Imaging with EOS, how does 3D help us with early onset deformity outcomes

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Disclosures

- Depuy Synthes spine (a, b),
- Canadian Institutes of Health Research (a),
- Scoliosis Research Society (a),
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- Medtronic (b),
- EOS-Imaging (a, b, d, e) and Royalties
- Spinologics (c)

(a)   Grants/Research Support
(b)   Consultant
(c)   Stock/Shareholder
(d)   Speakers' Bureau
(e)   Other Financial Support

Introduction

First Visit

- Prediction of scoliosis progression remains challenging in patients with spinal deformities
- Even more difficult in Early Onset Scoliosis (EOS)
  - Different pathologies
  - Significant growth remaining

CONSEQUENCES
- Multiple clinical visits
- Serial radiographs
- Psychological stress
- Difficult to determine which patients will need interventions (and what type of intervention)

Introduction

Known Predictive factors for curve progression

- Type of curve
- Age
- Maturity
- Severity of deformity at presentation
- These are classical factors for AIS
 - EOS is more complicated

Congenital Scoliosis

- The problem is asymmetric growth

- They can become very severe.

- Two basic types – failures of formation or segmentation

- Progression is based on the type of deformity
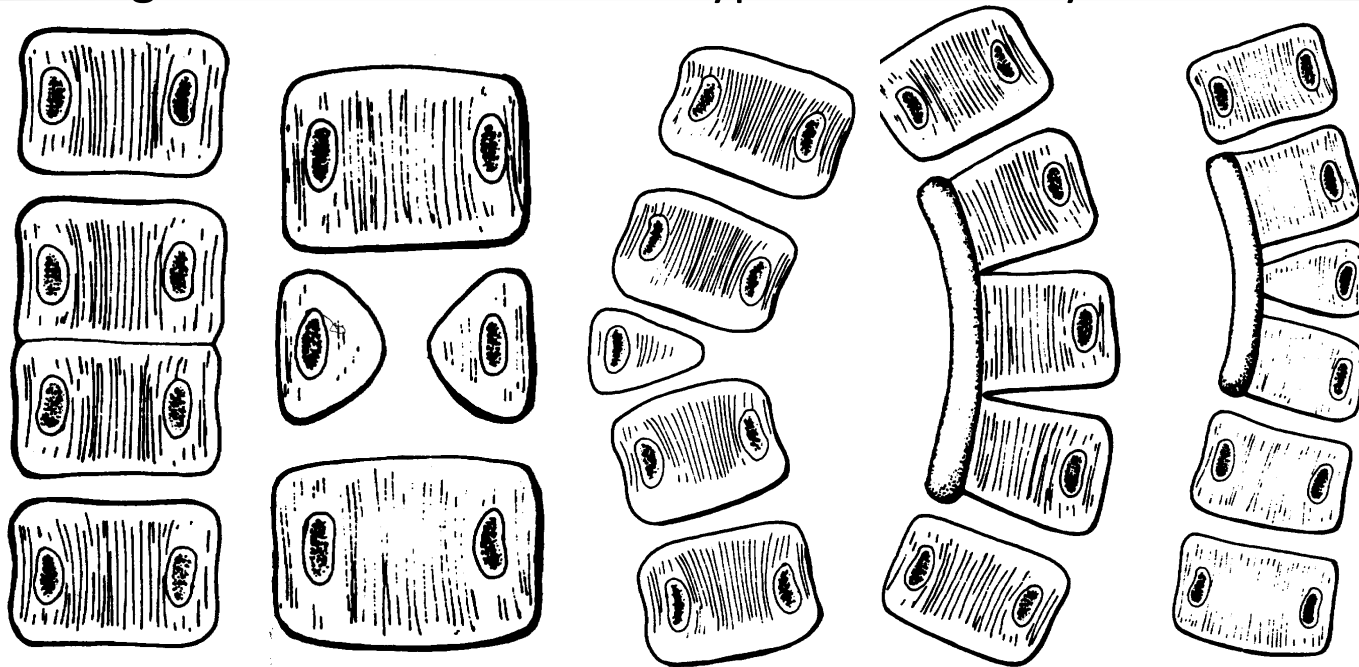
Idiopathic EOS- Separating Resolving from Progressive

- We have 3 Criteria:
- Curve Progression
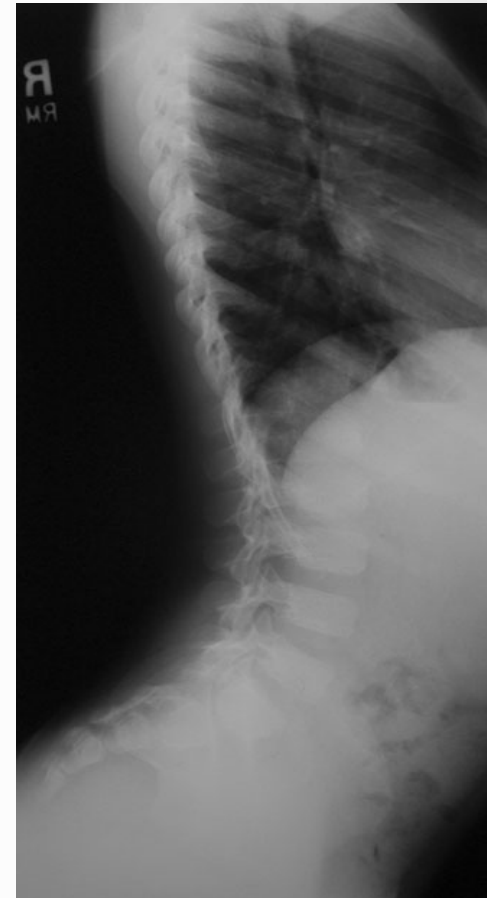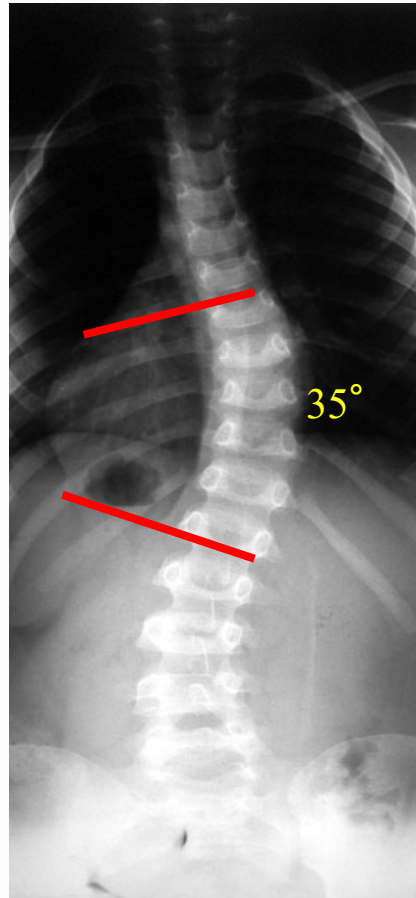- RVAD or RVAD Progression
- Rib Phase

