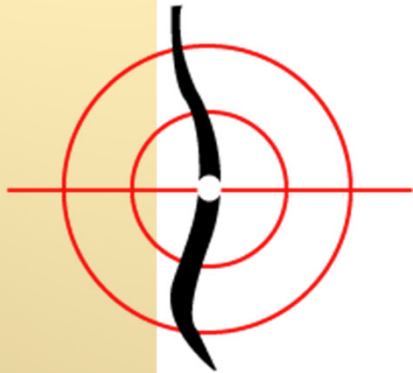


Biomechanical analysis of scoliosis correction using a novel fusionless intravertebral epiphyseal device



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CHU Sainte-Justine
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POLYTECHNIQUE
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Disclosures

PRESENTER:

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Co-authors:

J. Clin No disclosure

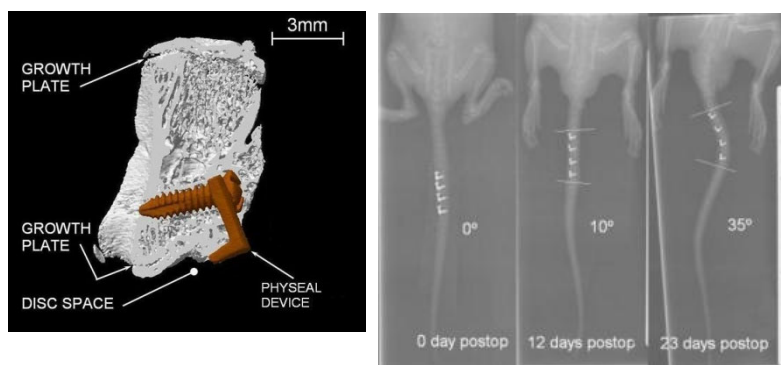
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- (c) Consultant (d) Honorarium
- (e) Board of medical organization and/or orthopedic publisher
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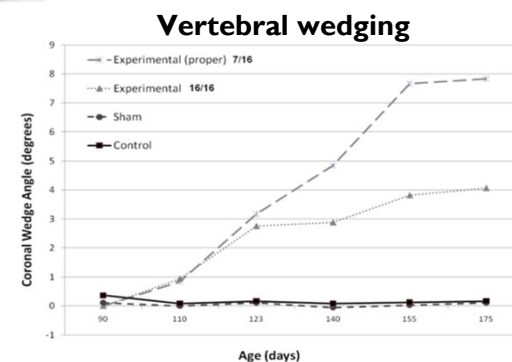
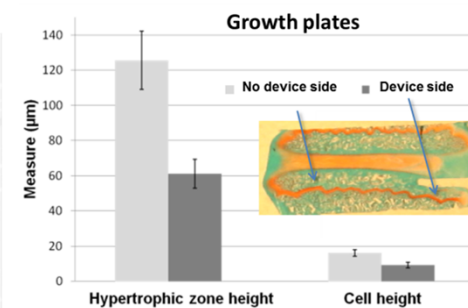
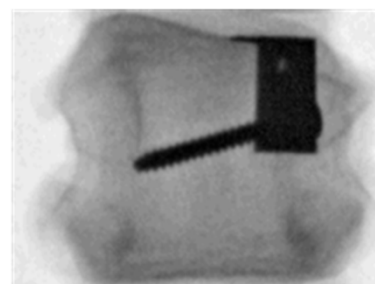
Introduction

- Many fusionless growth sparing instrumentation devices have been developed. Their influence on intervertebral disc and growth plate health, and on the control of the growing spine still remains a subject of attention.
- A new device (the “**hemi-staple**”; US 8,409,258) which locally compresses the growth plate without spanning the disc was developed and successively tested on two different animal models (1,2,3) :

Rat tail model (1)



Pig model (2,3)



- 1.Schmid EC , Aubin CE et al. , "A Novel Fusionless Vertebral Physéal Device Inducing Spinal Growth Modulation for the Correction of Spinal Deformities", Eur Spine J, 2008, Oct; 17(10):1329-35.
- 2.Driscoll M , Aubin CE ,et al. "Spinal Growth Modulation Using a Novel Intravertebral Epiphyseal Device in an Immature Porcine Model.", Eur Spine J, 2012 Jan; 21(1):138-44
- 3.Driscoll M , Aubin CE et al. "Novel Hemi-staple for the Fusionless Correction of Pediatric Scoliosis: Influence on Intervertebral Discs and Growth Plates in a Porcine Model", J Spinal Dis Tech, 2013 Mar 18. [Epub ahead of print]

