"New intraoperative simulator of navigated surgeries of the scoliotic spine: first results"

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Abstract

OBJECTIF Développer un nouveau simulateur numérique intra-opératoire pour la chirurgie naviguée du rachis scoliotique. MÉTHODES Une stratégie d'instrumentation (insertion des vis pédiculaires, attachement d'une tige et dérotation, et serrage des vis) a été simulée numériquement pour un modèle synthétique de rachis scoliotique à partir de ses radiographies en position érigée respectant les conditions pré-opératoires. Le positionnement intra-opératoire en décubitus ventral a été simulé, et ensuite identifié à partir d'un appareil d'imagerie fluoroscopique 2D/3D intra-opératoire et un système de navigation chirurgicale. La nouvelle géométrie du rachis scoliotique a été transmise au simulateur, ce qui a permis de mettre à jour la planification pré-opératoire du positionnement des vis, le calcul des indices cliniques (angles de Cobb, etc.), et la simulation des manœuvres chirurgicales. Les positions des vis, mises à jour dans le simulateur conf...

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Intraoperative simulator for navigated surgeries of the scoliotic spine: first results

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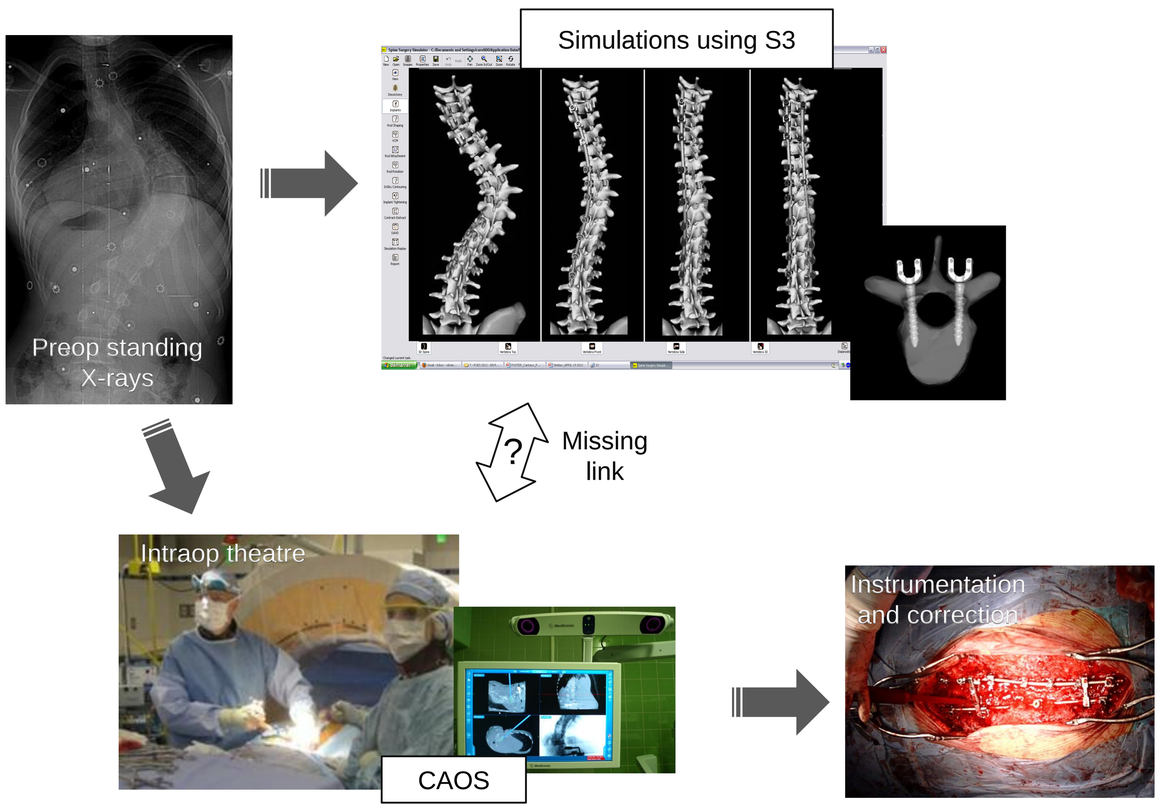
Introduction

- Scoliotic spine instrumentation = complex surgery requiring many decisions pre- and intraoperatively[1,2]
- Preop computational simulator (S3) → allows planning screw pattern design and simulating instrumentation correction[3]
- Commercially available intraop imaging/navigation systems (CAOS) → allow guiding pedicle screws insertion[4]



Objective

To develop a new computational simulator for navigated surgeries of the scoliotic spine.

