UMC Utrecht

Growth as outcome for growth friendly systems

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Surgical treatment of early onset scoliosis (EOS).

- One of the biggest challenges for pediatric spine surgeons is the surgical treatment of early onset scoliosis (EOS)

- When the spine is corrected and fused during growth, a disproportionately short trunk can result in lung and thoracic wall deficiency

- Current surgical treatments allow for growth of the spine while correcting the scoliosis

Main growth friendly techniques

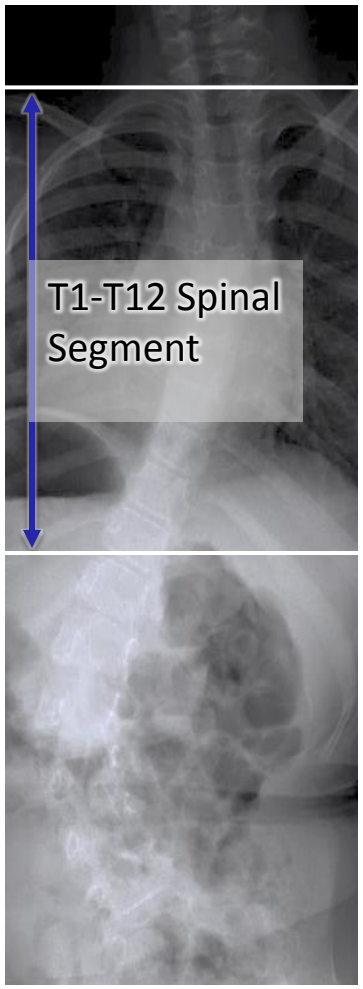
- Distraction based techniques
  - Traditional growing rods (TGR)
  - Vertical expandable prosthetic titanium rib expansion technique (VEPTR)
  - Magnetically controlled growth rods (MCGR)

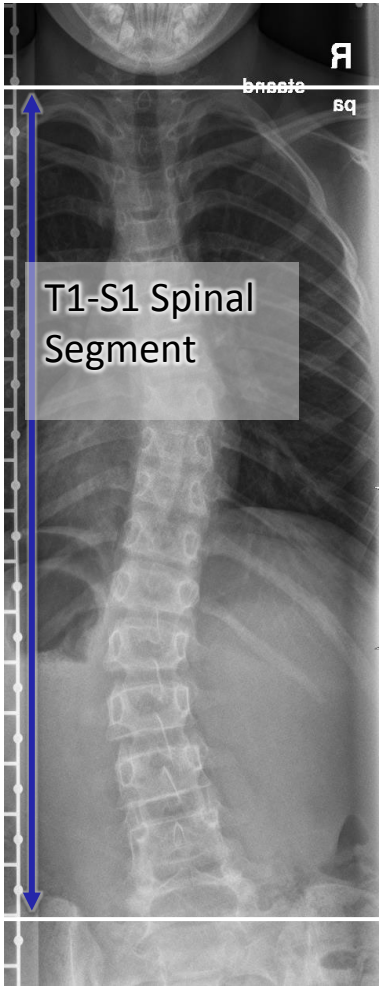
- Growth guidance procedures
  - Luque-trolley trolley
  - Shilla

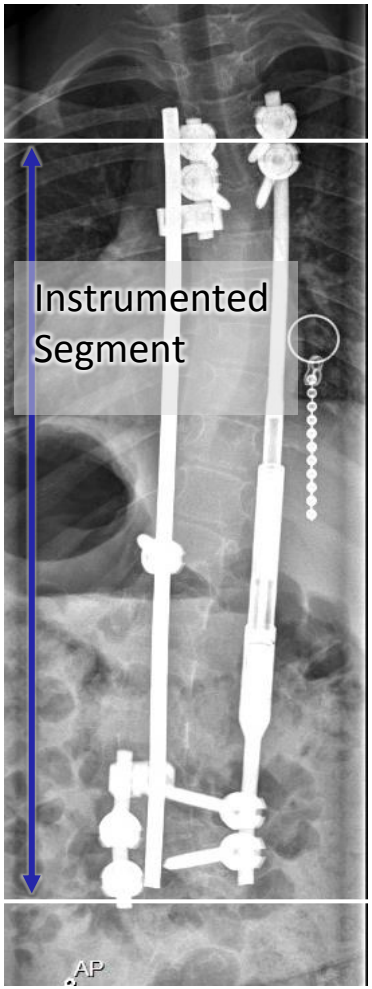
Growth as an outcome

- How do we measure spinal growth
  - What spinal segment is used?
  - What kind of measurement is used?
  - What time-frame is used ?
- What is normal spinal growth
  - What is the spinal growth in a normal population?
  - What is the spinal growth in an idiopathic scoliotic population?

