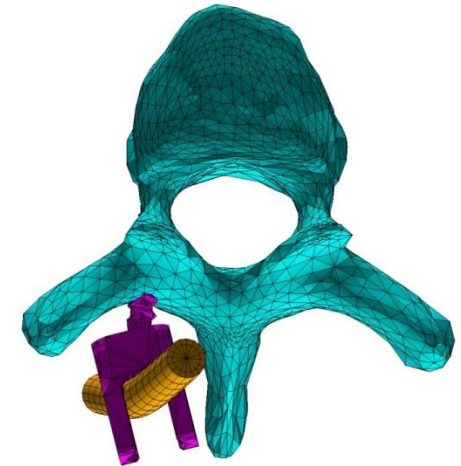
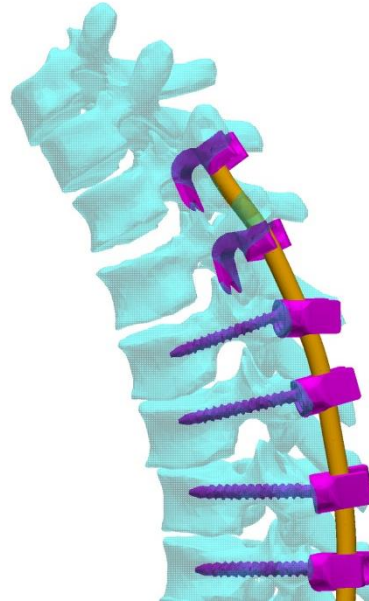
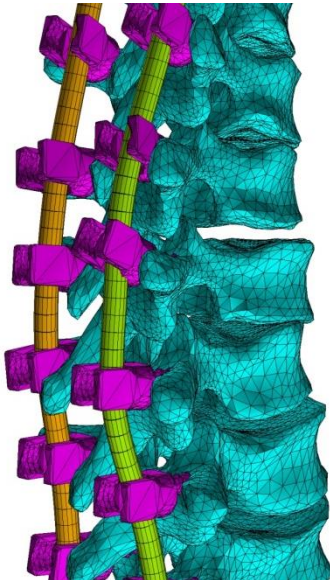




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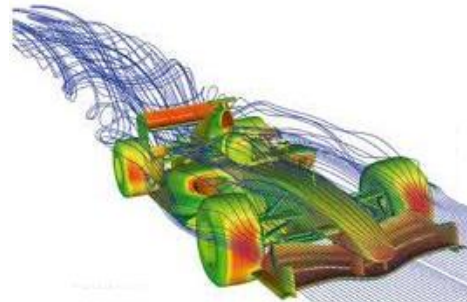
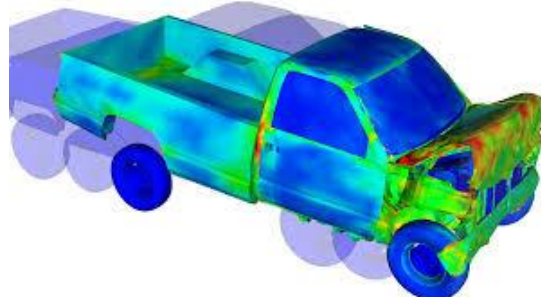
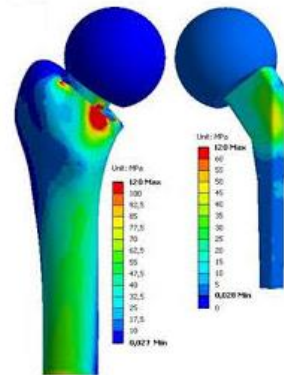
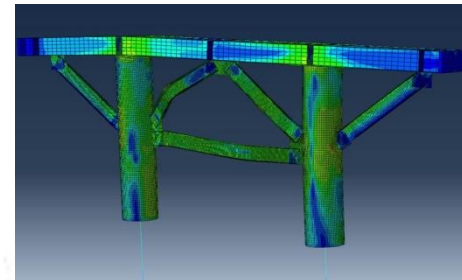
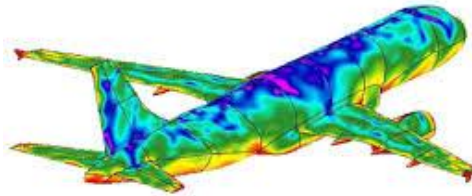
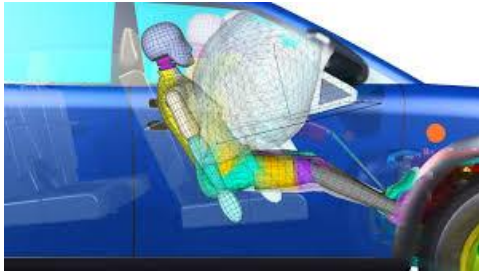
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Scoliosis Surgery *Simulation*

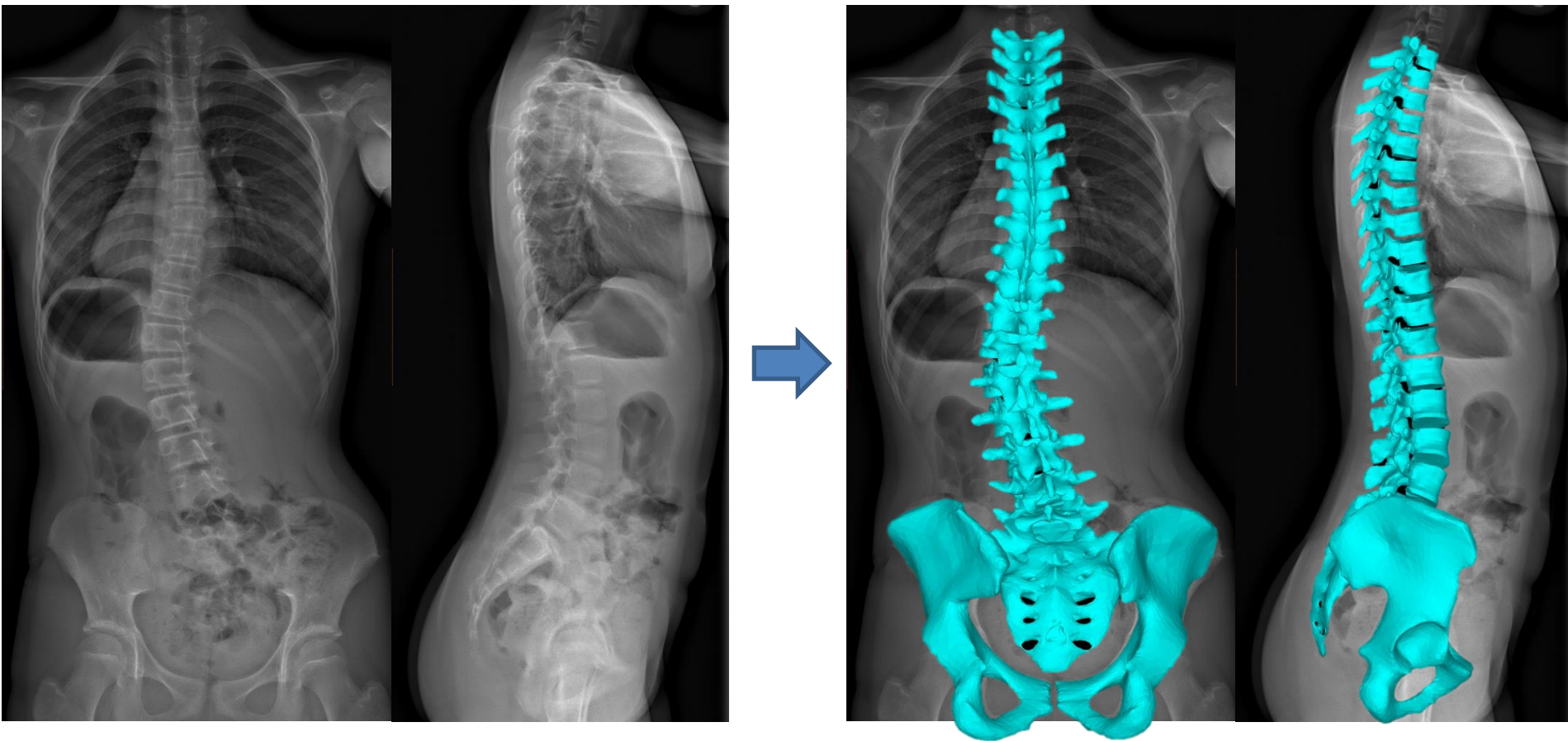


Finite Element (FE) Models

- Finite element model: mathematical method widely used in traditional engineering fields (aeronautics, car industry, civil engineering).
- Principle: Discretize a given geometry in order to compute the deformations of a body when external forces are applied on it.
- FE models are increasingly popular in the medical field.



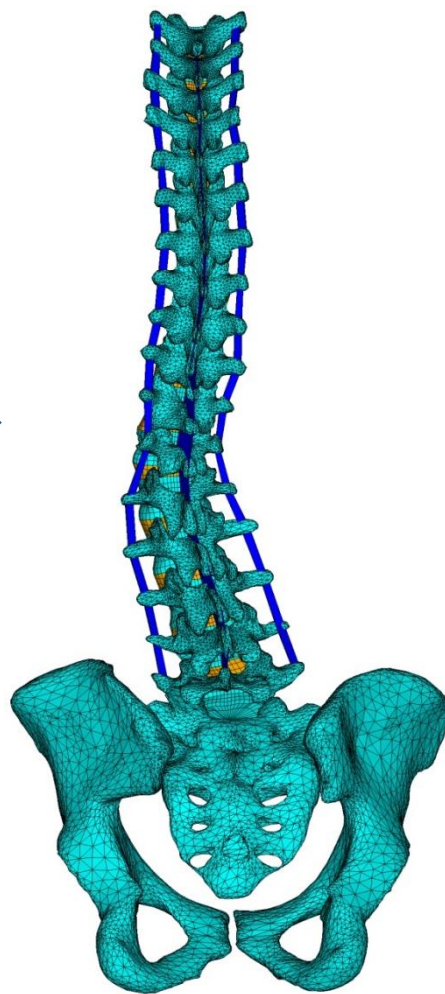
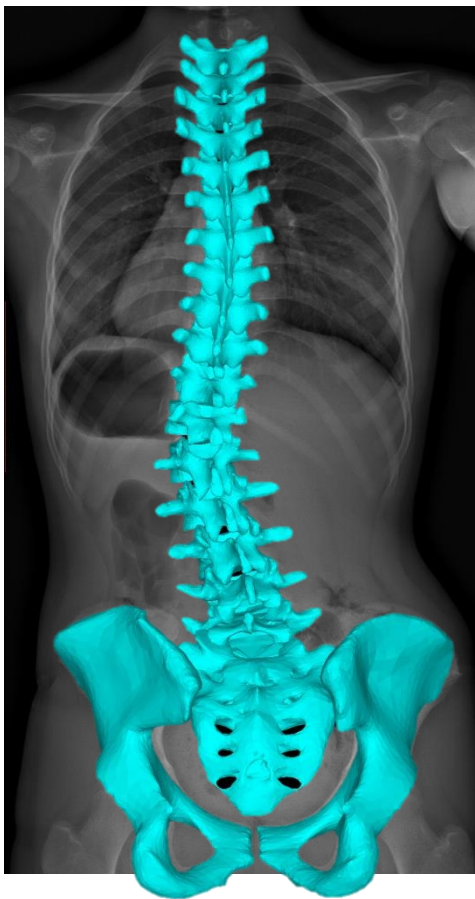
Methods: Personalized 3D Geometry



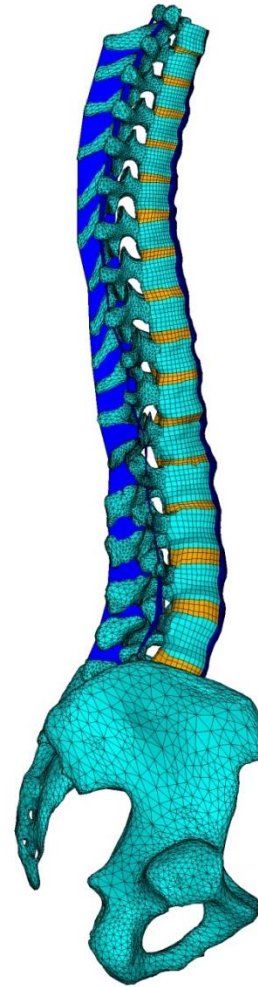
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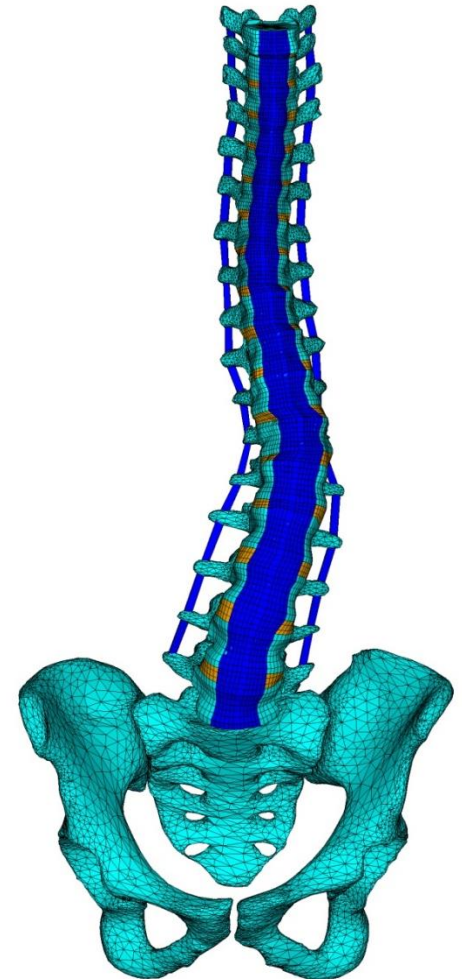
Spine FE Model