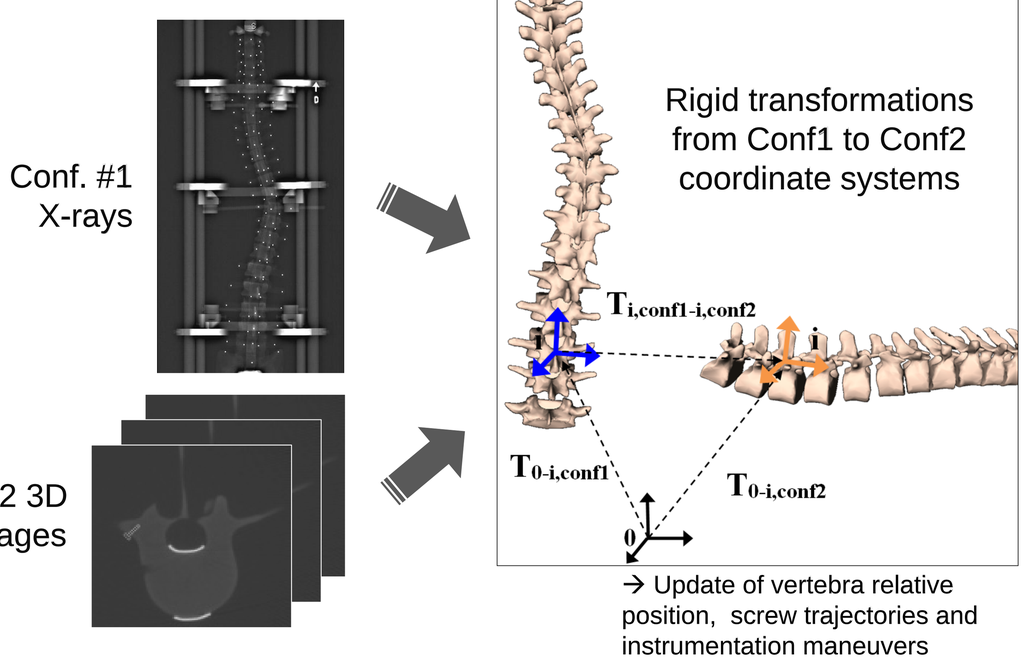
Prototype development and testing

- Synthetic model of a scoliotic spine
- Configuration #1
  - Preop standing posture
  - Biplanar radiographs
  - S3 simulation/planning
    1. Desired pedicle screw trajectories
    2. Correction maneuvers
    3. Resulting clinical indices (Cobb angles…)
- Configuration #2
  - Intraop prone positioning
  - Intraop 2D/3D fluoroscopic images

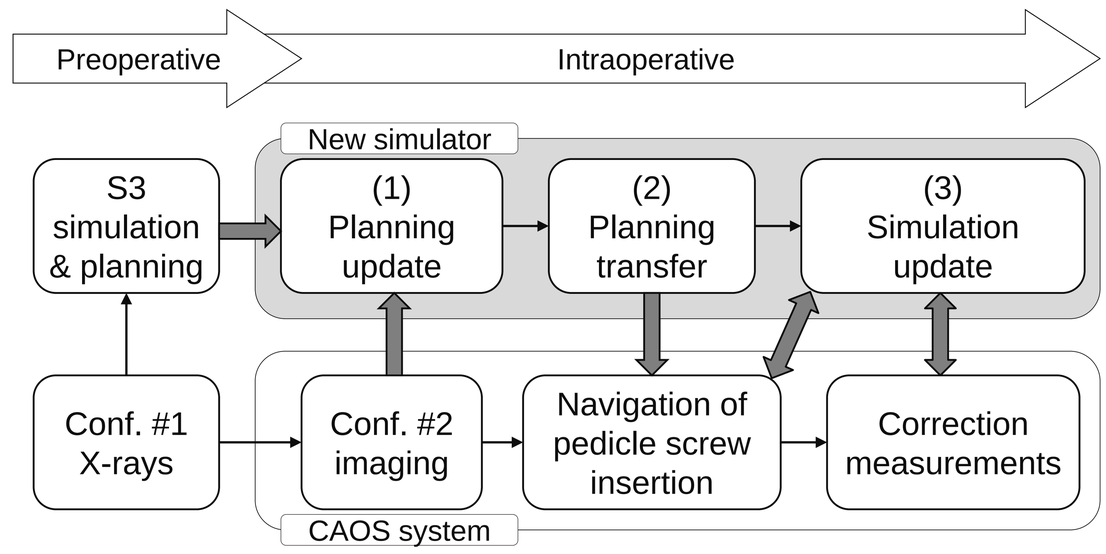
Conf. #1

Conf. #2

(1) Planning update

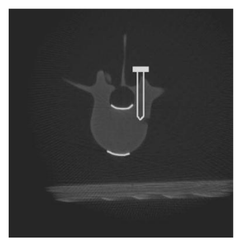


Workflow diagram

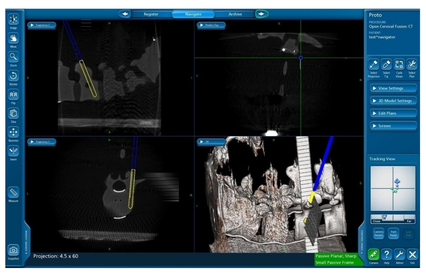


(2) Planning transfer

Conf. #2 fluoro images with updated screw trajectories



Optical navigation



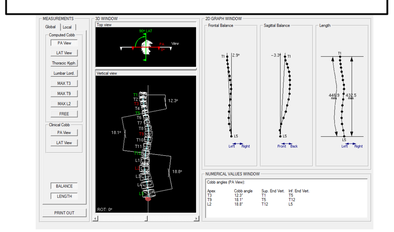
First results

(1) Planning update accuracy ~ 0.5 mm
(2) Planning transfer accuracy ~ 1 voxel
(3) Simulation update:

	Cobb angle	
	Pre-instrumentation	**Simulated instrumentation**
Conf. #1	34°	12°
Conf. #2	24°	12°

(3) Simulation update

Conf. #2 clinical indices and correction maneuvers



Preliminary conclusions and perspectives

- First results using a physical model:
  - Intraop data from CAOS systems can be used to update preop simulations/planning, account for changes occurring in the OR, and test other instrumentation strategies
    - These results have to be validated during real surgeries
  - The new intraop simulator may contribute to obtain real-time feedback during CAOS surgeries and optimize correction

References

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