Have We Improved Functional Outcomes?

2017 ICEOS

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Orthopedic Center

HARVARD MEDICAL SCHOOL
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Disclosures

None related to this talk

Speaker: Depuy/Synthes, Zimmer/Biomet, Nuvasive

Member : CSSG, GSSG, HSG

Consultant: Orthobullets

Acknowledgements: John Emans, Michael Vitale

Outline

Challenges unique to EOS

Outcomes:

- Pulmonary (previous talk)
- Radiographic
- Quality of life
- Surrogates for above?
- **Functional**

Why is it so Challenging?

Goals in EOS

What do we think is important?

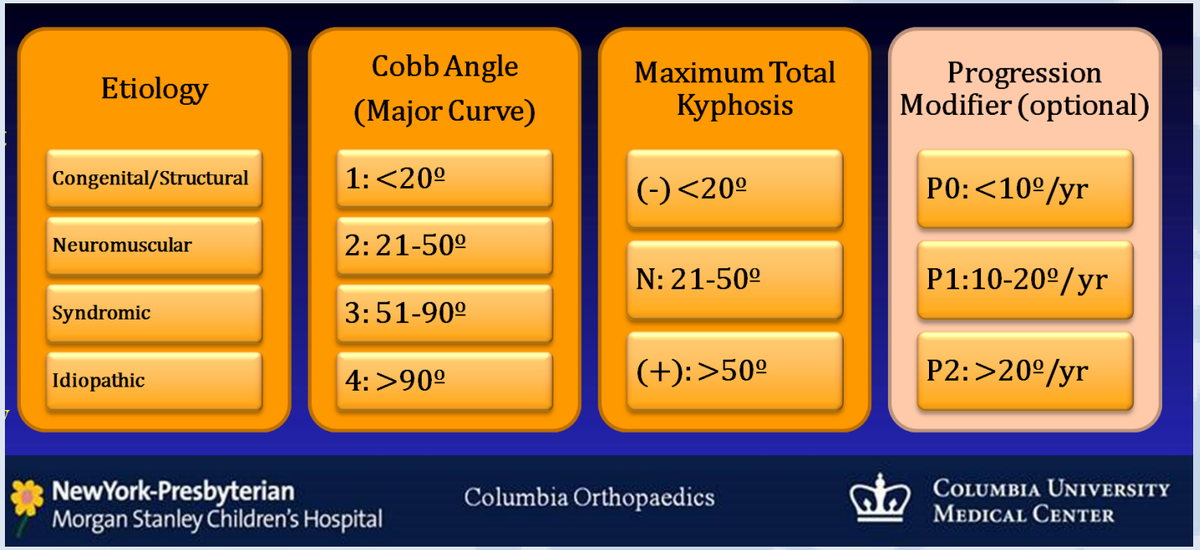
- Maximum spine length, residual mobility
- Maximum chest size/function
- Minimum surgeries, hospitalizations
- Minimum complications

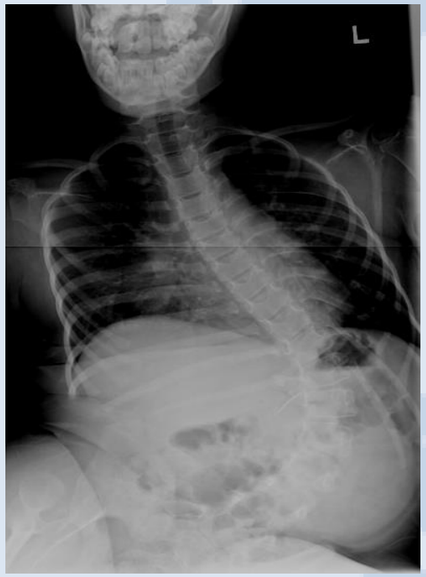
Obstacles to Measuring Outcomes in EOS
Why is it So Hard?

Diverse population

Various etiologies

Co-morbidities





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Obstacles To Measuring Outcomes In EOS
Why Is It So Hard?

Treatment occurs during growth

- Especially rapid spine growth

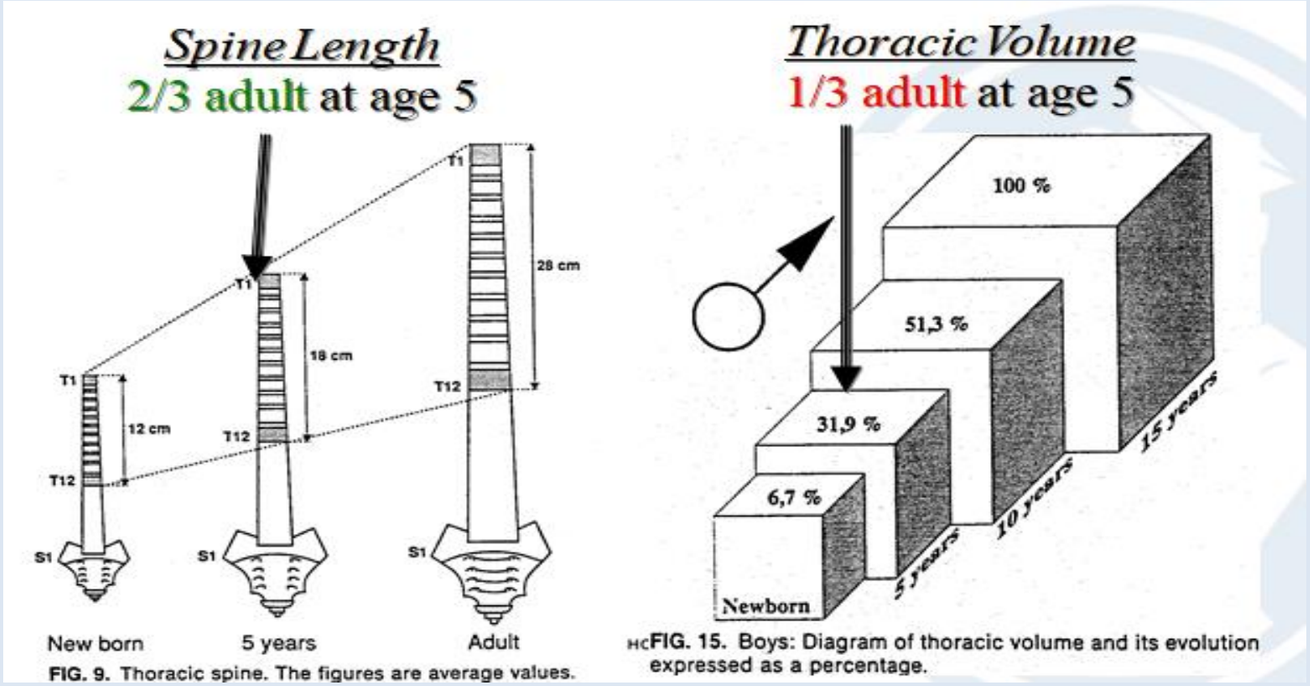
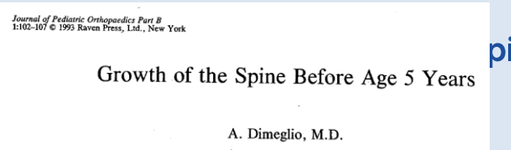


FIG. 9. Thoracic spine. The figures are average values.

