



UMC Utrecht



11th International
Congress on Early
Onset Scoliosis (ICEOS)

November 16 & 17, 2017
Hotel Del Coronado • San Diego, CA, USA

11th International Congress on Early Onset Scoliosis (ICEOS)
November 16-17, 2017

Use of 3D Technology in Assessment and Treatment of EOS

René M. Castelein, MD PhD

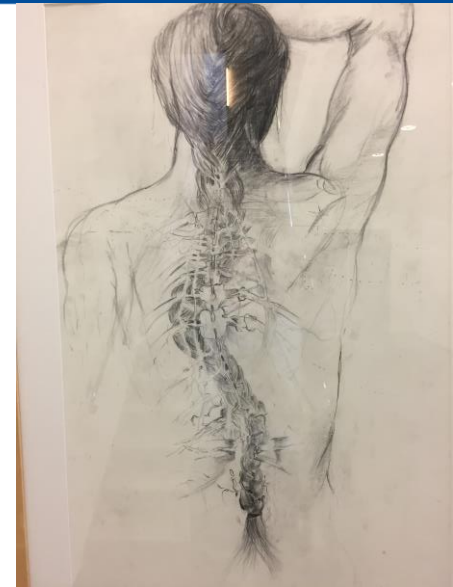
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Disclosures

- K2M Research Grant
- AO Research Grant
- Alexandre Suermann MD-PhD stipend
- Fondation Yves Cotrel Grant 2006 and 2017



Outline:

- Example
- 3D in detail
- How to acquire 3D



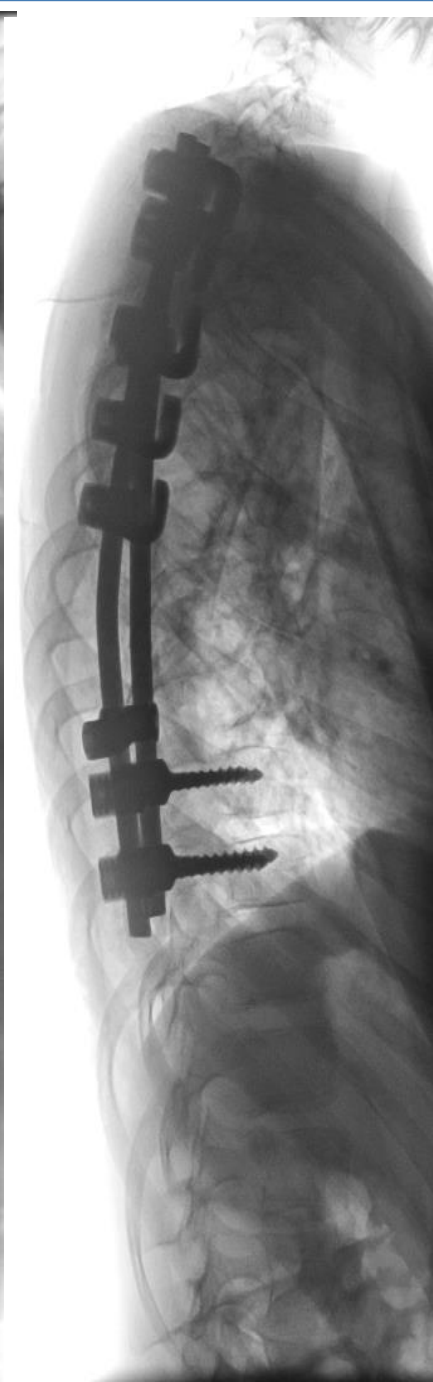
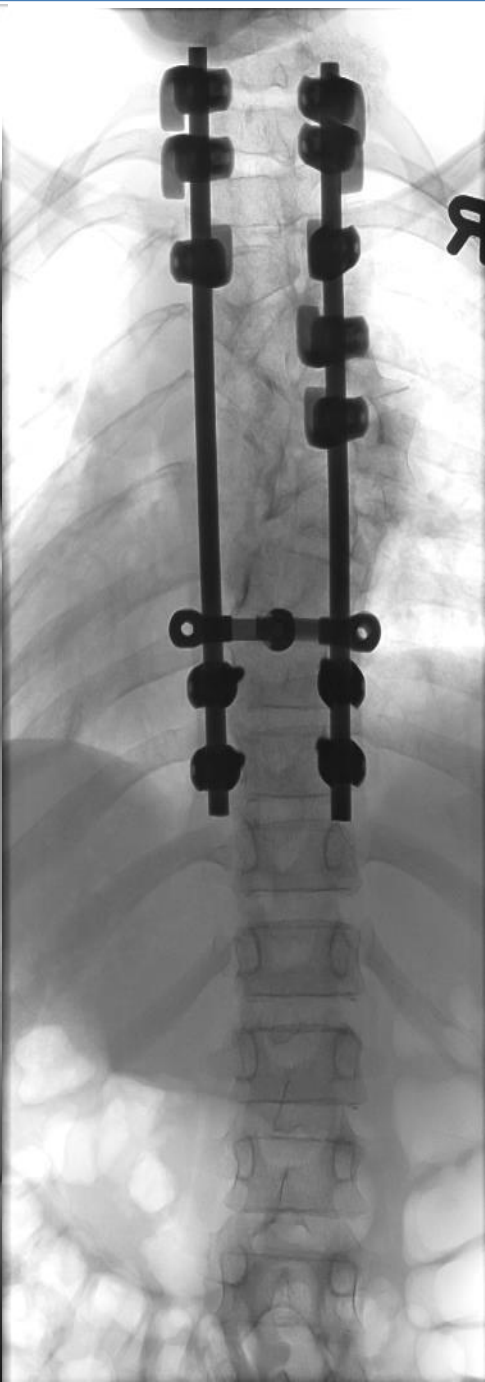
Let's start with a cool example of 3D



