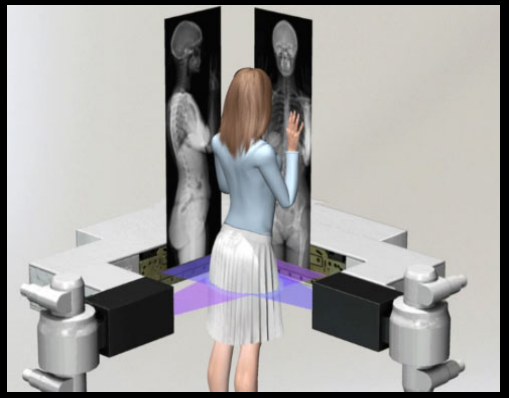
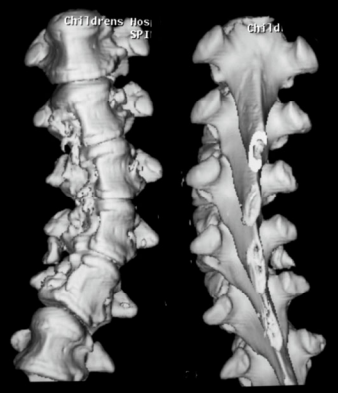
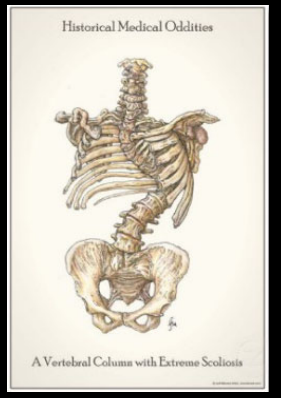
Low-Dose Digital Stereoradiography vs. Computed Tomography

Validation of 3D Reconstructions from digital Stereoradiography against Computed Tomography







Peter Newton, MD

Diana Glaser, PhD

Josh Doan, ME

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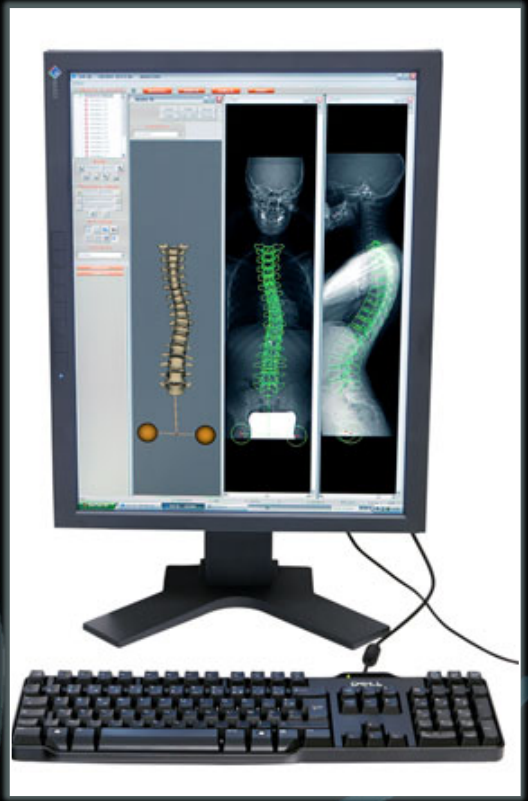
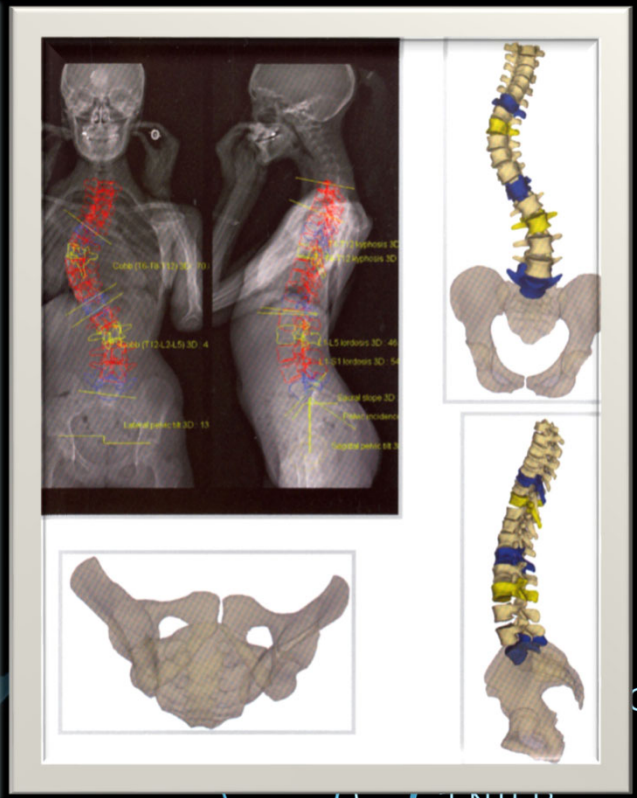
SLOTSCANNING BIPLANAR XRAYS

