Metals as Implantable Materials

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Disclosures

- **The author is employed by Nitinol Devices & Components, Inc. ("NDC"),**
- **a supplier and development partner to many companies developing Nitinol medical devices.**

Common Metallic Materials for Medical Implants

- Stainless Steel (316L)
- Cobalt–Chrome (MP35N, L-605, and Elgiloy)
- Titanium (Ti-6Al-4V and CP titanium)
- Nickel-Titanium (Nitinol)

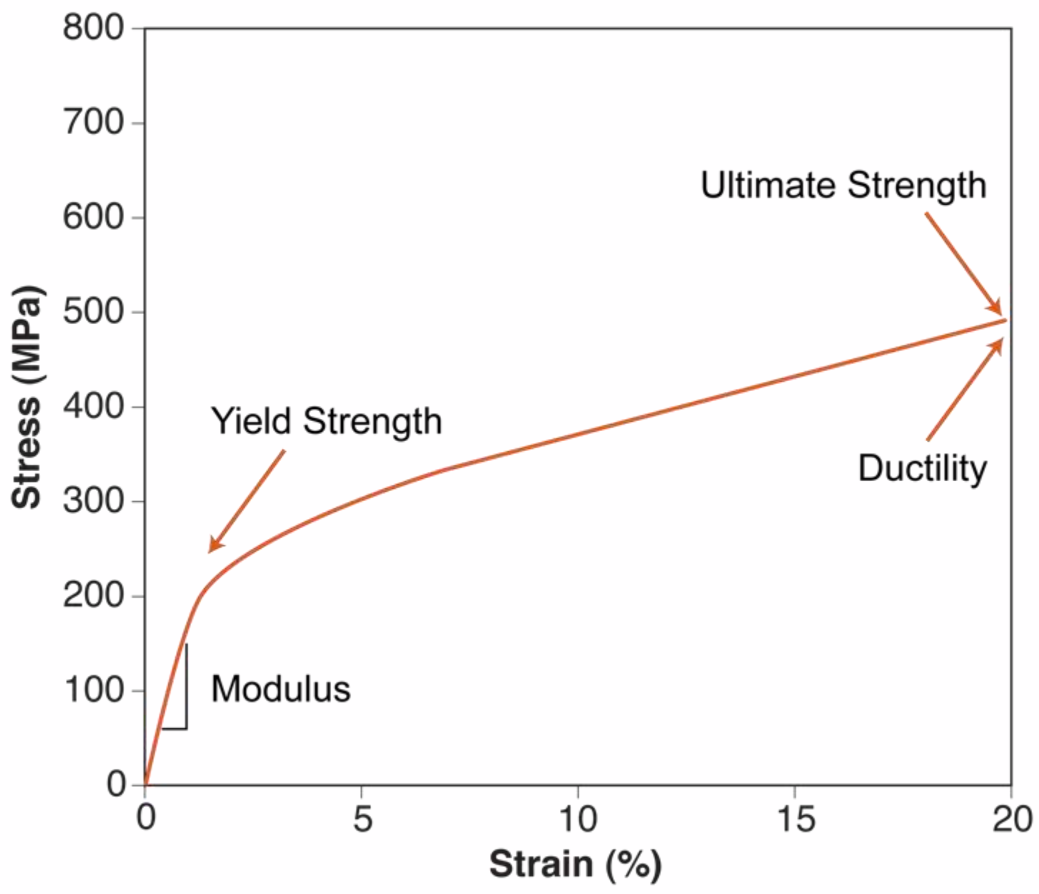
Compositions (in weight percent)

Key Element	Stainless Steel (316L)	Cobalt-Chrome (Elgiloy, MP35N, L-605)	Titanium (CP, Ti-6-4)	Nitinol
Iron	63%	1-15%		
Titanium			90-100%	45%
Nickel	14%	15-35%		55%
Chromium	18%	20%		
Cobalt		40-50%		
Other	Mo, Mn	Mo, Mn, W	Al, V	

Physical Properties of Implanted Metals

Attribute	Stainless Steel	Cobalt-Chrome	Titanium	Nitinol
Strength				
Stiffness				
Fatigue				
Corrosion				
Other				

Strength: What is it?