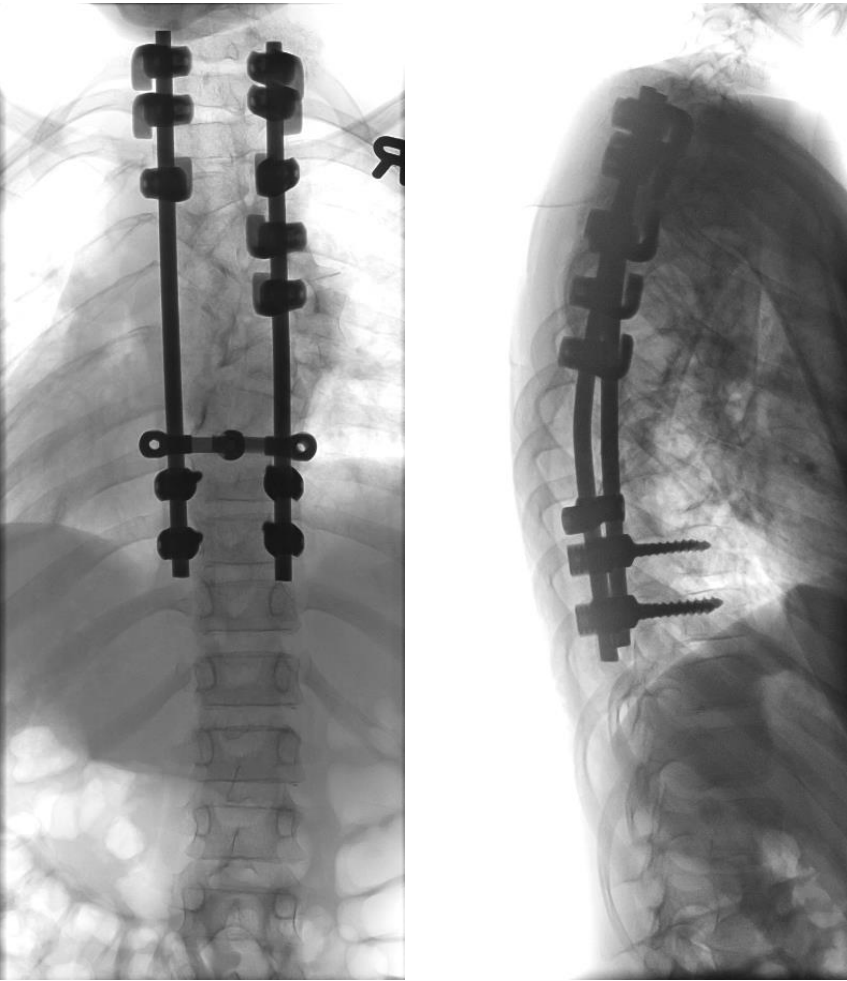
start with a coc

3D





February 2012



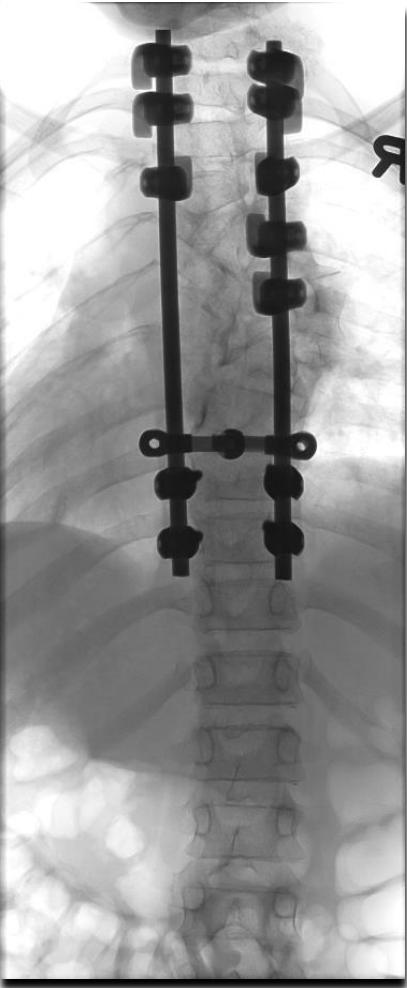
– February 2016



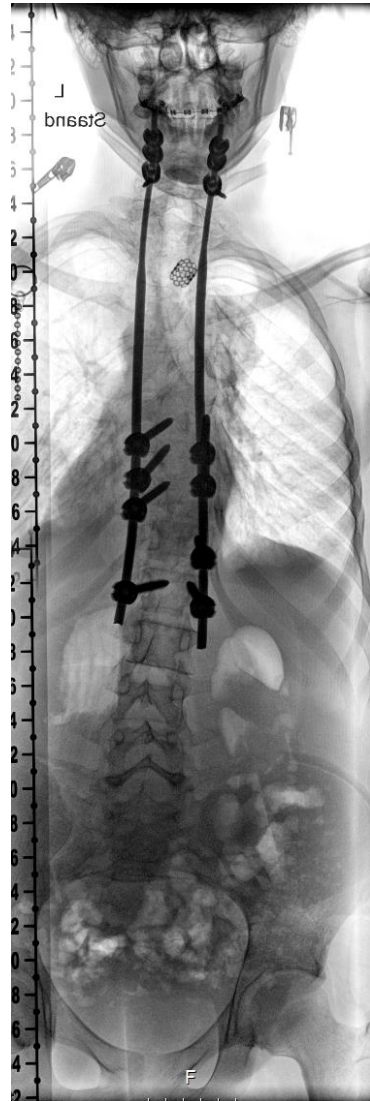
February 2012

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February 2016



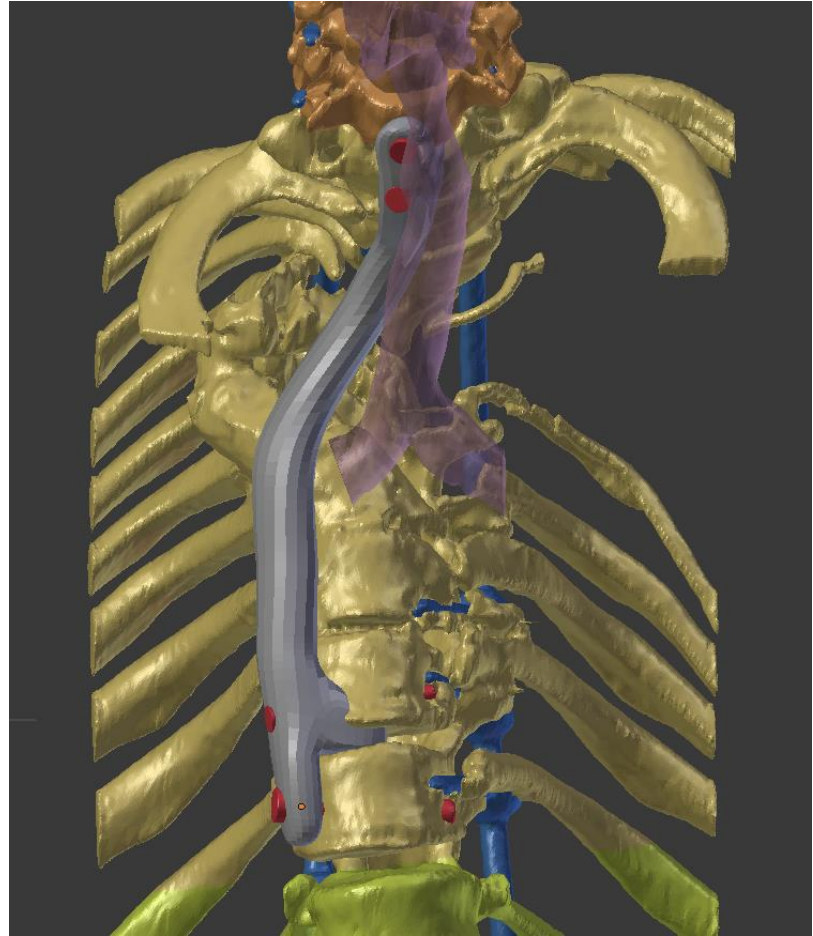
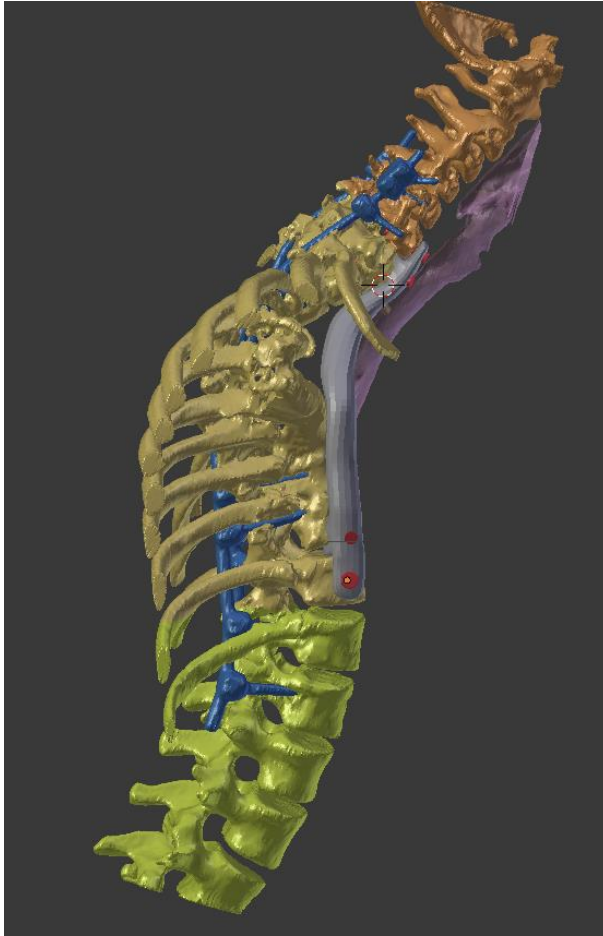
After 2nd operation: December 9th 2016



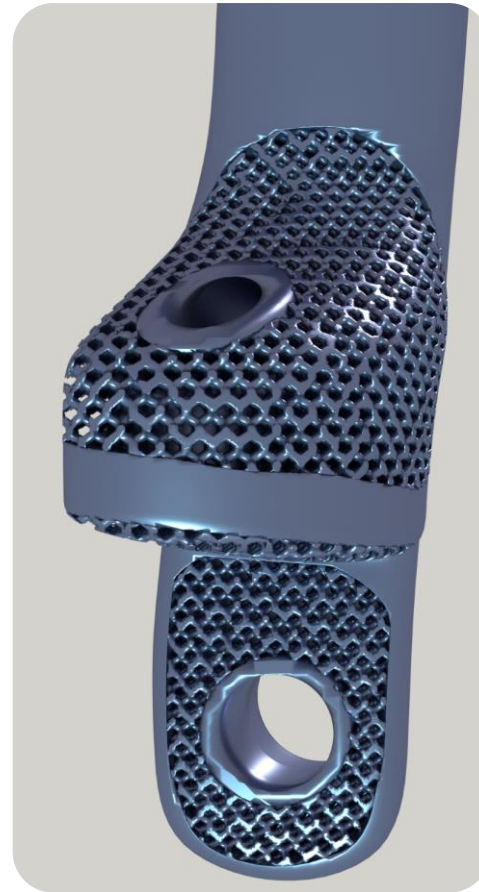
February 1st 2017: Lack of anterior support