PA View

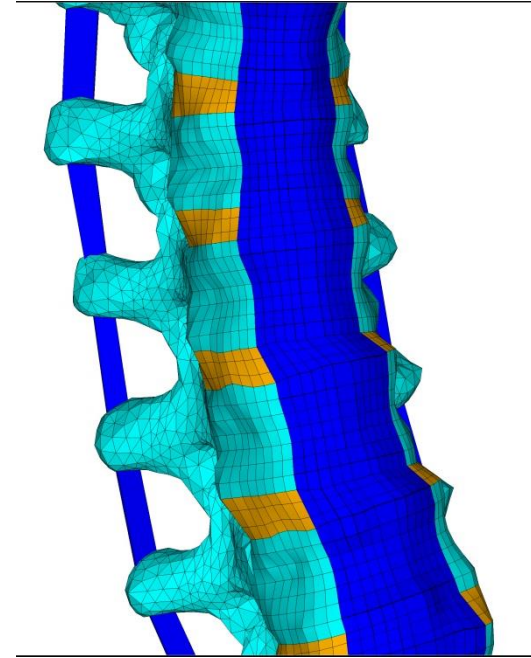
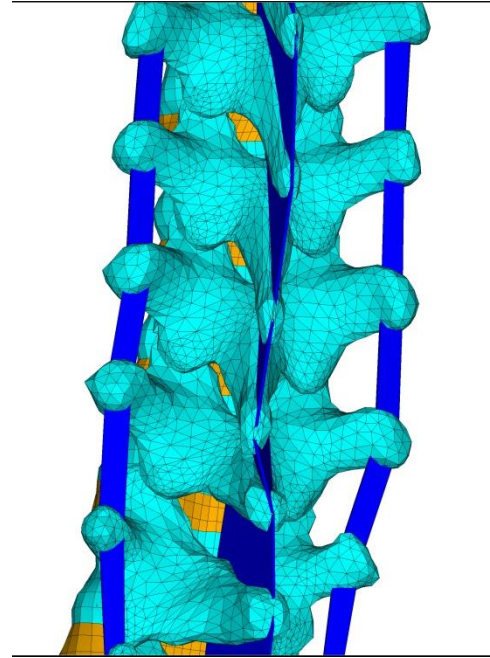
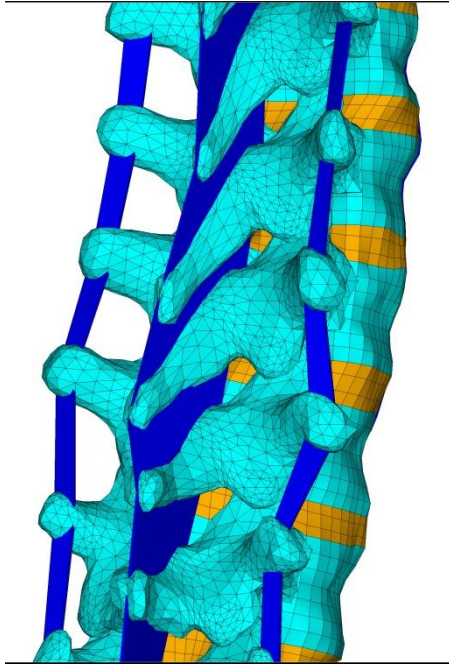
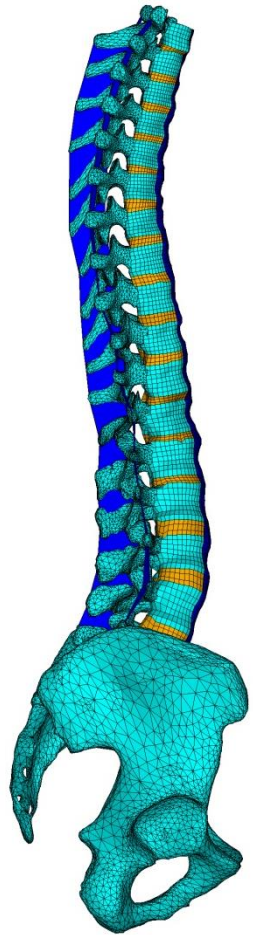


LAT R View

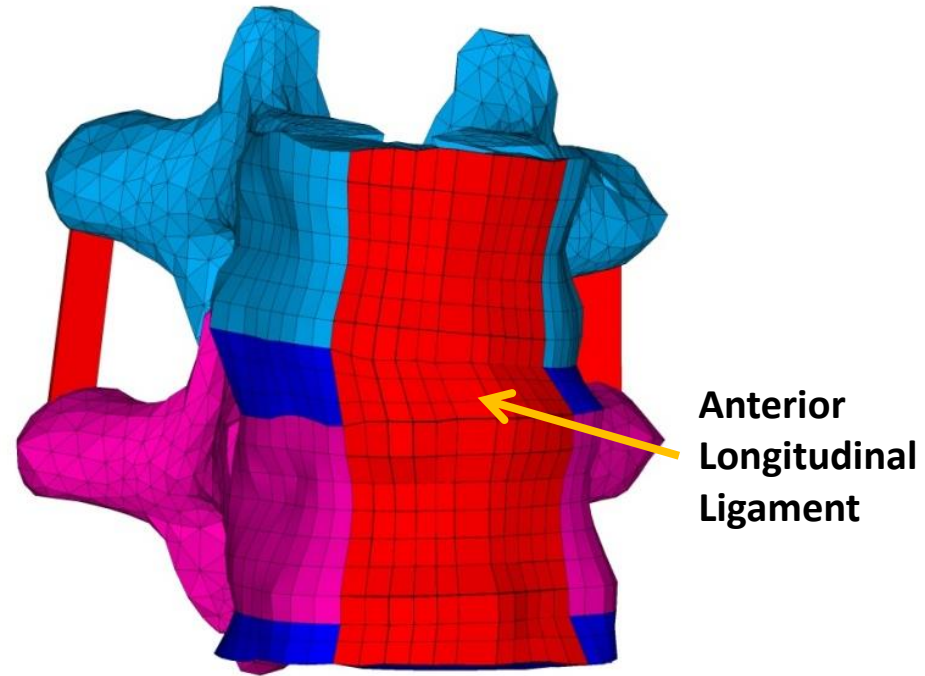
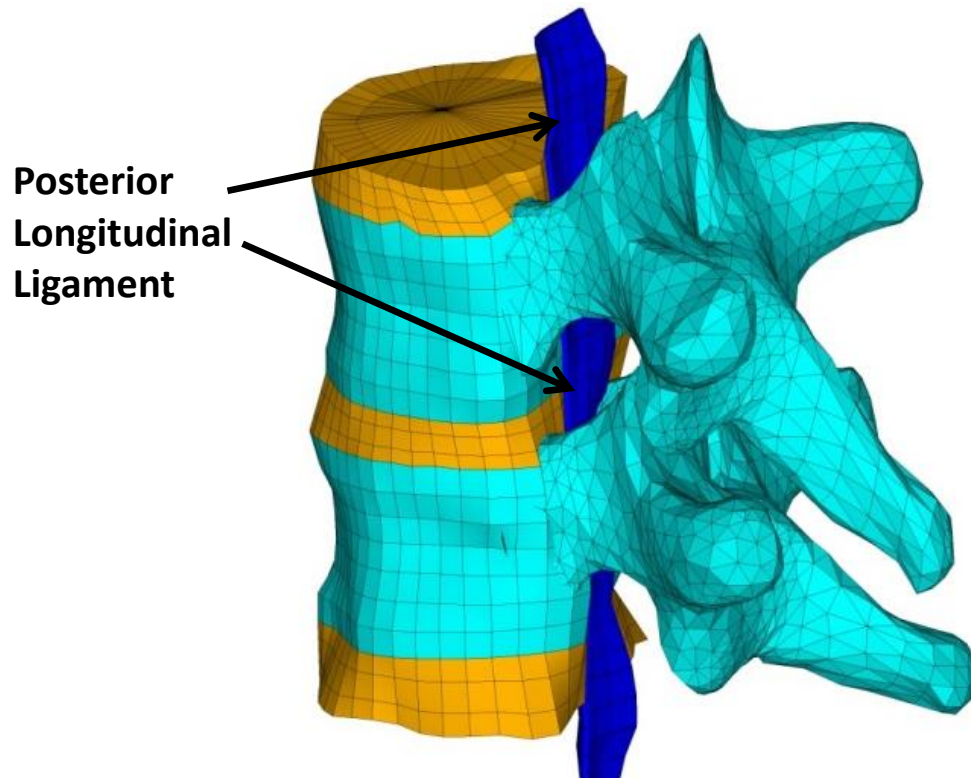


AP View

Spine FE Model

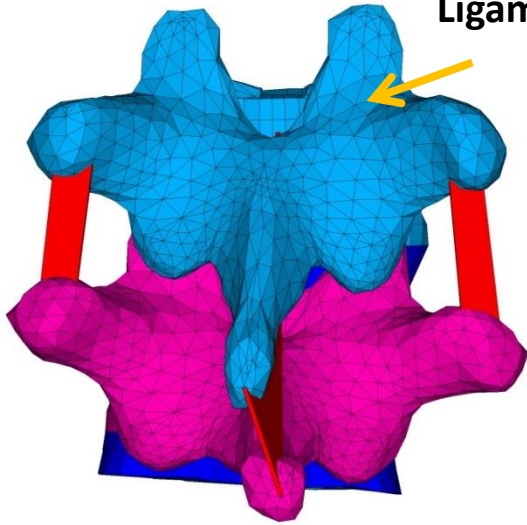


FE Model: Ligaments



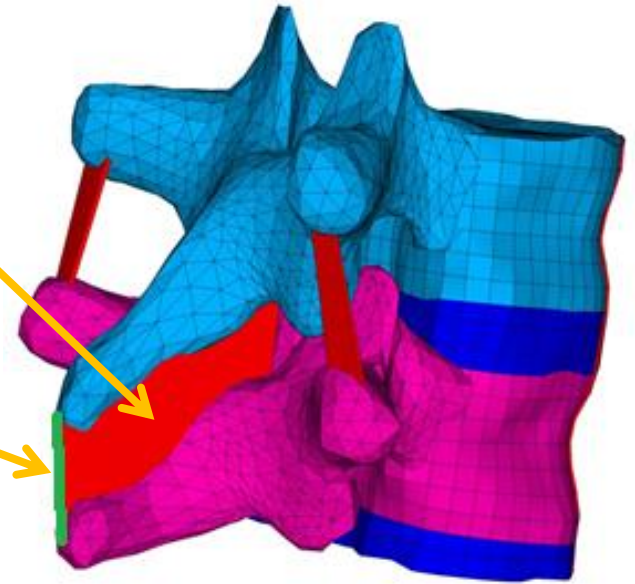
FE Model: Ligaments

Intertransverse
Ligament

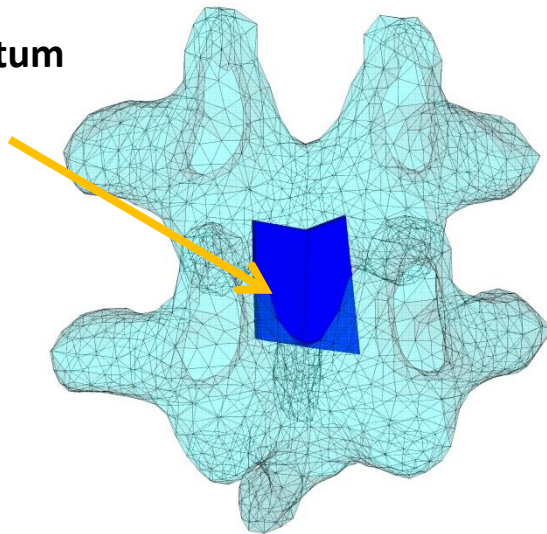
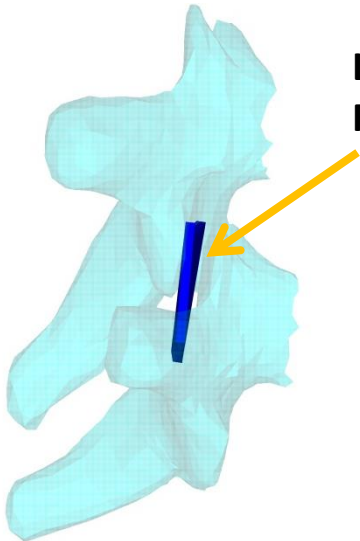


