Fundamentals of Shape Memory

Nitinol Processing

Design and Application

- Where is Nitinol Used?
- Medical Device Characteristics
- Design Case Studies

Environmental Effects

Applications of Nitinol

Nitinol History

1970 First aircraft applications

1975 Orthodontic arches — first superelastic application

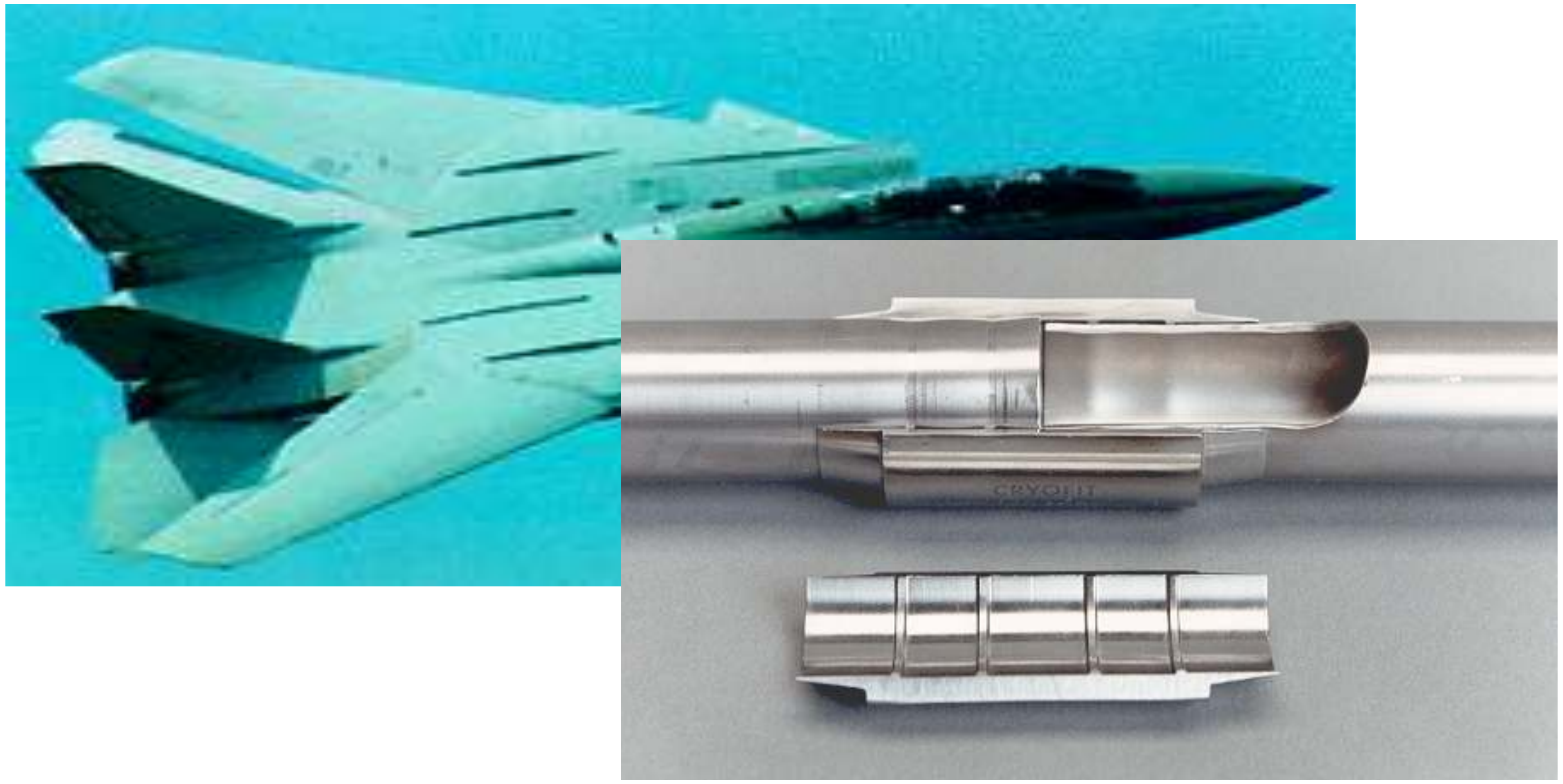
1980 Guidewires

1985 Instrument components

1990 Stents

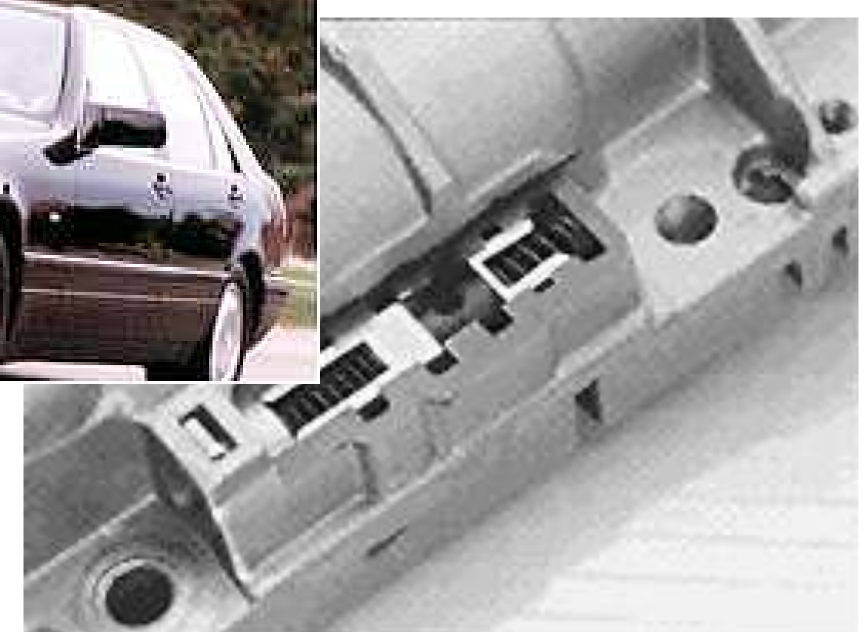
Where is Nitinol Used?

Constrained Recovery



Where is Nitinol Used?

Actuators



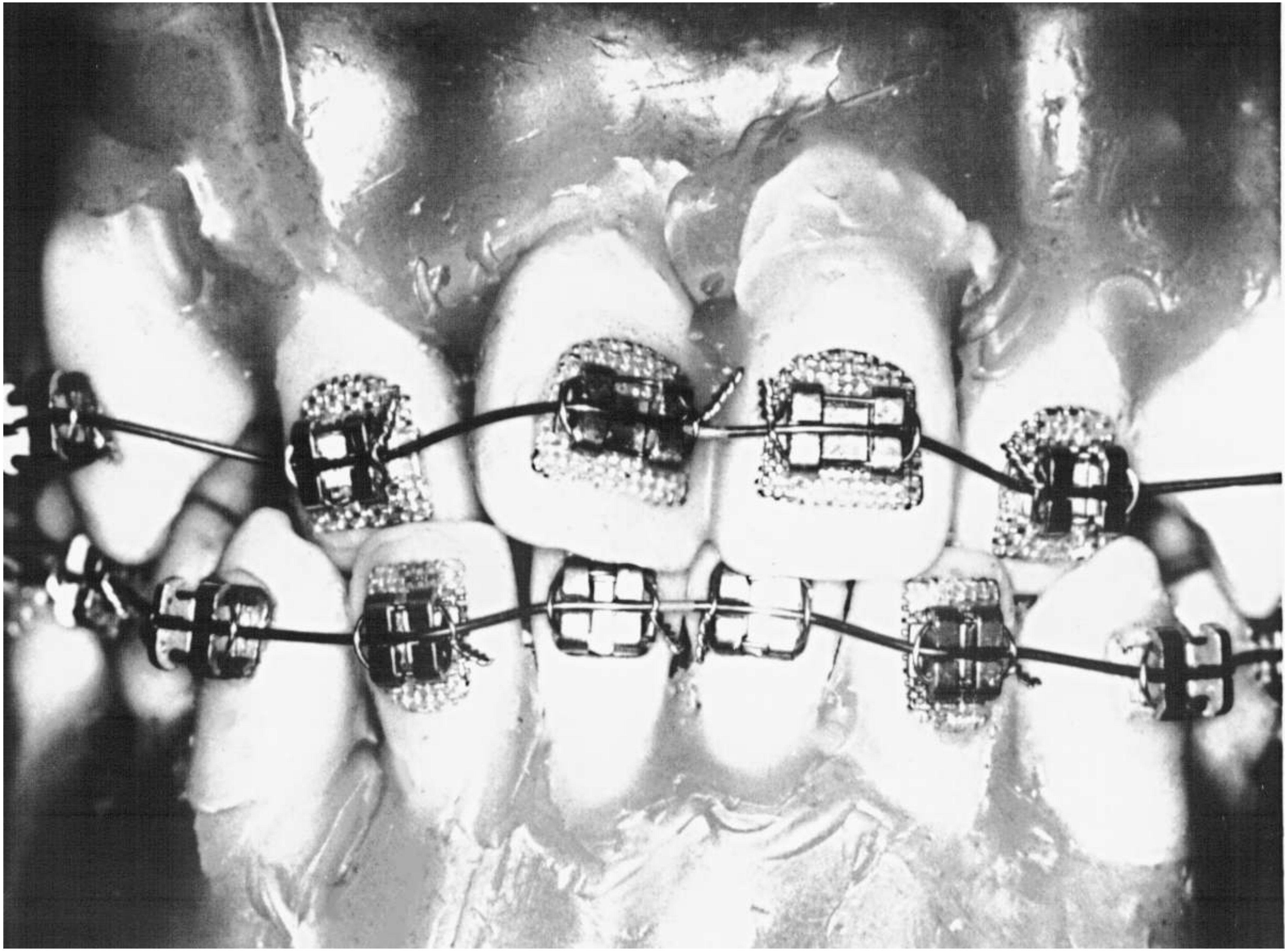
Where is Nitinol Used?

Grado Zero Espace S.l.r.

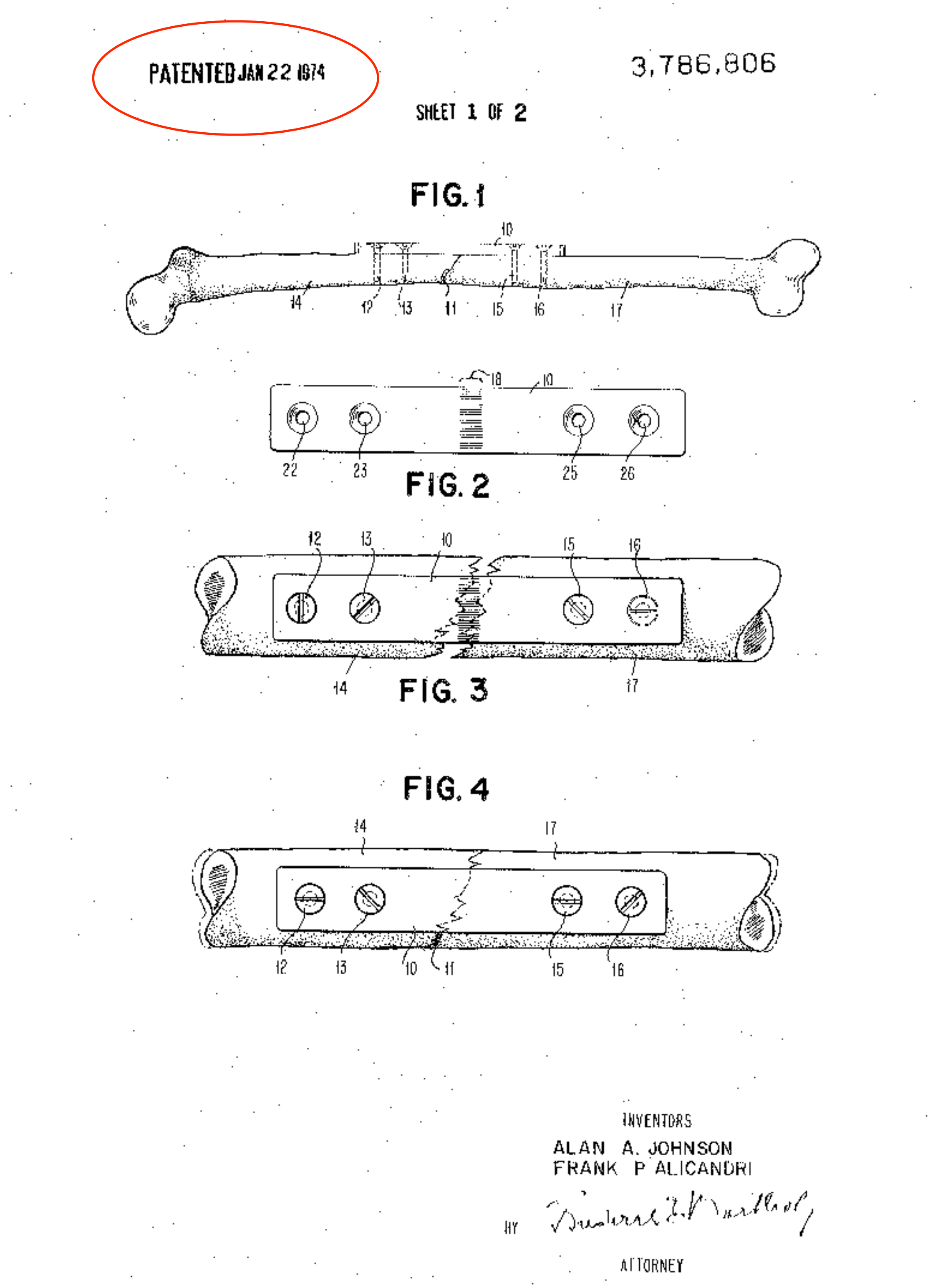
Actuators

Where is Nitinol Used?

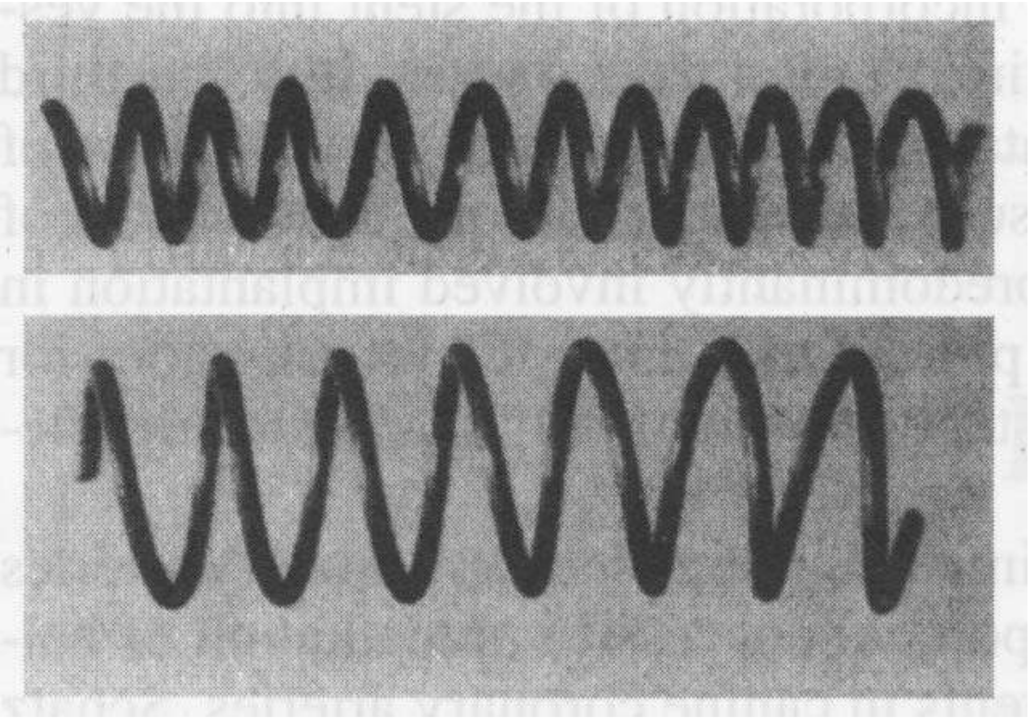
Superelasticity



Where is Nitinol Used?

