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Biomechanics of complications in spine surgery

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Implant failure

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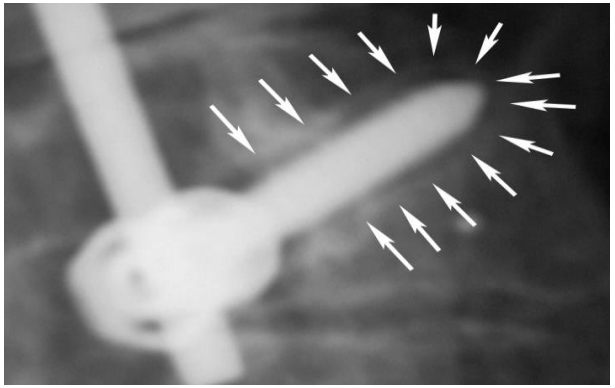
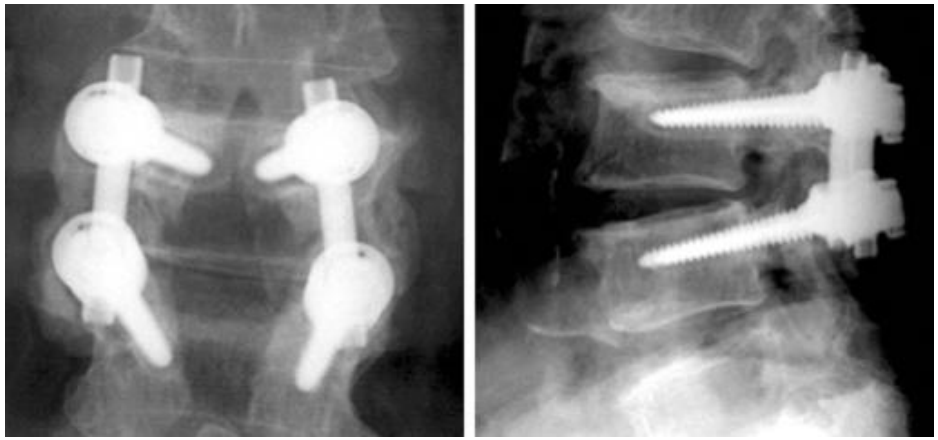
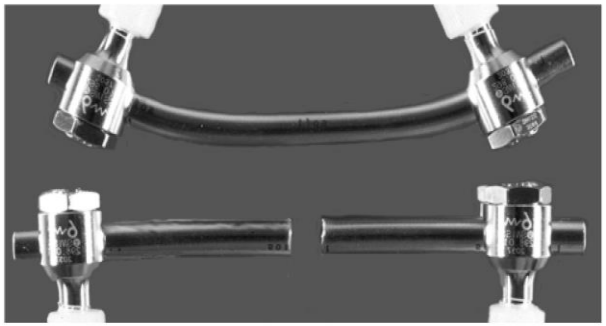


http://www.medscape.com



Kim et al. 2008

loosening and pull-out



Hahn et al. 2002

Hahn et al. 2002

static or fatigue failure

Fatigue fracture

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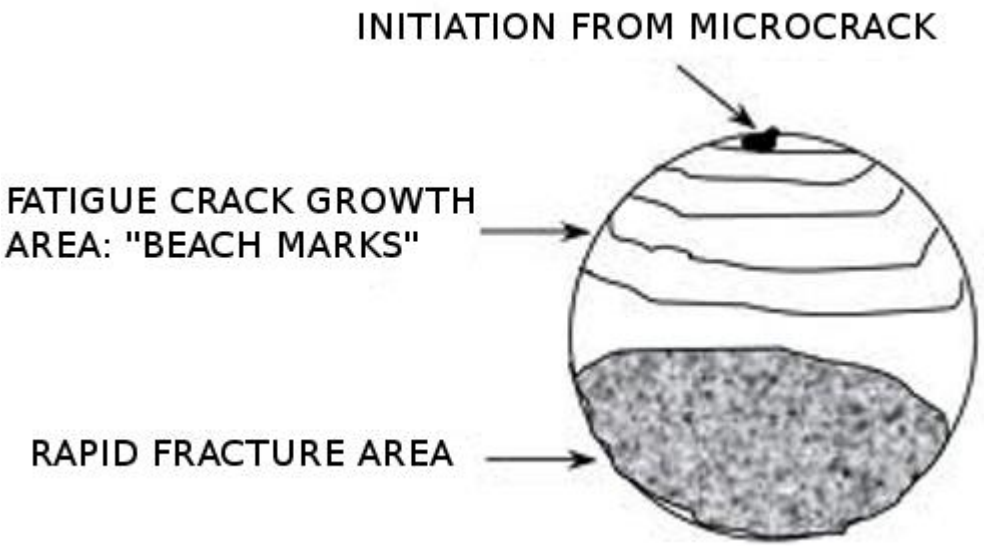

http://www.charlestongaragedoors.com

http://www.birmingham.ac.uk

due to repetitive loading

Factors that affect fatigue life

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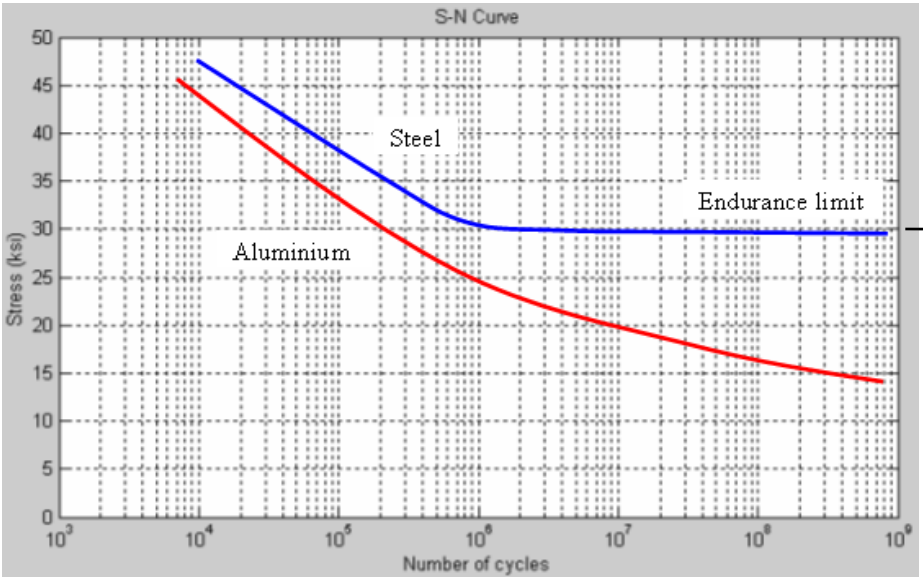
Surface quality

- SURFACE ROUGHNESS - MICRO STRESS CONCENTRATIONS
- SURFACE FINISH – HA COATING, NITRIDING

Mechanical properties of the material



fatigue failure never happens under this limit

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Factors that affect fatigue life

Size and distribution of internal defects

- Casting defects
- Gas porosity or non metallic inclusions
- Shrinkage voids

Direction of loading

- direction of the principal stress

Grain size

- smaller grains yield longer fatigue lives
- But,surface defects or scratches will have a greater influence than in a coarse grained alloy

Environment

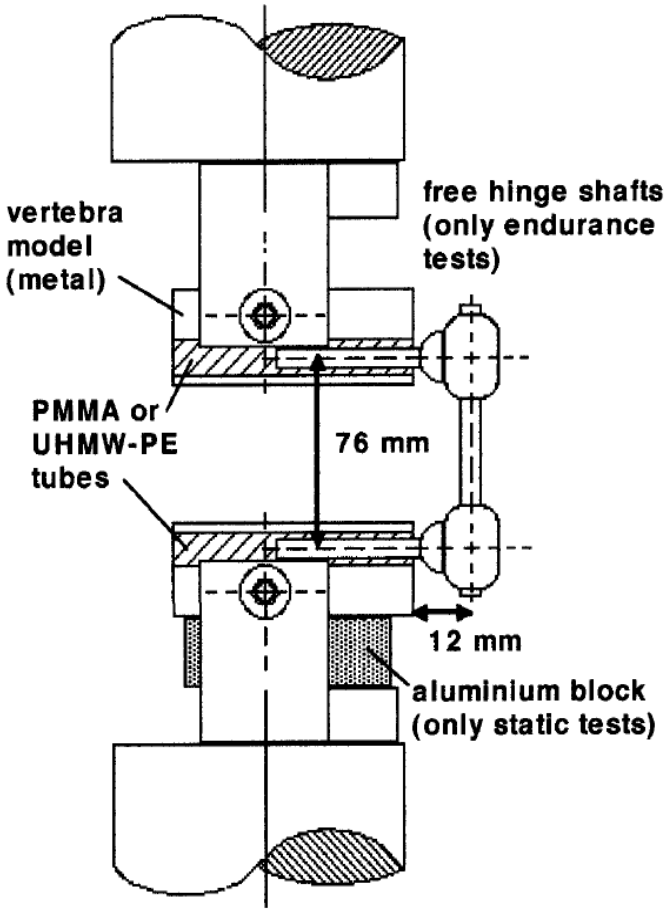
- Corrosion fatigue
- Galvanic corrosion