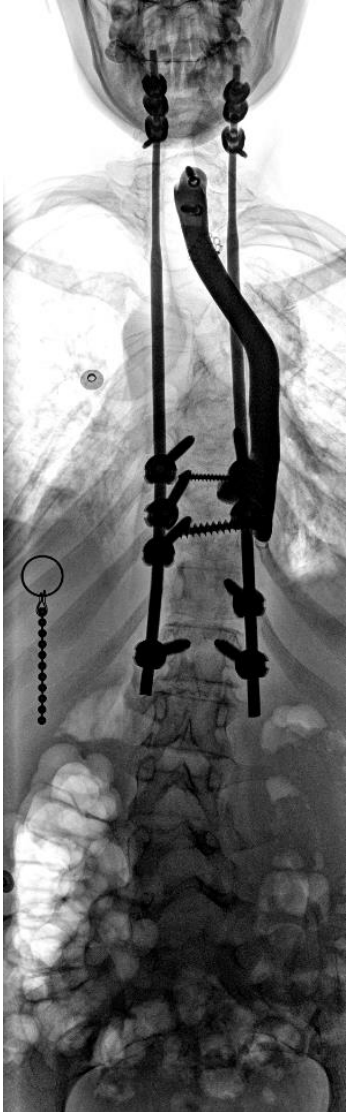
Planning



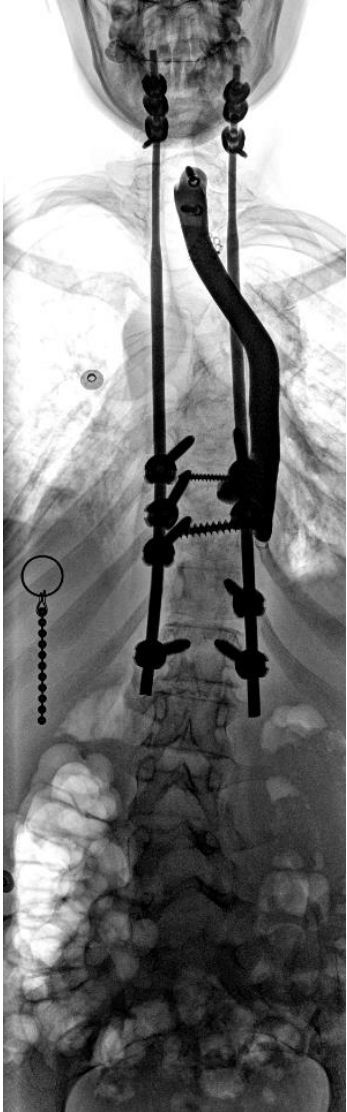
3D printing



Postoperative June 2017



Postoperative June 2017



How new is 3D?



How new is 3D?

Die Mechanik der Skoliose.

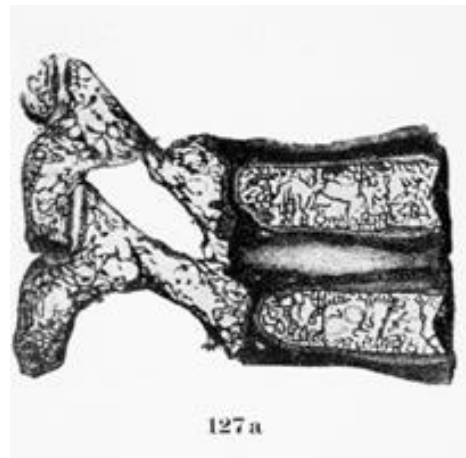
Ein Beitrag zur Lehre von den Missgestaltungen des Knochengengerüsts.

Von Prof. G. Hermann Meyer in Zürich.

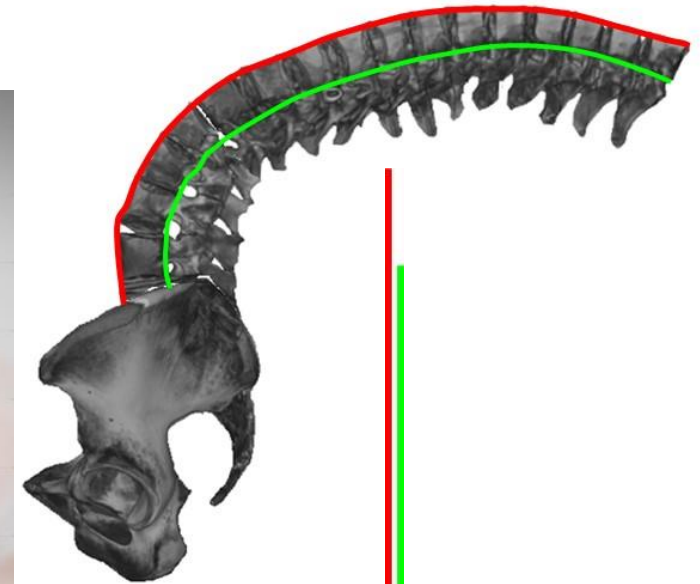


THE BASIC ANATOMY OF SCOLIOSIS

ROBERT ROAF, LIVERPOOL, ENGLAND



Now: What about this Relative Anterior Overgrowth (RASO)?



Anterior : Posterior

1.16 : 1



2000 Porter:

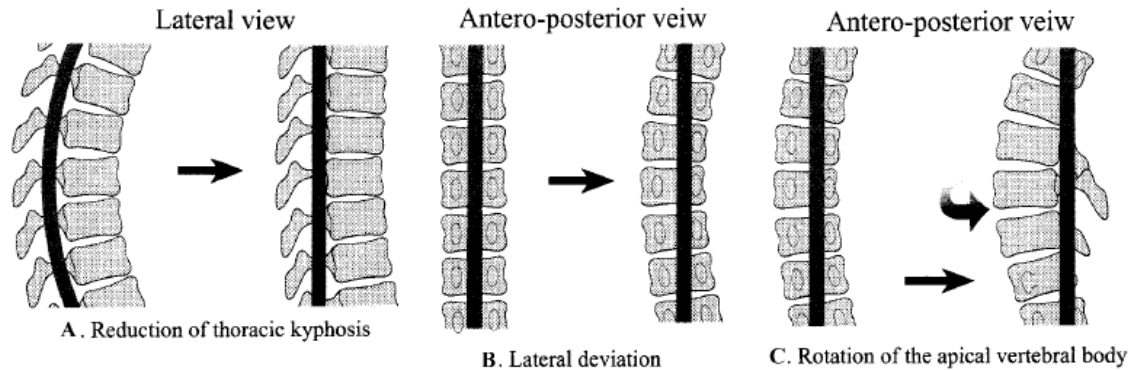
Idiopathic Scoliosis

SPINE Volume 25, Number 11, pp 1360–1366
©2000, Lippincott Williams & Wilkins, Inc.

The Relation Between the Vertebral Canal and the Vertebral Bodies

Richard W. Porter, FRCS

- The results of this study are consistent with a conceivable hypothesis that in some patients with idiopathic scoliosis, there may be impaired growth in the length of the spinal cord.



Eur Spine J (2001) 10:473–481
DOI 10.1007/s005860100311

REVIEW

The pathogenesis of idiopathic scoliosis: uncoupled neuro-osseous growth?

Richard W. Porter

2001 Porter:



These observations do not establish that a short spinal cord will result in scoliosis, but the results are compatible with this hypothesis, and that impairment of spinal cord growth factors may sometimes be responsible for scoliosis.