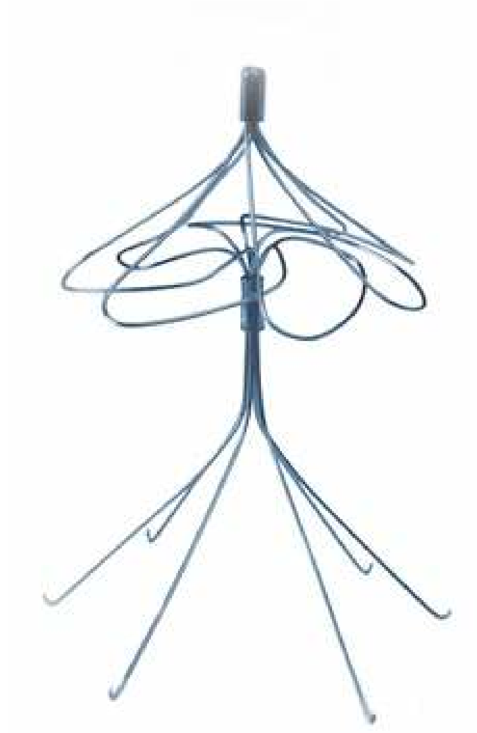


Thermal Actuation

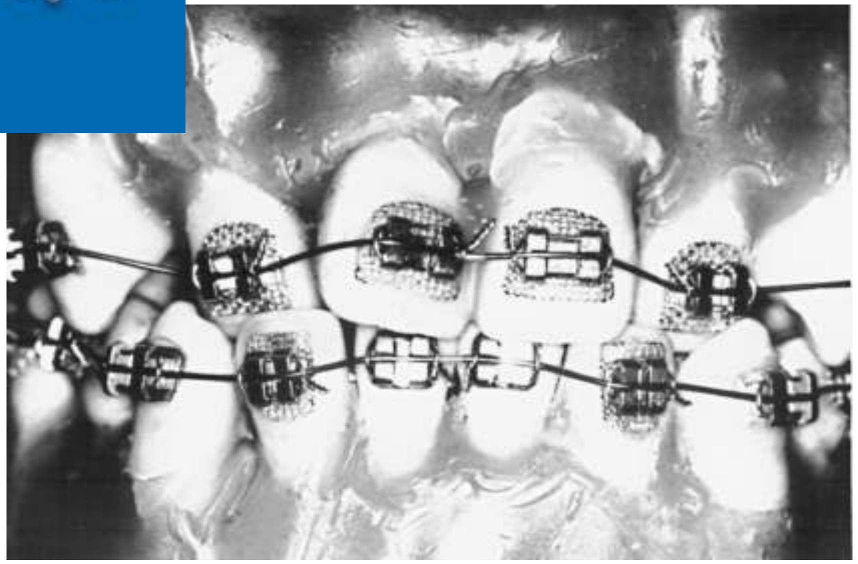


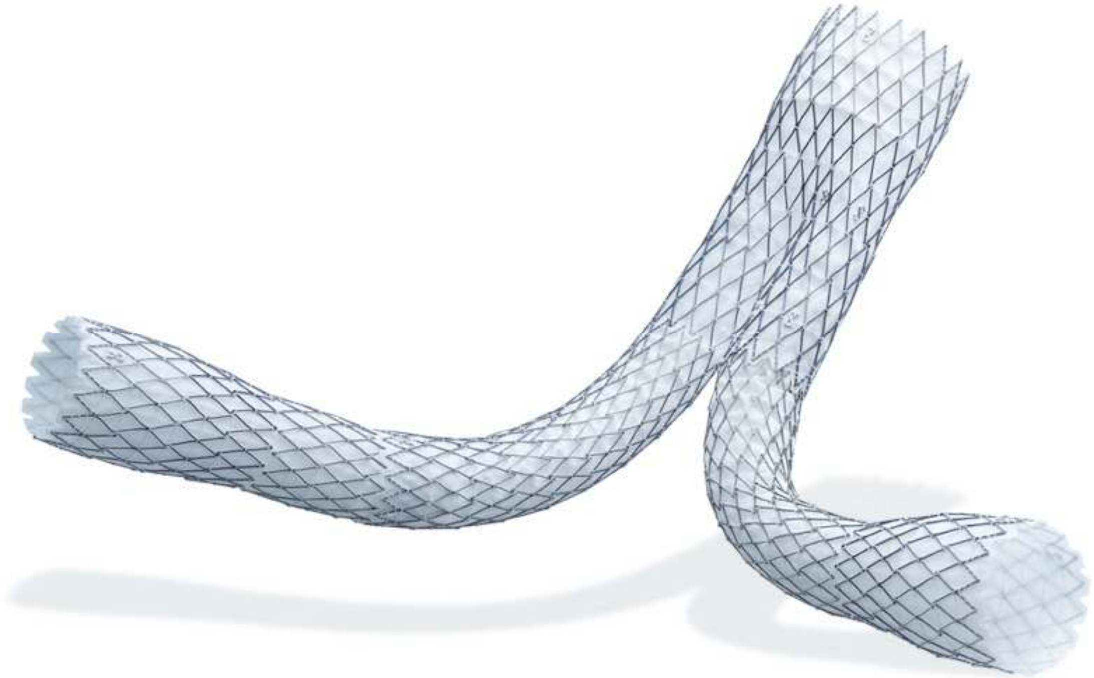
Dr. Charles Dotter

Where is Nitinol Used?



Medical Devices





Nitinol Medical Device Characteristics

Biomechanical Compatibility

Elastic Deployment

Thermal Deployment

Kink Resistance

Constancy of Stress

Dynamic Interference

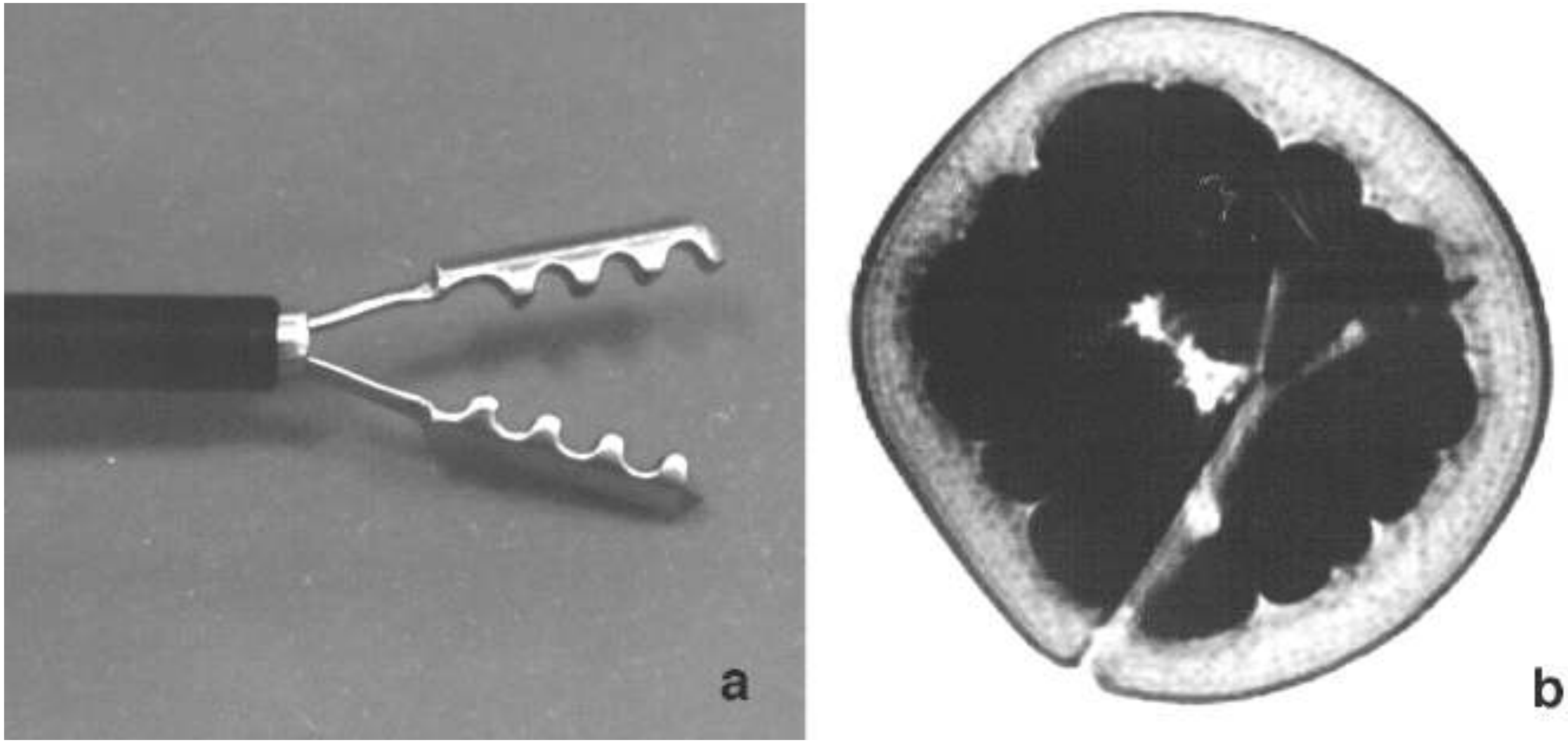
Hysteresis / Biased Stiffness

Fatigue Resistance

Biocompatibility

MR Compatibility

MR Compatibility



Guidewires

SMA, Inc.

- Elastic Deployment
- Kink Resistance
- Fatigue Resistance
- Biocompatibility
- MR Compatibility

Bone Reamers

Zimmer

Kink Resistance

Fatigue Resistance

Biocompatibility

MR Compatibility

Needle/Wire Localizer

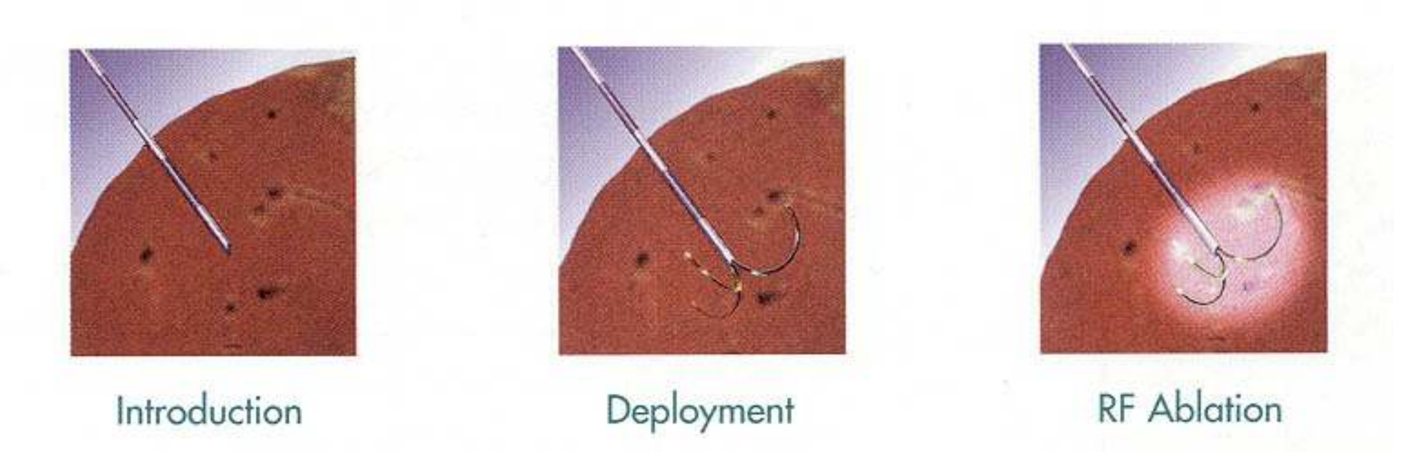
Homer Mammalok® (Mitek)

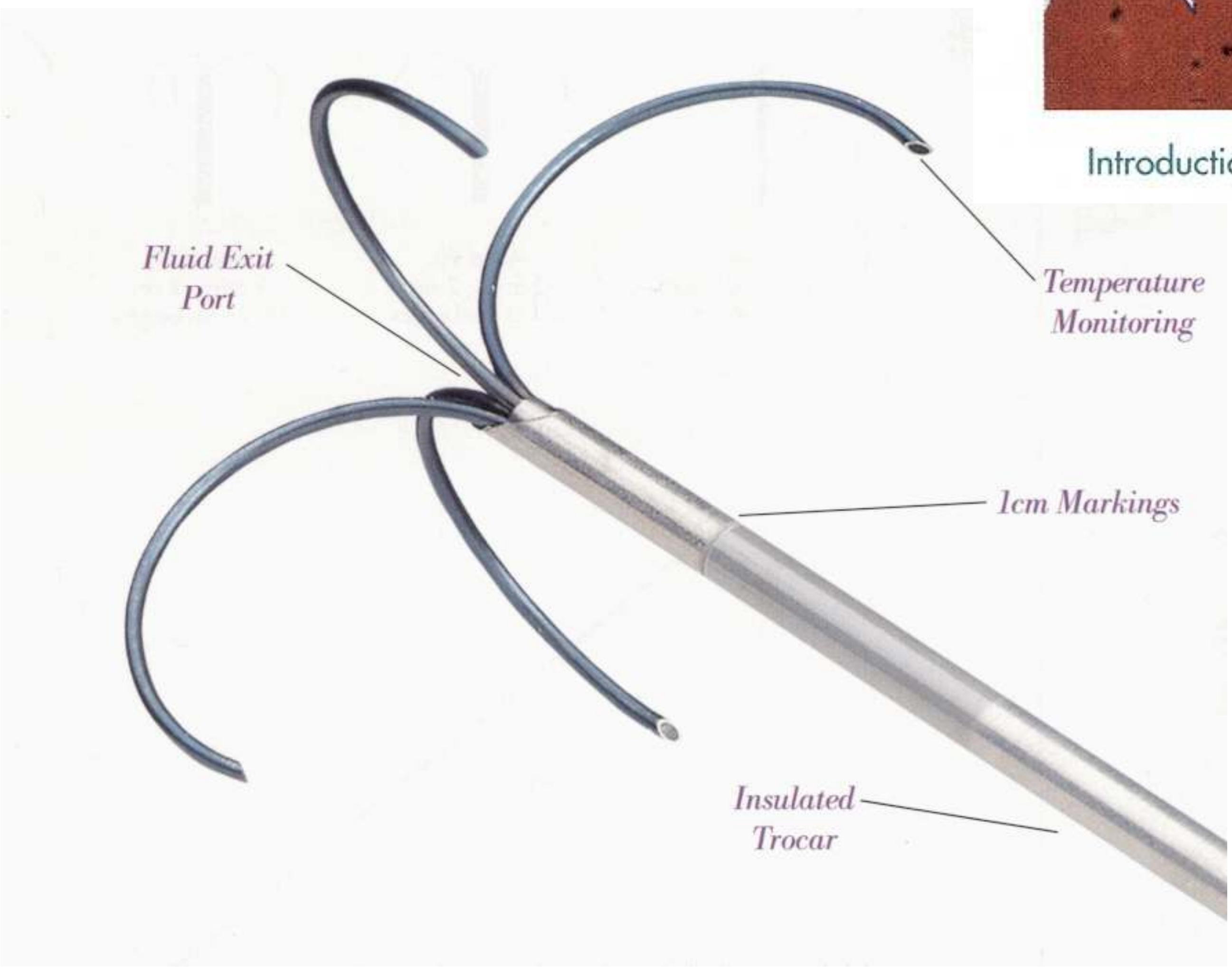
Elastic Deployment

Kink Resistance

Biocompatibility

RF Tissue Ablation





RITA Medical Systems, Inc.