Interspinous
Ligament

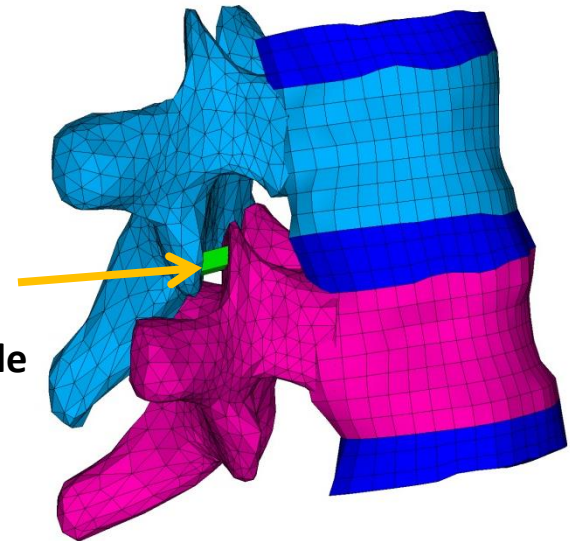
Supraspinous
Ligament



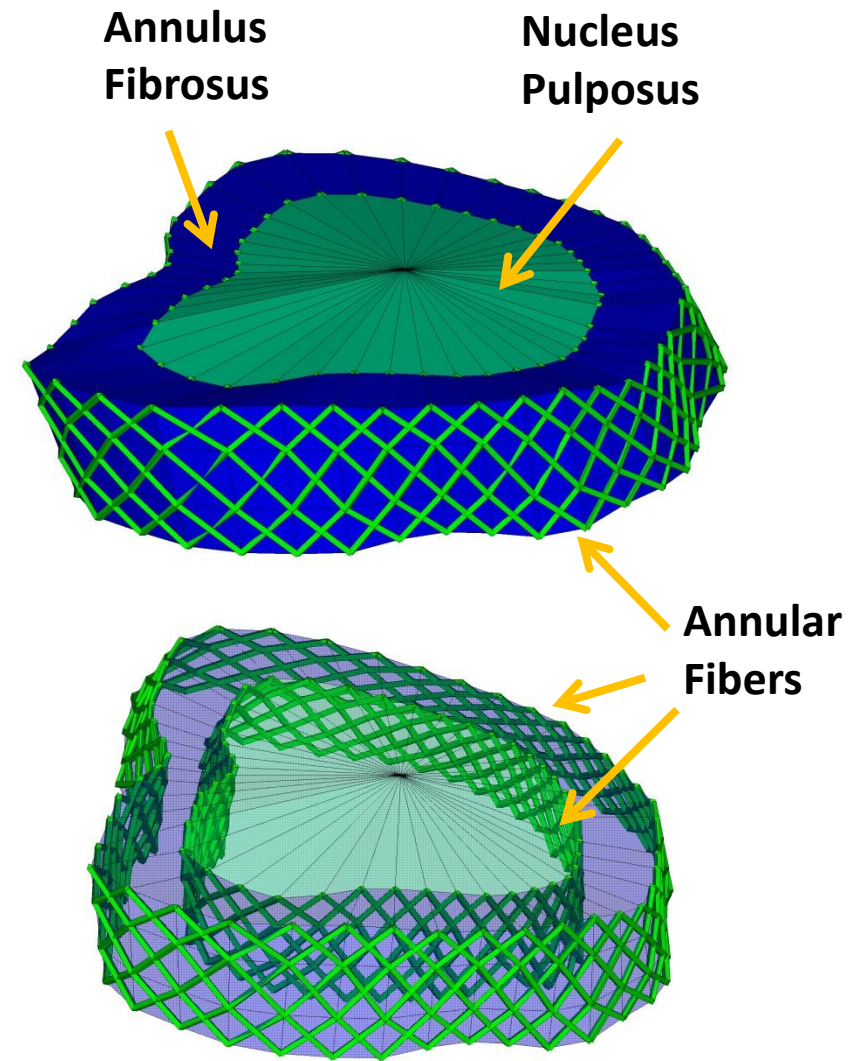
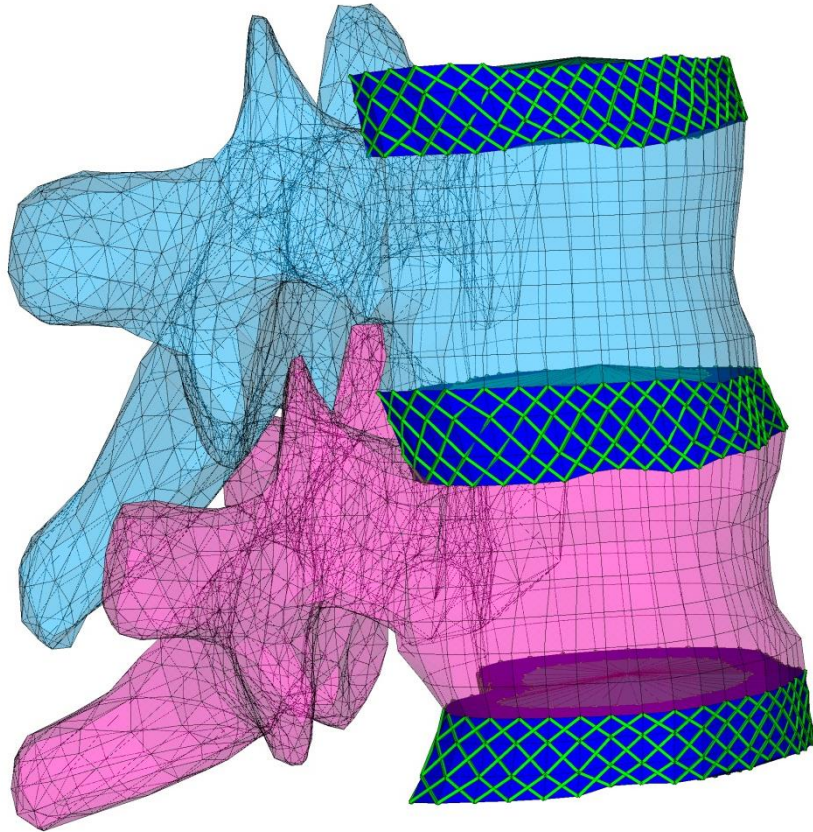
Ligamentum
Flavum



Facet
Joint
Capsule

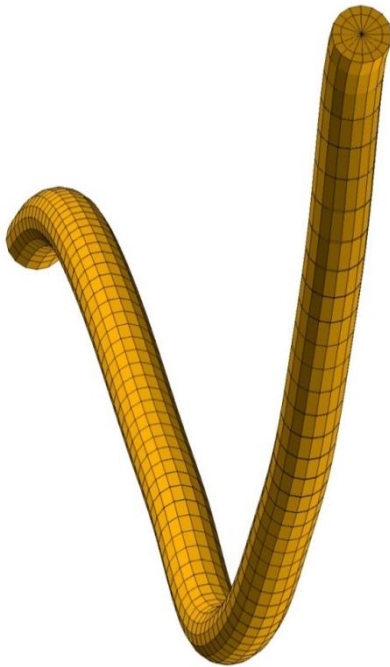


Spine FE Model: Intervertebral Disc



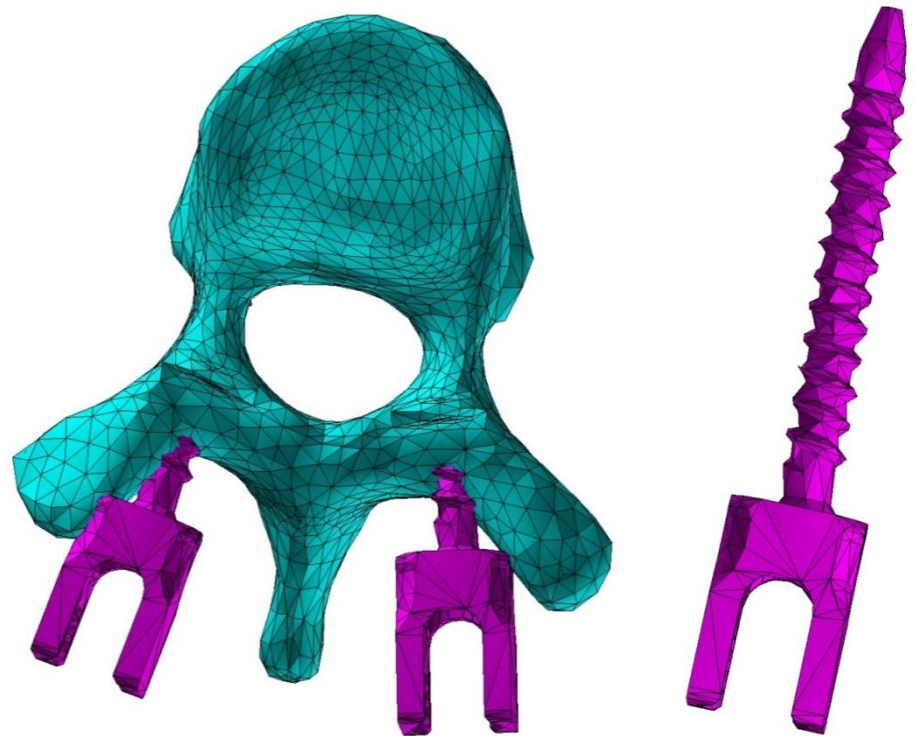
Rod FE Model

- Materials: Cobalt Chrome, Titanium, Stainless Steel
- Plasticity included.



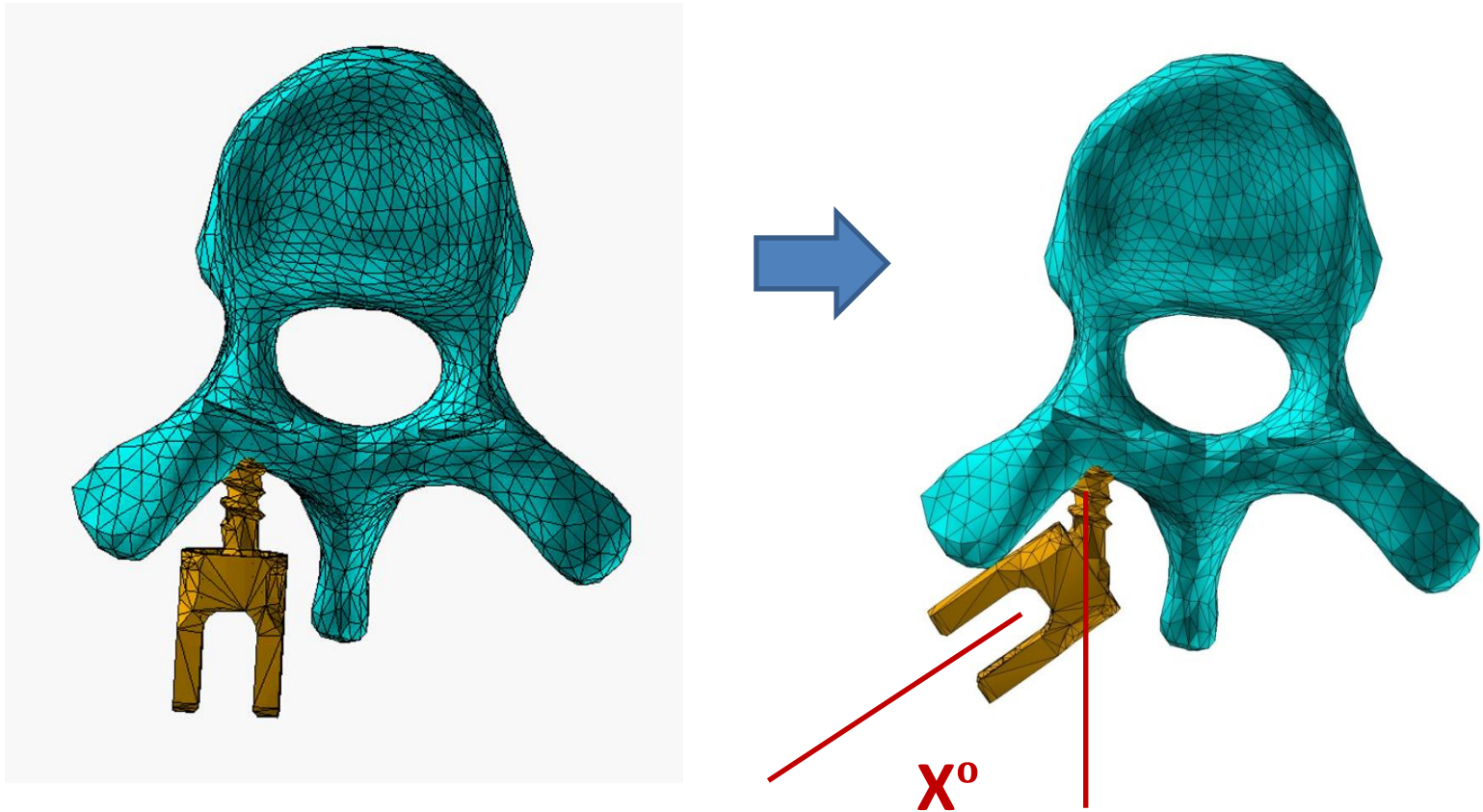
Screws FE Model

- Any type of screw can be modeled (here a 'generic' screw was used).

