How Do We Measure Outcomes In NM EOS?

Michael Glotzbecker MD

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Rainbow Babies and Childrens Hospital

University Hospitals

Rainbow Babies & Children's Hospital

Disclosures

None related to this talk

Speaker: Depuy/Synthes, Zimmer/Biomet, Nuvasive, Medtronic

Member : PSSG, HSG

Consultant: Nuvasive, Orthobullets

Equity: Orthobullets

Outline

Challenges unique to NM EOS

What are *Goals*?

Outcomes:

- Pulmonary
- Radiographic
- Quality of life
- Surrogates for above?

Why Is It So Challenging?

What Are The Challenges of EOS?

Lung development/pulmonary function

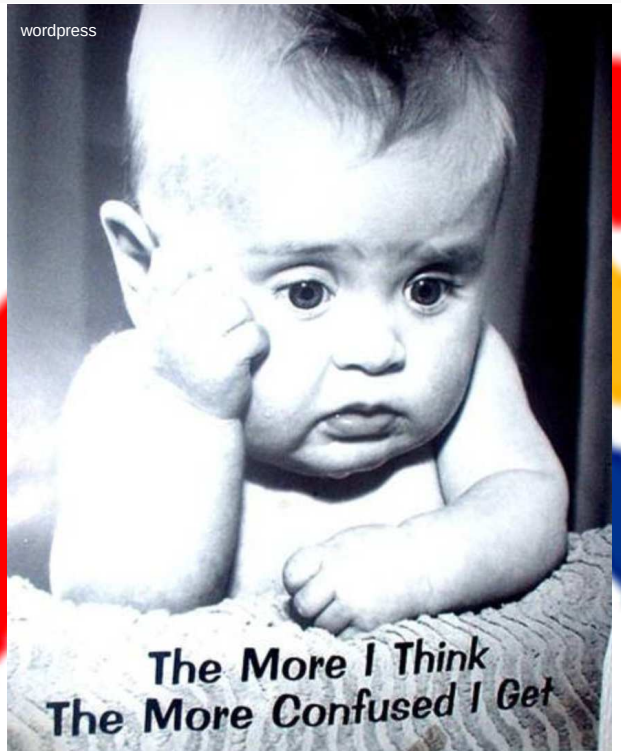
Nutritional status

Bone quality/fixation

Kyphosis/PJK

Medical co-morbidities

Others…….



What Are The Challenges of NM Scoliosis?

Lung development/pulmonary function

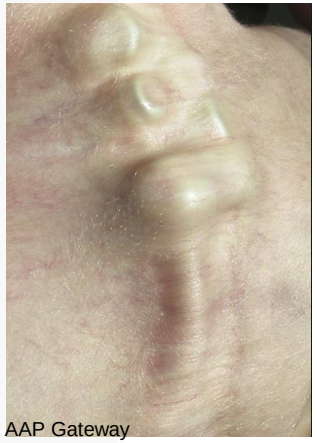
Nutritional status

Bone quality/fixation

Kyphosis/PJK

Medical co-morbidities

Others….



AAP Gateway

UT Southwestern

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What Challenges Are The With NM EOS?

