

# Comparison of Growth-friendly Surgery (GFS) with Rib-based Device (RBD) Between Congenital Scoliosis (CS) and Non-congenital Scoliosis (Non-CS): Five-year follow-up study

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# Disclosures

- Noriaki Kawakami (a) EOS imaging, JSDI  
Kisco (b) Medtronic, Depuy Synthes,
- Toshiki Saito No relationship
- Ryoji Tauchi No relationship
- Tetsuya Ohara No relationship
- Hironori Tanabe No relationship
- Kazuaki Morishita No relationship
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● No relevant financial relationships for this presentation

# Complications in Pediatric Spine Surgery Using the Vertical Expandable Prosthetic Titanium Rib

*The French Experience*

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**TABLE 2. Table of the Meta-Analysis Results Relative to Each of the Sections of Complications**

Reference	Fracture	Migration	Device-Related	Infection	Skin Lesion	Neurological	Statics	Other	Total No. of Complications
13 (27 patients)		11		3	4	3		1	22 (81.5% per patient)
14 (36 patients: 19 treated with VEPTR)	31			18		5		20	74 (45 in VEPTR group: 237%)
15	No figures (description of potential complications)								
16 (97 patients) dealing with infection only				19 (in 16 patients)					19.6% infection per patient
17 (23 patients)	5		2 failures	6	10		(6 not taken into account by the author)	(5 not taken into account by the author)	23 (100% per patient) (148% per patient, altogether)
18 (37 patients)	19			11				3	33 (89% per patient)
19 (6 VEPTR)	3	1		1	1	2	1	1	10 (166% per patient)
20 (20 patients)		5	1	7		1		2	16 (80% per patient)
21 (26 patients)		5		12		9		10	36 (138% per patient)
22 (15 patients)		3		1					4 (26% per patient)
23 (9 VEPTR)		2				1			3 (33% per patient)
24 (299 patients) dealing with neurology only						8 (+6 changes in SEP)			2.7% neurological complications
25 (10 patients)	1							5	6 (60% per patient)
26 (24 patients)		12		1	1				14 (58% per patient)
27 (11 patients)		5		1					6 (54% per patient)
28 (14 patients)	3	7		4	1	1			16 (114% per patient)
29 (22 patients)		7		1					8 (36% per patient)
30 (31 patients)	2	11		3		5		3	24 (77.5% per patient)
31 (14 patients)	4	7		2			11		24 (171% per patient)
32 (43 patients) dealing with mortality and comorbidity only								8	8 (19% morbidity/mortality)
33 (12 patients)	4	5	2				1	6	18 (150% per patient)

*VEPTR indicates vertical expandable prosthetic titanium rib.*

- Results of Meta-Analysis Based on 21 Articles Dealing with VEPTR.
- Fracture/Migration of anchors site (Both Upper & Lower) **153/371 (40%)**



# Purpose

To compare clinical outcomes of Growth-friendly surgery (GFS) with Rib-based device (RBD) between congenital scoliosis (CS) and non-congenital scoliosis (Non-CS) in order to develop a more precise indication for RBD in EOS.



# Surgical Treatment for EOS in Meijo Hospital

- Growth-friendly surgery (GFS)
- Surgical treatment at the age <10 yrs.
- 2005-2012

83 EOS pts.

- Rib-based 72
- Spine-based 11

## ◆ Inclusion criteria:

① Rib-based device

② Five-year follow-up

## ■ Exclusion:

- Myelomeningocele with kyphosis
- Previous surgical treatment



68 pts.