- Low dose radiation while weight bearing
- Software enables 3D reconstruction based on biplanar 2D radiographs

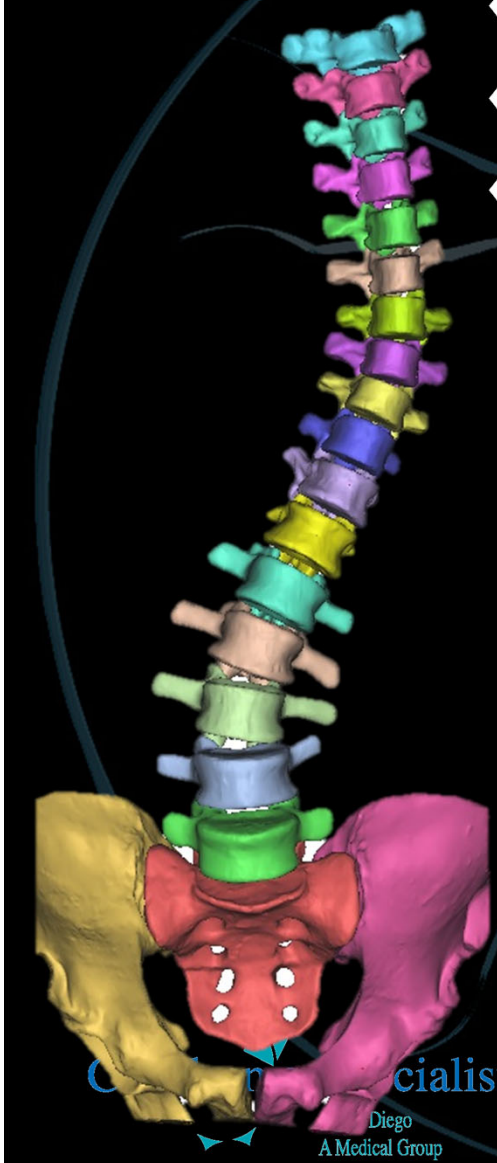




PURPOSE

- 3D spinal morphological analyses are rare
- 3D is critically important
- CT has high radiation

➔ Compare Low-Dose Digital Stereoradiography 3D Reconstructions to Computed Tomography (gold standard)



