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Rotational Atherectomy with Drug-eluting Balloon Angioplasty for Femoropopliteal Artery Occlusive Disease: Serial Case

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Abstract: Peripheral artery disease (PAD) leads to symptoms ranging from claudication to chronic limb threatening ischemia (CLTI), and is linked to aging, diabetes, hypertension, and smoking. While conventional treatments such as balloon angioplasty and stenting are effective for short lesions, they struggle with complex or calcified lesions. Rotational atherectomy has emerged as a promising solution, particularly for calcified lesions in the superficial femoral and popliteal arteries. This case series highlights the success of rotational atherectomy in treating PAD patients with non-healing ulcers, improving limb perfusion and healing, and offering a minimally invasive alternative to amputation. First case was an 80-year-old male with severe PAD and CTO of the left SFA and CFA, treated successfully with endovascular revascularization using atherectomy and drug-eluting balloon angioplasty. Second case was a 50-year-old diabetic male with gangrene and rest pain in the third toe, caused by a heavily calcified CTO in the mid-SFA. Endovascular revascularization using rotational atherectomy followed by drug-eluting balloon angioplasty were performed. Third case was a 63-year-old female with diabetes, hypertension, and chronic kidney disease, who presented with gangrene and rest pain in her right foot due to complex PAD with CTO. Endovascular revascularization using rotational atherectomy and drug-eluting balloon angioplasty was successfully performed. The outcomes showed successfully restored blood flow, alleviated symptoms, and improved limb perfusion, demonstrating the efficacy of these techniques in high-risk PAD patients. In conclusion, rotational atherectomy followed by drug-eluting balloon angioplasty effectively revascularized complex, calcified lesions in CLTI patients, offering a promising, minimally invasive alternative to surgery, though further studies are needed to confirm long-term benefits. Future studies should compare the long-term patency and major adverse events between this method and traditional balloon angioplasty alone.
Keywords: rotational atherectomy; drug-eluting balloon angioplasty; artery occlusive disease

INTRODUCTION

Peripheral artery disease (PAD) is a common and potentially debilitating condition characterized by the narrowing of peripheral arteries, primarily in the lower extremities, due to atherosclerosis. This disease restricts blood flow, leading to symptoms ranging from intermittent claudication (pain during exertion) to critical limb ischemia (CLI), which can cause severe rest pain, ulcers, and tissue necrosis.[1] If left untreated, PAD can result in amputation, significantly affecting the patient's quality of life and functional capacity.[1,2] This PAD affects over 200 million adults worldwide, with its prevalence increasing with age, diabetes, hypertension, and smoking. Epidemiological studies show that the incidence of PAD in older adults exceeds 20%, and the condition is associated with a higher risk of cardiovascular events, including heart attack and stroke.[3]

The global trend of aging populations and rising rates of diabetes and hypertension is mirrored in Indonesia, contributing to an increase in PAD incidence. In Indonesian population, traditional risk factors such as smoking, poor diet, physical inactivity, and increasing rates of diabetes and hypertension have heightened the burden of cardiovascular diseases, including PAD.[4]

Treatment for PAD traditionally involves lifestyle modifications, pharmacological management, and surgical revascularization procedures. Endovascular treatments have gained widespread popularity in recent years due to their minimally invasive nature and shorter recovery times.[5] The primary procedures for PAD include balloon angioplasty and stenting, which are effective for short, uncomplicated lesions in arteries like the superficial femoral artery (SFA) and popliteal arteries. However, these methods have limited efficacy when dealing with long, calcified, or complex lesions, which are often resistant to balloon dilation.[5,6]

Endovascular atherectomy has emerged as an innovative and promising treatment option for PAD, particularly for complex, calcified lesions that do not respond well to balloon angioplasty.[7] Atherectomy physically removes atherosclerotic plaque from the arterial walls, providing better results for patients with long lesions or chronic total occlusion (CTO). Among the different atherectomy techniques such as directional, rotational, orbital, and rotational atherectomy, the latest has shown significant promise, especially for calcified lesions in the SFA and popliteal arteries.[8] This technique offers advantages over traditional methods by effectively removing plaque without the need for more invasive surgical procedures.[6,8]

This paper aims to present a case series of PAD patients with non-healing leg ulcers (Rutherford Grade VI) treated with rotational atherectomy. By exploring the outcomes of using this endovascular technique in patients with severe PAD, we seek to demonstrate its efficacy in improving limb perfusion, promoting ulcer healing, and preventing the need for amputation. Through this case series, we aim to highlight the benefits of rotational atherectomy in enhancing clinical outcomes for patients with complex PAD and advanced vascular lesions, offering a minimally invasive alternative to traditional surgical revascularization.