**Participants**  
(FU rate 100%)

# Methods

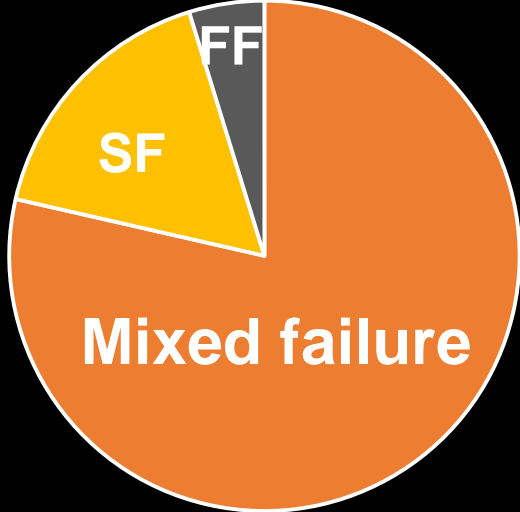
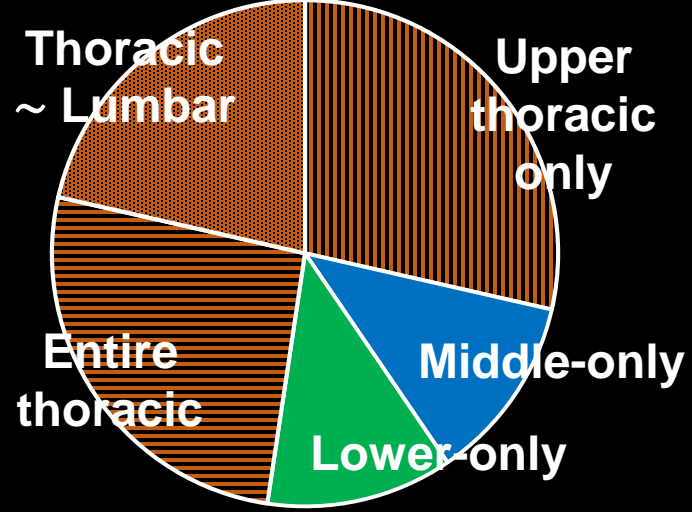
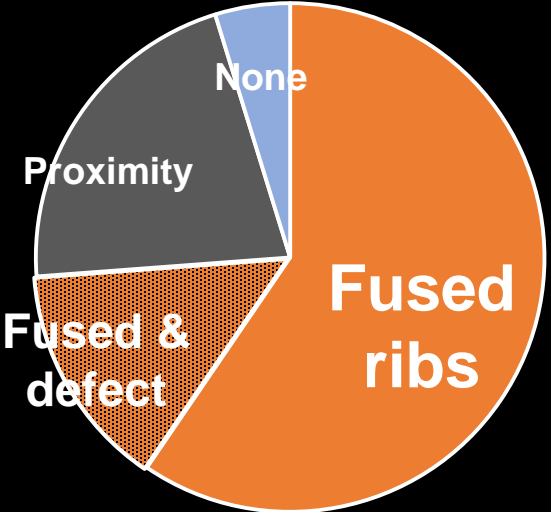
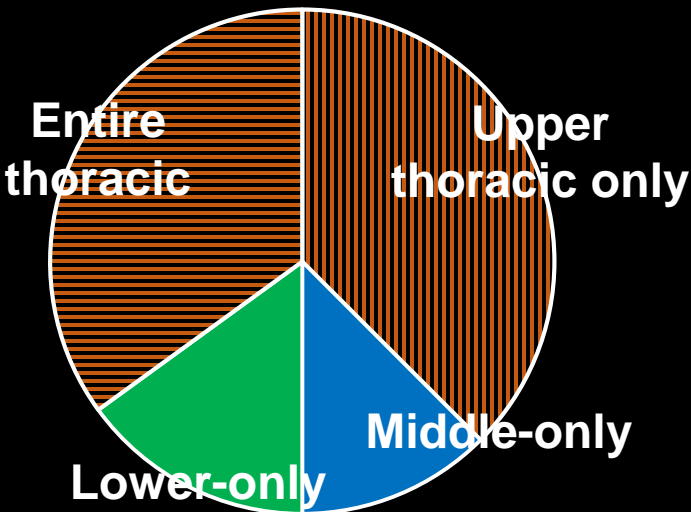
- Retrospective cohort, single center study
- Comparison of surgical outcome between CS and non-CS
  - Scoliosis, thoracic height (TH)
    - Immediate postop.
    - Postop 1 year
    - Postop. 5 years
  - Device-related complications (DRC)
    - Intraop.
    - Within postop. 1 month
    - Within postop. 1 year (2 months ~ 12 months)
    - Within postop. 5 years (1 year ~ 5 years)