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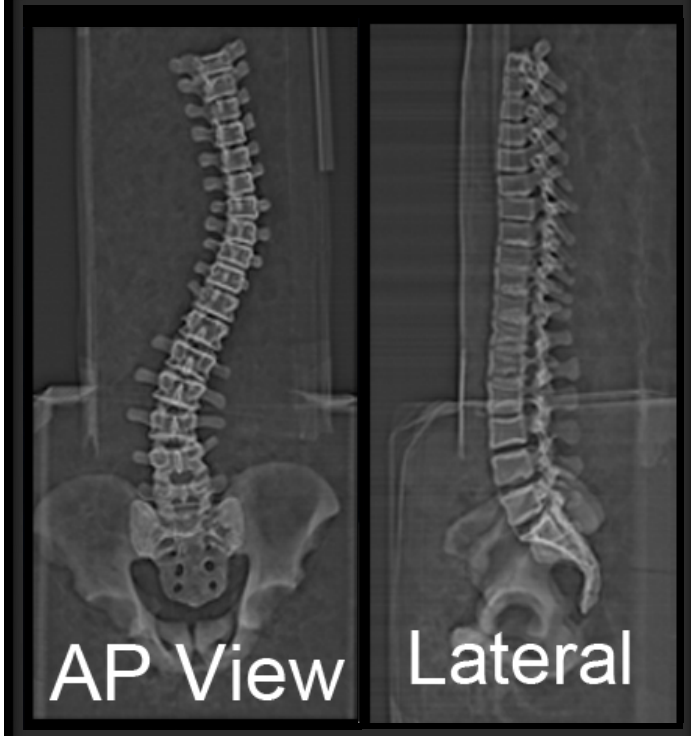
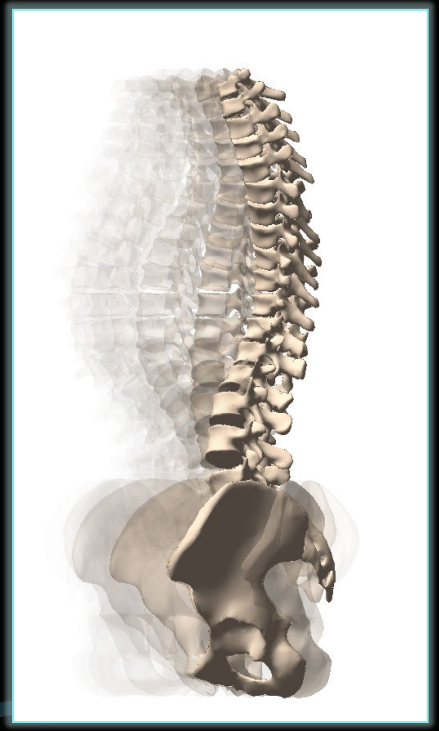
METHODS

3 Scoliotic Phantoms (Synthetic Spine Models)



CT (supine position)

Stereoradiography (upright position) in 0, ±5, ±10° axial rotation



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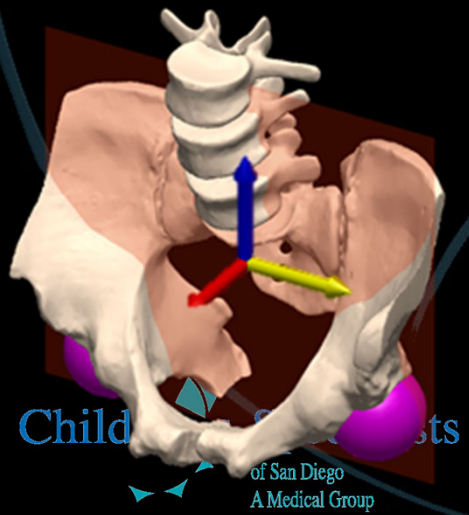
METHODS

3D CT → ***CT:*** Slice thickness 0.7mm, pixel size 0.5mm

3D CT: 4000 points per VB, average element size: 1mm^2

3D Stereoradiography → ***3D Stereoradiography :*** 2000 points per VB, average element size 3mm^2



Parameters to be analyzed:

Position Accuracy
Orientation Accuracy
Shape Accuracy
Radiographic Parameters

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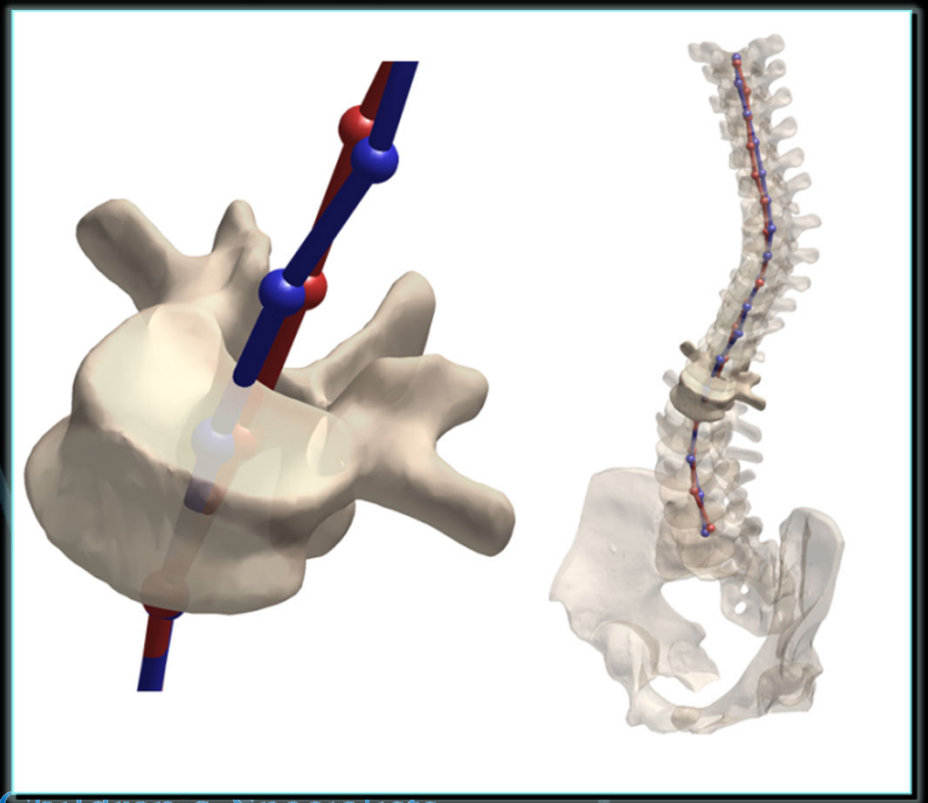
METHODS

