

Intra-operative simulator for scoliotic spine surgeries

Preliminary prototyping results

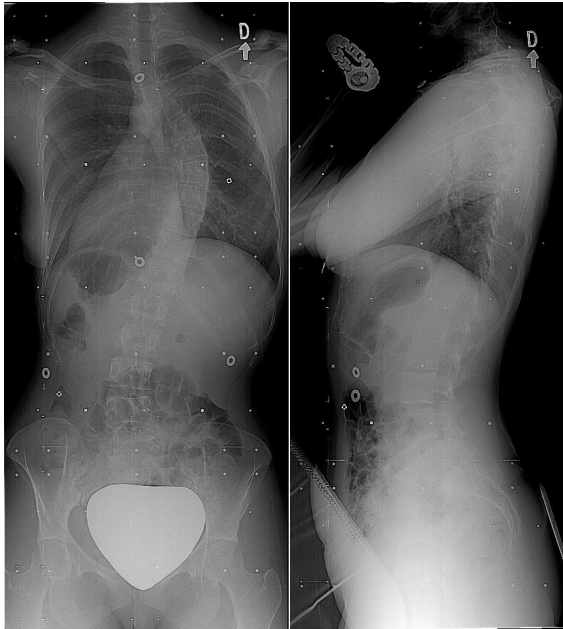
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Context (1/3)

Instrumentation surgeries of the scoliotic spine

- **High variability** in correction objectives¹: Cobb angles, balance, etc.
in instrumentation strategies²: fusion levels, rotation maneuvers, etc.



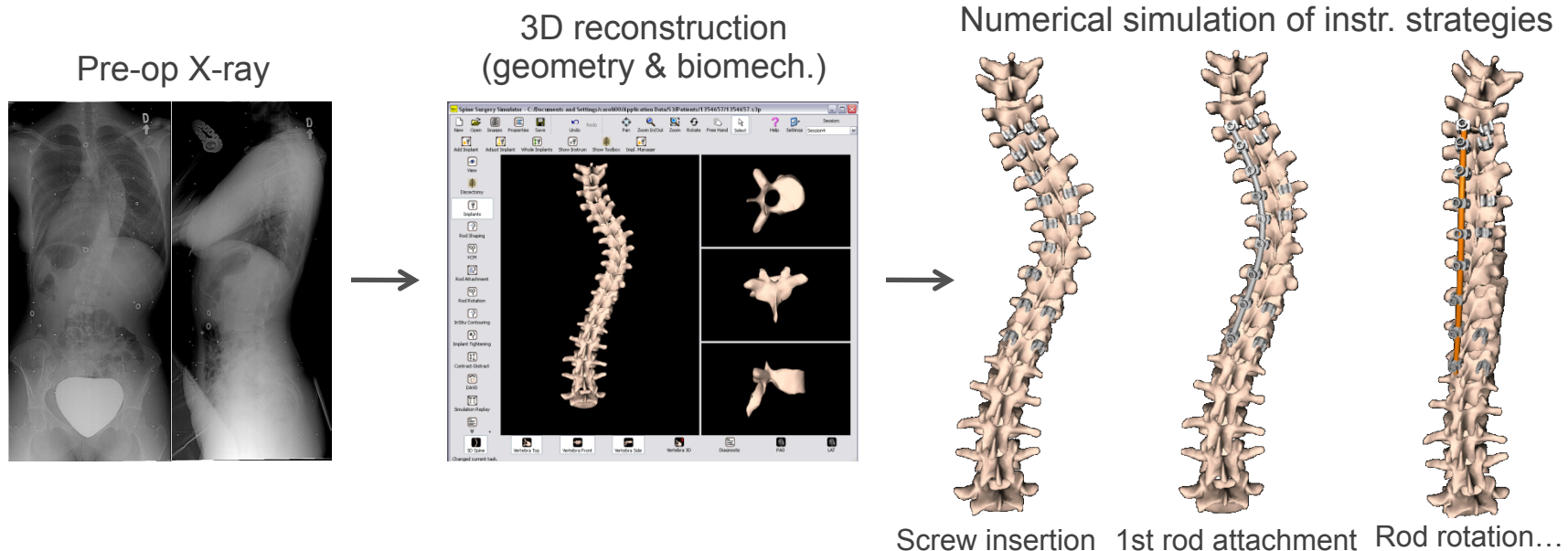
→ **No consensus about what the
« best » surgical approach is**

¹Majdouline et al., *J Pediatr Orthop*, 2007

²Robitaille et al., *Eur Spine J*, 2007

Context (2/3)

Spinal surgery simulator (S3) for pre-operative planning³



Prediction of results (scoliosis correction, force analysis, etc.)

