Non-Fusion Technique for Growth Guidance in the Treatment of Spinal Deformities in Young Children

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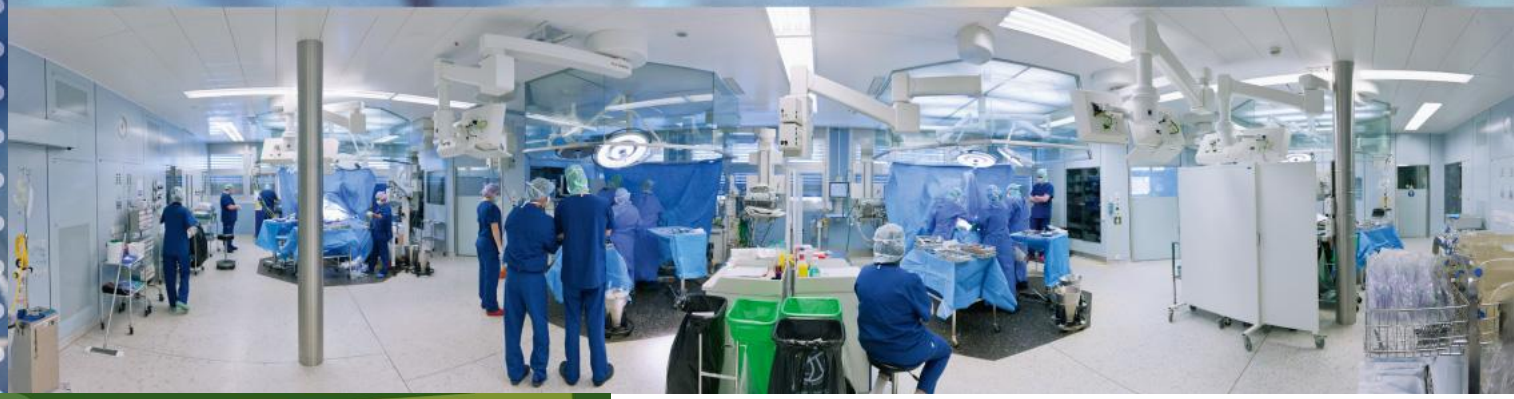

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Introduction

- Spinal deformities in young children cover a group of mixed entities: congenital, syndromic and early/ late onset scoliosis (EOS/ LOS).
- Historically, in the growing child early in situ fusion or after introduction of spinal instrumentation, correction and instrumented fusion was performed.
- However, early long segment fusion inevitably resulted in a short trunk with poor cosmesis and inferior body height or if exclusively performed from posteriorly may have led to crankshafting with progression of the scoliosis and lordotic development. Similarly, Blount hemiepiphysiodesis has shown to be to some extent incalculable.
- Nowadays, in its surgical treatment growth-sparing techniques with growing rods have become standard techniques. But so far the indications and the most appropriate surgical technique are not well defined due to the low prevalence and the limited experience with its management.
- Cases can be substantially heterogenic and curve behaviour under continuous distraction may be unpredictable; hence, a non-fusion instrumentation at the foundation of the growing rod would be desirable. It offers undisturbed spinal growth with a potentially shorter final spondylodesis.

Objective

- The authors report on their experiences and clinical and radiological results with the surgical treatment of early onset scoliosis (EOS) using a pedicle screw-based growing rod construct without fusion at the foundation of rod fixation

- The purpose of this study was to illustrate that a non-fusion technique with growth preservation of the entire spine is as feasible as the established selected bony fusion at the proximal and distal rod anchorage sites

