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Next BRS : What Are Going to Change?

April 28 10:18-10:26 AM

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What are the new BRS going to change?

Mechanical, design, and material improvements of new BRS:

1. Stronger and ductile scaffold

1. Thinner/round struts

1. Fast resorption without inflammation

Expected clinical improvements with new BRS:

1. More radial strength, flexible sizing, resistance to fracture

2. improved deliverability with thinner profile; Improvement in rheology and decreased thrombogenicity

3. Early manifestation of anatomo-physiological benefits: late lumen enlargement, restoration of vasomotion, and plaque reduction; Reduction of late events

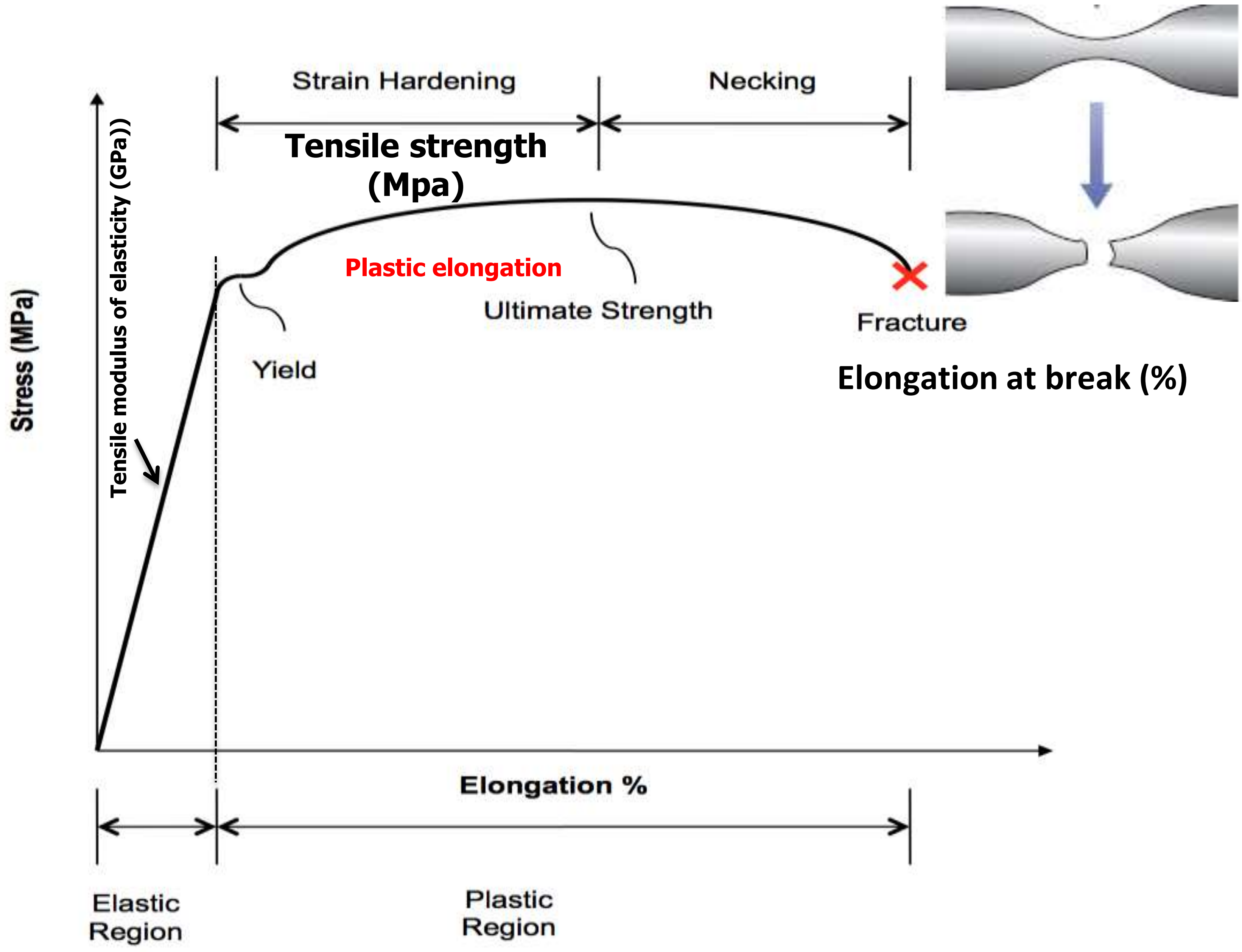
Current limitation of BRS

If a bioresorbable scaffold is ultimately expected to have the same range of applicability as a durable metal stent, the gap in mechanical properties must be reduced.

Currently, three primary limitations exist:

- **Low tensile strength and stiffness which require thick struts to prevent acute recoil**
- **Insufficient ductility which impacts scaffold retention on balloon catheter and limits the range of scaffold expansion during deployment**
- **Instability of mechanical properties during vessel remodeling if bioresorption is too fast**

Let’s take a “crash course” of material science



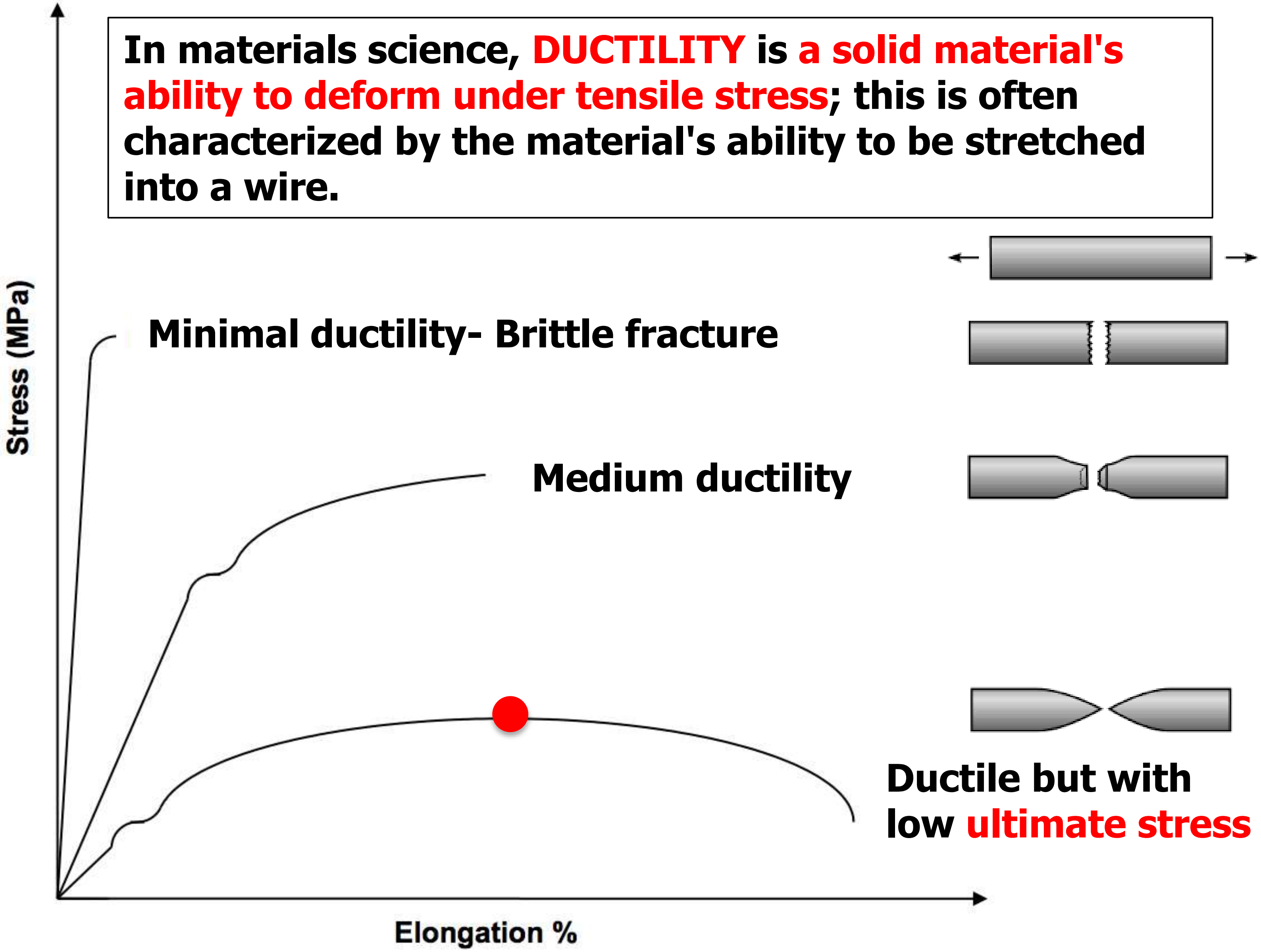
Mechanical properties of metal vs. PLLA

Polymer/ metal	Tensile modulus of elasticity (Gpa)	Tensile strength (Mpa)	Elongation at break (%)
Poly(L-lactide)	3.1-3.7	60-70	2-6
Poly (DL-lactide)	3.1-3.7	45-55	2-6
Cobalt chromium	210-235	1449	～40
Magnesium alloy	40-45	220-330	2-20

Onuma, Serruys Circulation 2011

Insufficient ductility impacts scaffold retention on balloon catheter and limits the range of scaffold expansion during deployment

In materials science, **DUCTILITY** is **a solid material's ability to deform under tensile stress**; this is often characterized by the material's ability to be stretched into a wire.