HCFIG. 15. Boys: Diagram of thoracic volume and its evolution expressed as a percentage.



Journal of Pediatric Orthopaedics Part B
1:103-107 © 1995 Raven Press, Ltd., New York

Growth of the Spine Before Age 5 Years

A. Dimeglio, M.D.

pital

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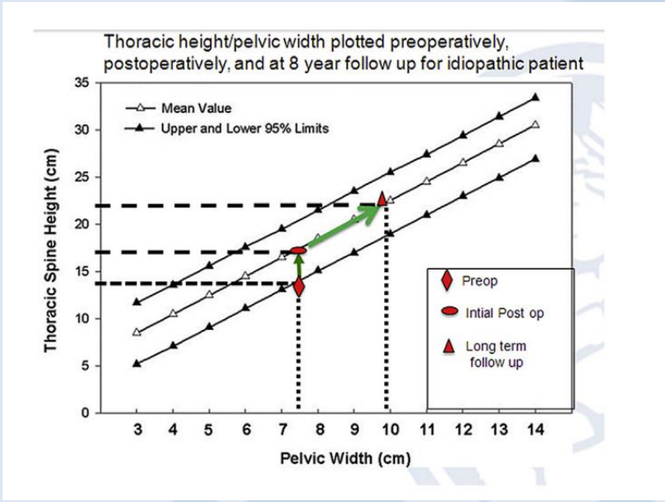
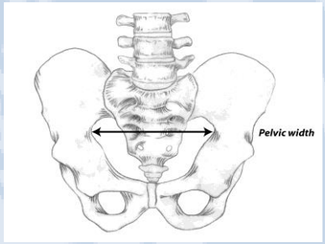
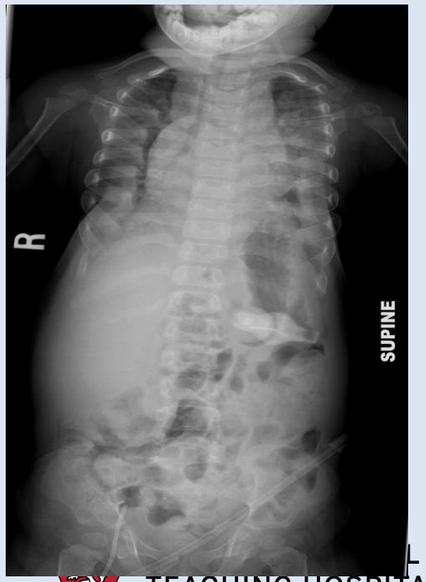
Obstacles To Measuring Outcomes In EOS
Why Is It So Hard?

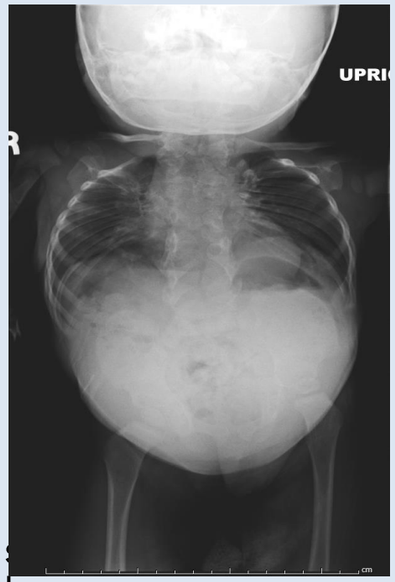
Different skeletal structures

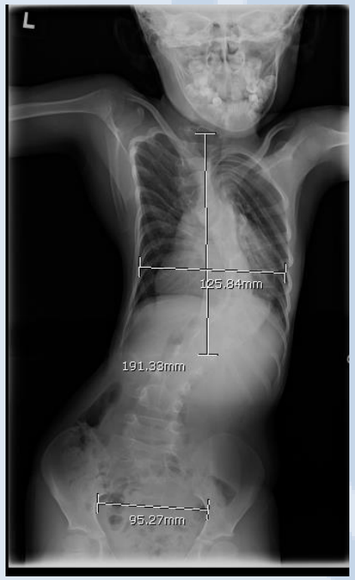
Abnormal growth rates

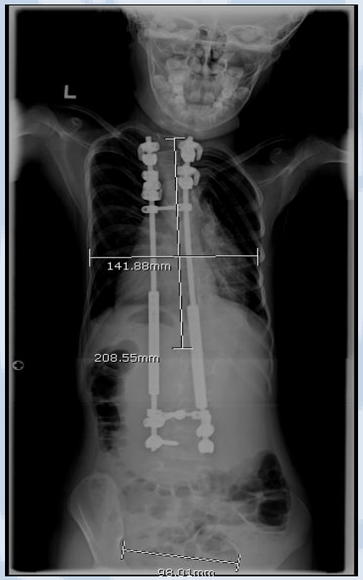






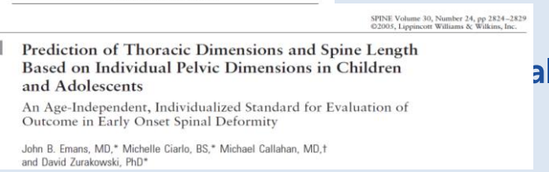







Spine Deformity

Distraction-Based Treatment Maintains Predicted Thoracic Dimensions in Early-Onset Scoliosis


SPINE Volume 30, Number 24, pp 2824–2829
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Prediction of Thoracic Dimensions and Spine Length Based on Individual Pelvic Dimensions in Children and Adolescents

An Age-Independent, Individualized Standard for Evaluation of Outcome in Early Onset Spinal Deformity

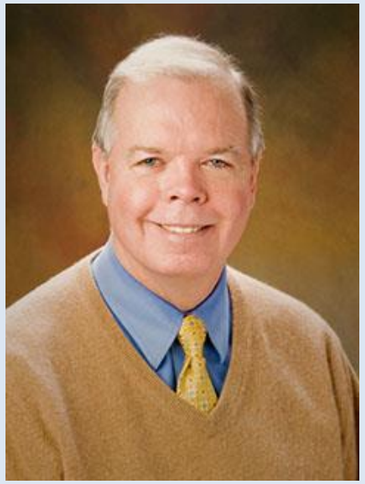
John B. Emans, MD,* Michelle Ciarlo, BS,* Michael Callahan, MD,† and David Zurakowski, PhD*

