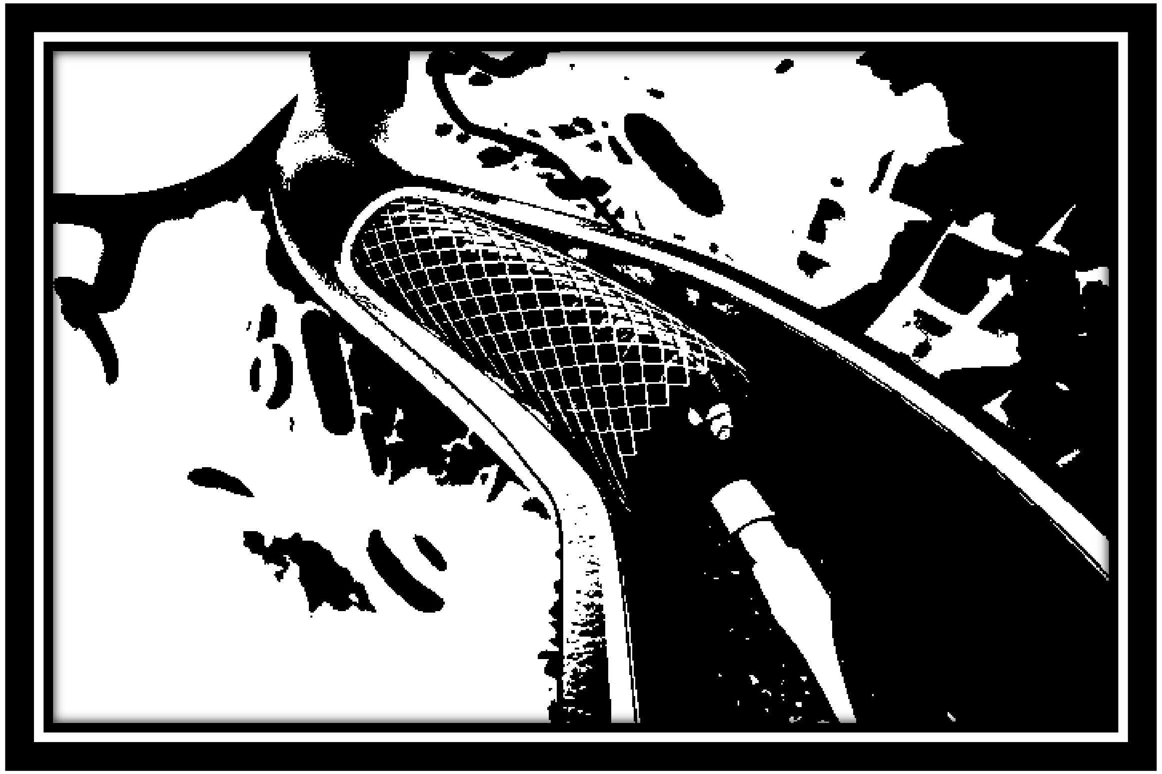
LASER ATHERECTOMY



0. OVERVIEW

Type of Laser:

Recent studies have examined how pulsed UV lasers can ablate atherosclerotic plaque with high precision and minimal damage to surrounding tissue. Multiple laser types and parameters were evaluated, with a focus on understanding the relationship between laser settings, tissue effects, and ablation efficiency.

First: ArF Laser on Arterial Wall Tissue (193 nm)

Parameters: ~14 ns pulse duration; fluence of 200–300 mJ/cm^2; 3–10 Hz pulse rate.

Observations:

-Trenches with sharp, clearly defined boundaries.
-Ablation depth increased proportionally with the number of pulses.
-Minimal thermal damage observed; endothelial cells within crater borders remained intact.

0. OVERVIEW

Type of Laser:

Second: Thermal Effects of Pulsed UV Laser Radiation (193 nm)

Method: Temperature measurements at various distances from the crater edge using a thermocouple.

Results:

- -No microscopic damage to adjacent endothelial cells.
- -Crater walls were smooth and free of thermal or carbonization residues.

Third: XeCl Laser on Atherosclerotic Aorta Samples (308 nm)

Parameters: 85 ns pulse duration; 10 Hz repetition rate; experiments conducted in both air and saline.