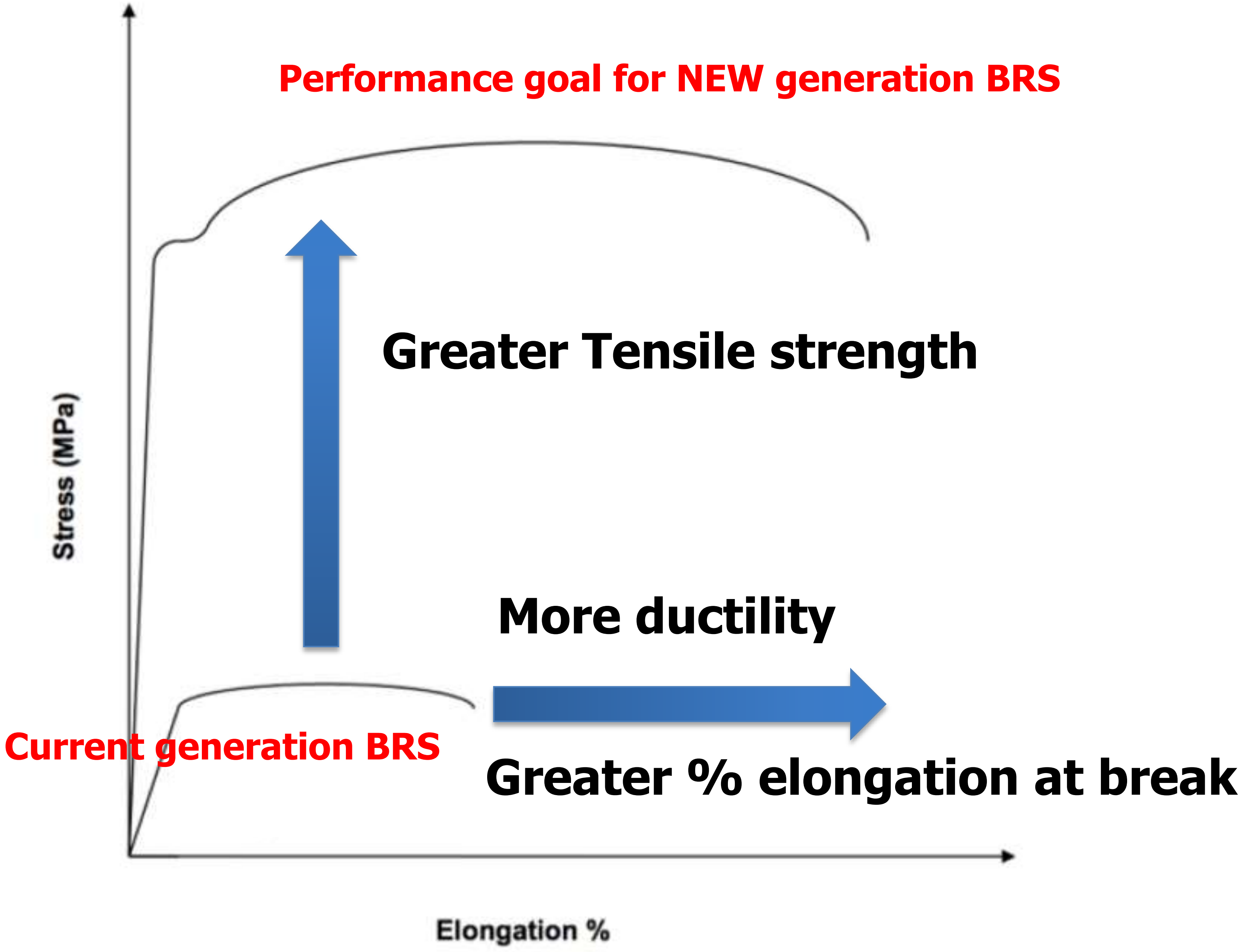


Minimal ductility- Brittle fracture

Medium ductility

Ductile but with low ultimate stress

Performance goal and mechanical dilemma



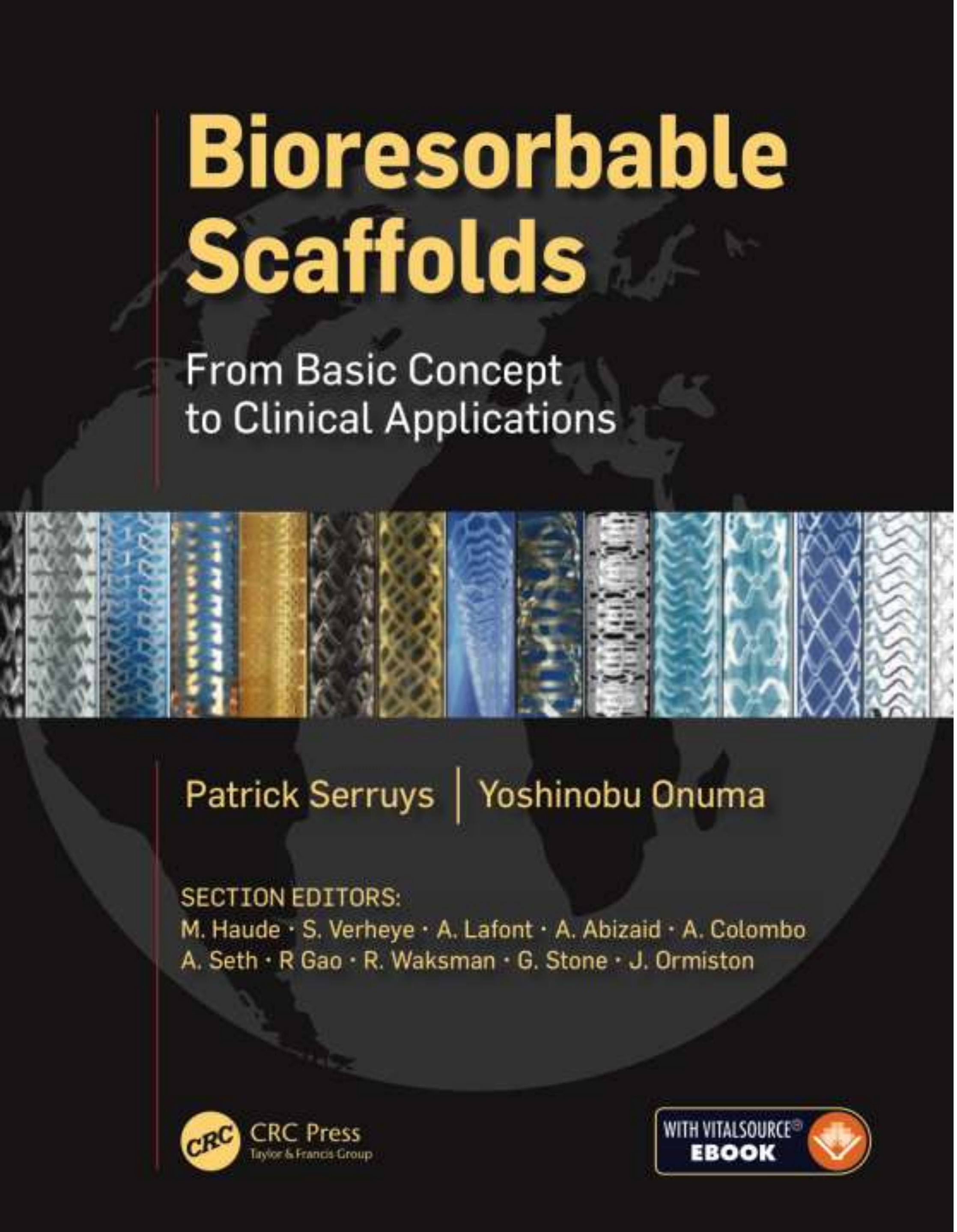
Performance goal for NEW generation BRS

Greater Tensile strength

More ductility

Current generation BRS

Greater % elongation at break



Bioresorbable Scaffolds

From Basic Concept
to Clinical Applications

Patrick Serruys | Yoshinobu Onuma

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EBOOK

Chapter 10
Emerging technologies (Pre-CE mark, Pre FDA, pre PMDA and pre CFDA)

Lifetech

Qualimed

Meril life

Orbus Neich

Abbott: New generation Absorb scaffold

Arterius

Manli

Boston Scientific

Huaan tech

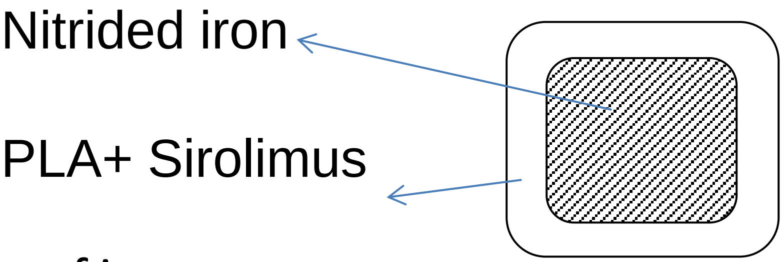
Lepu

Use of metal stand alone
or in combination of polymer

Use of metal stand alone or in combination of polymer

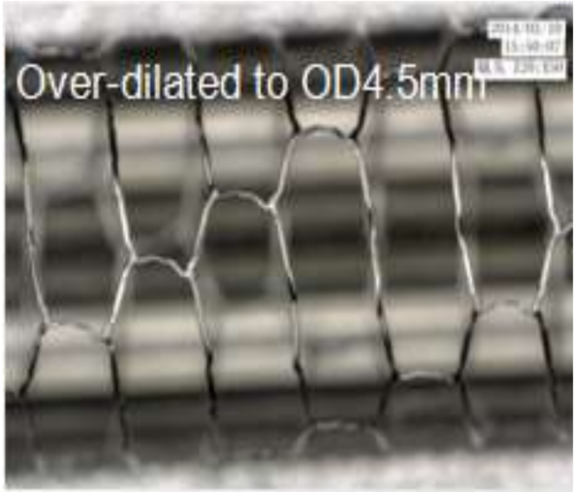
e.g. Nitrided iron bioresorbable stent

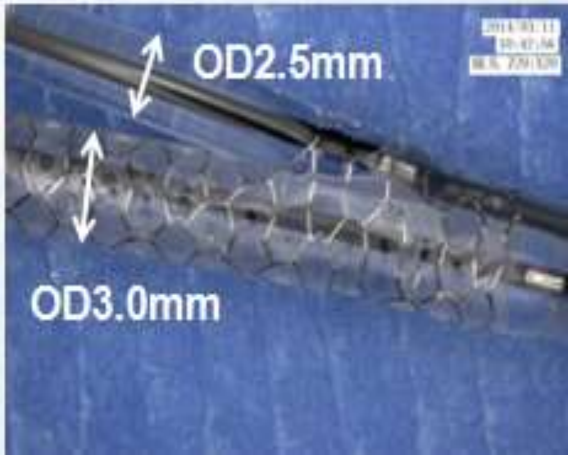
BRS:



Nitrided iron

PLA+ Sirolimus



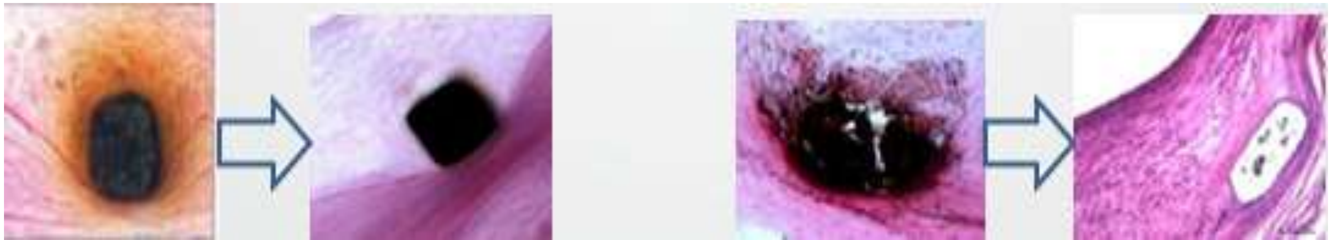


Unique problems of iron stent:

1. Material aspects
   - a) Understand how iron behaves in vivo and in vitro situations
   - **b) Expedite in vivo corrosion of iron**
   - c) Eliminate particulates during in vivo corrosion

2, Biological aspects
   - a) Develop extraction methodology for biological tests of iron ions
   - b) Remove rust staining from tissue for subsequent histological observation ……….

Long way to go before CE marking



Use of metal stand alone or in combination of polymer

e.g. Unity Hybrid BRS: Magnesium Core with Polymer Outer

- **Stent Expansion**

Uniform expansion of the stent. No cracks or flakes were observed during visual inspection of crimped stents and during expansion to maximum diameter (4.8 mm)

- **Foreshortening**

Measurements of foreshortening resulted to almost zero foreshortening

- **Radial Force (RF)**

Radial force measurements resulted to about 1.500 mN which is comparable to regular stainless steel stents

- **Visibility**

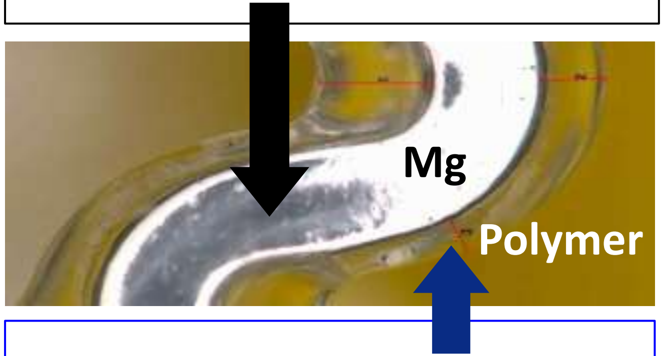
Fluoroscopic visibility can be improved by FePt particle incorporation in the coating of adding markers

- **Acute Recoil Measurement**

Very low acute recoil which ranged between 1.98% and 1.13%

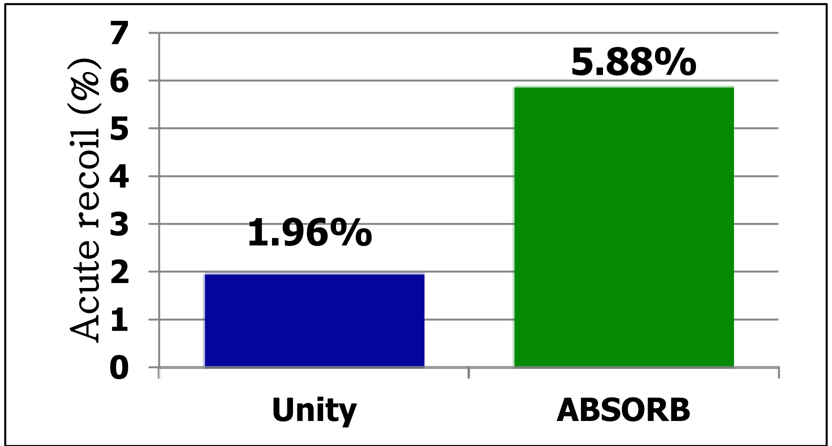
Backbone (Mg)

The Skeletal portion of the system serves as the main support structure for the body.



Muscle (polymer)

The Muscles keep bones in place and also play a role in the movement of bones.



“Playing” with composition of polymers

Polymer composition
Poly(L-lactide)
Poly (DL-lactide)
Poly (glycolide)
50/50 DL-lactide/glycolide
82/18 L-lactide/glycolide
70/30 L-Lactide/ε-caprolactone etc…

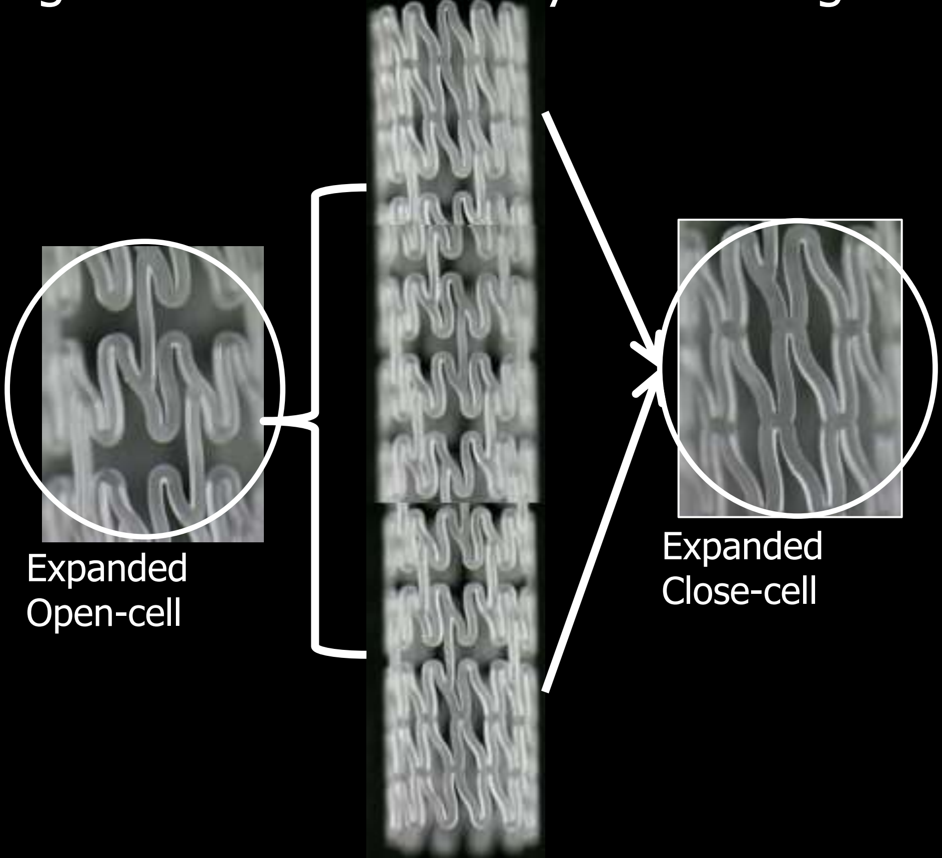
Onuma and Serruys Circulation 2011

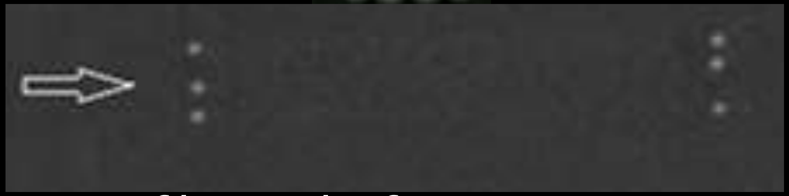
"Playing" with composition of polymers

e.g. MERES: Meril life sciences

MeRes™ - Merilimus Eluting Resorbable Coronary Scaffolding

- New PLA formulation for enhanced radial strength ?
- Hybrid stent geometry
- Strut thickness : 150±20μm
- Top coat: PDLLA + Sirolimus
- Coating thickness: <5μm
- Sirolimus loading: 1.25μg/mm^2
- RO markers: 3 tri-axial at each end
- Scaffold surface: 28.50%