Methods

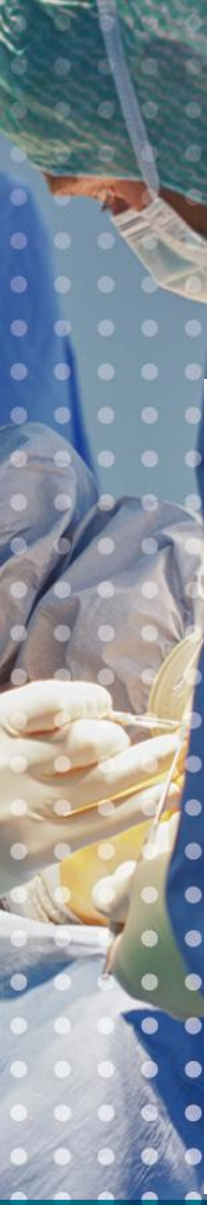
- 86 surgical procedures including the implantation of growing rod construct were performed in 19 children (11 f, 8 m) with progressive (kypho-) scoliotic deformities
- Patients were treated with a growing rod technique and repeated concurrent lengthening procedures with non-fusion fixation of the pedicle screws at the cranial and caudal foundation of rod fixation
- In 6 children the growing rod construct was used as a single measure
- In 13 children growing rod treatment followed different types of corrective operations (vertical column resection, osteotomies etc.)
- The mean age at the first operation was 4.9 ± 2.5 (range 2.4 – 10.6) years
- The preoperative Cobb angle of the major scoliotic curve was 75 ± 26 (48 – 132) degrees
- The follow-up time was 4.12 ± 2.9 (0.5 – 11.8) years
- Relevant data were collected retrospectively from patient charts and long spine x-rays

Results

- In 9 patients, deformity was associated with a syndrome (Beals, Marfan (Fig. 2), arthrogryposis cong., SEDC, undefined)(Tab. 1)
- In 5 children a non-syndromic congenital scoliosis was present and 5 were classified as idiopathic (EOS by definition)(Tab. 1)
- In 11 patients, additional surgical measures such as posterior vertebral column or hemivertebra resection, rib and bar osteotomies were performed
- In 2 children the final spondylodesis was performed and the treatment could be completed
- After primary surgery including the initial distraction, a mean improvement of Cobb angle to 36 ± 16 (17 – 78) degrees and at the latest follow-up 33 ± 20 (8 – 98) degrees e.g. 56% ± 21% correction was demonstrated (Fig. 1)

Results

- Multiple relevant implant problems occurred in 7 patients:
  - rod breakage n=7 in 5 pt., screw breakage n=2 in 2 patients
- Other complications (Tab. 1):
  - loss or insufficient correction (n=3), SSEP/MEP signal loss (n=2), anaesthetic complication with successful CPR, skin break-down, granuloma formation, dural tear (each n=1)
- 14 unplanned revisions had to be performed
- No neurological complications were observed
- All patients/ parents were satisfied with the clinical outcome