Lung development/pulmonary function

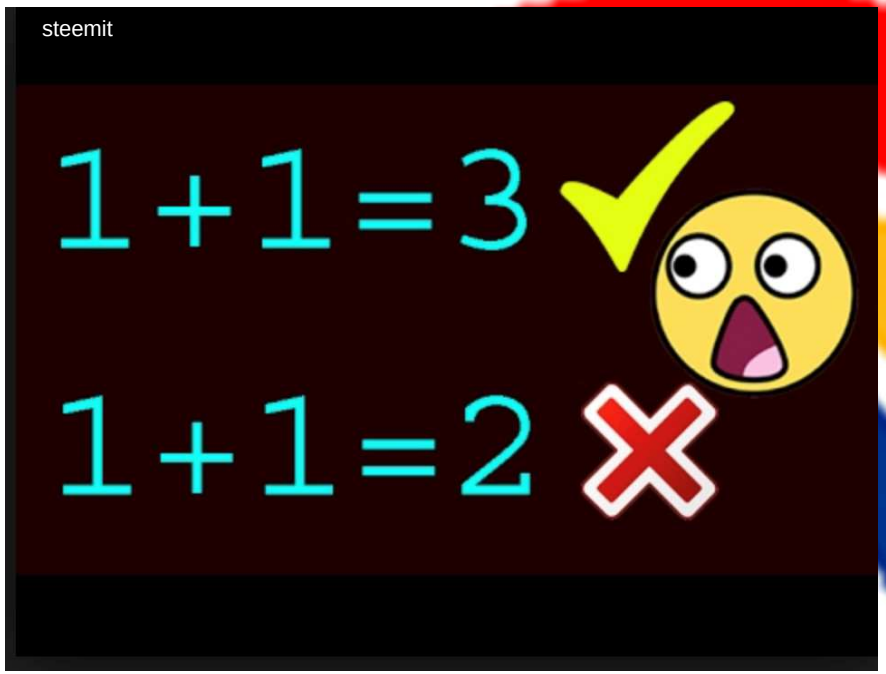
Nutritional status

Bone quality/fixation

Kyphosis/PJK

Medical co-morbidities

Others…..



Complications Will Happen

Failure to prepare is preparing to fail.

Benjamin Franklin

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Growth Friendly=Complications =Outcome?

- Rod breakage
- Loss of fixation
- Implant prominence
- Infection
- PJK/DJK
- Curve progression
- Autofusion

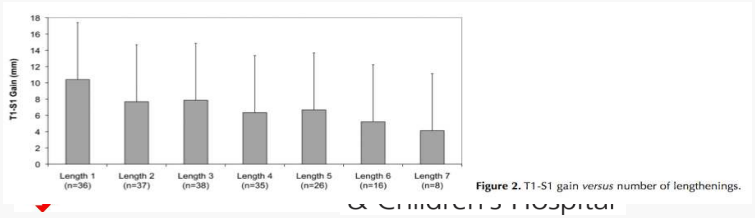
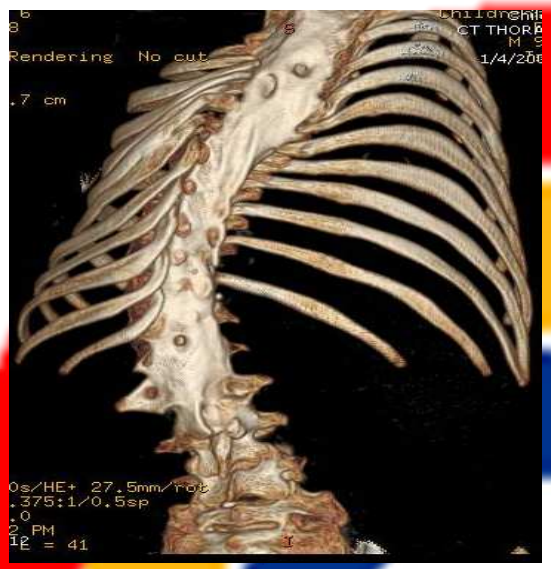


Figure 2. T1-S1 gain *versus* number of lengthenings.



Complications of Growing-Rod Treatment for Early-Onset Scoliosis: Analysis of One Hundred and Forty Patients

Bess, Shay, MD[1]; Akbarnia, Behrooz A., MD[2]; Thompson, George H., MD[3]; Sponseller, Paul D., MD[4]; Shah, Suken A MD[5]; El Sebaie, Hazem, FRCS, MD[6]; Boachie-Adjei, Oheneba, MD[7]; Karlin, Lawrence I., MD[8]; Canale, Sarah, BS[2]; Poe-Kochert, Connie, RN, CNP[3]; Skaggs, David L., MD[9]