CASE REPORT

Case I

This case report presented an 80-year-old male with a history of hypertension and type 2 diabetes mellitus (T2DM), with a necrotic wound on the left ankle, which had not healed despite prior debridement and wound care. On examination, the patient exhibited a poorly palpable femoral artery pulse, with absent pulses in the left popliteal, posterior tibial, and dorsalis pedis arteries. Vascular examination revealed a left ankle-brachial index (ABI) of 0.6, suggesting significant arterial insufficiency. Doppler ultrasound and angiography confirmed severe PAD with CTO of the left superficial femoral and common femoral arteries, complicated by heavily calcified plaque. The lesion was classified as TASC II type C, indicating a complex, long, and calcified lesion. Post-procedural angiography demonstrated successful revascularization with no visible stenosis, dissection, or embolization. The patient was monitored closely and received antibiotics, pain management, and wound care. One month after the procedure, the wound showed significant improvement, with reduced necrosis and enhanced healing.

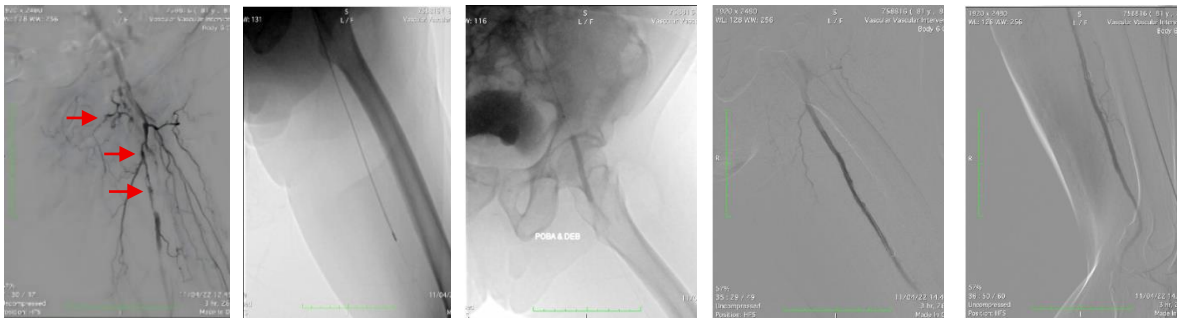


Figure 1. Treatment procedure and result of CTO in SFA and POPA. A, Multiple occlusions in the superficial femoral artery and its branches; B, Endovascular atherectomy followed by DEB angioplasty in POPA; C, Endovascular atherectomy followed by DEB angioplasty in SFA; D, Smooth flow and minimal occlusion in SFA; E, Smooth flow and minimal occlusion in POPA

In follow-up, the patient reported improved function and less pain, with an increased ABI of 0.9, indicating better vascular perfusion. Duplex ultrasound confirmed patent flow through the treated arteries (Fig. 1D, 1E). Long-term follow-up included monitoring for restenosis, lifestyle modifications, and rehabilitation to improve lower limb function. Psychological support was also provided to address the emotional and social aspects of the patient's recovery. This case demonstrates the efficacy of endovascular revascularization, including atherectomy and DEB angioplasty, in managing complex PAD with chronic total occlusion and non-healing ulcers, leading to significant improvement in vascular perfusion and wound healing.

Case II

This case report presents a 50-year-old male patient with rest pain and gangrene affecting the third toe of his right foot. The patient had a significant medical history, including T2DM and hypertension, and had previously undergone amputation of the fourth and fifth toes on the right foot due to complications from PAD. He sought medical attention for worsening symptoms of rest pain and gangrene on the remaining toe, which indicated a further progression of his arterial disease. On physical examination, the vascular status was assessed, revealing that pulses in the right femoral, popliteal, dorsalis pedis, and posterior tibial arteries were all clearly palpable. The right ABI was measured at 0.7, indicating mild arterial insufficiency, while the left ABI was 0.9, suggesting relatively better vascular status on the contralateral side. Doppler ultrasound examination showed a triphasic flow spectrum in the common femoral artery, indicating good flow proximally, while a biphasic flow spectrum was observed from the popliteal artery to the distal arteries. Morphologically, the ultrasound revealed a heavily calcified CTO plaque in the mid segment of the SFA, causing significant stenosis and narrowing of the arterial lumen.