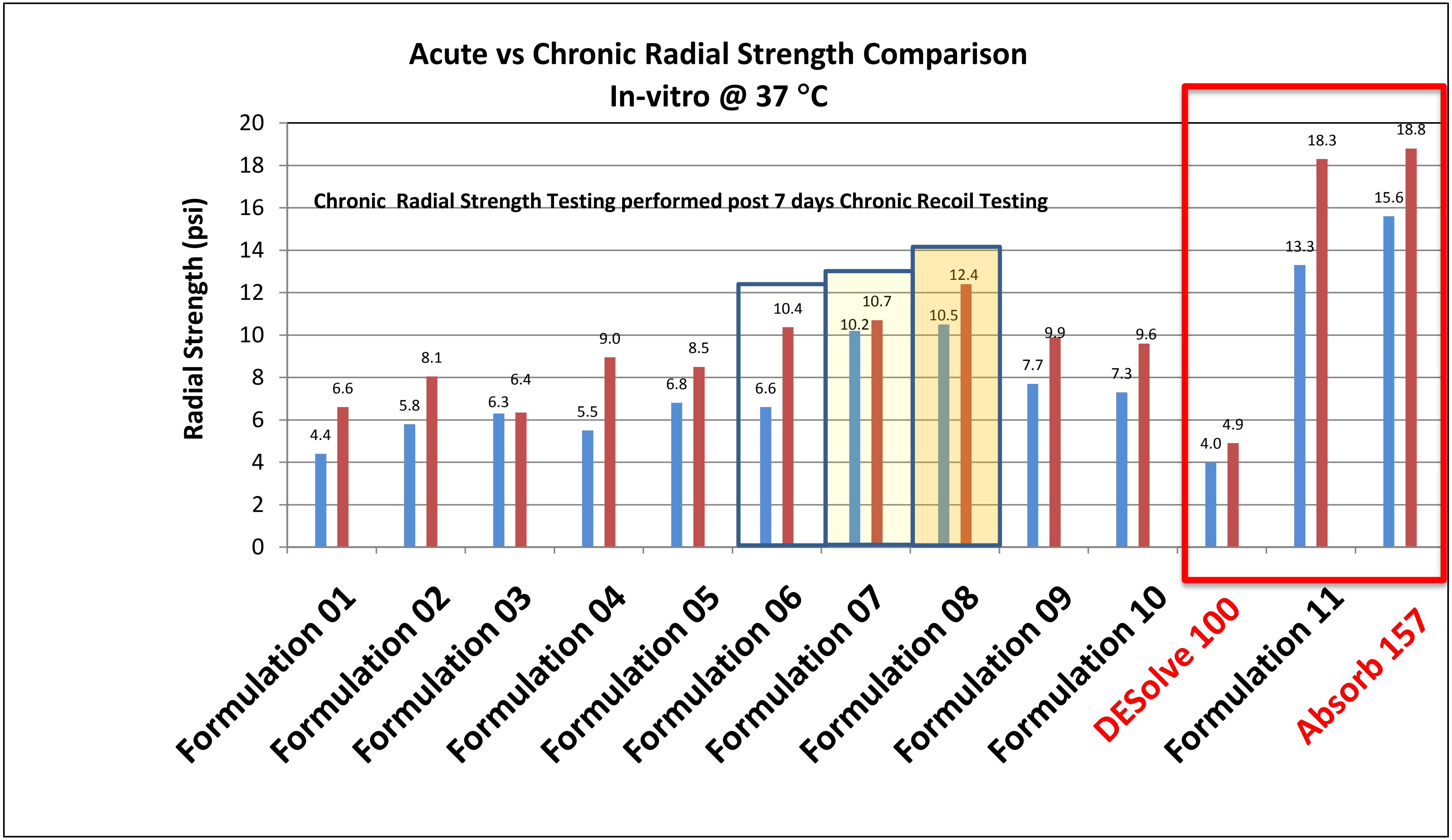


Actual device photographs. Data on file Meril Life Sciences.

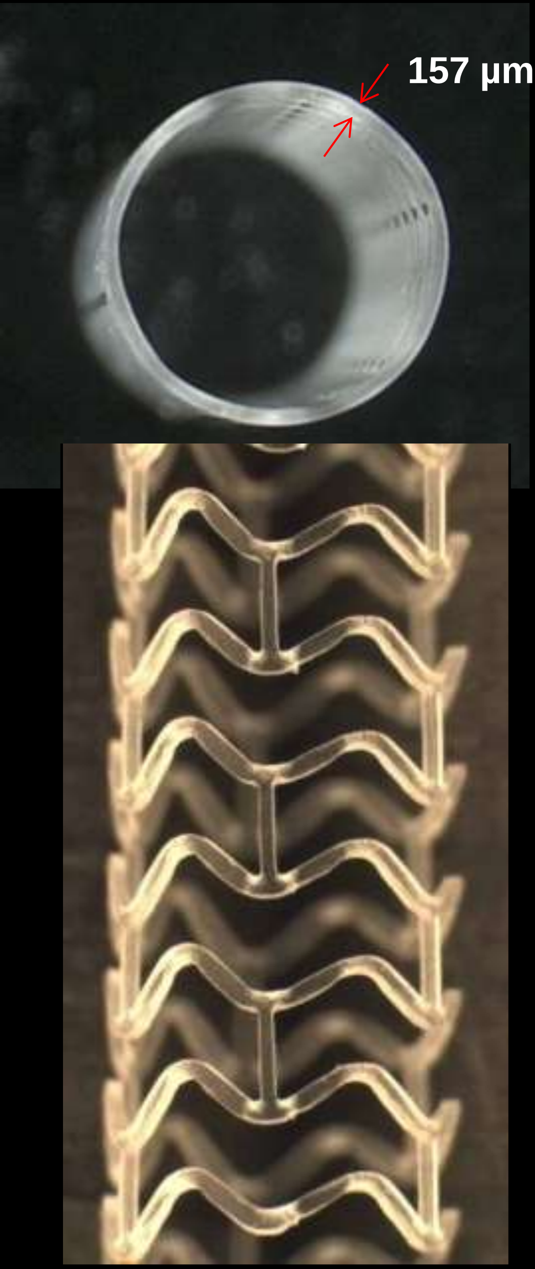
“Playing” with composition of polymers

Acute Radial Strength vs Chronic Radial Strength

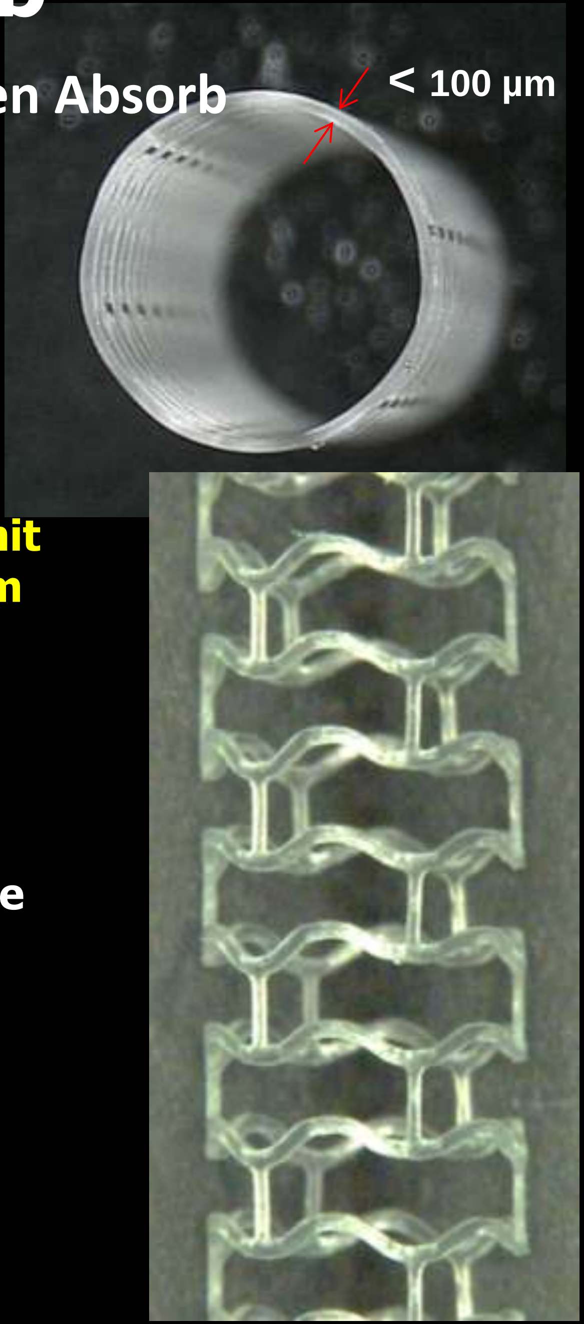
Chronic radial strength higher than acute radial strength



To the next generation Absorb



Absorb → **Next Gen Absorb**



Thinner Struts
- < 100 micron

Smaller profile
- ≤ 1.245 mm (3.0x18)
- ≤ 1.270 mm (3.0x38)

Larger functional expansion limit
- post-dilatation of **0.75 mm** over nominal of largest diameter scaffold in size family
- ≥ 4.1 mm at t=aged* (2.25x28, 3.0x18)