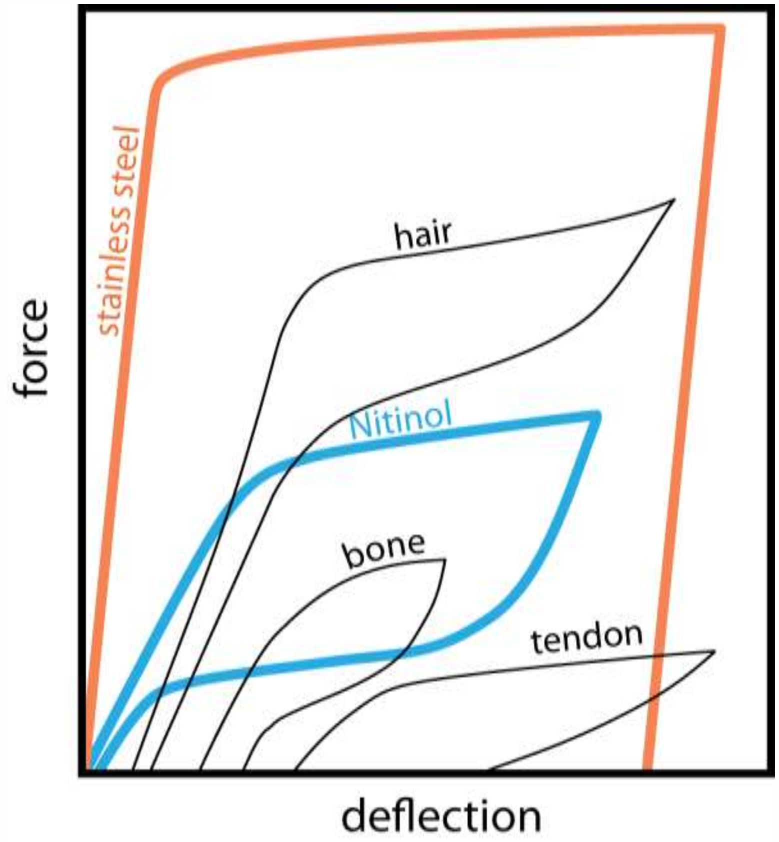


Physical Properties of Implanted Metals

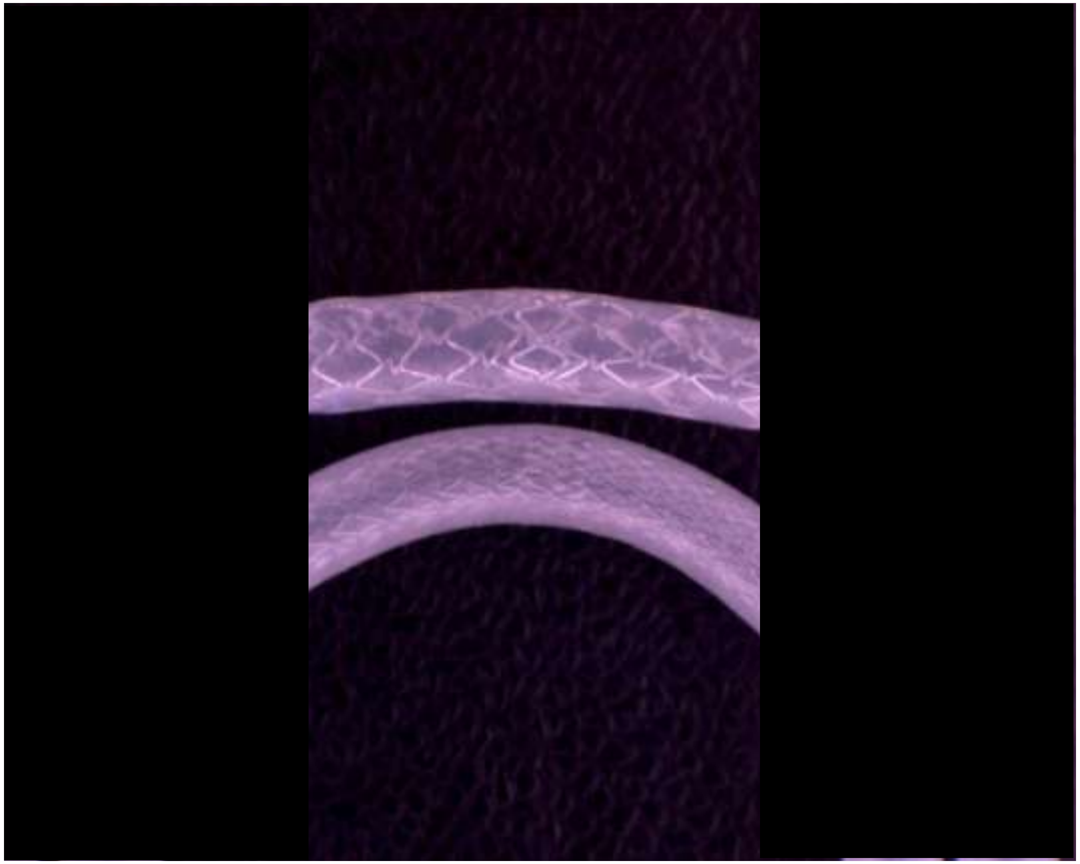
Attribute	Stainless Steel	Cobalt-Chrome	Titanium	Nitinol
Strength	medium (300/560 MPa)	high (600/1140 MPa)	high (880/950 MPa)	high (500/1400 MPa)
Stiffness				
Fatigue				
Corrosion				
Other				