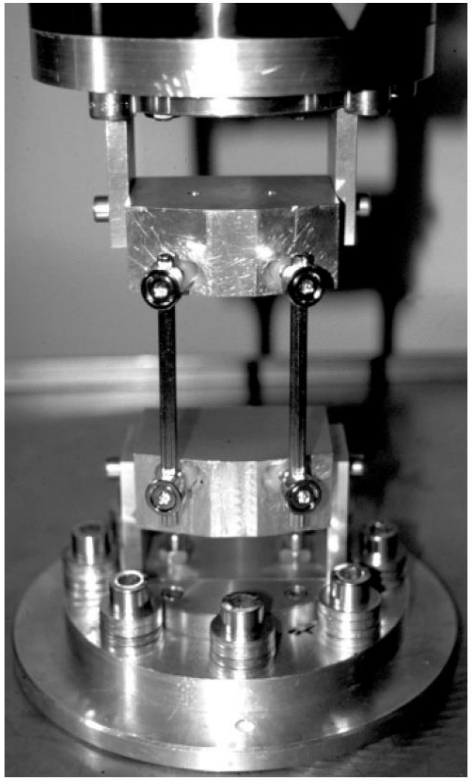
Temperature

- Extreme high or low temperatures can decrease fatigue strength

Standard mechanical tests: fatigue life

ASTM F1717





Hahn et al. 2002

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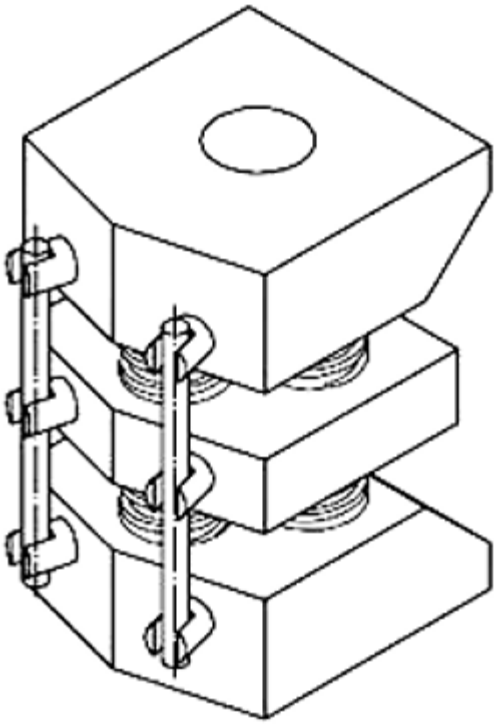
ISO 12189



http://www.endolab.org

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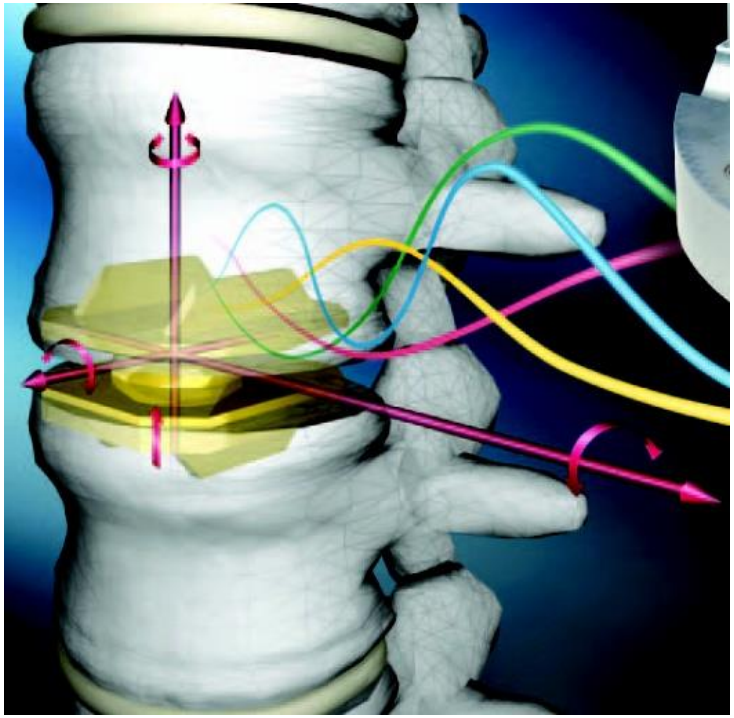
Standard mechanical tests: wear

Relevant standards: ASTM F2423, ISO 18192



http://www.mts.com

http://www.mts.com

http://www.exponent.com

wear patterns in an artificial disc

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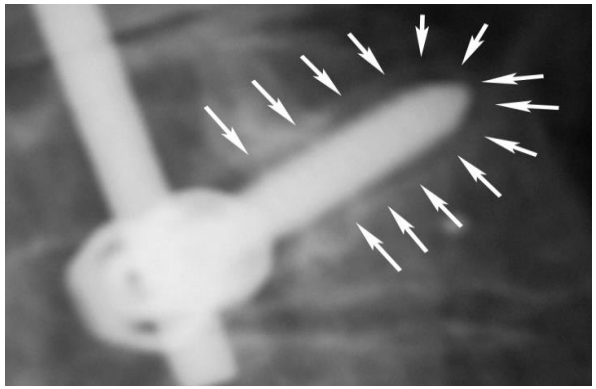
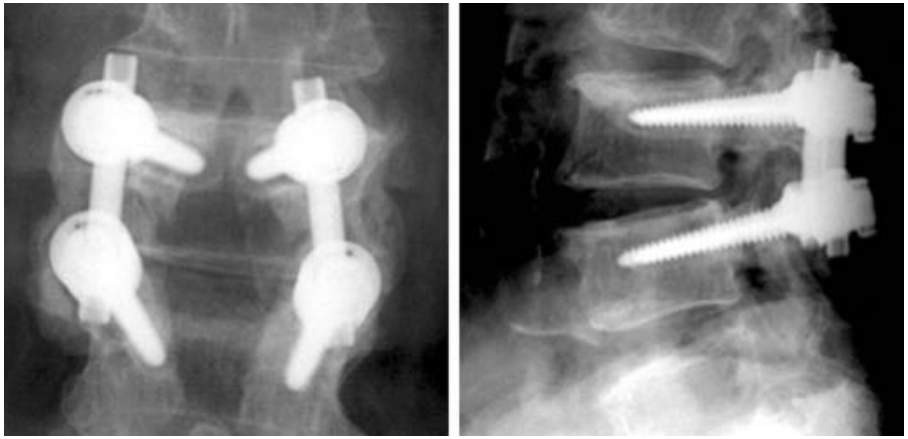
Loosening and pull-out

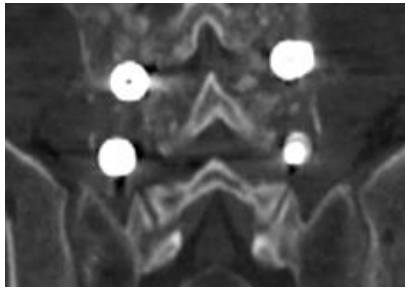


http://www.medscape.com

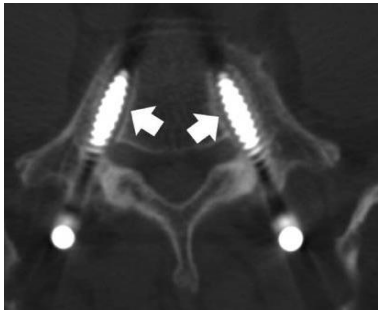


Kim et al. 2008

usually detected as a radiolucent zone and/or a halo around the implant



Young et al. 2007



Kang et al. 2011

better evaluated with CT scans

Loosening and pull-out: biomechanical testing

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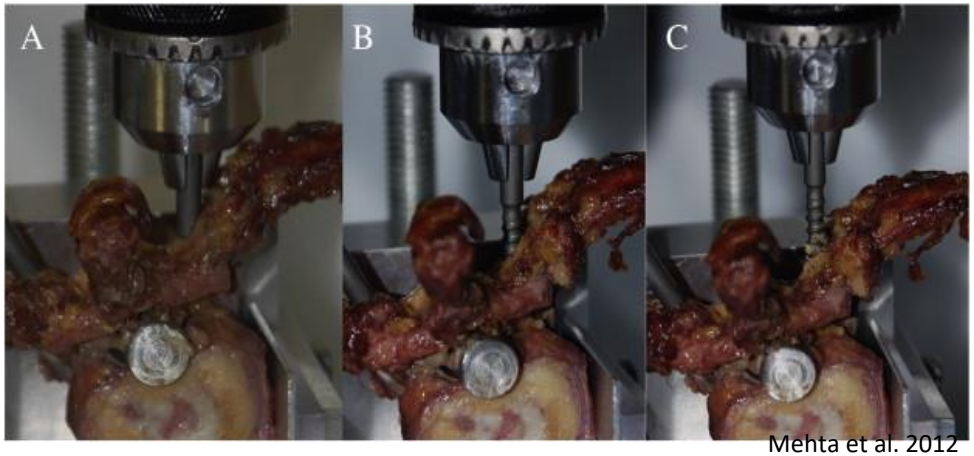
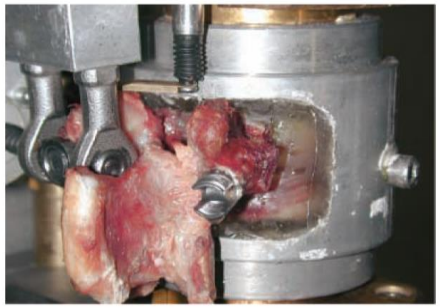