JBJS: November 3, 2010 - Volume 92 - Issue 15 - p 2533-2543

Spine

DEFORMITY

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

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

Treatment occurs during growth

- Especially rapid spine growth

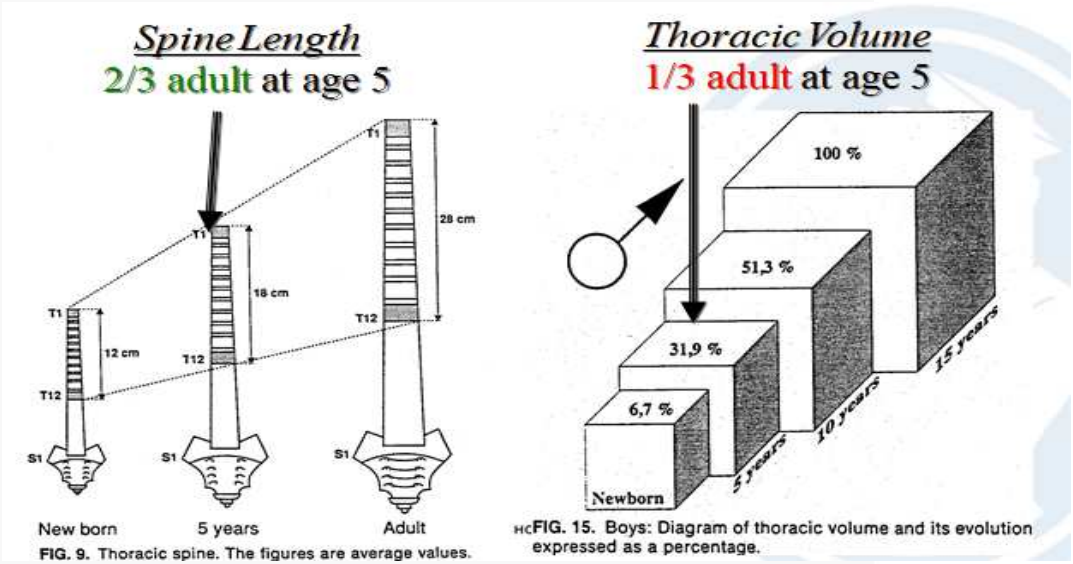


FIG. 9. Thoracic spine. The figures are average values.

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

Journal of Pediatric Orthopaedics Part B
3:102-107 © 1993 Raven Press, Ltd., New York

Growth of the Spine Before Age 5 Years

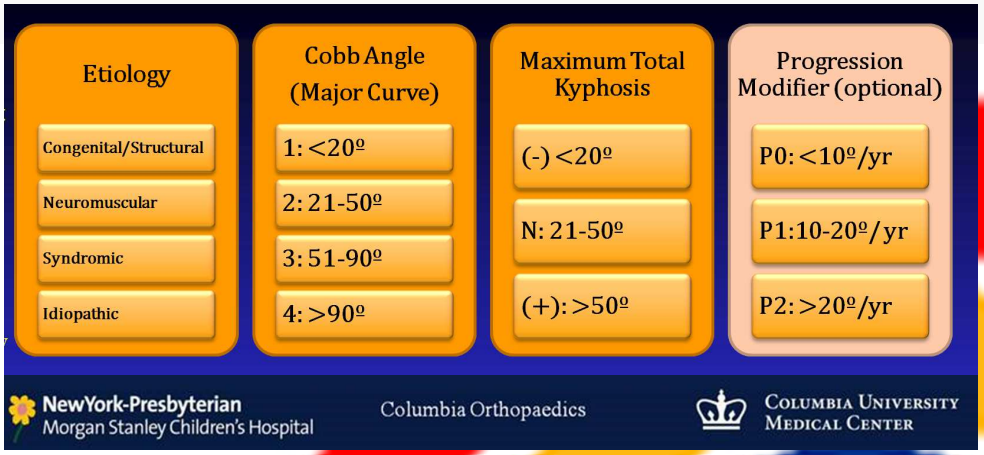
A. Dimeglio, M.D.