Broader pressure working range

Shorter Resorption time

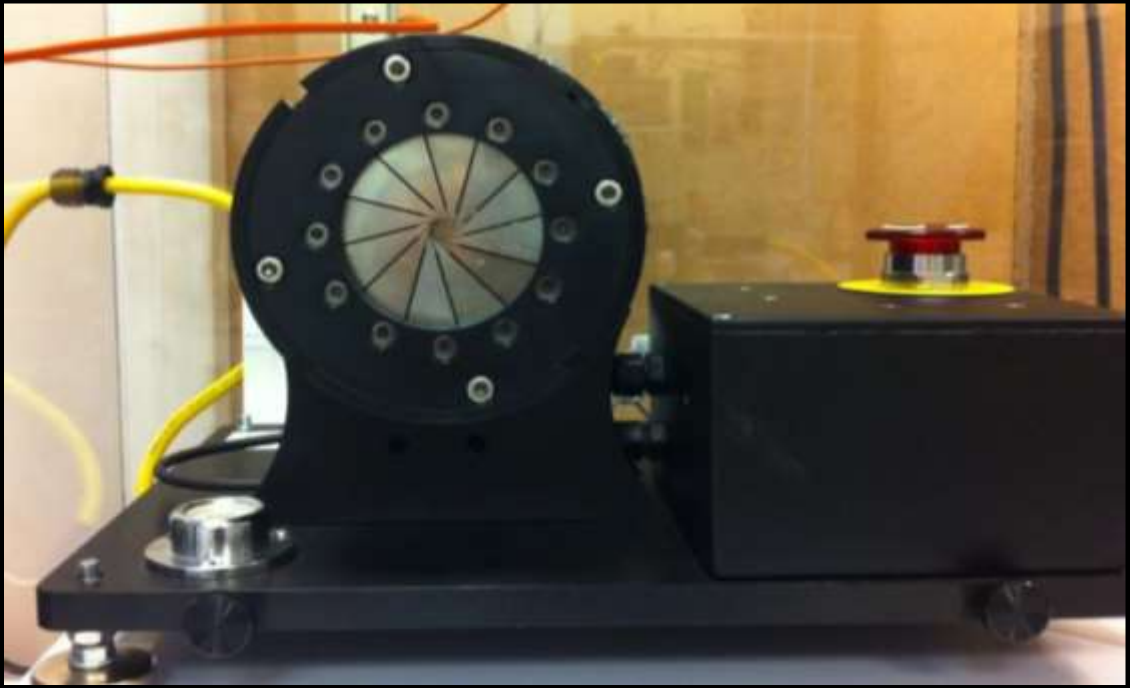
Unchanged:
- Drug content & elution rate
- Pattern & footprint
- Radial strength
- Scaffold retention

Photos taken by and on file at Abbott Vascular

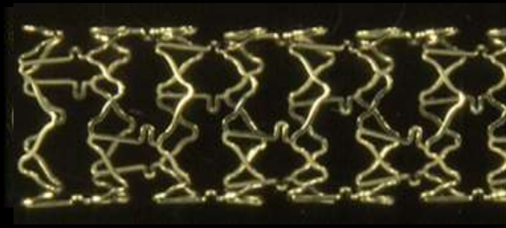
“Playing” with composition of polymers and design of scaffold platform

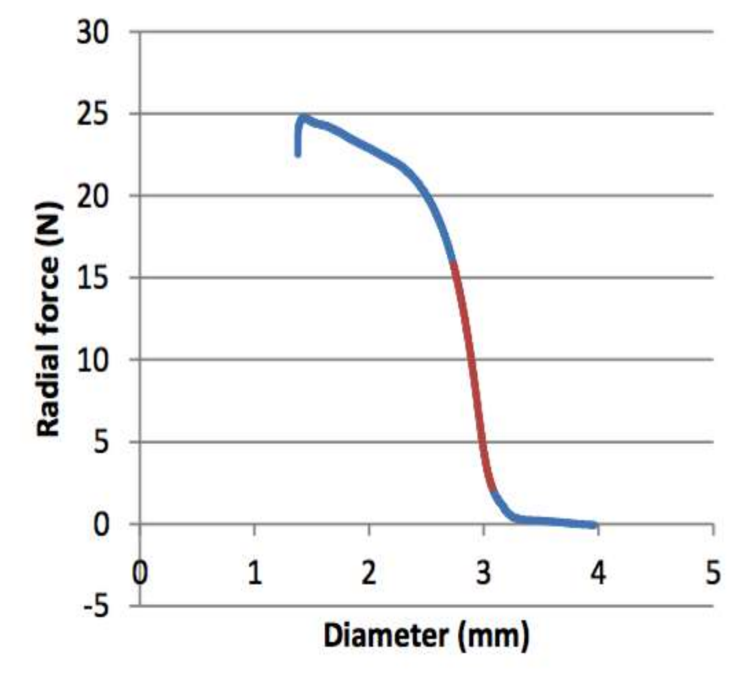
“Playing” with composition of polymers and design of scaffold platform

Impact of platform and polymer on radial force compared to metallic stents



Metallic stent





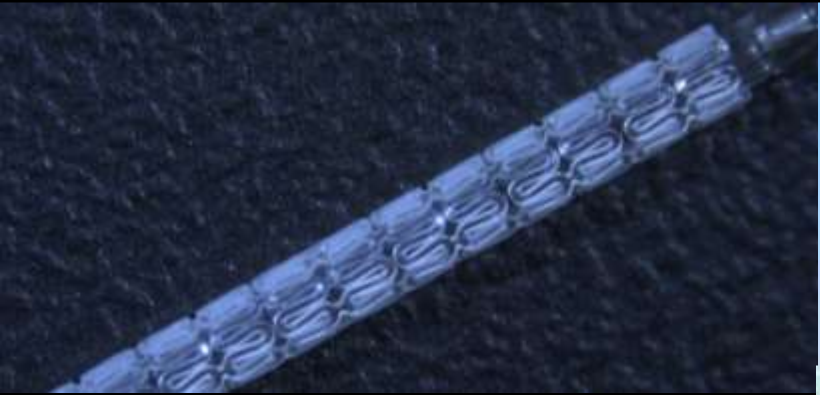
Crush resistance test

15.8 N

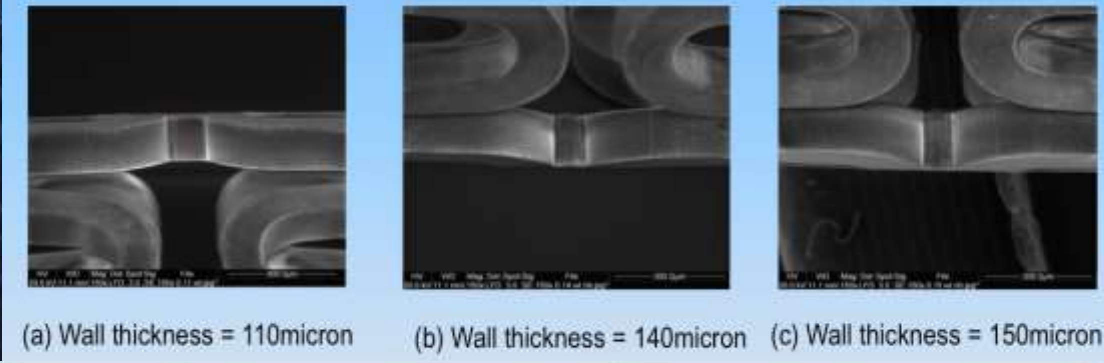
“Playing” with molecular orientation and mechanical property of PLLA

“Playing” with molecular orientation and mechanical property of PLLA

e.g. ARTERIUS: ArterioSorb scaffold

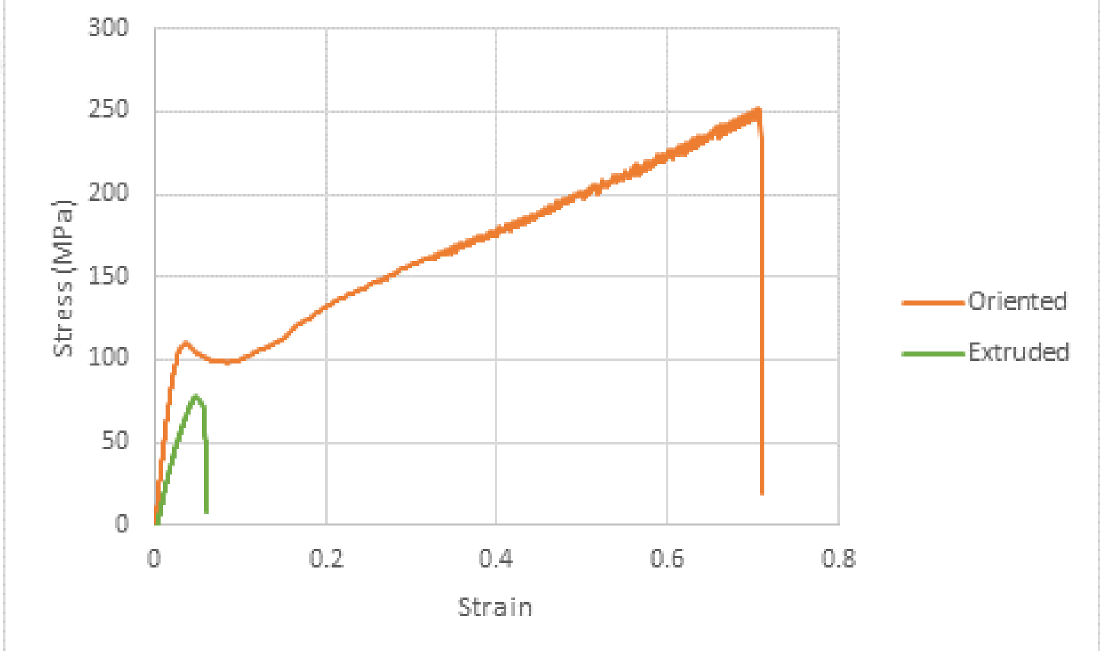


- PLLA based
- Melt processing (EXTRUSION) and DIE-DRAWING (solid phase orientation)
- Solid-Phase Oriented tube with very high mechanical properties
- Thinner strut (≲ 150μm wall thickness, including 140μm and 110μm) to be manufactured with enhanced physical performance similar to that of metal alloy stents.