Mehta et al. 2012

axial pull-out test

Paik et al. 2012

cyclic axial loading



Reichle et al. 2002

cyclic sagittal loading

Spinal loads

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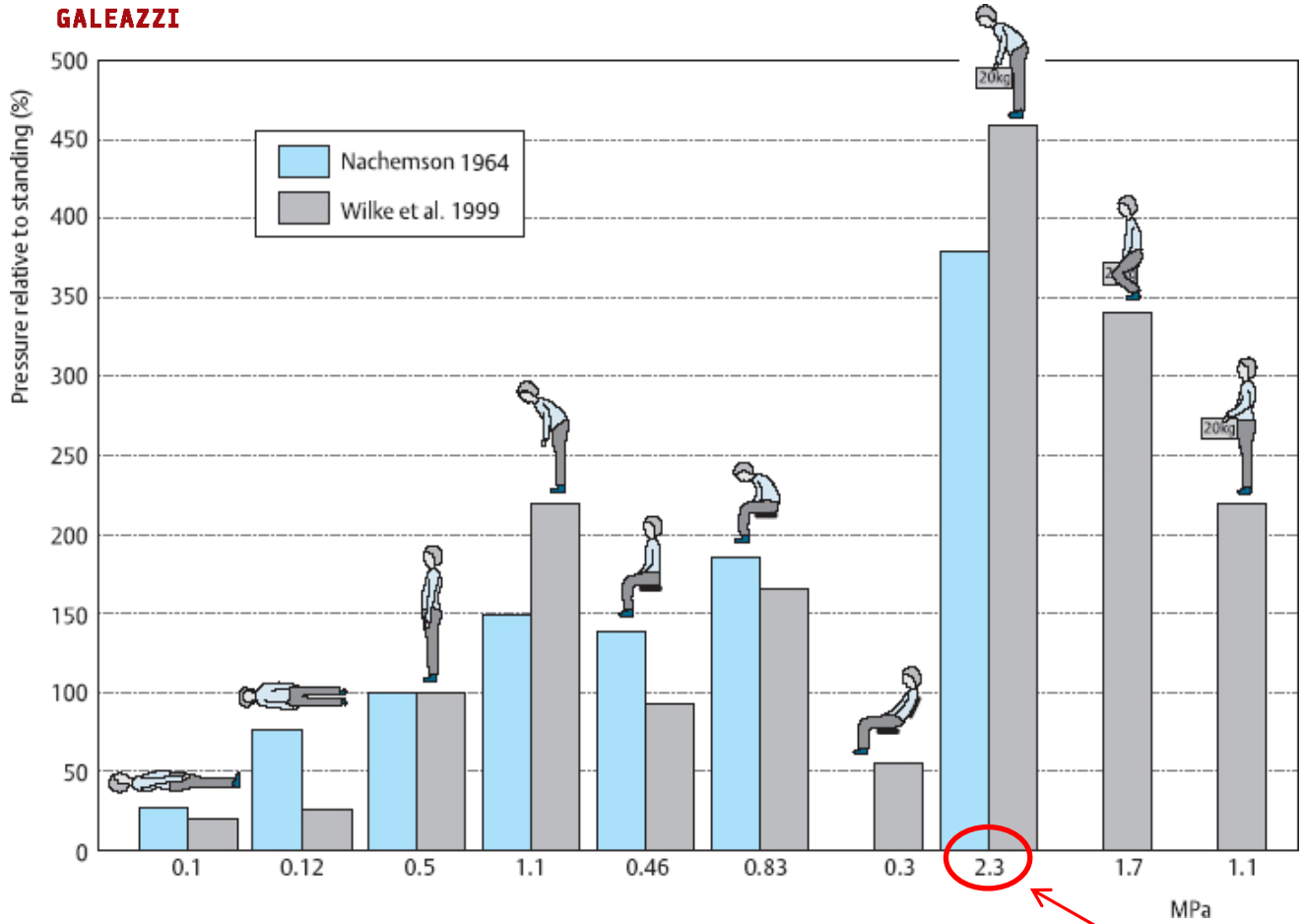

(measured with a needle sensor in human patients)

0.23 MPa in a tyre!

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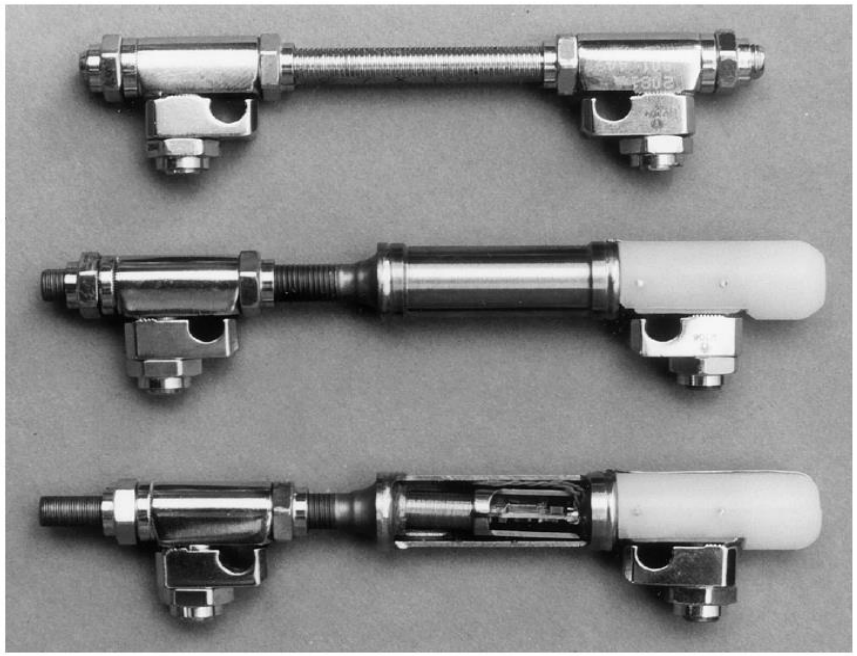
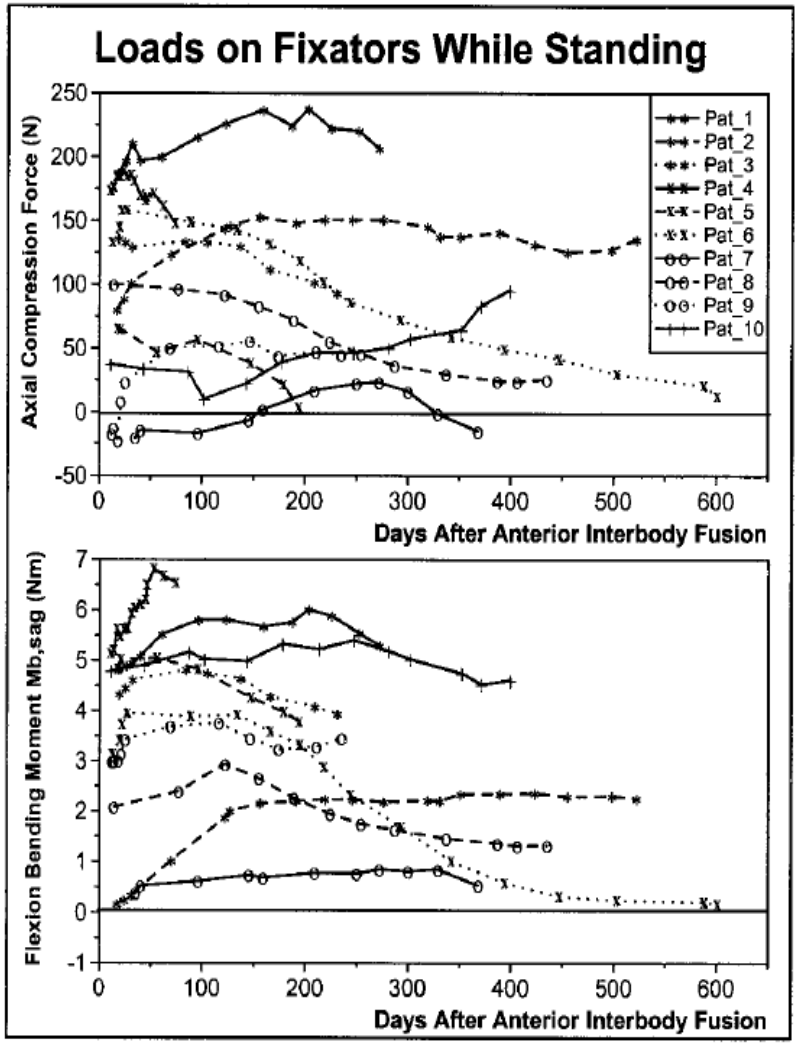
How to estimate loads on implants?