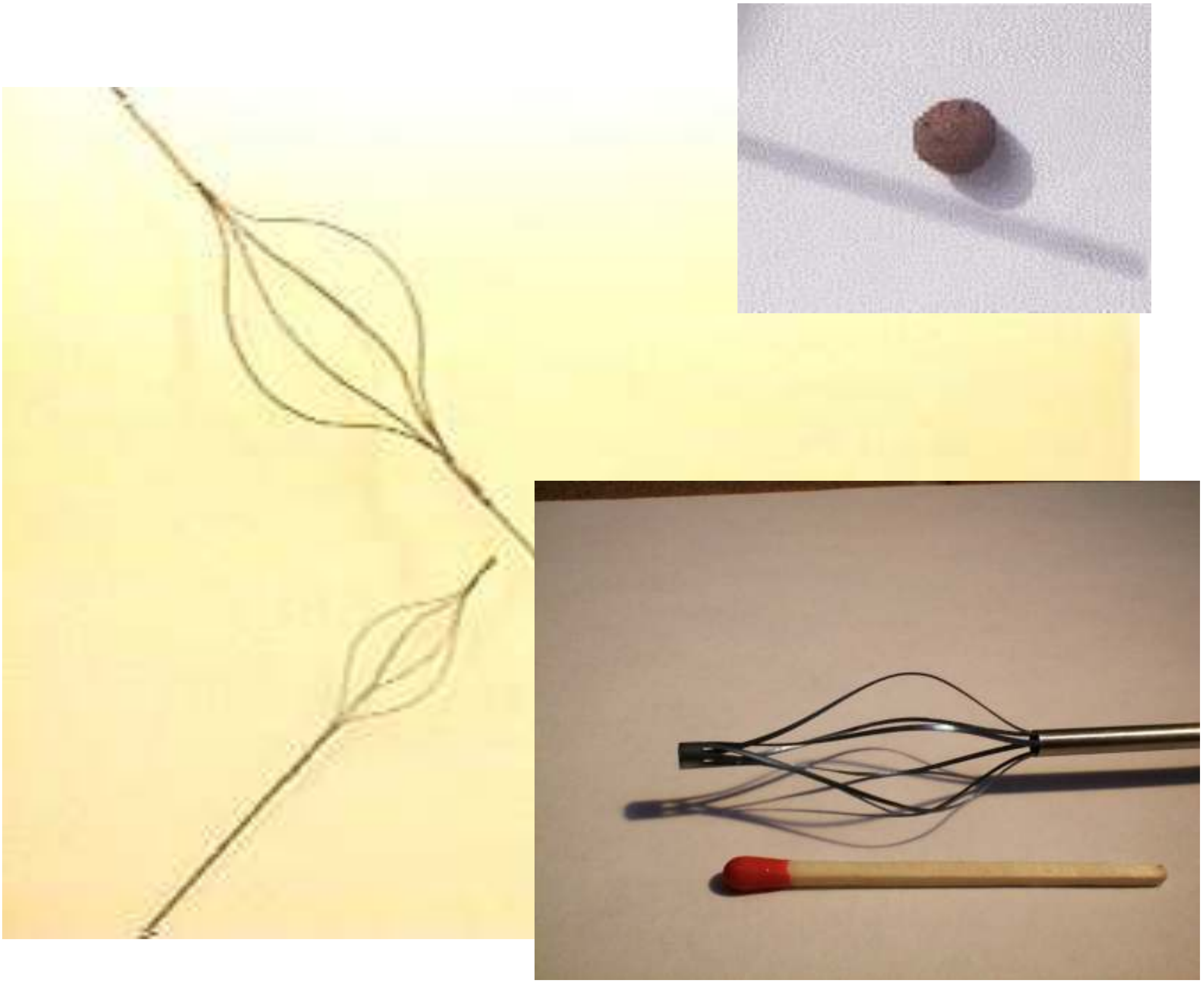
Elastic Deployment

Kink Resistance

Fatigue Resistance

Biocompatibility

Baskets



Elastic Deployment

Kink Resistance

Dynamic Interference

Fatigue Resistance

Biocompatibility

MR Compatibility

Organ Retrieval

Covidien

- Elastic Deployment
- Kink Resistance
- Fatigue Resistance
- Biocompatibility
- MR Compatibility

