



Designing an Interlocking Biodegradable Drug-eluting Left Atrial Appendage Occlusion Device

A "Seal and Heal" Approach to Stroke Prevention in Atrial Fibrillation Patients

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of ENGINEERING

The Problem

In **atrial fibrillation (AFib)**, blood can pool in the left atrial appendage (LAA), a small pouch in the heart's upper left chamb, forming clots that may travel to the brain and cause strokes.

90%

Strokes caused by clots in the LAA

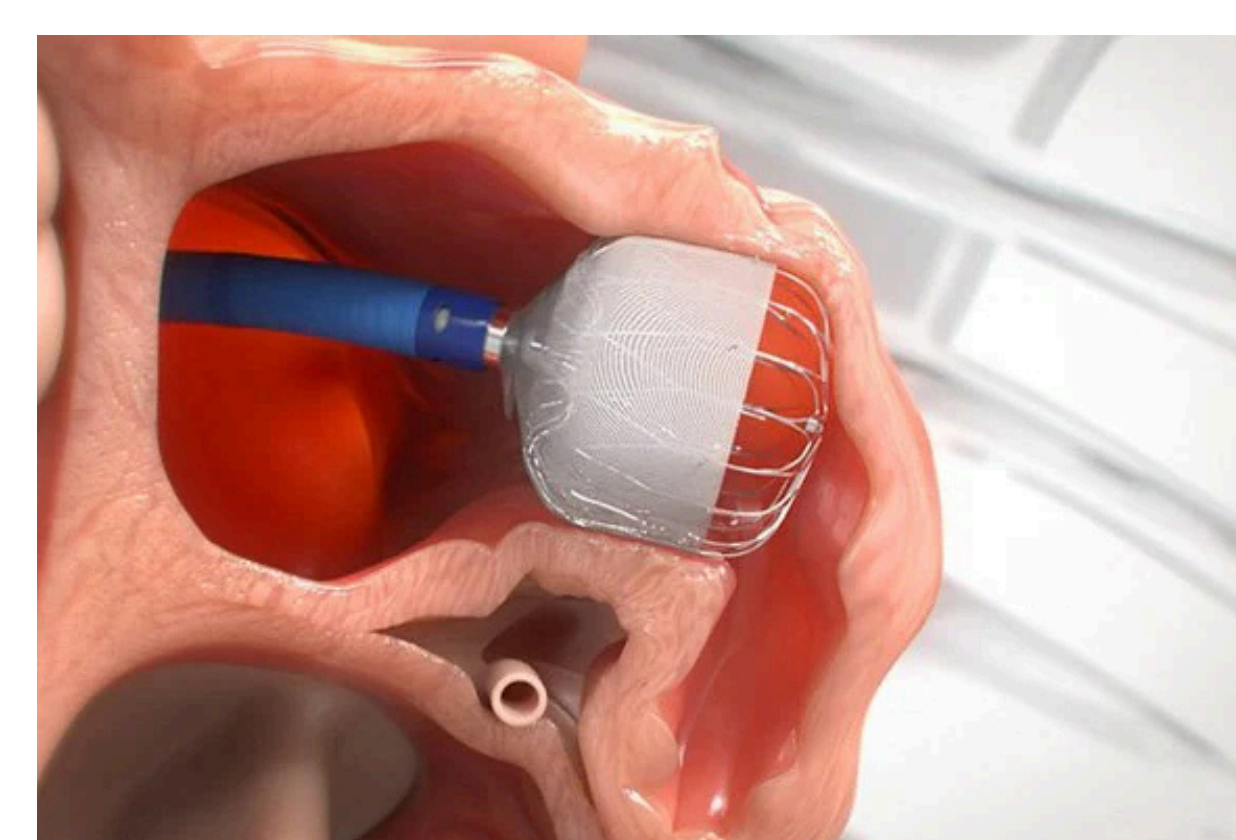
10.55M

Predicted Adult Afib Patients in the US (2024)