Centroids mapped to identify differences

Red: CT centroids
Blue: Stereography centroids

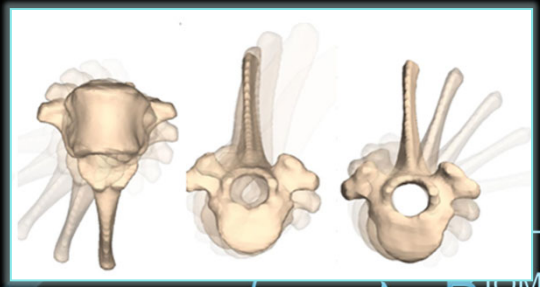


Position Accuracy

Offset (Translations)

Orientation Accuracy

Lateral–Sagittal–Axial (L–S–A) angles (Rotations)



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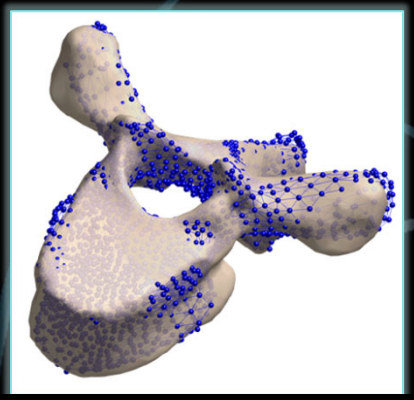
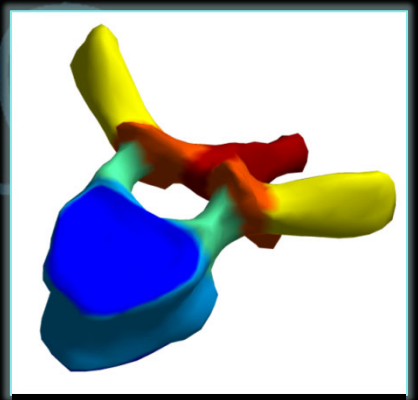
METHODS



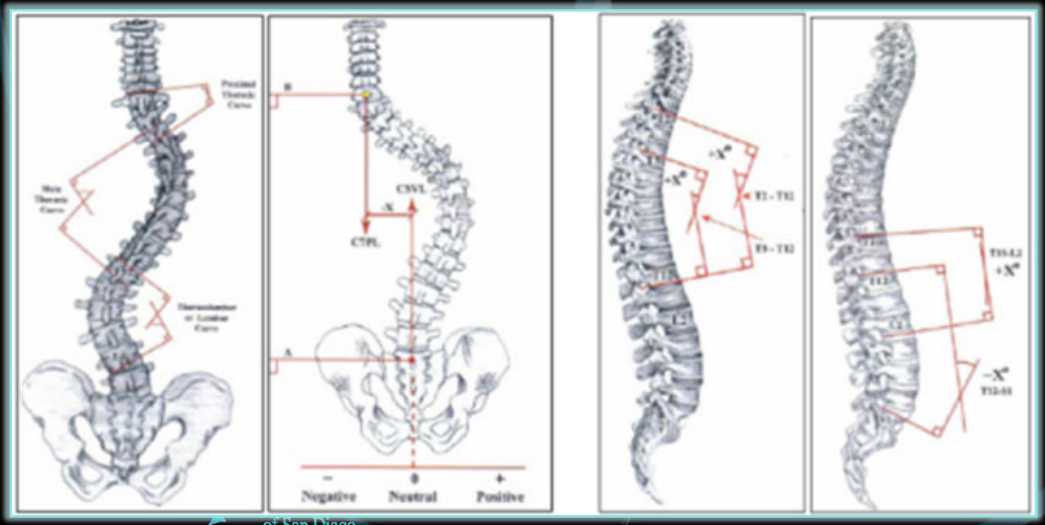
Tan shape: CT VB
Blue dots: Stereography VB