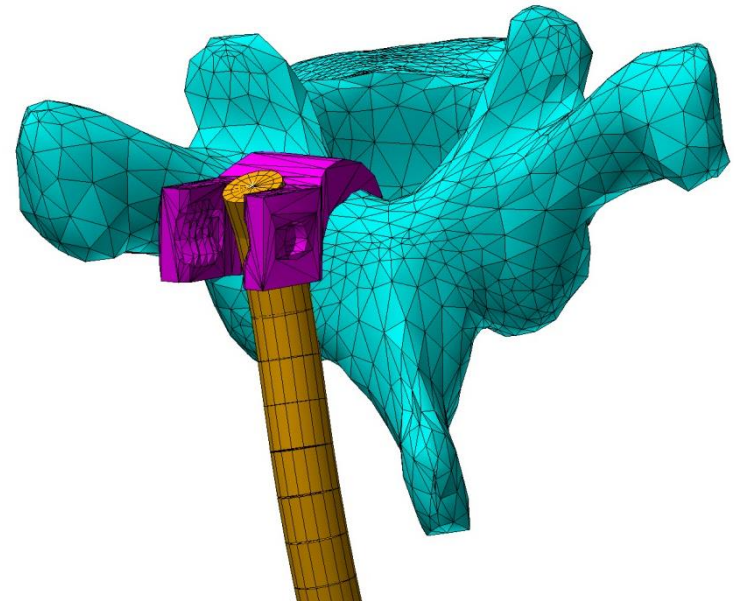
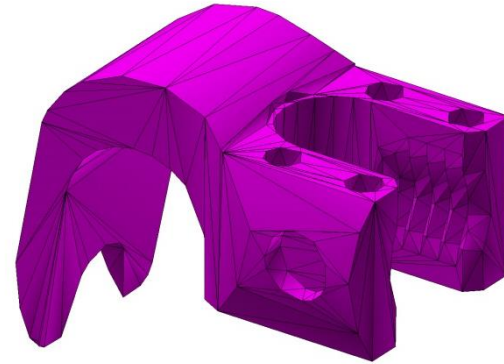
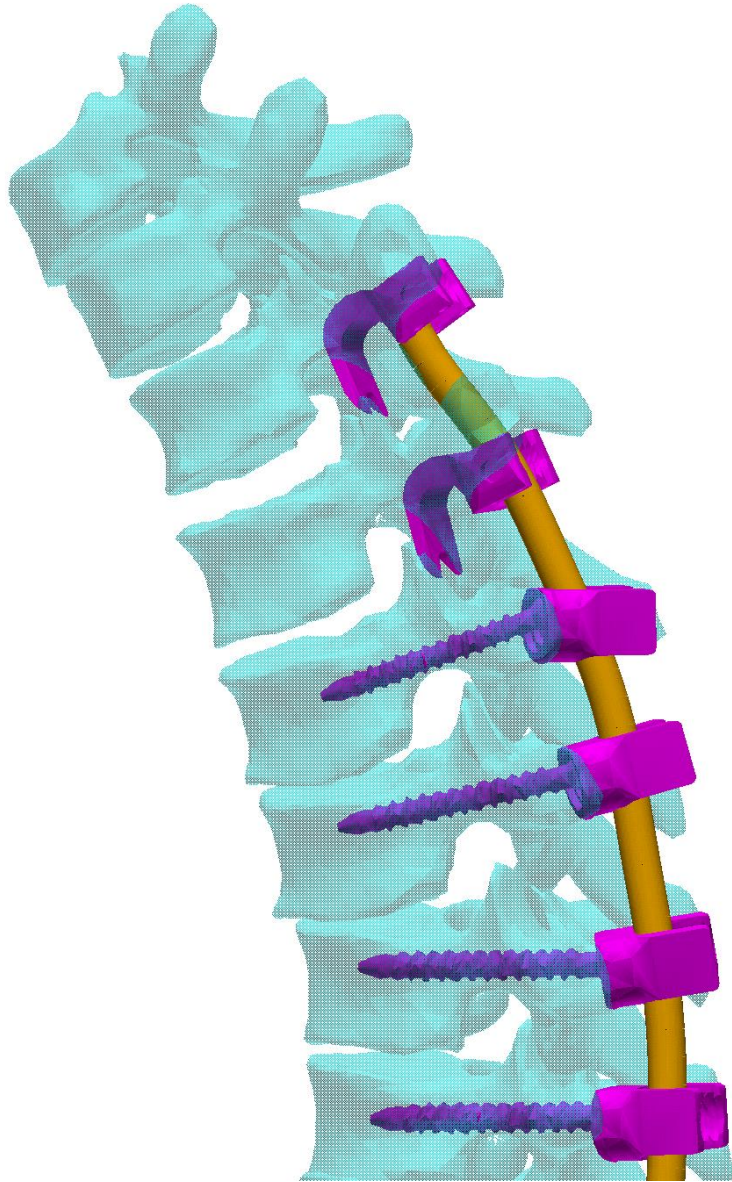


Screw Behavior

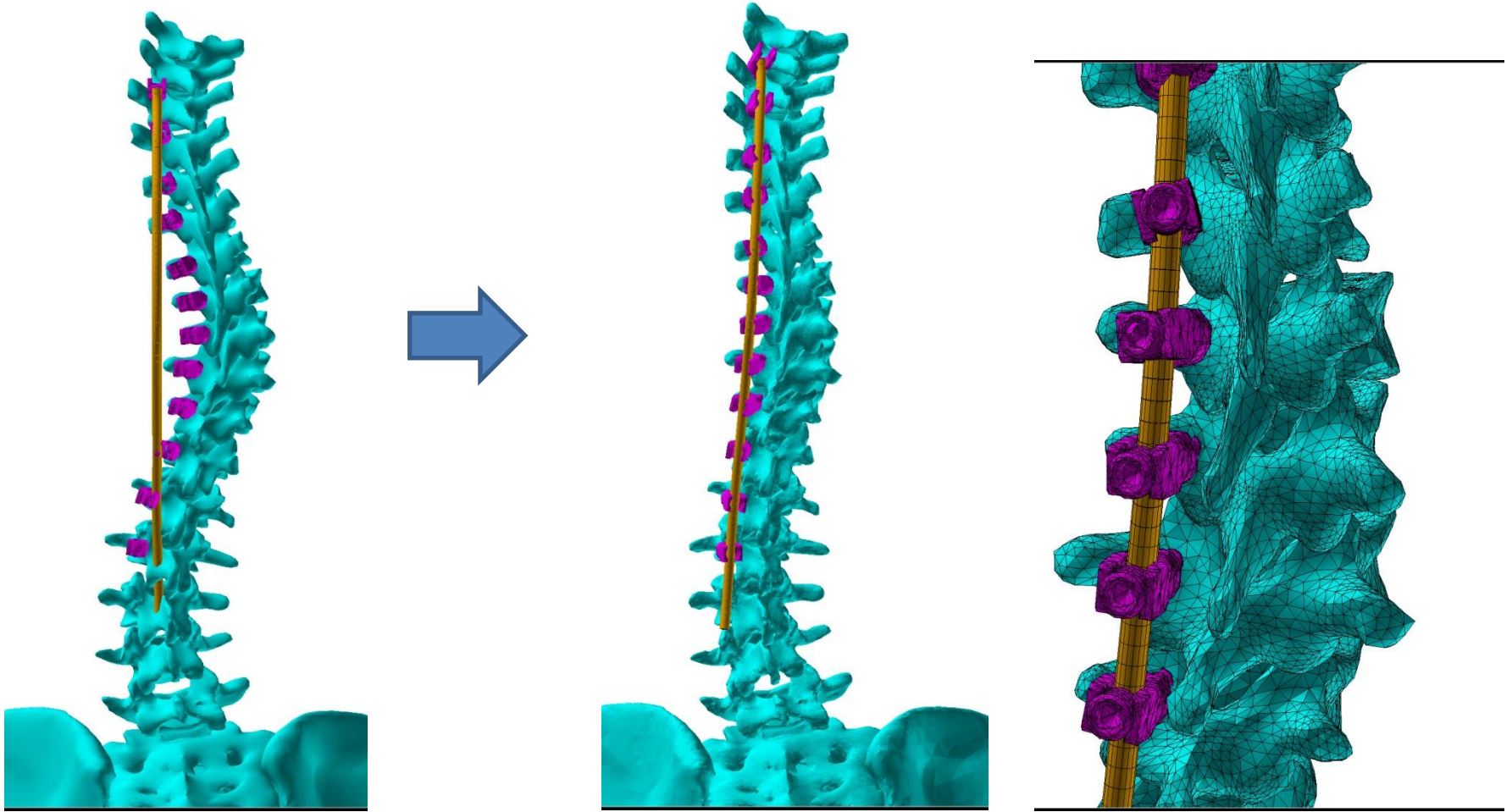
Mono-Axial, Multi-Axial, Uniplanar Screws can be modeled.



