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Percutaneous Peripheral Revascularisation with Excimer Laser: Equipment, Technique and Results

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Abstract. Laser angioplasty has been evaluated for coronary applications since the early 1980s. Early complications of dissection, perforation and thermal injury led to a loss of enthusiasm for this technique. Recent advances in catheter development, including optimally spaced laser fibres, athermic 308 nm wavelength catheters, and saline infusion techniques have produced larger laser channels, minimised thermal injury and significantly reduced vessel dissection. This improvement in equipment and technique has led to the growing use of lasers in the field of percutaneous treatment of peripheral vascular interventions. Convincing data supporting laser use in thrombus may lead to widespread use of laser in diffuse, thrombotic, long occlusions in the SFA (superficial femoral artery) and for infrapopliteal disease treatment in patients with non-healing ulcers. Little literature exists on the specific results of 308 nm Excimer laser catheter use for peripheral angioplasty. Significant research is still needed to prove the role of debulking in peripheral applications, but upcoming clinical trial data from the PELA (peripheral angioplasty vs. laser study in long SFA occlusions) and LACI (laser angioplasty in chronic ishaemia) may help to solve these questions in the near future. This article attempts to outline the technical issues of laser catheter use in percutaneous peripheral interventions, including access, sheath selection and wire techniques to cross even the most challenging obstructions in the peripheral circulation.

Keywords: Aortoiliac; Atherosclerosis; Excimer; Infrainguinal; Ischemia; Laser; Laser technique; Peripheral angioplasty; Tibeoperoneal

INTRODUCTION

The recognition of peripheral arterial disease is on the rise in the United States for a variety of reasons. The advancing age of the population results in the increased prevalence of the disease. Widespread education of cardiovascular specialists in the diagnosis and treatment of associated peripheral vascular disease has led to more intense screening. An active population has subsequently sought out treatment which is less invasive, of lower morbidity and with shorter recovery time. These factors have lowered the traditional threshold for percutaneous interventions to lifestyle limiting claudication from the traditional surgical revascularisation indications of rest pain or tissue ischaemia. In addition to traditional percutanous transluminal angioplasty (PTA) of peripheral arteries, a variety of adjunctive techniques have been employed, including thrombolysis, endovascular stents and debulking devices including rotational atherectomy and laser. This article will focus on the clinical use of the Excimer (xenon chloride) 308 nm wavelength laser in peripheral percutaneous interventions including aortoiliac, femoropopliteal and infrapopliteal disease.

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BACKGROUND

Laser angioplasty has been considered for percutaneous vascular intervention since the early 1980s. The concept of plaque ablation and potential vaporisation of atherosclerotic material appealed to interventionalists attempting to treat often-diffuse peripheral arterial lesions. This early enthusiasm led to widespread laser use, often with disparate equipment, techniques, and results. In addition, using the general acronym of laser to describe all devices, despite their wavelength or properties of tissue interaction led to misconceptions of poor results from one particular