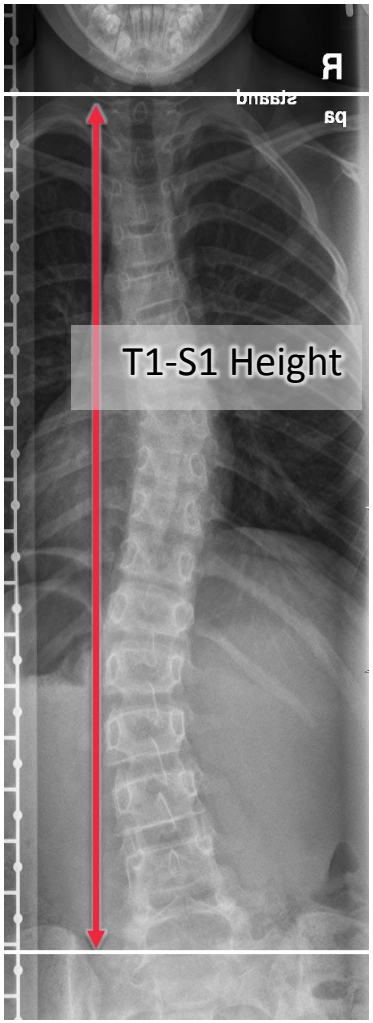
Spinal segments

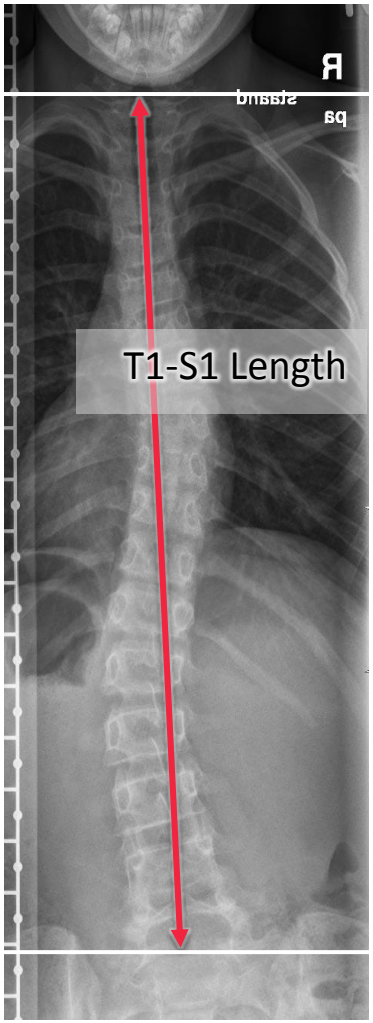


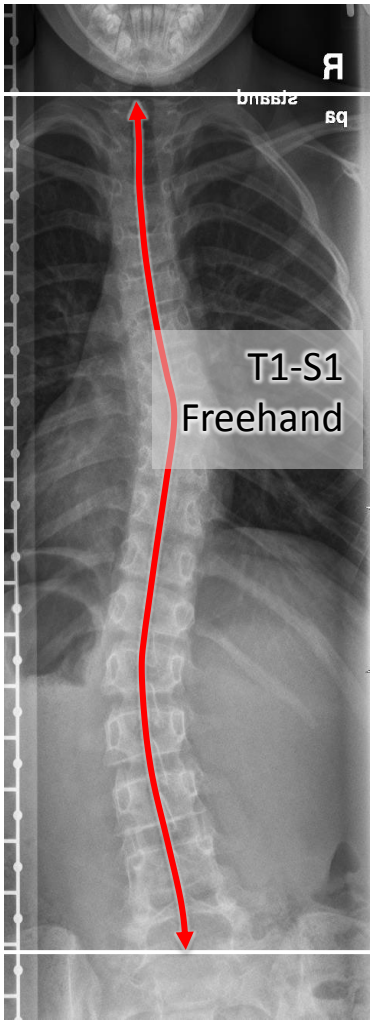