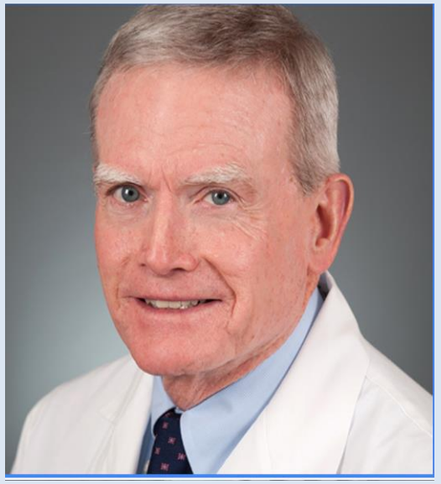
TEACHING HOSPITAL

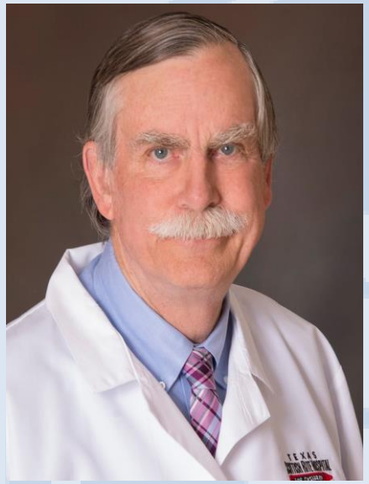
Obstacles To Measuring Outcomes In EOS
Why Is It So Hard?

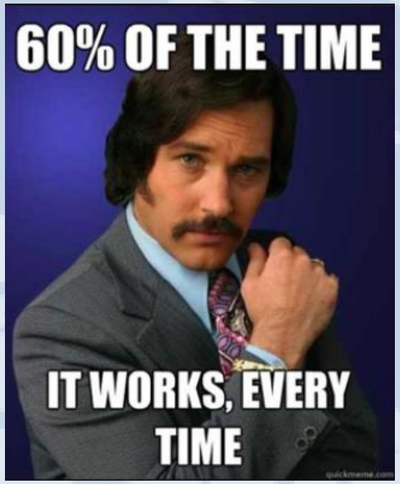
Surgeon variability

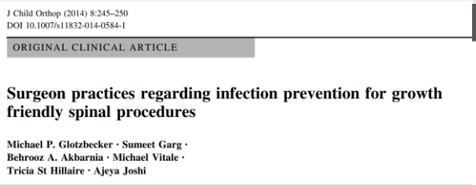
- Indications
- Timing
- Technique
- Execution










J Child Orthop (2014) 8:245–250
DOI 10.1007/s11832-014-0584-1

ORIGINAL CLINICAL ARTICLE

Surgeon practices regarding infection prevention for growth friendly spinal procedures

Michael P. Glotzbecker · Sumeet Garg · Behrooz A. Akbarnia · Michael Vitale · Tricia St Hillaire · Ajeya Joshi


Spine Deformity

SPINE Volume 36, Number 10, pp 806–809
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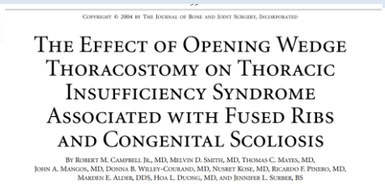
Lengthening of Dual Growing Rods and the Law of Diminishing Returns

Wudbhav N. Sankar, MD, David L. Skaggs, MD, Muharrem Yazici, MD, Charles E. Johnston II, MD, Suken A. Shah, MD, Pooya Javidan, MD, Rishi V. Kadakia, BS, Thomas F. Day, MD, and Behrooz A. Akbarnia, MD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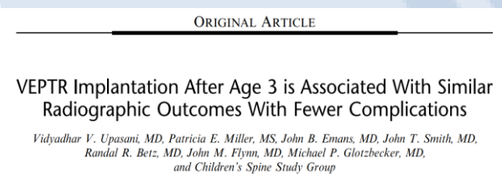
THE EFFECT OF OPENING WEDGE THORACOSTOMY ON THORACIC INSUFFICIENCY SYNDROME ASSOCIATED WITH FUSED RIBS AND CONGENITAL SCOLIOSIS

By Robert M. Campbell Jr., MD, Melvin D. Smith, MD, Thomas C. Mayes, MD, John A. Mangos, MD, Donna B. Willey-Courand, MD, Nusret Kose, MD, Ricardo F. Pinero, MD, Marden E. Alder, DDS, Hoa L. Duong, MD, and Jennifer L. Surber, BS


ORIGINAL ARTICLE

VEPTR Implantation After Age 3 is Associated With Similar Radiographic Outcomes With Fewer Complications

Vidyadhar V. Upasani, MD, Patricia E. Miller, MS, John B. Emans, MD, John T. Smith, MD, Randal R. Betz, MD, John M. Flynn, MD, Michael P. Glotzbecker, MD, and Children's Spine Study Group


Spine Deformity

www.spine-deformity.org

Spine Deformity 4 (2016) 344–350

Age at Initiation and Deformity Magnitude Influence Complication Rates of Surgical Treatment With Traditional Growing Rods in Early-Onset Scoliosis

Vidyadhar V. Upasani, MD*, Kevin C. Parvaresh, MD, Jeff B. Pawelek, BS, Patricia E. Miller, MS, George H. Thompson, MD, David L. Skaggs, MD, MMM, John B. Emans, MD, Michael P. Glotzbecker, MD, Growing Spine Study Group

How Can We Measure Outcomes?

Pulmonary Function (Previous Talk)

Gold standard?

PFTs difficult in EOS

- Cooperation
- Effort
- Techniques

Curr Allergy Asthma Rep (2011) 11:473–481
DOI 10.1007/s11882-011-0220-9

PEDIATRIC ALLERGY AND IMMUNOLOGY (JAY M. PORTNOY AND CHRISTINA E. CIACCIO, SECTION EDITORS)

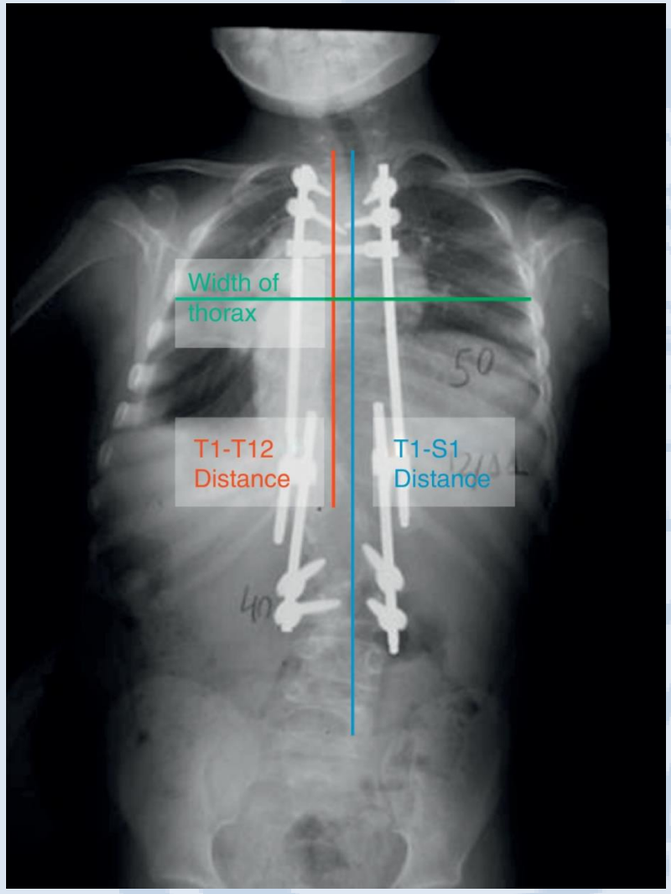
Pulmonary Function Testing in Young Children

Hugo Escobar · Terrence W. Carver Jr.