(a) Wall thickness = 110micron (b) Wall thickness = 140micron (c) Wall thickness = 150micron

Strut wall thickness (micron)	Target size (mm)
110	2.5 - 3.00
140	3.00 – 3.50
150	3.5 – 4.00

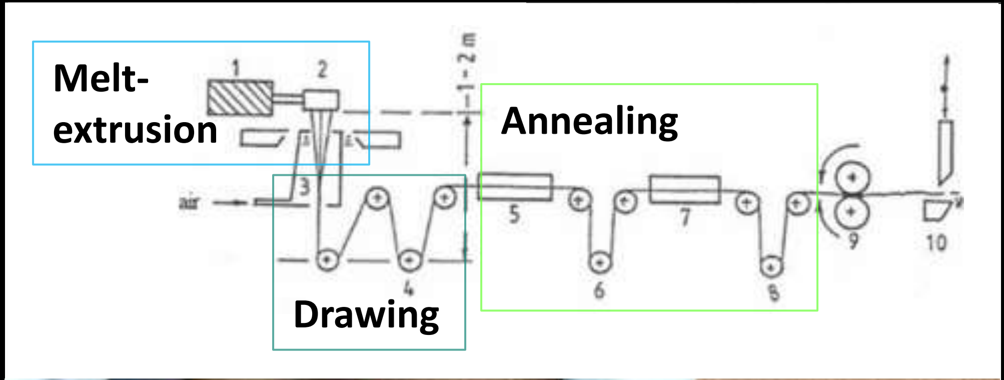


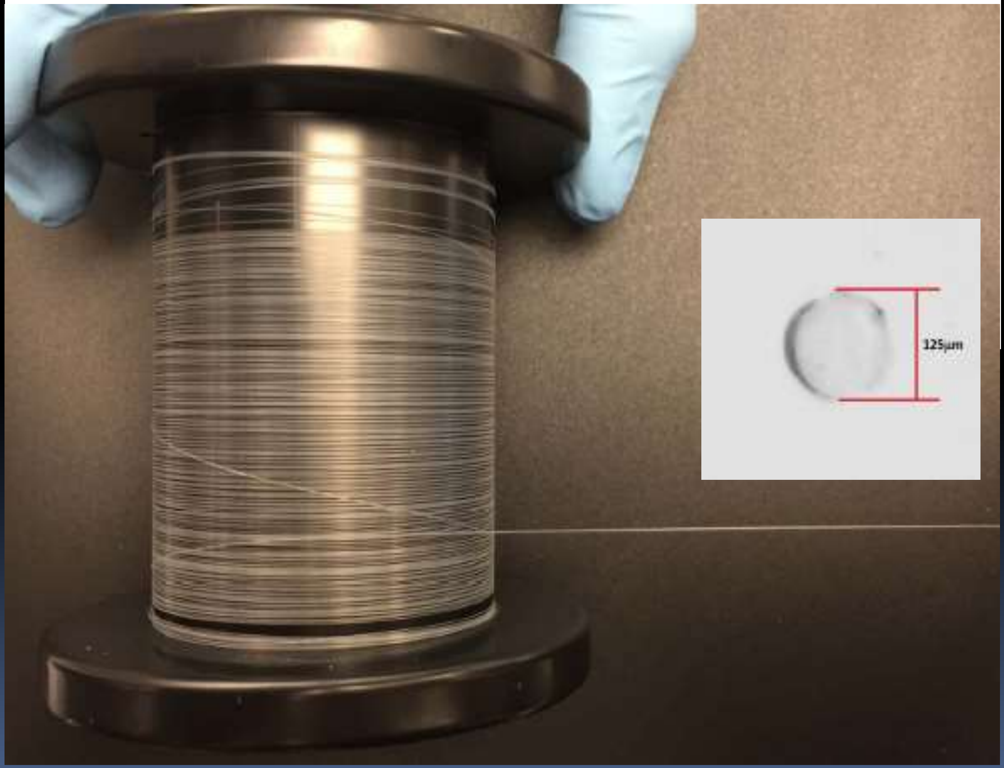
Manli Cardiology's Microfiber Technology

1. **Highly oriented polylactide constituting a circular monofilament with preferred directional mechanical properties.**

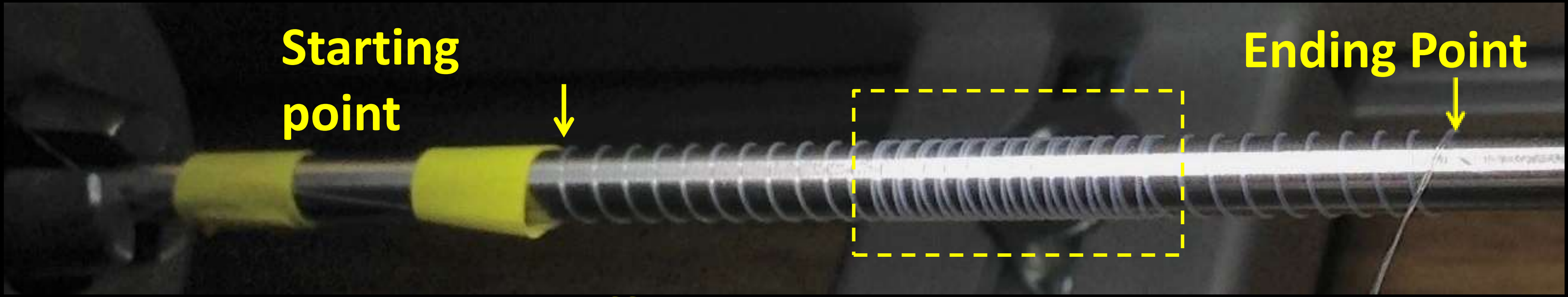
2. **Convert monofilament's directional mechanical properties into scaffold's radial mechanical properties.**

3. **Transform circular monofilament into a scaffold with circular strut geometry.**





Manli Cardiology's Microfiber Technology

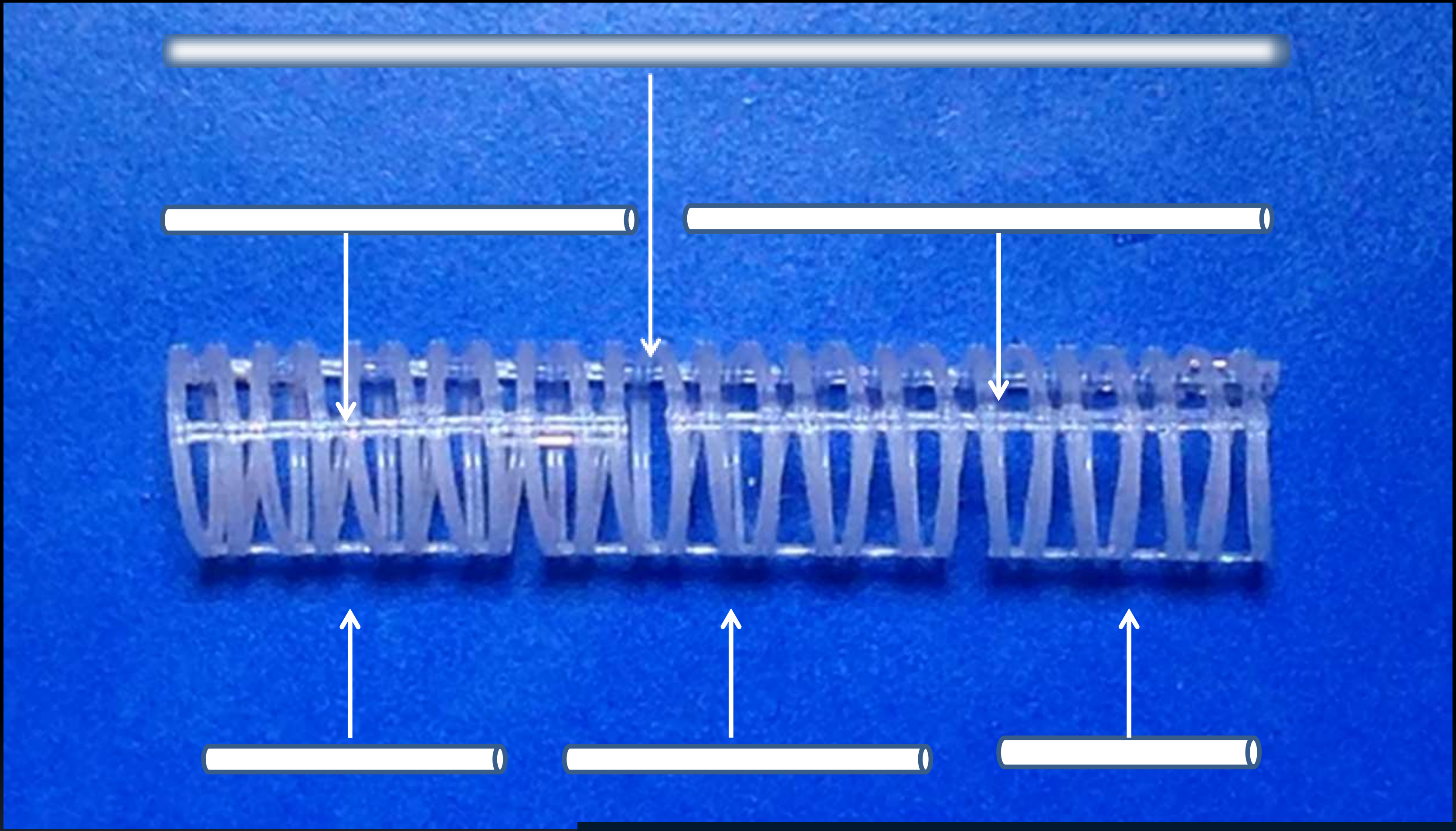


Coil design enables scaffold to

- **Inherit monofilament's directional mechanical properties.**
- **Inherit monofilament's circular geometry**

3. **Make monofilament's circular geometry into scaffold strut's circular geometry.**
4. **Ambient temperature assembly process**