“Strength” is often confused with “Stiffness”

Stiffness is the opposite of compliance



Significance to a stent



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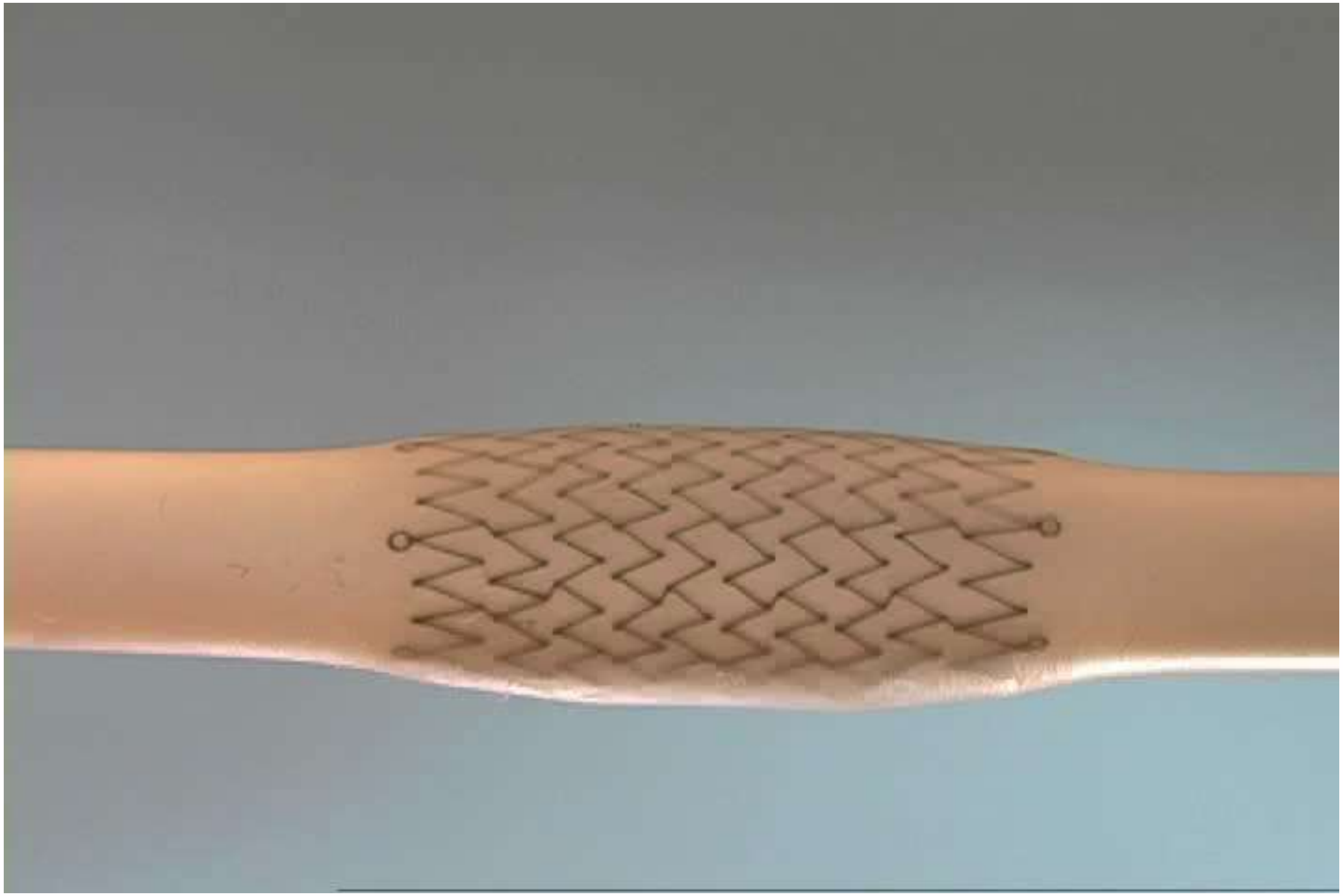
Strength	medium (300/560 MPa)	high (600/1140 MPa)	high (880/950 MPa)	high (500/1400 MPa)
Stiffness	high (200 GPa)	High (200 GPa)	moderate (90 GPa)	very low (~25 GPa)
Fatigue				
Corrosion				
Other				