Findings:

- -Results consistent with the ArF laser study—minimal collateral tissue damage.
- -Demonstrated that both laser types produce precise cuts with limited thermal and mechanical effects.

0. OVERVIEW

Precision & Safety:

Both the ArF (193 nm) and XeCl (308 nm) lasers are effective in creating clean, sharply defined craters with minimal adjacent tissue damage. This high degree of precision supports their potential use in vascular procedures.

Laser Types and Tissue Effects:

UV Excimer Lasers (193 nm, 248 nm, 351 nm):

- Produce constant ablation rates linearly dependent on laser power.
- Show no charring or tissue disruption under light microscopy.

Visible Lasers (CW or chopped argon, frequency doubled Nd:YAG):

- CW argon lasers cause extensive charring and coagulation necrosis.
- Chopped argon lasers produce a narrow rim of damage.
- Pulsed Nd:YAG lasers create subtle clefts without significant thermal damage.

0. Overview

Absorption Properties & Selectivity:

Photoacoustic measurements revealed no significant difference in the absorption of UV light between healthy arterial tissue and plaque.

This similarity limits the possibility of selectively ablating diseased tissue while sparing healthy tissue.

Threshold Fluence and Wavelength Dependence:

Threshold Fluence: Increases with longer wavelengths.
Shorter wavelengths (with higher absorption coefficients) require lower energy to initiate ablation.
Consistent threshold values were determined using multiple methods (microscopy, hydrocarbon product analysis, photoacoustics).

0. OVERVIEW

Pulse Duration and Fluence per Pulse:

Pulse Width Comparison: Similar high-quality cuts were produced with both 300 ns and ~10 ns pulse widths.

Fluence Effects:

-An optimal fluence range of 2–15 J/cm^2 was identified.

-Too low fluence results in shallow, thermally damaged cuts; too high fluence causes surface disruption and acoustic damage.

1. LASER

Type of Laser:

•**Excimer Laser**: The most commonly used laser in atherectomy procedures is the excimer laser. This type of laser emits ultraviolet (UV) light and is known for its precision and ability to ablate tissue without causing significant thermal damage to surrounding areas.

1. **Wavelength**: The excimer laser used in atherectomy typically operates at a wavelength of 308 nanometers (nm). This specific wavelength is highly effective at breaking down plaque while minimizing damage to the arterial wall.
2. **Pulsed Energy**: The laser delivers energy in short, controlled pulses. This pulsed delivery helps to vaporize the plaque efficiently while reducing the risk of overheating and damaging the surrounding tissue.
3. **Fiber Optic Delivery**: The laser energy is delivered through a flexible fiber optic catheter, which can be navigated through the vascular system to the site of the plaque buildup.

2.Components

1.Laser Console:

The main unit that generates and controls the laser energy.

Typically uses an **excimer laser** with a wavelength of 308 nm (ultraviolet light).

Delivers energy in short, controlled pulses to minimize thermal damage.

Includes adjustable settings for energy output, pulse duration, and frequency.

2.Catheter System:

A flexible, thin tube that delivers the laser energy to the target site.

Contains a **fiber optic core** that transmits the laser light.

The catheter tip is designed to emit laser energy in a controlled manner, often with a **side-firing** or **forward-firing** configuration.

May include additional features like **guidewire compatibility** for precise navigation.

2.Components

3.Guidewire: A thin, flexible wire used to guide the catheter through the vascular system to the site of the plaque. *Helps ensure accurate placement of the laser catheter.*

4.Imaging and Monitoring Systems:

- **Fluoroscopy**: Real-time X-ray imaging to visualize the catheter and guidewire during the procedure.
- **Intravascular Ultrasound (IVUS)**: Provides detailed images of the artery and plaque to guide treatment.
- **Optical Coherence Tomography (OCT)**: High-resolution imaging to assess plaque composition and vessel structure.

5.Cooling System: Some devices include a saline flush or cooling mechanism to reduce heat buildup and protect the arterial wall.

6.Control Interface: A user-friendly interface for the operator to adjust laser settings, monitor energy delivery, and ensure safe operation.

2.COMPONENTS

FIGURE 4. The excimer laser atherectomy device (Spectranetics) consists of a variably sized fiber-optic catheter (2.7-7.5 Fr) and a central console.