Radiographic-Traditional Measurements

Traditional study group measurements

- 2D measurements
- T1-T12, T1-S1 length, Cobb, etc.



Advantages

- Easily available

Disadvantages

- 2D, static, not normalized to growth


Revista Española de Cirugía Ortopédica y Traumatología

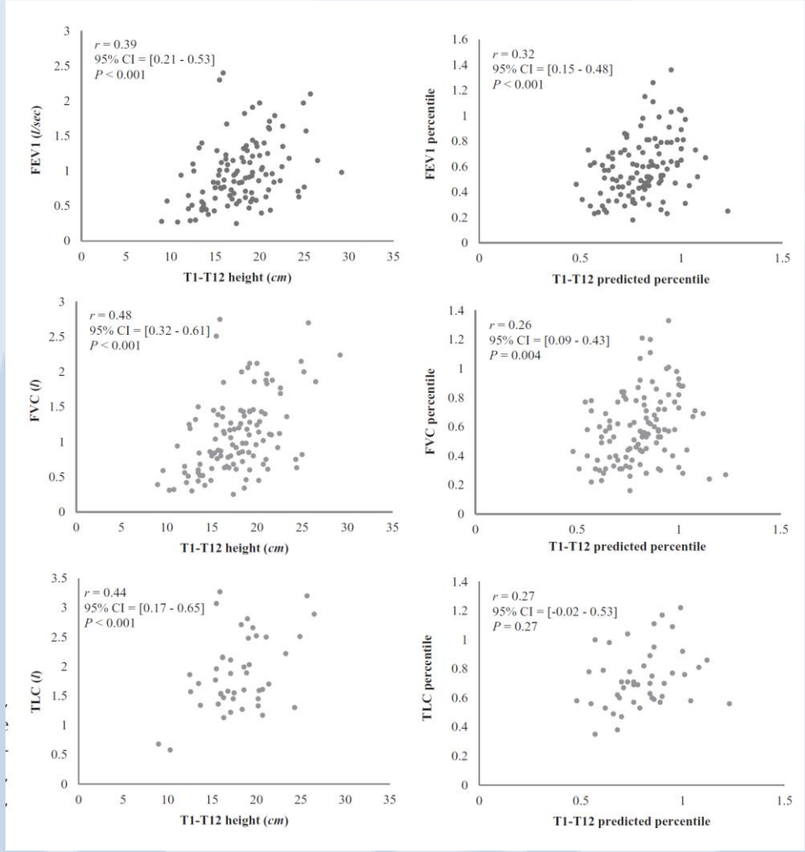
ORIGINAL ARTICLE

Growing rods in early-onset scoliosis. Do they really help to control the deformity and spinal and thoracic growth?

Do 2D Measurements Correlate With Pulmonary Function?

2D measurements correlate poorly w/ PFTs

- Not surprising!
- Chest is a dynamic 3D structure



Spine
SPINE Volume 39, Number 19, pp 1590-1595
©2014, Lippincott Williams & Wilkins
DEFORMITY

Is There a Relationship Between Thoracic Dimensions and Pulmonary Function in Early-Onset Scoliosis?

Michael Glotzbecker, MD,* Charles Johnston, MD,† Patricia Miller, MS,* John Smith, MD,‡ Francisco Sanchez Perez-Grueso, MD,§ Regina Woon, MPH,¶ John Flynn, MD,‖ Meryl Gold, BA,* Sumeet Garg, MD,** Gregory Redding, MD,†† Patrick Cahill, MD,‡‡ and John Emans, MD*

Radiographic-Better Measurements?

True spine length?

- Growth friendly constructs pro-kyphotic
- Growth out of coronal plane
- 3D techniques

More accurate…but better?

- Still a static measure

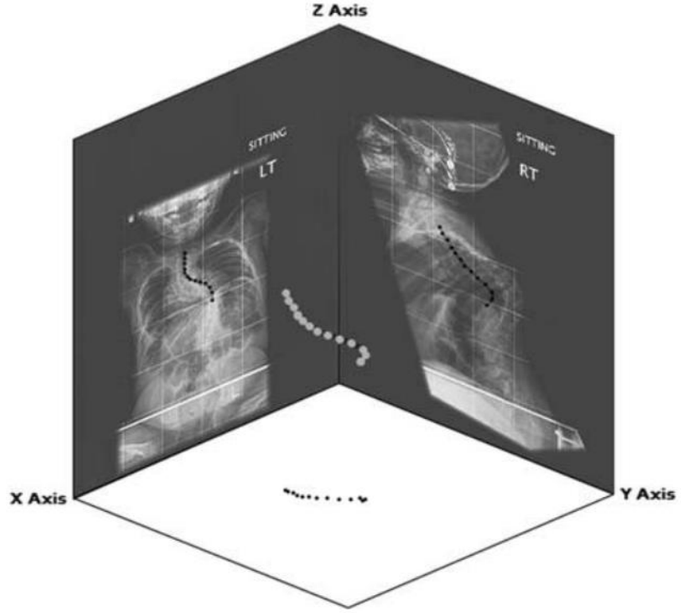


FIGURE 3. Graphical representation of how the 3-dimensional true spine length measurement is generated from the 2 curved measurements from the orthogonal coronal and sagittal radiographs.