Given the presence of gangrene and ongoing symptoms, the patient was deemed a candidate for endovascular revascularization. An antegrade femoral puncture was performed on the ipsilateral side using a 6Fr femoral sheath. Initial angiography confirmed a heavily calcified CTO lesion in the mid-SFA (Fig. 2A), with a stenotic segment approximately 5 cm in length, classified as TASC II Type B femoropopliteal lesions. The lesion's complexity and calcification indicated the need for advanced endovascular techniques to restore blood flow. Rotational atherectomy was performed using a Jetstream XC atherectomy catheter (2.1/3.0), which successfully removed the calcified plaque. This was followed by DEB angioplasty to further dilate the stenotic segment and reduce the risk of restenosis (Fig. 2B).

The post-procedure angiographic results showed a successful revascularization with an open occlusion segment and smooth flow to the distal arteries (Fig. 2C). No complications such as dissection or distal embolization were observed, and the treated segment remained patent.

A B C

Figure 2. Treatment procedure and result of CTO in SFA. A, Heavy calcification in the superficial femoral artery and its branches; B, Endovascular atherectomy followed by DEB angioplasty in SFA; C, Smooth flow and minimal occlusion in SFA

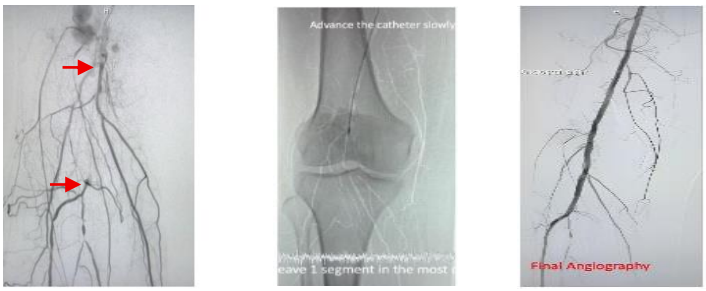
The patient was closely monitored in the immediate post-procedural period and was managed with appropriate pain relief, antibiotics, and wound care. Over the following weeks, the gangrene and rest pain began to improve, with the patient reporting reduced discomfort and improved function in the affected foot. Further follow-up included continued monitoring of the ABI, which remained at 0.7, and periodic Doppler ultrasound to assess for restenosis. Additionally, the patient was provided with education on lifestyle modifications, including blood sugar control, smoking cessation, and exercise to optimize vascular health. This case demonstrates the successful use of endovascular rotational atherectomy and drug-eluting balloon angioplasty in managing complex PAD with CTO in a diabetic patient, leading to significant improvement in limb perfusion and symptom relief.

Case III

This case report discusses a 63-year-old female patient who presented with rest pain and gangrene on the fifth toe of her right foot. The patient had a significant medical history, including T2DM, hypertension, and chronic kidney disease (CKD) requiring hemodialysis. These comorbid conditions placed her at high risk for developing PAD, which likely contributed to the gangrenous changes in her foot. The patient sought medical attention due to worsening symptoms, including severe rest pain and the appearance of gangrene, which had not improved despite previous wound care. On physical examination, the vascular status of the lower limbs was assessed. The right femoral artery pulse was clearly palpable, suggesting adequate proximal circulation. However, pulses in the popliteal, dorsalis pedis, and posterior tibial arteries were difficult to palpate, indicating reduced blood flow to the distal foot. The right ABI was found to be 0.6, confirming significant arterial insufficiency in the right leg, while the left ABI was 0.9, indicating better perfusion on the contralateral side. These findings, along with the clinical presentation of gangrene, pointed to a severe vascular pathology in the right leg. Doppler ultrasound was performed to further evaluate the vascular condition. The study revealed a triphasic flow spectrum in the right common femoral artery, indicating good proximal circulation. However, a monophasic flow spectrum was noted in the popliteal artery extending distally, suggesting a more severe, obstructive disease process. The ultrasound also demonstrated a heavily calcified CTO plaque in the distal segment of the SFA extending to the popliteal artery, which was confirmed to be the source of the vascular occlusion and impaired perfusion to the foot.