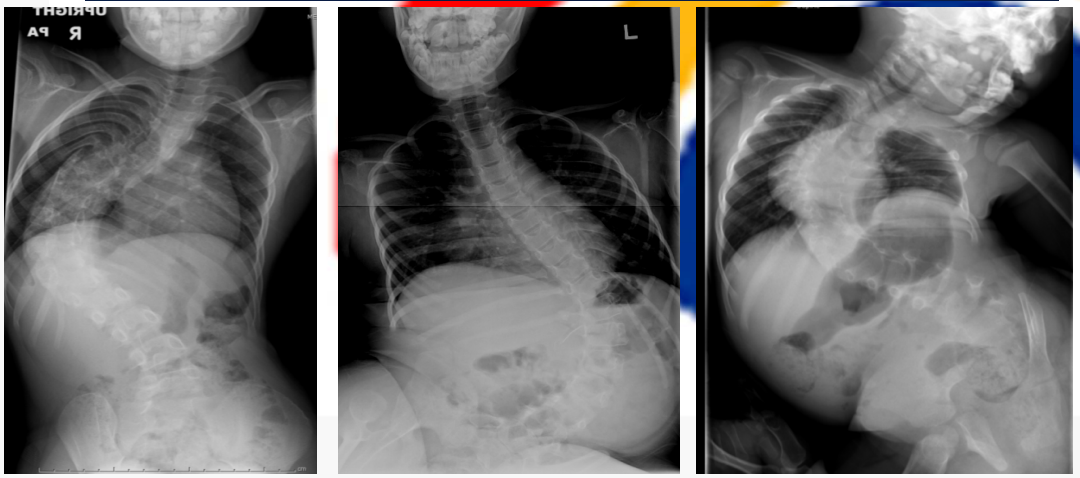
Rainbow Babies
Children's Hospital

EOS/NM EOS Diversity

Diverse population

Various etiologies





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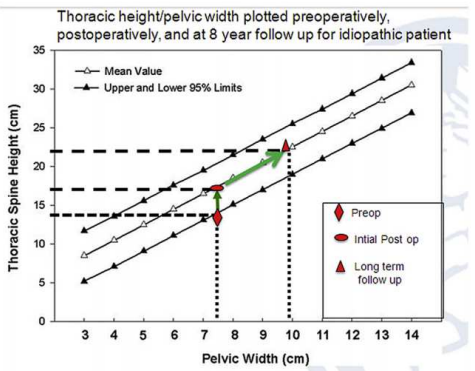
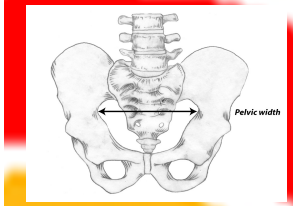
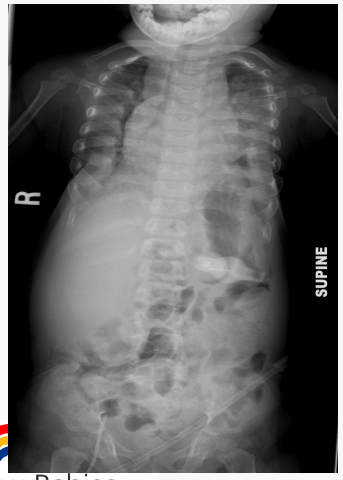
Obstacles To Measuring Outcomes In EOS
Why Is It So Hard?

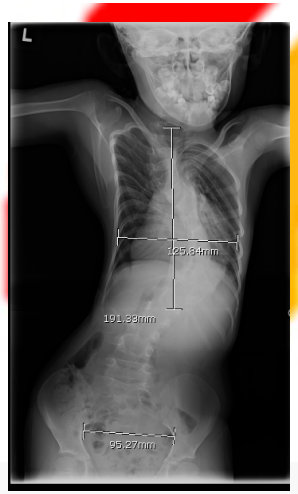
Variable diagnoses

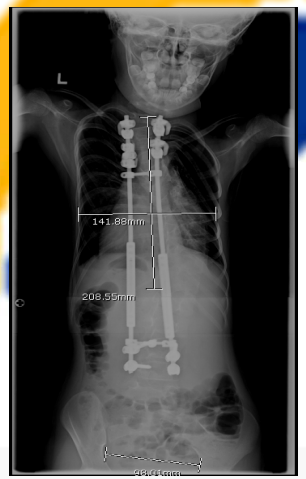
- Different skeletal structures
- Abnormal growth rates





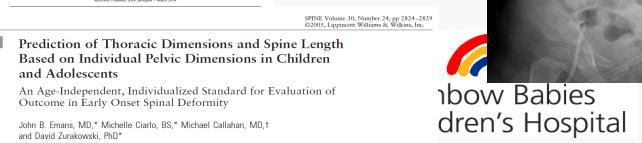







Spine Deformity

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


Prediction of Thoracic Dimensions and Spine Length Based on Individual Pelvic Dimensions in Children and Adolescents

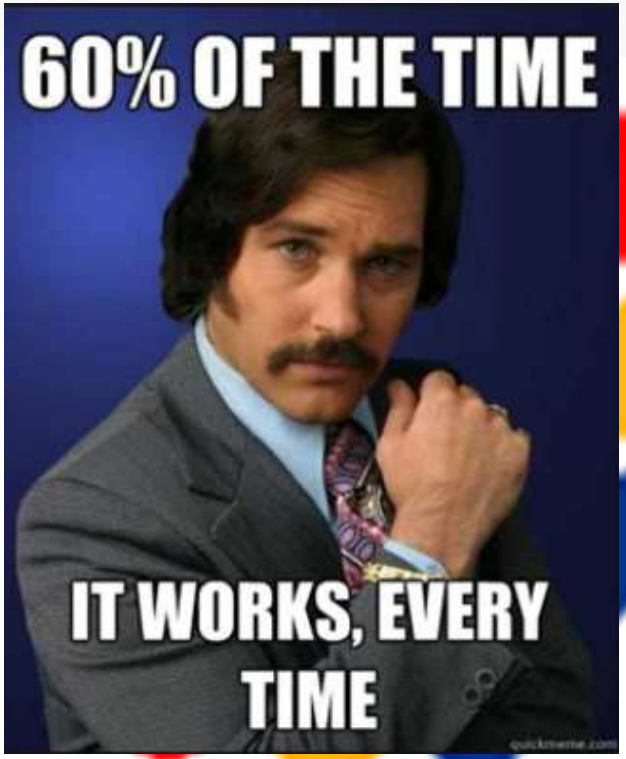
An Age-Independent, Individualized Standard for Evaluation of Outcome in Early Onset Spinal Deformity