Three-dimensional True Spine Length: A Novel Technique for Assessing the Outcomes of Scoliosis Surgery

Alan J. Spurway, P.Eng., MASc, Jennifer K. Hurry, P.Eng., MASc,* Luke Gauthier, MD, FRCS(C),* Ben Orlik, MD, FRCS(C),*† Chukwudi K. Chukwunyerenwa, MD, MCh, FRCS(C),* Waleed E. Kishta, MD, PhD, FRCS(C),* and Ron El-Hawary, MD, MSc, FRCS(C)*†‡*

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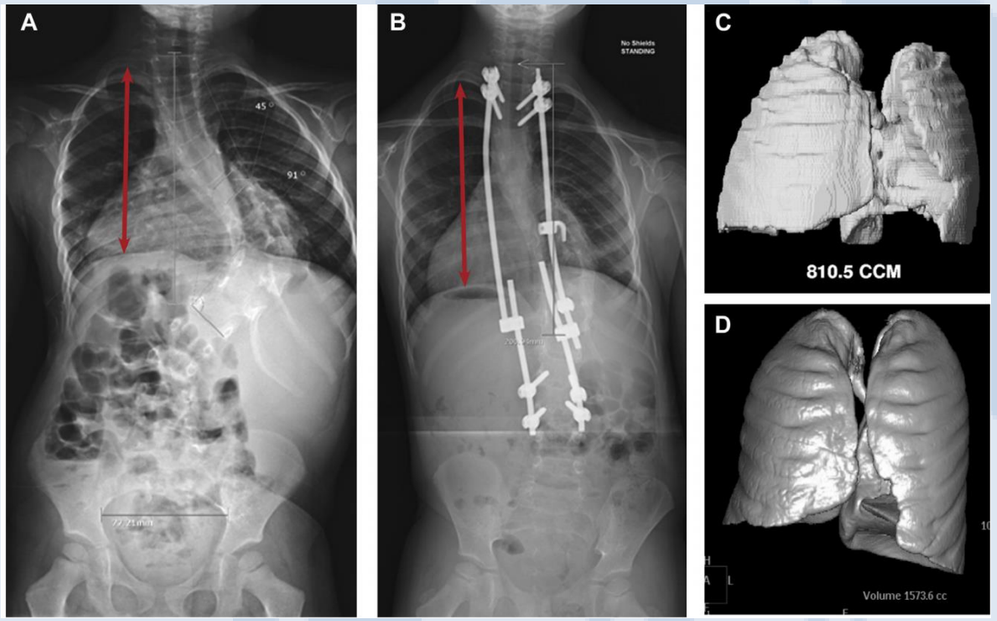
Is 3D Better?

Advantages

- 3D volumes quantifies
  - Chest volume
  - Effect of treatment

Disadvantages

- Relationship to PFTs?
  - You can make the box bigger…
  - Still a static measure



Spine Deformity

Computed Tomography Lung Volume Changes After Surgical Treatment for Early-Onset Scoliosis

Charles E. Johnston, MD, Anna McClung, RN, BSN, Salah Fallatah, FRCSC

Boston Children's Hospital Orthopedic Center

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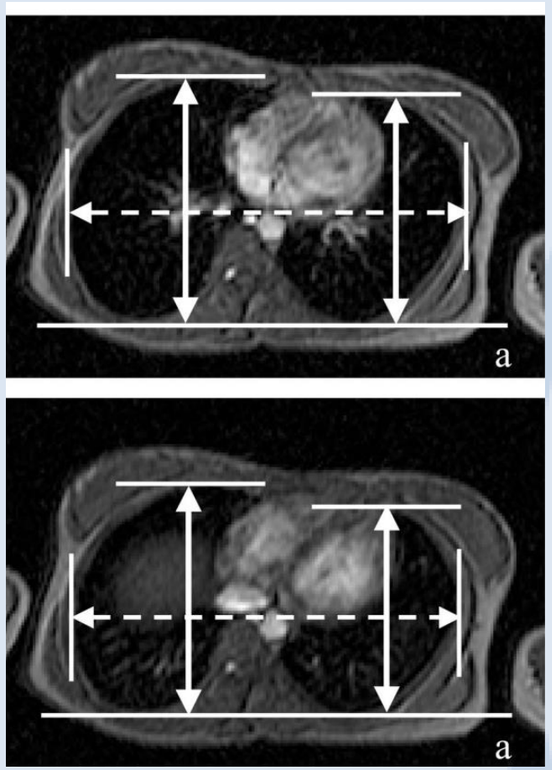
Dynamic 3D MRI

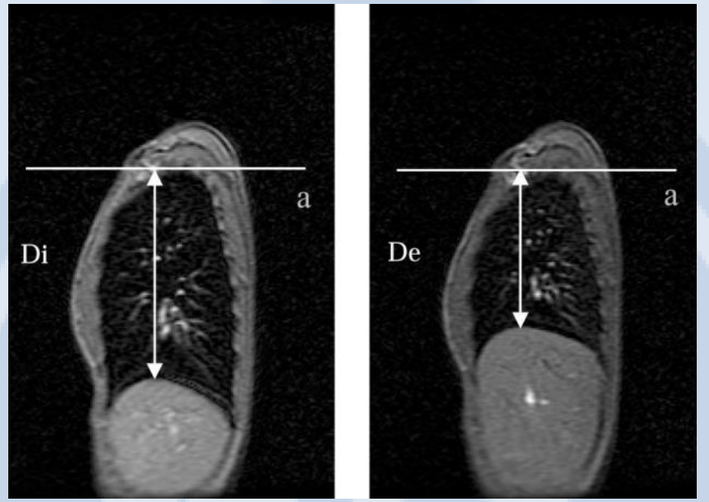
Advantages

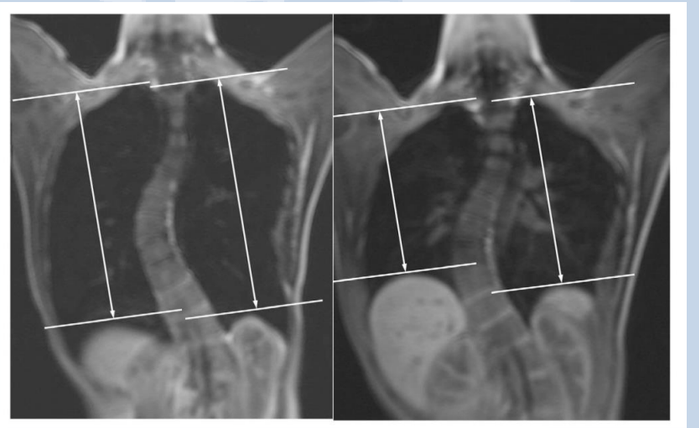
- Dynamic
  - Chest wall
  - Diaphragm

Disadvantages

- Unproven in EOS
- Sedation concerns








SPINE Volume 31, Number 19, pp 2243–2249
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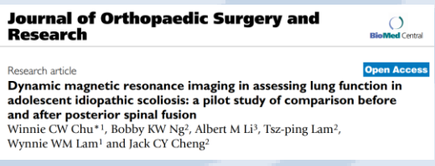
Dynamic Magnetic Resonance Imaging in Assessing Lung Volumes, Chest Wall, and Diaphragm Motions in Adolescent Idiopathic Scoliosis *Versus* Normal Controls

Winnie C. W. Chu, FRCR,* Albert M. Li, MRCP,† Bobby K. W. Ng, FRCS Ed (Orth),‡ Dorothy F. Y. Chan, MRCP,† Tsz-ping Lam, FRCS Ed (Orth),‡ Wynnie W. M. Lam, FRCR,* and Jack C. Y. Cheng, FRCS Ed (Orth)‡


SPINE Volume 29, Number 3, pp 298–302
©2004, Lippincott Williams & Wilkins, Inc.