6 regions
compared per VB

Shape Accuracy

VB superposition of Stereoradiographic and CT models



Radiographic Parameters

- Pelvic incidence/ Pelvic tilt/Sacral slope
- Cobb angle (Scoliosis/ Kyphosis/Lordosis)
- Inter-vertebral and vertebral 3D rotations

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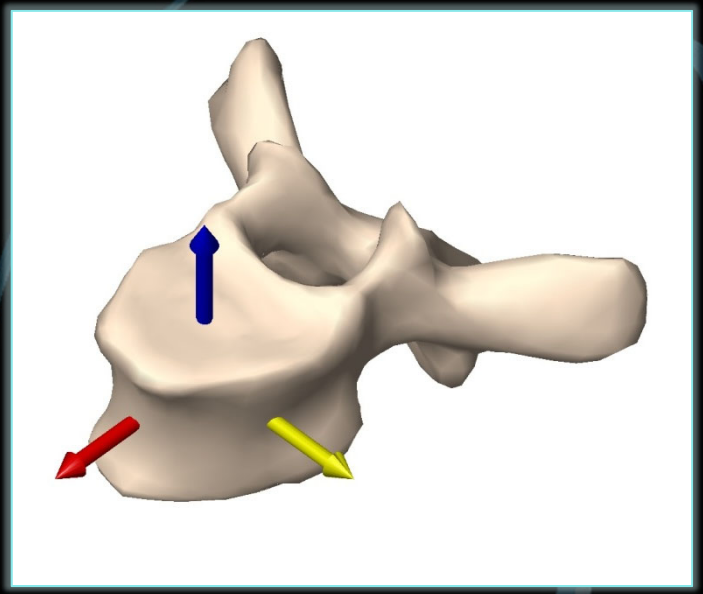
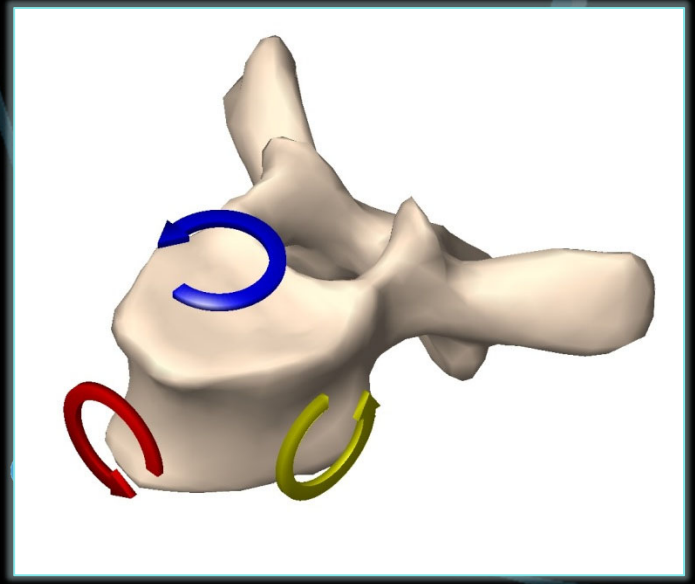
RESULTS: Position and Orientation





- **Accuracy is very high**

(all values reposted in RMS*/Absolute max)