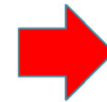
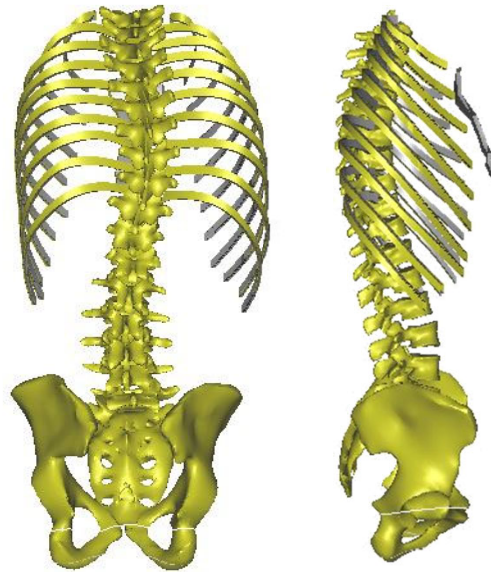


Objective

- To further analyze the hemi-staple biomechanical action on a **human** finite element model

Cases

- 10 thoracic scoliosis cases (11.7 ± 0.9 yr; MT Cobb: $35^\circ \pm 7^\circ$; TL/L: $24^\circ \pm 6^\circ$)
- For each case:
 - Spine, pelvis and rib cage reconstructed in 3D
 - Finite Element Model (FEM):
 - Vertebrae, Discs; Articular joints; Ligaments; Rib cage; Soft tissues; Pelvis; Growth plates

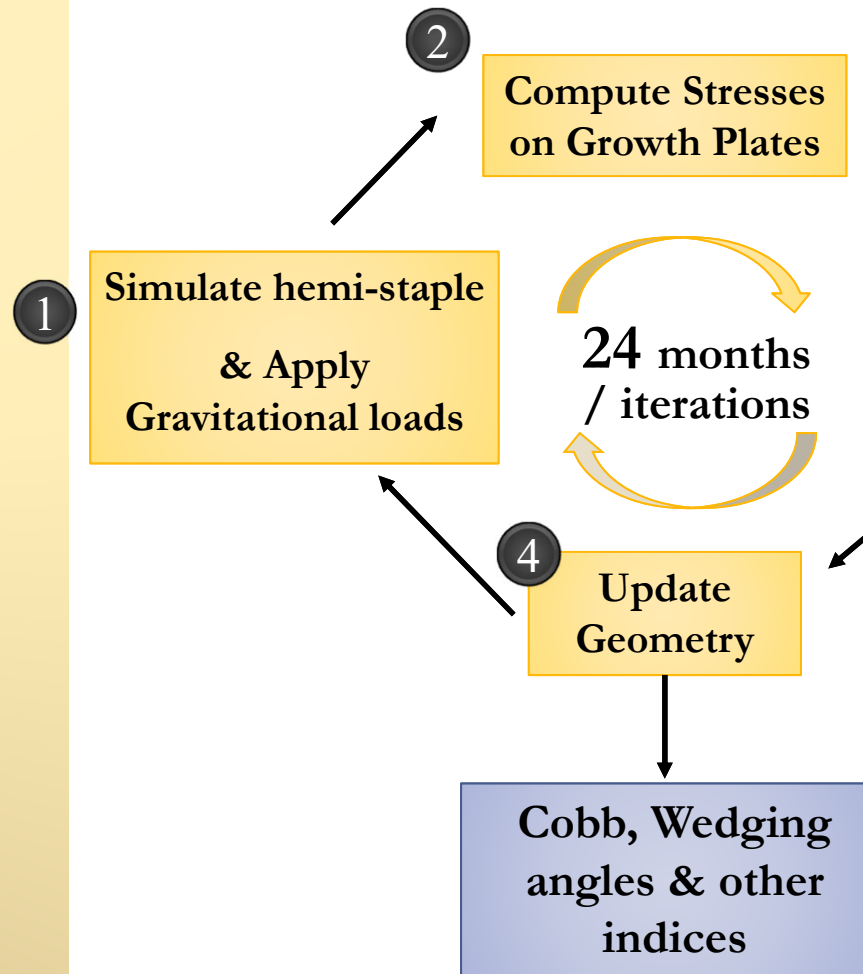


bi-planar calibrated radiographs

3D Reconstruction

Finite Element Model

Growth Dynamics Modeling



- Growth dynamics governed by the **Hueter-Volkman** principle integrated in FEM

- Controlling equation:

(based on Stokes 90 & Villemure 02):

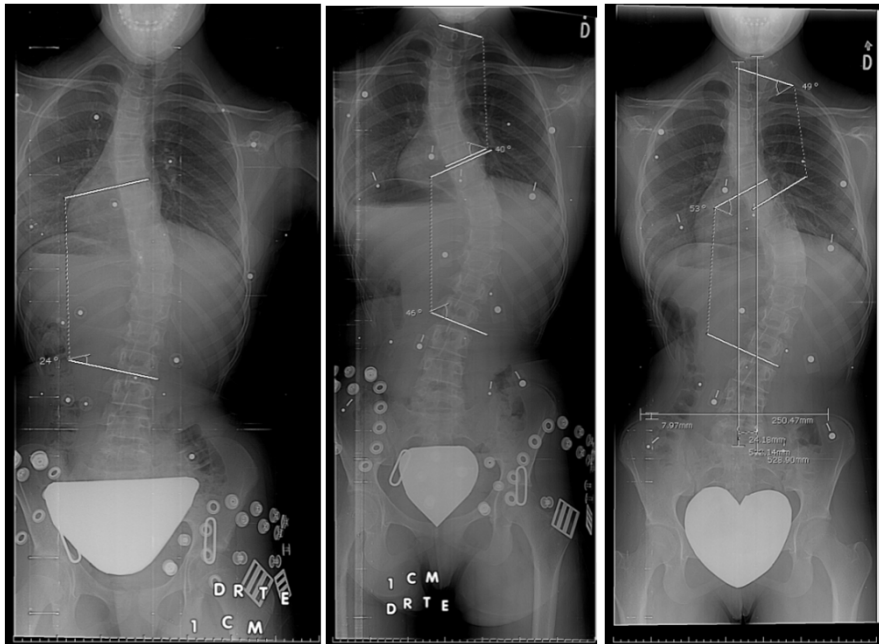
$$\mathbf{G} = \mathbf{G}_m [1 - \beta (\sigma - \sigma_m)]$$

G_m = growth rate (0.8-1.1 mm/year)
 β = bone sensitive factor (1-3 MPa⁻¹)
 σ = stress in pathologic spine
 σ_m = normal stress

- Validated model to predict scoliotic progression (Villemure 2002, Stokes 2007, Lin 2011)

Growth Modeling Validation

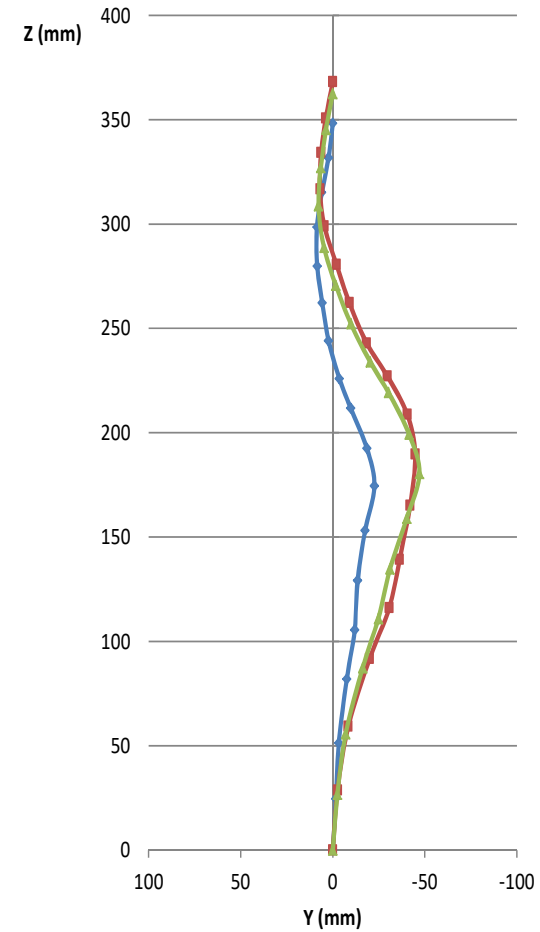
(2 yrs growth simulation; case #1)