## Demographic Data of CS Group and Non-CS Group

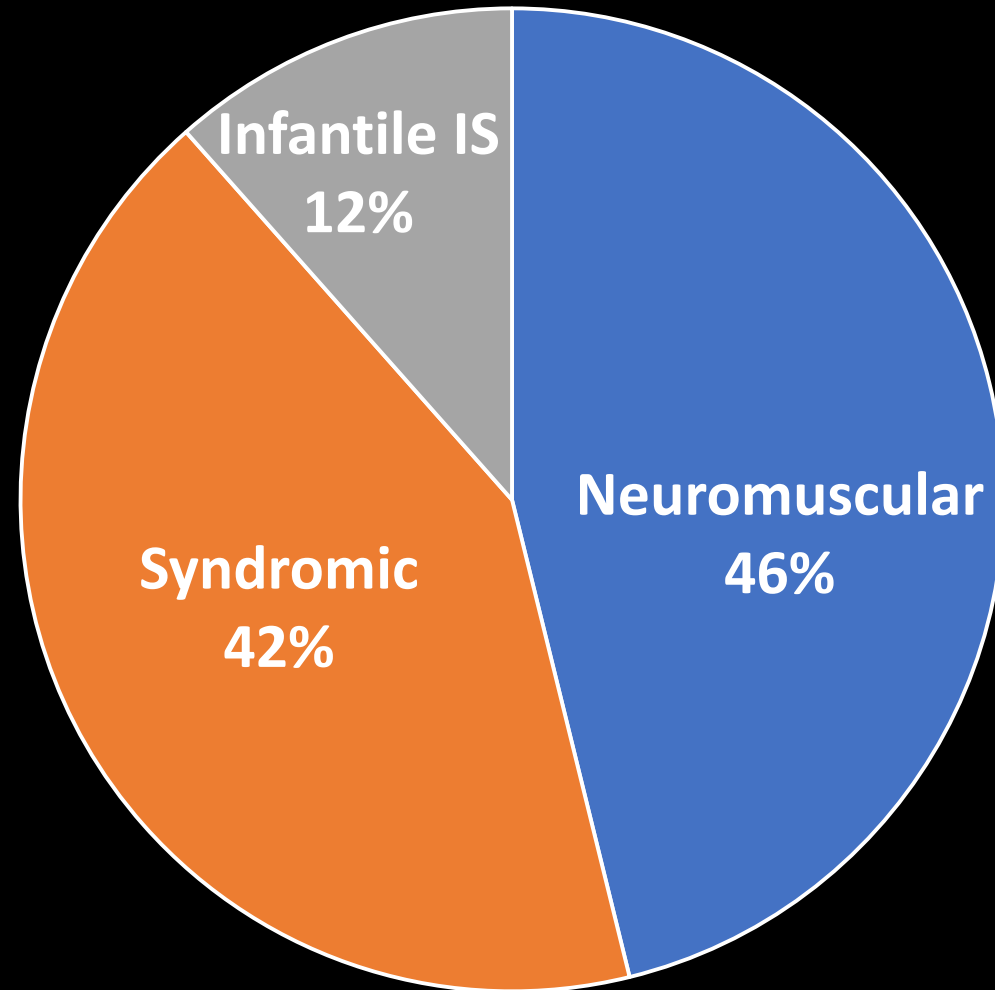
	CS	Non-CS	p value
Number of patients	42	26	
Sex	M: 13, F: 29	M: 13, F: 13	0.1163
Age at primary surg.	5.8 ± 1.7	<b>6.8 ± 1.8</b>	<b>0.0156</b>
Preop. height (cm)	97.7 ± 12.2	102.4 ± 11.1	0.1190
Preop. BW (kg)	15.6 ± 5.1	15.5 ± 4.2	0.7139
Preop. BMI	<b>16.1 ± 2.4</b>	14.5 ± 2.4	<b>0.0153</b>
Follow-up time (Y)	4.8 ± 0.1	5.0 ± 0.1	0.2076