An Analysis of Chest Wall and Diaphragm Motions in Patients With Idiopathic Scoliosis Using Dynamic Breathing MRI

Toshiaki Kotani, MD,* Shohei Minami, MD,* Kazuhisa Takahashi, MD,* Keijiro Isobe, MD,* Yoshinori Nakata, MD,* Masashi Takaso, MD,* Masatoshi Inoue, MD,* Tetsuro Maruta, MD,* Tsutomu Akazawa, MD,* Takuya Ueda, MD,† and Hideshige Moriya, MD*


Journal of Orthopaedic Surgery and Research

BioMed Central

Research article

Open Access

Dynamic magnetic resonance imaging in assessing lung function in adolescent idiopathic scoliosis: a pilot study of comparison before and after posterior spinal fusion

Winnie CW Chu*[1], Bobby KW Ng[2], Albert M Li[3], Tsz-ping Lam[2], Wynnie WM Lam[1] and Jack CY Cheng[2]

Boston Children's Hospital Orthopedic Center

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QOL (EOSQ-24)

Early Onset Scoliosis Questionnaire

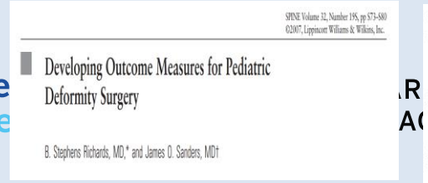
Advantages:

- Good to excellent agreement w/ test and re-test
- Correlated with PFTs

Disadvantages:

- Early experience
- Parent vs patient reported outcomes
- Others: SRS, PODCI, CHQ

Domains Tested
General health
Pain/Fatigue
Pulmonary function
Transfer
Physical function
Daily living
Fatigue/Energy level
Emotion
Parental Burden
Financial Burden


SPINE Volume 32, Number 19, pp 573-580
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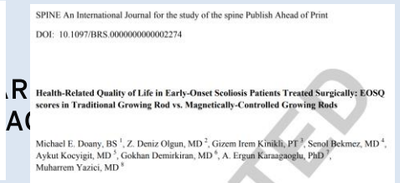
Developing Outcome Measures for Pediatric Deformity Surgery

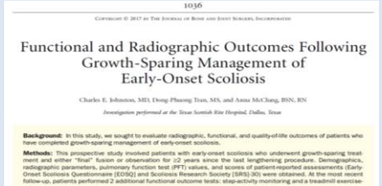
B. Stephens Richards, MD,* and James O. Sanders, MD†


SPINE An International Journal for the study of the spine Publish Ahead of Print

DOI: 10.1097/BRS.0000000000002274

Health-Related Quality of Life in Early-Onset Scoliosis Patients Treated Surgically: EOSQ scores in Traditional Growing Rod vs. Magnetically-Controlled Growing Rods

Michael E. Doany, BS [1], Z. Deniz Olgun, MD [2], Gizem Irem Kinikli, PT [3], Senol Bekmez, MD [4], Aykut Kocyigit, MD [3], Gokhan Demirkiran, MD [5], A. Ergun Karaagaoglu, PhD [3], Muharrem Yazici, MD [6]


1036

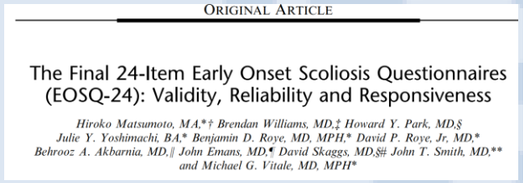
Functional and Radiographic Outcomes Following Growth-Sparing Management of Early-Onset Scoliosis

Charles E. Johnston, MD, Dong-Phuong Tran, MS, and Anna McClung, BSN, RN

Investigation performed at the Texas Scottish Rite Hospital, Dallas, Texas

Background: In this study, we sought to evaluate radiographic, functional, and quality-of-life outcomes of patients who have completed growth-sparing management of early-onset scoliosis.

Methods: This prospective study involved patients with early-onset scoliosis who underwent growth-sparing treatment and either "final" fusion or observation for ≥2 years since the last lengthening procedure. Demographics, radiographic parameters, pulmonary function test (PFT) values, and scores of patient-reported assessments (Early Onset Scoliosis Questionnaire [EOSQ] and Scoliosis Research Society [SRS]-30) were obtained. At the most recent follow-up, patients performed 2 additional functional outcome tests: step-activity monitoring and a treadmill exercise-


ORIGINAL ARTICLE

The Final 24-Item Early Onset Scoliosis Questionnaires (EOSQ-24): Validity, Reliability and Responsiveness

Hiroko Matsumoto, M.A.† Brendan Williams, MD,‡ Howard Y. Park, MD,§ Julie Y. Yoshimachi, BA,* Benjamin D. Roye, MD, MPH,* David P. Roye, Jr, MD,* Behrooz A. Akbarnia, MD,‖ John Emans, MD,¶ David Skaggs, MD,## John T. Smith, MD,** and Michael G. Vitale, MD, MPH**


ORIGINAL ARTICLE

Measuring Quality of Life in Children With Early Onset Scoliosis: Development and Initial Validation of the Early Onset Scoliosis Questionnaire

Jacqueline Corona, MD,† Hiroko Matsumoto, M.A.*† David P. Roye, Jr, MD,*† and Michael G. Vitale, MD, MPH*†*

Other Surrogates…Hemoglobin

Emans et al 2009:

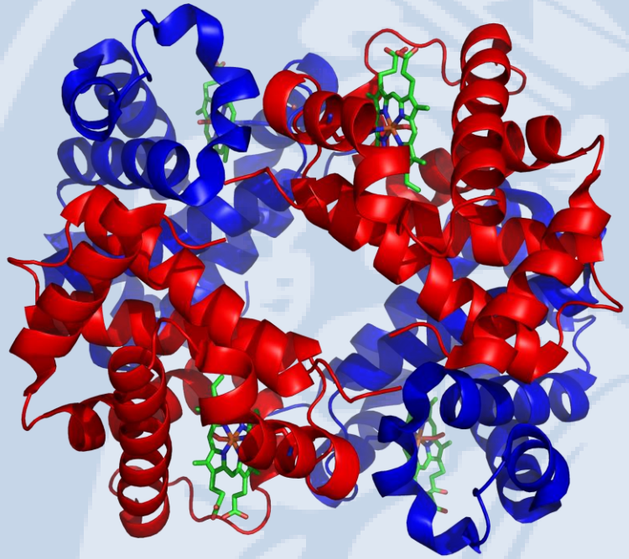
Retrospective review EOS

- -23% prevalence elevated Hgb
- -Significant treatment effect w/ rib based growing construct (n=85)
- -No treatment effect for GR patients (n=53)

Skaggs JPO 2016:

Retrospective review GR patients (n=66)

- -15% elevated Hgb prevalence (z>2)
- -Improved with surgery



Other Surrogates…Hemoglobin

Prospective study of growth friendly implants

48/268 (18%) elevated Hemoglobin

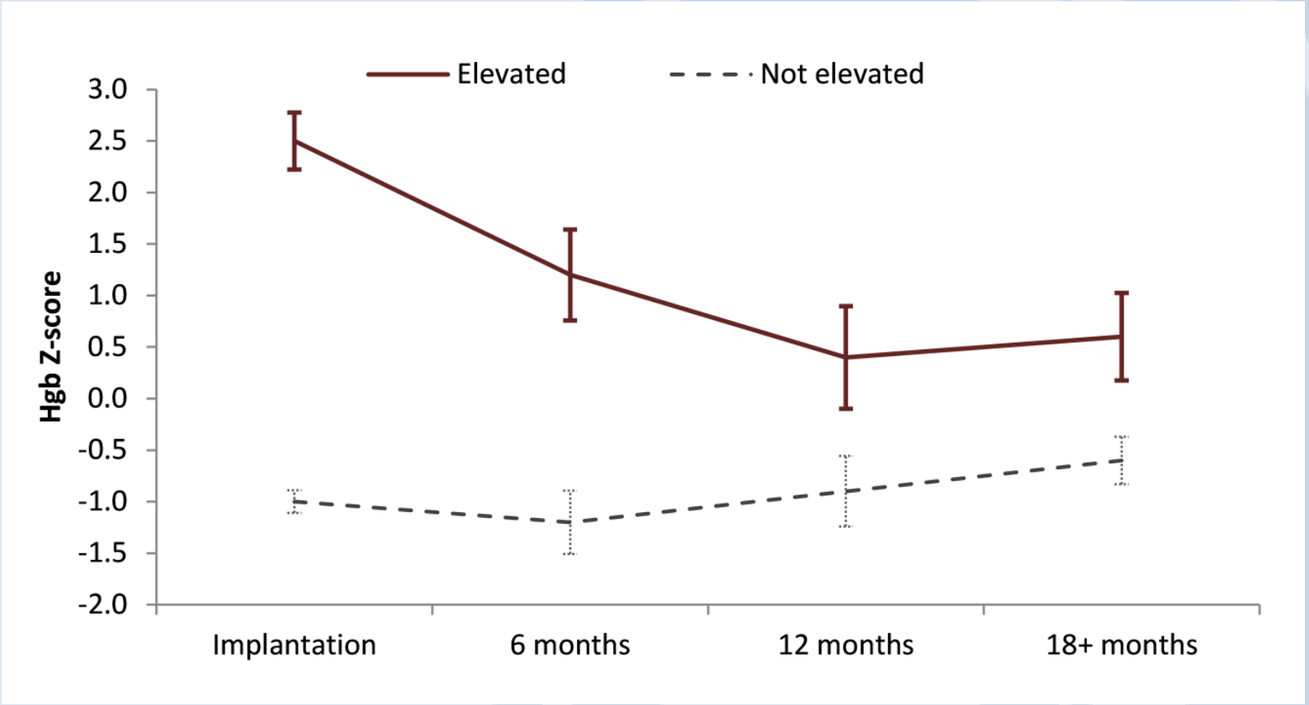
Other Surrogates…Hemoglobin

<u>Elevated Hgb preop:</u>

-Hgb decreases over time

<u>Normal Hgb preop:</u>

-No change in Hgb



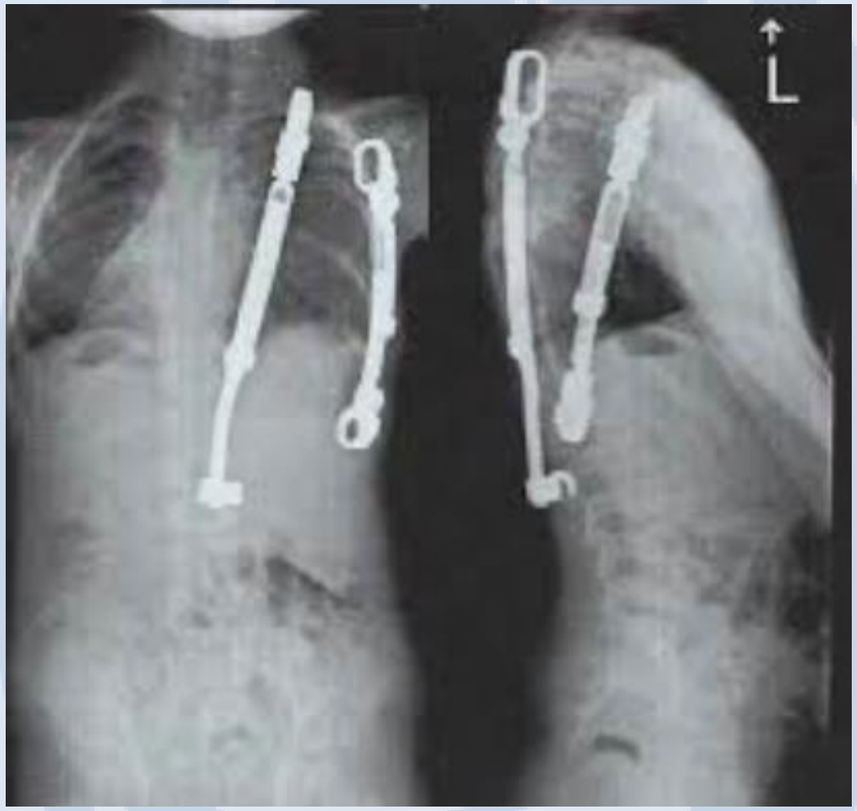
Other Surrogates…Hemoglobin

Elevated Hgb in small percentage (18%) of EOS

Respond to treatment when elevated

Useful in subset of younger, sicker patients?

Are there better surrogates?