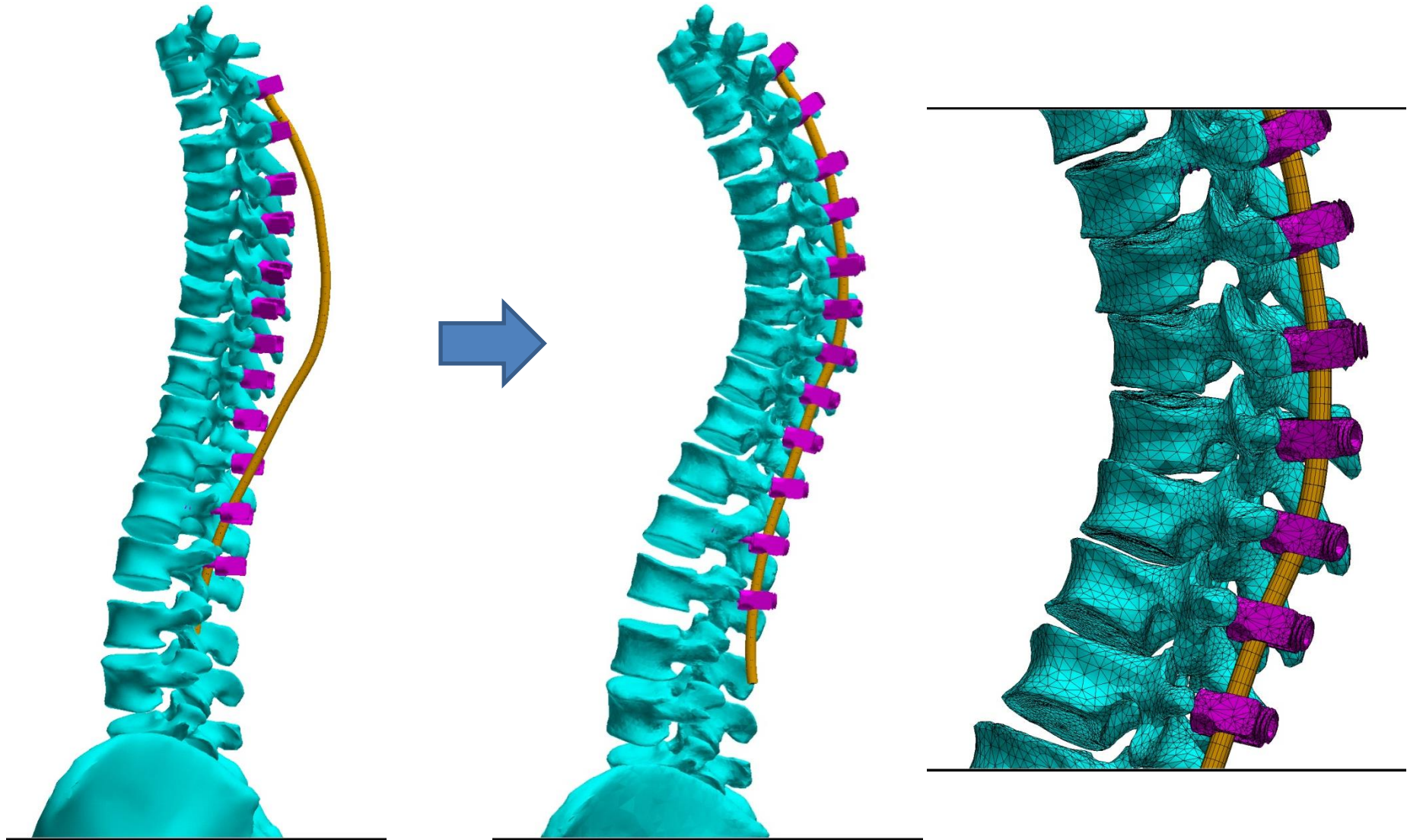
Hook FE Model



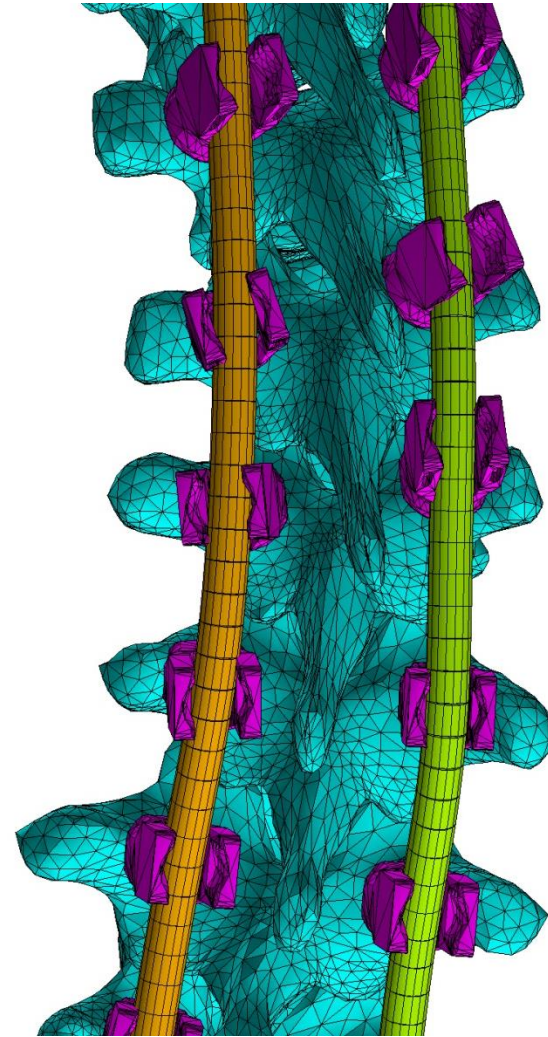
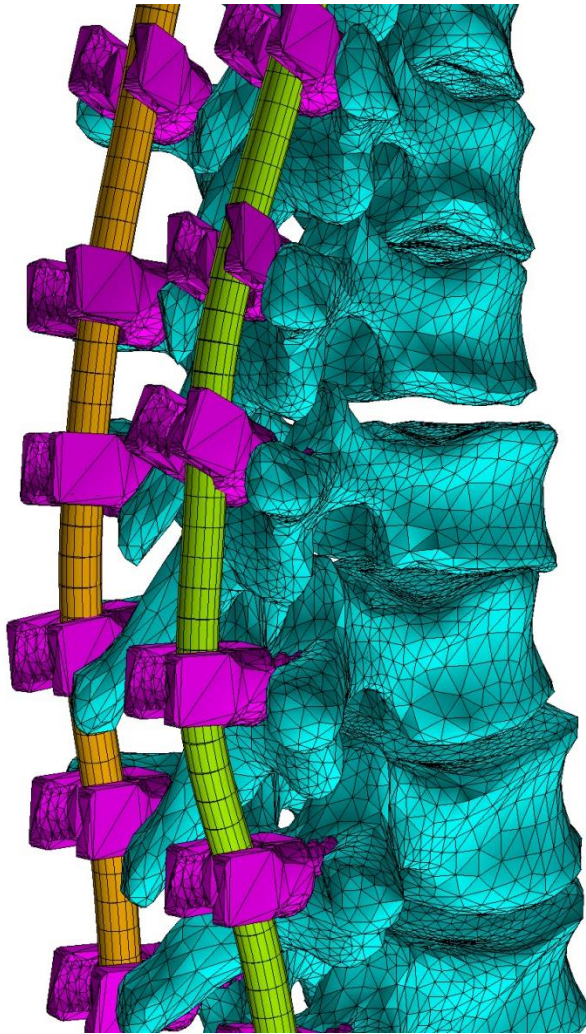
Simulation: 1st Rod Attachment