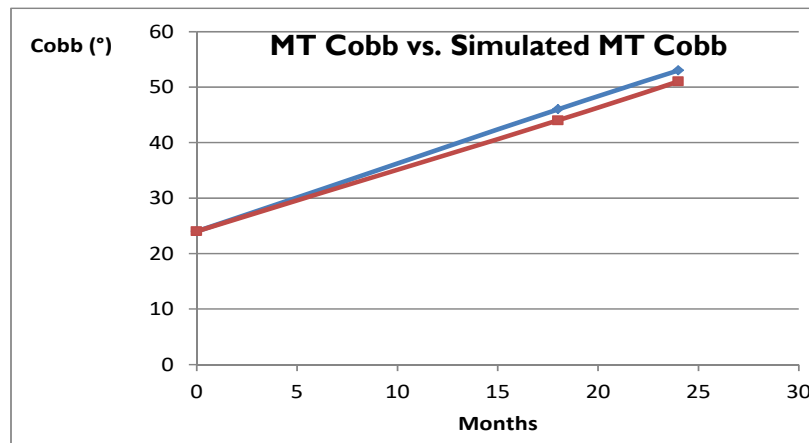
Sept. 2004

April 2006

Sept. 2006

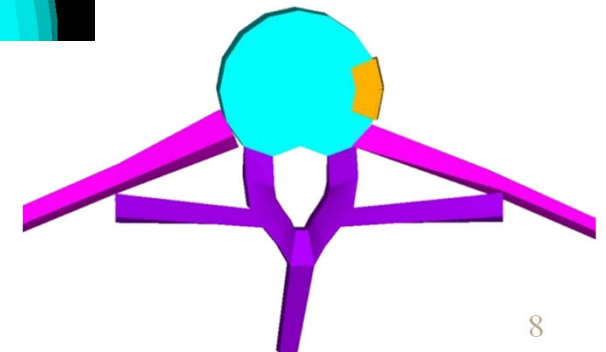
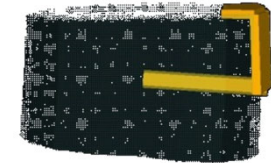
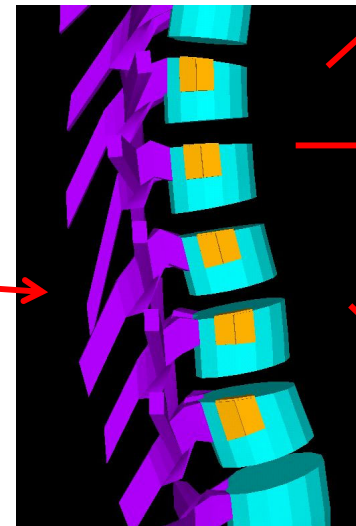
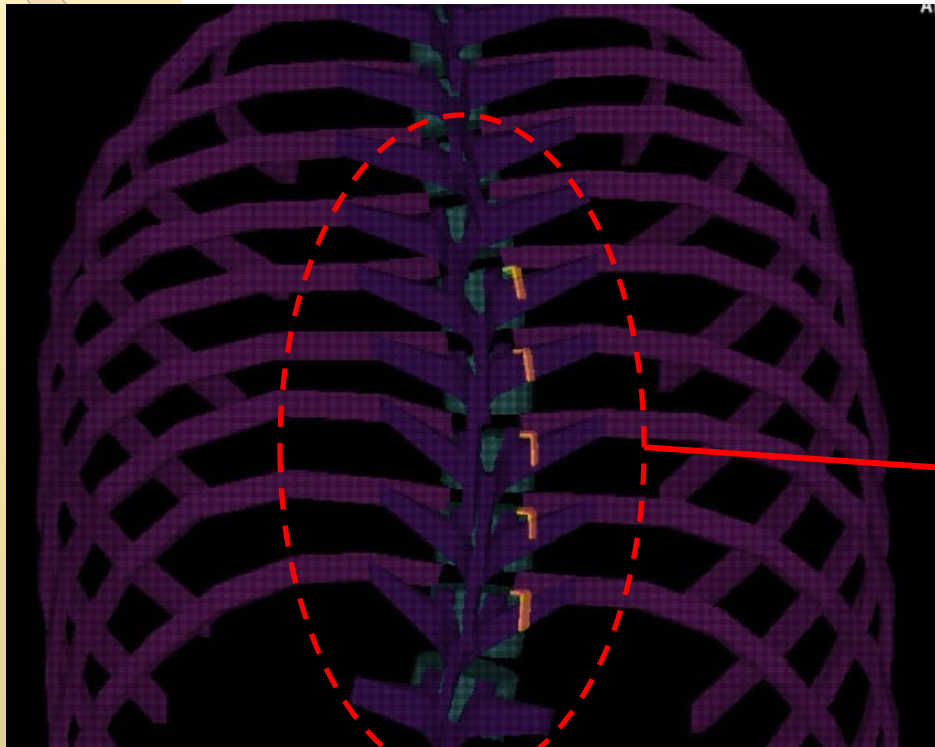