3. Mechanism

A. Photoablation

1.Energy Absorption:

The laser emits high-energy light (often ultraviolet (UV) light in the case of excimer lasers) at a specific wavelength (e.g., 308 nm).

The plaque absorbs this energy, which is highly selective for the molecular structure of the plaque.

2.Molecular Bond Breaking:

The absorbed energy breaks the molecular bonds within the plaque, causing it to disintegrate into tiny particles.

This process is sometimes referred to as "cold ablation" because it minimizes heat generation, reducing the risk of thermal damage to the arterial wall.

3.Vaporization:

The plaque is vaporized into gas and microscopic particles, which are either absorbed by the body or carried away by the bloodstream.

3. Mechanism

B. Micro-explosions

Laser Energy Delivery: The excimer laser delivers short, high-energy pulses of ultraviolet (UV) light (typically at a wavelength of 308 nm). The plaque absorbs this energy, which is highly selective for the molecular structure of the plaque.

Rapid Energy Absorption:The absorbed energy causes the plaque to heat up extremely quickly at a microscopic level.

This rapid heating leads to the formation of tiny gas bubbles within the plaque.

Explosive Vaporization:The gas bubbles expand and collapse almost instantly, creating micro-explosions. These explosions break the plaque into tiny particles, effectively vaporizing it.

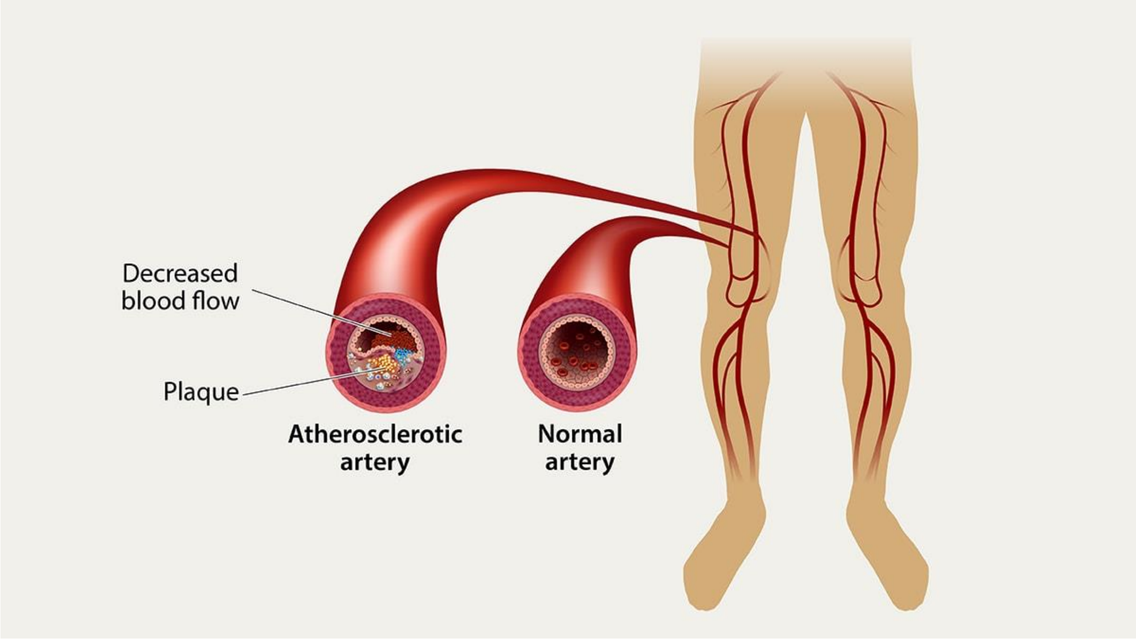
Particle Formation:The plaque is fragmented into microscopic particles, typically smaller than 10 microns in diameter. These particles are small enough to be safely absorbed by the body or carried away by the bloodstream without causing blockages in smaller vessels.