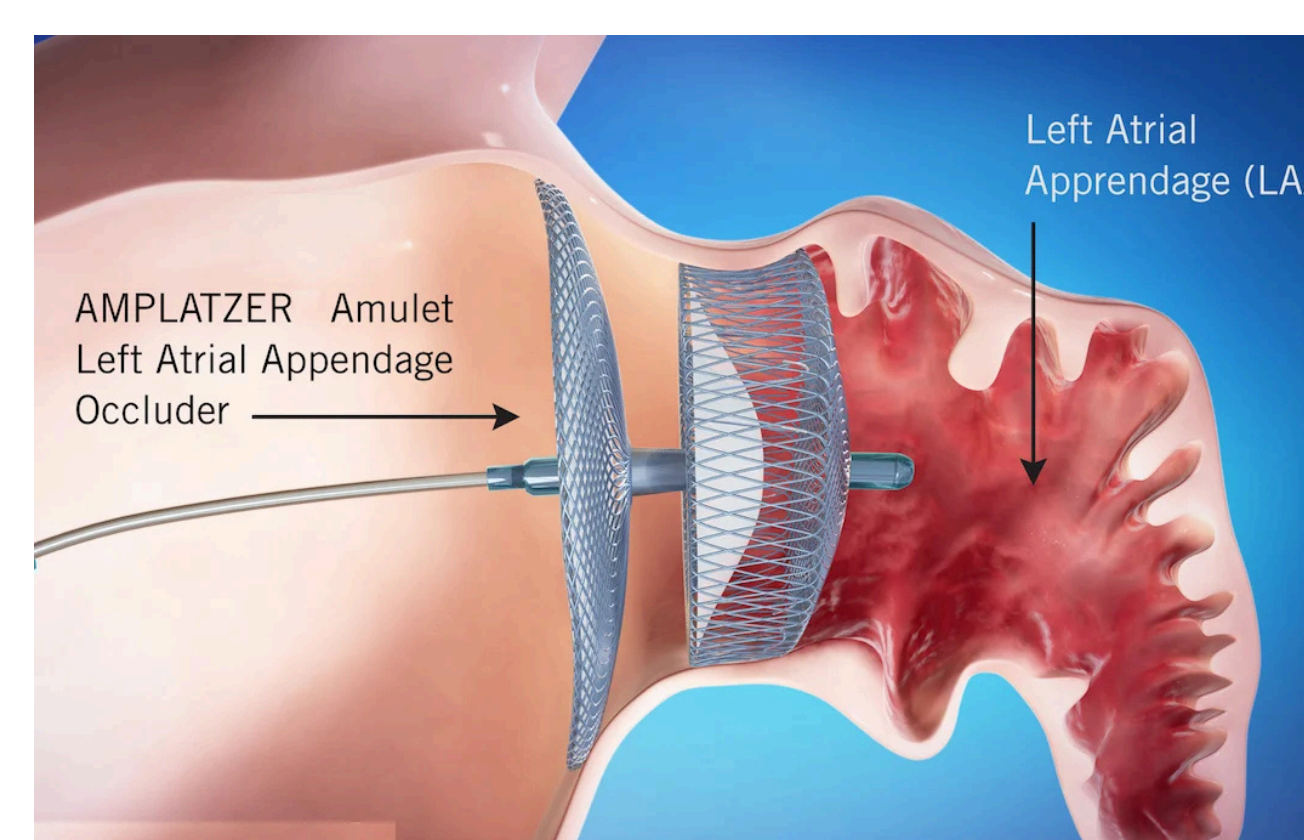
40%

Reduced risk of thromboembolism with LAA removal

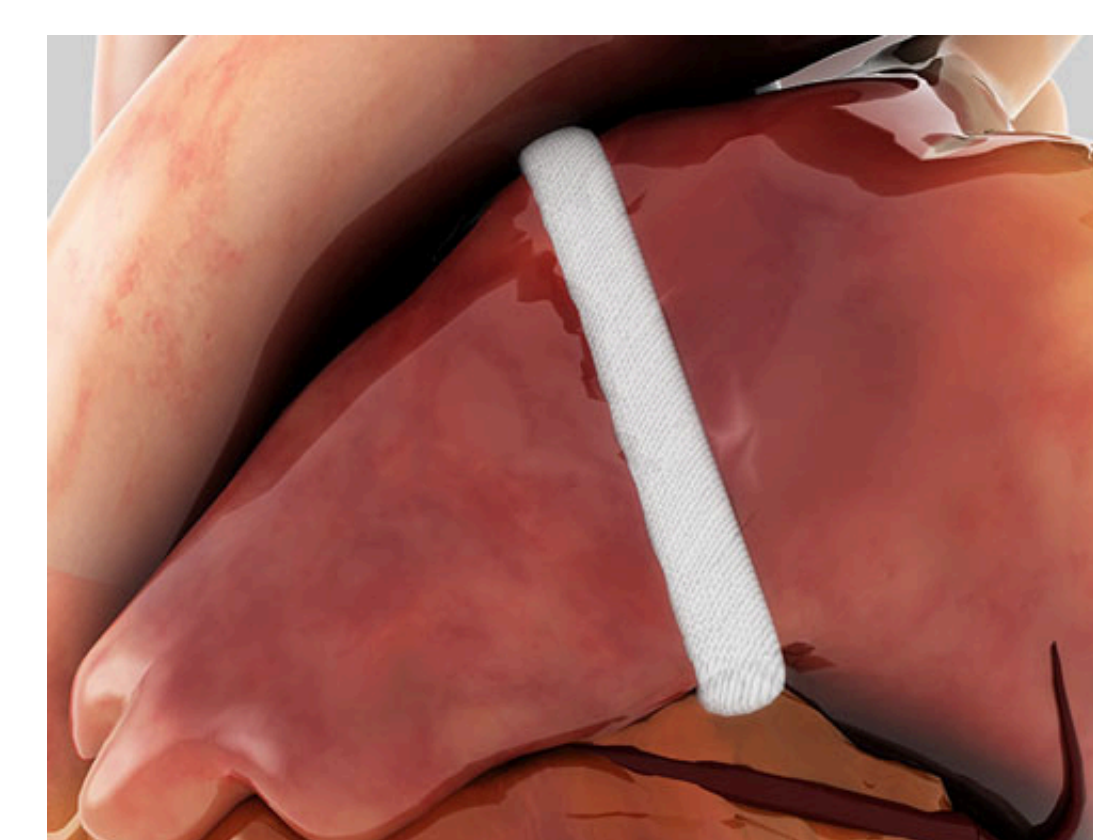
Limitation of Current Devices



WATCHMAN by Boston Scientific



Amplatzer Amulet LAA by Abbott



Atriclip by AtriCure

Current devices can have incomplete sealing, device-related thrombosis (DRT), and long-term complications. There's a need for a **biodegradable, drug-eluting LAA occlusion device** that can promote proper healing and safely resorb.