Pulasatile durability



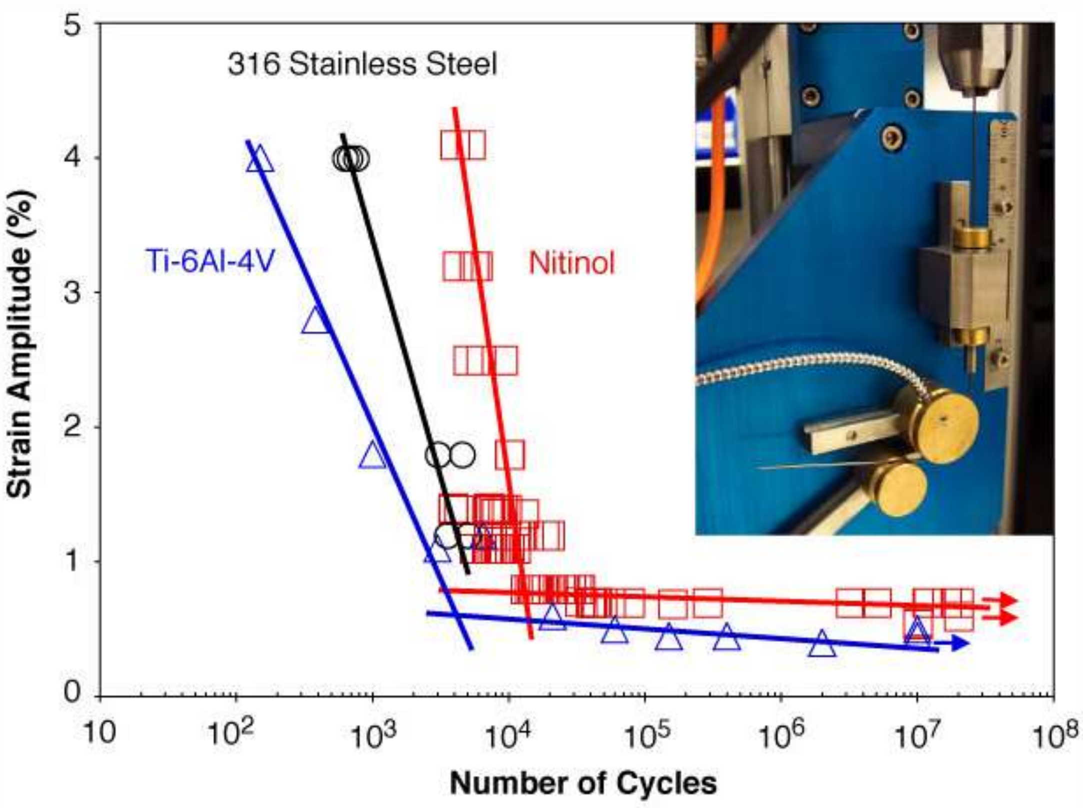
Which is more fatigue resistant, a rubber band, or a steel band?

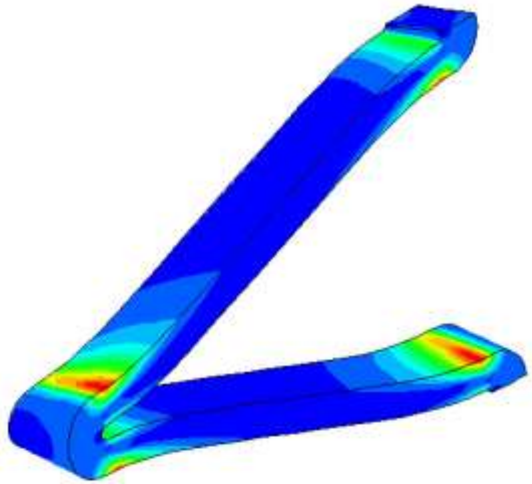
They both are.