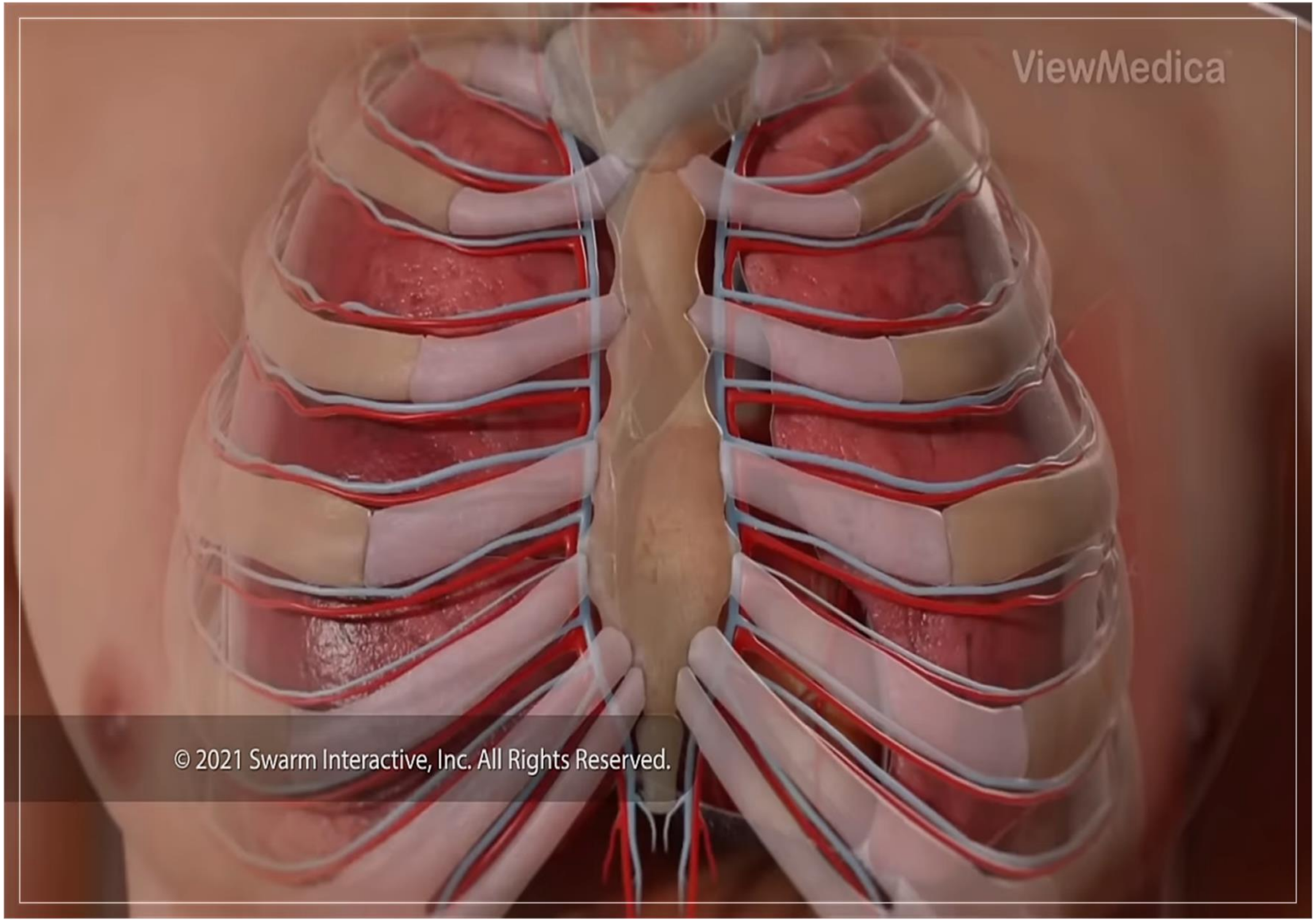
4. Indications

•**Peripheral Artery Disease (PAD)**: Often used in leg arteries to improve blood flow.

•**Coronary Artery Disease (CAD)**: Sometimes used in heart arteries, especially in cases where traditional angioplasty or stenting is challenging.

•**Calcified Lesions**: Effective for heavily calcified plaques that are difficult to treat with other methods.

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5. Risks and Complications

- **Artery Damage**: Potential for perforation or dissection of the artery.
- **Embolization**: Small particles of plaque can break off and block smaller vessels.
- **Restenosis**: Re-narrowing of the artery over time.
- **Infection**: Risk of infection at the catheter insertion site.

Much thanks