Manli Cardiology's Microfiber Technology

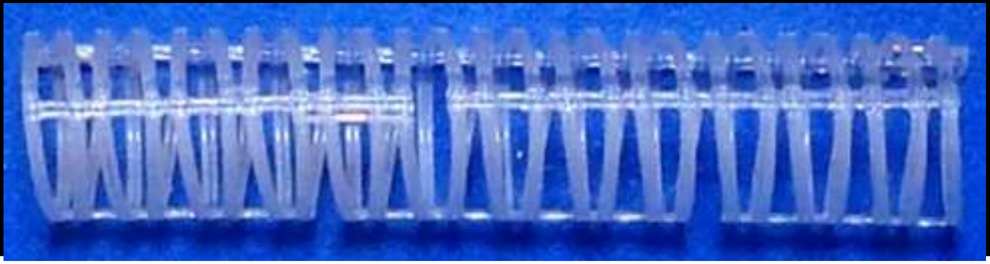


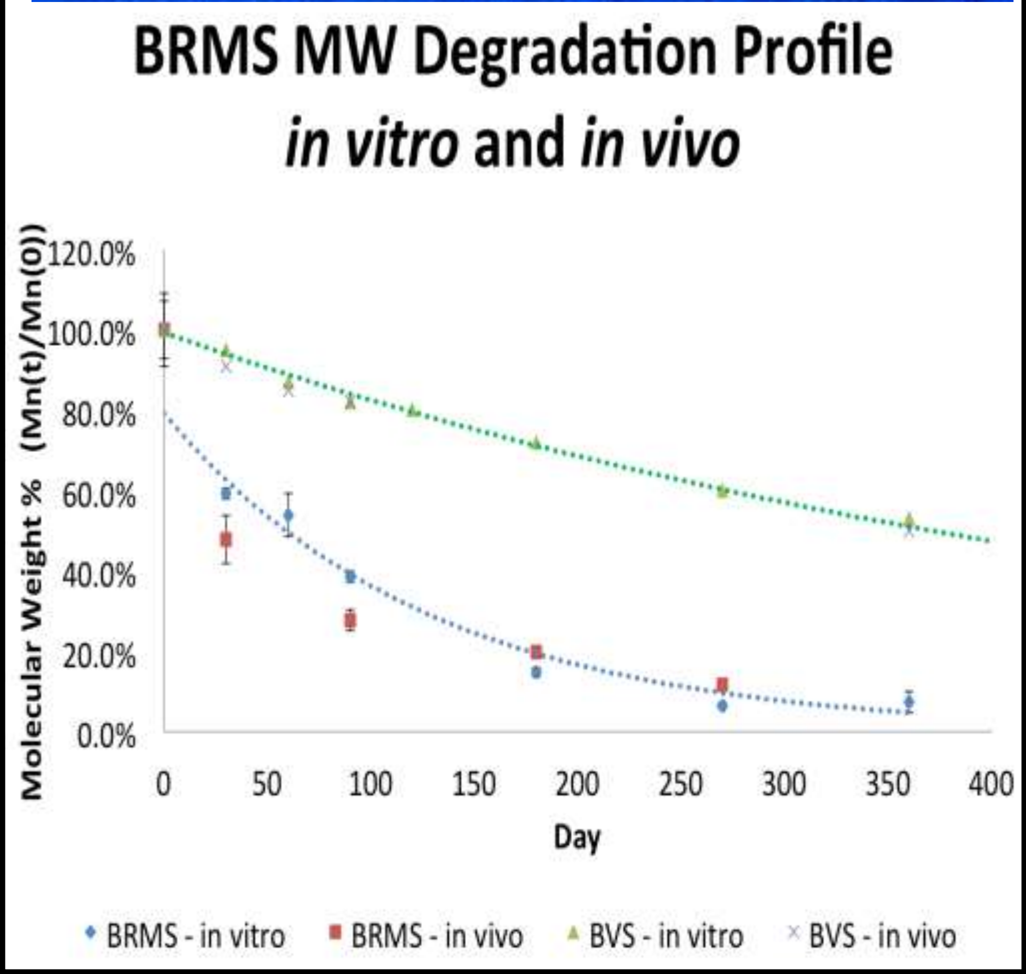
4. **Ambient temperature assembly process**

Multiple axial microfibers and radiopaque markers are attached at ambient temperature in the final subassembly process.

Manli Cardiology’s Microfiber Technology

1. **Start with highly oriented circular polylactide monofilament with preferred directional mechanical properties.**
2. **Convert monofilament’s directional mechanical properties into scaffold’s radial mechanical properties.**
3. **Make monofilament’s circular geometry into scaffold strut’s circular geometry.**
4. **Ambient temperature assembly process**