# Congenital Vertebral & Rib Anomalies

	Type	Location
Vertebral Anomalies	 <p>Mixed failure</p> <p>SF</p> <p>FF</p>	 <p>Upper thoracic only</p> <p>Middle-only</p> <p>Lower-only</p> <p>Entire thoracic</p> <p>Thoracic ~ Lumbar</p>
Rib Anomalies	 <p>Fused ribs</p> <p>Proximity</p> <p>Fused &amp; defect</p> <p>None</p>	 <p>Upper thoracic only</p> <p>Middle-only</p> <p>Lower-only</p> <p>Entire thoracic</p> <p>Middle-only</p>



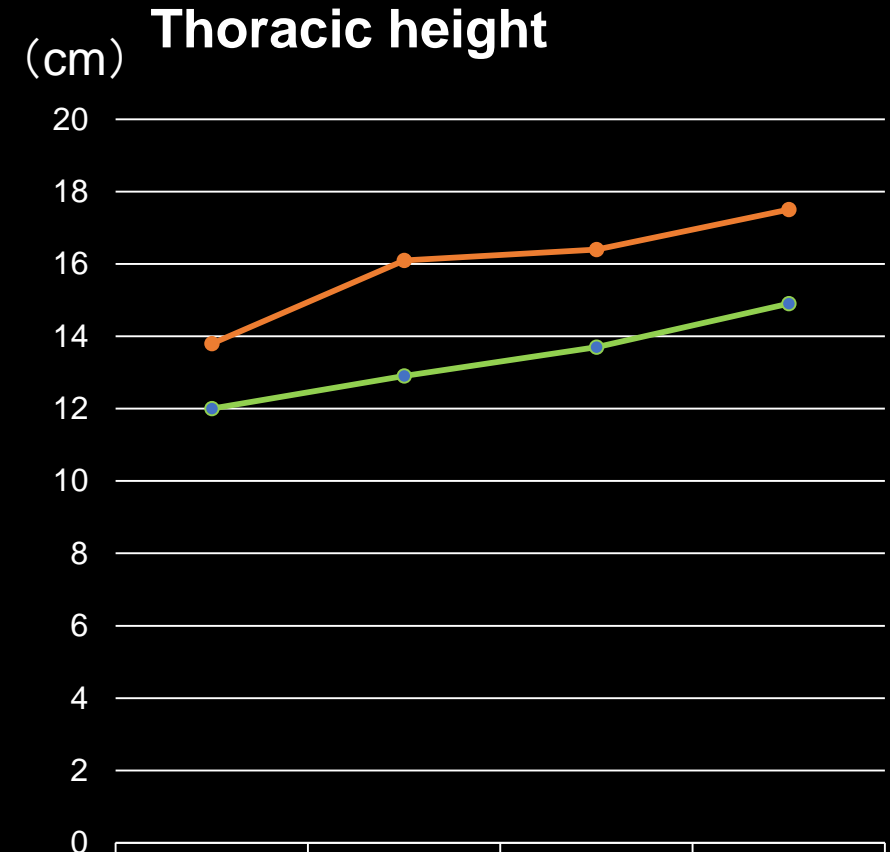
# Etiologies in Non-CS Group



# Radiographic Outcomes



	Pre	PO	PO2	PO5
CS	72	53	56	52
Non-CS	92	54	62	53
p value	0.011	NS	NS	NS



	Pre	PO	PO2	PO5
CS	12	12.9	13.7	14.9
Non-CS	13.8	16.1	16.4	17.5
p value	0.011	<0.01	<0.01	<0.01

- Scoliosis: Non-CS > CS preoperatively, no differences postoperatively
- Thoracic height: non-CS > CS throughout perioperative course



# Surgical Procedures in Each Group

		CS	Non-CS	p value
Number of patients		42	26	
Surgery with Rib-based device	Extension	6.4 ± 1.7	5.4 ± 1.9	0.0258
	Replacement	1.5 ± 1.8	1.5 ± 1.2	0.8217
	Removal	0.8 ± 0.9	0.9 ± 0.8	0.7291
Number of pts. who switched to <b>Growing rod</b>		3/42	5/26	0.1327
Number of pts. who underwent <b>Final fusion</b>		19/42	13/26	0.7022
Total number of operation		6.7 ± 1.2	6.7 ± 2.3	0.4928
Number of <b>Unplanned surgery</b>		<b>0.4 ± 0.6</b>	<b>1.2 ± 1.3</b>	<b>0.0087</b>

# Poisson Regression Model controlling for Confounders

CS has decreased amount of unplanned return to OR  
by 16% compared to non-CS  
controlling for preop. major curve and thoracic height  
( $p=0.002$ ).