Given the patient's critical condition, endovascular revascularization was chosen as the treatment option. A right antegrade femoral puncture was performed using a 6Fr femoral sheath. Initial angiography confirmed the presence of heavily calcified occlusion lesions in the distal popliteal segment (P3-P4) extending to the tibio-peroneal trunk and the anterior tibial artery, with a total occlusion segment length of approximately 10 cm. The lesion was classified as TASC II Type C, indicating a more complex and challenging lesion.

To address this, rotational atherectomy was performed using a Jetstream XC atherectomy catheter, which helped to remove the calcified plaque and prepare the vessel for further treatment.



A B C

Figure 3. Treatment procedure and result of CTO in SFA extending to POPA. A, Heavy calcification in the superficial femoral artery extending to POPA; B, Endovascular atherectomy followed by DEB angioplasty in SFA dan POPA; C, Smooth flow and minimal occlusion in SFA to POPA

Following the atherectomy, drug-eluting balloon angioplasty was performed to further dilate the treated segment and reduce the risk of restenosis. The final angiographic results showed successful revascularization, with the occlusion segment open and smooth flow restored to the distal arteries. No complications, such as dissection, recoil stenosis, or distal embolization, were observed. The patient was closely monitored in the post-procedure period, and her gangrenous symptoms showed gradual improvement. She was provided with appropriate pain management, antibiotics, and wound care. During follow-up visits, the patient continued to report reduced pain and improved circulation in the affected foot. Her ABI remained at 0.6, and periodic Doppler ultrasound showed improved flow in the treated vessels. The patient was also advised on strict glycemic control, blood pressure management, and lifestyle modifications to optimize vascular health. This case demonstrates the successful use of endovascular rotational atherectomy and drug-eluting balloon angioplasty to treat complex PAD with CTO in a diabetic patient with multiple comorbidities, resulting in significant improvement in limb perfusion and an improvement clinical outcome.

DISCUSSION

The treatment of long and complex SFA or popliteal lesions, particularly those with heavily calcified plaques, remains a challenge in the management of PAD. These calcified lesions pose difficulties for traditional treatment methods such as balloon angioplasty and stenting.[9] The calcific burden impedes proper stent apposition and dilates poorly, resulting in suboptimal outcomes. The removal of calcified plaque is crucial to restoring patency, improving blood flow, and increasing the success of subsequent angioplasty. However, there is currently no widely accepted evidence-based consensus on how best to approach these complex lesions, as conventional methods often fail to address the specific needs of these advanced cases.[10]

Rotational atherectomy has emerged as an effective treatment for heavily calcified lesions, offering distinct advantages over traditional methods. This technique involves the use of a rotating catheter to mechanically shave and remove calcified atherosclerotic plaque while preserving the healthy, elastic arterial wall.[10,11] Rotational atherectomy effectively removes calcium, facilitating subsequent angioplasty and improving stent apposition. This method is particularly advantageous in treating CTO, as it allows for better vessel preparation, improving the efficacy of balloon dilation and stenting. In addition to plaque removal, rotational atherectomy may also expose underlying smooth muscle cells in the arterial wall, which enhances the uptake and effectiveness of subsequent therapies, such as DEB.[12,13]

Rotational atherectomy is particularly beneficial for treating complex, calcified PAD because it specifically targets and removes inelastic, calcified atherosclerotic plaque while preserving the healthy, elastic arterial tissue. This selective plaque removal process is crucial in preventing damage to the artery's structural integrity, which can occur with more aggressive techniques like directional atherectomy or balloon angioplasty.[14] By carefully eliminating calcified plaque,

rotational atherectomy helps to restore vessel compliance, improving the effectiveness of subsequent interventions such as balloon angioplasty or stenting. This technique is especially useful for lesions that are resistant to standard treatments due to heavy calcification, as it facilitates better blood flow and prepares the vessel for more optimal stent apposition or drug-eluting balloon delivery, ultimately improving long-term clinical outcomes and reducing restenosis risk.[15]