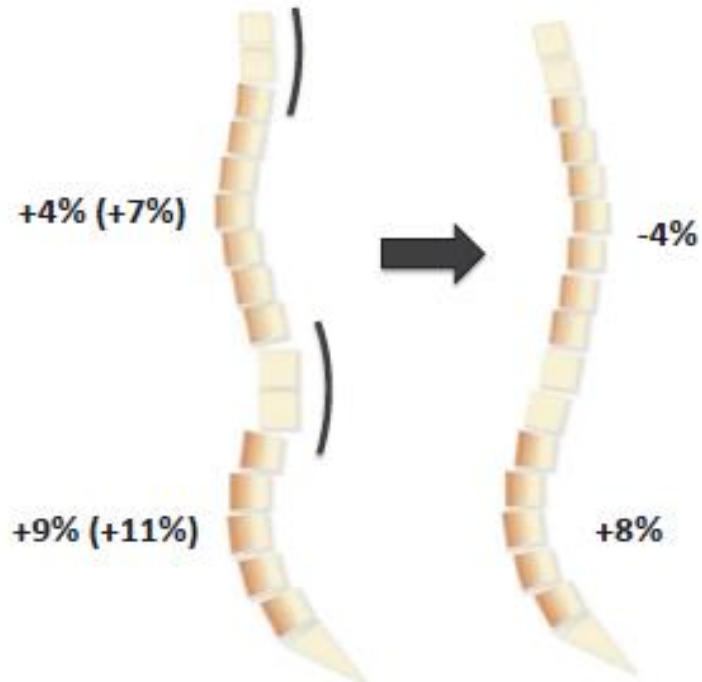
+7.1%

1.0 ± 2.7%

+11.2%



Thoracic lordosis



Disc versus vertebra: 'Anterior-overgrowth'

Main thoracic curve

+3,9% anterior overgrowth

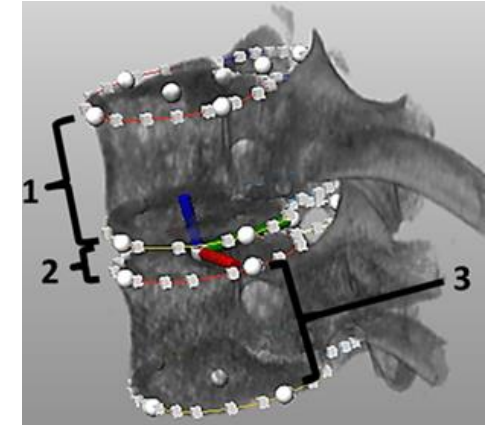
Vertebrae

+2,6%

Discs

+9,8%

$P < .001$



(Thoraco)lumbar curve

+9,4%

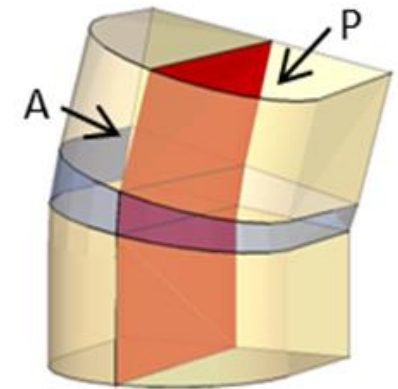
Vertebrae

+3,1%

Discs

+35%

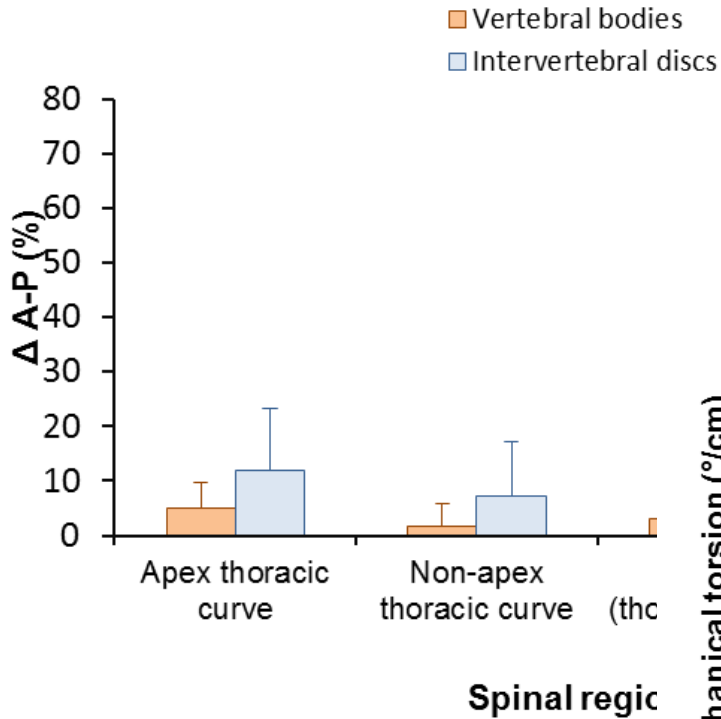
$P < .001$



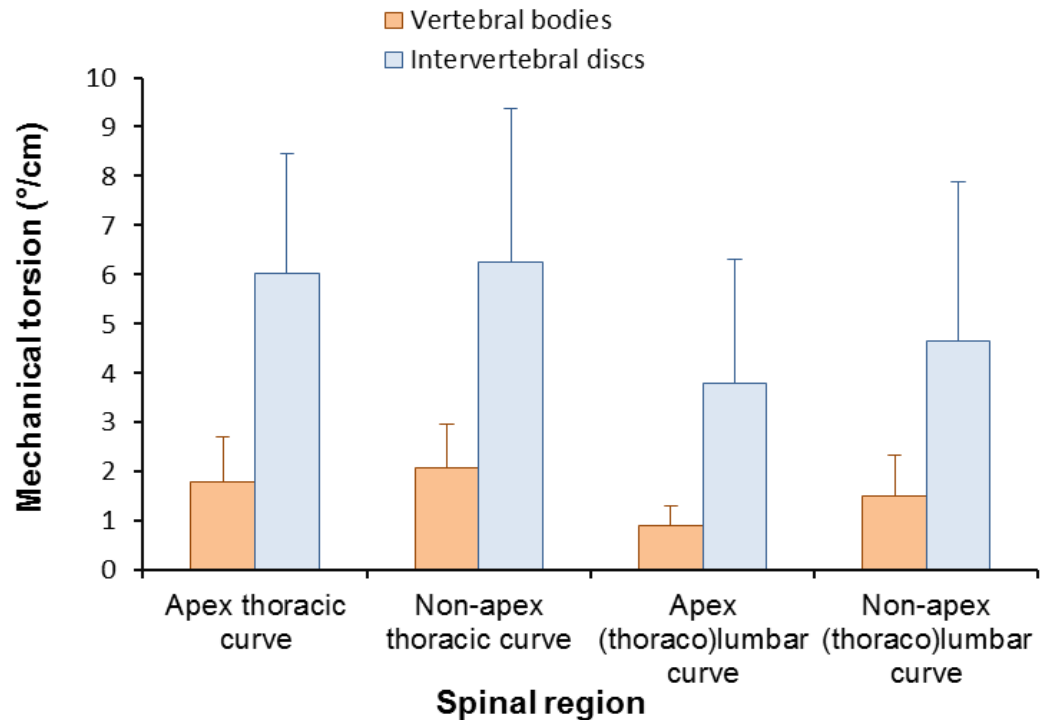
Anterior-posterior
length difference
($\Delta A-P$)

3-D deformity is most in the disc in all regions of the spine!

Anterior-posterior length difference ($\Delta A-P$)



Mechanical torsion



Anterior “overgrowth” specific for idiopathic scoliosis, or secondary to the scoliotic deformity?

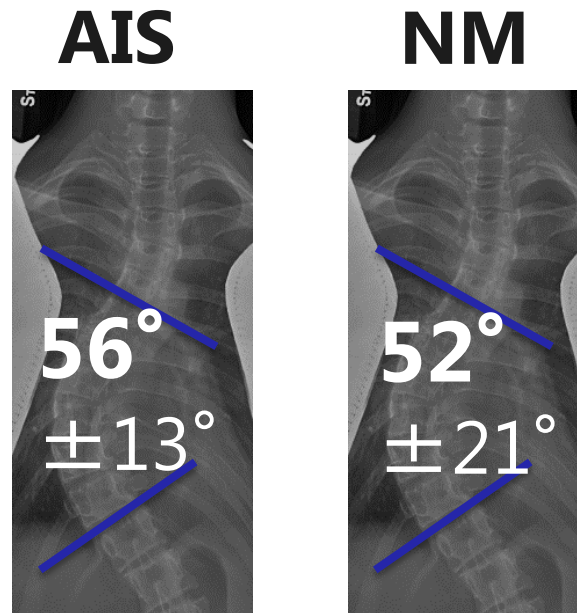
Anterior Spinal Overgrowth Is the Result of the Scoliotic Mechanism and Is Located in the Disc

Rob C. Brink, MD,* Tom P.C. Schlösser, MD, PhD,* Dino Colo, MD,* Ludvig Vavruch, MD,†
Marijn van Stralen, PhD,‡ Koen L. Vincken, PhD,§ Marcus Malmqvist, BSc,† Moyo C. Kruyt, MD, PhD,*
Hans Tropp, MD, PhD,† and René M. Castelein, MD, PhD*