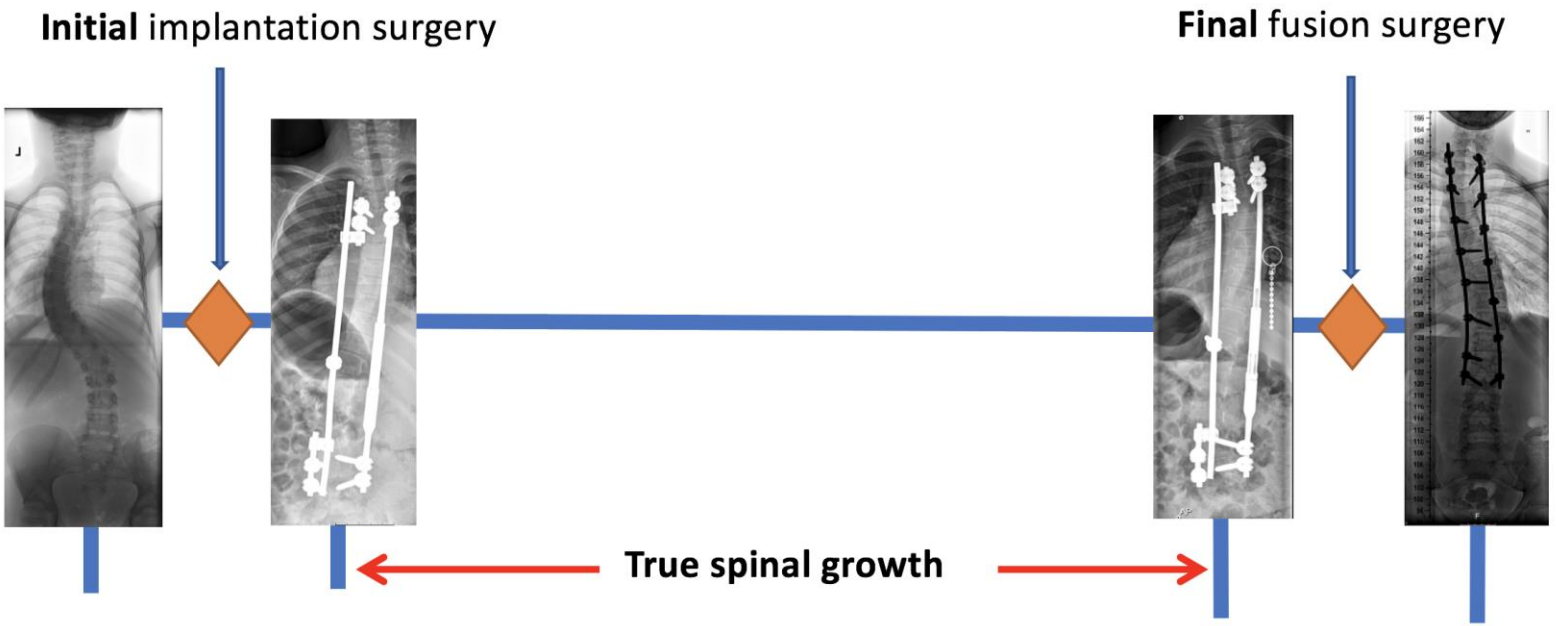
Different distances



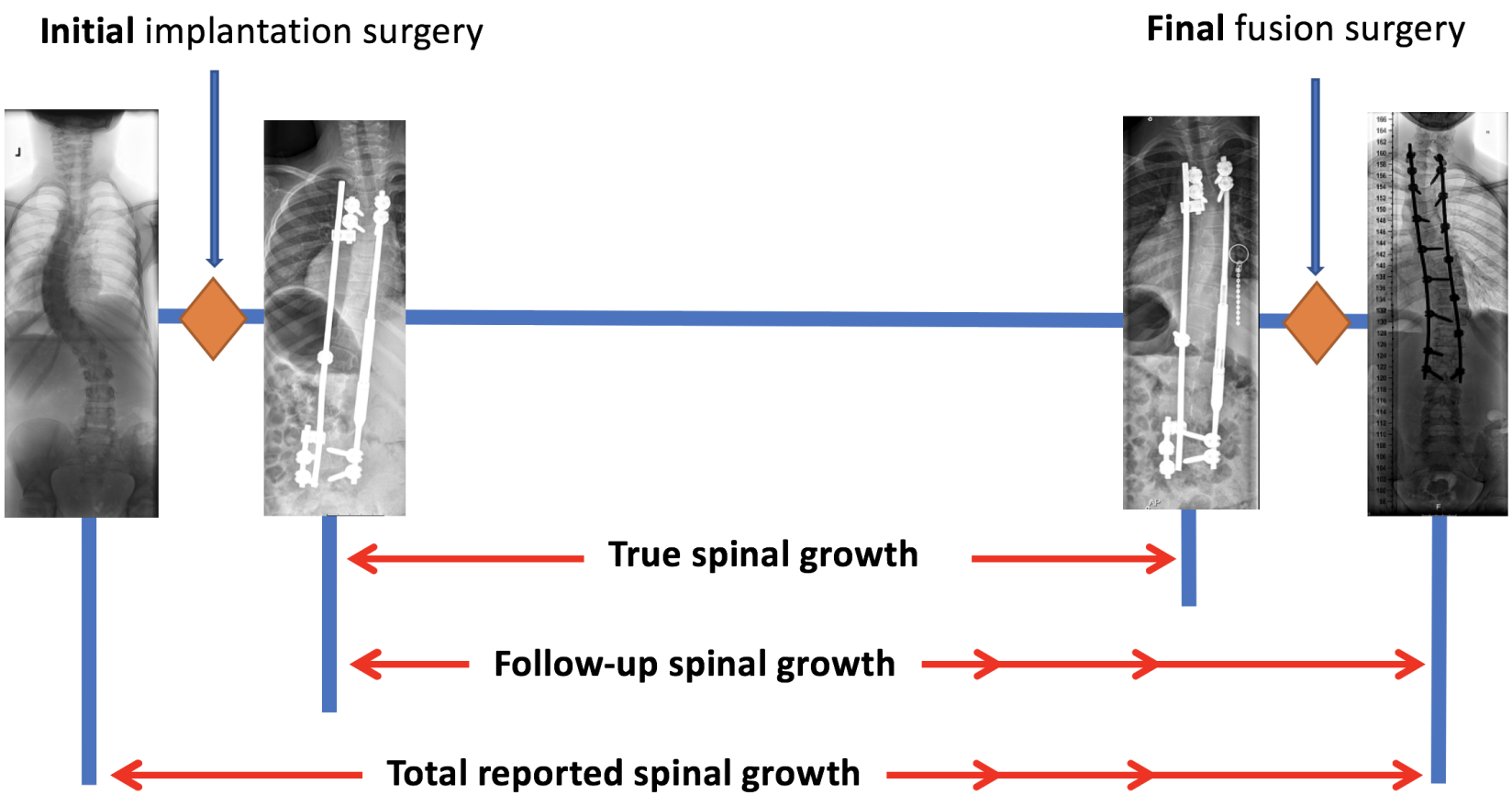




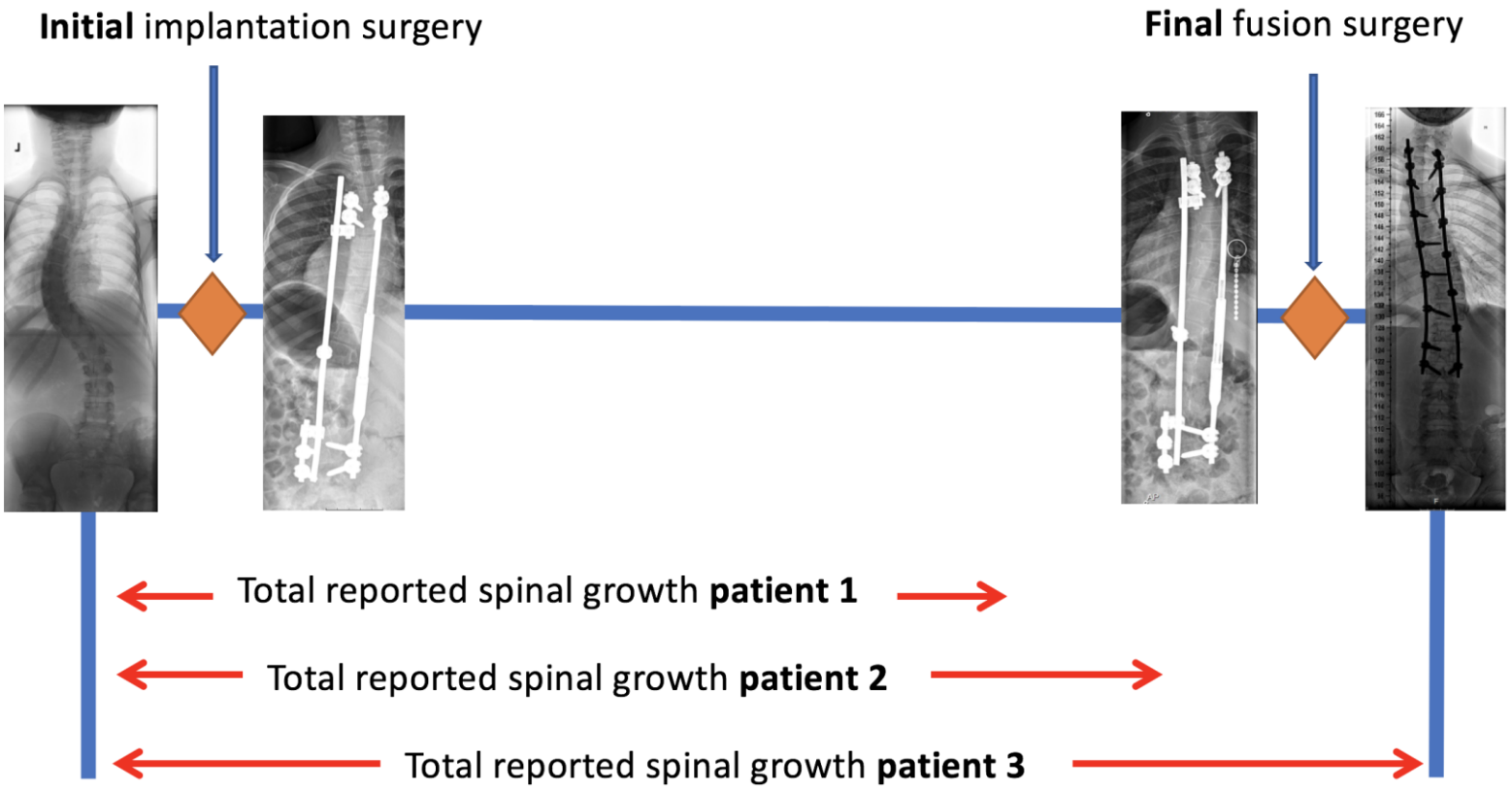
True growth of the system



Time frames


Initial implantation surgery
Final fusion surgery
True spinal growth
Follow-up spinal growth
Total reported spinal growth