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

bow Babies
dren's 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

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 R. Willey-Courand, MD, Murry Kim, MS, Ricardo E. Pinero, MD, Marion 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

What Are Goals?

Achieving Goals=Outcome, Right?

What do we think is important?

- Maximum spine length, residual mobility
- Maximum chest size/function
- Minimum surgeries, hospitalizations
- Minimum complications
- Sitting balance
- Functional outcomes?
- Quality of Life

Recovery Goals Vary By Diagnosis

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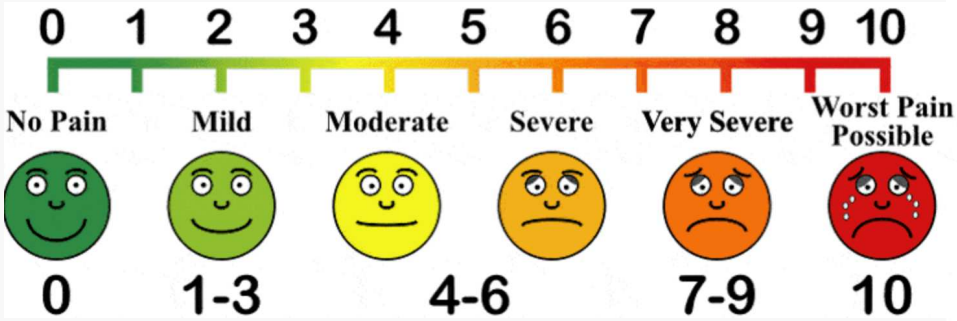
Assessing Pain Varies By Age/Diagnosis



Faces Legs Activity Cry Consolability Revised Scale (FLACC-R)

Categories	0	1	2
Face	No particular expression or smile	Occasional grimace or frown, withdrawn, disinterested, **sad, appears worried**	Frequent to constant quivering chin, clenched jaw, **distressed looking face, expression of fright/panic**
Legs	Normal position or relaxed, **usual tone & motion to limbs**	Uneasy, restless, tense, **occasional tremors**	Kicking, or legs drawn up, **marked increase in spasticity, constant tremors, jerking**
Activity	Lying quietly, normal position, moves easily, **regular, rhythmic respirations**	Squirming, shifting back and forth, tense, **tense/guarded movements, mildly agitated, shallow/splinting respirations, intermittent sighs**	Arched, rigid or jerking, **severe agitation, head banging, shivering, breath holding, gasping, severe splinting**
Cry	No cry (awake or asleep)	Moans or whimpers; occasional complaint, **occasional verbal outbursts, constant grunting**	Crying steadily, screams or sobs, frequent complaints, **repeated outbursts, constant grunting**
Consolability	Content, relaxed	Reassured by occasional touching, hugging or being talked to, distractible	Difficult to console or comfort, **pushing caregiver away, resisting care or comfort measures**

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Pediatric Spine Surgery: Common Concerns

Pain management

Infection/complication prevention

Nutrition

Activity restrictions

etc…

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How Can We Measure Outcomes?

Pulmonary Function

Gold standard?

PFTs difficult in NM and 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.

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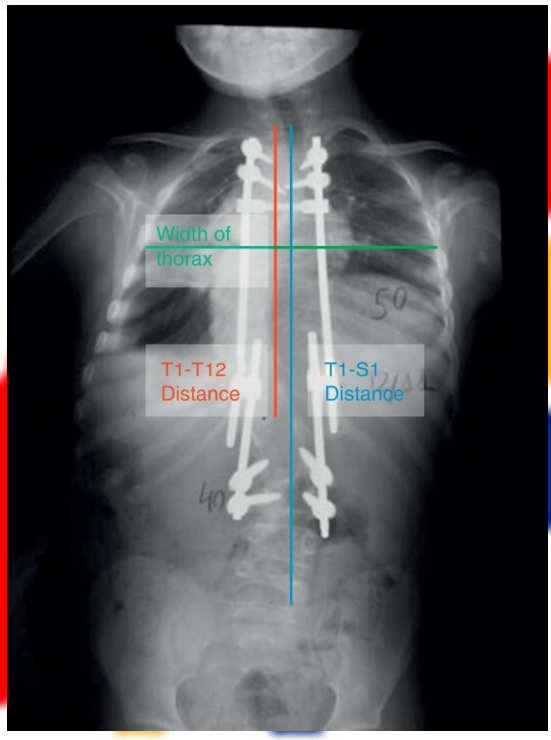
Radiographic-Traditional Measurements