- ◆— Initial
- + 2 yrs growth
- ◆— Simulation 2 yrs growth



Instrumented FEM

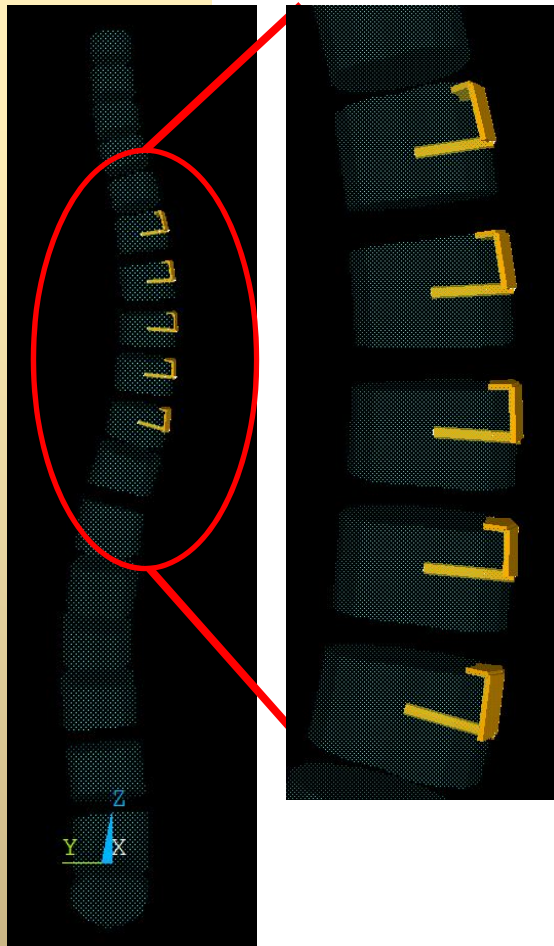
Hemi-staple model
(shell elements)



Tested configurations

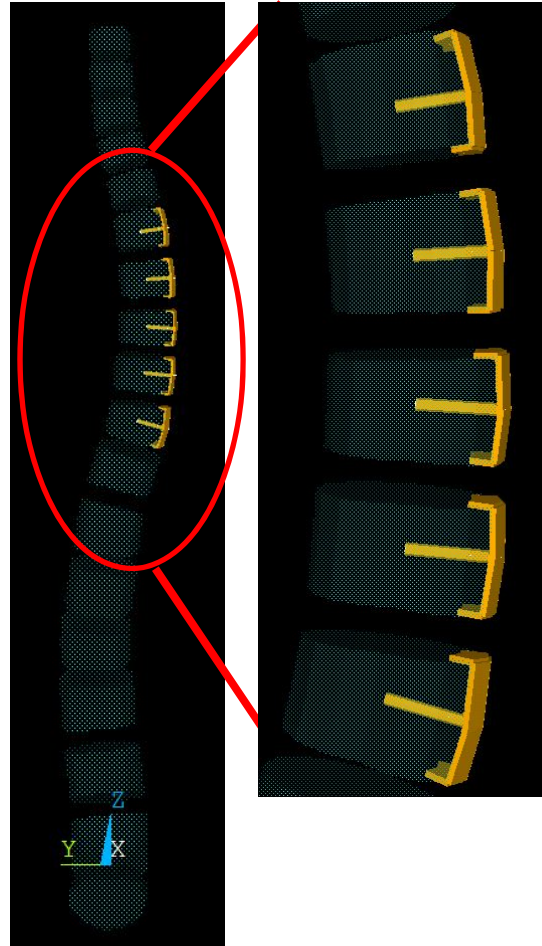
Config #1:

5 instrumented levels
(MT spine)
Single growth plates



Config #2:

5 instrumented levels
(MT spine)
Both growth plates



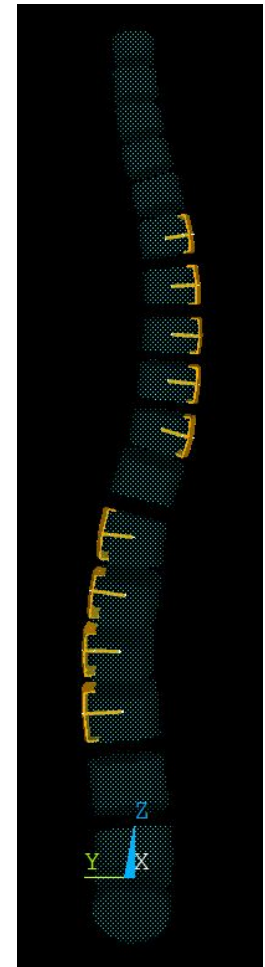
Config #3:

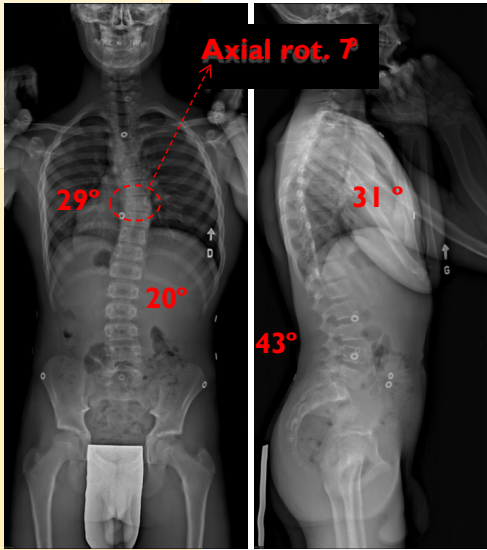
9 instr. levels
(MT & TL/L spines)
Single growth plates



Config #4:

9 instr. levels
(MT & TL/L spines)
Both growth plates





Case #1 - 2 yrs simulation

Natural Growth

Conf #1

Conf #2

Conf #3

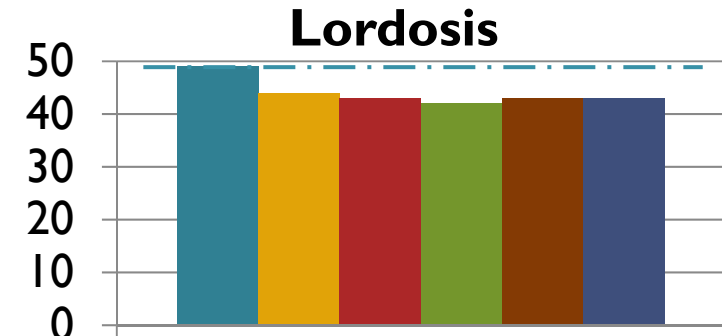
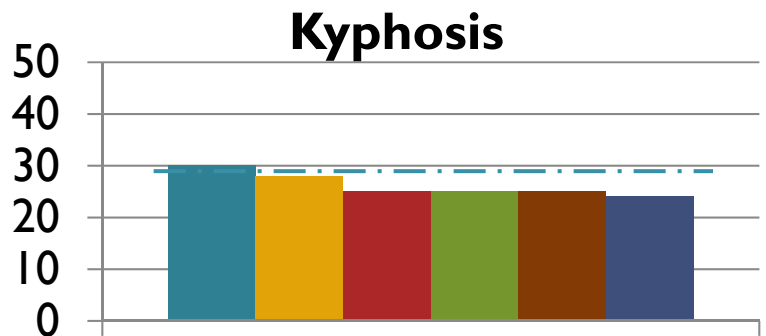
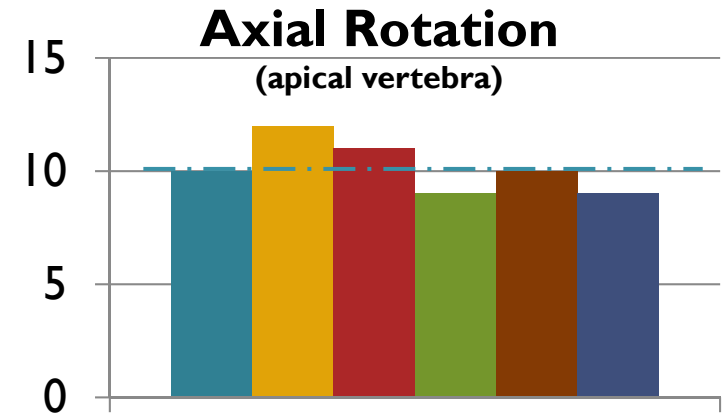
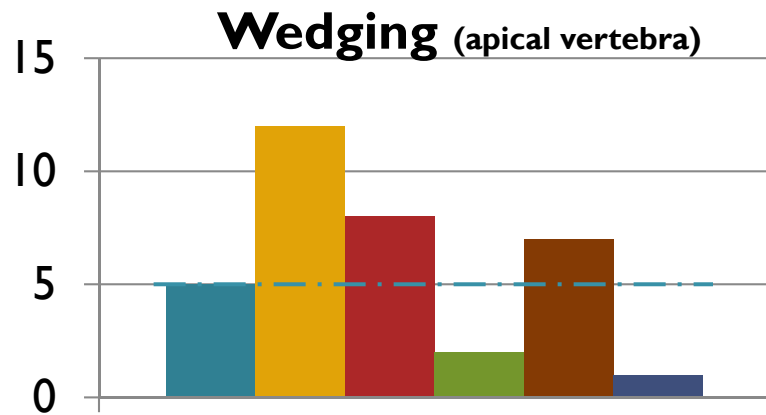
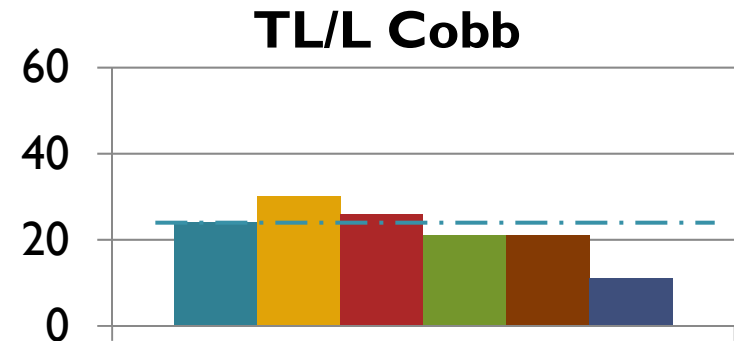
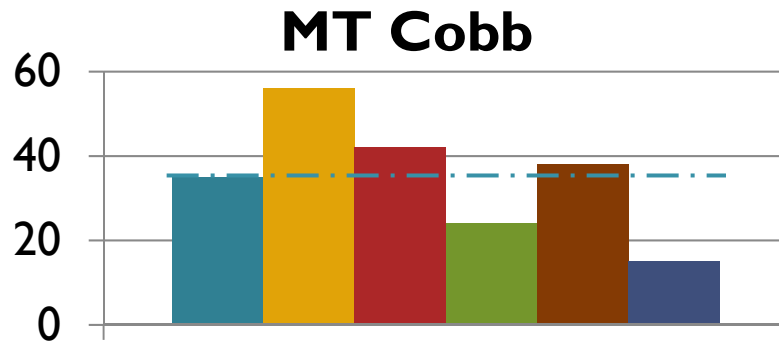
Conf #4

Initial



Synthesis (average for all cases)

- Pre-op
- Natural Growth
- Config #1
- Config #2
- Config #3
- Config #4





Discussion & Conclusion

- Biomechanical potential of the hemi-staple device to control the scoliosis progression
- Relevant alternative for the early treatment of idiopathic scoliosis
- Importance of the instrumentation configuration to correct the spinal deformity: a 'two hemi-staples per vertebra' strategy is more effective
- Model limitations: spinal loading due to gravity (no muscle), linear growth modulation, ... An extended validation is necessary.