Rohlmann et al. 2000

temeleterized internal fixators

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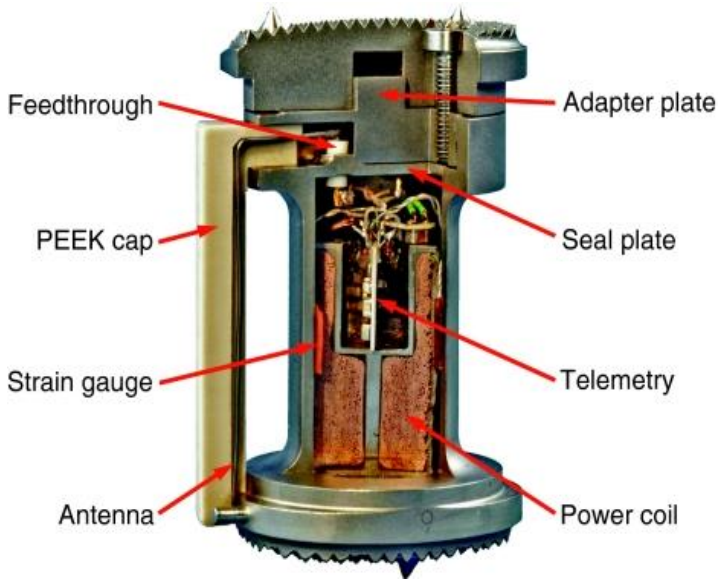
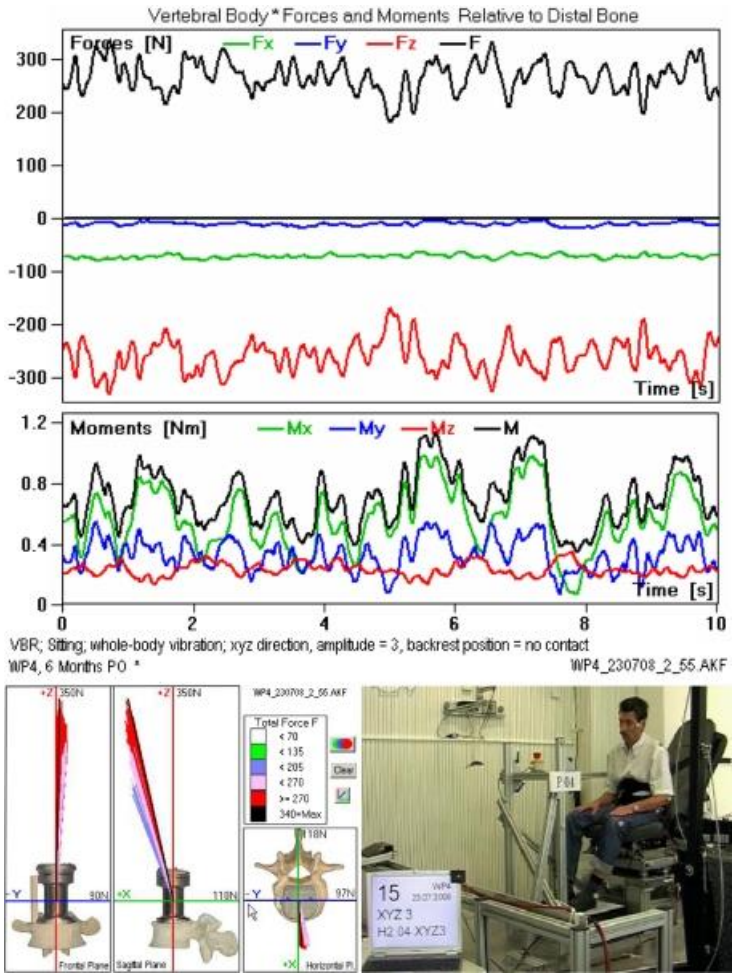
How to estimate loads on implants?





Rohlmann et al. 2010

temeleterized cage for vertebral body replacement

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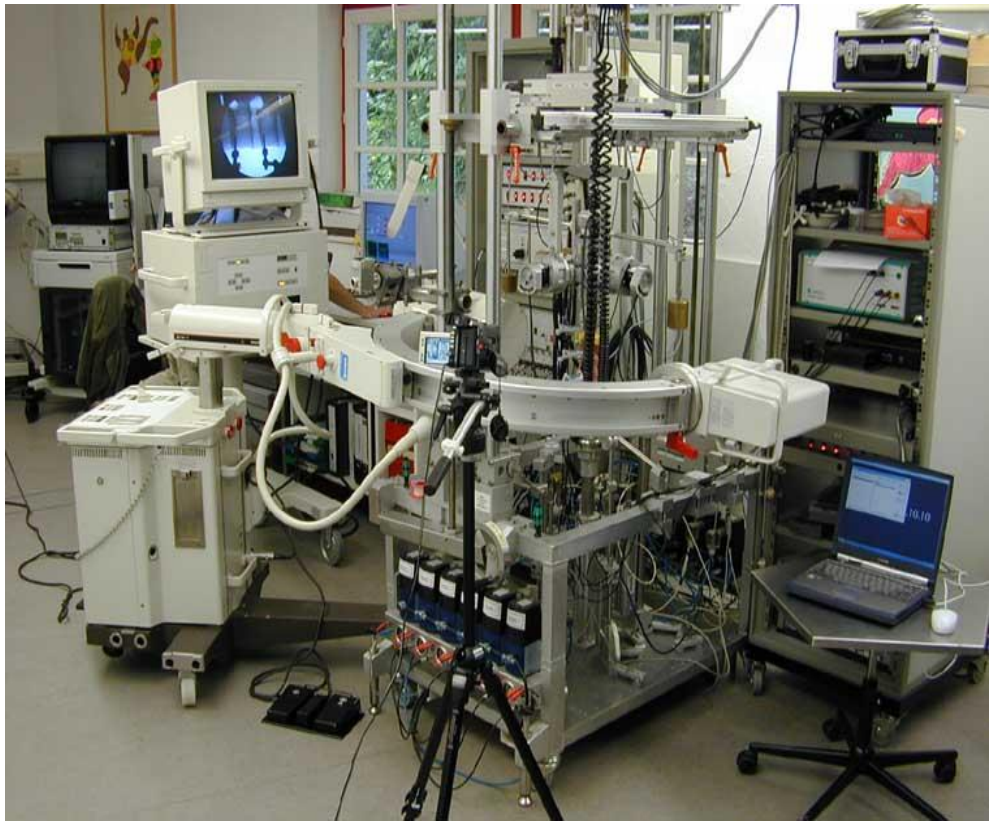
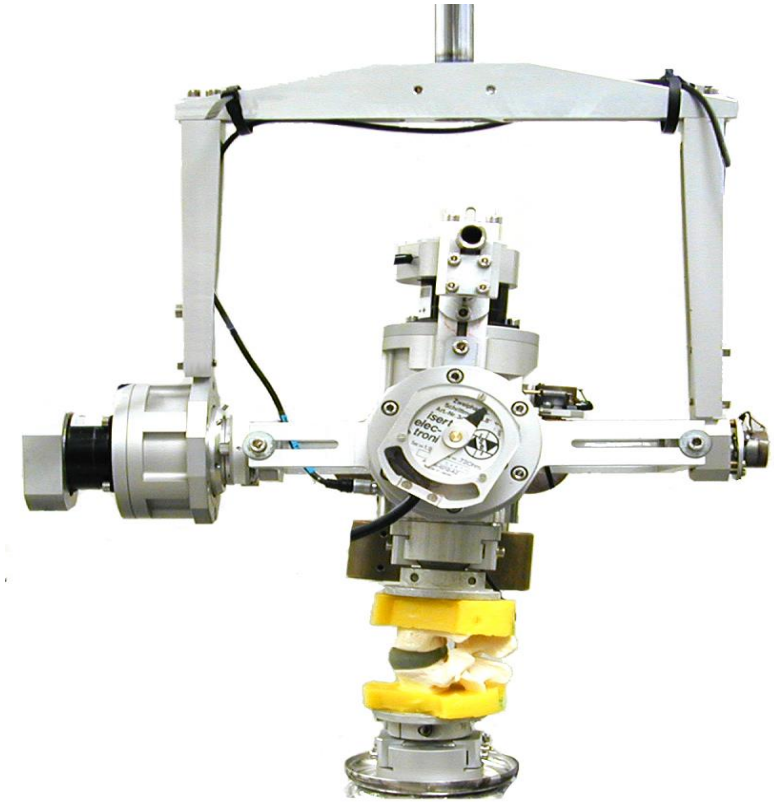
How to estimate loads on implants?





in vitro tests under standardized loads

How to estimate loads on implants?

