr as the burr cuts only in forward motion.

To retract the Rotablator Catheter, the brake button on the advancer will have to be kept pressed or the clip torque can be fitted into the provided slot and the brake will remain continuously depressed. While withdrawing the burr system, in dynaglide mode, keep the O-ring (Y-connector) open and then withdraw the whole advancer unit while continuously pushing the wire forward to maintain guide wire position.

TIPS AND TRICKS

- Do not over tighten the hemostatic valve (Y-adaptor). If it is too tight to allow burr movement, the stall light may illuminate, the sheath around the drive shaft can be crushed causing permanent damage to the Rotalink catheter.

- Avoid dottering (always use pecking motion). Never stop the burr in the lesion or distal to lesion. Never adjust RPM's during ablation. Do not allow burr to remain in one location while rotating at high speeds as the burr may cut the rota wire when rotating in the same position on the wire. Preferably avoid burring in the guide catheter.

- **Bifurcation lesions:** Rotablation can be useful in bifurcation lesions as plaque is removed rather than shifting it into the side branch ostium.[19] Importantly, ablation should be performed using the Rota wire alone and a second wire is only positioned after ablation has been completed.

- **Aorto-ostial lesions:** The guide catheter should be coaxial in order to avoid the burr becoming stuck. A large size guide catheter is preferable to allow rotablation to start just within the tip of the guide catheter. An extra support Rota wire may be preferable over a floppy Rota wire in this situation.

- **Temporary pacemaker (TPM):** For dominant RCA, dominant LCX or LMS ablation, consideration has traditionally been given to positioning a prophylactic temporary pacing lead. At the very least femoral venous access is secured at the start of the procedure and IV atropine drawn up ready to be administered. In this regard, Aminophylline, given via intravenous route, 250-300 mg over 10 minutes or 20-40 mg intracoronary through guide catheter may also be used for prevention of bradyarrhythmias and preclude the need for temporary pacing as an additional invasive step.[20] For intracoronary injection goal is to make Aminophylline in 1 mg/ml concentration. A vial of aminophylline has 250mg/10ml (25mg/ml) concentration. 2ml (or 4 ml) aminophylline may be mixed in 50ml (or 96 ml) of saline in a bowl. This will make 1 mg/ml (50mg in 50ml or 100 mg in 100 ml) concentration. 20ml syringe of this fluid (now equal to 20 mg) may be drawn and Injected intracoronary via guide catheter when required. Repeated as needed. Most patients do fine with 20 mg single bolus but may need to be repeated in case of multiple rota runs. For more obese patients with complete heart block or asystole, 40 mg dose may be required. There is no need to give it prophylactically in every case because not every case develops heart block with rotablation. In case of transient heart blocks with first rota run, aminophylline may be given as a push through the guide before the next rota run and repeated if needed.

- **LMS ablation:** Particularly when there is poor LV function and/or complete occlusion of the RCA, rotablation for a LMS lesion may require adjunctive hemodynamic support.

- **Chronic total occlusion (CTO):** After crossing a CTO with the wire, if no other hardware like balloons, micro catheters or tornus are able to cross the lesion then engage the microcatheter into the CTO lesion as distal as possible and exchange the PCI wire to a Rota wire. The operator must confirm Rota wire tip position with a contralateral injection and a 1.25mm burr is usually sufficient to achieve plaque modification.

- **Stent ablation:** The use of Rotablation in this situation can be done but as a last resort due to the risk of the burr becoming lodged. This is particularly the case for the 1.25mm burr, which should not be used.

- **Advancer issue:** If the advancer was previously working and now stops then check all connections and the gas source. Make sure the cylinder tank is open and delivering the required amount of air. A lack of continuous saline flow could cause burn out and that would require changing the advancer.

- **Stall light:** As a safety feature, the system automatically stalls when there is a >15000 rpm drop (If revs keep dropping by >5000 RPM, downsize burr). Check that the burr is not lodged. Check all connections and air supply. Ensure saline flow and verify that hemostatic valve (Y Connector-O ring) is not too tight.

- **Lodged/Entrapped burr:** An oversized burr in diffuse calcium and too much pressure can jam the burr. Also, a small burr specially 1.25mm in an eccentric lesion and too much pressure can cause watermelon seeding of the burr through the lesion and with no diamonds on the proximal side of the burr, there is no way to get back. In this situation do not attempt to start the burr spinning once it is stuck. Try coughing, intracoronary nitroglycerine and giving time. Try dynaglide briefly while gently pulling back. If this does not work then cross a second wire (start with a hydrophilic wire and move up to stiffer wire like conquest if required) adjacent to the stuck burr and take a compliant balloon, next to or just proximal to the burr, and inflate at low pressure (1-2 atm) to open up and dislodge the burr (a second guide catheter may be required). Back out the guide catheter to prevent guide catheter induced coronary dissection and try by pulling the burr firmly.

Cautious deep intubation of guide catheter and sometimes mother-in-child catheter technique (after cutting the proximal connector of the burr drive shaft near the advancer) may be tried for better support and controlled pull and push of the drive shaft. By cutting the drive shaft, another useful approach is to pass a snare into the coronary artery, even through the same guide catheter, just proximal to the lesion, snaring the burr shaft and simultaneously retracting both snare and burr shaft, allowing direct traction to be exerted on the burr shaft.[21] If all of the above techniques fail, then surgical removal of the burr may be required.

- **Blood in the sheath:** Stop rotablation and verify saline connection, pressure and continuous flow. If all of the above are correct but the blood continues to flow up the sheath, then replace the Rotalink catheter with a new device.

- **Slow flow:** Avoided by using small burrs and low speeds with intermittent runs. A saline-based cocktail of nitrates, verapamil, and heparin has been shown to reduce the incidence of spasm and slow flow.[22] To manage slow flow optimize BP if low (hydration, vasopressors and IABP if needed). Intracoronary vasodilators like nitrates / verapamil / adenosine / nitroprusside may be used.

- **Hypotension:** Nowadays, rarely occurs if the recommended approach is followed. Pre-hydration is important. However, metaraminol, given in 0.5 – 1.0 mg boluses intravenously are useful to maintain systolic blood pressure. Ongoing hypotension may require the placement of an intra-aortic balloon pump.

Rotational atherectomy (Rotablation) can be an effective tool in appropriately selected patients by observing the safety and operational principles.

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