# Device-Related Complications (DRC)

Time of occurrence	CS (N=42)	Non-CS (N=26)	p value
Intraop. + postop.	18	8	
Intraop.	<b>8</b>	1	0.0176
Postop.	18	<b>20</b>	0.0002

		CS		Non-CS	
Intraop.		8	<b>Fracture of the rib</b> 5 Fracture of Lamina 2 Pedicle screw misplacement 2	1	<b>Fracture of the rib</b> 1
Postop.	~1 month	3	<b>Dislodge of rib hook</b> 1 Dislodge of lamina hook 1 Decompensation 1	2	Dislodge of lamina hook 1 Screw misplacement 1
	~1 year	2	<b>Dislodge of rib hook</b> 1 <b>PJK</b> 1	6	S-hook migration/fx. 3 <b>PJK</b> 3
	~5 years	14 (7/14)	<b>Dislodge of rib hook</b> 7 Dislodge of lamina hook 1 S-hook breakage 1 <b>PJK</b> 5 Decompensation 2	15 (15/15)	<b>Dislodge of rib hook</b> 7 S-hook migration/fx. 2 <b>PJK</b> 15



# Multiple Logistic Regression Model controlling for Confounders

CS group has decreased amount of implant-related complications by 73% compared to non-CS group controlling for preop. major curve and thoracic height ( $p=0.013$ ).



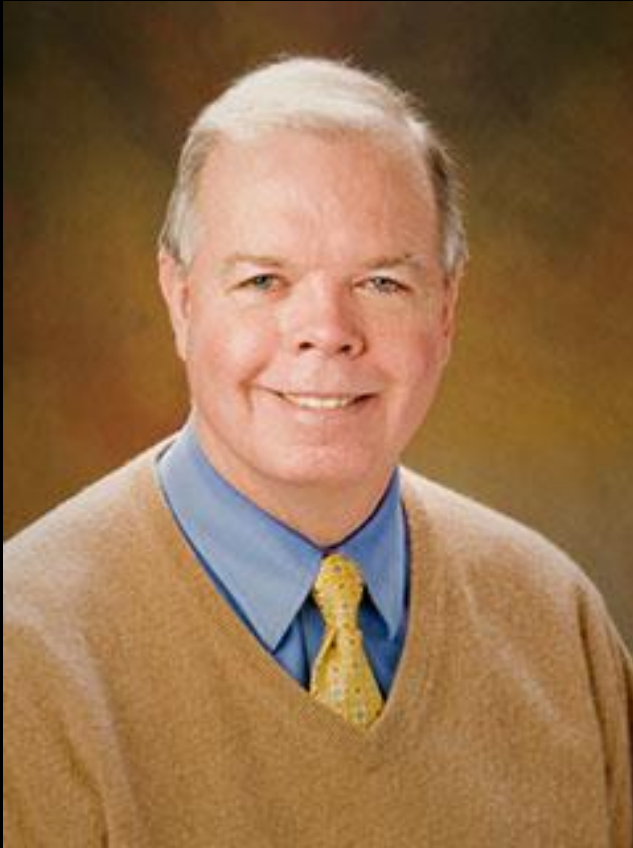
# Conclusion

Patients with CS are more suitable than patients without CS for receiving Rib-Based Devices

as the former group of pts. had lower rates of postop. Device-Related Complications and unplanned surgeries.