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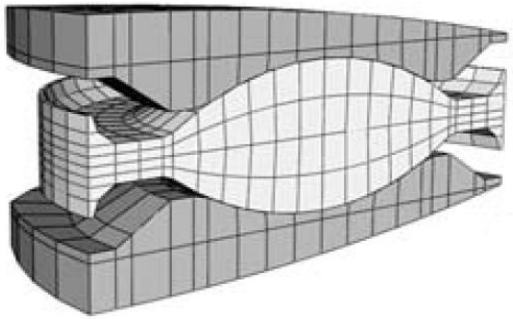
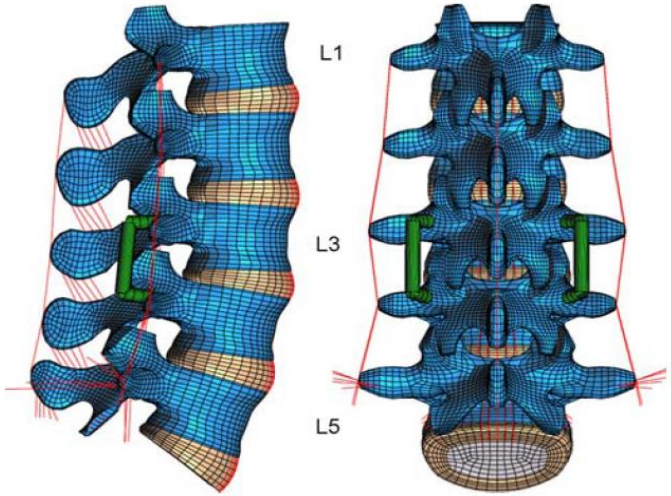
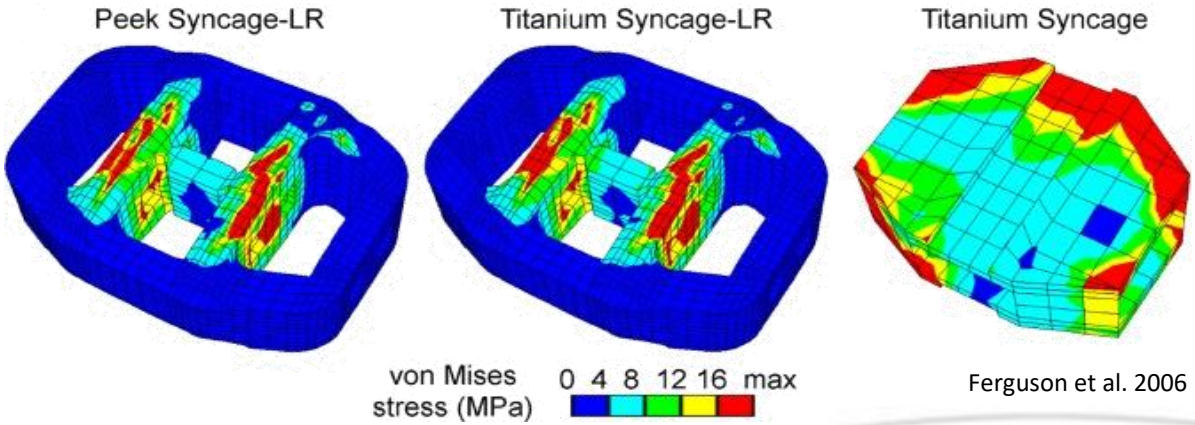


Schmidt et al. 2010

Rohlmann et al. 2007





Ferguson et al. 2006

finite element modeling

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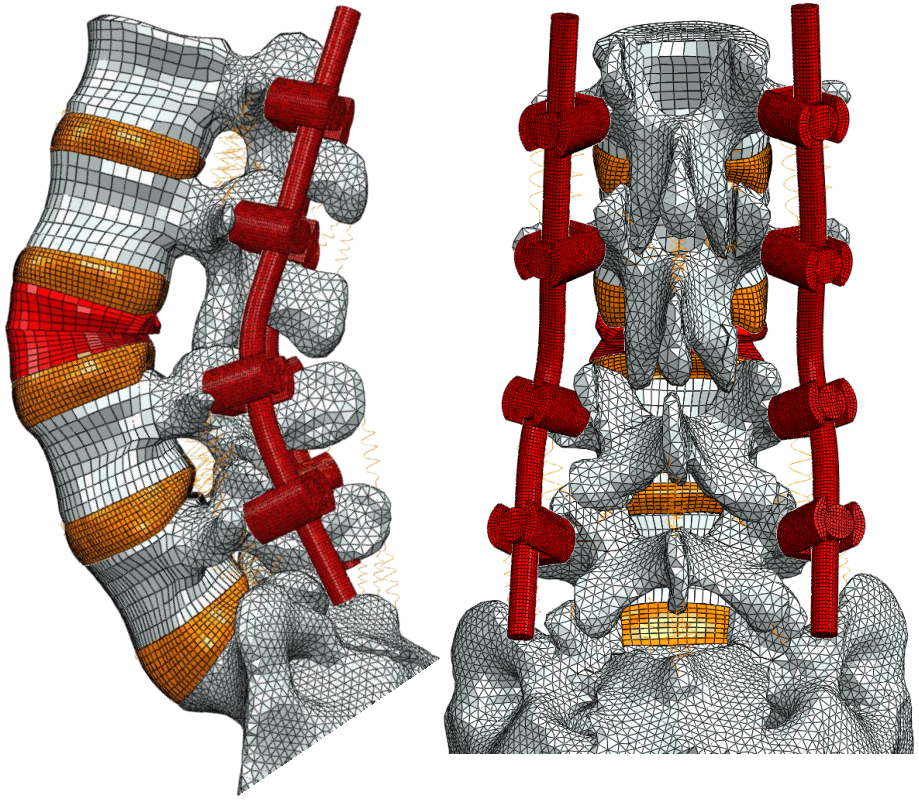
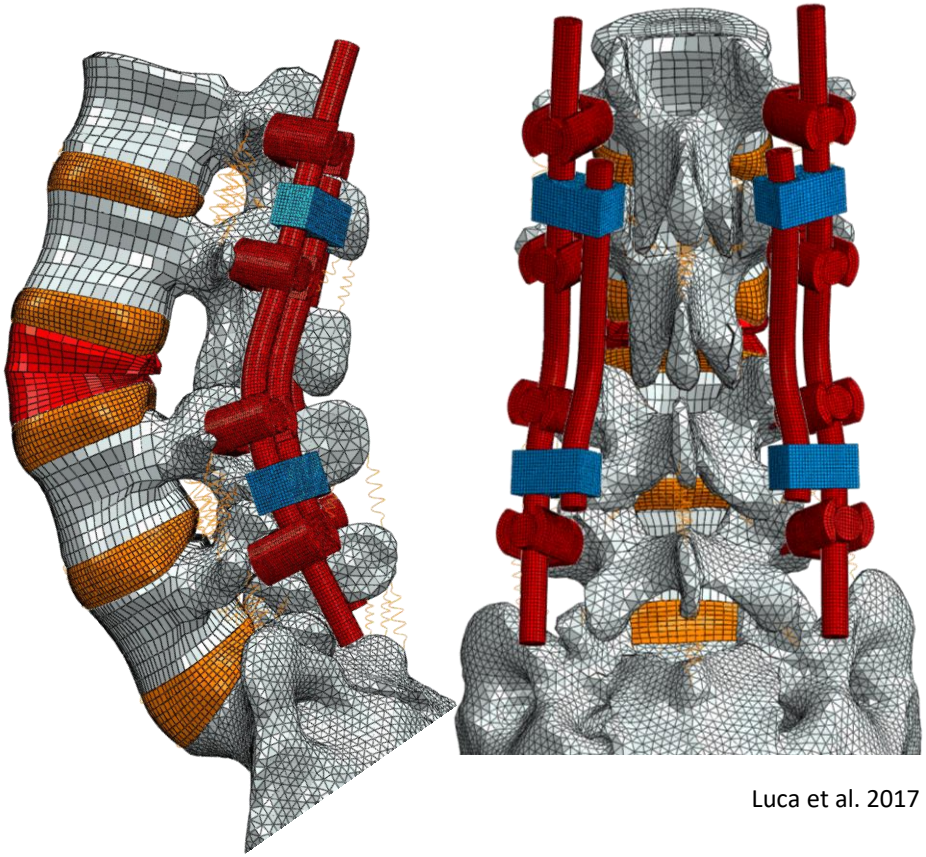
Rods stresses after PSO