Traditional study group measurements

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



Advantages

- Easily available

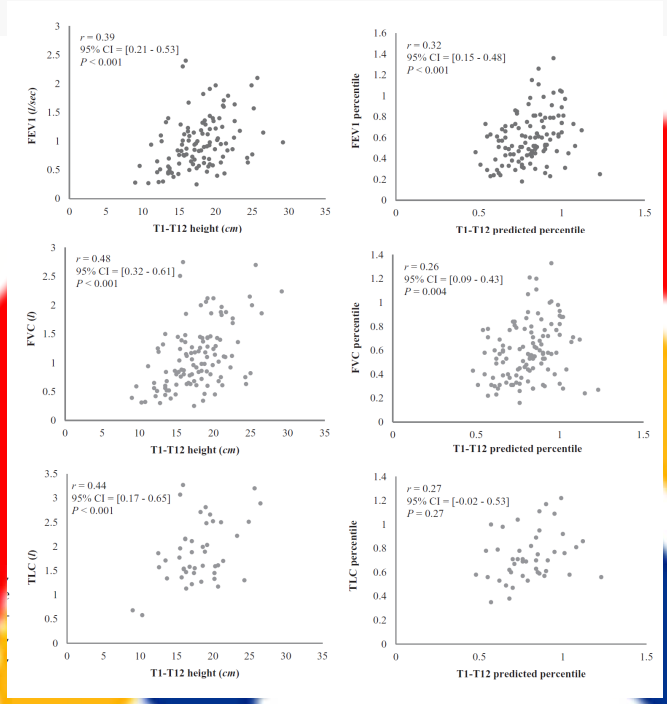
Disadvantages

- 2D, static, not normalized to growth

Do 2D Measurements Correlate With Pulmonary Function?

2D measurements correlate poorly w/ PFTs

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



Spine
DEFORMITY
SPINE Volume 39, Number 19, pp 1590-1595
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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*

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Radiographic-Better Measurements?

True spine length?

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

More accurate…but better?

- Still a static measure

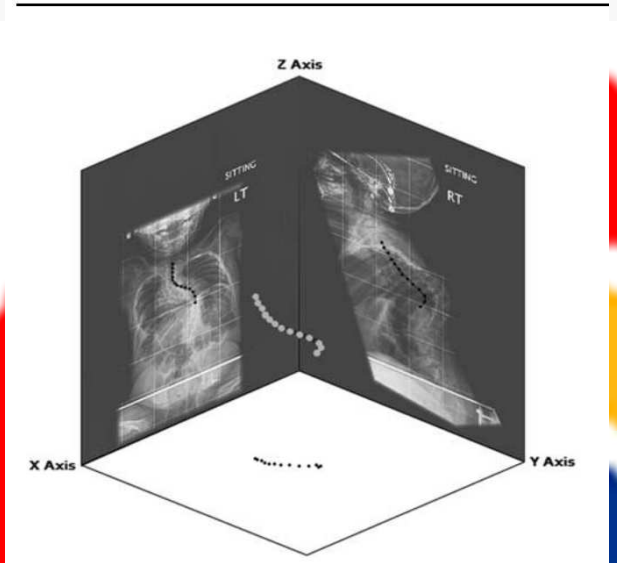

FIGURE 3. Graphical representation of how the 3-dimensional true spine length measurement is generated from the 2 curved measurements from the orthogonal coronal and sagittal radiographs.