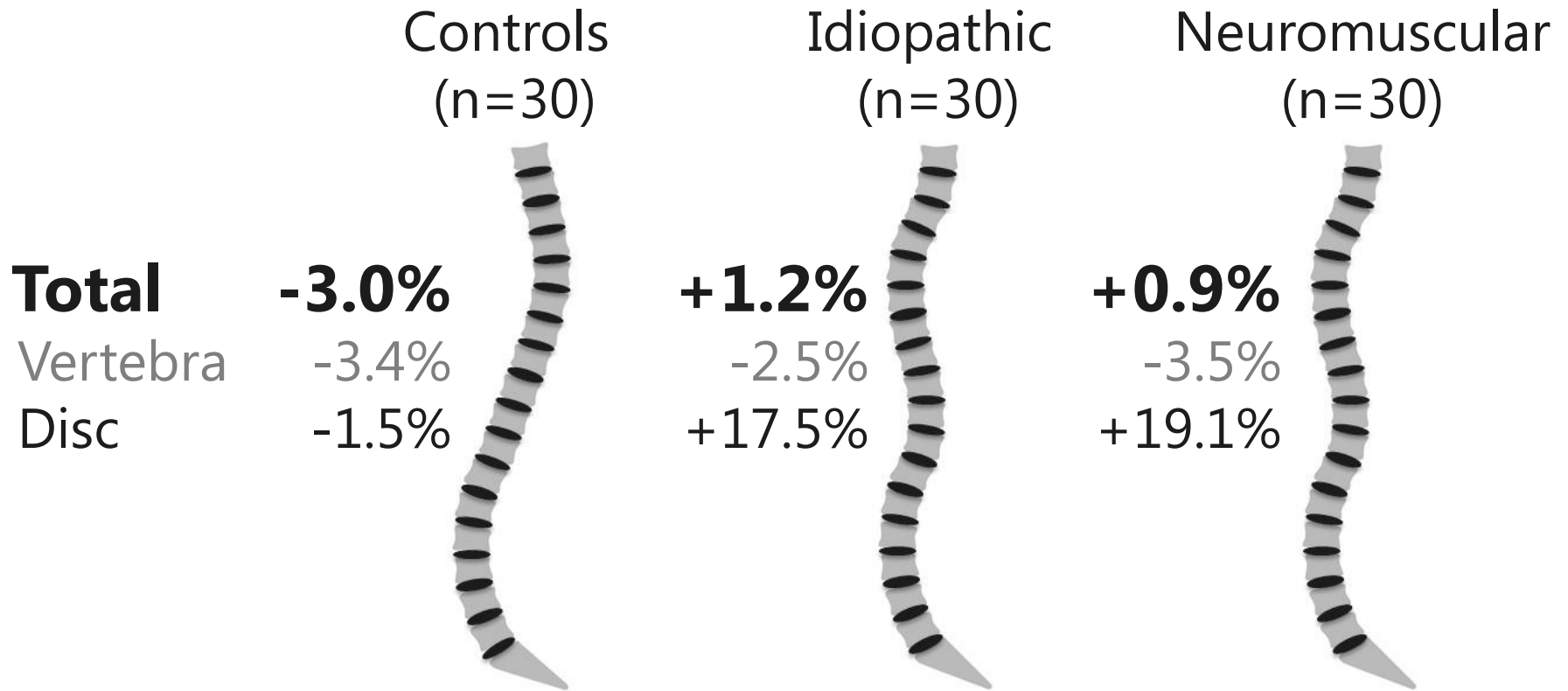
CT scans of:

- 30 NM patients
- 30 AIS patients
- 30 Non-scoliotic controls

10-18 years of age



Thoracic lordosis in idiopathic and neuromuscular scoliosis



Congenital scoliosis?



Thoracic lordosis in idiopathic, neuromuscular and congenital scoliosis

Controls

-3.0%



AIS

+1.2%



NM

+0.9%

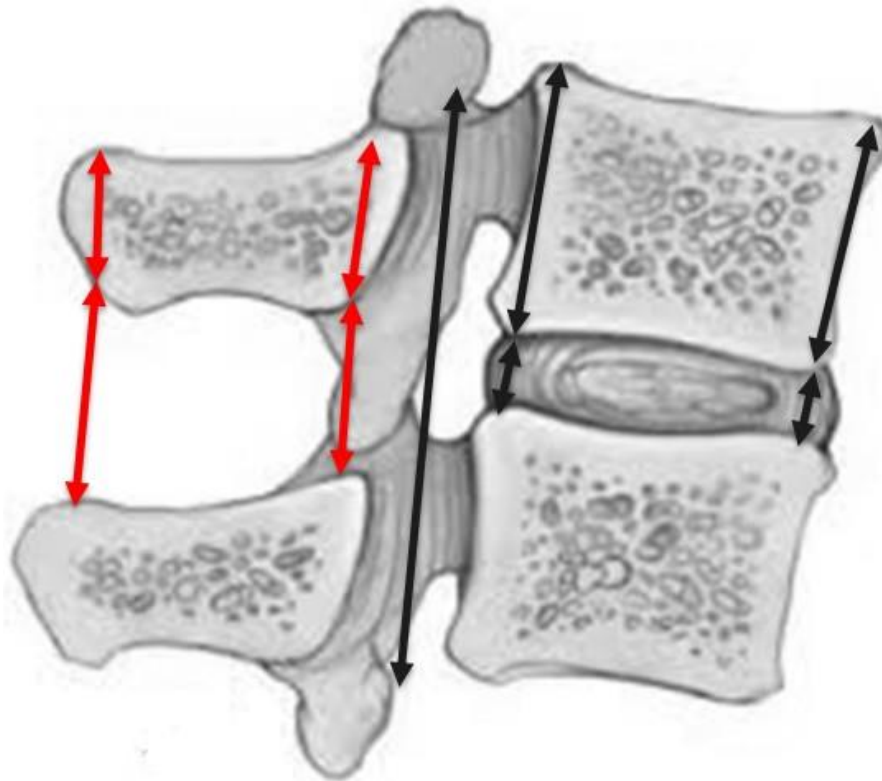


Congenital

+1.1%

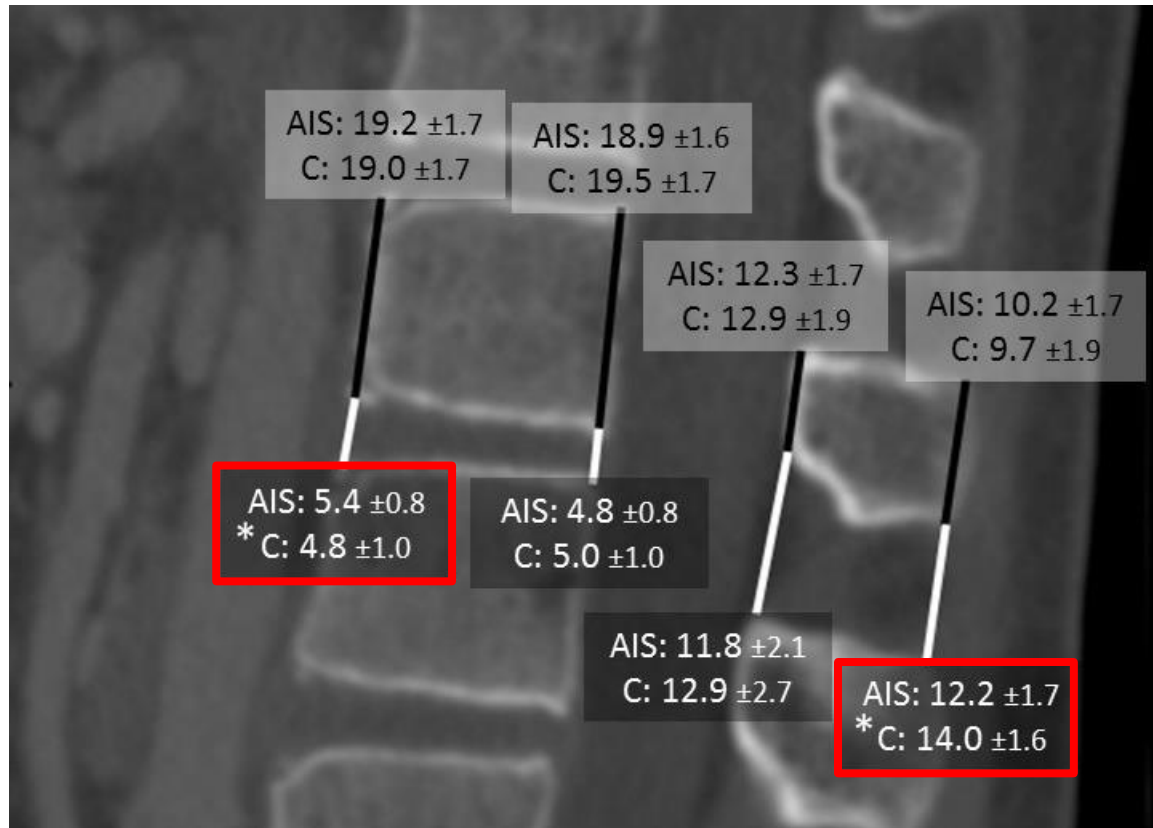


Relative anterior lengthening or relative posterior shortening?