Articles combine short follow-up, long follow-up and fusions



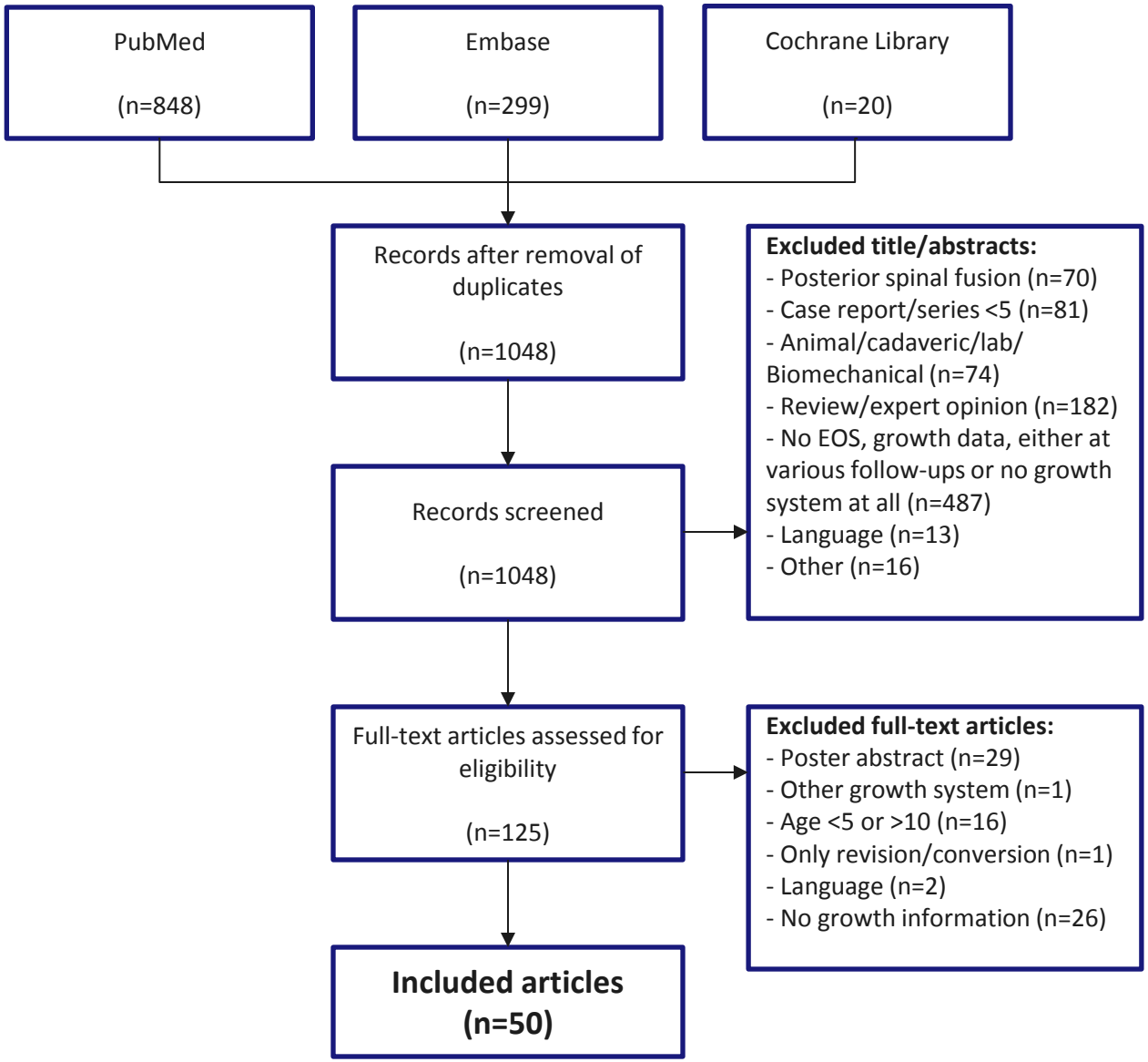
Methods

- Aim
  (1) Assess what outcome measurements are used
  (2) Identify the system that allows most length gain

- Extensive literature search with meta-analysis

- Only Included TGR, Shilla, VEPTR, MDGR or Luque systems
- Only included articles with average age of surgery between 5 and 10 years
- Weighted means were calculated for every outcome (based on included patients)

Systematic review



Results of the literature search

Number of articles per growth friendly system						
Systems	Traditional growing rod	MDGR	Luque	VEPTR	Shilla	Mixed treatment
Articles	24	12	4	6	1	3

Mixed treatment: Two articles compared Shilla with TGR and one article compared MCGR with TGR.

Segments measured

	Articles that only reported 1 segment		
Measurement	T1-S1	T1-T12	Instrumented length
Articles	21	2	5

	Articles that reported on 2 segments	
Measurement	T1-S1 and T1-T12	T1-S1 and instrumented length
Articles	15	7

None of the included articles reported on all 3 segments.