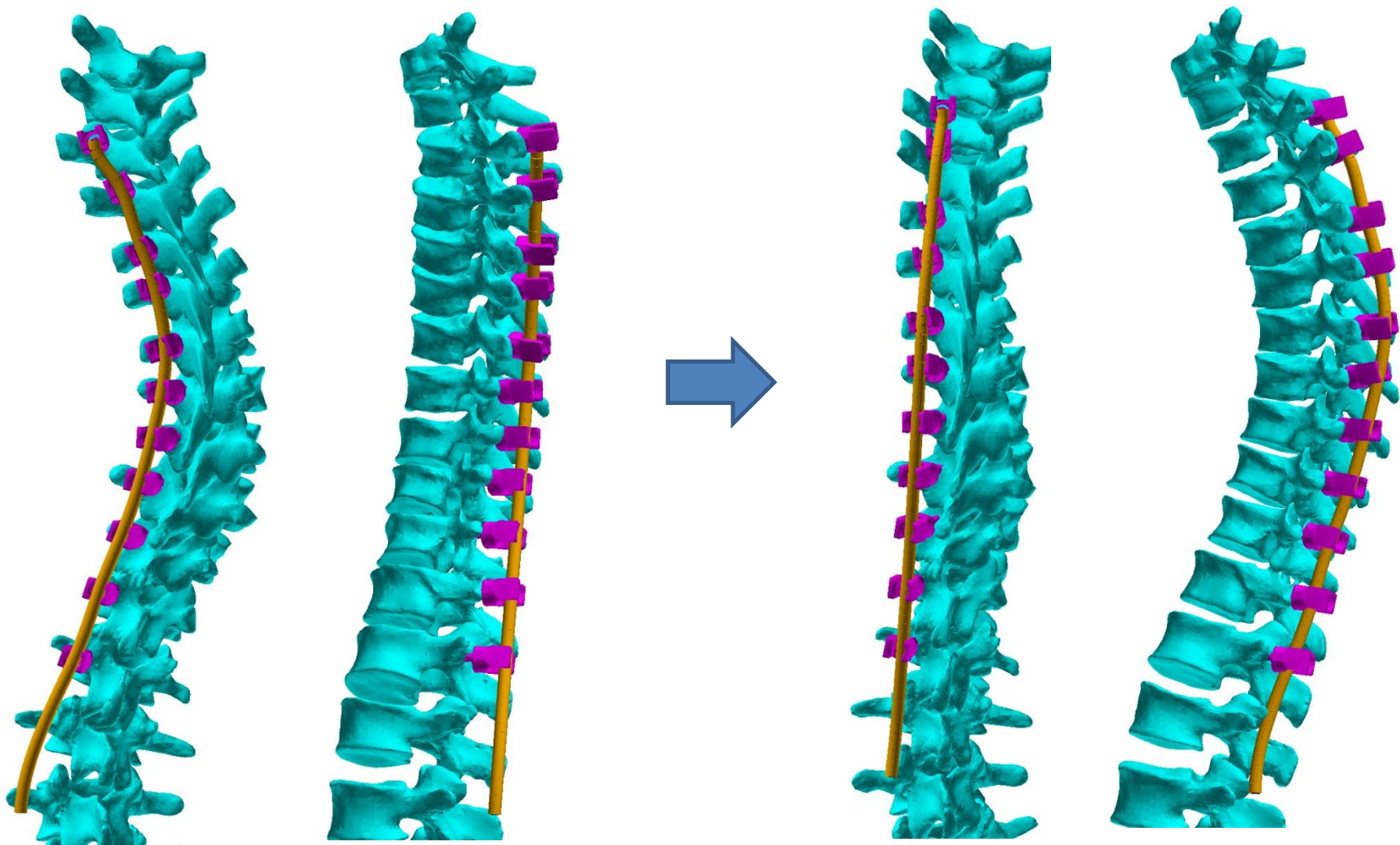
Simulation: 1st Rod Attachment

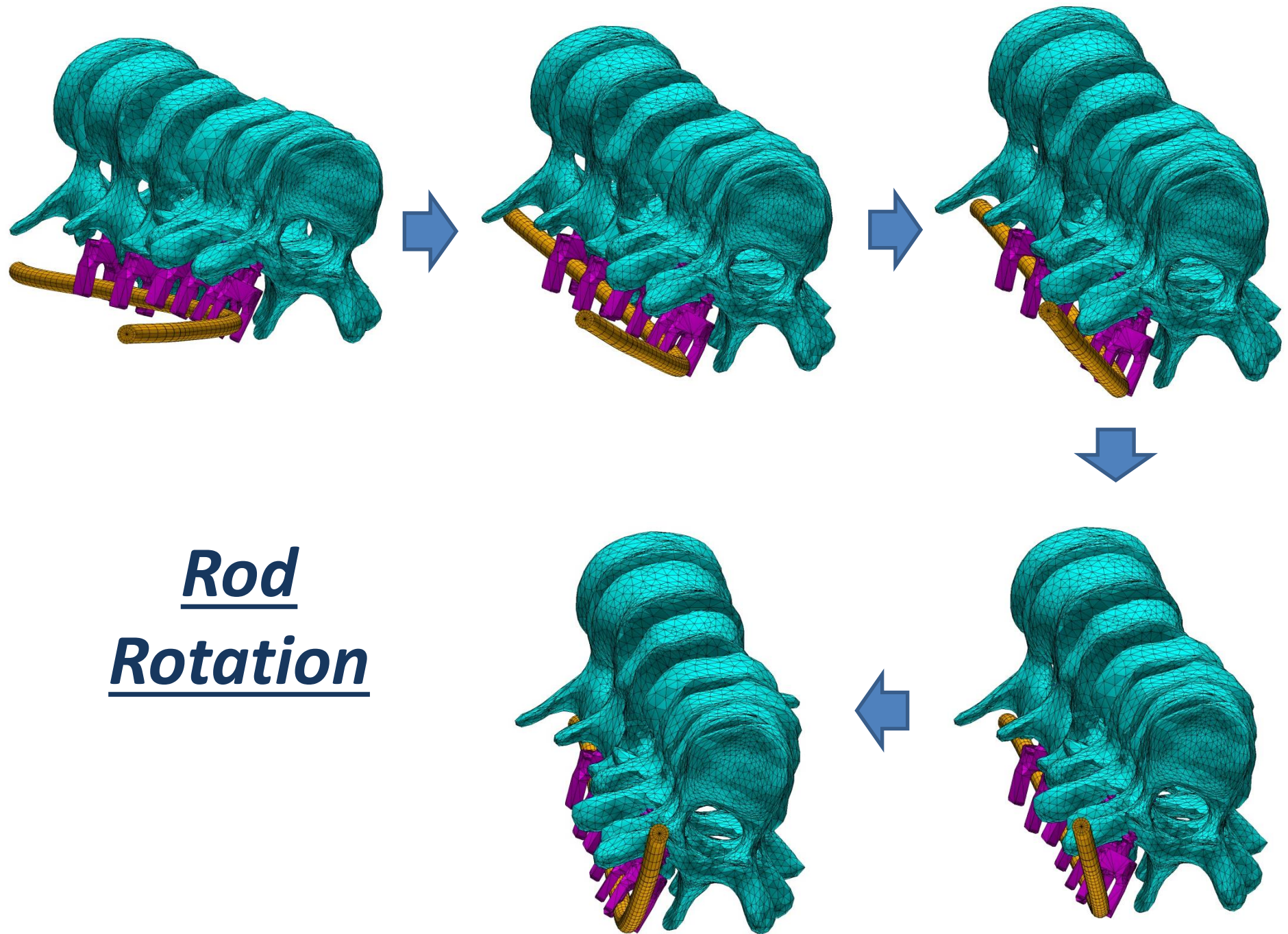


Simulation: 2nd Rod Attachment



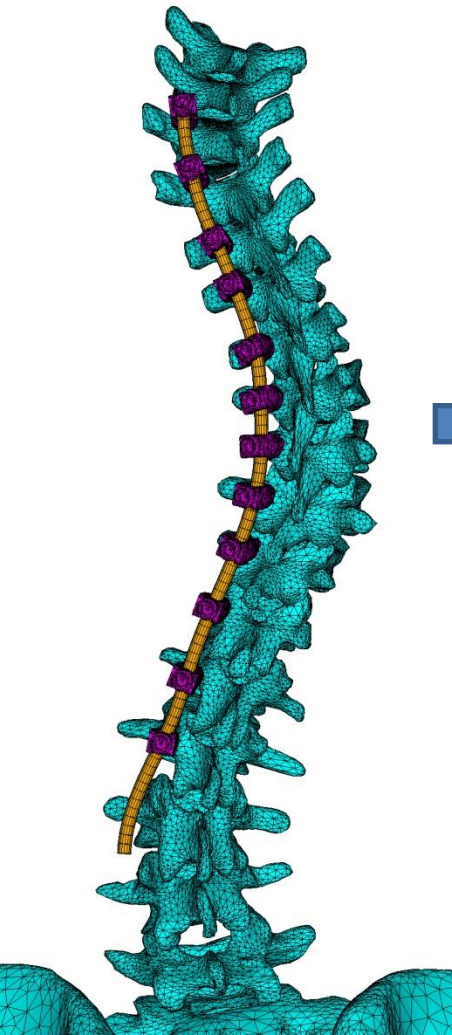
Simulation: Rod Rotation



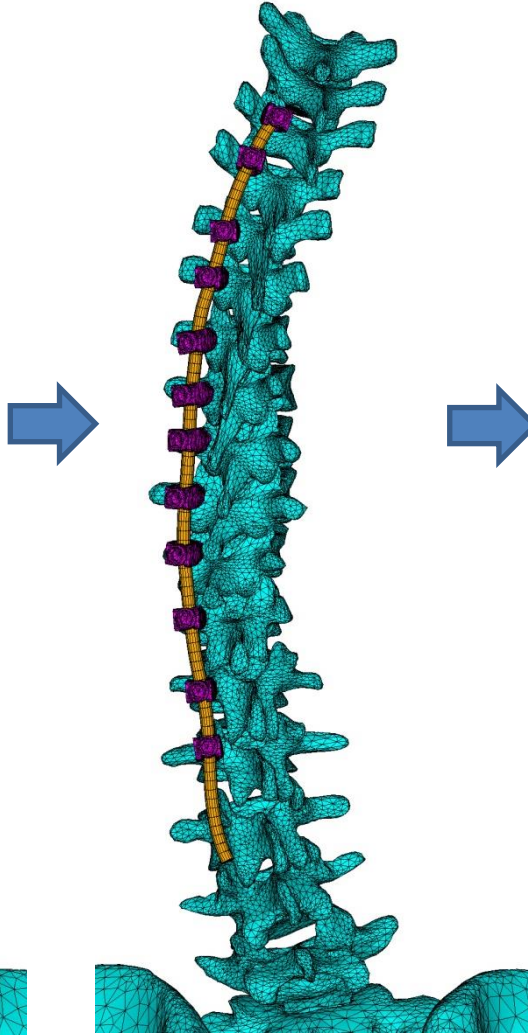


Simulation: In-Situ Bending

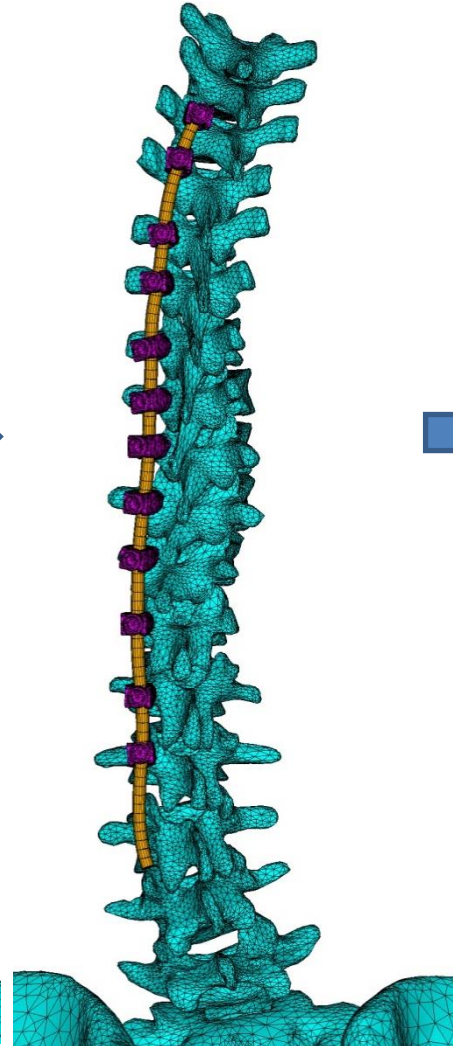
1: Rod attached



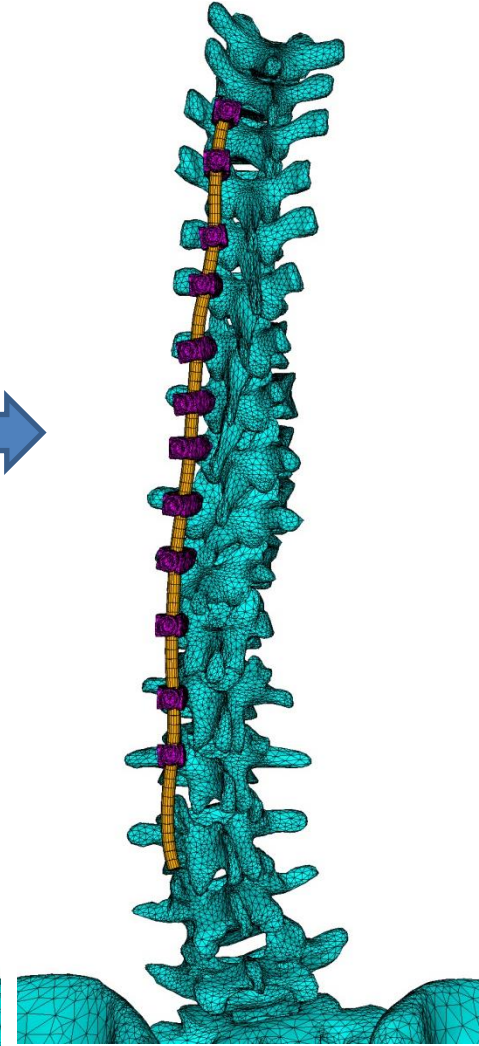
2: Bending moment applied on the rod



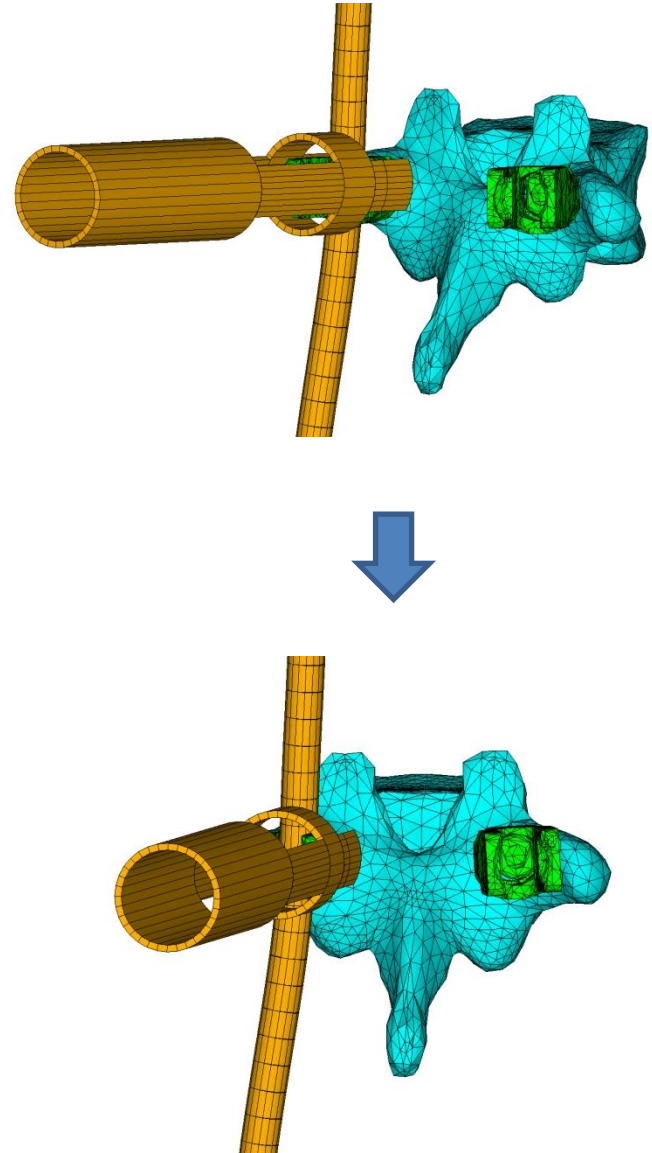
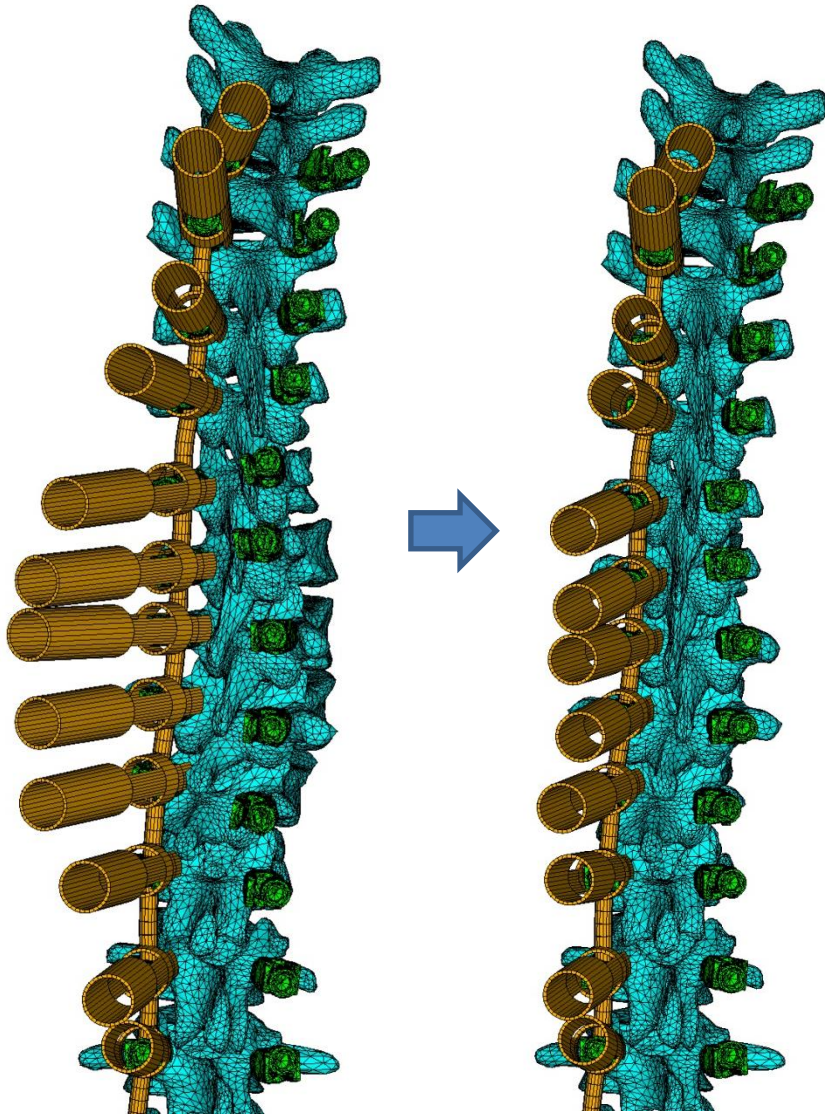
3: Bending moment released.
New equilibrium state
(plasticity)