A rubber band resists cyclic displacements better, but

a steel band resists cyclic loads better.

Fatigue Resistance is Related to Stress/Strain





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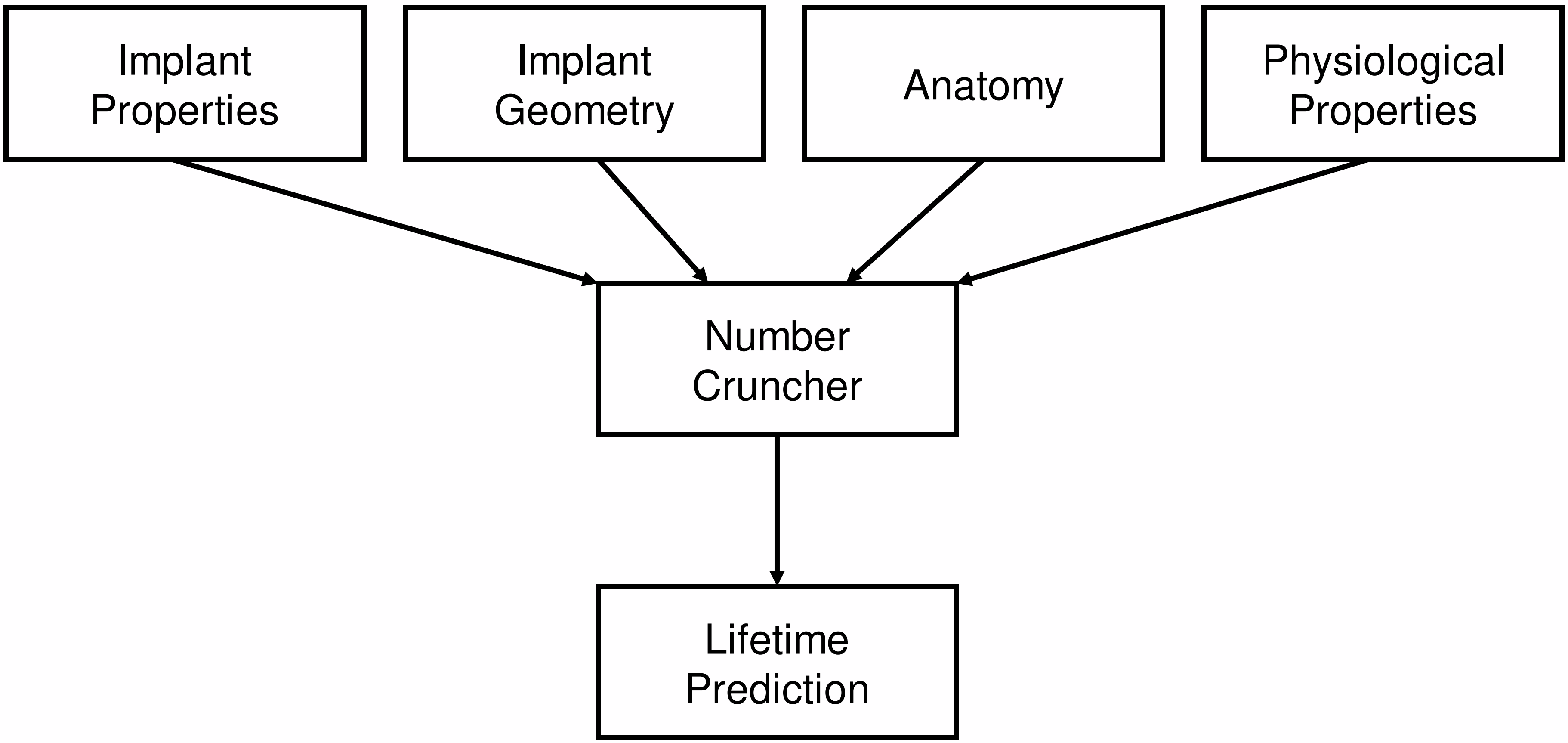
Fatigue	Good in load control	Good in load control	Good in load control	Good in strain control
Corrosion				
Other				

Why do we still design devices that fracture?