Snares

ev3

Elastic Deployment

Kink Resistance

Dynamic Interference

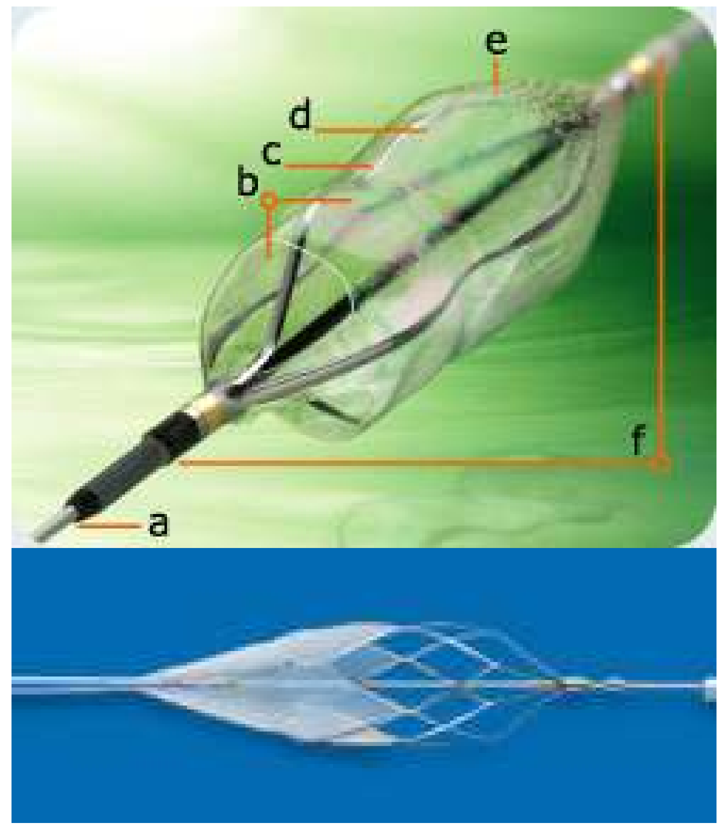
Fatigue Resistance

Biocompatibility

MR Compatibility

Embolic Protection Devices

BSC



Abbott

Cordis

Elastic Deployment

Kink Resistance

Dynamic Interference

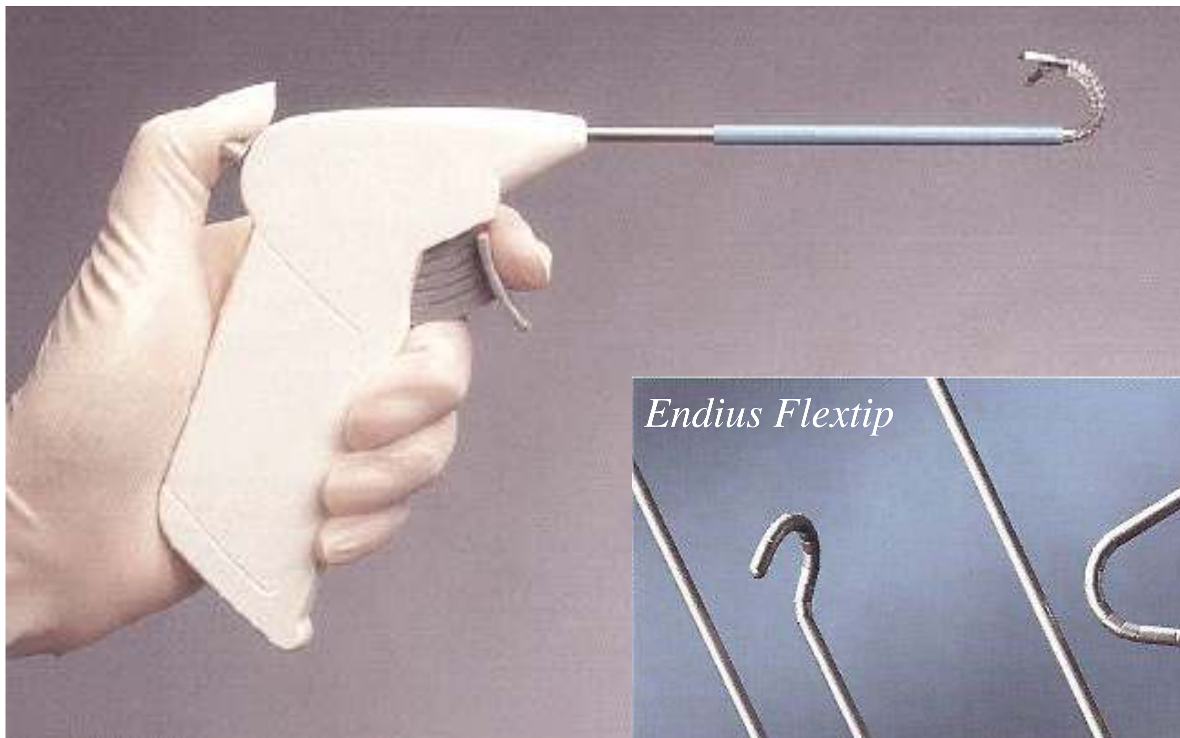
Fatigue Resistance

Biocompatibility

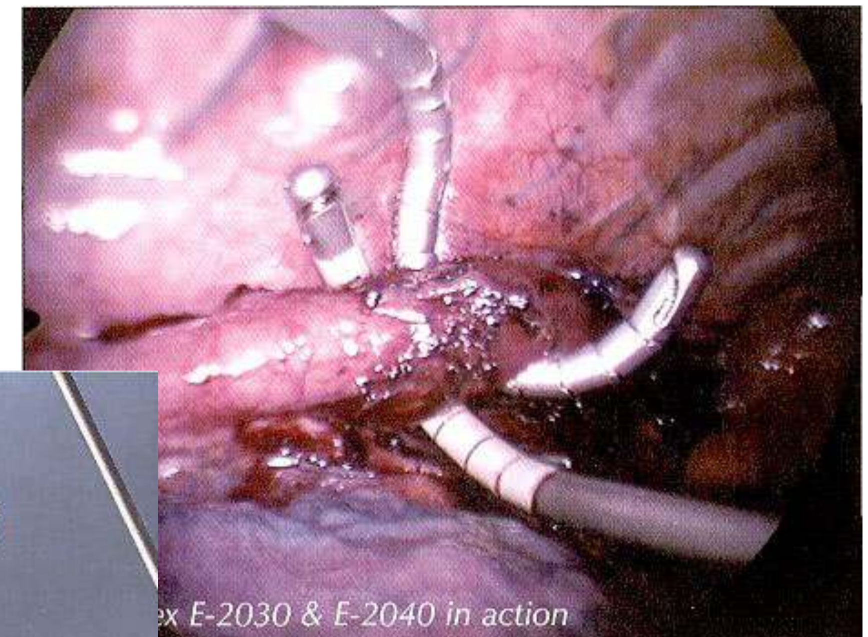
MR Compatibility

ev3

Deflectable Instruments


Endius


Endius Flextip



Surgical Innovations

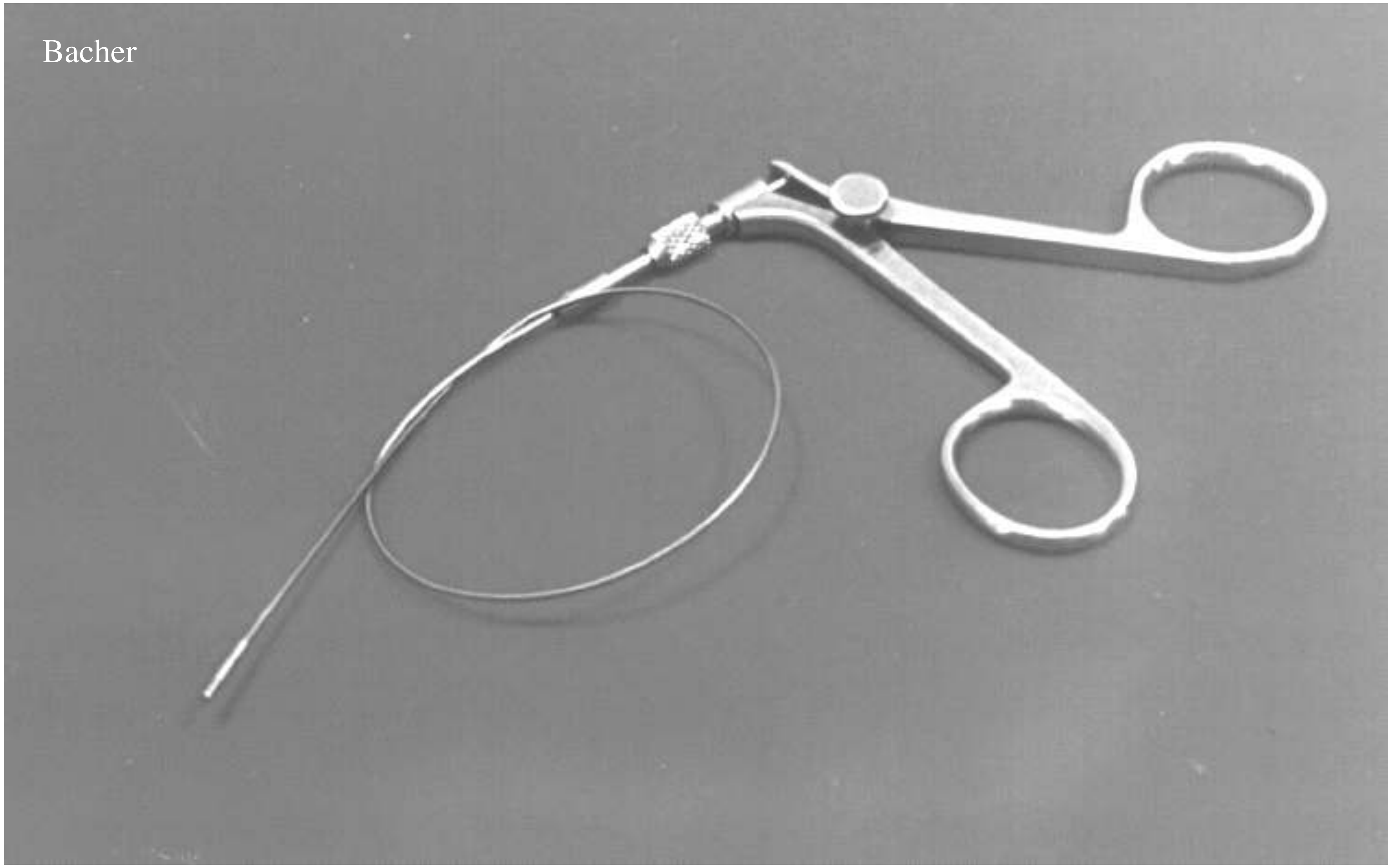
Elastic Deployment

Kink Resistance

Biocompatibility

MRI Compatibility

Flexible Micrograsper



Elastic Deployment

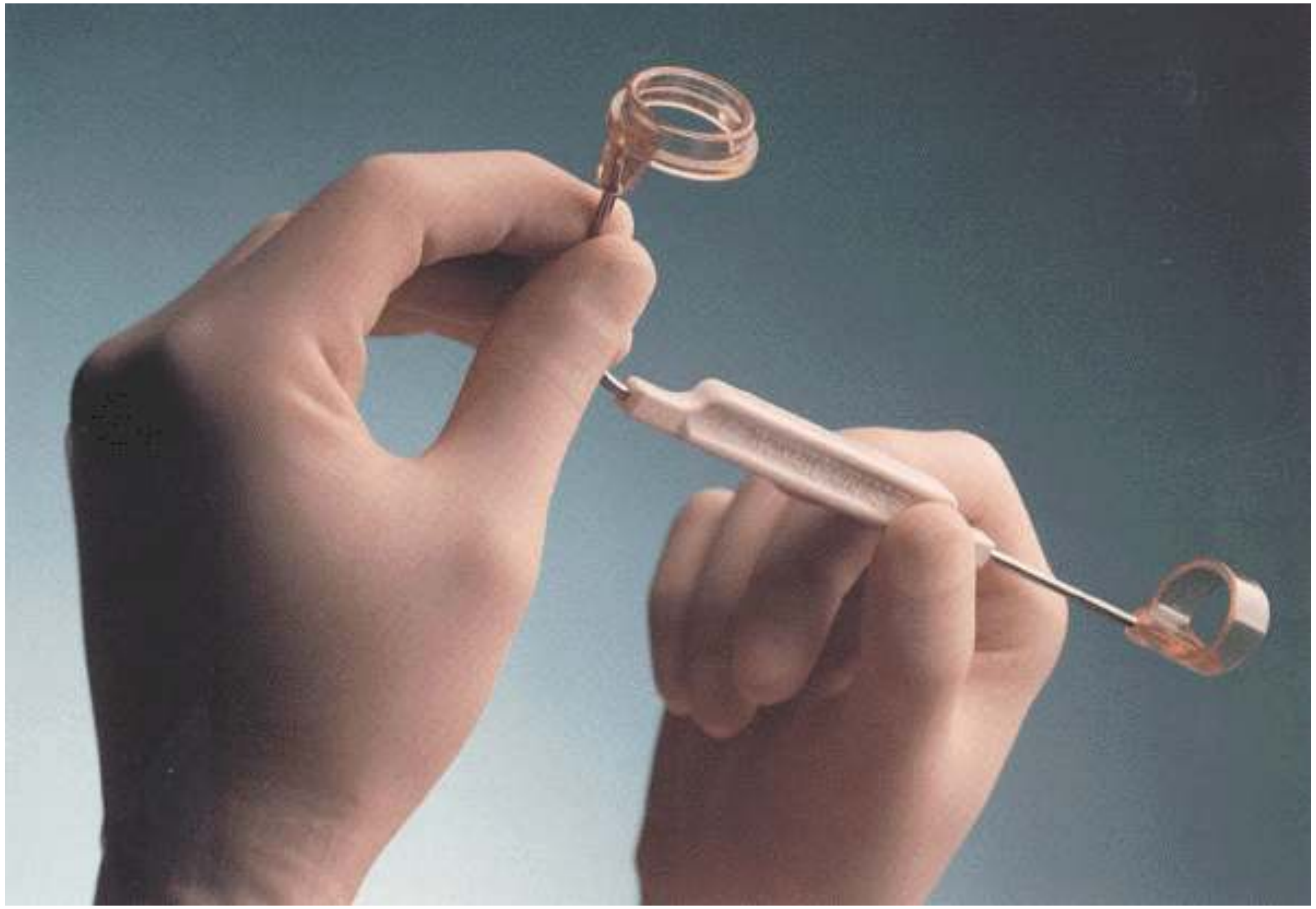
Kink Resistance

Fatigue Resistance

Biocompatibility

MR Compatibility

Heart Valve Sizer



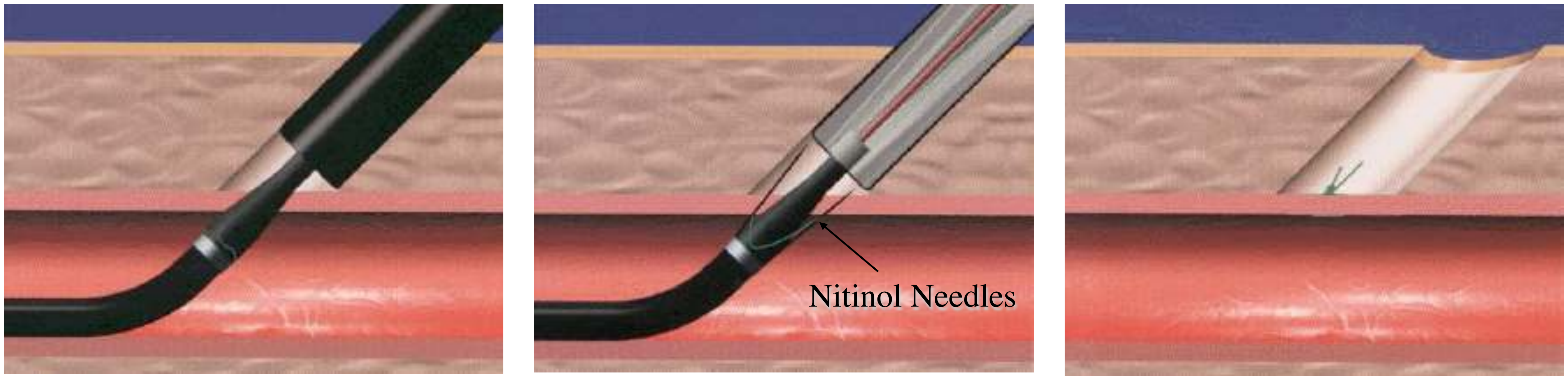
St. Jude

Deformable Martensite

Fatigue Resistance

Biocompatibility

Vascular Closure Devices



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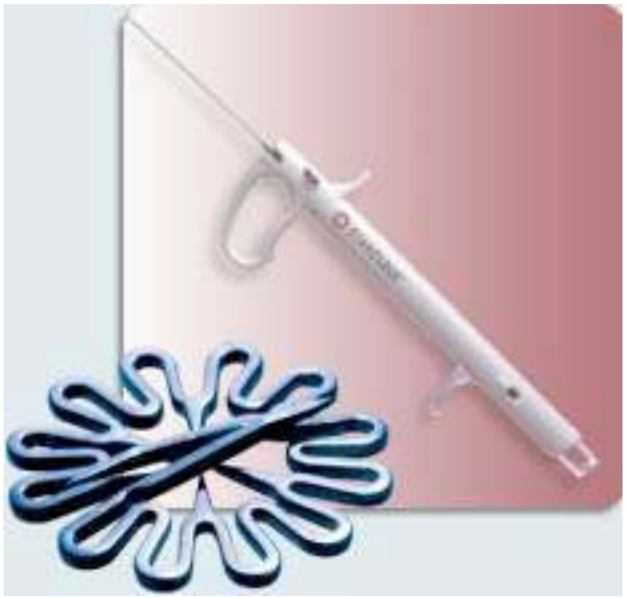


Abbott

Elastic Deployment

Kink Resistance

Fatigue Resistance

Biocompatibility

Suture Anchor

Biomechanical Compatibility

Elastic Deployment

Biocompatibility

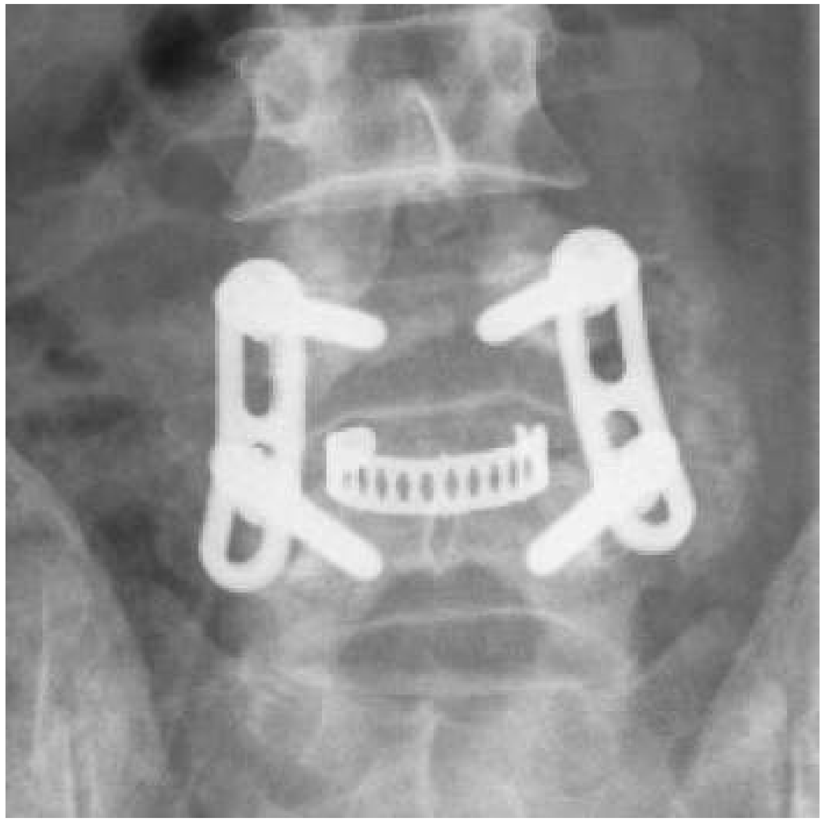
MR Compatibility

Bone Staples

- Biomechanical Compatibility
- Thermal Deployment
- Fatigue Resistance
- Biocompatibility
- MR Compatibility

BME, Inc.

Spinal Cage



Depuy Spine

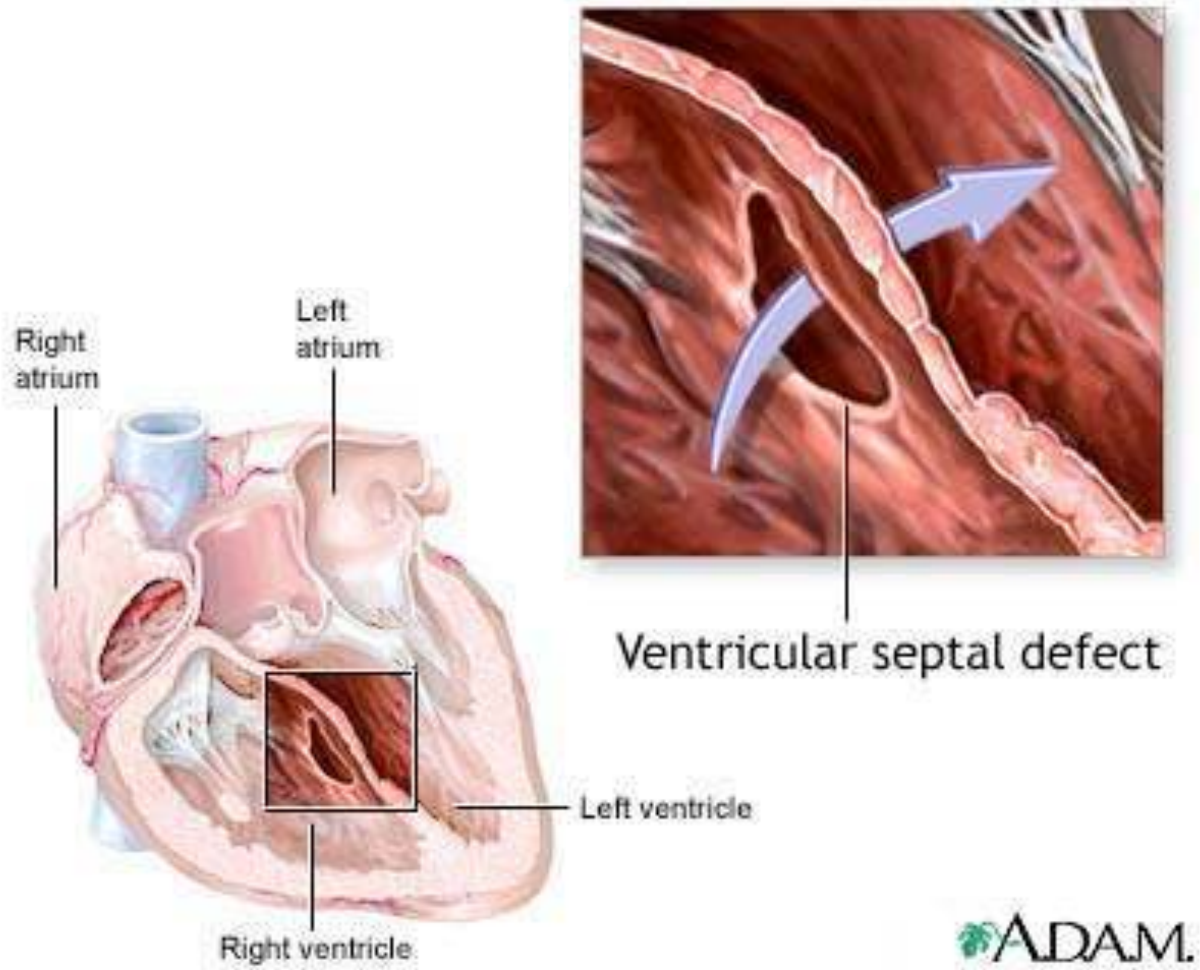
Biomechanical Compatibility

Elastic Deployment

Biocompatibility

MR Compatibility

Septal Occlusion



AGA Medical

W.L. Gore

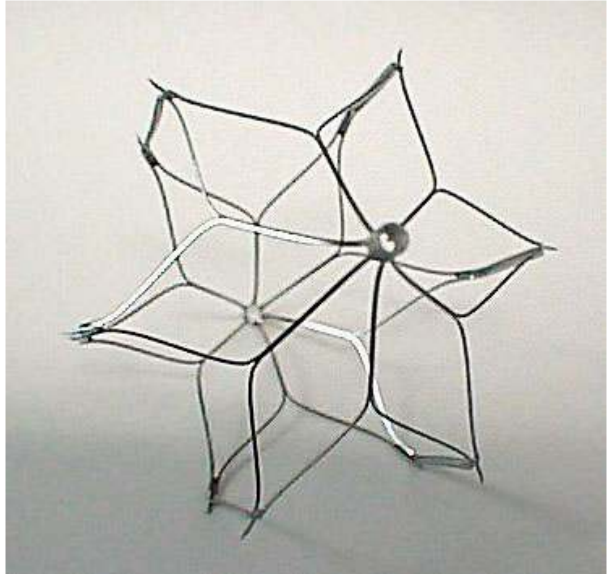
Biomechanical Compatibility

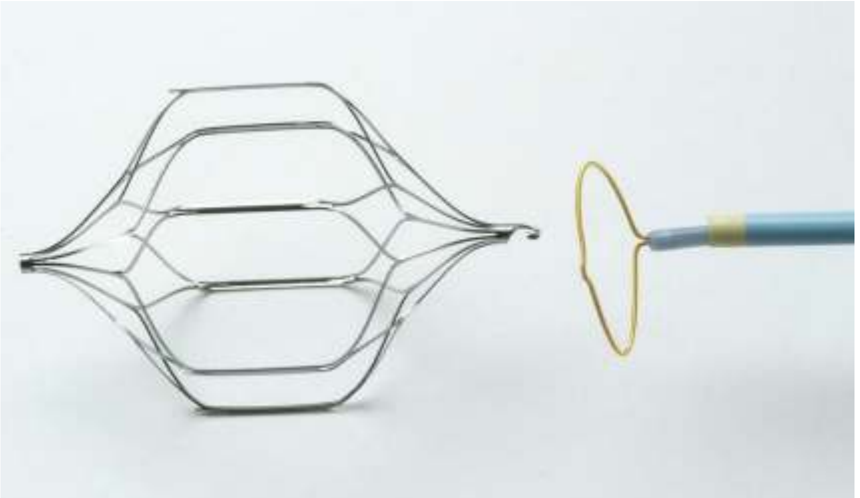
Elastic Deployment

Biocompatibility

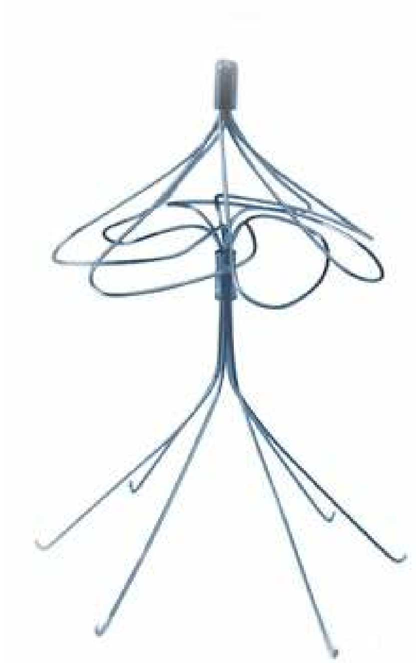
MR Compatibility

Vena Cava Filters





Cordis

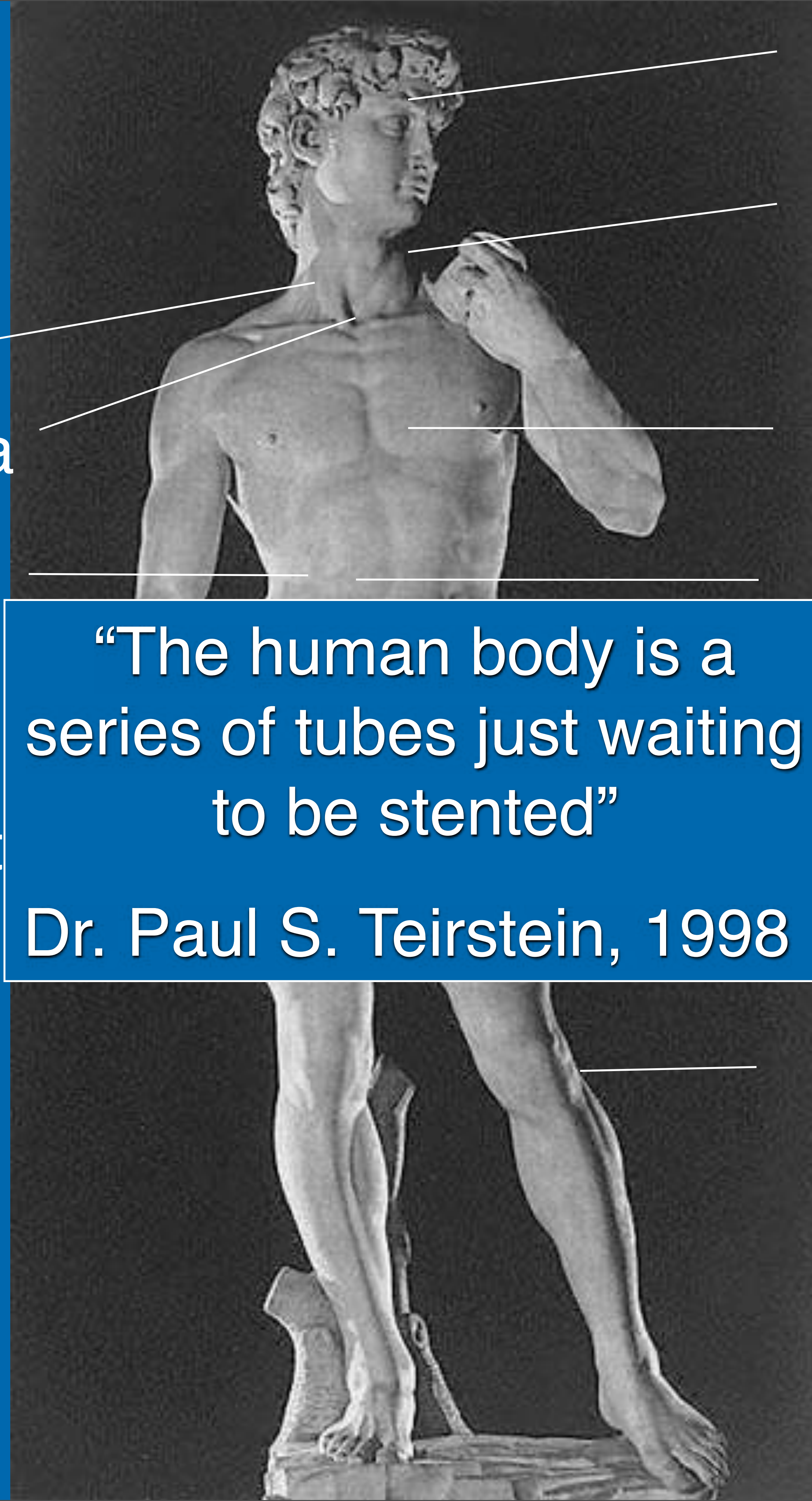


C.R. Bard

Stents and Stent Grafts

Stents use a wide range of properties

- Biomechanical Compatibility
- Elastic or Thermal Deployment
- Kink Resistance
- Constancy of Stress
- Dynamic Interference
- Hysteresis / Biased Stiffness (COF and Crush Resistance)
- Fatigue Resistance
- Biocompatibility
- MR Compatibility