single rod



double rods

Luca et al. 2017

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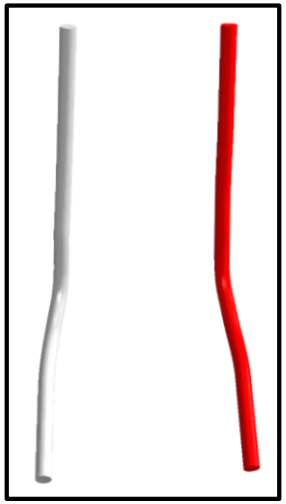
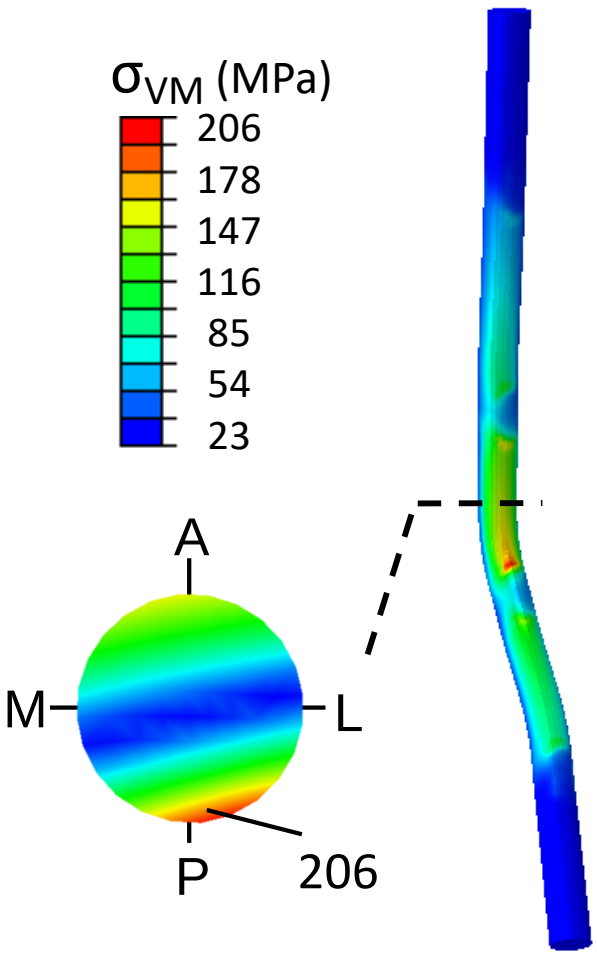
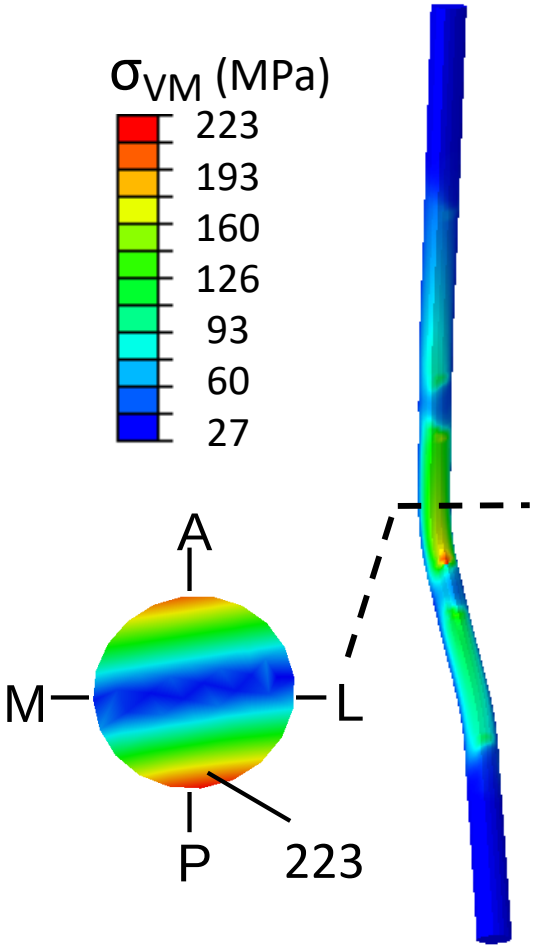
Rods stresses after PSO – effect of rod diameter





OL4-Ti-6mm



OL4-Ti-5mm

Rods stresses after PSO – effect of rod material

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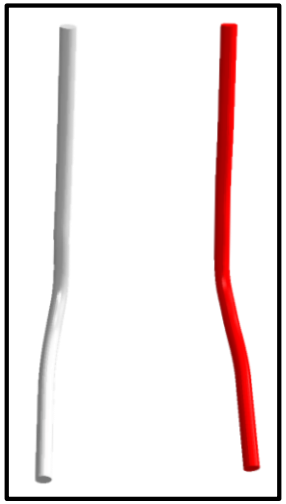
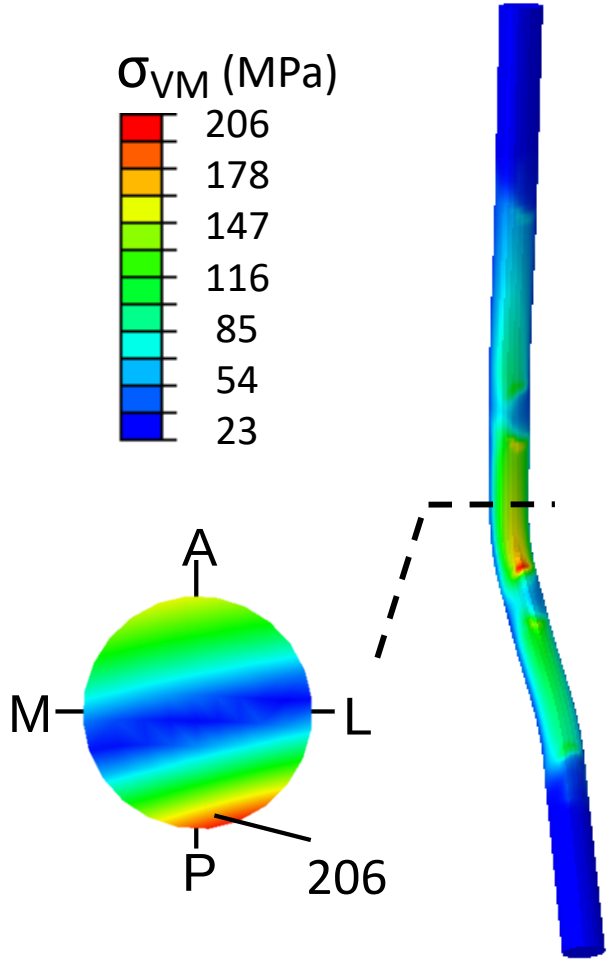
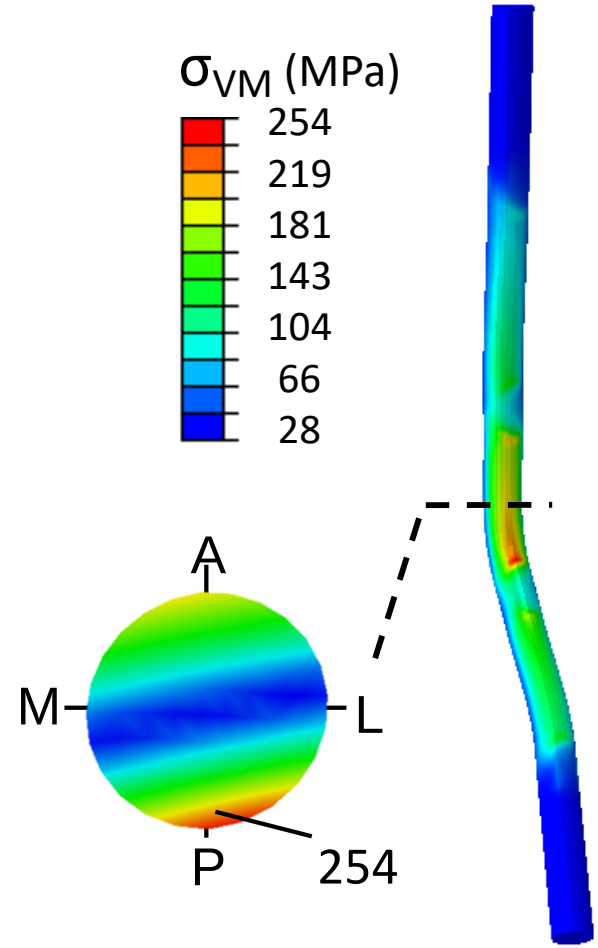