convex   concave   Phase 1

convex   concave   Phase 2
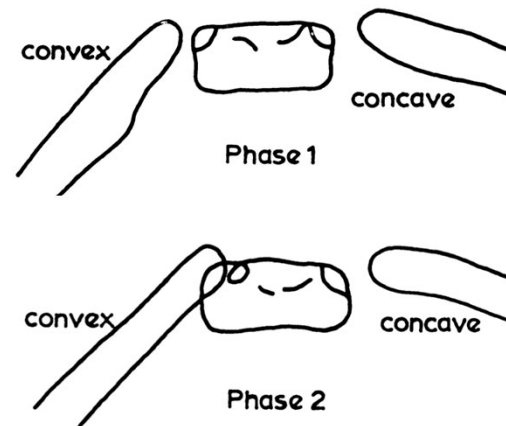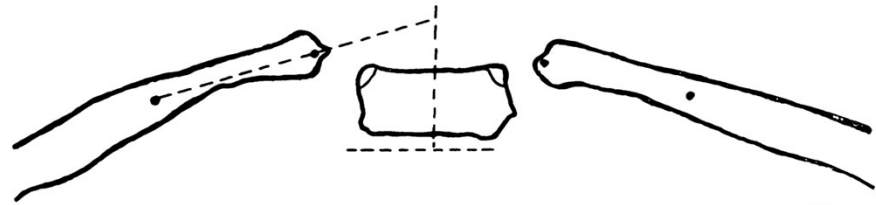
Illustrative case

Idiopathic EOS

- 8 years old boy
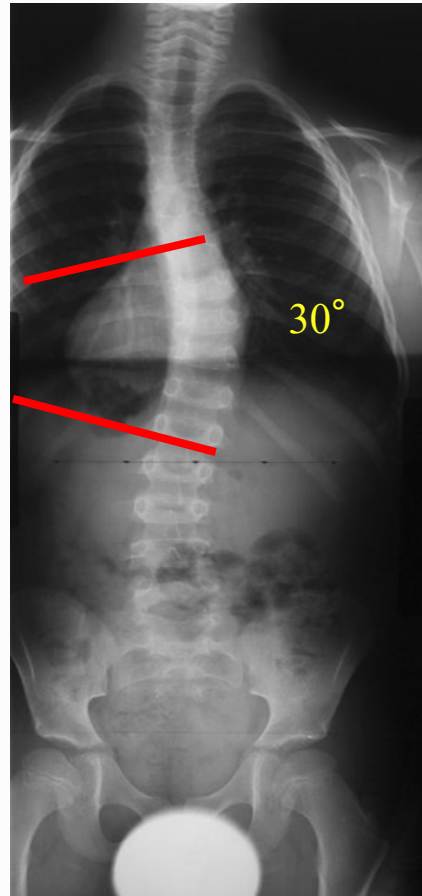- Otherwise healthy
- Referred for treatment
- Neuro exam normal

1/3/00

35°

5/14/01
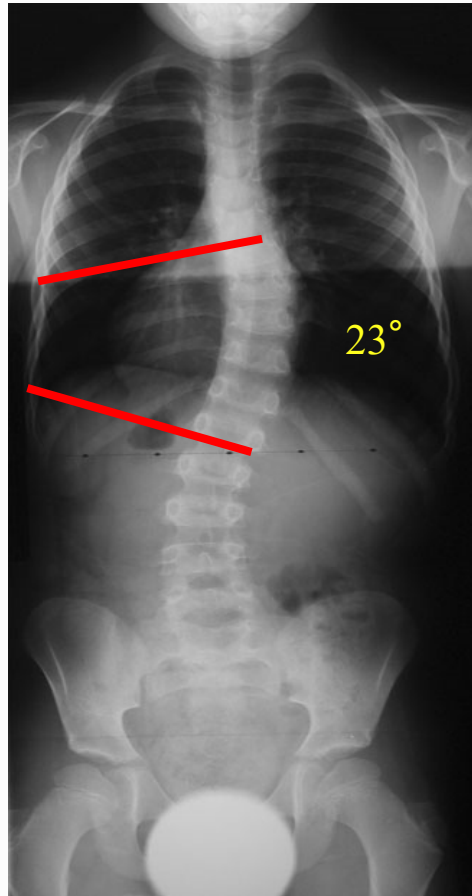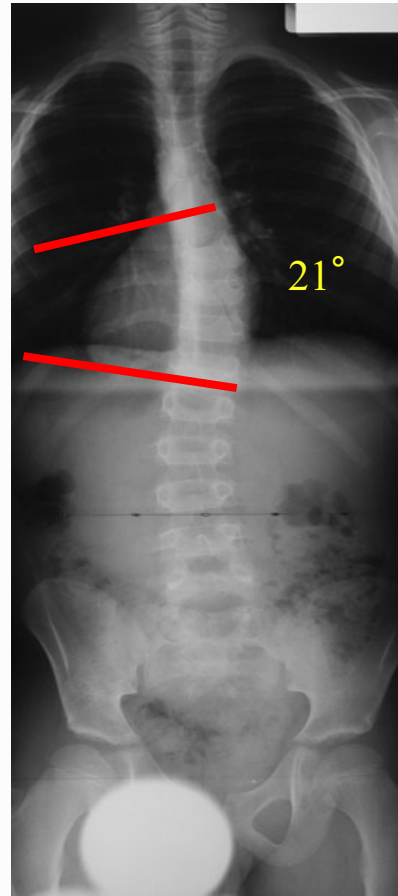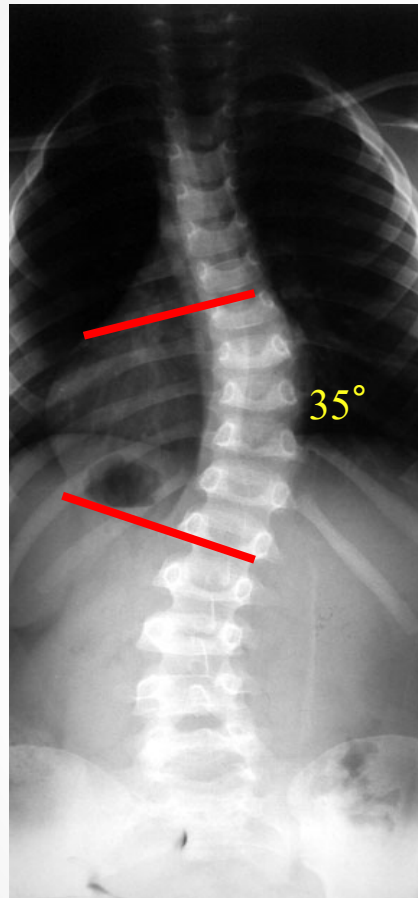
10/22/01