"The human body is a series of tubes just waiting to be stented"

Dr. Paul S. Teirstein, 1998

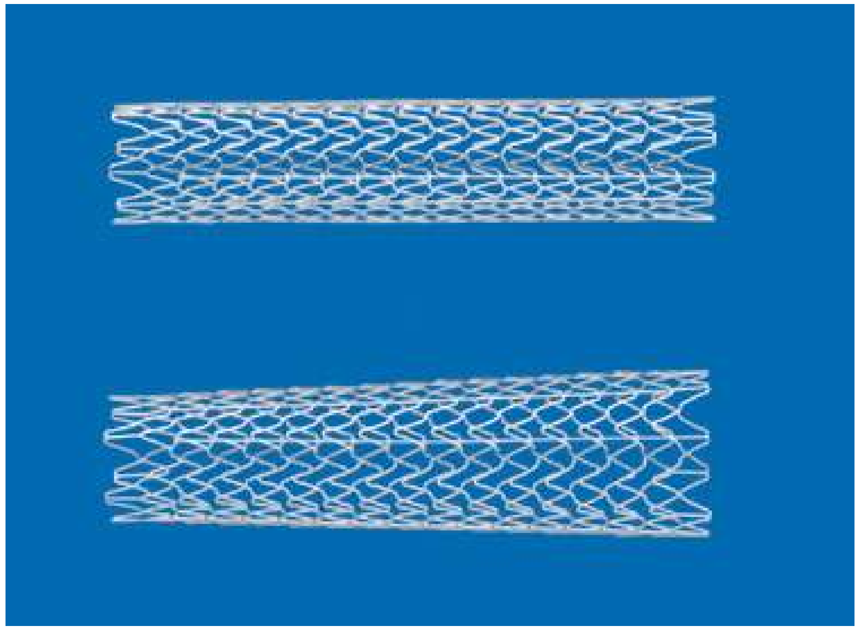
Nitinol Self-Expanding Stents

Coil Stents

Woven Wire Stents

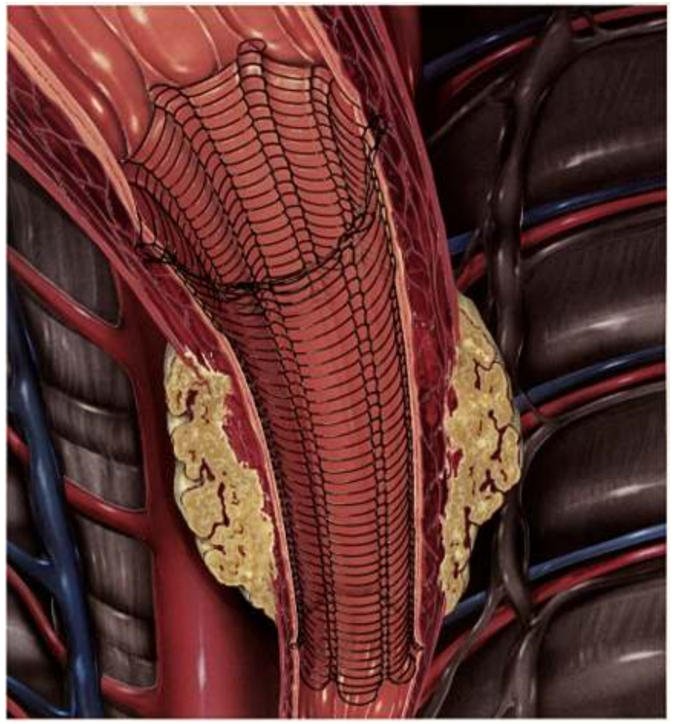
"Wiggle Wire" Stents

"Slotted Tube" Stents

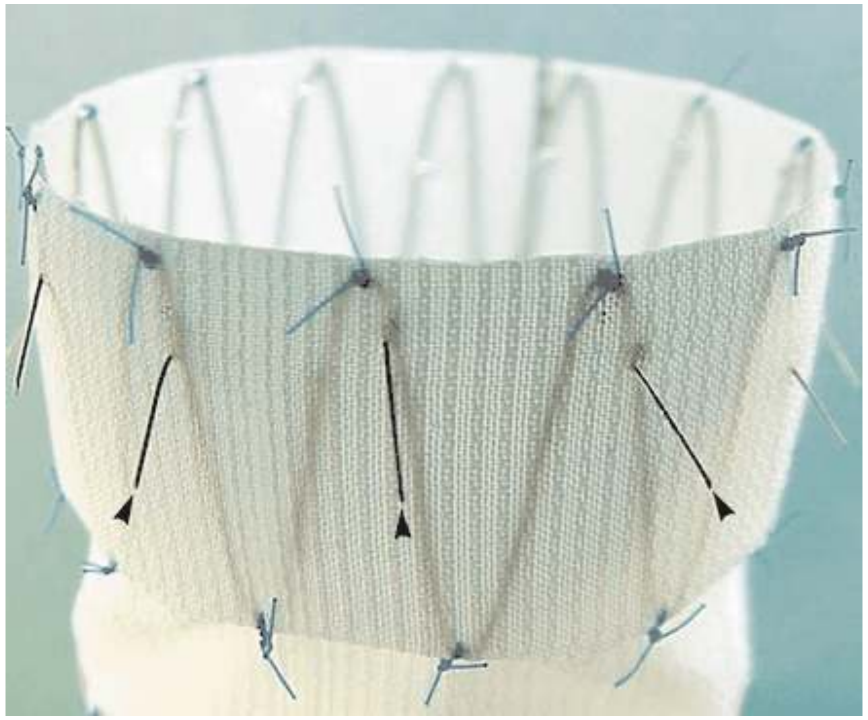


Abbott

ev3



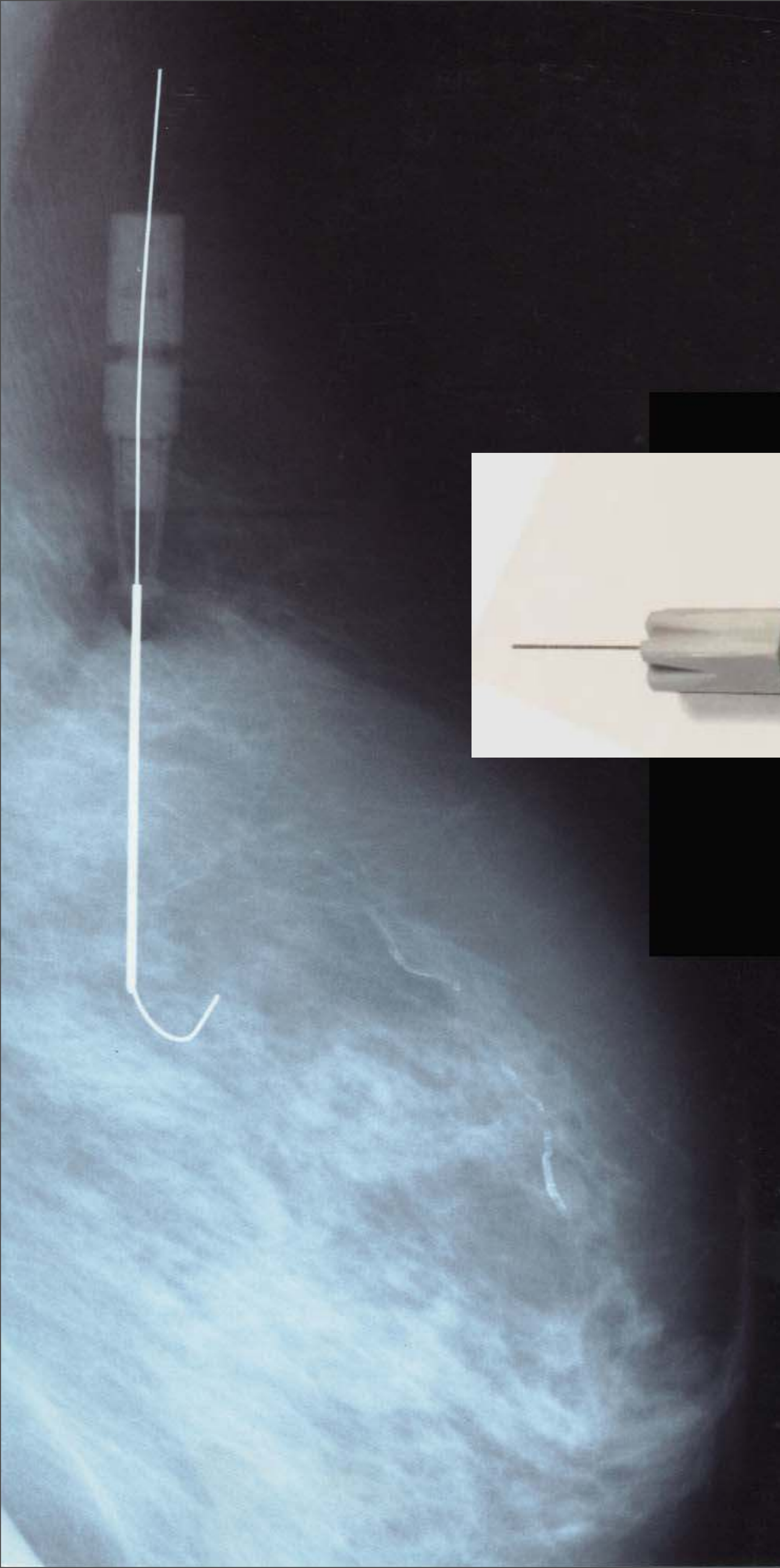
BSC



Medtronic

Design: Case Studies of Engineering Challenges of Selected Nitinol Medical Devices