OL4-Ti



OL4-Cr-Co

Rods stresses after PSO – effect of double rods

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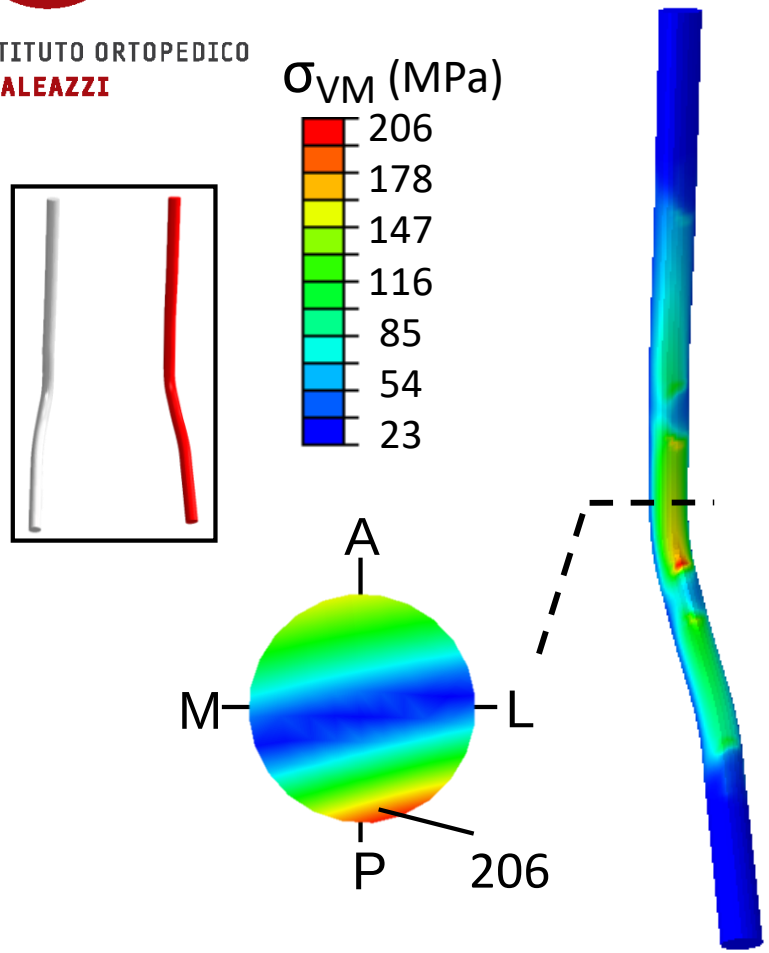
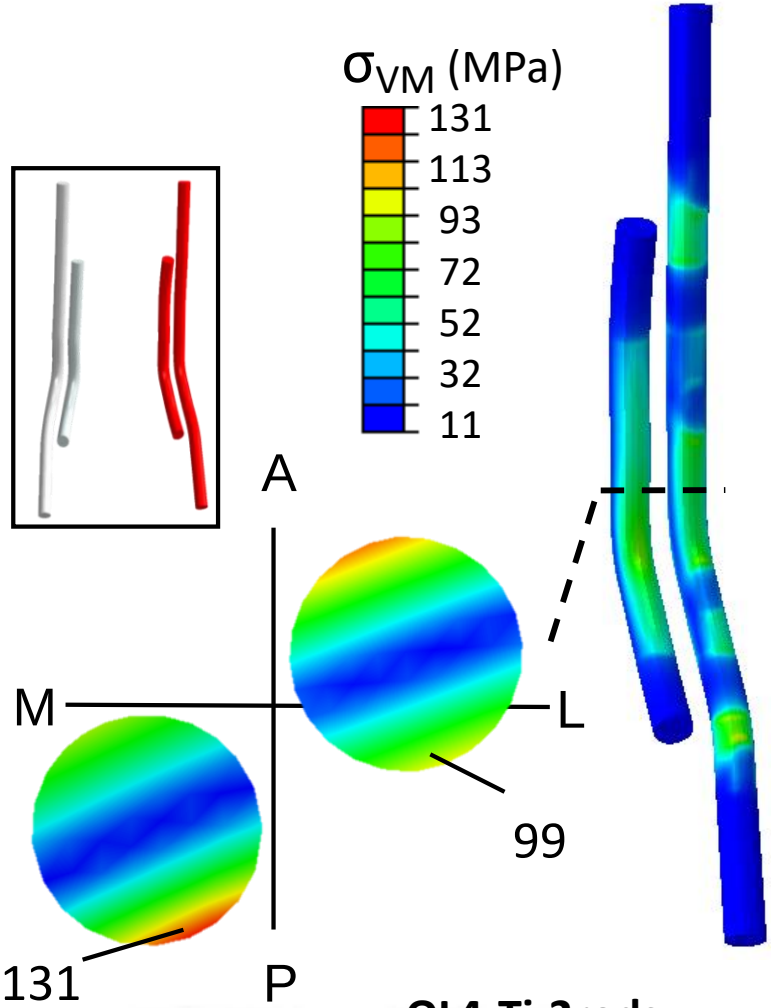


OL4-Ti



OL4-Ti-2rods

Rods stresses after PSO – effect of interbody cages

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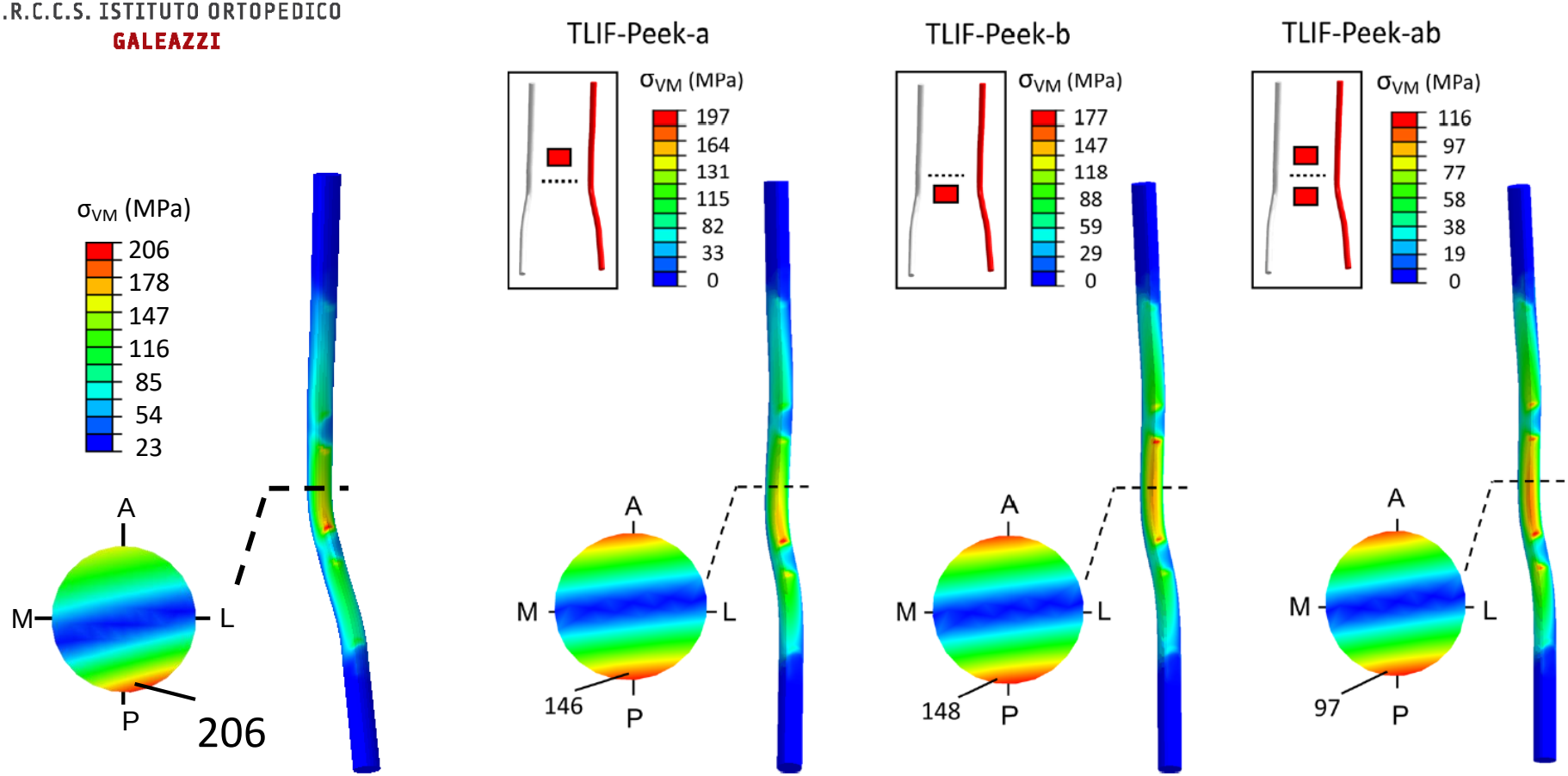