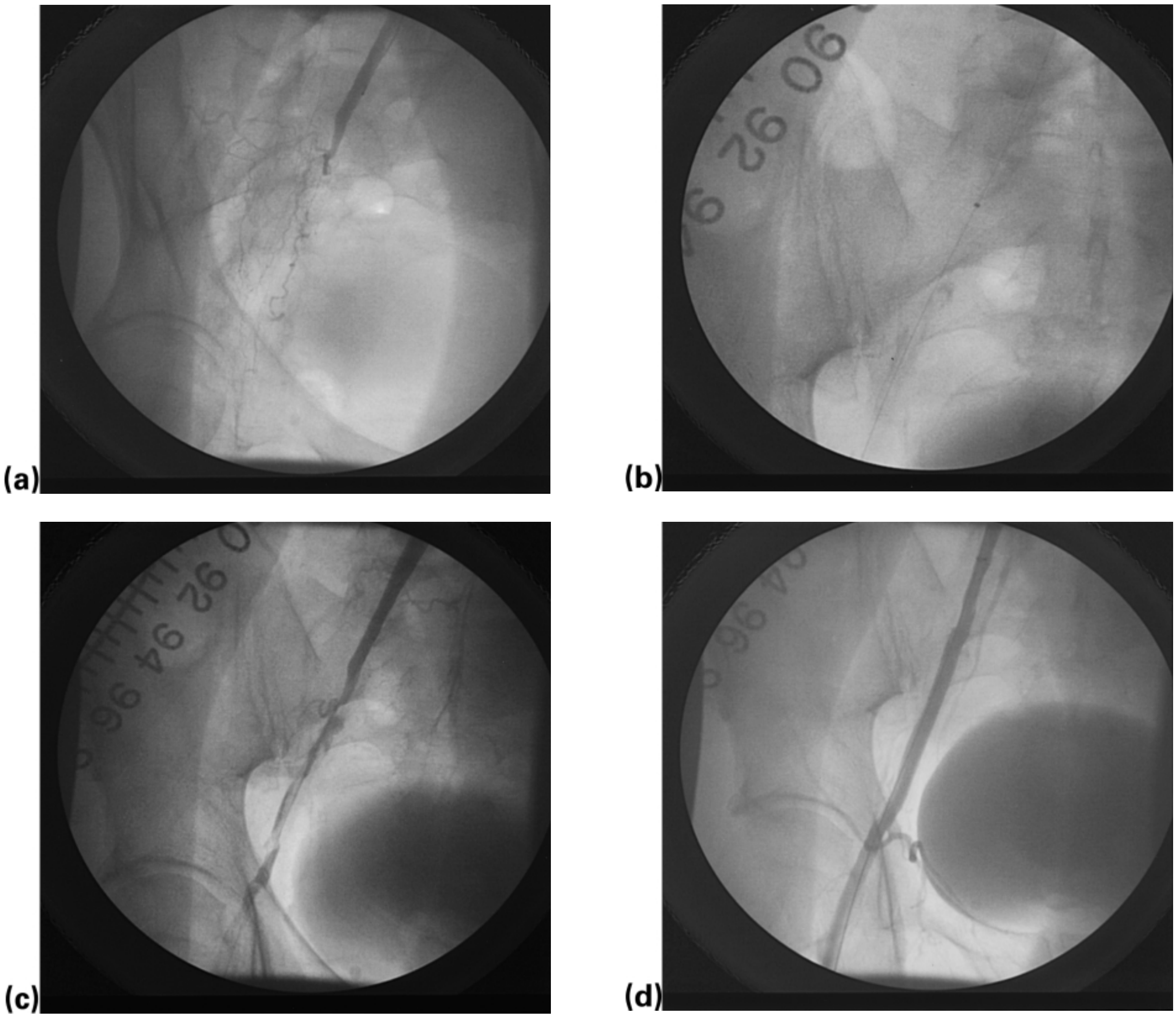


Fig. 1. Aortoiliac disease. (a) Right common iliac artery occlusion; (b) laser catheter in artery; (c) post-laser; (d) post-laser and stents.

system of laser delivery to be representative of all laser catheters.Therefore, assumptions of laser catheter success or failure become quite difficult due to the lack of standardisation in reporting results of different wavelength lasers. For instance, heat-producing lasers are often thought to be thrombogenic whereas athermic Excimer lasers of the 308 nm wavelength may be useful in treating thrombus [1]. Pulsed lasers have photochemical, photomechanical and photothermal effects. The ultraviolet 308 nm Excimer laser has minimal photothermal effects due to short pulse duration. The Excimer (308 nm) laser photon energy of 4.0 eV is higher than the enthalpies of a single carbon–carbon bond (3.6 eV) and leads to photochemical ablation. Vaporisation of tissue and bubbles by protein absorption of Xe-Cl lasers favour photomechanical ablation [2].

Recent advances in catheter technology, including optimally spaced fibres, athermic 308 nm wavelength spectrum catheters and saline infusion techniques [3], have greatly reduced the previously concerning problems of vessel injury, dissections and perforation.