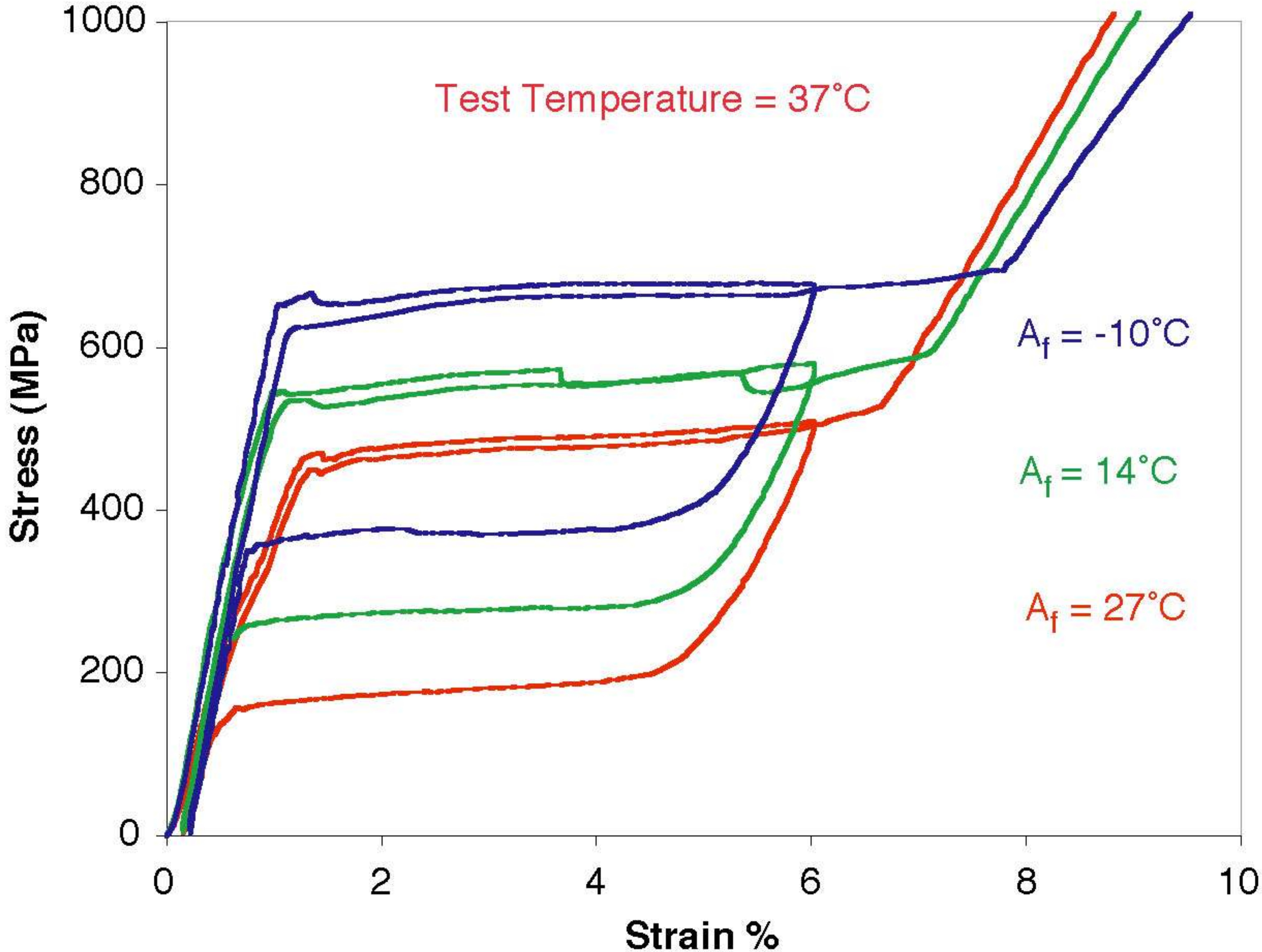
Case Study 1: Homer Mammalok



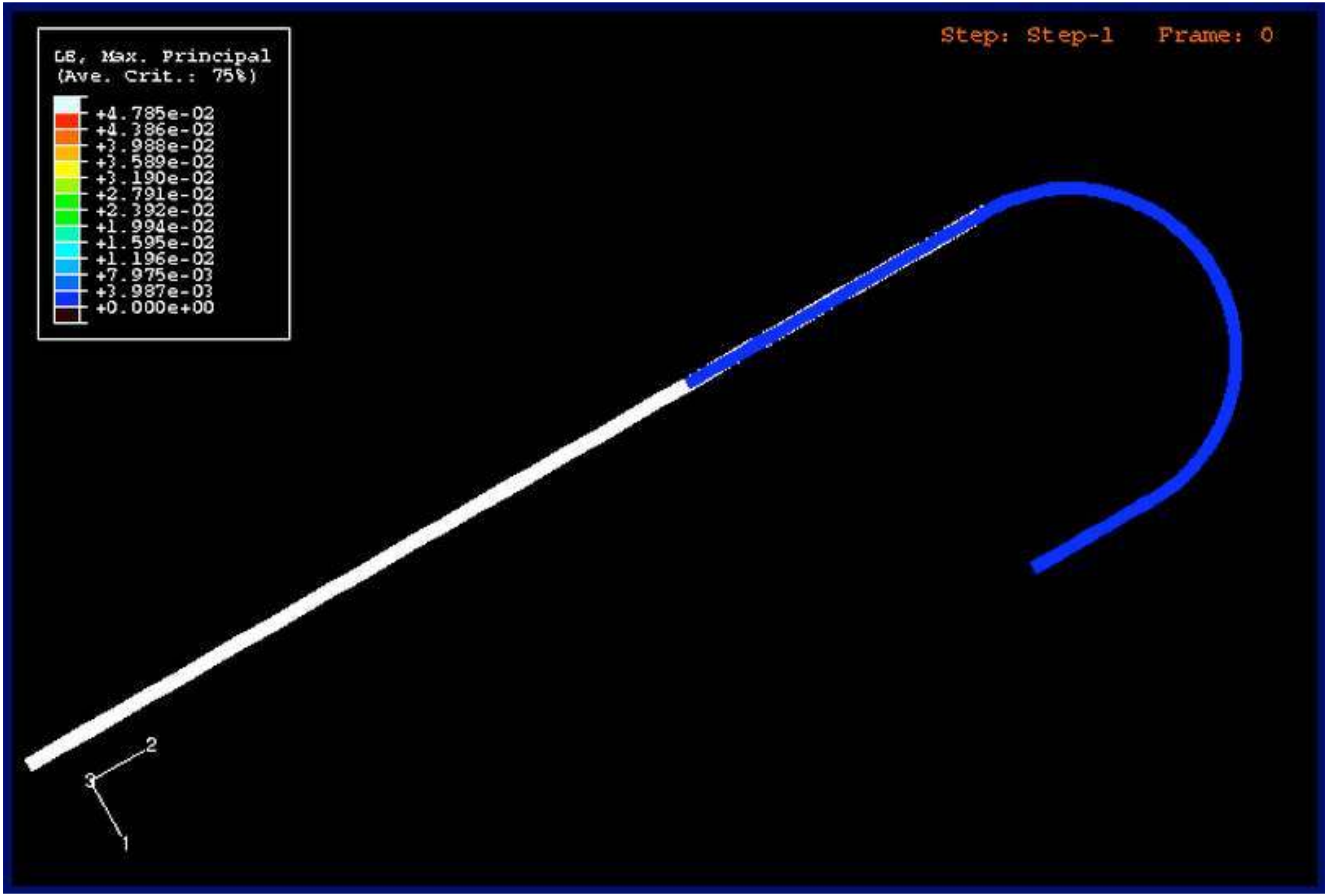
$A_f = -10^\circ C, 14^\circ C, 27^\circ C$