30°

2/4/02

23°

2/10/03

21°

35°

13

Why 3D?

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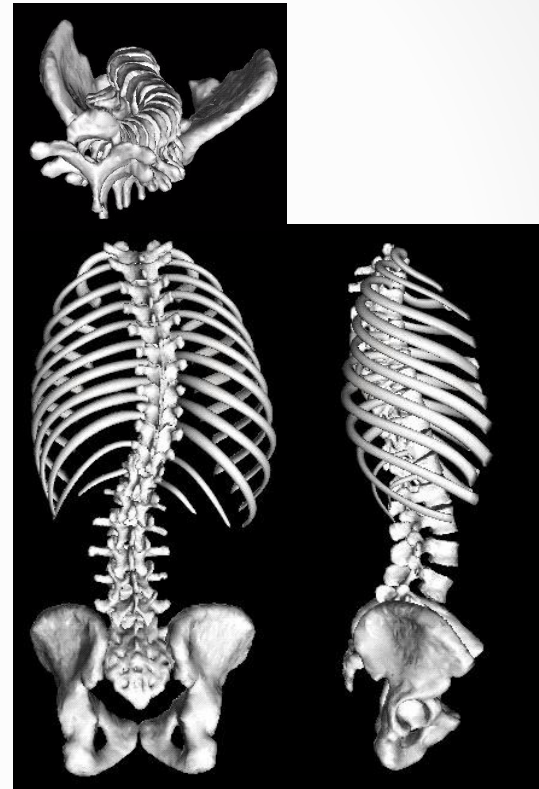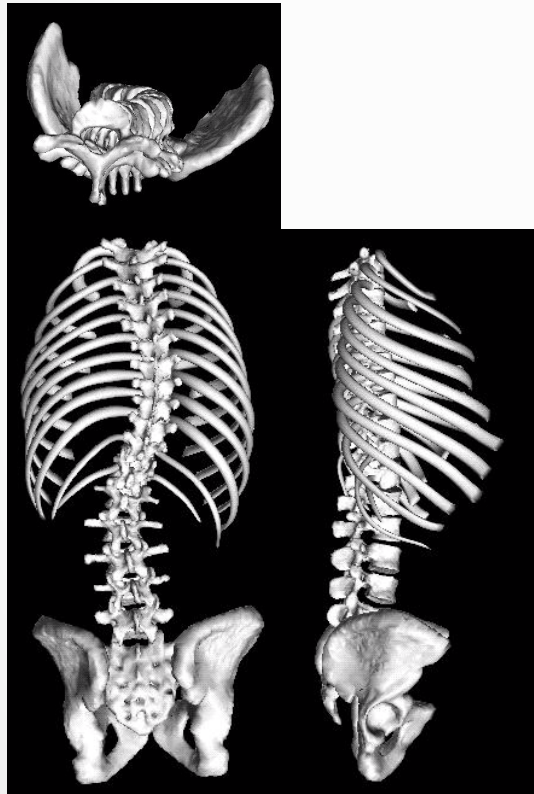
3D reconstructions with EOS system

■ Musculoskeletal Diseases and Rehabilitation
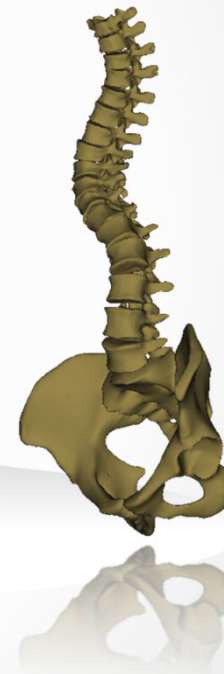
Why is EOS™ so different

- Only method to acquire simultaneous radiographs
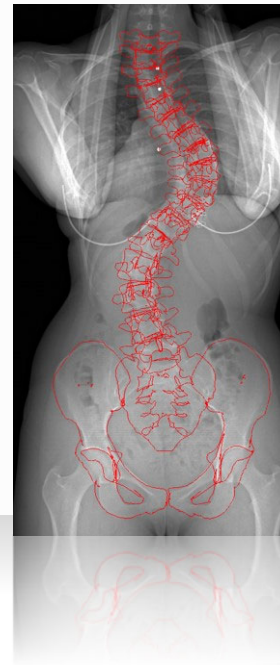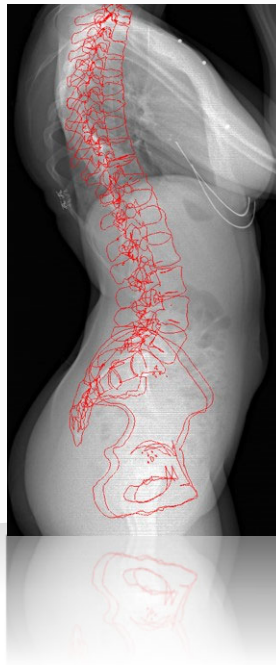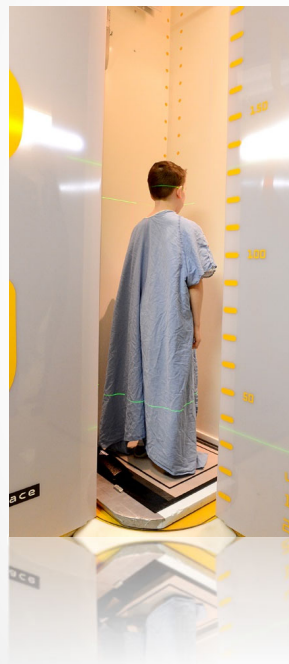- Calibrated environment
  - Possible to know exactly where the patient is in space
- Rapid 3D reconstruction
- 3D parameters calculated specifically for each patient

How can we use this information?