3D semi-automatic measurements (CT scans)

Absolute heights (mm): AIS (n=80) vs matched controls (n=30)



* = significant difference between AIS and controls.

So:

- No discussion if RASO exists, all scoliosis are *lordotic* (not hypokyphotic)
- RASO is not a generalized phenomenon, it is restricted to the apex of the curve
- It is not active growth, it is passive expansion of the disc and compression of the interspinous space
- It is part of any scoliotic mechanism, idiopathic, neuromuscular, compensatory congenital
- It is not the *cause* of scoliosis, it is its *consequence!*



How to acquire 3D

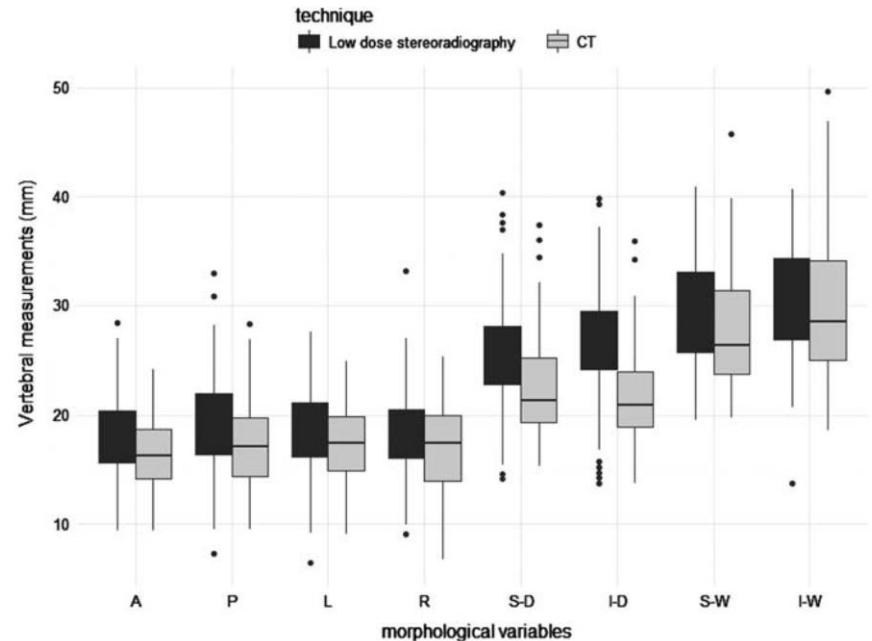
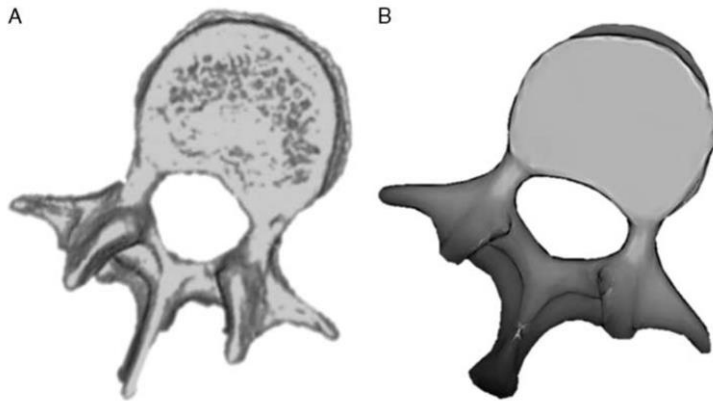
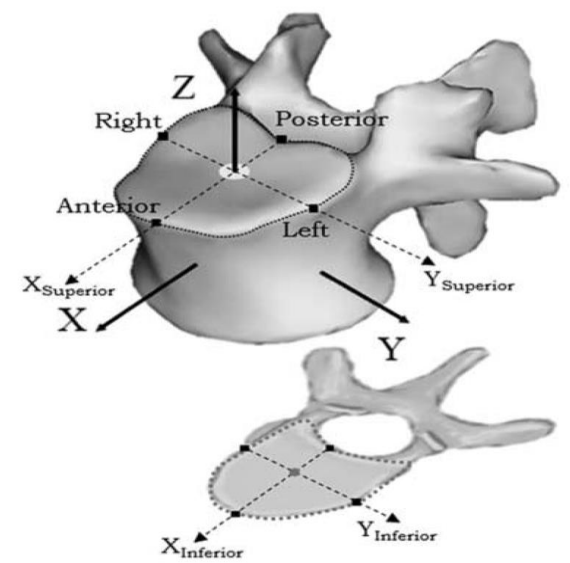
- CT(gold standard)
- EOS
- Ultrasound



Application of Low-dose Stereoradiography in In Vivo Vertebral Morphologic Measurements: Comparison With Computed Tomography

Saba Pasha, PhD,* Tom Schlösser, MD, PhD,† Xiaowei Zhu, PhD,‡ Xochitl Mellor, BS,* René Castelein, MD, PhD,† and John Flynn, MD*

J Pediatr Orthop • Volume 00, Number 00, ■ ■ 2017



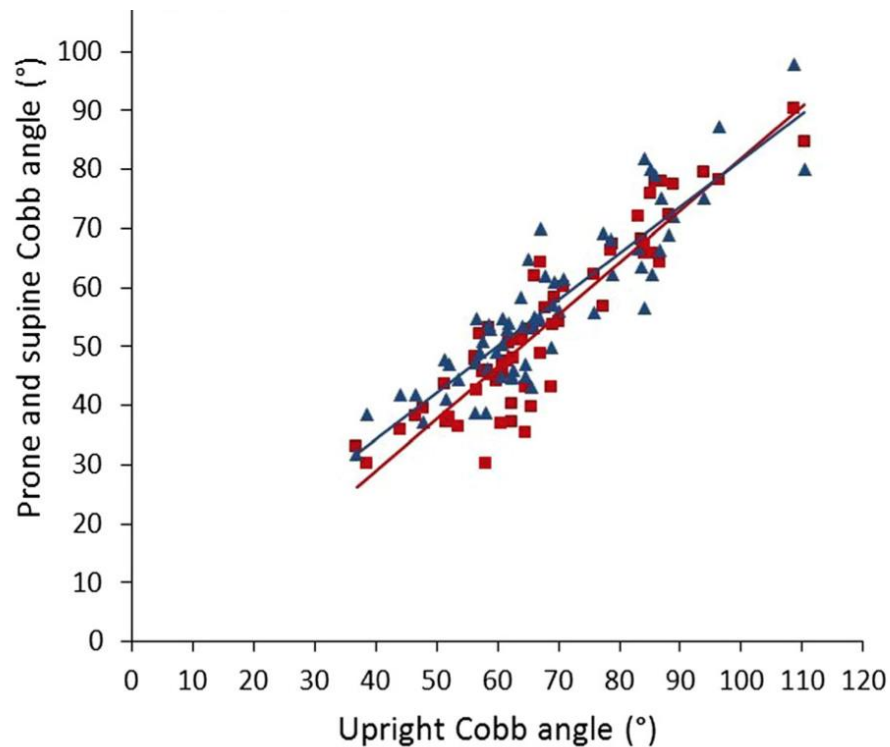
RESEARCH

Open Access



Upright, prone, and supine spinal morphology and alignment in adolescent idiopathic scoliosis

Rob C. Brink^{1*}, Dino Colo¹, Tom P. C. Schlösser¹, Koen L. Vincken², Marijn van Stralen³, Steve C. N. Hui⁴, Lin Shi⁵, Winnie C. W. Chu⁴, Jack C. Y. Cheng⁶ and René M. Castelein¹