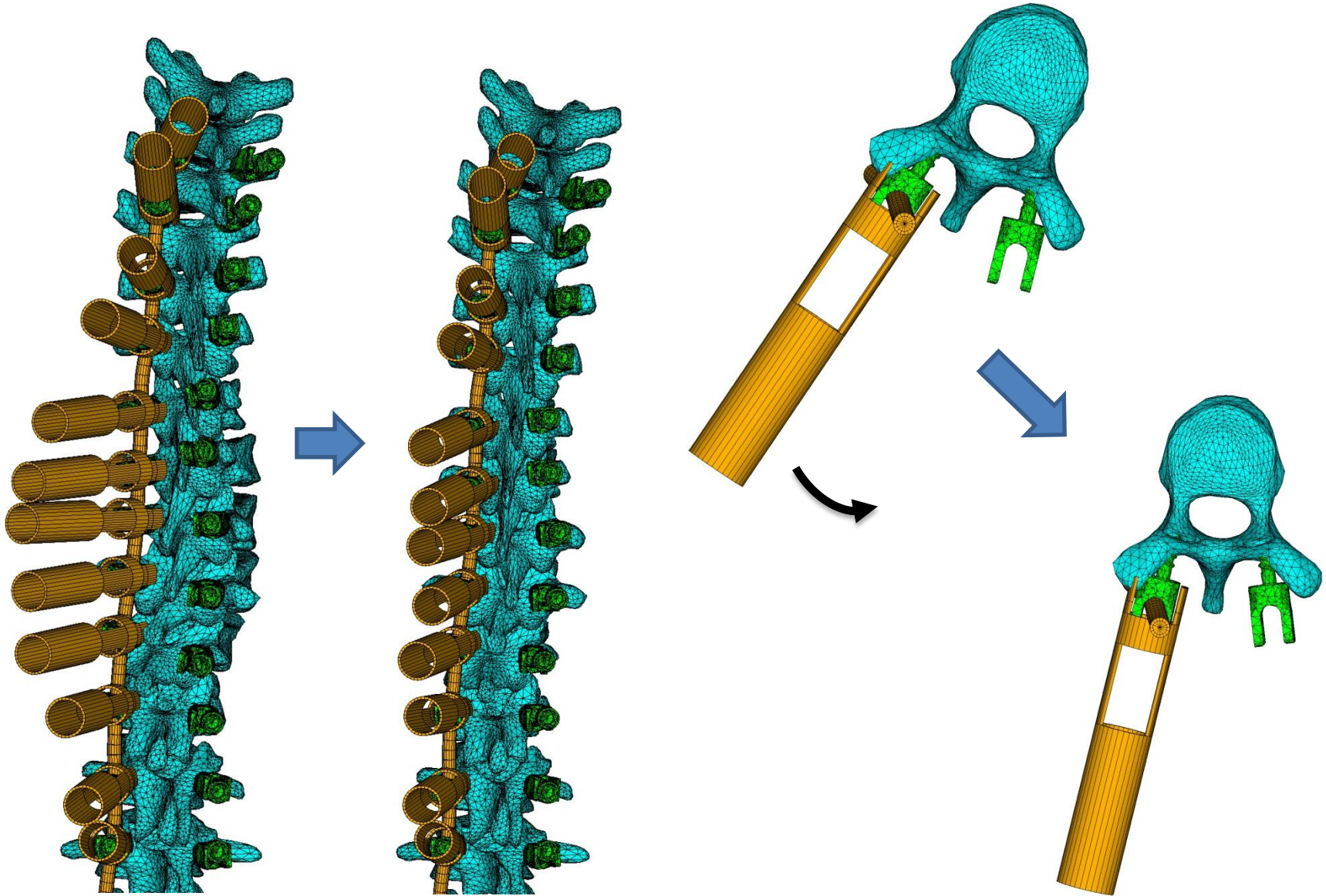
4: Final state after
several iterations



Simulation: Vertebral Derotation



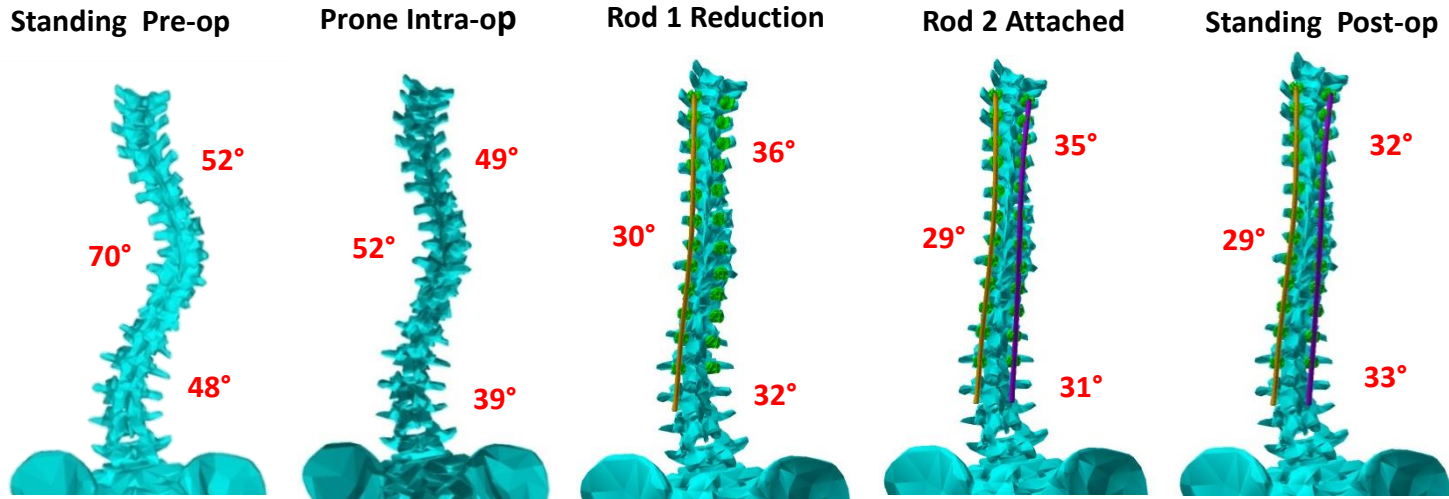
Simulation: Vertebral Derotation



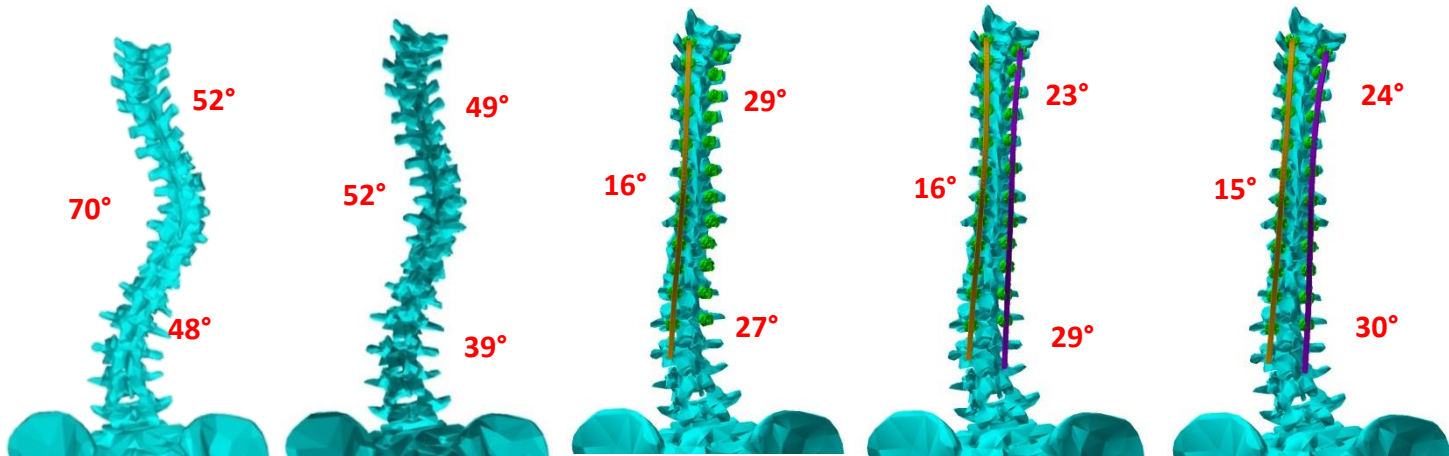
Simulation Output: Geometrical Corrections

Coronal Plane (Cobb Angles)

Generic
System



System X

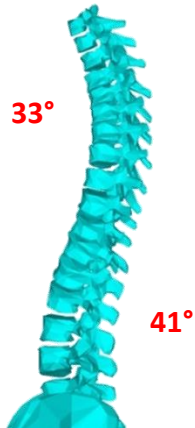


Output: Geometrical Corrections

Sagittal Plane (Kyphosis, Lordosis)

Generic
System

Standing Pre-op



Prone Intra-op



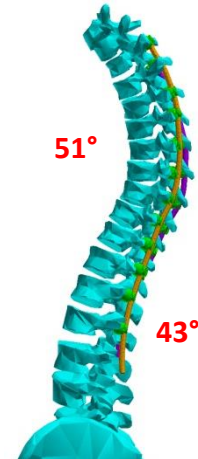
Rod 1 Reduction



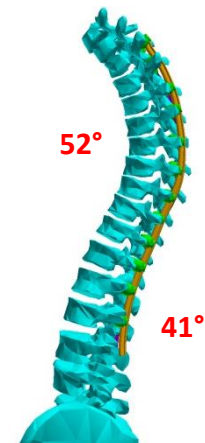
Rod 2 Attached



Standing Post-op

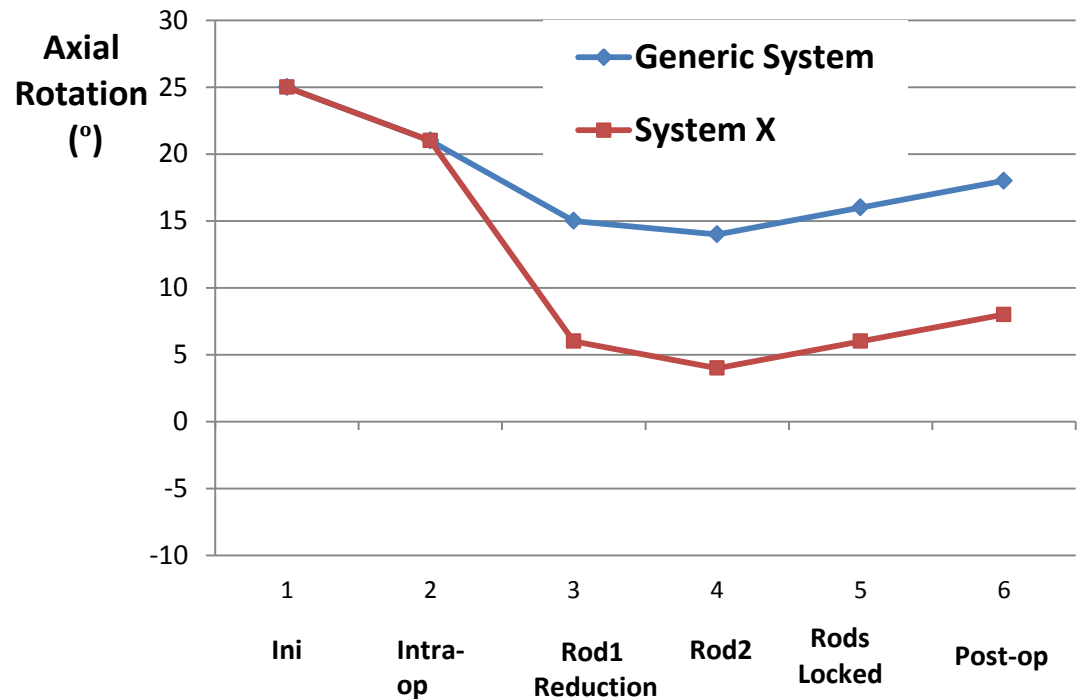
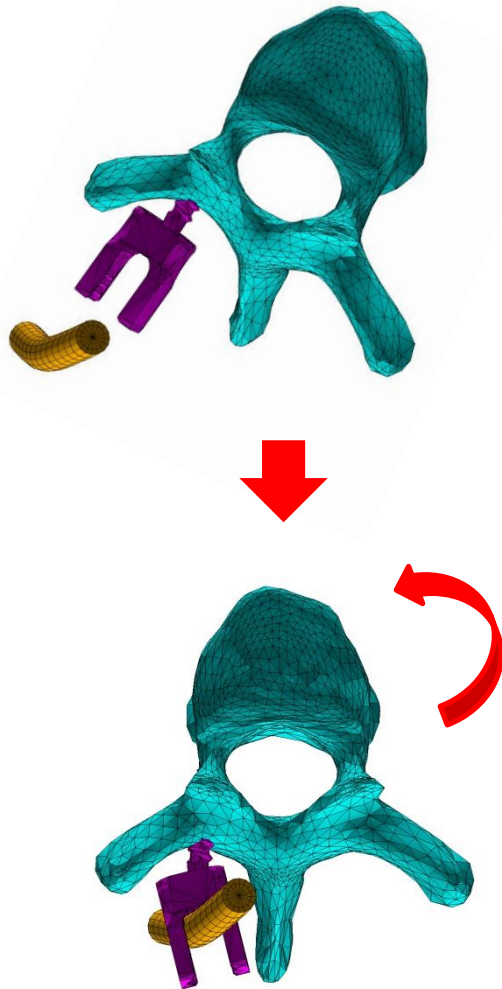