- Every patient is different
- Every patient's anatomy is unique
- Specific 3D parameters may have an impact on progression of the deformity
  - Some spines may be inherently more stable
  - Some spines may be more prone to progression

Prospective model - Methods

- Prospective cohort – Single center

- Statistical model

- Outcome: Final deformity at the end of growth

- Complete model:

  • 3D spine parameters as predictors

  • Skeletal maturity

  • Type of curve

  • Initial Cobb angle

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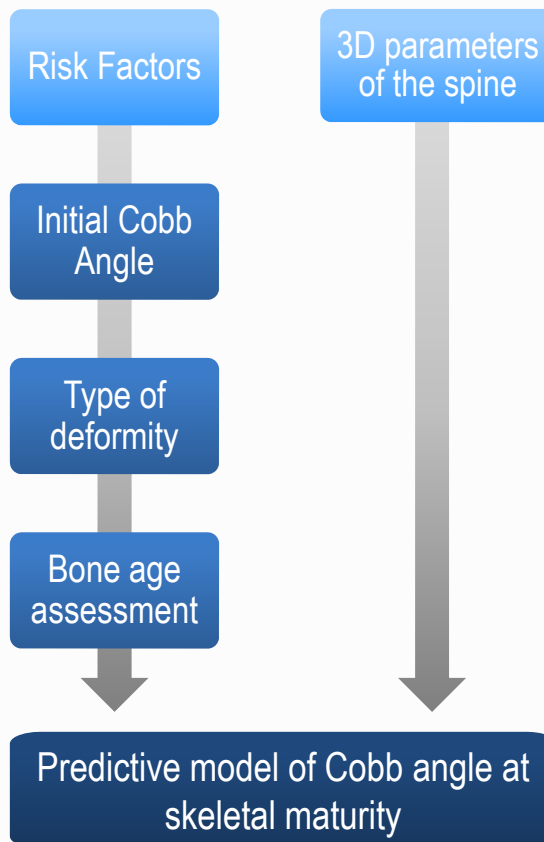
Predictive model

- Predictive model includes:
  - Skeletal maturity system
  - Type of curvature
  - Initial deformity severity ⎤ Historical
  - Angle of the plane of maximal curvature
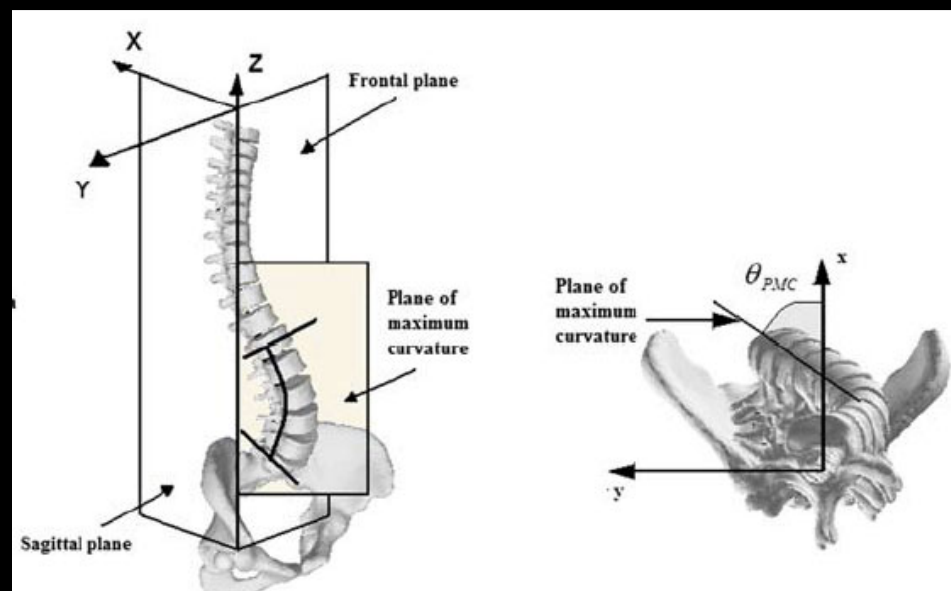 - 3D wedging of two specific disk levels ⎤ 3D
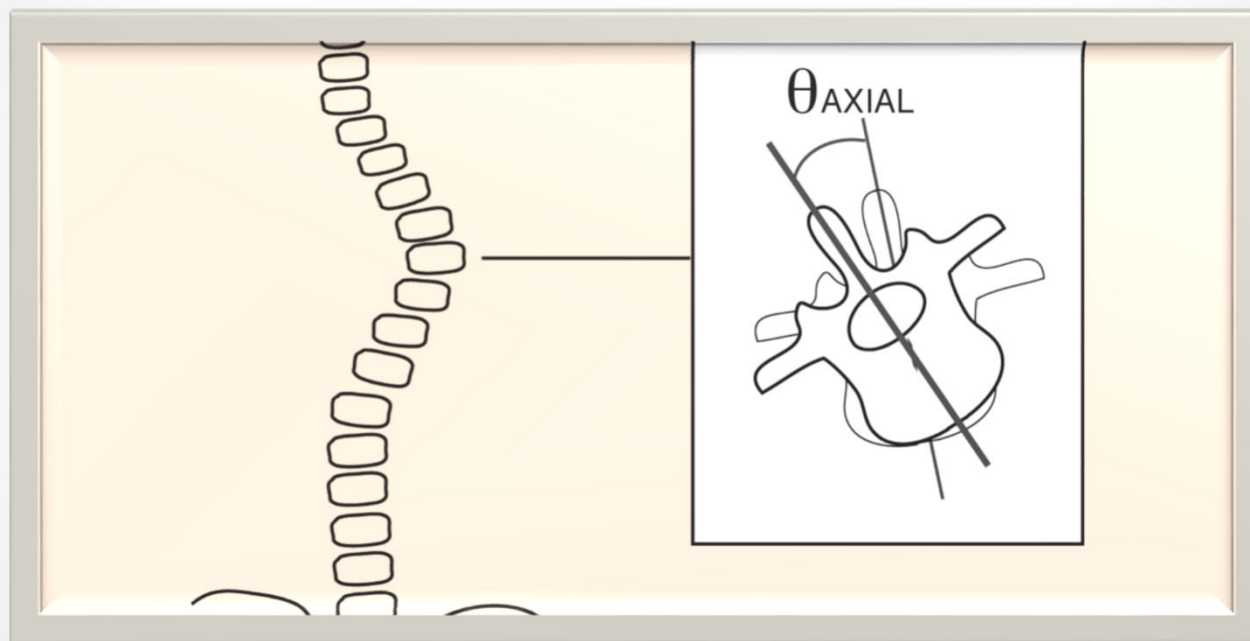 - Apical intervertebral rotation
- $R^2 = 0,702$