Challenge: Determine the Effect of A_f on Deployment Stress and Strain

Effect of A_f on Tensile Properties

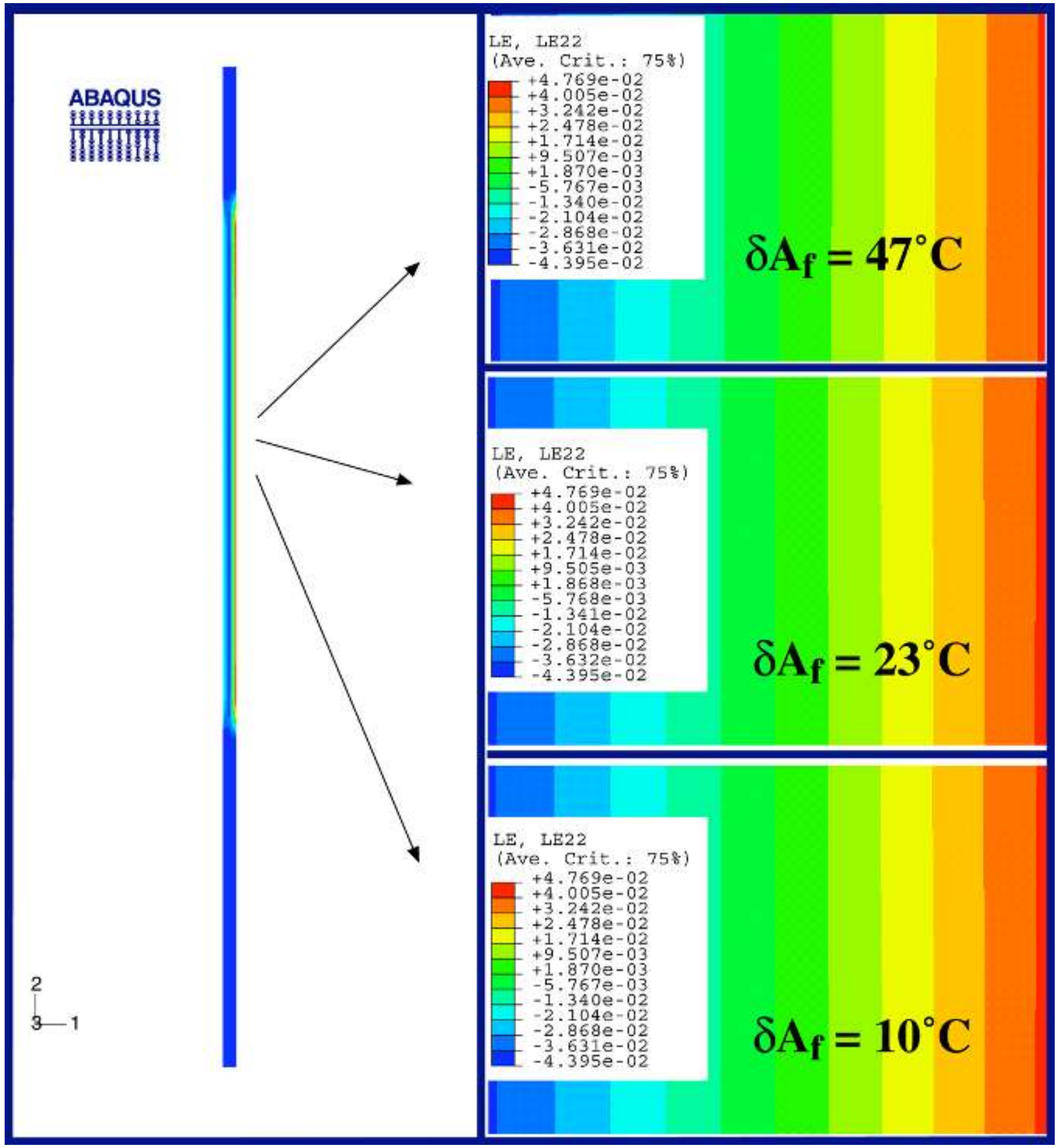


FEA of Hook Retraction



FEA Strain Distribution

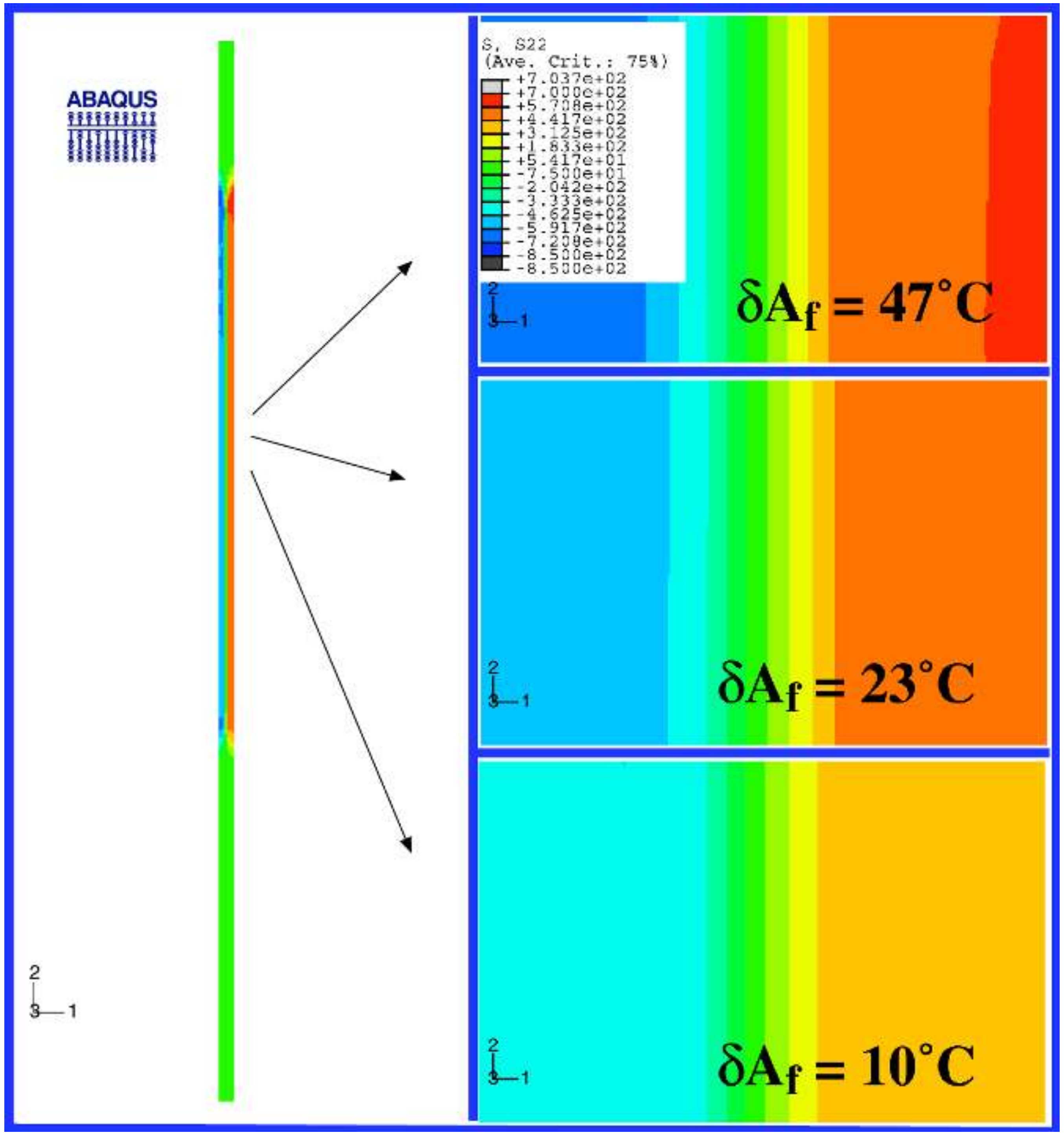
$\delta A_f = T_T - A_f$



STRAIN

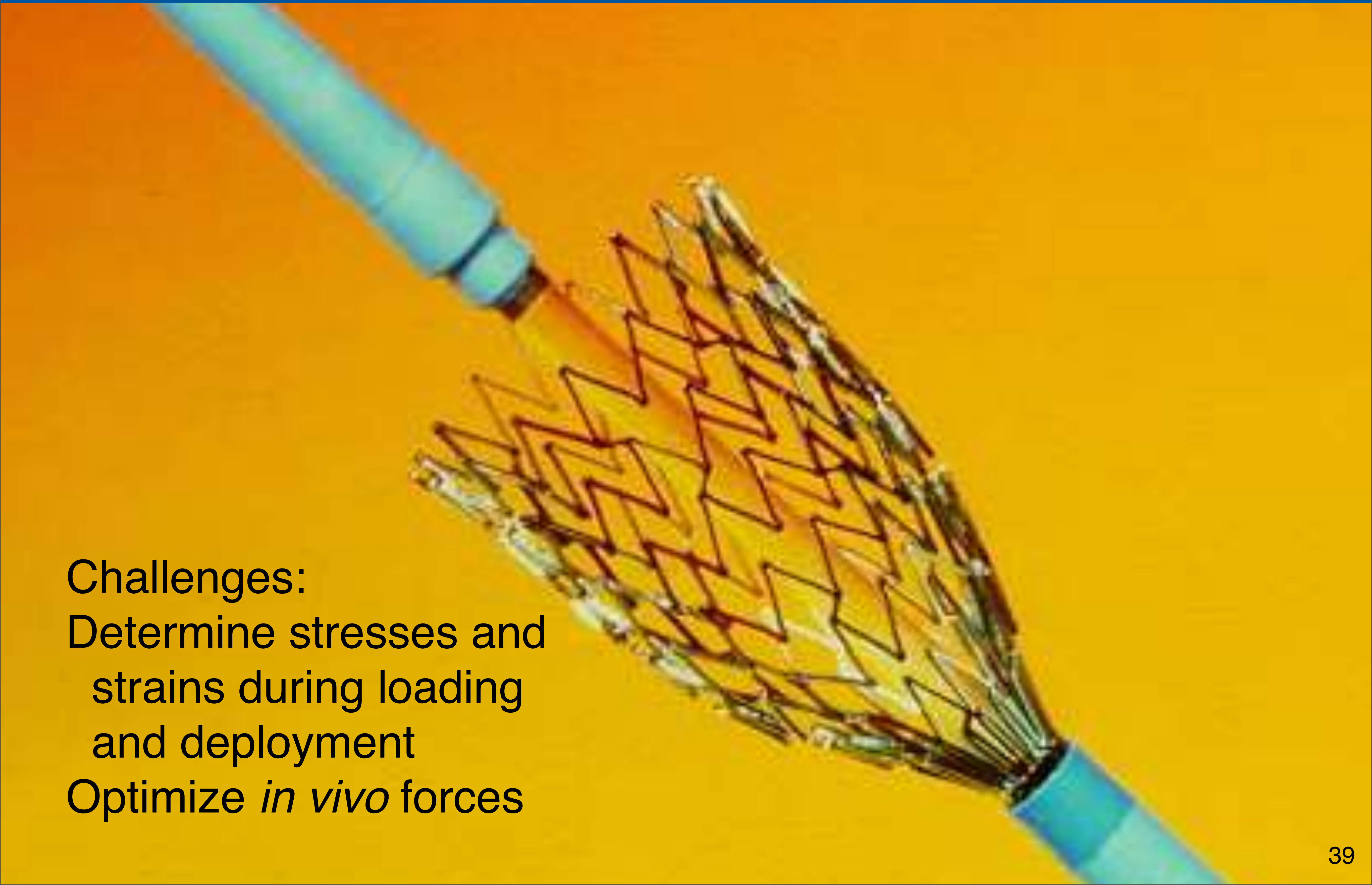
FEA Stress Distribution

$\delta A_f = T_T - A_f$



STRESS

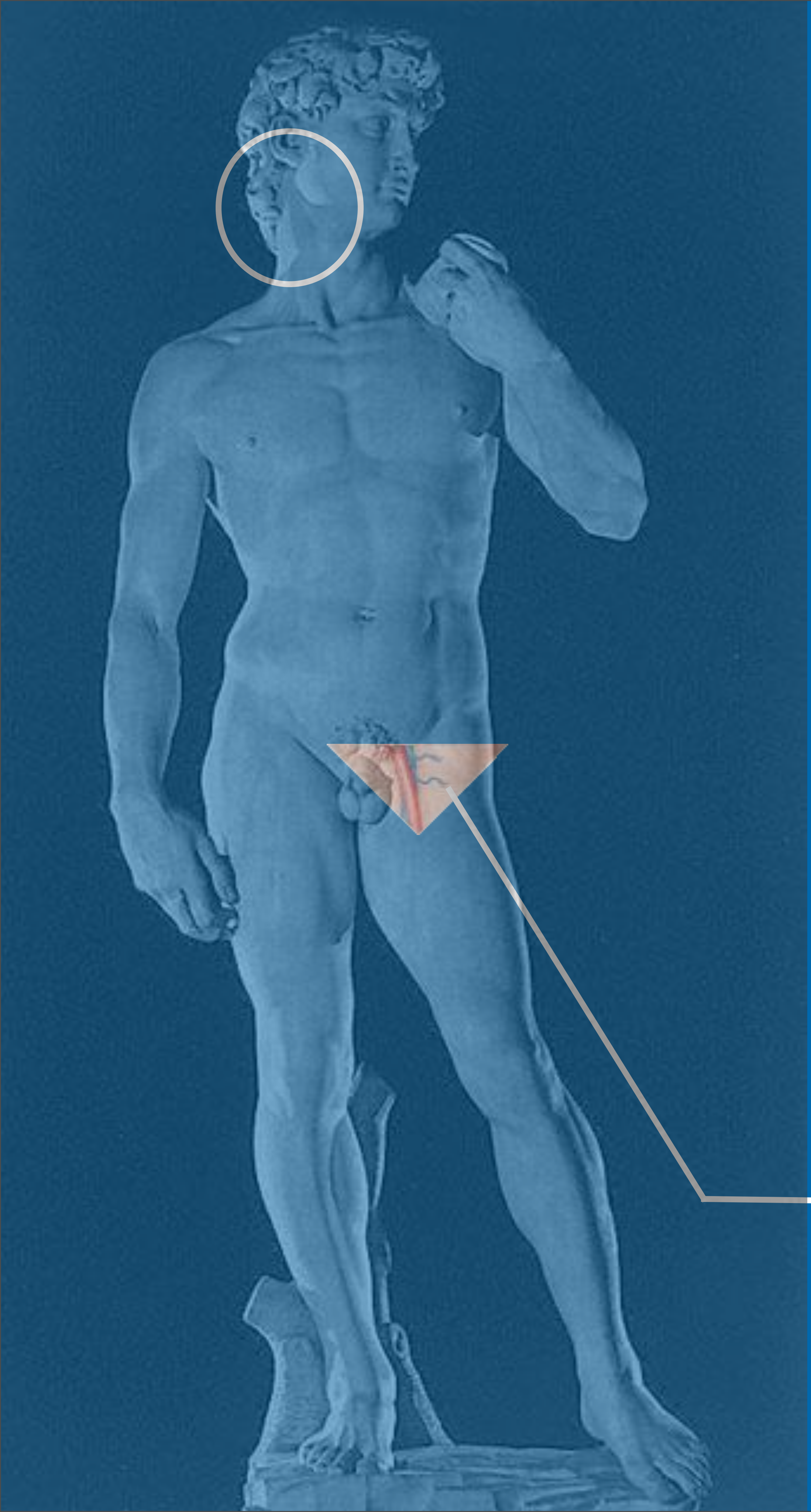
Case Study 2: Stents

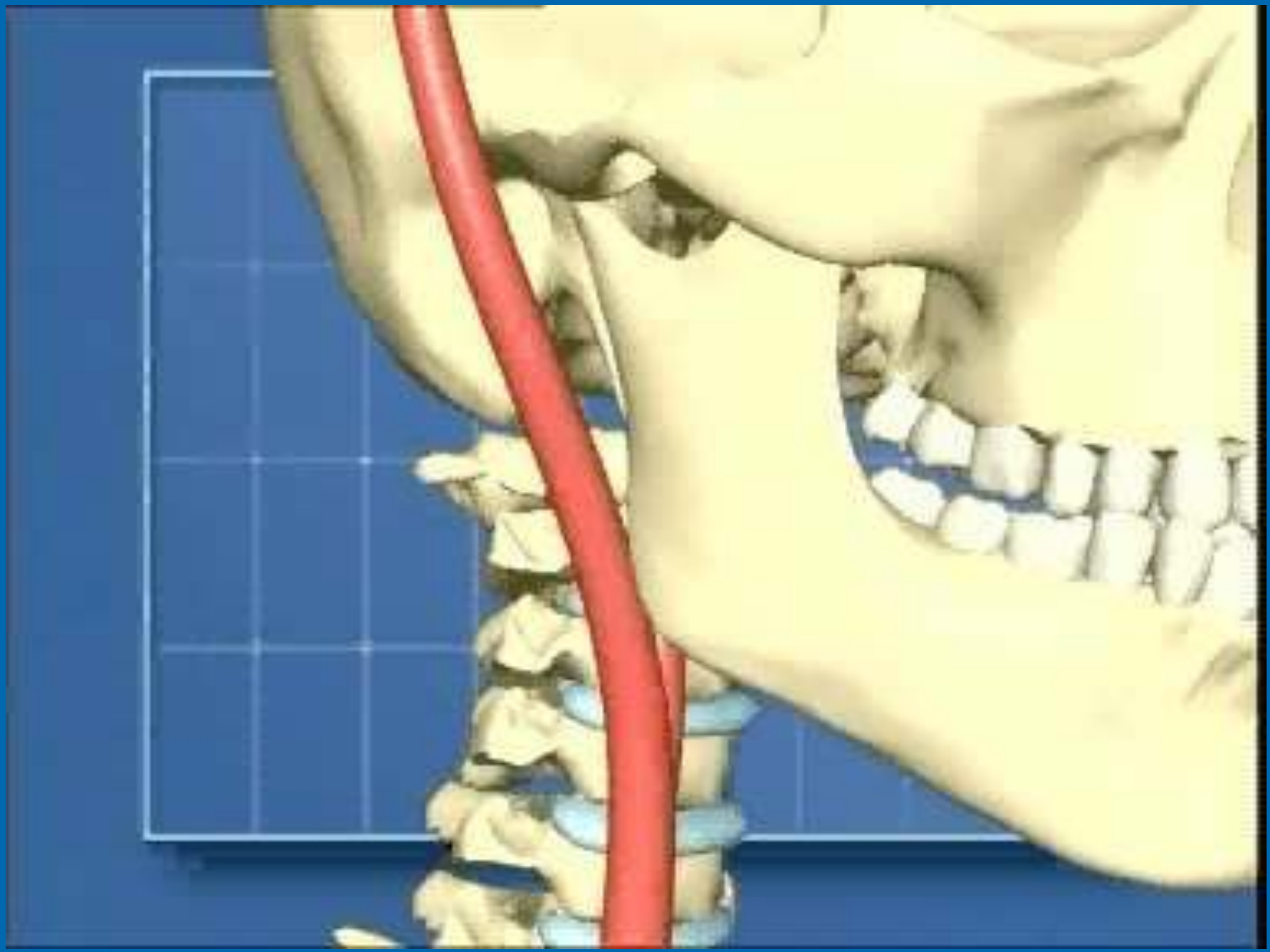


Challenges:

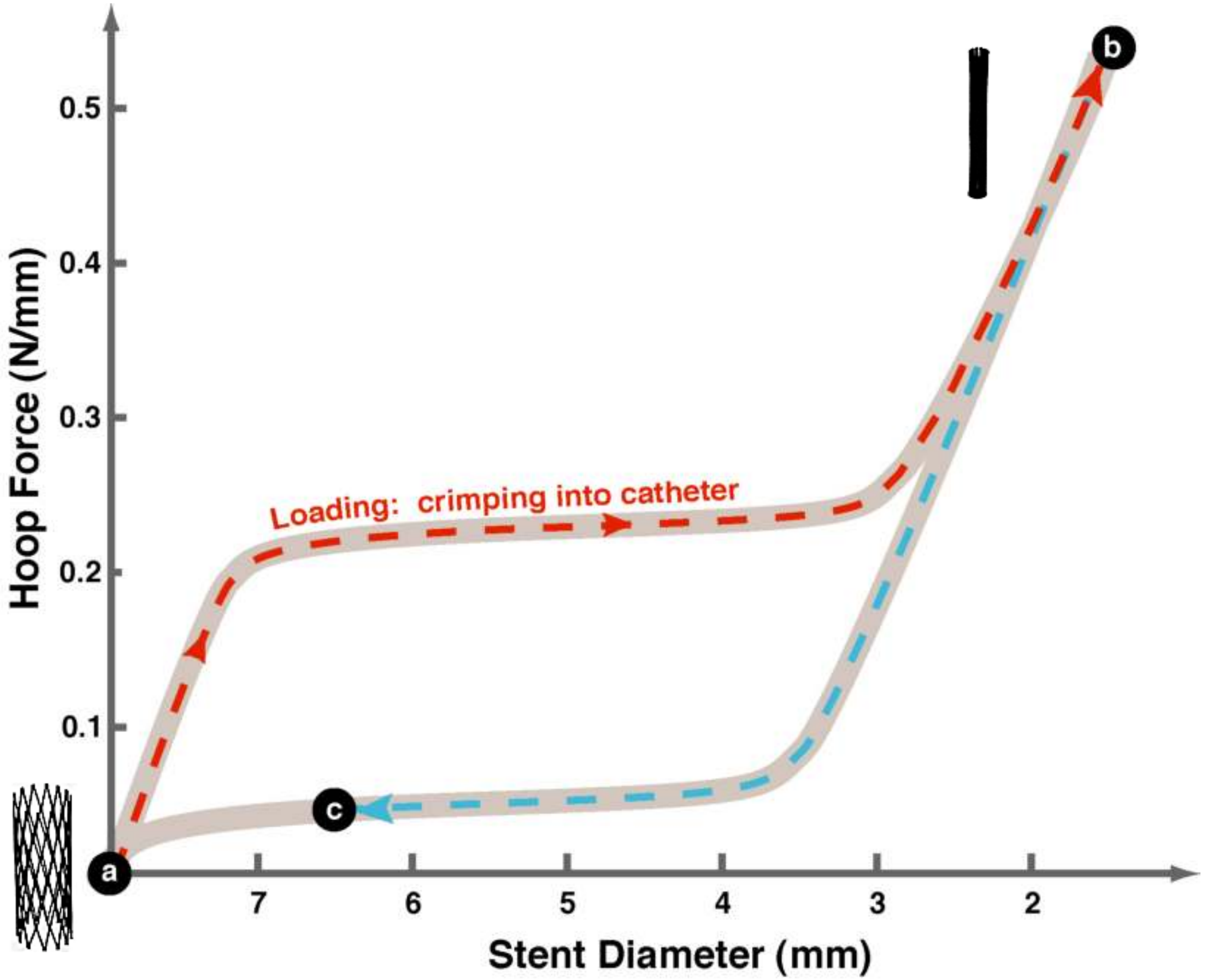
Determine stresses and strains during loading and deployment