AORTOILIAC DISEASE

Roughly one-third of peripheral arterial stenoses occur in the aortoiliac location (Fig. 1). Percutaneous transluminal angioplasty (PTA) has been shown to be an effective technique for focal iliac stenosis. The immediate technical success rate is 90–95% [4]. The patency rates are comparable to surgical series of roughly 80% at 5 years [5]. However, chronic occlusions of the iliac artery are technically much more challenging than stenoses. Since thrombotic material nearly always accompanies occluded iliac lesions, laser may be a safe alternative to thrombolysis [6]. Debulking the fibrotic and thrombotic atheromatous material in occluded aortoiliac segments may improve long-term outcome. However, the currently available laser catheters have a maximum diameter of 2.0 mm, thus limiting the effect of plaque vaporisation in less than critical lesions. Optimally spaced laser fibre catheters may improve the channel produced by the laser, but this remains to be proven in the peripheral circulation.

Lesion Considerations

Many interventionalists prefer the retrograde ipsilateral approach to aortoiliac occlusions. However, one should be aware of the potential complications of dissection of the distal aorta if the guidewire is not successfully passed intraluminally through the occluded segment [7]. For this reason, we prefer the contralateral approach for proximal aortoiliac occlusions.

Unilateral iliac artery occlusions can be divided into those with an adequate stump to engage a contralateral guiding catheter, and those which are flush occluded at the aortoiliac junction. The contralateral femoral approach is preferred for the former and brachial access is preferred for the latter. Adequate angiography is performed with 4–5 F pigtail catheters, using digital subtraction and roadmapping techniques to visualise the reconstitution of the distal iliac artery in the anteroposterior (AP) and ipsilateral lateral 30° views.

Equipment

The currently available laser catheters approved for coronary use which are used off-label in peripheral arterial disease include 1.4 mm concentric and 1.7 and 2.0 mm concentric and eccentric and the new 1.4, 1.7 and 2.0 mm optimally spaced (OS) RX catheters (0.014 inch guide wire compatible) and the 2.0 mm OTW Extreme catheters (0.018 inch guide wire compatible) (Spectranetics, Colorado Springs, CO). Currently being tested for peripheral use are the 2.2 and 2.5 mm extreme catheters (0.035 guide wire compatible).

Aortoiliac Laser Technique

After a 6F sheath is placed in the contralateral femoral artery, a guide catheter (internal mammary curve) is placed in the stump of the occluded iliac artery. An angled Terumo (Meditech, Watertown, MA) guide wire (0.035 in) is used to cross the occlusion with the support of a 4–5F straight glide catheter. The guide wire is then snared through the ipsilateral femoral artery via a 5–6F sheath and a 5–10 mm snare (Microvena Corporation, White Bear Lake, MN). The wire is then exchanged to an 0.018 inch guide wire (V-18 Control wire, Boston Scientific, Watertown, MA) which is placed in the proximal aorta. This is followed by laser plaque ablation using 2.0 mm or larger laser catheter. Typical fluence of 45–50 mJ/mm^2 and a repetition rate of 25–30 pulses/s is delivered. Multiple passes at 1 mm/s are performed to ensure complete plaque ablation. Saline infusion is used via the sheath when possible. Adjunctive laser plaque ablation in aortoiliac PTA may limit the frequency of peripheral embolic events in occluded iliac segments [8]. Usual PTA and stent techniques are then used to optimise the angiographic result and lumen size.

FEMOROPOPLITEAL DISEASE

Laser application may be well suited for infrainguinal percutaneous intervention because of the diffuse nature of the disease. In addition, occlusions outnumber stenoses 3:1. Superficial femoral artery (SFA) occlusions (Fig. 2) are five times more common than iliac occlusive disease. Difficulty in crossing occlusions greater than 5 cm has led to alternative techniques of recanalisation including laser angioplasty. The high restenosis rate in SFA stenoses with PTA alone may be theoretically lowered by debulking the atheromatous material with laser techniques.