Plane of Maximal deformity

Apical Vertebral Rotation

Peri-apical disk wedging

1°

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Risk Factors

3D parameters of the spine

Initial Cobb Angle

$R^2=0,702$

Type of deformity

Bone age assessment

Predictive model of Cobb angle at skeletal maturity

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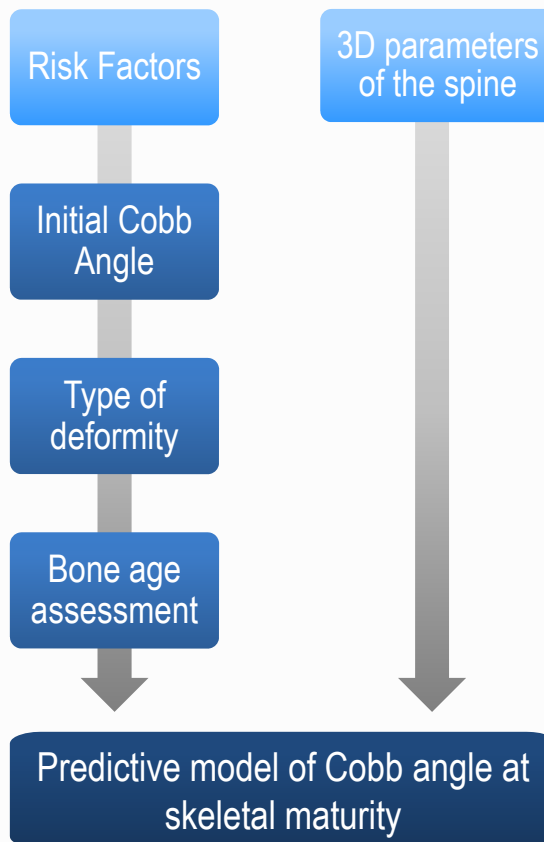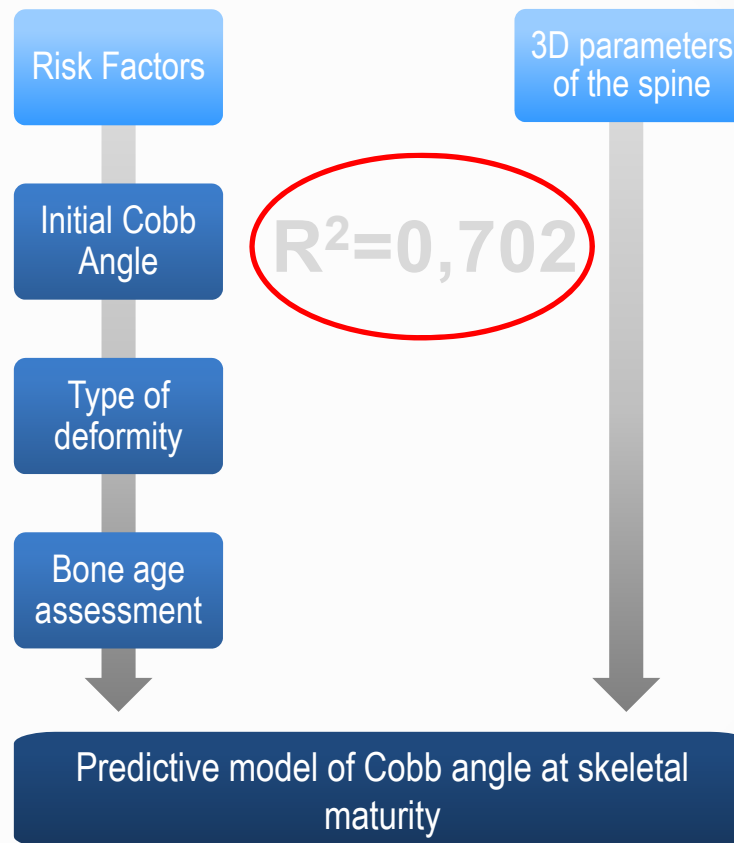
What about linear measurements?

Spine
Deformity

www.spine-deformity.org

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Case Series

Sagittal Spine Length Measurement: A Novel Technique to Assess Growth of the Spine

Alan J. Spurway, PEng, MSc[*], Chukwudi K. Chukwunyerenwa, MD, MCh, FRCS (C)[1],
Waleed E. Kishta, MD, PhD, FRCS (C)[2], Jennifer K. Hurry, MSc,
Ron El-Hawary, MD, MSc, FRCS (C)

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Sagittal Spine length

Spine Deformity
www.spine-deformity.org

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Spine Deformity 4 (2016) 331–337

Case Series

Sagittal Spine Length Measurement: A Novel Technique to Assess Growth of the Spine

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Orthopaedics Department, IWK Health Centre, 5980 University Ave, Halifax, Nova Scotia, B3K6R8, Canada
Received 7 August 2015; revised 22 December 2015; accepted 11 March 2016

- Spine length measured on PA radiographs does not take into account sagittal deformity
- The greater the kyphosis, the less reliable the spine length is
- How about in 3D?