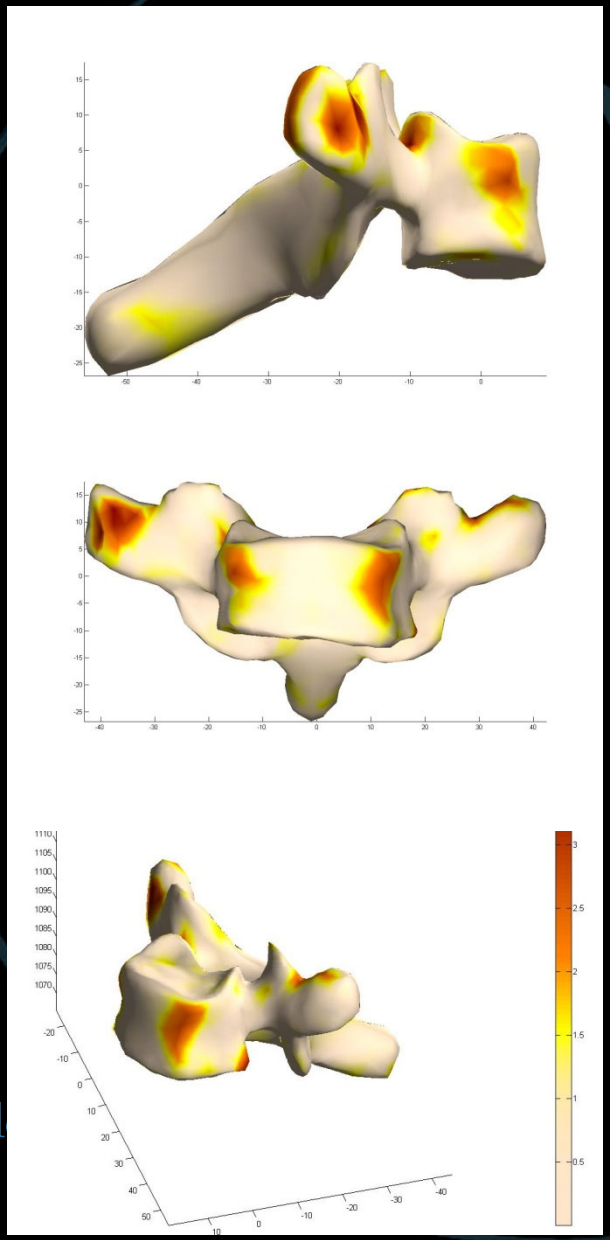
- Position (Translational differences):
  - AP: 0.87mm /2.71mm
  - LAT: 0.51mm/1.83mm
  - Axial: 0.89mm/3mm
- Orientation (Rotational differences):
  - AP: 0.76° / 4.2°
  - LAT: 1.81° /3.4°
  - Axial: 1.91° /5.8°

---

* RMS (root mean square) is quadratic mean, a statistical measure of the magnitude of the variation (error).

$$RMS = \sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2}$$

RESULTS: Shape Accuracy



- Mean Stereography shape accuracy: 1.05 ± 0.21mm (max 1.56 mm)
- VB, pedicles and posterior arch were equally well reconstructed

Differences in shape between both models are shown in color (yellow to red)

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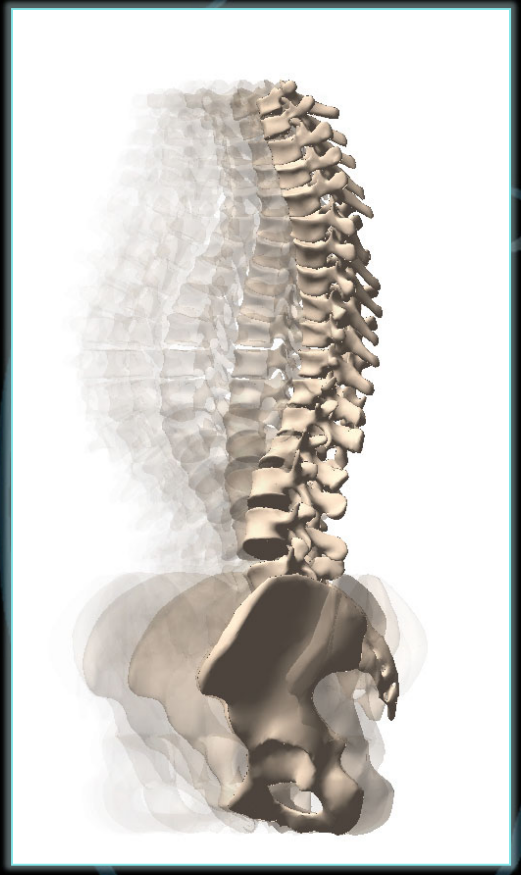
RESULTS: Phantom Rotation