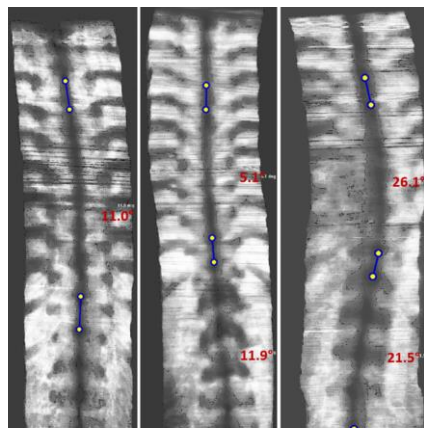
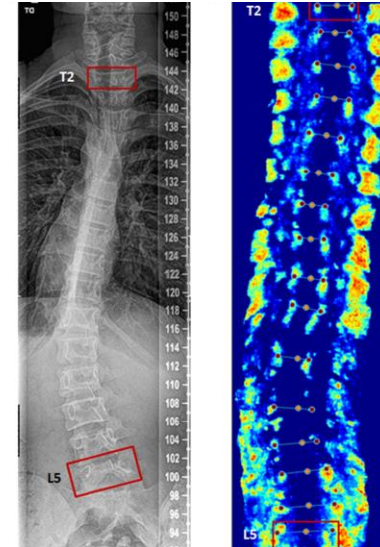
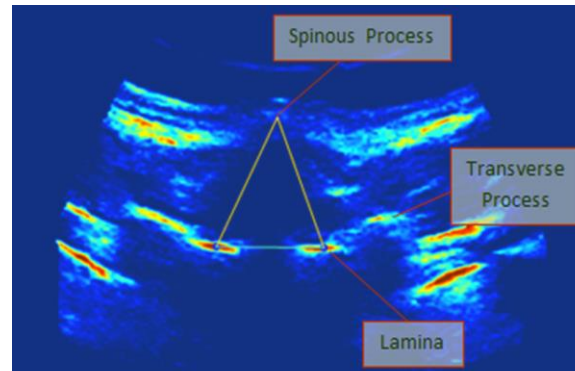
Several valid and reliable ultrasound angles

ORIGINAL ARTICLE

Eur Spine J (2015)

Reliability and accuracy of ultrasound measurements with and without the aid of previous radiographs in adolescent idiopathic scoliosis (AIS)

Michelle Young · Douglas L. Hill · Rui Zheng · Edmond Lou



RESEARCH

Open Access

A reliability and validity study for Scolioscan: a radiation-free scoliosis assessment system using 3D ultrasound imaging

Zheng *et al.* *Scoliosis and Spinal Disorders* (2016)

the lifetime solid cancer incidence increases at a rate of 1.4% and 2.4% for men and women, respectively.

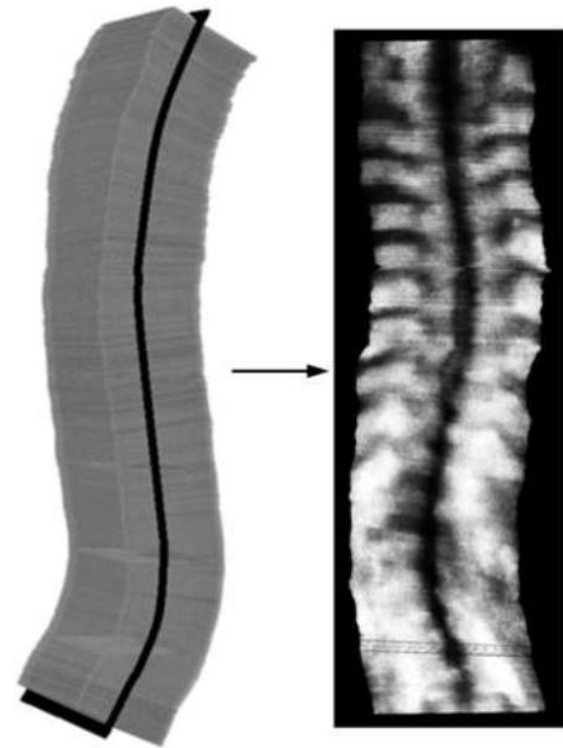


Scolioscan

Telefield Medical Imaging Ltd, Hong Kong



2000 transverse images
Scan speed: 1 cm/sec



Raw images in 3-D space

2-D projection image

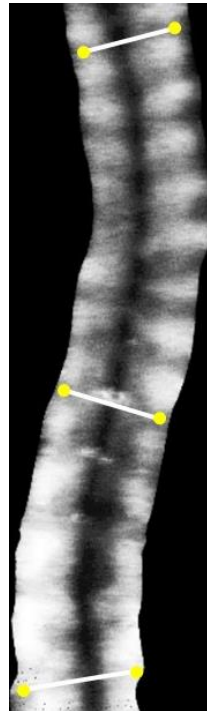


Methods – X-ray vs. Ultrasound

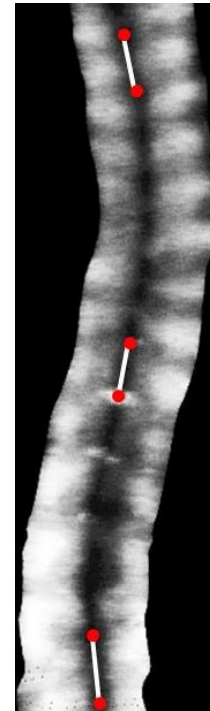
Cobb
X-ray



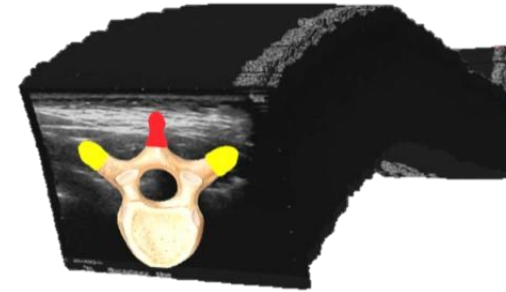
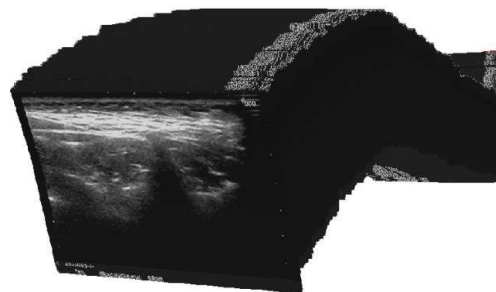
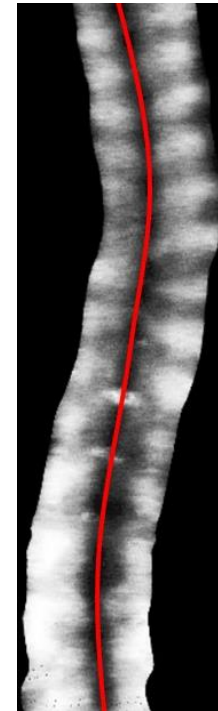
Manual
TP angle