→ **Patient-specific planning of the "best" instrumentation strategy**

- Implants → instrumented levels, type, number, and positioning
- Rods → diameter, length, and shape
- Derotation maneuvers
- Vertebra-vertebra and implant-vertebra forces

³Aubin et al., *Spine*, 2008

Context (3/3)

Intra-operative imaging and navigation systems⁴

Intra-op 2D/3D imaging



3D navigation (intra-op guidance)



- **Screws positioning planning and real-time guidance**, using intra-op images
- **BUT no prediction of results**

⁴Clinical Value of Image Guided Surgery for Spinal Procedures, Medtronic, www.medtronic.com, 2011

Objective

To develop a new intra-operative simulator for spine surgeries

New intra-op simulator

**1. Pre-op planning
update**

**2. Simulations &
prediction of results**

Intra-op data
transfer

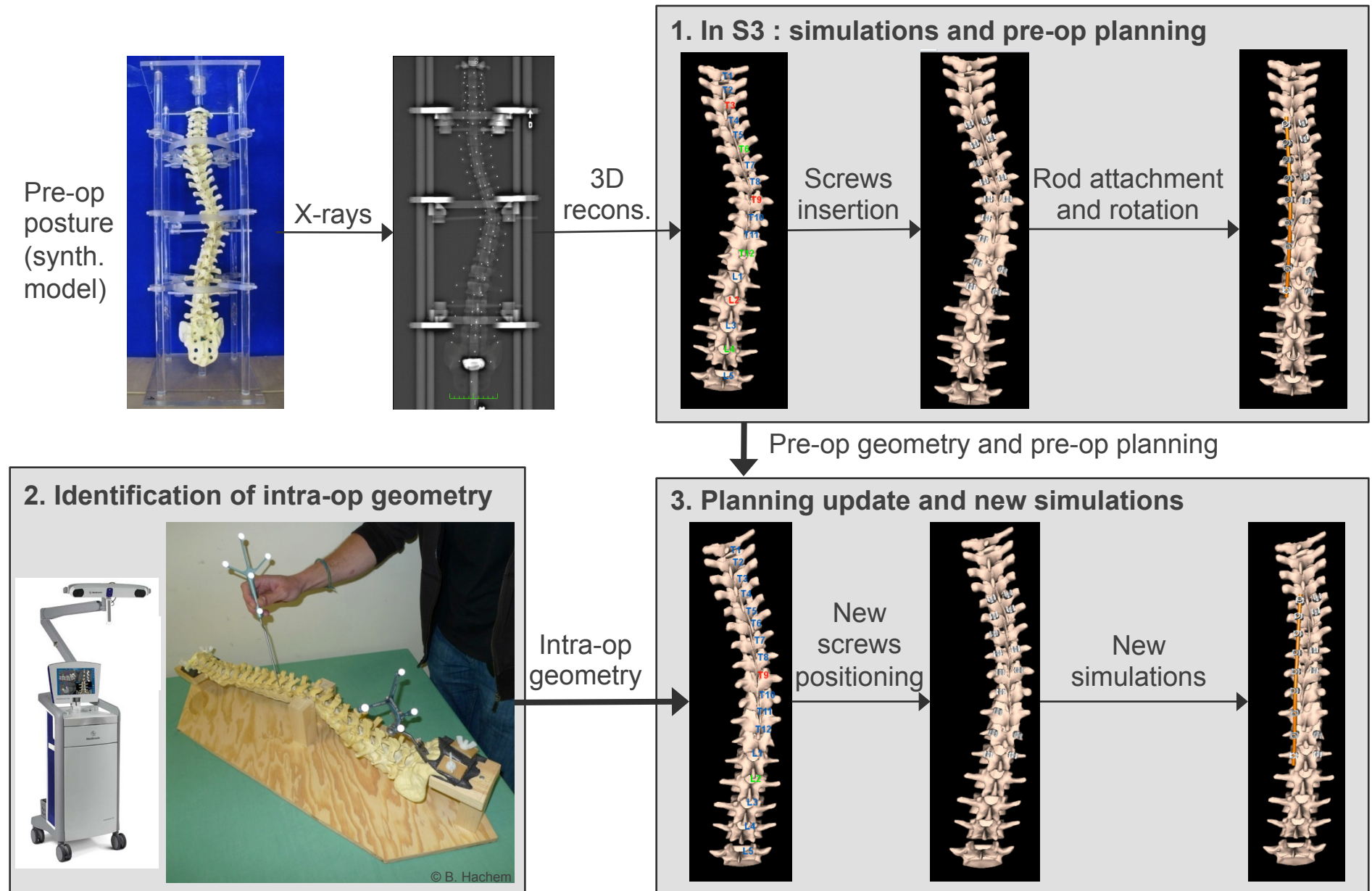
1. Planning transfer
2. Biomechanical feedback