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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)*†‡*

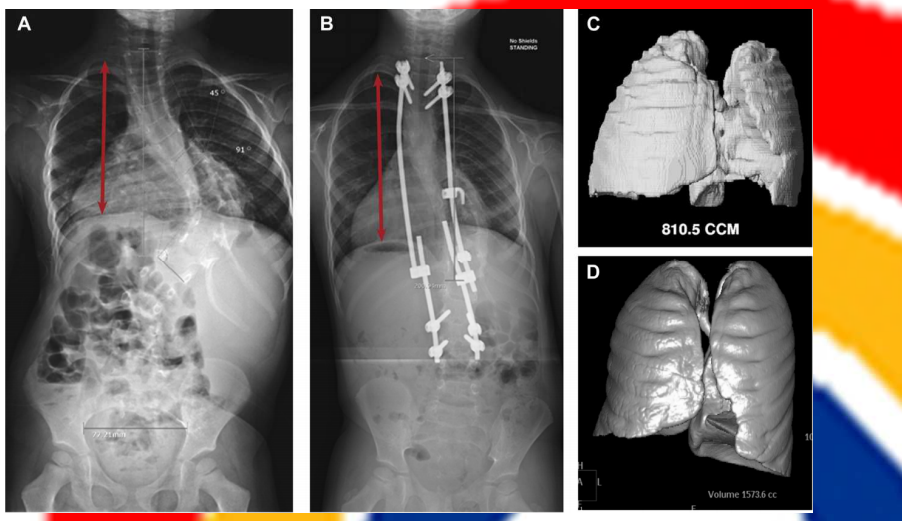
Is 3D Better?

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

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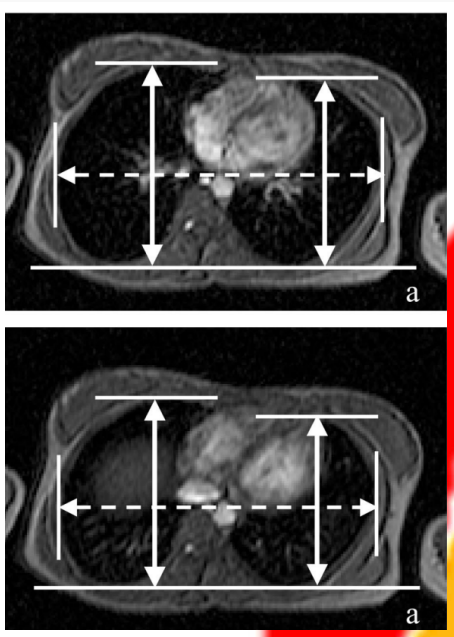
Dynamic 3D MRI

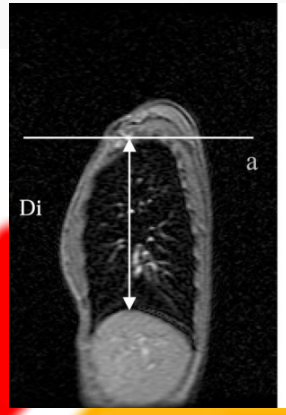
Advantages

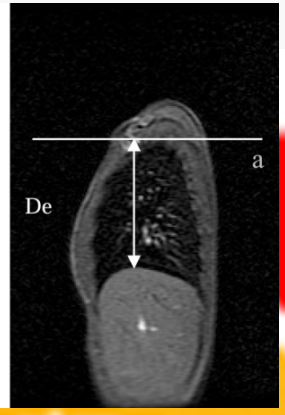
- Dynamic
  - Chest wall
  - Diaphragm

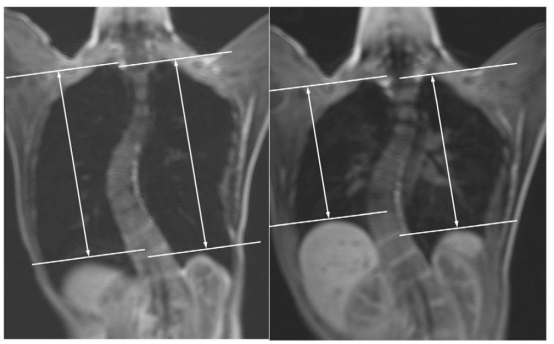
Disadvantages

- Early experience
- Sedation concerns









J Pediatr Orthop. 2018 Sep 20. doi: 10.1097/BPO.0000000000001258. [Epub ahead of print]

Understanding Respiratory Restrictions as a Function of the Scoliotic Spinal Curve in Thoracic Insufficiency Syndrome: A 4D Dynamic MR Imaging Study.

Udupa JK[1], Tong Y[1], Capraro A[2], McDonough JM[2], Mayer OH[2], Ho S[2], Wileyto P[3], Torigian DA[1], Campbell RM Jr[2].