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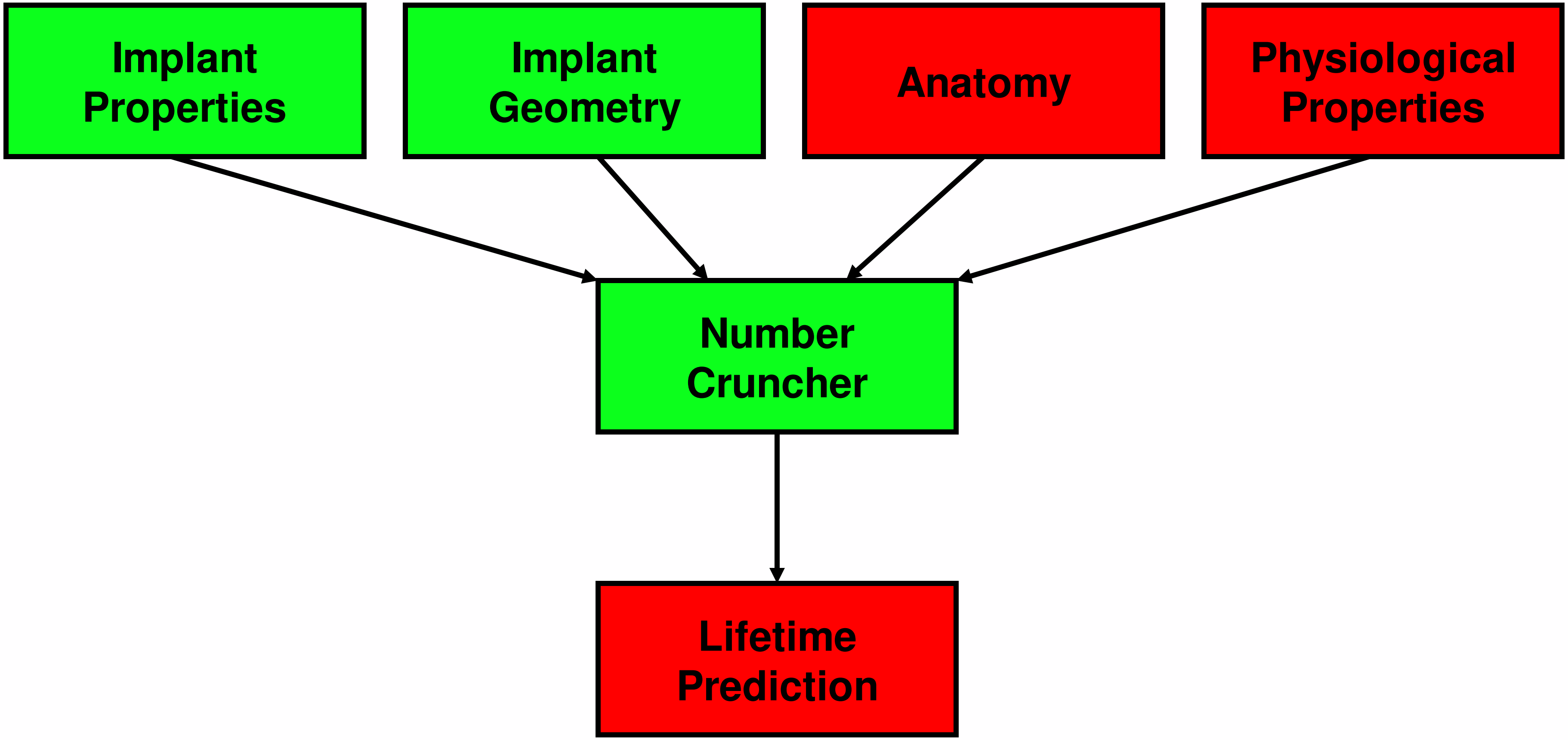
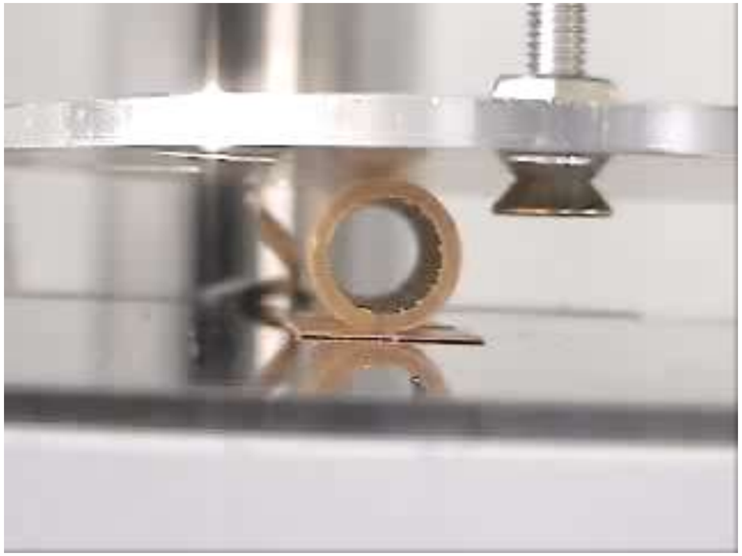
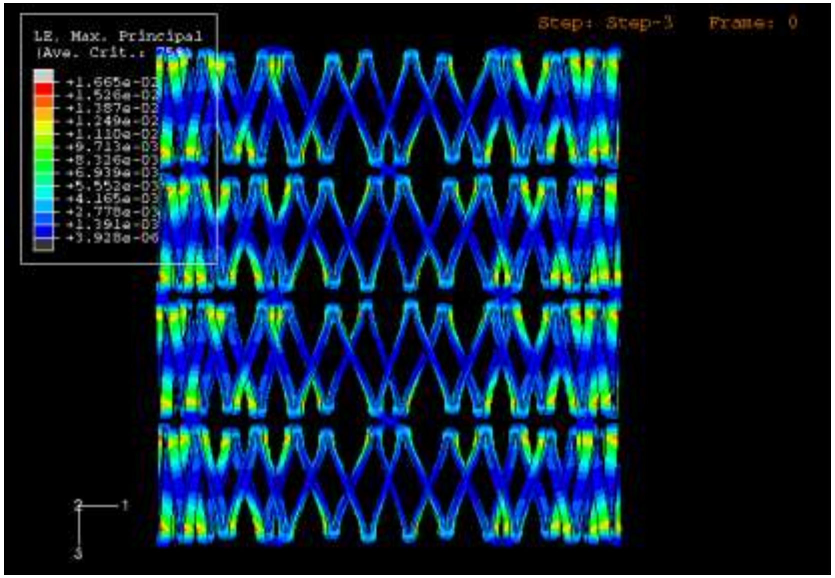