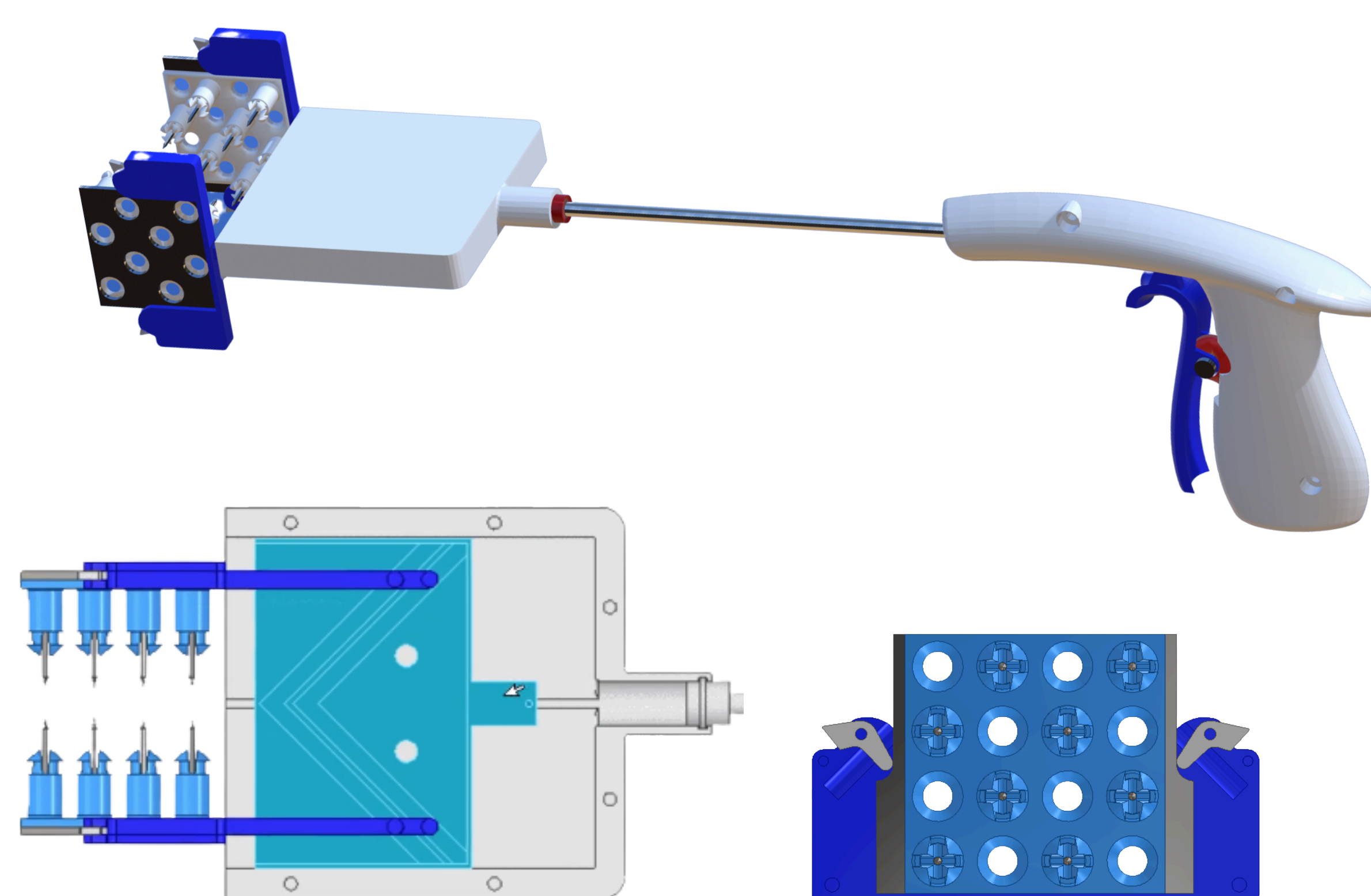
Mechanical Design

Design Evolution

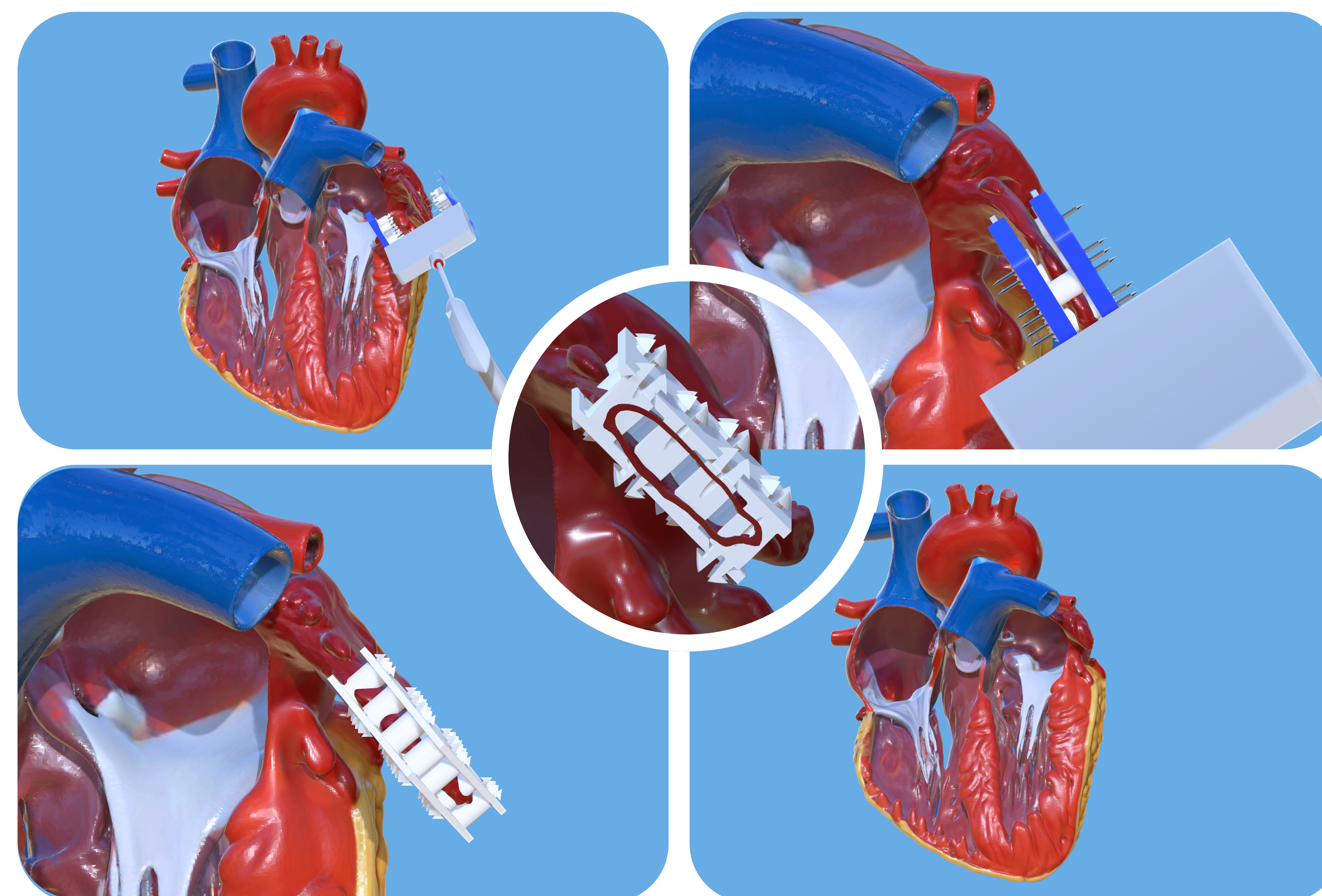
- Initial **hook-and-loop fastener** design
- Switched to **snap-fit** geometry for tunable application force
- Easily manufacturable in **sheets** that can be cut afterwards

Applicator Mechanism

- Single trigger activates a **parallel sliding actuator**
- Designed for simple, controlled operation with minimally invasive procedures
- Easily producible via additive manufacturing