Functional Outcomes: EOSQ

EOSQ has functional domains

Early experience

Hidden within larger scale

Daily Living: During the past 4 wk

11. How difficult has it been for your child to dress him/herself or assist with dressing? (examples: helping remove/putting-on clothing, pushing arms and legs through shirts and pants, or assisting with fasteners, zippers, snaps, buttons, velcro)

Difficult	Somewhat difficult	Neutral	Somewhat easy	Easy

12. My child needs more time than a healthy child to eat the same amount of food.

Strongly agree	Inclined to agree	Neither	Inclined to disagree	Strongly disagree

Physical Function: During the past 4 wk

8. How difficult has it been for your child to move his/her upper body?

Difficult	Somewhat difficult	Neutral	Somewhat easy	Easy

9. How difficult has it been for your child to sit up on his/her own?

Difficult	Somewhat difficult	Neutral	Somewhat easy	Easy

10. How difficult has it been for your child to keep his/her balance while crawling, walking, or running?

Difficult	Somewhat difficult	Neutral	Somewhat easy	Easy

Fatigue/Energy Level: During the past 4 wk

13. How often has your child had fatigue?

All of the time	Most of the time	Some of the time	A small amount of the time	None of the time

14. How difficult has it been for your child to keep up his/her energy all day?

Difficult	Somewhat difficult	Neutral	Somewhat easy	Easy

ORIGINAL ARTICLE

Measuring Quality of Life in Children With Early Onset Scoliosis: Development and Initial Validation of the Early Onset Scoliosis Questionnaire

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HARVARD MEDICAL SCHOOL TEACHING HOSPITAL

Functional Outcomes in EOS… The Extent of the Literature

Growing rods vs Brace

EOIS

ASKp (Activities Scale for Kids performance)

GR reduction in activity and participation

Brace no change in activity and participation

Table II. Activity and participation and pain outcomes over the 1-year study period

Outcome measures	Brace group (n = 30)	Growth rod group (n = 30)
Activity and participation (mean score with range)		
ASKp at beginning	91.7 (80-100)	91.2 (78-100)
ASKp at 1 y	91.5 (83-100)	88.1 (81-100)*
Pain (No./%)		
Spinal pain at start		
None	26 (87%)	27 (90%)
Very mild or mild	4 (13%)	2 (7%)
Moderate, severe, or very severe	0 (0%)	1 (3%)
Spinal pain at 1 y		
None	26 (87%)	24 (80%)
Very mild or mild	4 (13%)	5 (17%)
Moderate, severe, or very severe	0 (0%)	1 (3%)

*Significant difference $P < .01$.

THE JOURNAL OF PEDIATRICS • www.jpeds.com ORIGINAL ARTICLES

Do Growing Rods for Idiopathic Early Onset Scoliosis Improve Activity and Participation for Children?

Mathew David Sewell, FRCS[1], Johnson Platinum, MRes[1], Geoffrey Noel Askin, FRACS[2], Robert Labrom, FRACS[2], Mike Hutton, FRCS[3], Daniel Chan, FRCS[3], Andrew Clarke, FRCS[3], Oliver M. Stokes, FRCS[3], Sean Molloy, FRCS[4], Stewart Tucker, FRCS[4], and Jan Lehovsky, FRCS[4]

Functional Outcomes…Graduates

Oxygen consumption testing

Submaximal graded exercise test

12 EOS Graduates

- PFTs showed compromise
- Keep up with peers with daily exercise

Can’t use in young kids….

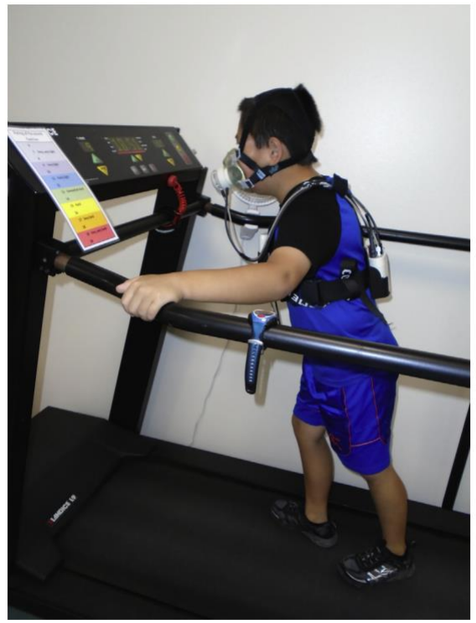

Fig. 1. A patient with EOS completing the graded exercise testing protocol.

Spine Deformity
www.spine-deformity.org

Spine Deformity 4 (2016) 413–419

Exercise Tolerance in Children With Early Onset Scoliosis: *Growing Rod Treatment “Graduates”*

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Received 3 March 2016; revised 27 June 2016; accepted 29 June 2016

EOS Outcomes: ICEOS 2017

Still searching for better outcome measures!

Classification of Early Onset Scoliosis (C-EOS) and Pulmonary Function Outcomes

Summary
Etiology of early onset scoliosis as described by C-EOS does not predict pulmonary function. Further study is required to provide granularity with regard to specific C-EOS classifications.

Pre-operative Six Minute Walk Performance in Children with Congenital Scoliosis

Summary
The 6 minute walk (6MW) correlates with age and inversely with the Cobb angle for patients with congenital scoliosis prior to spine surgical intervention. All had low 6MW values compared to age-matched norms. 6MW is useful as a serial measure of functional status for each patient over time.

Conclusions

Conclusions

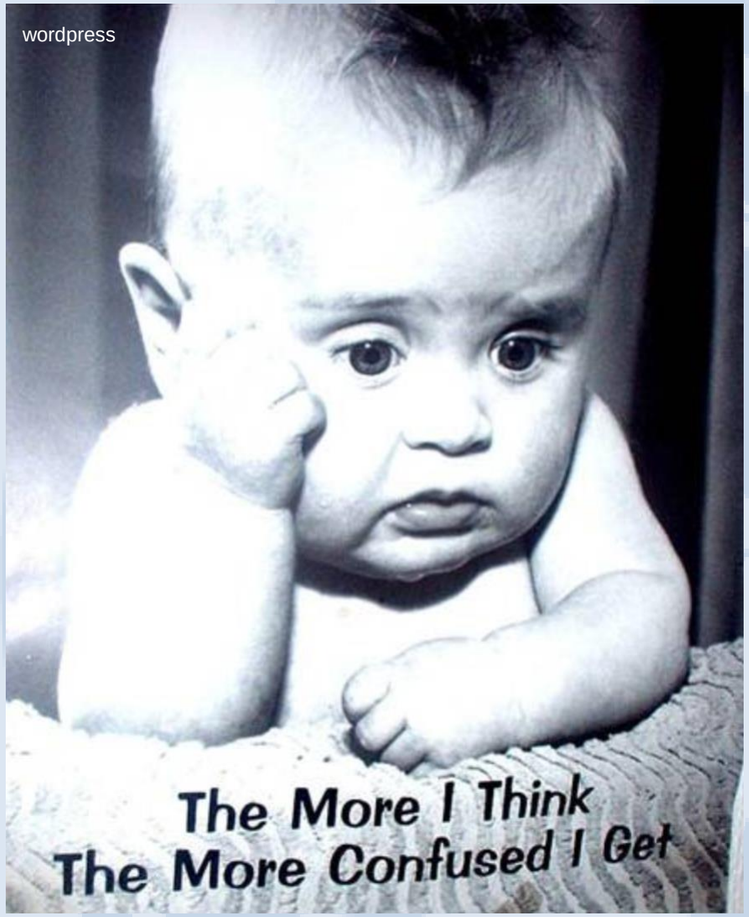
How do we define outcome?

- At best we have a bunch of surrogates
- Probably involves some combination
- May be different for different populations

We make children different (taller, straighter)

…….but better?

We are still searching!



Thank you!