27

Spinal Growth In Normal Children Between 3 And 11 Years Old Using 3D Reconstruction: A Longitudinal Study

Leonie Tremblay, Patrick Tohmé, Marjolaine Roy-Beaudry, Marie Beauséjour, Hubert Labelle, Stefan Parent.

CHU Sainte-Justine, Montreal, Canada

Centre de Recherche du CHU Sainte-Justine
Le centre hospitalier universitaire mère-enfant

Pour l'amour des enfants

Université de Montréal

SRS 2015

Study Objectives

A) To measure reference values for:

- Total spinal height

- Vertebral dimension

- Kyphosis

- Lordosis

3D
Visualisation

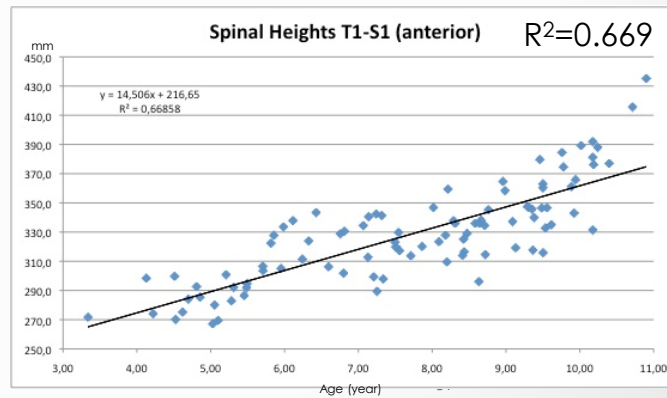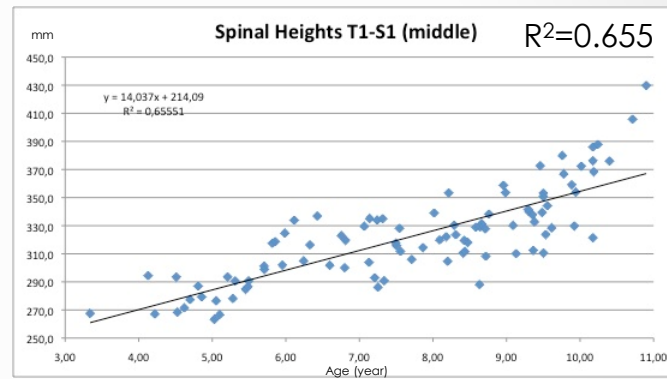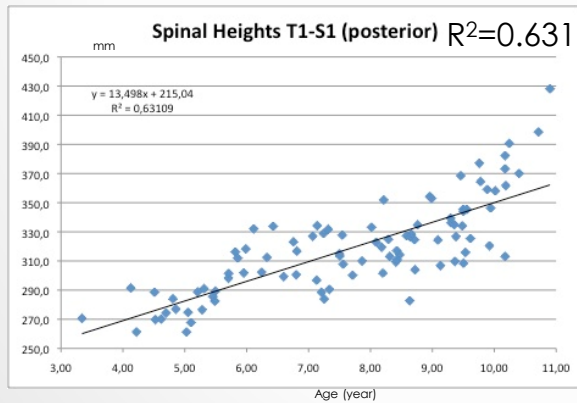B) To calculate growth rate per month for the age categories

METHODS

- All asymptomatic patients with a curve of less than 10° and more than one visit were identified,

- Absence of pathology with spinal growth influence

- PA and LAT calibrated radiographies were used for 3D reconstruction of the spine, using IdefX.

- Values for total height, vertebral dimension, vertebral growth, kyphosis and lordosis were calculated.

3D Height

- 3D evaluation allows calculation of spinal heights from different perspectives: posterior, middle or anterior side of the spine.

- Spinal heights increase as the child ages.

Spinal Heights T1-S1 (middle) $R^2=0.655$

$y = 14{,}037x + 214{,}09$
$R^2 = 0{,}65551$

Spinal Heights T1-S1 (posterior) $R^2=0.631$

$y = 13{,}498x + 215{,}04$
$R^2 = 0{,}63109$

Spinal Heights T1-S1 (anterior) $R^2=0.669$

$y = 14{,}506x + 216{,}65$
$R^2 = 0{,}66858$

What is the significance of RVAD?

Case Series

Physical Significance of the Rib Vertebra Angle Difference and Its 3-Dimensional Counterpart in Early-Onset Scoliosis

Genevieve Foley[a], Carl-Eric Aubin, PhD, PEng[a,b,*], Stefan Parent, MD, PhD[b], Hubert Labelle, MD[b], Jacques d'Astous, MD[d], Charles Johnston, MD[e], James Sanders, MD[c]
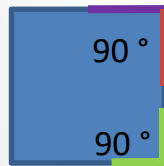
Genevieve Foley[a], Carl-Eric Aubin, PhD, PEng[a,b,*], Stefan Parent, MD, PhD[b], Hubert Labelle, MD[b], Jacques d'Astous, MD[d], Charles Johnston, MD[e], James Sanders, MD[c]

3D : all angles of a cube = 90 °
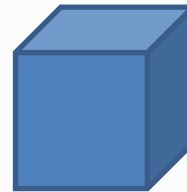
2D Projection of 3D angles