Author information

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 296–302
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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[3] and Jack CY Cheng[2]

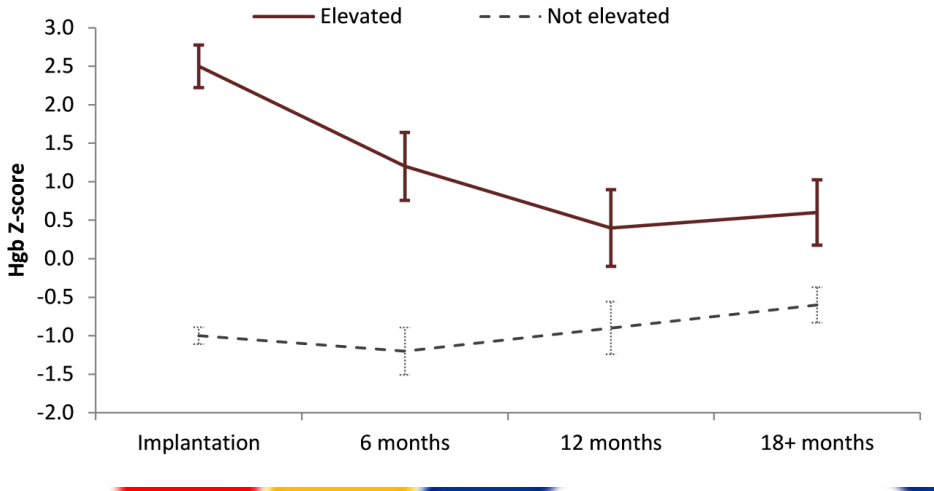
Hemoglobin

Elevated Hgb preop (15-23%):

-Hgb decreases w/ treatment

Normal Hgb preop:

-No change in Hgb



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Emans et al, Skaggs et al, Glotzbecker et al

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?

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CHILDREN'S SPINE STUDY GROUP

QOL (EOSQ-24)

Early Onset Scoliosis Questionnaire

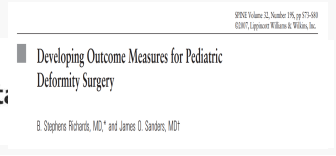
Domains Tested
General health
Pain/Fatigue
Pulmonary function
Transfer
Physical function
Daily living
Fatigue/Energy level
Emotion
Parental Burden
Financial Burden

Advantages:

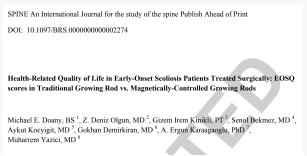
- Good to excellent agreement
- Correlated with PFTs

Disadvantages:

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


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 [1], Senol Bekmez, MD [4], Aykut Kocyigit, MD [2], Gokhan Demirkiran, MD [4], A. Ergun Karaagaoglu, PhD [3], Muharrem Yazici, MD [1]


1036

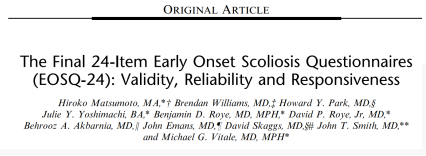
Functional and Radiographic Outcomes Following Growth-Sparing Management of Early-Onset Scoliosis

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

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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, MA,*† David P. Roye, Jr, MD,*† and Michael G. Vitale, MD, MPH*†

Quality of Life

No studies assessing QOL in NM EOS

Parent reporting bias

- Guilt of putting patient through procedure
- Clouds outcomes in NM scoliosis

What About Function?

What Abut Function?

Oxygen consumption testing

6 minute walk test

EOSQ functional domains

ASKp (Activities Scale for Kids performance)

Challenges in:

- Young kids
- Neuromuscular

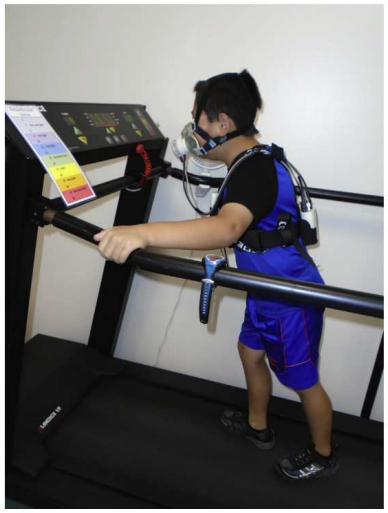

Fig. 1. A patient with EOS completing the graded exercise testing protocol.

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.

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[3], Stewart Tucker, FRCS[3], and Jan Lehovsky, FRCS[3]

Spine Deformity

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

Kelly A. Jeans, MS*, Charles E. Johnston, MD, Wilshaw R. Stevens, Jr. BS, Dong-Phuong Tran, MS

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!