Lesion Considerations

Long-term patency is negatively influenced by longer lesion length, occlusion, resting ischaemia, poor distal runoff and diabetes [9]. Case selection for femoropopliteal laser include visible proximal stump, reconstitution at the popliteal artery, minimal to no calcification and at least one vessel runoff. The actual

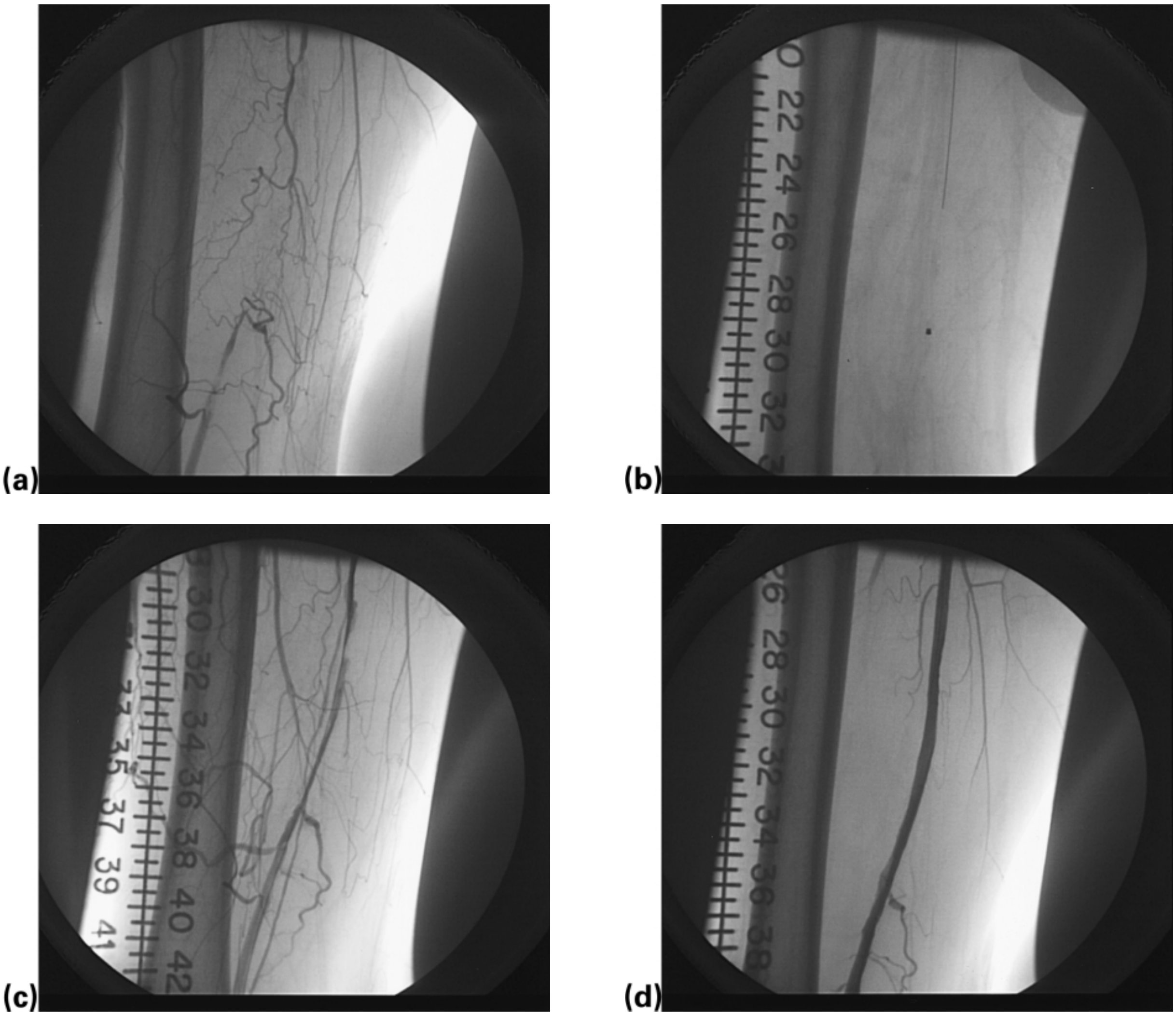


Fig. 2. Femoropopliteal disease. (a) Superficial femoral artery occlusion; (b) crossed with laser, step-by-step approach; (c) post-laser; (d) post-laser and stents.

length of the occlusion should not dissuade one from consideration of laser recanalization, particularly in light of the step-by-step technique (described below).