Our Solution



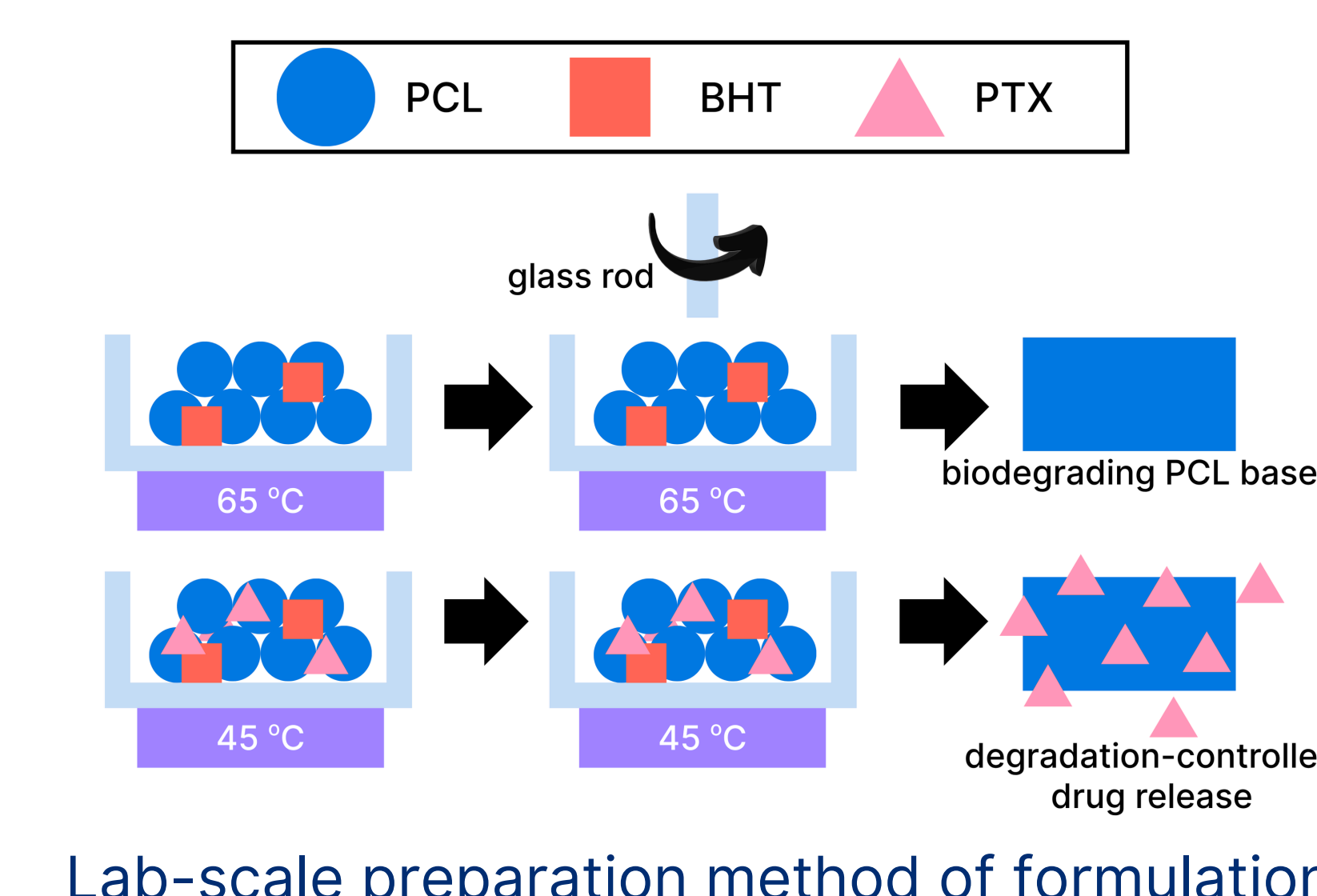
Materials Selection

- Polycaprolactone (PCL)** for biodegradability, easy drug loading, and tunable degradation
- Butylated hydroxytoluene (BHT)** added as a low-weight % antioxidant to prevent oxidation and discoloration during melting



Drug Selection & Delivery

- Paclitaxel (PTX)**, Sirolimus, Amiodarone explored to suppress endothelial regrowth and restenosis
- PTX stabilizes microtubules, arrests G2/M phase, inhibits smooth muscle and endothelial proliferation while allowing controlled fibrotic healing
- Hydrophobic, thermally stable PTX enables melt-blending and sustained **8-10 week** release at 0.5-1 $\mu\text{g}/\text{mm}^2$