True growth rate

Four studies reported on graduates and the true growth rate in the T1-S1 segment[1-4]

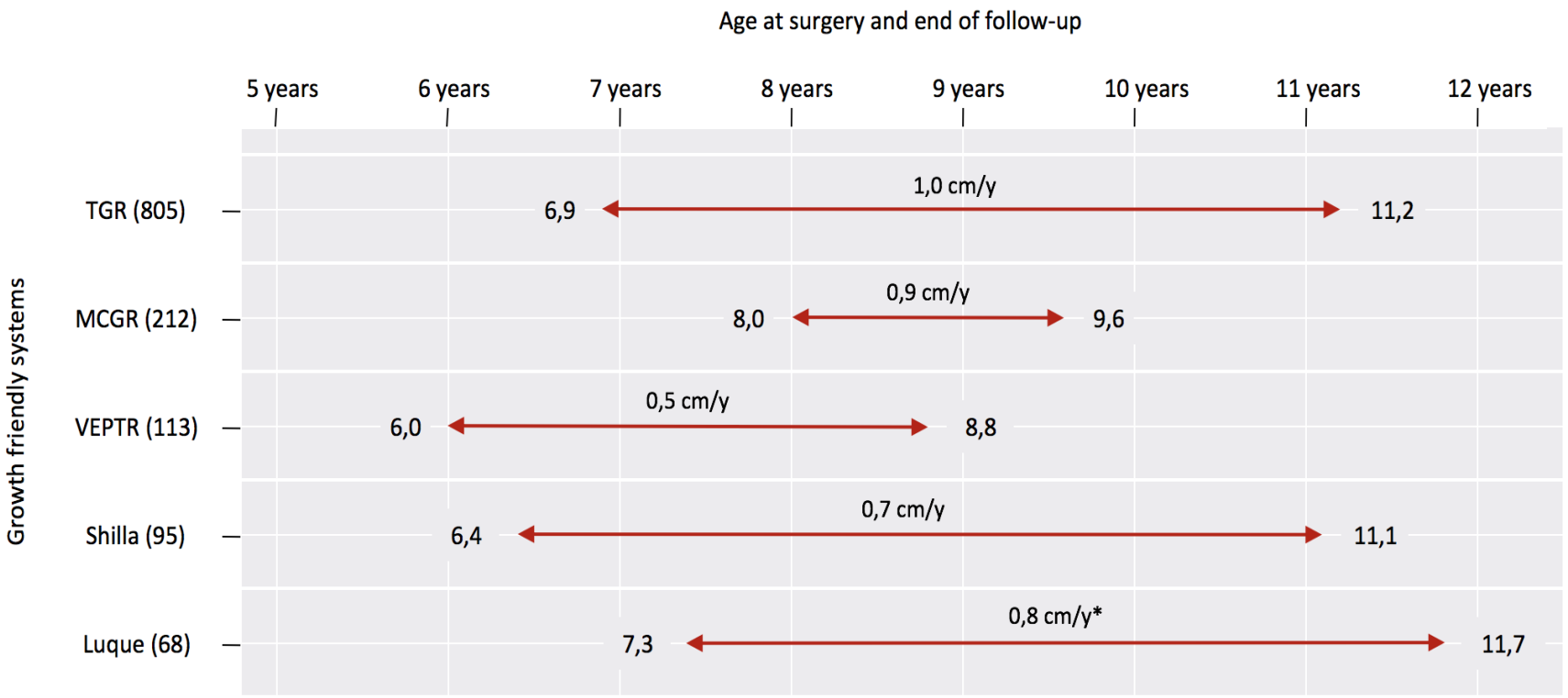
	True spinal growth in cm/year (Excluding initial and final fusion surgery)	
T1-S1	TGR (174)	0,6 [0,4-1,1]
T1-T12	TGR (110)	0,3
Instrumented	TGR (36)	0,9 [0,9-1,0]

1. Akbarnia 2005, 2. Thompson 2005, 3. Akbarnia 2008, 4. Upasani 2016

Remaining growth results

	Follow-up spinal growth in cm/year (Excluding initial surgery)		Total reported spinal growth in cm/year (Including initial surgery)	
T1-S1	TGR (799)	**1,0** [0,5-2,3]	TGR (663)	**1,8** [1,0-2,7]
	MCGR (212)	**0,9** [0,3-1,9]	MCGR (207)	**3,4** [1,5-5,5]
	VEPTR (113)	**0,5** [0,0-1,0]	VEPTR (125)	**1,9** [1,0-3,0]
	Shilla (76)	**0,7** [0,6-0,8]	Shilla (95)	**1,4** [1,4-1,6]
	Luque		Luque (47)	**1,8**
T1-T12	TGR (175)	**0,7** [0,2-1,5]	TGR (128)	**0,8** [0,7-1,1]
	MCGR (181)	**0,6** [0,2-1,2]	MCGR (116)	**2,4** [1,9-3,6]
	VEPTR (99)	**0,3** [0,2-0,6]	VEPTR (119)	**1,3** [0,6-2,1]
	Shilla (40)	**0,6**	Shilla (40)	**0,9**
	Luque		Luque	
Instrumented	TGR (135)	**1,0** [0,8-1,1]		
	MCGR (9)	**1,1**		
	VEPTR			
	Shilla			
	Luque (68)	**0,8** [0,3-1,0]		