Optimize *in vivo* forces

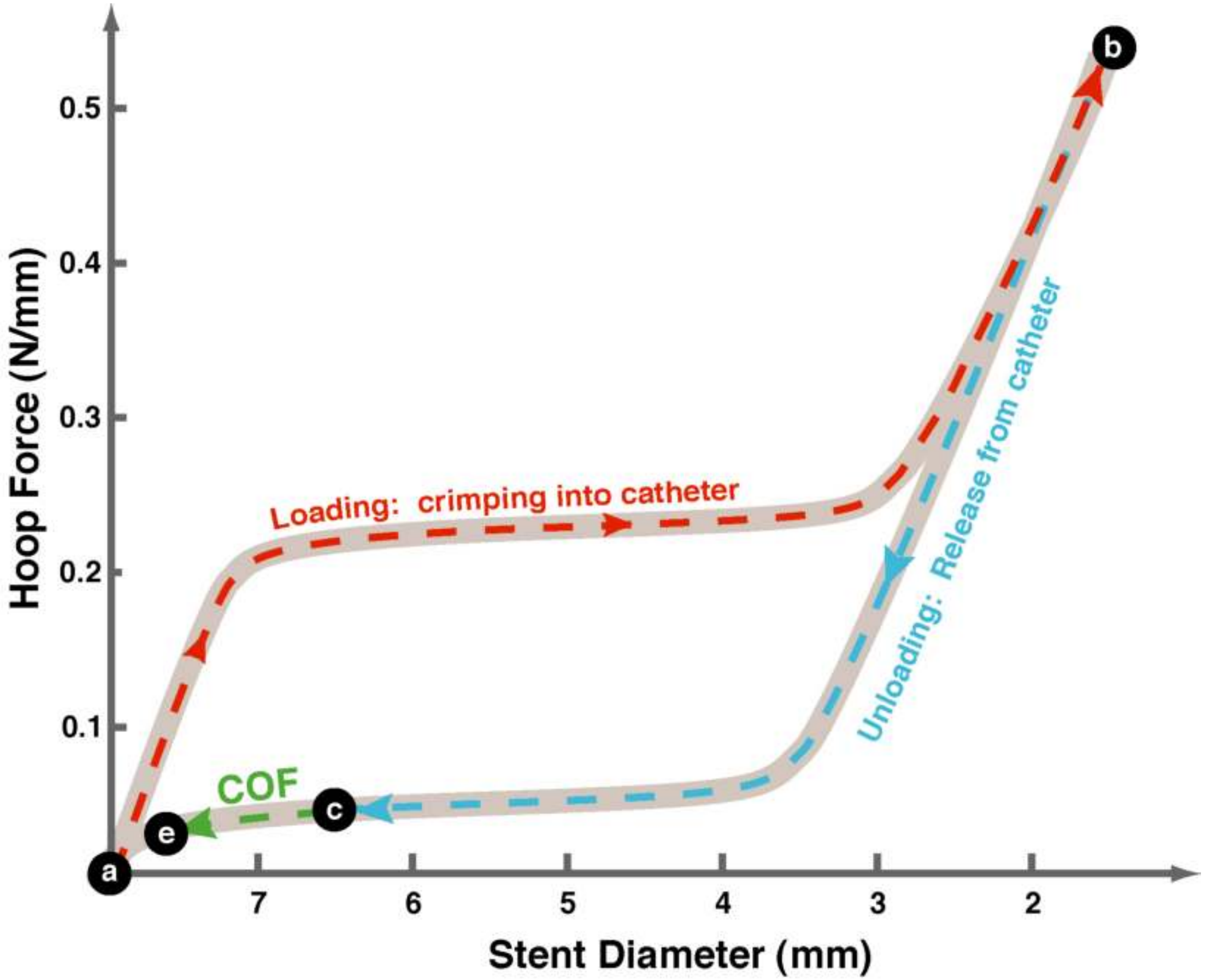


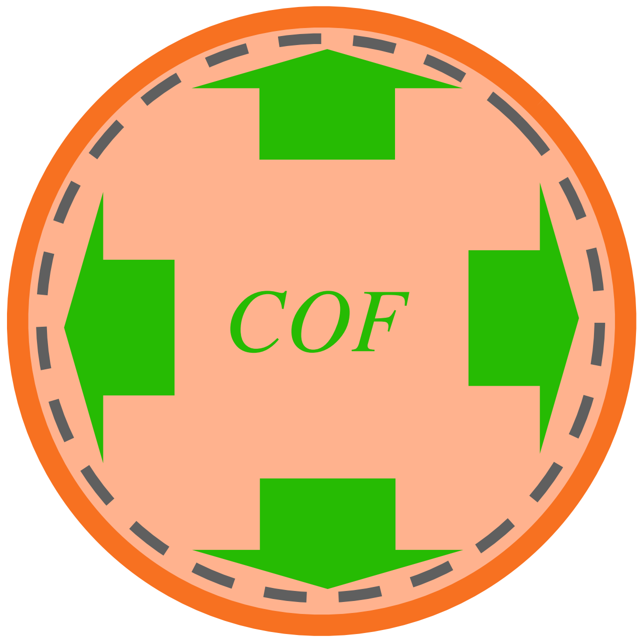


Loading into the Catheter

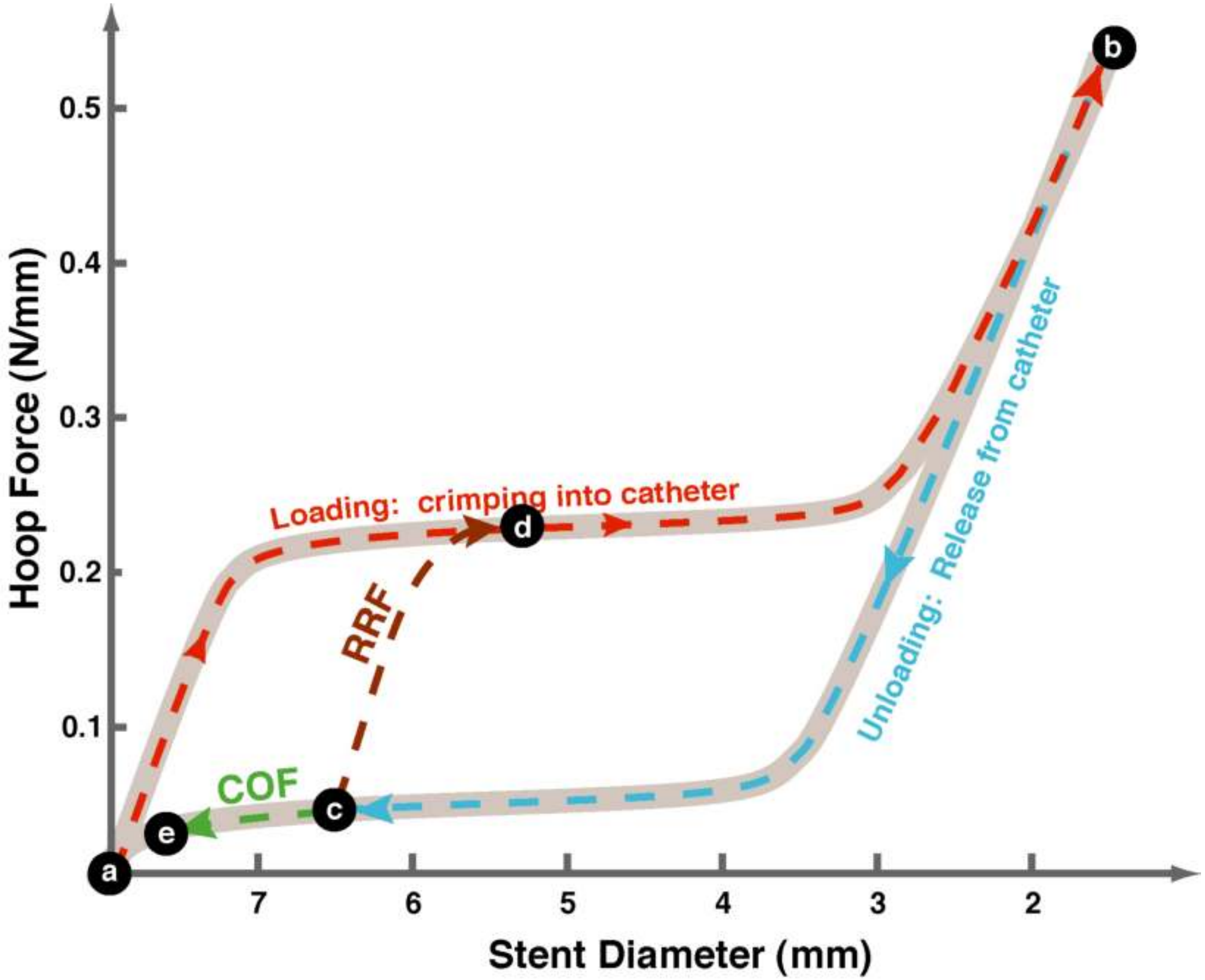


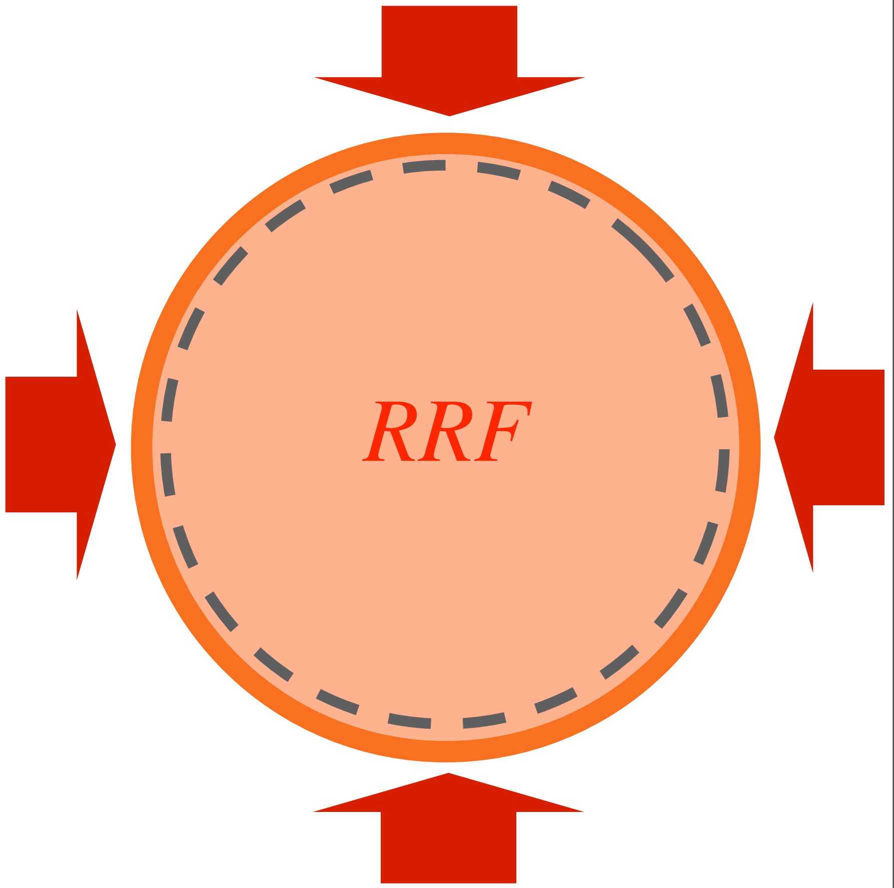
Chronic Outward Force



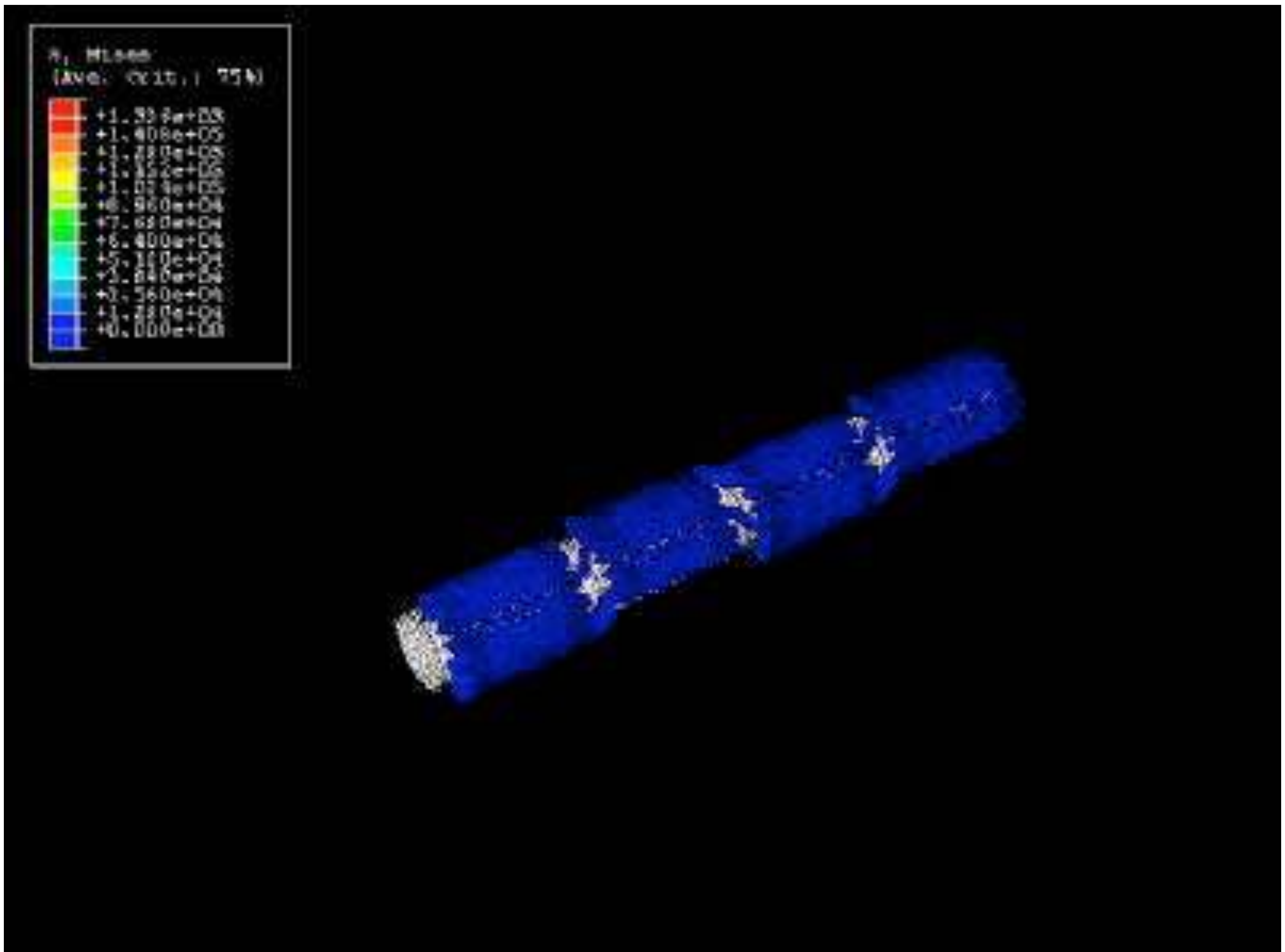


Radial Resistive Force (RRF)

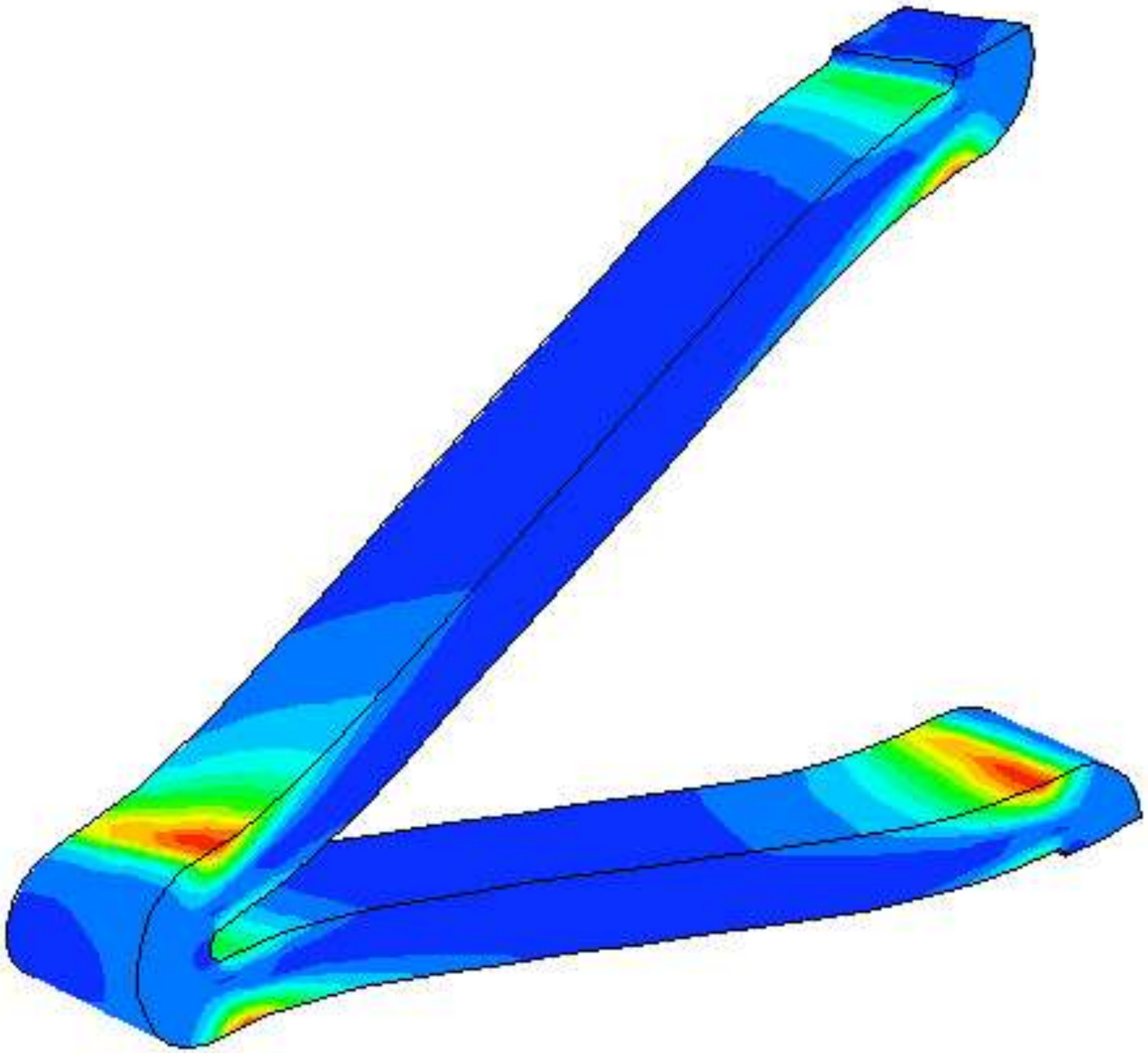




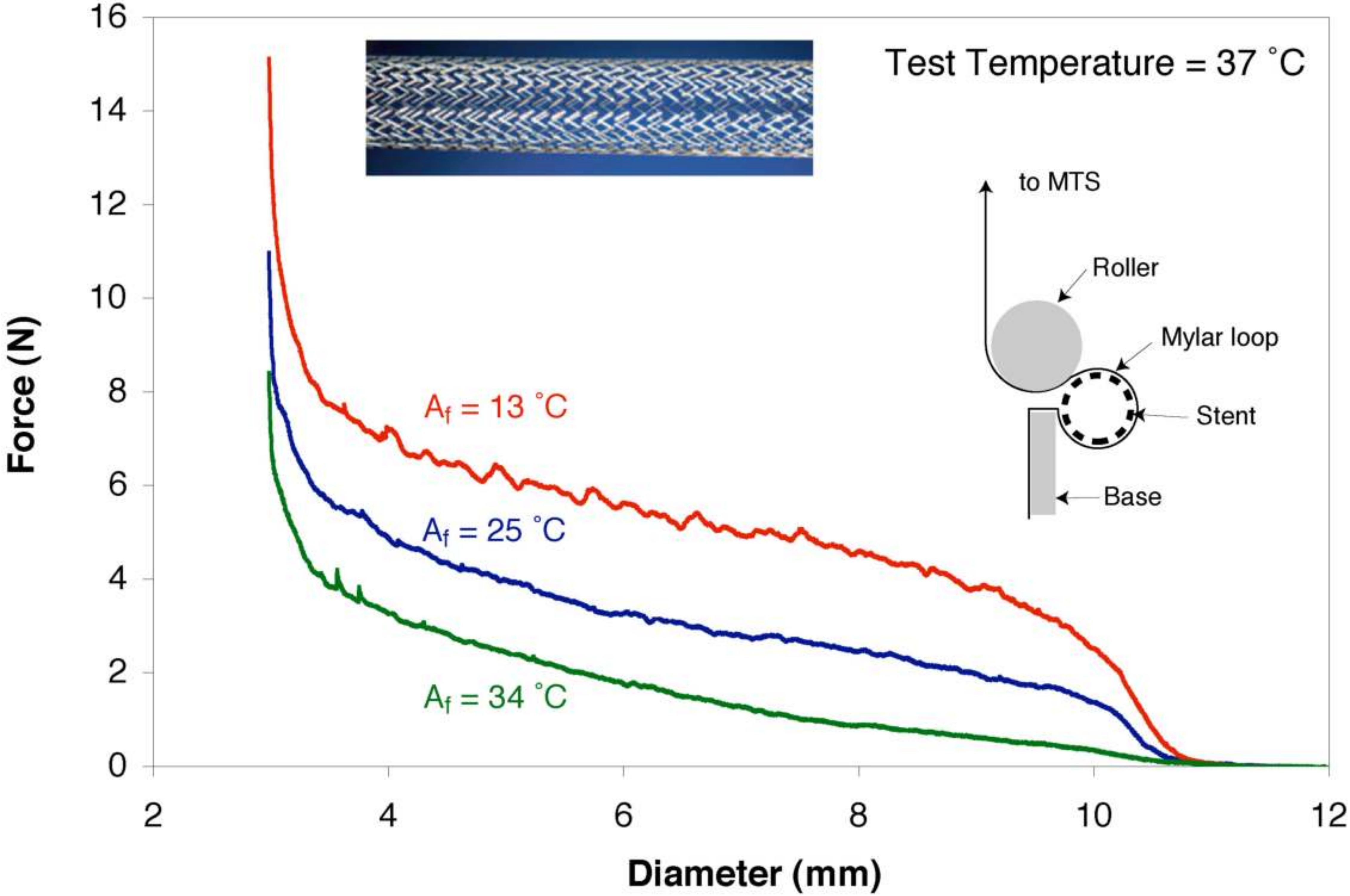
Stress and Strain Analysis



Stress - Strain Distribution



Radial Force Testing



Is there an ideal A_f for a stent? What are the effects of A_f?