Results

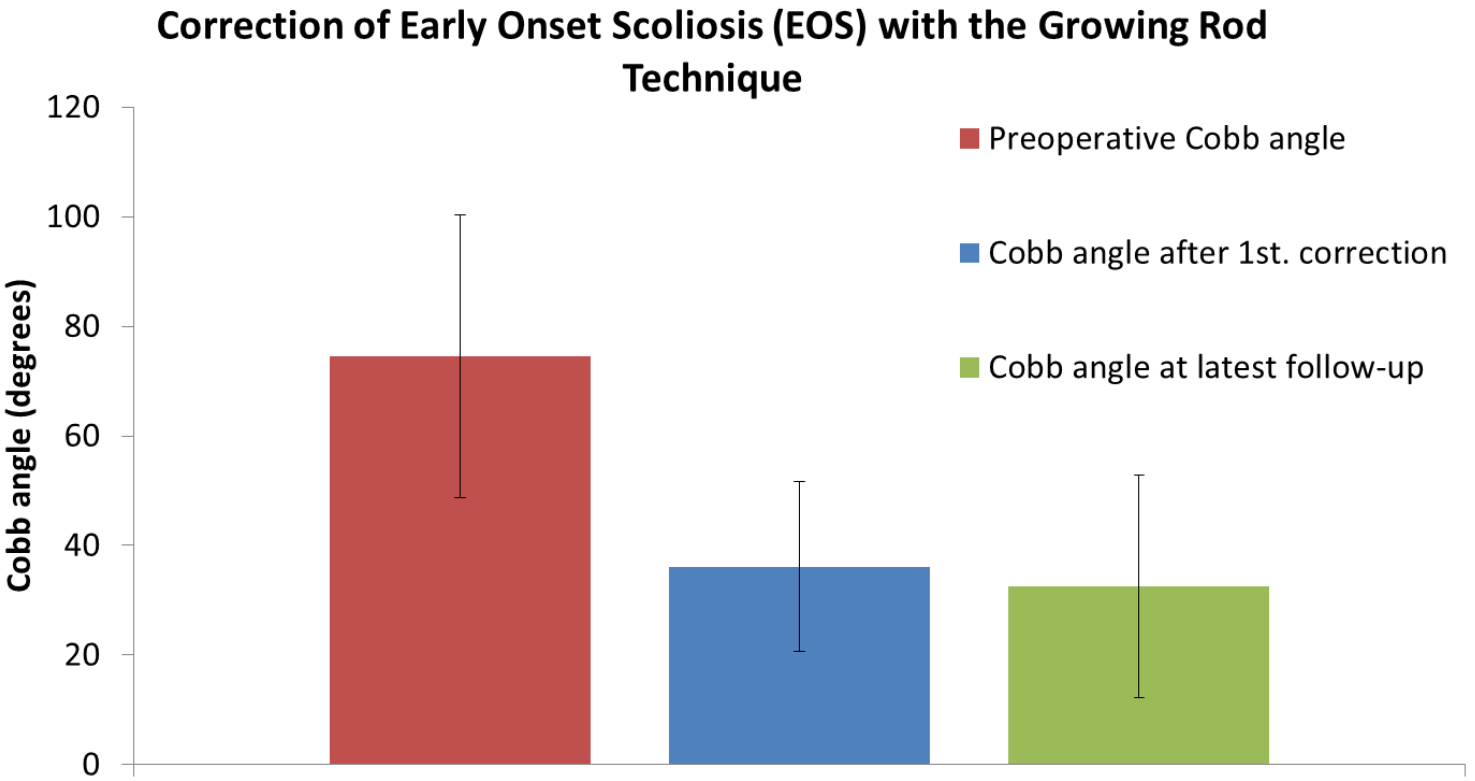


Fig. 1. Correction of EOS with the Growing Rod Technique. Values are scoliosis angles of the major curve from19 patients as measured by the Cobb method ± standard deviation. At latest follow-up a correction of 56% ± 21% was achieved. Treatment was completed in 2/19 patients.

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Table 1

Pt. #	BA (f)	BB (m)	DP (m)	DG (m)	ES (m)	GS (m)	HS (f)	KN (m)	KS (f)	KL (m)	ML (f)	PMat (f)	PM (f)	PE (f)	SJ (f)	SA (f)	TJ (f)	VL (f)	ZM (m)
Additional Surgerys	PVCR	muscle biopsiy	none	hemivertebra resection, 2xOT	none	OT	OT	OT	none	none	PVCR	none	OT	OT	OT	none	PVCR	none	OT
Pathology	Arthrogryposis congenita	idioathic	idiopathic	congenital	Muscle dystrophia	Beals Syndrome	Beals Syndrome	idiopathic	Marfan Syndrome	SEDC	unknown syndrome	unknown syndrome	congenital	congenital	congenital	idiopathic	unknown syndrome	idiopathic	congenital
age 1st OP (y)	3.3	5.2	10.6	5.5	2.9	6.0	2.6	5.2	3.0	4.7	2.5	8.3	3.5	4.3	3.4	10.5	3.8	5.4	2.4
Halo	y	n	n	n	n	n	y	n	n	n	y	n	n	n	n	n	n	y	n
Nr. Surgeries	8	1	7	2	2	7	5	5	8	2	5	2	4	8	2	1	5	3	7
Final Fusion	y	n	y	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
f/u time (years)	11.75	0.00	4.33	0.67	3.33	5.17	2.92	5.67	6.00	4.67	4.58	2.92	3.83	8.83	1.50	0.00	3.42	2.92	5.75
Cobb preOP	99	72	85	59	108	48	115	52	99	76	58	132	68	61	41	50	50	85	59
Cobb postOP	44	49	43	17	29	24	56	33	26	22	26	78	46	46	23	27	41	16	41
Cobb latest f/u	33	49	12	30	44	37	47	22	14	34	9	98	39	44	24	27	8	27	20
Correction %	67	32	86	49	59	23	59	58	86	55	84	26	43	28	41	46	84	68	66
Complications	none	none	screw breakage (2x), rod breakage	loss of correction	none	rod breakage (2x), screw loosening	rod breakage, screw pull-out, screw migration	screw loosening, intraOP MEP signal loss	rod breakage	none	anaesthetic accident, loss of correction	Shilla system not feasable	Screw breakage, wound problem	rod breakage (2x), screw loosening (2x)	none	none	wound infection, screw pull-out, loss of correction	none	termination of surgery due to MEP signal loss
unplanned revisions	none	none	2	1	none	2	1	1	1	none	1	1	none	none	none	none	3	none	1