Intra-op navigation and imaging



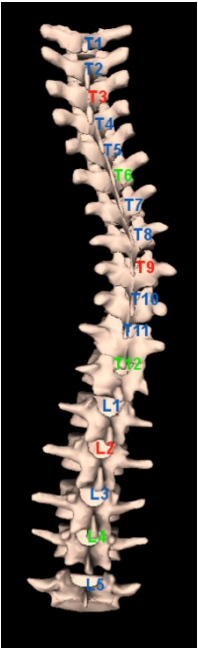
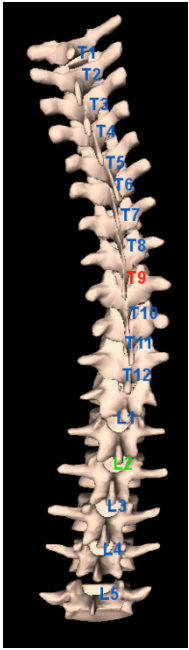
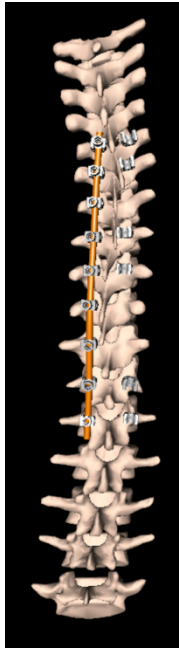
Methods

1st study: to update pre-op planning & simulations w.r.t. intra-op navigation data



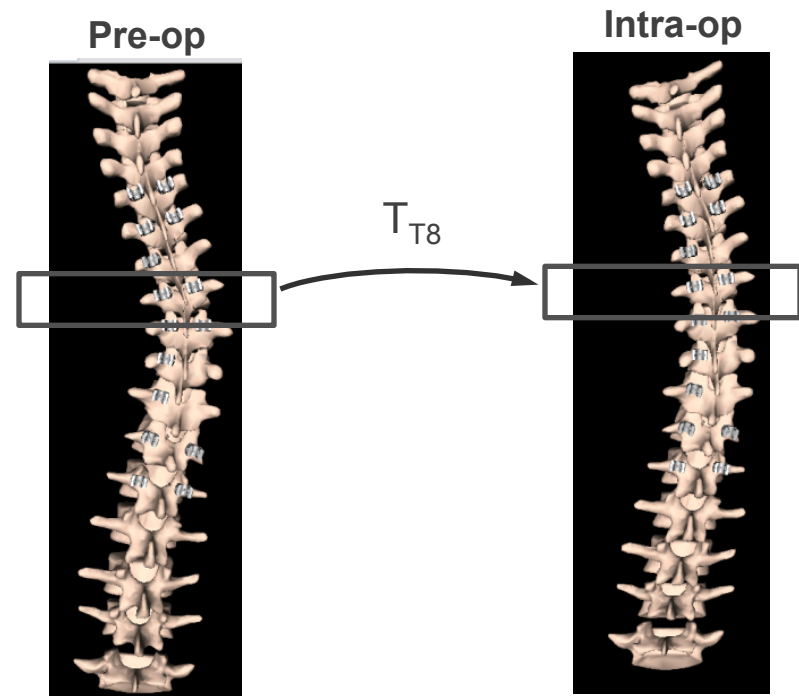
First results

1. Pre- and intra-op simulation results

Cobb angles for the 3 simulated geometries		
Pre-op.	Intra-op. pre-instr.	Intra-op. post-instr.
34°	24°	12°
		