Heavily calcified lesions in arteries are challenging to treat because the calcified plaque obstructs balloon dilation. Balloon angioplasty works by expanding the balloon within the artery, pushing the plaque against the arterial wall to restore blood flow. However, calcified plaques are rigid and do not deform easily, making it harder for the balloon to conform to the vessel wall. Rotational atherectomy uses a high-speed rotating device (e.g., Jetstream or Diamondback 360) to mechanically ablate the calcified plaque.[16] The plaque is pulverized into smaller particles that are easier to dilate, ensuring that the balloon can expand more effectively. Rotational atherectomy is effective in reducing calcific plaque burden, which allows for better balloon expansion and greater stent apposition in complex lesions. When atherectomy is performed first, it removes the hard, calcified material, making the remaining plaque more compressible, which facilitates better balloon dilatation. This is crucial for ensuring that the balloon can fully expand the artery without causing recoil or incomplete dilation.[16,17]

Studies have shown that rotational atherectomy creates a smoother, more uniform surface by removing calcified plaque, which enhances the drug delivery efficiency of DEBs. Using atherectomy prior to DEB angioplasty has been shown to improve the uptake of paclitaxel into the arterial wall. This is because the mechanical action of atherectomy exposes smooth muscle cells and the deeper layers of the vessel wall, which are more receptive to the drug. The paclitaxel in DEBs acts by inhibiting the proliferation of smooth muscle cells, which is key to preventing the artery from narrowing again after the procedure. Atherectomy reduces the calcific barrier and prepares the vessel wall for better drug absorption.[18]

The combination of rotational atherectomy with DEB angioplasty demonstrated excellent outcomes in three patients with CLTI, Rutherford grade VI, who presented with CTO of the SFA and popliteal arteries. The cases showed no residual or recoil stenosis, no dissection, and importantly, no distal embolism.[19] These results underline the safety and efficacy of this combined approach for complex PAD lesions. The use of Jetstream atherectomy (Boston Scientific) helped to remove the calcified plaque, allowing for improved vessel dilation and optimal drug delivery with DEB angioplasty. This strategy has the potential to provide superior results compared to traditional balloon angioplasty, which may not adequately address the complications posed by calcified lesions. In the presented case series, three patients with CLTI Rutherford grade VI underwent endovascular revascularization using the Jetstream rotational atherectomy catheter followed by drug-eluting balloon angioplasty. The procedure yielded positive outcomes, with successful correction of CTO lesions, no residual or recoil stenosis, no dissection, and importantly, no instances of distal embolism.[20]

Despite the promising results observed with rotational atherectomy and DEB angioplasty, further studies are needed to establish long-term outcomes and compare this approach to traditional revascularization techniques, such as standard balloon angioplasty or stenting.[21] Future studies should focus on assessing long-term patency rates, restenosis rates, and the incidence of major adverse events, including distal embolism and vessel dissection. Additionally, studies with larger cohorts and longer follow-up periods are required to better understand the role of rotational atherectomy in improving patient outcomes and its cost-effectiveness in the management of complex PAD. Future research should focus on comparing the long-term patency of this procedure with traditional revascularization methods, such as standard balloon angioplasty, and evaluating the rates of distal embolism and other major adverse events.[21,22] Although rotational atherectomy has many advantages, there are several complications that can arise from the intervention, such as embolization, ischemia leading to infarction, perforation, and the no-reflow phenomenon.[23]

CONCLUSION

Rotational atherectomy with the Jetstream catheter (Boston Scientific) followed by Drug-Eluting Balloon Angioplasty has shown promising results in the treatment of CLTI, particularly in patients with heavily calcified plaque lesions. The three cases presented demonstrate that this combination approach effectively revascularized the affected arteries, with no occurrences of distal embolism, dissection, or other major adverse events. These results highlight the potential of rotational atherectomy to address complex, calcified lesions, improving vessel preparation for subsequent balloon angioplasty and enhancing the outcomes of drug-eluting balloons. The most common complications, such as distal embolization leading to ischemia and iatrogenic perforation, frequently occur during rotational atherectomy. This approach offers a viable, minimally invasive alternative to traditional surgical methods, providing a safer and more effective option for patients with advanced PAD. However, further studies with larger cohorts and long-term follow-up are needed to validate these findings and confirm the broader applicability and long-term benefits of this treatment strategy.

Conflict of Interest

The authors affirm no conflict of interest in this study.

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