Equipment

The primary access for occluded and diffusely diseased SFA lesions should be contralateral. This avoids compression of the puncture site on the ipsilateral side of the intervention which may increase acute thrombosis. Contralateral access is followed by the passage of a stiff guide wire (0.035 Angled Terumo, Extra Stiff, or SuperCore wire, Guidant Corporation, Santa Clara, CA) to facilitate passage of a contralateral 8F sheath (Arrow International, Reading, PA). This large lumen sheath allows adequate saline infusion during laser passage. For femoropopliteal occlusions the 2.0 mm Extreme over-the-wire (0.018 inch guide wire compatible) catheter is used. A steerable wire with a hydrophilic tip (V-18 Control wire, Boston Scientific, Watertown, MA) can be used.

Technique

Primary wire passage of occluded SFA lesions greater than 5 cm may be difficult, or at least is unpredictable. Our experience suggests several critical points of attention during wire passage. First, in order to visualise the stump of an occluded SAF, try 30° of ipsilateral lateral rotation on the image intensifier. This separates the profunda femoris and SFA bifurcation well. Manoeuvre the hydrophilic guide wire to the stump of the lesion. Gently attempt to pass the guide wire using a soft-glide catheter for support. If it crosses the fibrotic cap which typically starts the lesion, attempt to cross distally and confirm wire placement by angiography in two views. If, however, the wire does not easily pass, place the Excimer laser catheter in the lesion stump. The step-by-step approach may allow safe passage of the laser through long occlusions of the SFA (Fig. 2b). Activate the laser catheter at a fluence of 45 mJ/mm^2 and 25 pulses/s and advance the catheter in small increments down the SFA using roadmapping imaging to visualise the distal vessel. While passing the catheter, note the course of the tip which should remain straight. If tip deformity occurs, or if the patient complains of leg pain, assume intimal disruption and pull the catheter back for contrast angiography. Attempt to pass the guide wire to the distal reconstituted vessel periodically, and especially try to cross the final 2–3 cm of the occlusion with the wire to avoid perforation around the adductor canal region. Interestingly, perforation in this step-by-step approach is 2.2% in large series. Confirm intraluminal position by passing a 0.014 inch or 0.018 inch support catheter (Spectranetics, Colorado Springs, CO) distally for selective injection. Repeat laser passes three or four times using the saline-infusion technique. Unfortunately, the maximum laser catheter approved in the US is 2.0 mm and adjunctive balloon angioplasty and stenting is often necessary for optimal results.

Results

SFA laser angioplasty results are difficult to compare. This problem exists due to the multiple wavelength catheters the tissue interaction of which is dramatically variable and cannot be adequately compared. The initial success rates of Excimer laser angioplasty in superficial femoral artery occlusions varies in older literature from 50% to 80% [10]. The majority of studies quote a 70–75% patency rate at 12 months, regardless of the laser used [11]. Nonetheless, the largest series of SFA occlusions treated by Excimer laser comes from Biamino et al. [12]. In that series 411 lesions with a mean occlusion length of 19.4 ± 6 cm, showed clinical benefit after secondary intervention of 75.1% at one year. More results should become available from the ongoing PELA trial (Peripheral Excimer laser vs. angioplasty trial) comparing laser to balloon in 10 cm or longer SFA occlusions.