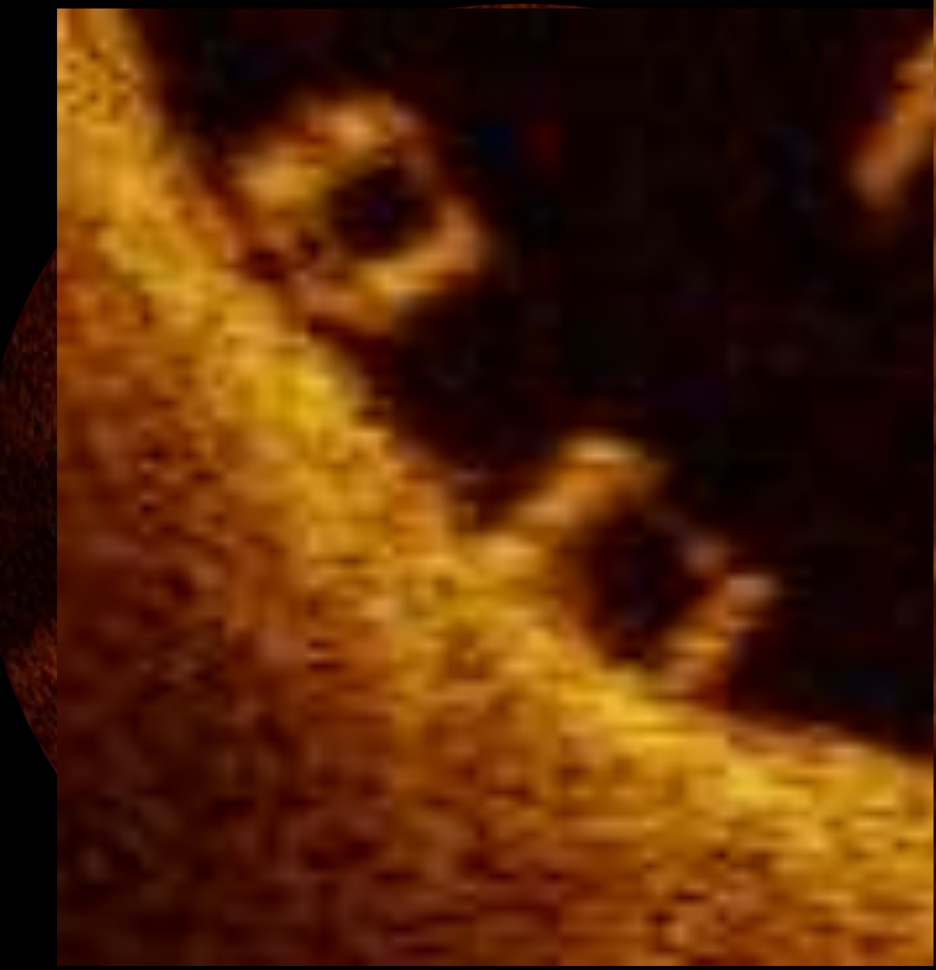


BRMS MW Degradation Profile

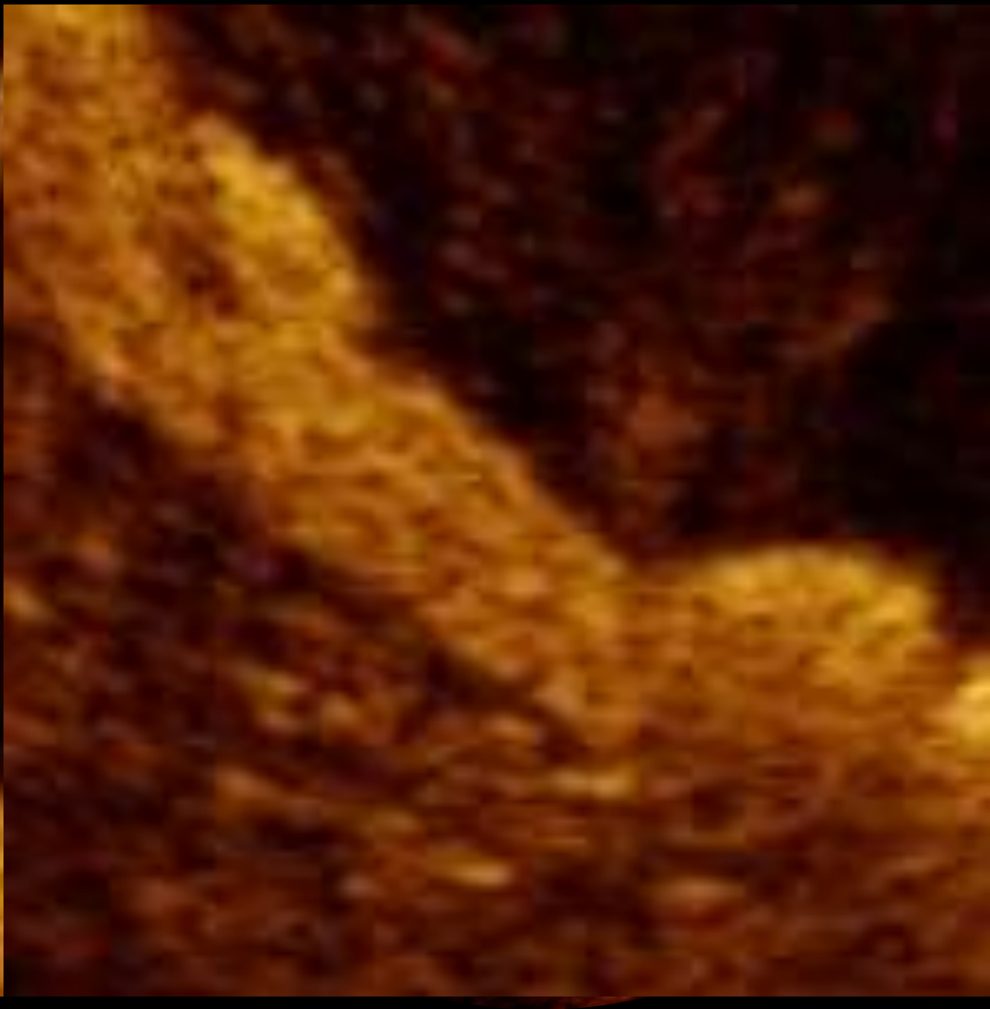
in vitro and *in vivo*

From the rectangular shape of the struts into the ovoid shape

Absorb

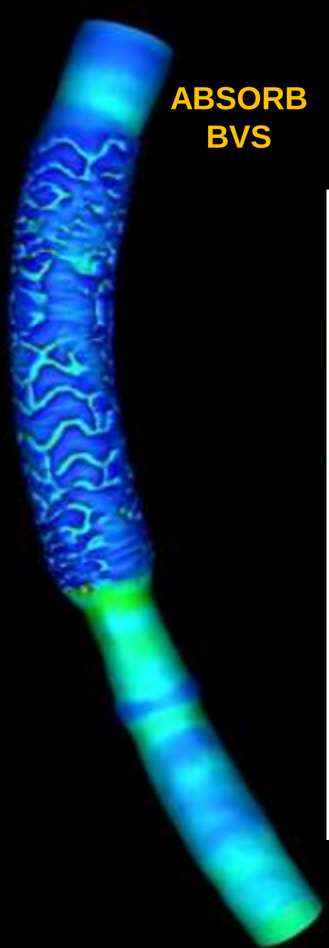


Mirage

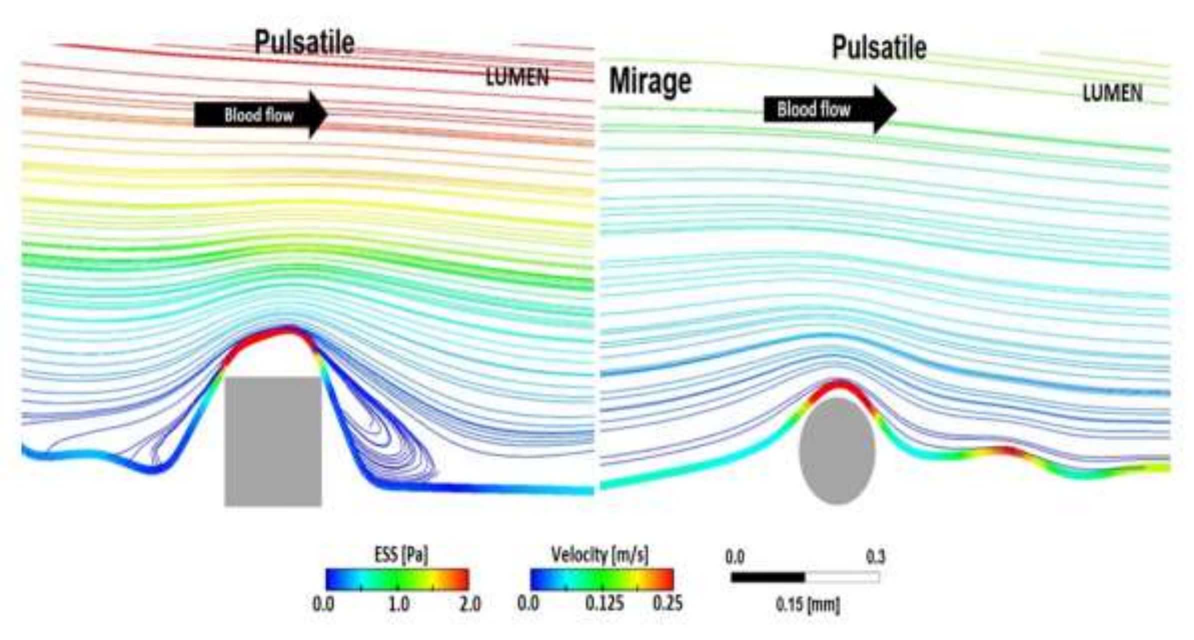


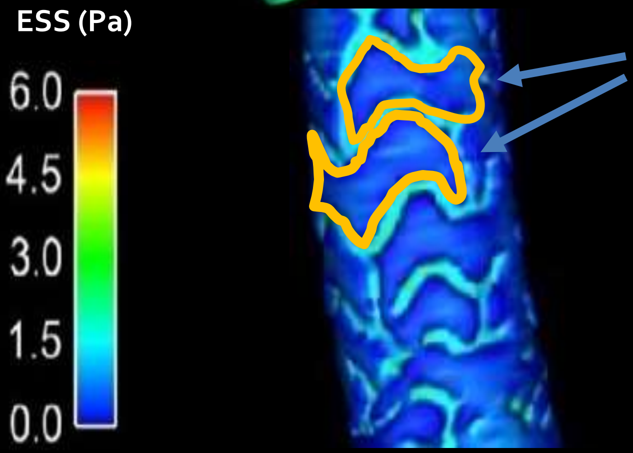
Shear stress and flow analysis in ABSORB and MIRAGE

ABSORB BVS

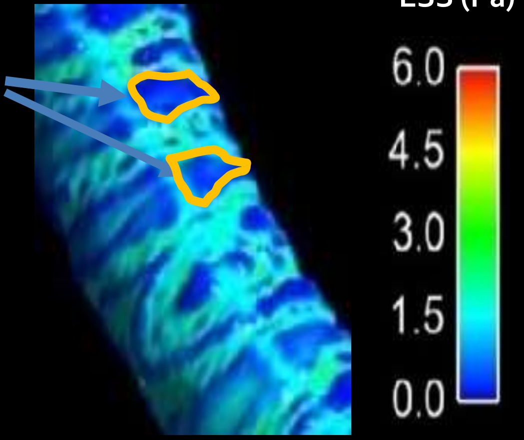


MIRAGE BRMS





The lower ESS (**dark blue area**) had a wider distribution in the Absorb BVS compared to the Mirage BRMS



Conclusions

Future struts of BRS are to be:

- Stronger and ductile
- Thinner and round
- Potentially quickly resorbable but without inducing inflammatory reaction

… Yes, we can!

Thank You!

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INTERVENTIONS FOR VALVULAR DISEASE AND HEART FAILURE

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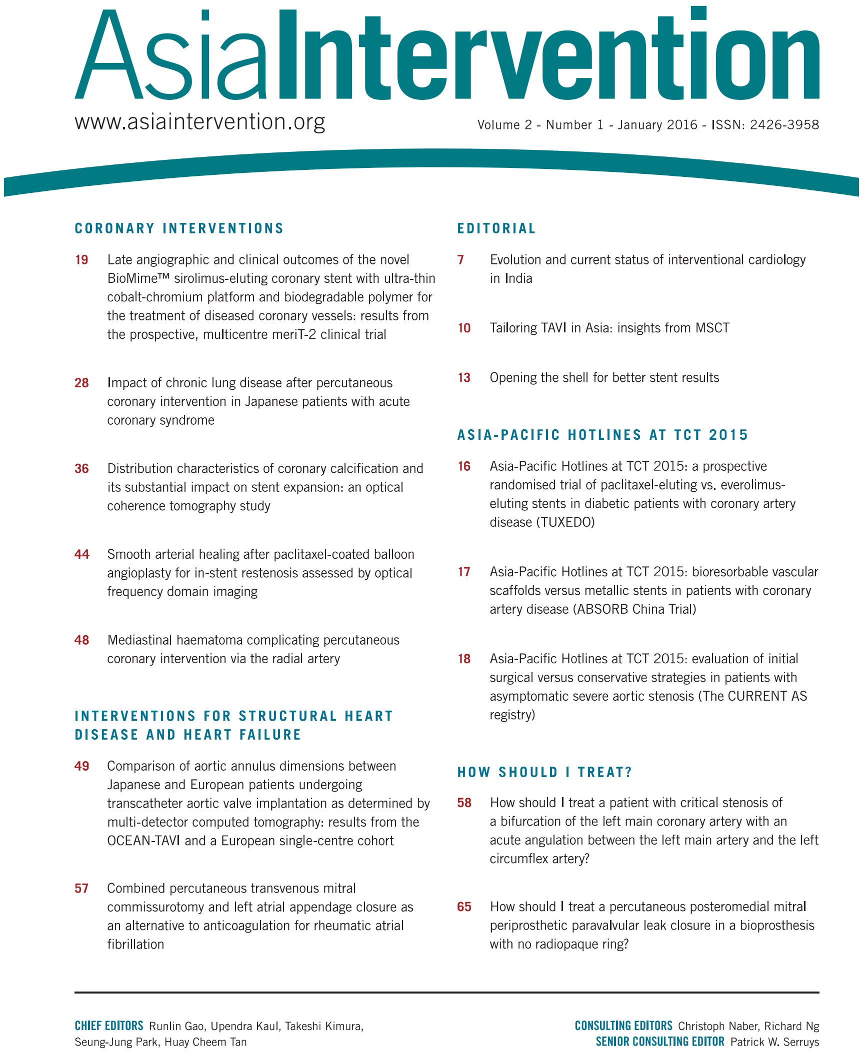

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INTERVENTIONS FOR STRUCTURAL HEART DISEASE AND HEART FAILURE

EDITORIAL

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