Average age at start of treatment



Influence of cobb angle

Initial implantation surgery

- 32˚ COBB

+3,64 CM T1-S1 *

True Growth period

+15˚ COBB

+3,56 CM T1-S1

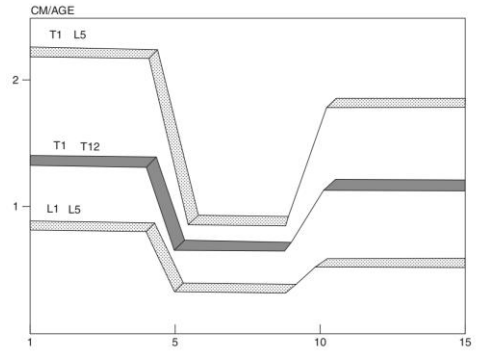
Final fusion surgery

-15˚ COBB

+2,33 CM T1-S1

The growing spine: how spinal deformities influence normal spine and thoracic cage growth

Alain Dimeglio · Federico Canavese



- T1-S1 Growth
  - First 5 years of life; **2 cm/year**
  - Between 5 and 10; **1 cm/year**
  - Between age 10 and skeletal maturity; **1.8 cm/year**

- T1-T12 growth
  - The first 5 years of life; **1,3** cm/year
  - Between 5 and 10; **0,7** cm/year
  - Between age 10 and skeletal maturity; **1,1** cm/year

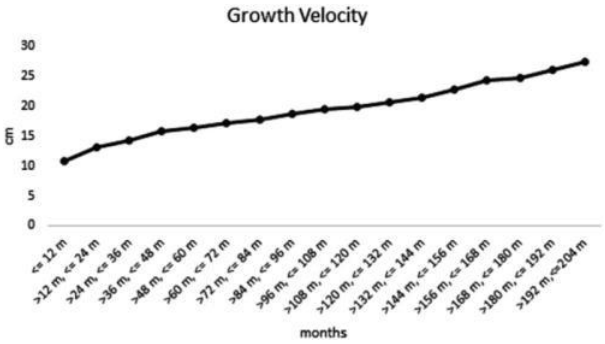
Thoracic Spine Growth Revisited

How Accurate Is the Dimeglio Data?

Ozgur Dede, MD,* Kadir Büyükdoğan, MD,† Halil Gökhan Demirkıran, MD,† Erhan Akpınar, MD,‡ and Muharrem Yazici, MD†

- Cross-sectional CT study in 133 patients (did not follow growth over time)

- T1-T12 growth
  - Between 1 and 4 years; **1.71** cm/year
  - Between 4 and 8 years; **0.55** cm/year
  - Between 8 and 10 years; **0.74** cm/year
  - Between 10 and 12 years; **0.69** cm/year
  - between 12 and 16; **1.61** cm/year



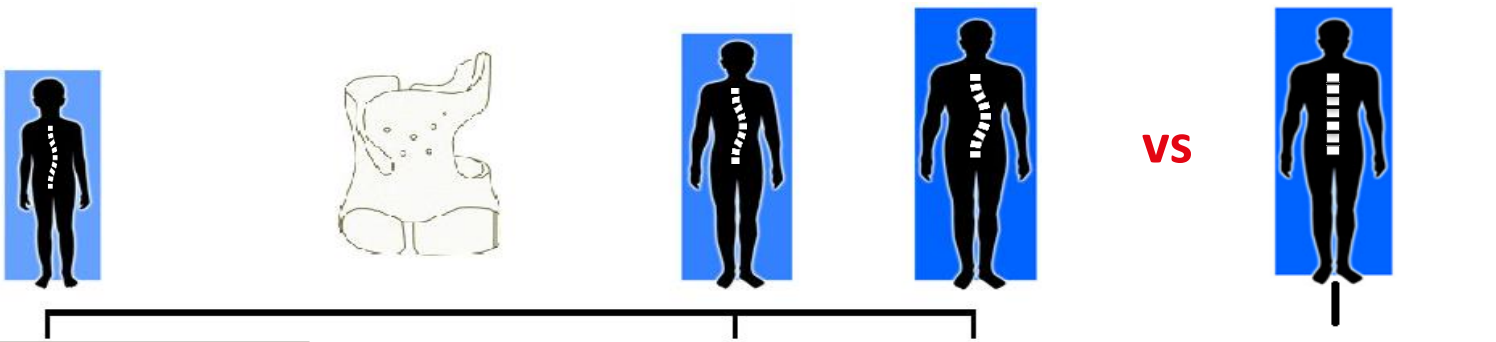
Growth in Boston Brace

- Selection of all JIS patients treated with Boston brace at OLVG
  - Ordered when a curvature was between 25˚ and 45˚
  - Worn > 20 hours a day
  - Radiographs present from before brace, after removal of brace and at skeletal maturity