CT vs. Stereoradiography
in 0, ±5, ±10° axial rotation

- ***Phantom rotation has no influence on reconstruction accuracy***
- No statistical difference in all analyzed parameters ($p>0.05$)
  - T-Spine or L-Spine shape (mm)
  - Sagittal/Lateral/Axial offset (mm)
  - Sagittal/Lateral/Axial rotation (°)

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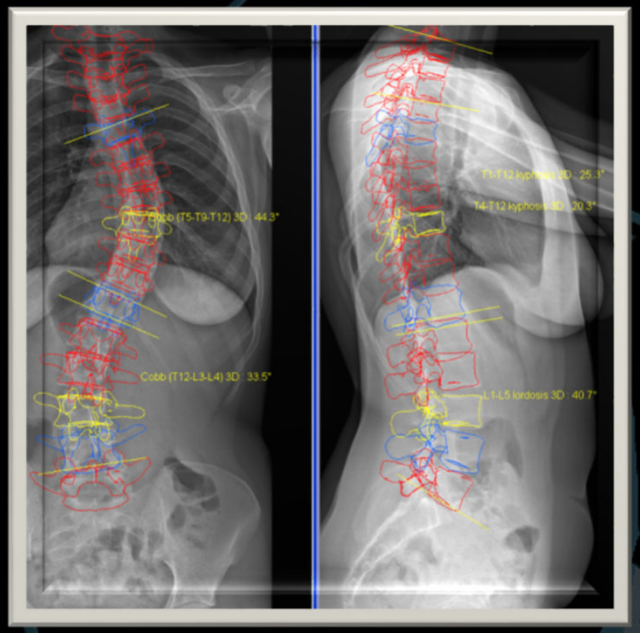
RESULTS: Radiographic Parameters



- Pelvic Parameters: very good accuracy
  < *1° mean* difference (***max 3°***)
- Scoliosis Parameters:
  Good accuracy for **Cobb**
  (***mean 2°/max 3.6°***) and
  axial rotation of apical vertebra
  (***mean 1.5°/max 3.8°***)
- Sagittal balance:
  Good accuracy
  Kyphosis ***1° to 4.9°***

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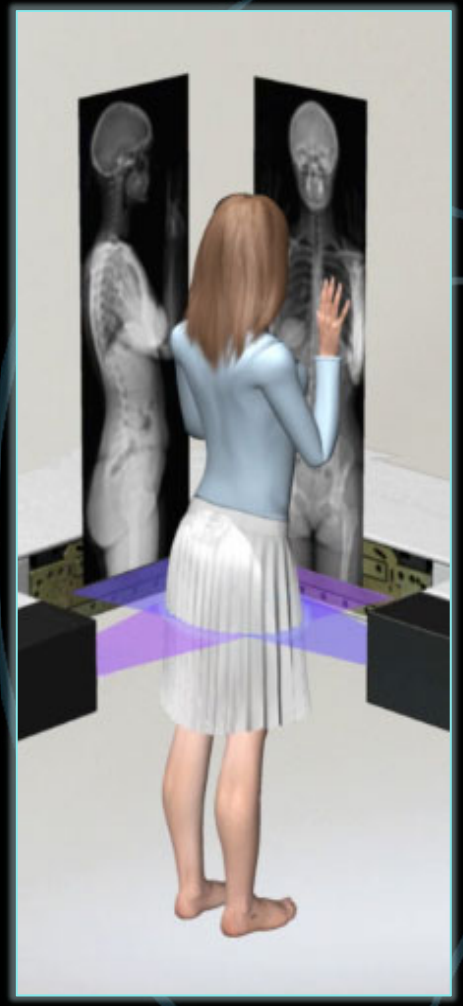
DISCUSSION



- *3D from biplanar X-Ray is accurate*
- *Low radiation alternative* for acquiring 3D scoliosis data
- Hope for greater understanding of the deformity of the spine… **better future outcomes**.

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