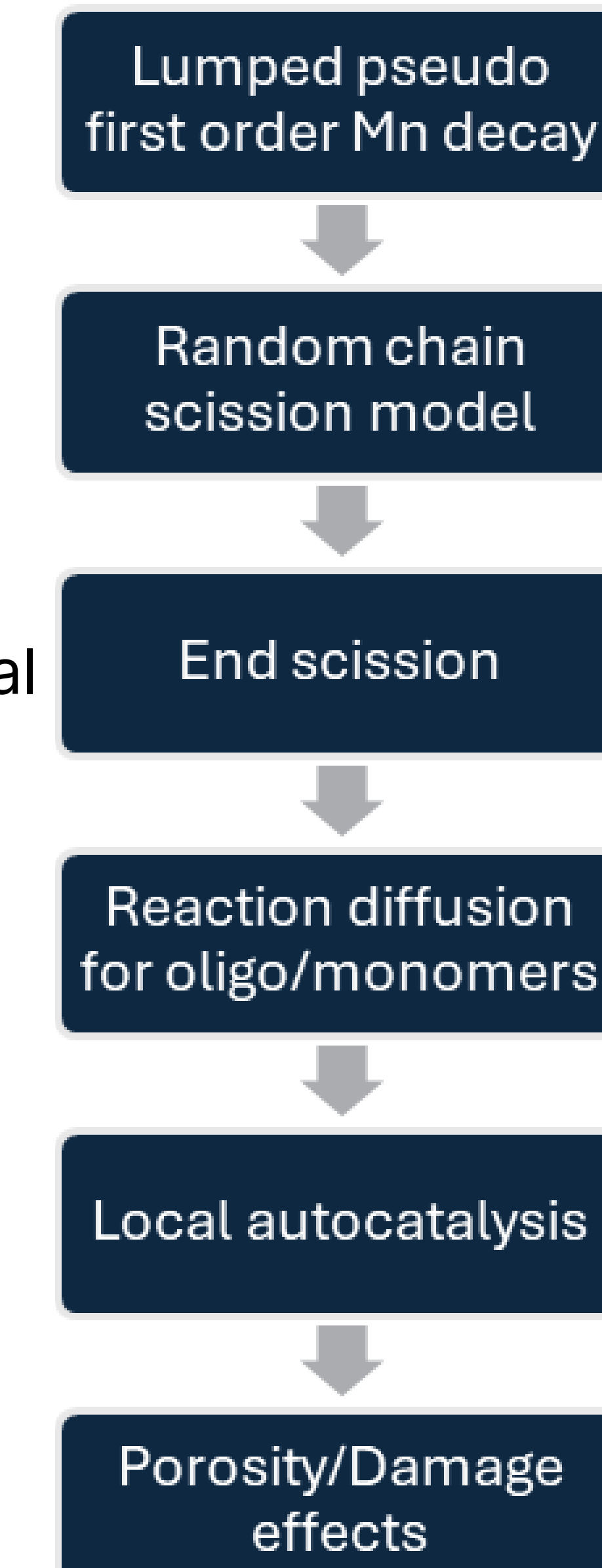
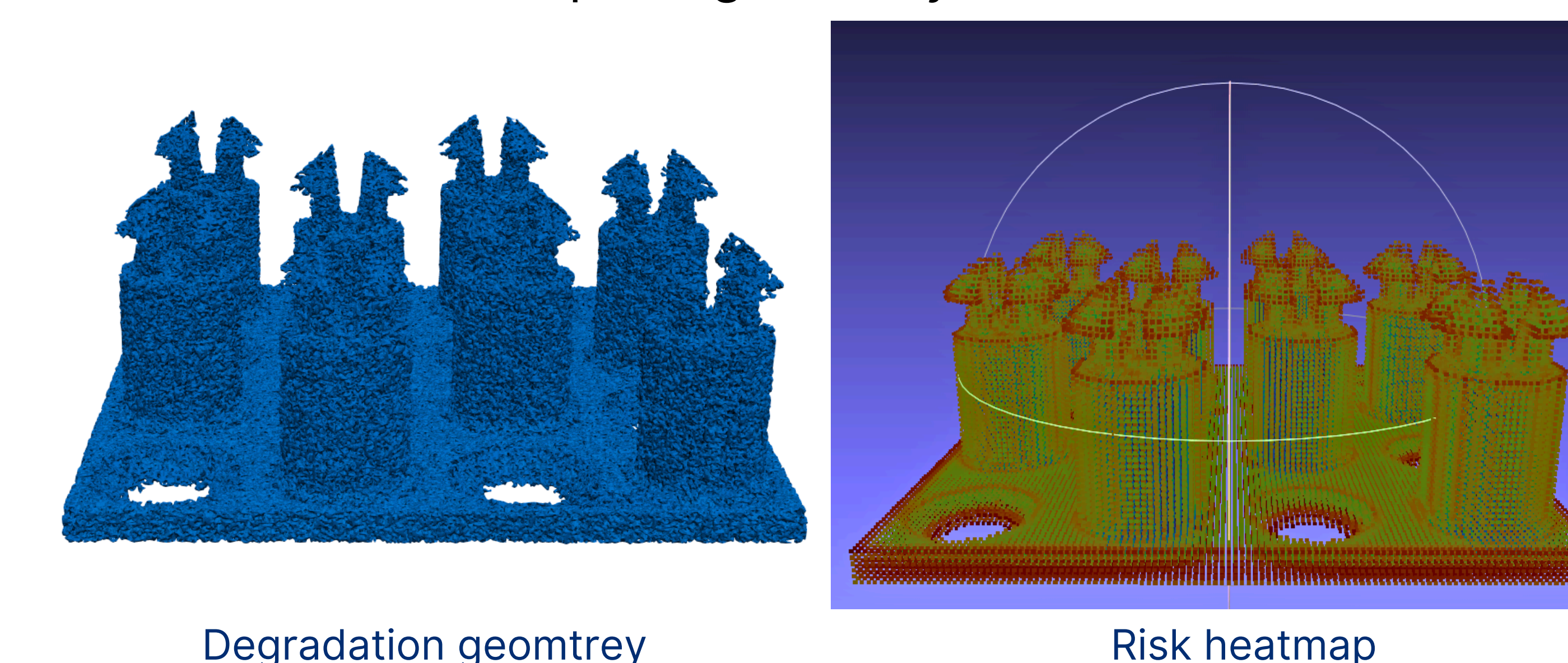