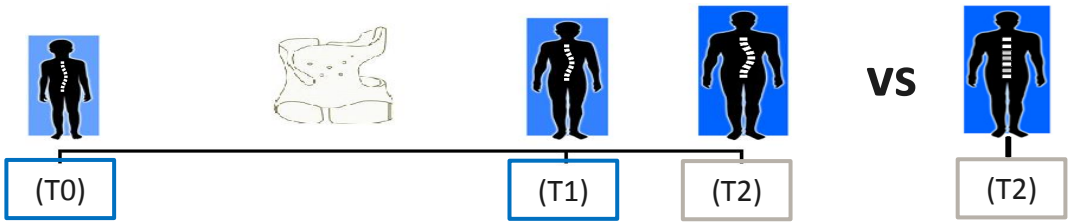
- Control group was matched on age and sex

50 JIS patients treated with Boston brace

77 controls without scoliosis



Results



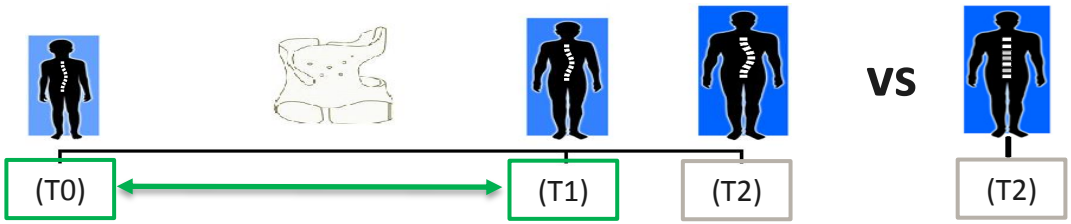
(T0) Before bracing

N = 50	
Female (%)	44 (88%)
Mean age at diagnosis	7.4 y (±1.7)
Age	10.4 *y*
Cobb	33°
T1 – T12 freehand	**24.5 *cm***
T1 – S1 freehand	**39.1 *cm***
Total body height	153.0 *cm*

(T1) After bracing

N = 36	***Only Brace treatment***	***N=14***	***Surgery after Brace***
Age	14.7 *y*	*Age*	*12.8 y*
Cobb	26° (±8.9°)	*Cobb*	*51° (±16.2°)*
T1 – T12	**29.0 *cm***	*T1 – T12*	***27.9 cm***
T1 – S1	**46.4 *cm***	*T1 – S1*	***45.4 cm***
Total	171.7 *cm*	*Total*	*164.2 cm*

Results



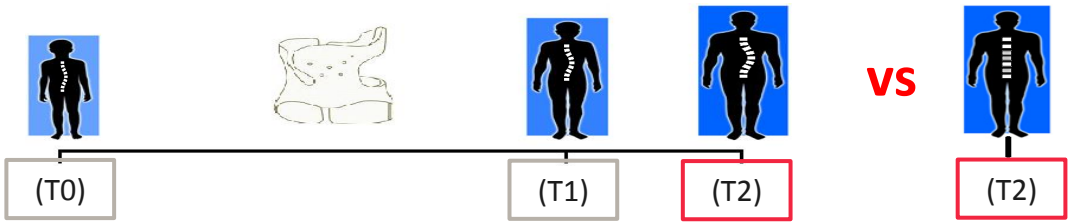
- Comparing Dimeglio's growth data from 10 years to skeletal maturity with growth during brace treatment (T0 – T1)

N=50	Spinal growth during brace treatment		Dimeglio's spinal growth data[1]	
	Total growth	Growth/year	Growth/year	P-value*
T1-T12 freehand	4.22 cm (±2.6)	**1.08 cm/ year** (±0.5)	**1.1 cm/ year**	0.723
T1-T12 freehand	7.00 cm (±4.6)	**1.74 cm/ year** (±0.7)	**1.8 cm/ year**	0.604

1. Dimeglio A, Canavese F. The growing spine: how spinal deformities influence normal spine and thoracic cage growth.Eur Spine J. 2012 Jan; 21(1): 64–70.

* One sample T-test

Results



	T2: Only braced JIS patients (n=36)		T2: controls (n=77)		
	Height	**Freehand**	**Freehand = Height**	**Height vs Controls**	**Freehand vs Controls**
Age	18.1 y		18.6 y		
Cobb	27,7 (±9.5)		0°		
T1 – T12	**28.9** cm (±1.8)	**29.4** cm (±1.9)	**29.9** cm (±2.2)	**0.014***	.227
T1 – S1	**46.2** cm (±3.3)	**46.9** cm (±3.4)	**47.6** cm (±3.3)	**0.036***	.299
Total	172.3 cm (±8.4)		175,3 cm (±8.8)		

*compared between brace JIS and controls at skeletal maturity with two sided t-test

Conclusion

- Reporting on growth and measurement methods is substandard
- Growth can be achieved with growth friendly systems
- Majority of growth is achieved with initial and final fusion surgery
- The true growth reported in the literature is lower than the reported growth of Dimeglio