# Robert M Campbell Jr. (1951~2018)



**We pray from the bottom of my heart that his soul rests in peace.**







# Limitations of This Study

- Retrospective study with relatively small number of patients.
- No comparison of DRCs and occurrence rate of unplanned surgery between GFS with Rib-Based Device and GFS with Spine-Based Device.
- Not followed up until maturity

## Growth (cm) /year in Two Groups During Five-year Follow-up Period

Growth/year (cm/y)	CS	Non-CS	p -value
Height	6.6 ± 1.7	6.2 ± 1.4	0.3066
Thoracic height	0.5 ± 0.3	0.7 ± 0.5	0.0817

# Surgical Outcome

		CS group	Non-CS group	p value
Number of patients		42	26	
Scoliosis	Preop.	72 ± 29	92 ± 31	<b>0.0108</b>
	Imm. postop.	53 ± 24	54 ± 21	0.7714
	Postop. 2 yrs.	56 ± 23	62 ± 20	0.2280
	Posop. 5 years	52 ± 24	52 ± 21	0.8172
Thoracic height	Preop.	120 ± 24	138 ± 26	<b>0.0059</b>
	Imm. postop.	129 ± 23	161 ± 22	<b>&lt;0.0001</b>
	Postop. 2 yrs.	137 ± 25	164 ± 21	<b>&lt;0.0001</b>
	Posop. 5 years	148 ± 25	176 ± 24	<b>&lt;0.0001</b>
SAL	Preop.	74.4 ± 14.6	83.2 ± 11.6	<b>0.0159</b>
	Imm. postop.	84.9 ± 13.9	90.5 ± 6.9	0.2663
	Postop. 2 yrs.	87.9 ± 11.1	90.3 ± 6.4	0.8203
	Posop. 5 years	89.4 ± 9.0	91.7 ± 5.6	0.6342

# Demographic Data of CS Group and Non-CS Group

	CS	Non-CS	p value
Number of patients	42	26	
Sex	M: 13, F: 29	M: 13, F: 13	
Age at primary surg.	5.8 ± 1.7	<b>6.8</b> ± 1.8	0.0156
Preop. height (cm)	97.7 ± 12.2	102.4 ± 11.1	0.1190
Preop. BW (kg)	15.6 ± 5.1	15.5 ± 4.2	0.7139
Preop. BMI	<b>16.1</b> ± 0.4	<b>14.6</b> ± 0.5	0.0153

	CS group	Non-CS group	p value
Age at Postop. 5 years	10.6 ± 0.3	<b>11.8</b> ± 0.3	0.0079
Postop. 5 ys. height (cm)	123.7 ± 1.8	<b>129.0</b> ± 2.3	0.0370
Postop. 5 ys. BW (kg)	26.2 ± 1.3	24.7 ± 1.7	0.4850
Postop. 5 ys. BMI	<b>16.7</b> ± 0.5	<b>14.6</b> ± 0.6	0.0079

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Preop. BW (kg)	15.6 ± 5.1	15.5 ± 4.2	0.7139
Preop. BMI	<b>16.1</b> ± 2.4	14.5 ± 2.4	0.0153
Follow-up time (Y)	4.8 ± 0.1	5.0 ± 0.1	0.2076
Preop. thoracic height (mm)	<b>120</b> ± 24	<b>138</b> ± 28	0.0109
Space available of lung (SAL) (%)	<b>74.4</b> ± 14.6	83.2 ± 11.7	0.0162
Preop. Scoliosis	72 ± 29	<b>92</b> ± 31	0.0108

# Complications in GR and VEPTR

**Table 1. Comparison of Indications, Treatment, and Complications in GR and VEPTR in EOS**

	Growing Rods	VEPTR
Best indication	Normally segmented spine, flexible chest deformity	Thoracogenic scoliosis or fused ribs
Relative contraindication?	Primary chest wall deformity	Poor soft tissue coverage
Multiple operations needed?	Yes	Yes
Upper thoracic kyphosis?	Possible control	Poor control
Spine growth?	+	+
Chest deformity correction?	When flexible	Direct, invasive
Ease of final fusion	Difficult, scarred	Easier, unscarred
Final fusion needed?	Yes	Yes
Failures—common	Rods break	Rib attachments drift
Complication—severe	Spontaneous posterior spine fusion	Chest wall stiffness

GR indicates growing rods; VEPTR, vertical expandable prosthetic titanium rib; EOS, early onset scoliosis.

Akbarnia & Emans, 2010

- Anchor site problems
- Brachial plexus problems
- Chest wall problems
- Shoulder problems
- Wound problems and infection
- Kyphosis and sagittal plane problems
- Neurological problems