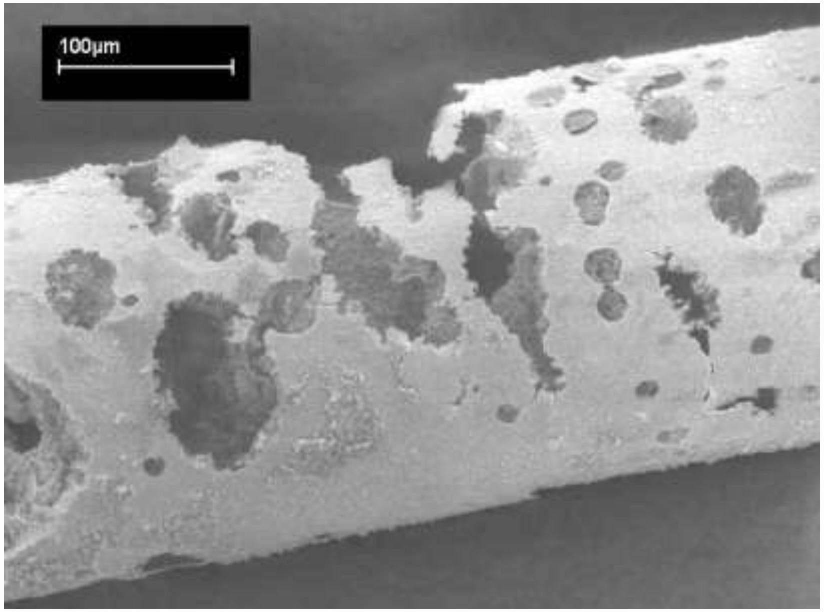
Non-pulsatile Influences

Non-Pulsatile durability





Corrosion Resistance



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Corrosion	Good – Cr_2O_3 (500 mV)	Good – Cr_2O_3 (500 mV)	Excellent – TiO_2 (800 mV)	Excellent – TiO_2 (800 mV)
Other				

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Other	MRI artifacts	L-605 is radiopaque	Can be radiopaque	Shape Memory