2. Planning update :

differences in screw positioning < 0.5 mm
b/w pre-op planning and intra-op situation

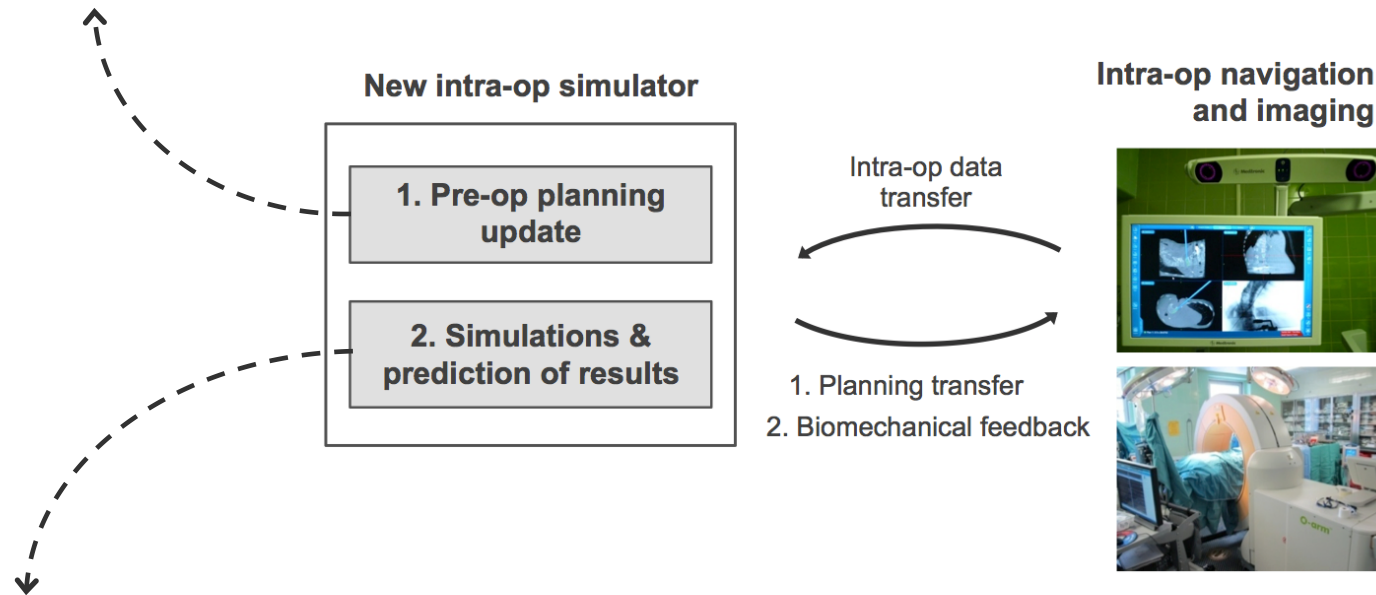


For T8: geom transformation b/w pre and intra-op positions
→ update of screws positioning planning

$$T_{T8} = \begin{pmatrix} 0.80 & 0.23 & -0.55 & 490.51 \\ 0.10 & -0.95 & -0.28 & 74.17 \\ -0.60 & 0.18 & -0.78 & -1355.85 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Conclusion and perspectives

Conclusion: feasibility of **planning update** according to intra-op information



Next: Intra-op tools for automated 3D reconstruction, model registration, planning transfer and real-time simulations

- **Predict results of correction maneuvers in real time**
→ indices (Cobb angle...), simulations, force analysis, etc.
- **Adjust instrumentation parameters intra-operatively**
→ instrumented levels, surgical maneuvers, etc.

Acknowledgements

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