System X

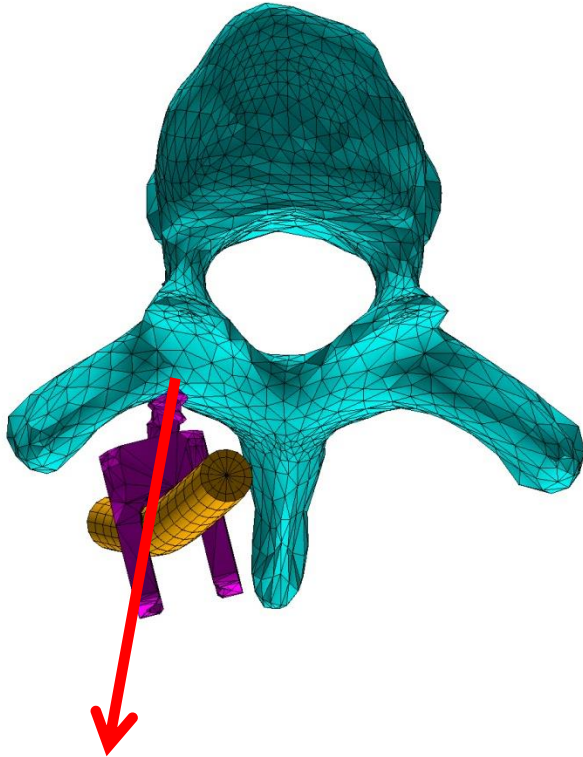


Output: Geometrical Corrections

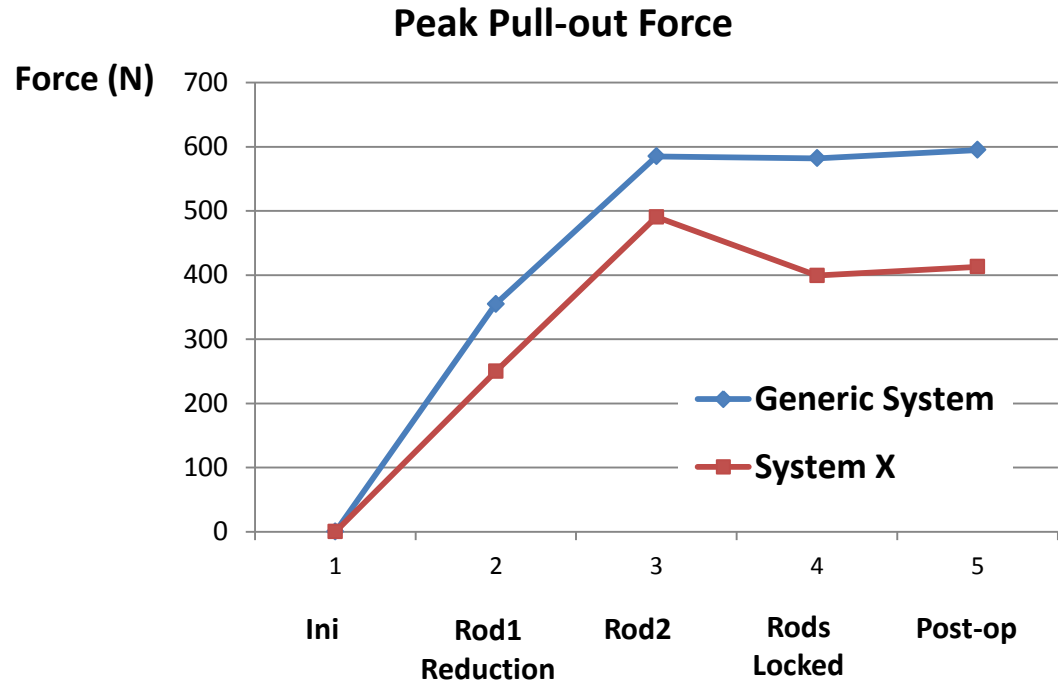
Transverse Plane (Axial Rotation)



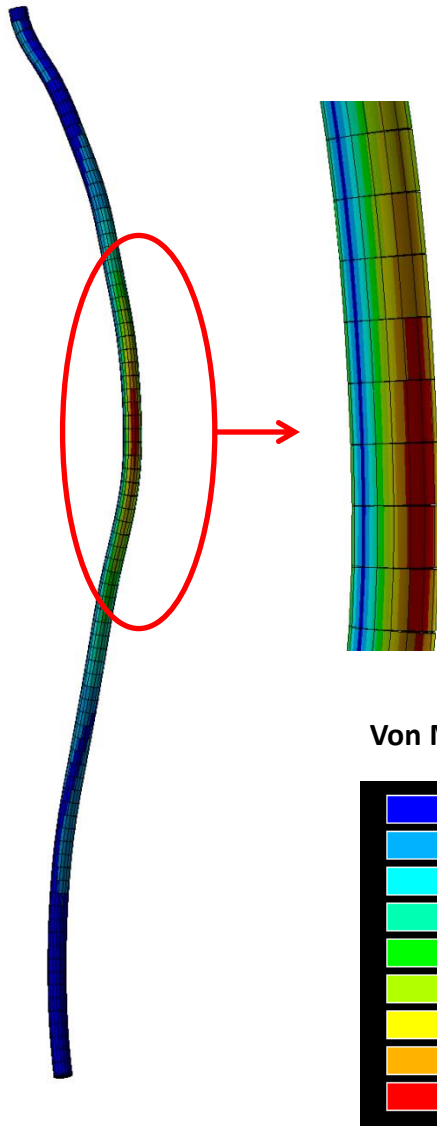
Output: Peak Pull-out Forces



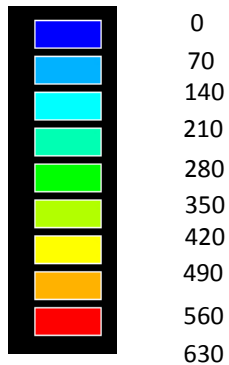
**F = Axial Pull-out
Force (N)**



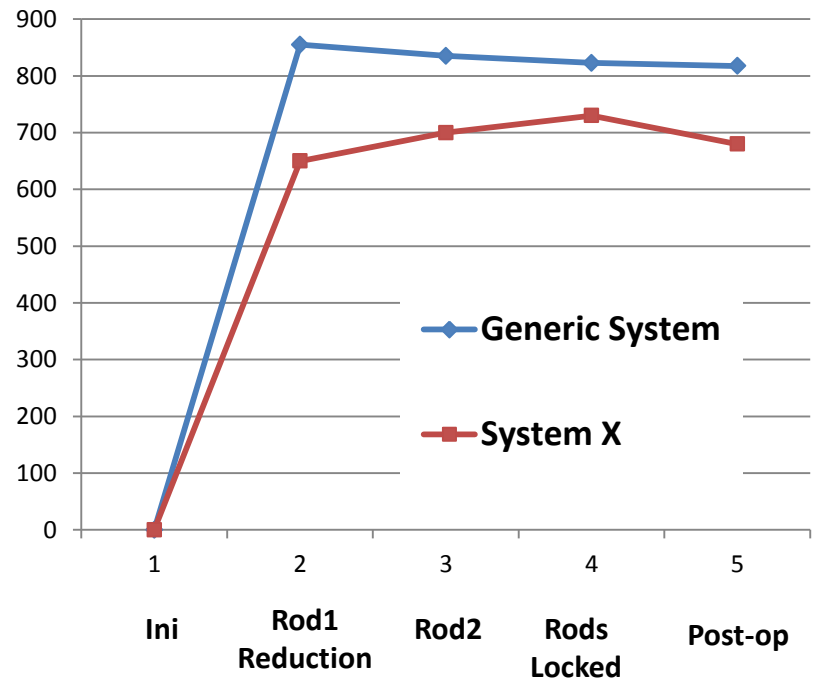
Output: Rods Stresses



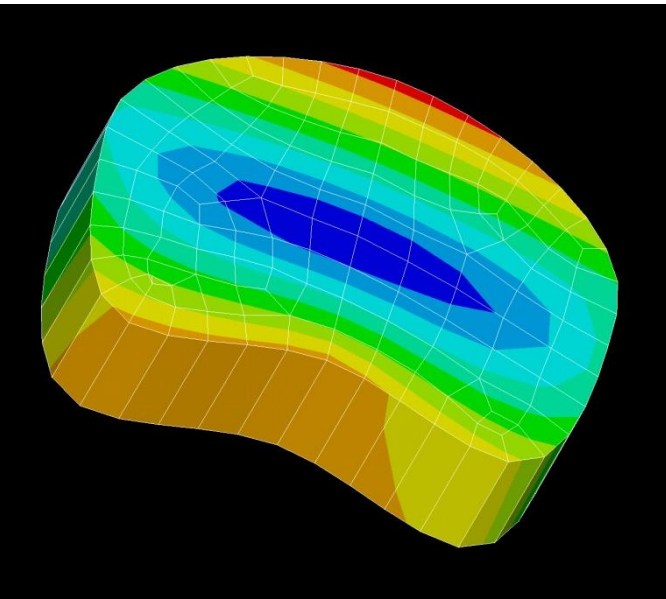
Von Mises Stresses (MPa)



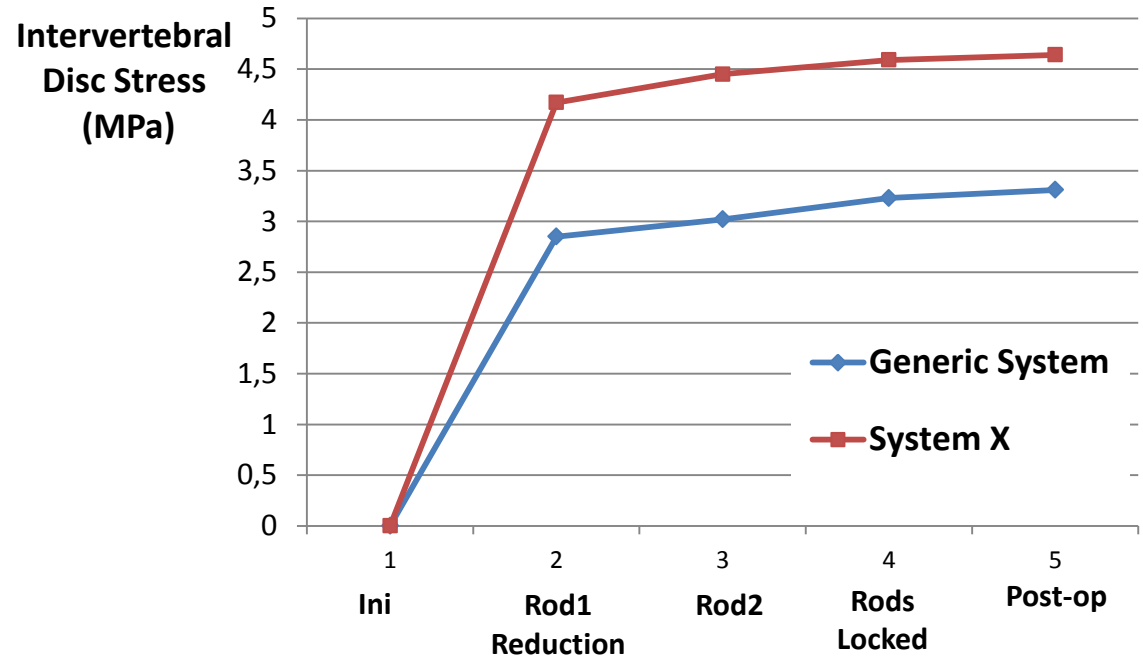
Rod 1
Von Mises
Stress
(MPa)



Output: Intervertebral Disc Stresses



Von Mises Stresses (MPa)



Spinologics: A Team with over 300 *Scientific Publications*

- **Driscoll Mark, Mac-Thiong JM., Labelle H., Parent S,** *Biomechanical Assessment of Reduction Forces Measured During Scoliotic Instrumentation Using Two Different Screw Designs.* Spine Deformity, 2013. **1**(1): p. p. 94-101.
- **Driscoll Mark, Mac-Thiong JM., Labelle H., Parent S.,** *Development of a detailed volumetric finite element model of the spine to simulate surgical correction of spinal deformities.* Biomed Res Int, 2013(2013: 931741).
- **Clin Julien,** Aubin CE, Lalonde N., **Labelle H., Parent S.,** *A new method to include the gravitational forces in a finite element model of the scoliotic spine.* Med Biol Eng Comput, 2011. **49**(8): p. 967-77.
- **Clin Julien,** Aubin CE, Sangole A, **Labelle H, Parent S,** *Correlation between immediate in-brace correction and biomechanical effectiveness of brace treatment in adolescent idiopathic scoliosis.* Spine. 35(18):1706-1713, August 15, 2010.
- **Mac-Thiong JM, Labelle H, Parent S,** Hresko MT, Deviren V, Weidenbaum M; members of the Spinal Deformity Study Group, *Reliability and development of a new classification of lumbosacral spondylolisthesis,* Scoliosis. 2008 Dec 10;3:19. doi: 10.1186/1748-7161-3-19.

Scoliosis Surgery Simulation

- To **test/optimize** your spinal instrumentation design during or after product development.
- To **compare** your spinal instrumentation to a generic design.
- To prove your new spinal instrumentation design is an **improvement** over previous versions or other existing designs.
- To assist in obtaining **regulatory approval**.



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CONCEPT

DESIGN

PRACTICE



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