Manual
SP angle

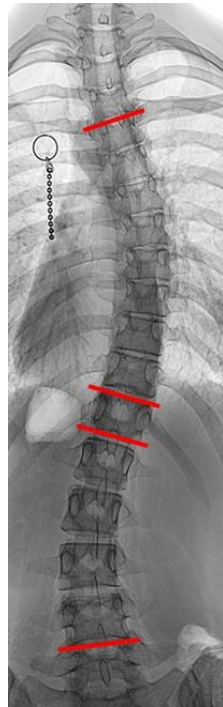


Automatic
SP angle

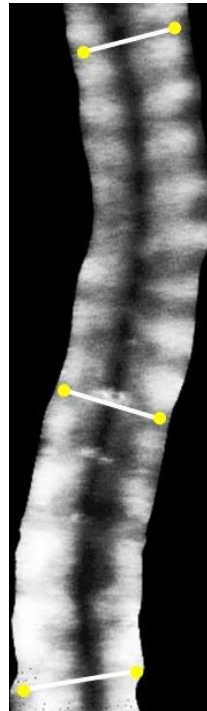


Results

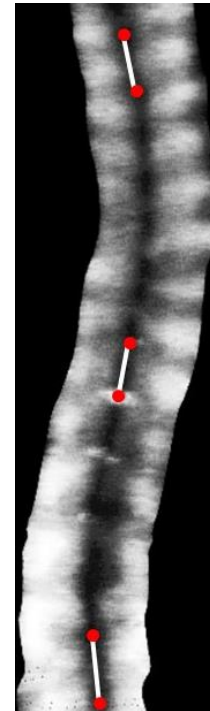
Cobb
X-ray



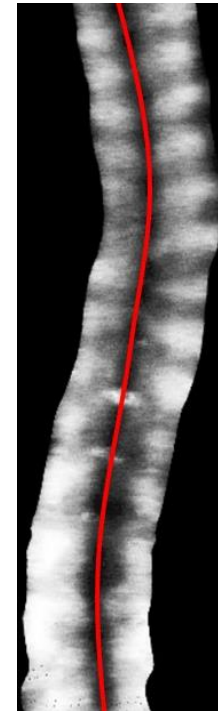
Manual
TP angle



Manual
SP angle



Automatic
SP angle



Thoracic
Lumbar

$38 \pm 20^\circ$
 $29 \pm 11^\circ$

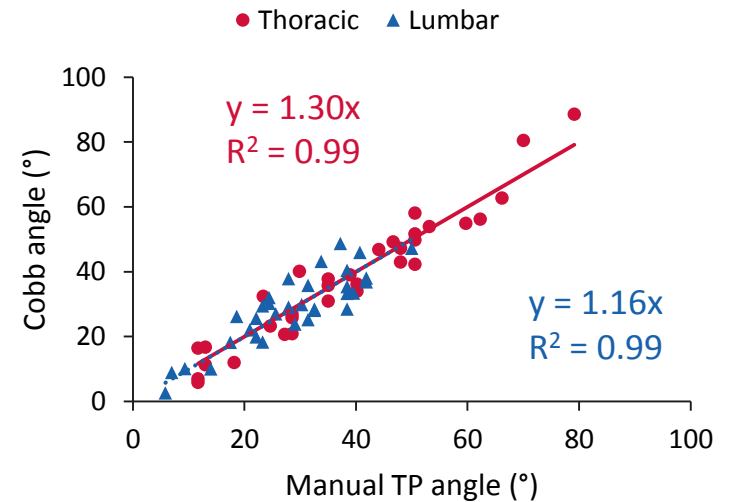
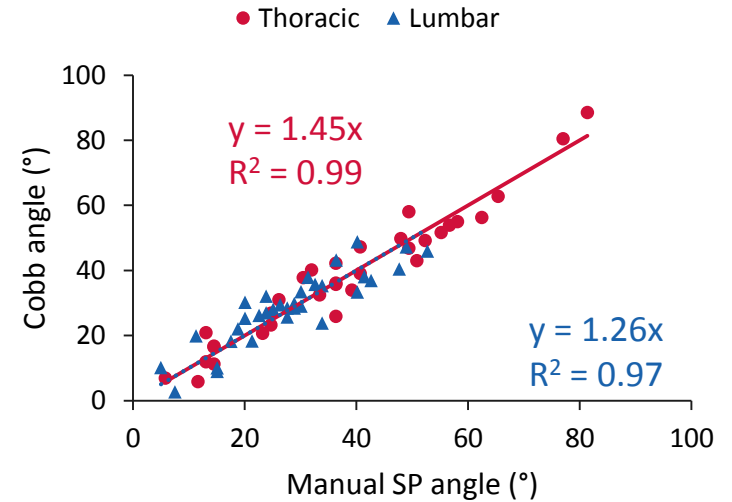
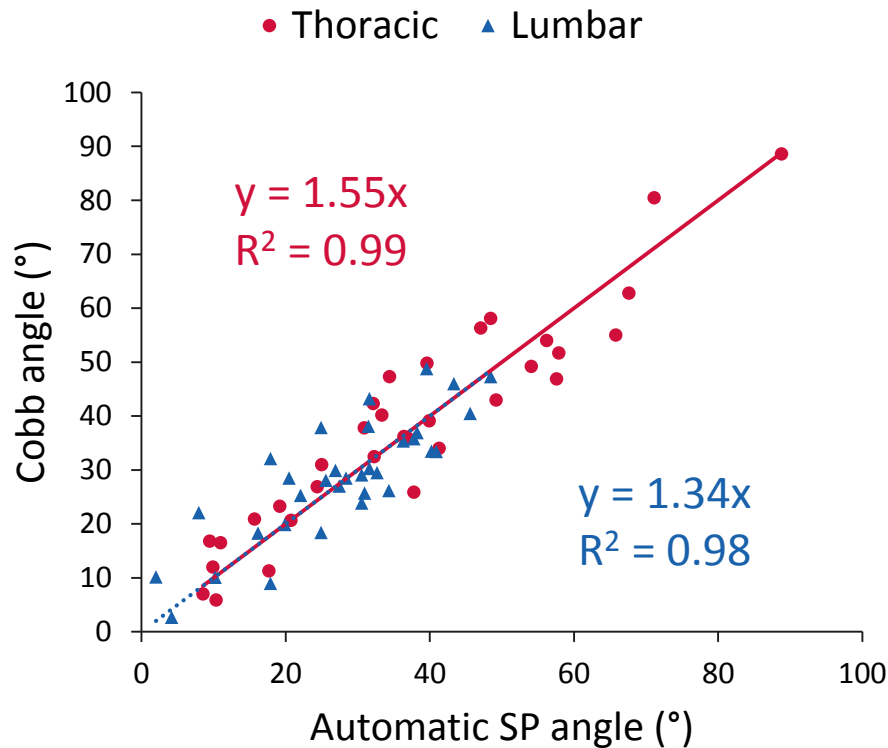
$24 \pm 14^\circ$
 $21 \pm 9^\circ$

$26 \pm 13^\circ$
 $22 \pm 10^\circ$

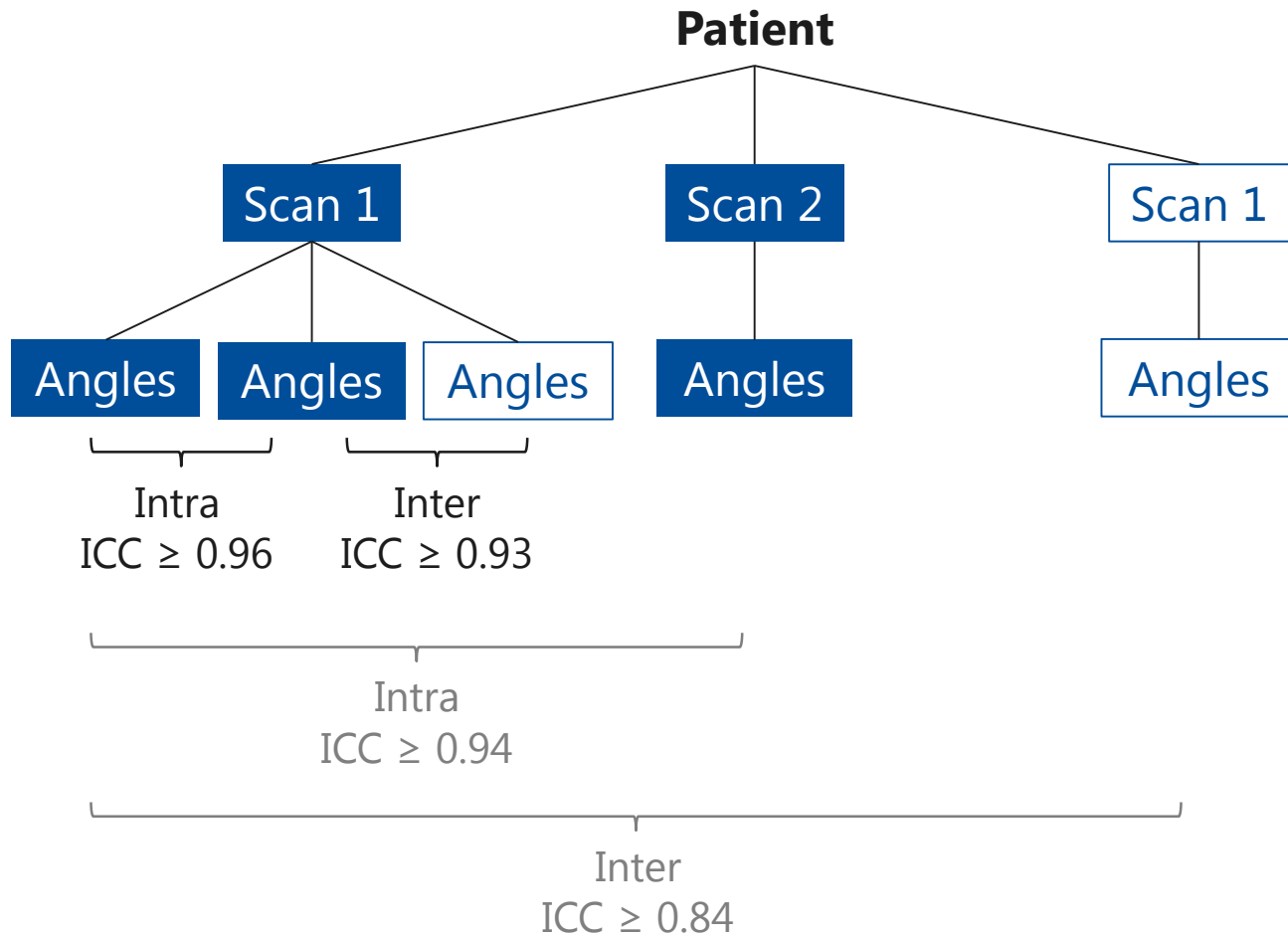
$30 \pm 14^\circ$
 $24 \pm 9^\circ$



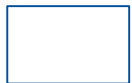
Excellent linear correlations (validity)



Good to excellent reliability



= observer 1



= observer 2

ICC

= interclass correlation coefficient



Conclusions



- Excellent correlations between ultrasound and X-ray
- High reliability
- No differences in reliability and validity between different ultrasound measurements

Scoliosis progression can be assessed without ionizing radiation