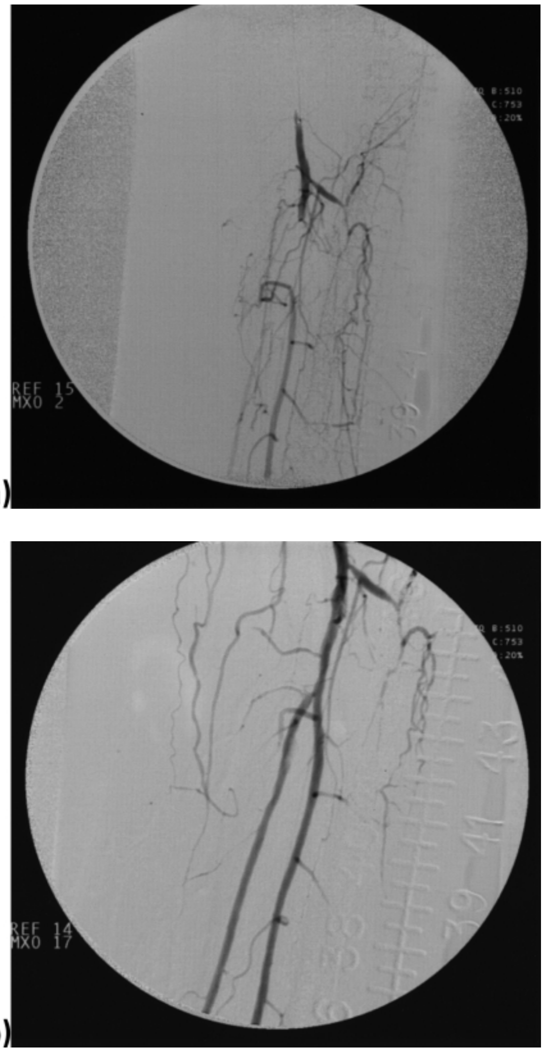
(a)
(b)


Fig. 3. Tibioperoneal disease (non-healing ulcer). (a) Left tibioperoneal trunk pre-laser; (b) post-laser and percutaneous transluminal angioplasty (balloon).

INFRAPOPLITEAL DISEASE

Lesion Considerations

Peripheral vascular disease below the knee is often diffuse. The goals of treatment are, however, different from above the knee intervention. A primary indication for infrapopliteal angioplasty with laser is for treating non-healing ulcers (Fig. 3). In this clinical scenario, restoration of one vessel blood flow, even if transient, may accomplish the goal.

Restenosis rates are uniformly high in below-the-knee interventions [13]. Generally speaking, single vessel runoff to the foot is sufficient to prevent critical lower limb ischaemia.

Equipment

Coronary techniques, including 0.014 inch guide wires and coronary balloons lead the equipment list in infrapopliteal intervention. Access is often antegrade due to the long distance of lesions from a contralateral approach, although I personally use cross-over techniques more frequently to avoid antegrade access complications. Laser catheters of the 1.4 mm, 1.7 mm and 2.0 mm both concentric and OS are used. The only downside to these catheters from a contralateral approach is the monorail system which limits pushability, although this does not usually preclude successful ablation. Stent placement below the knee is done only for focal occlusive dissection and is done with coronary stents.

Technique

Standard hydrophilic 0.0014 inch guidewires (Choice PT, Boston Scientific, Watertown MA) with a 0.014 inch support catheter (Spectranetics, Colorado Springs, CO) can be used to cross the lesions. The laser should not be activated to ablate plaque below the knee unless the wire has completely crossed the lesion. Blind laser passage using the step-by-step approach could lead to perforation and compartment syndrome, which should clearly be avoided.

Results

Published clinical information on percutaneous intervention of the tibeoperoneal trunk vessels and below is far more scarce than iliac or SFA lesion data. There are no randomised data comparing large numbers of patients with limb ischaemia, or non-healing ulcers or even intermittent claudication with anatomical below-the-knee disease. In addition, surgical patency of prosthetic graft material below the knee is not encouraging [14]. Calcification is common below the knee and the 308 nm laser system has shown promise in the subset [15]. Current investigation of laser technique for non-healing ulcers in the LACI (Laser angioplasty for chronic ischaemia) is ongoing and should help answer these questions.

CONCLUSIONS

Excimer laser angioplasty has changed dramatically since its inception in the early 1980s. New catheter designs with optimally spaced fibres and larger lumen sizes of the 308 nm wavelength type have confronted prior problems of vessel thermal injury, perforation and dissection and have proven to be very clinically useful. In the peripheral circulation, especially for long SFA occlusions, lasers appear to be very promising to create a channel in the most challenging cases. Most intriguing, however, may be laser interactions with thrombus to decrease platelet aggregation and combat areas of clot formation in the peripheral anatomy. This technique, possibly used adjunctively with endovascular radiation and endoluminal graft placement may prove to be revolutionary for improvement of long-term patency for peripheral percutaneous interventions.

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