2D : angles vary according to the position of the observer

90 °

90 °

135 °

90 °   135 °

90 °

120 °

120 °   120 °

60 °

RVDA = -12°

T10

ROT: 180°
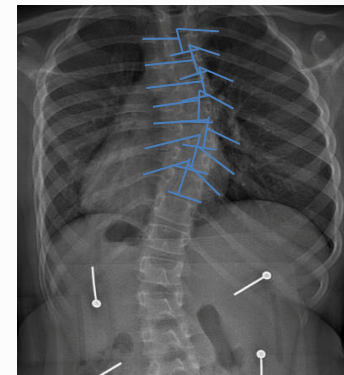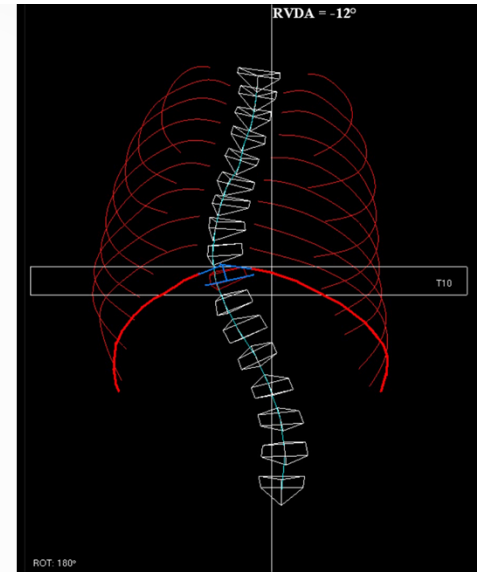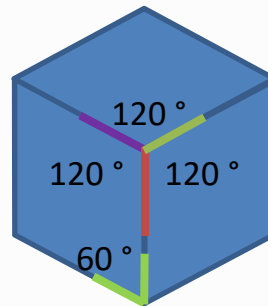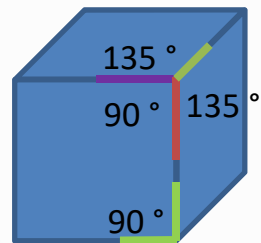
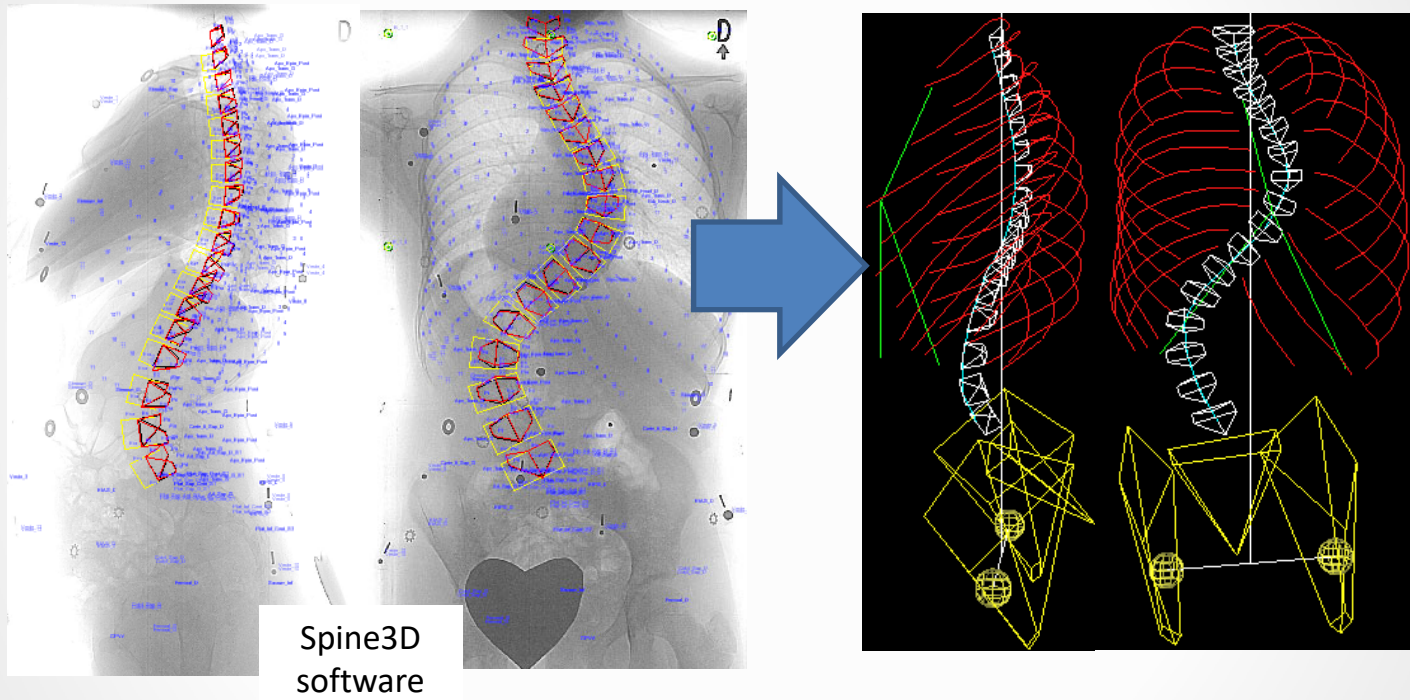# Patient data

- **42** Early Onset Scoliosis patients (26 females, 16 males)
- Age : 5.4 ± 2.3 years
- Cobb : 43.3° ± 19.9 °
- 18 Phase I, 24 Phase II

Sites	# of Patients
CHU Sainte-Justine (QC)	27
University of Rochester (NY)	5
Texas Scottish Rite Hospital (TX)	5
Shriners Hospitals for Children (UT)	5

3D Reconstruction

Spine3D software
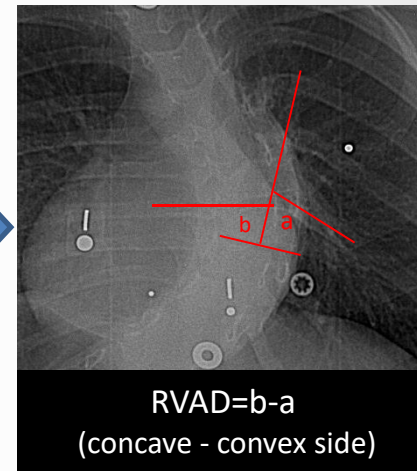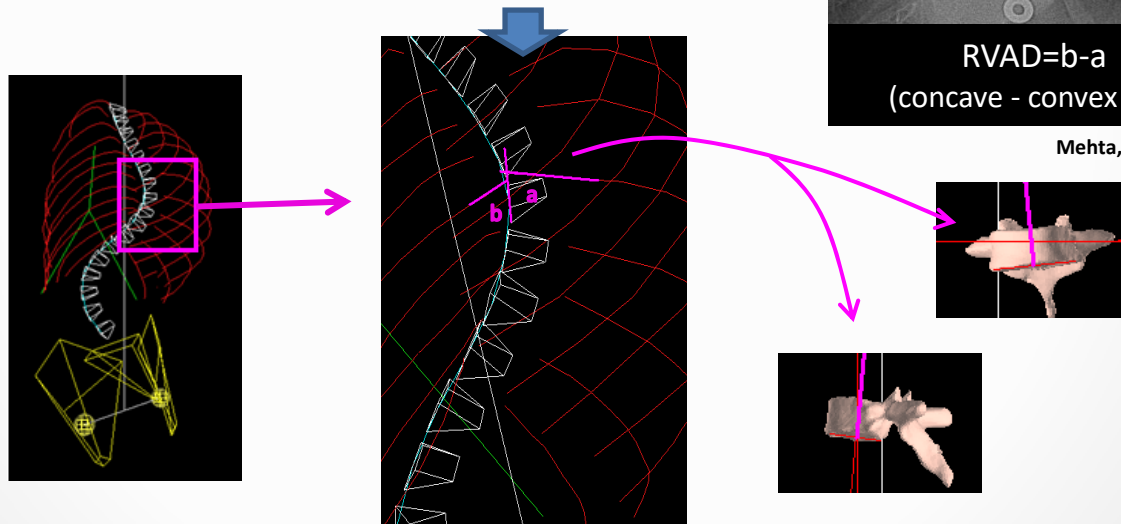
Measurement methods