Melt-blending

- Simple production method that serves as a **bridge between benchtop formulation and scalable implant manufacturing**
- No residual solvent** means less cytotoxicity concerns and cleaner regulatory path

Computational Degradation Model

- CAD-based** degradation model predicts molecular weight loss, porosity, and structural risk over time for PCL devices based on diffusion-reaction systems and known polymer degradation mechanisms
- Voxel grid simulates water uptake and retained acidic byproducts, visually couples mass loss and erosion behavior
- Heatmap highlights **regions most prone to failure** over time using stress-to-strength ratio, enables prediction of functional lifetime for a set implant geometry

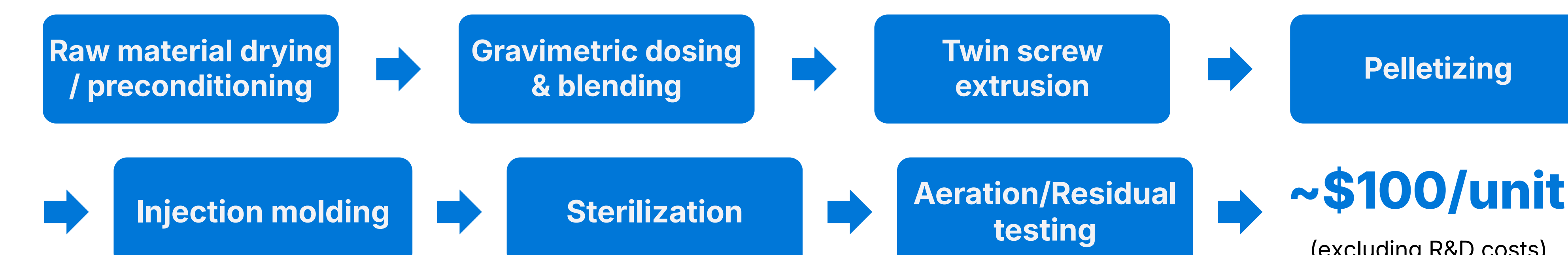


Scale-up & Broader Impact

- Injection molding** method proposed for scale-up
- Adaptable geometry** for other occlusion therapies
- Tunable drug delivery options** with post-production dip coating
- Low-cost & low-risk alternative** to typical occlusion implants

~98%

cost reduction
(excluding R&D costs; predicted WATCHMAN gross margin of 85%, per industry avg)



Acknowledgements

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