no cages | cage above | cage below | cage above and below

Luca et al. 2017

PSO – in vitro testing

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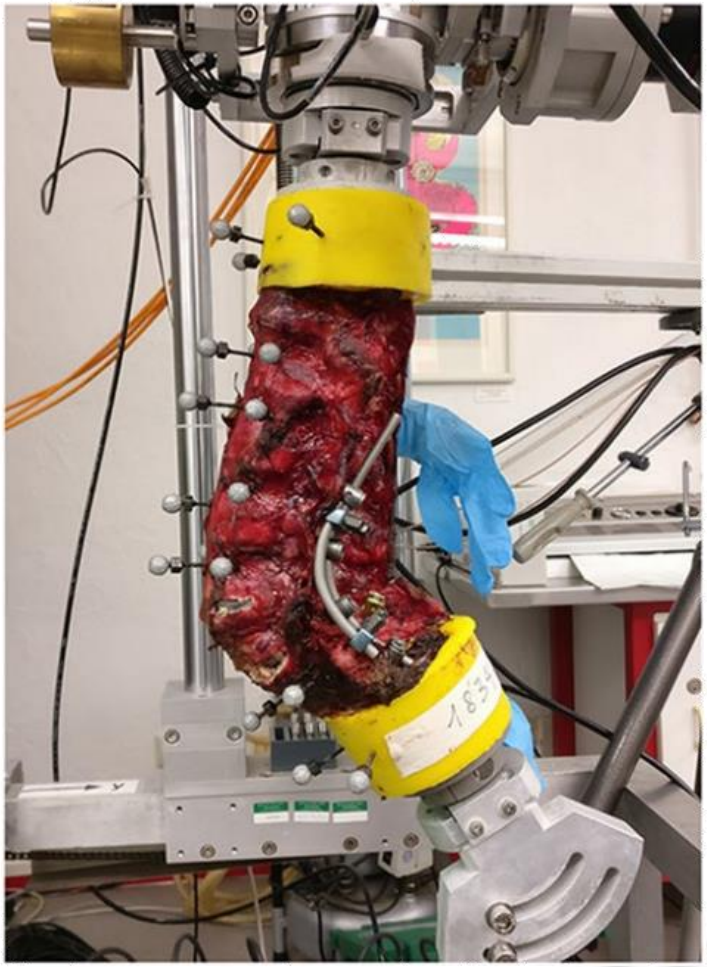
PSO-4+Cages



La Barbera et al. 2018

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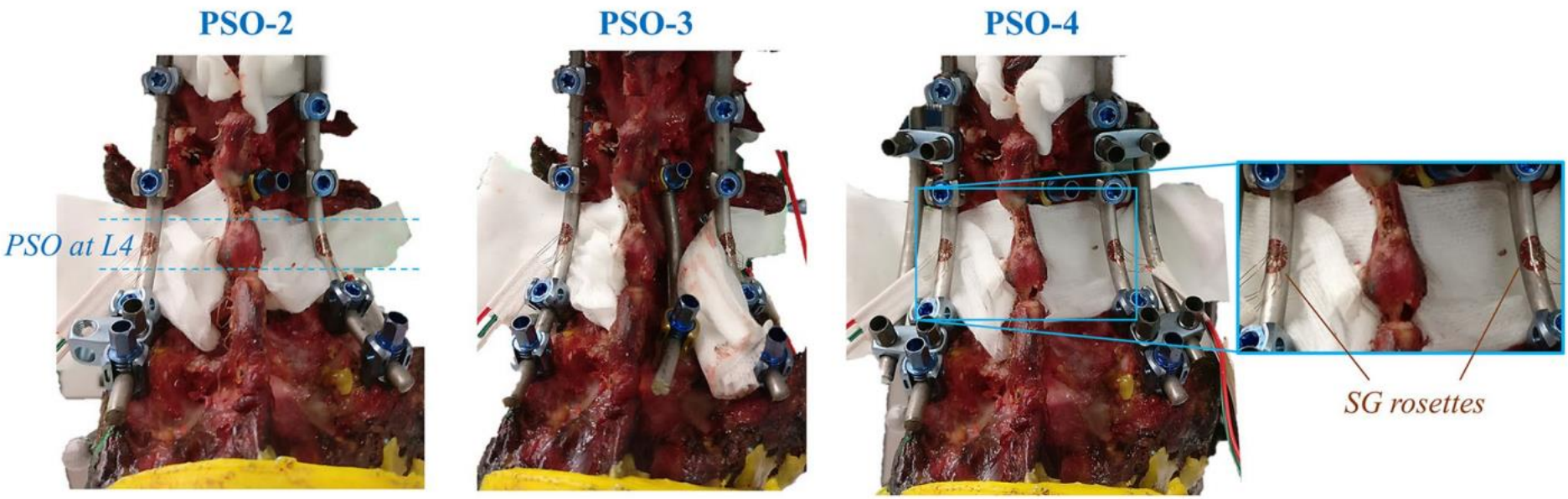
PSO – in vitro testing



La Barbera et al. 2018

PSO – in vitro testing

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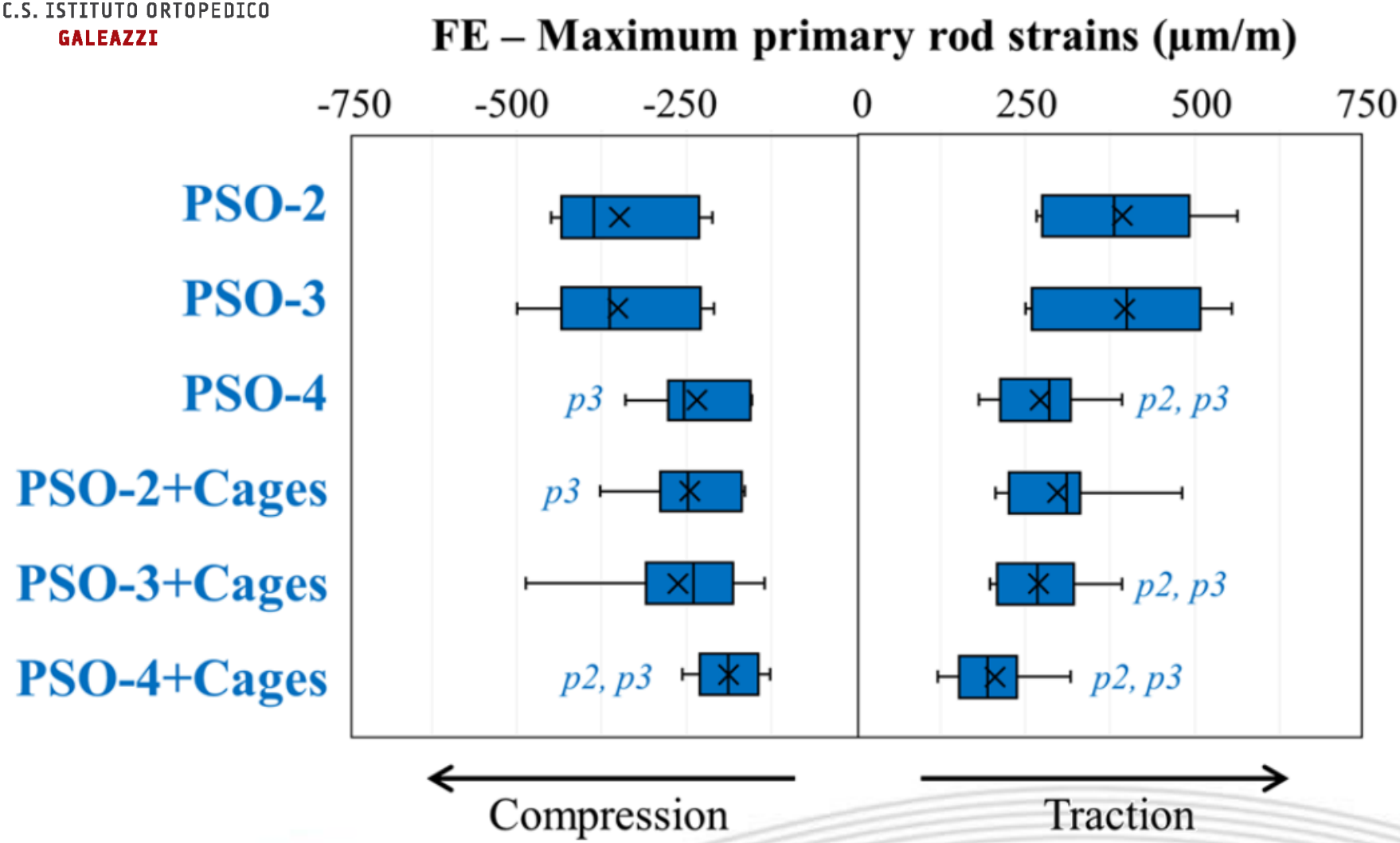

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THANK YOU