■From T4-T10:

- **RVAD** (measured on PA radiograph, Mehta's method)
- **« True » RVAD3D**: Computed in 3D

RVAD=b-a
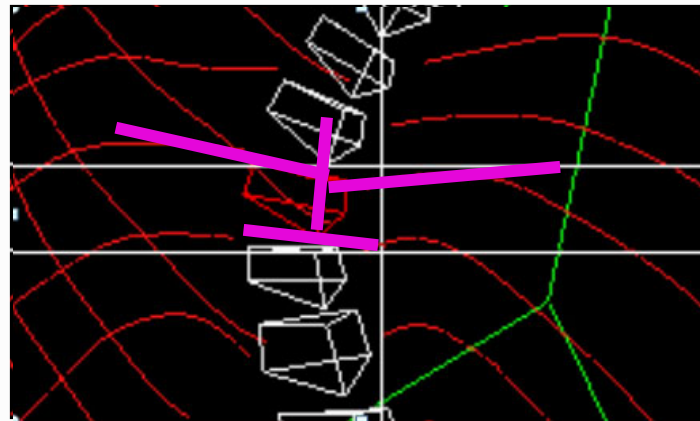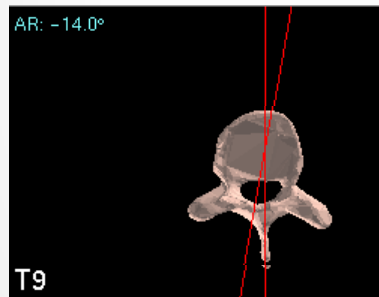(concave - convex side)

Mehta, 1972

Measurement methods (cont'd)

- **Axial vertebral rotation (Stokes' method)**
- **Local RVAD**
  - Measured in the local plane of the vertebra (similarly to Stagnara's plan d'election) using the 3D reconstruction

Results

	Apex level		Maximum	
	RVAD	**RVAD 3D**	**RVAD**	**RVAD 3D**
Phase I	12 ± 9°	2 ± 12°	38 ± 24 °	29 ± 15°
Phase II	22 ± 19°	7 ± 22°	61 ± 39°	40 ± 16°

▸ RVAD varies depending of the measurement technique, but are correlated

▸ Phase II > Phase I

▸ The RVAD not associated w/ spinal axial rotation at apex, but correlated at max. level

Phase II
$R^2 = 0.6059$

Phase I
$R^2 = 0.7507$

RVAD 3D

RVAD Rx
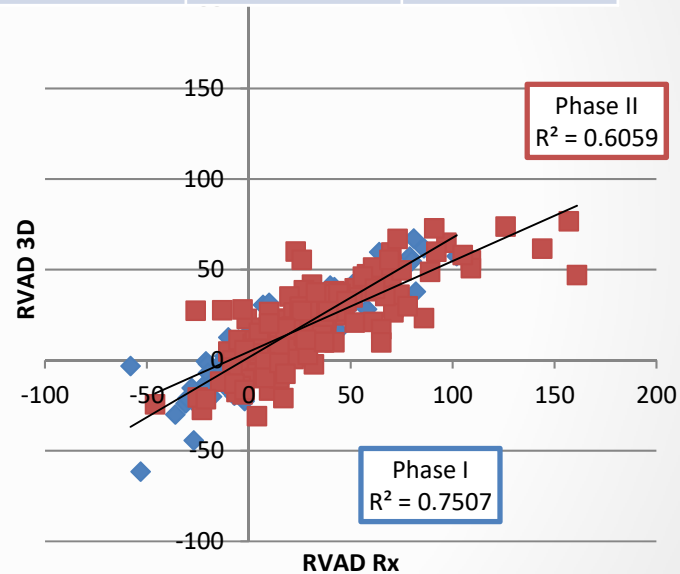
Discussion and Conclusion

▶ RVAD is a projection of 3D geometry of chest wall/spine

  ◦ Not true representation of 3D nature of deformity

  ◦ Compound of factors : Projection, axial rotation, chest wall/spine asymmetry

  ◦ RVAD is really a spine to rib (chest wall) measure and not a rotation measure

  ◦ Challenge to measure on deformed/curved ribs

▶ **RVAD 3D**

  ◦ True deformation of rib cage in relation to spine
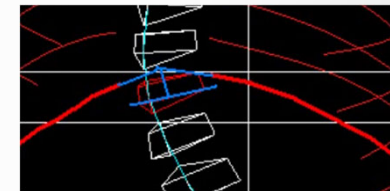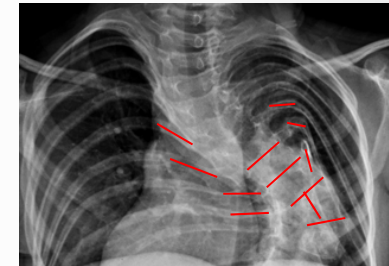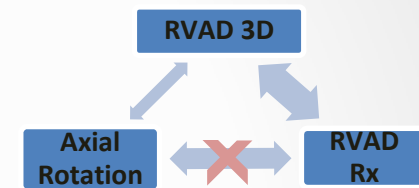
Summary

- Predicting outcomes in EOS = challenge
- Current knowledge mostly based on 2D information
  - RVAD, Cobb Angle, type of deformity
- This is a true 3D deformity
- Probably best evaluated in 3D but still needs work to determine which parameters can be used in prediction

40

Acknowledgements

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