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Case

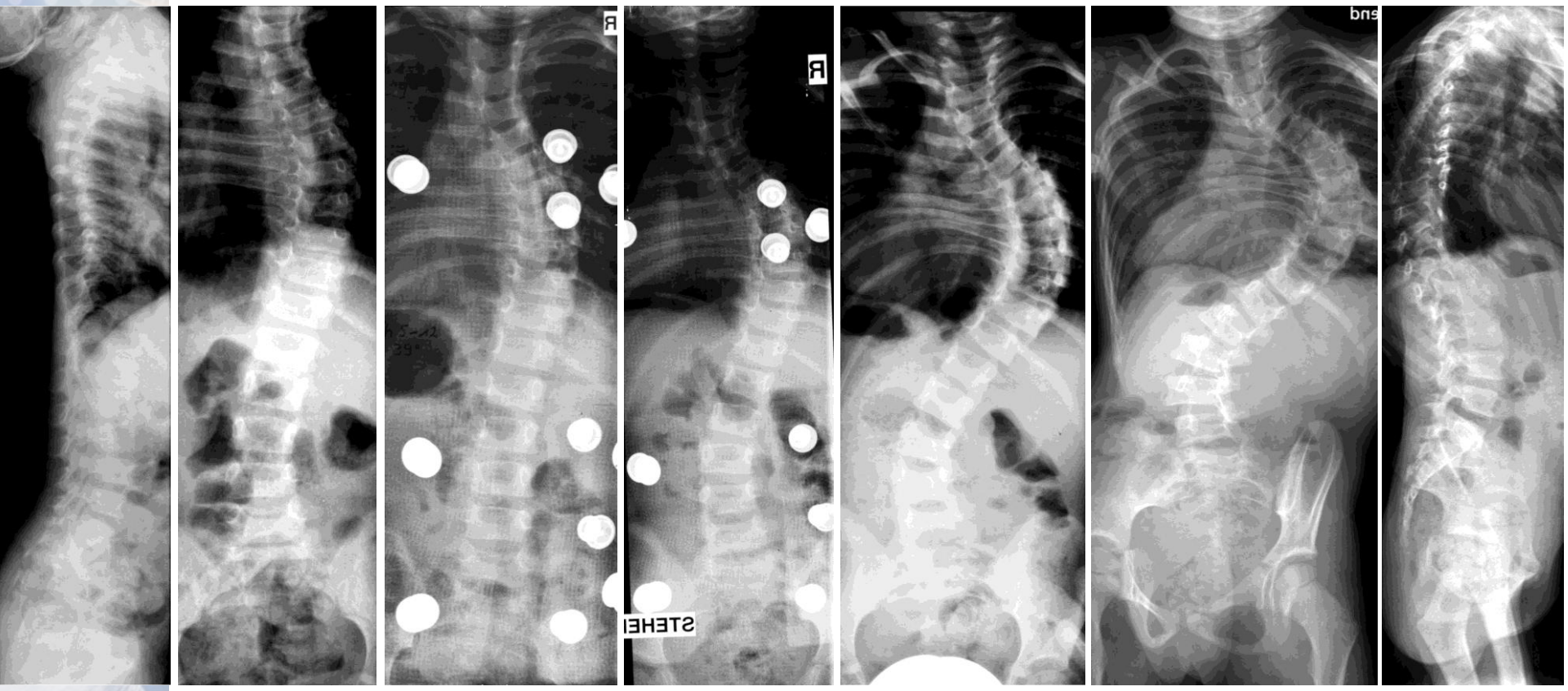
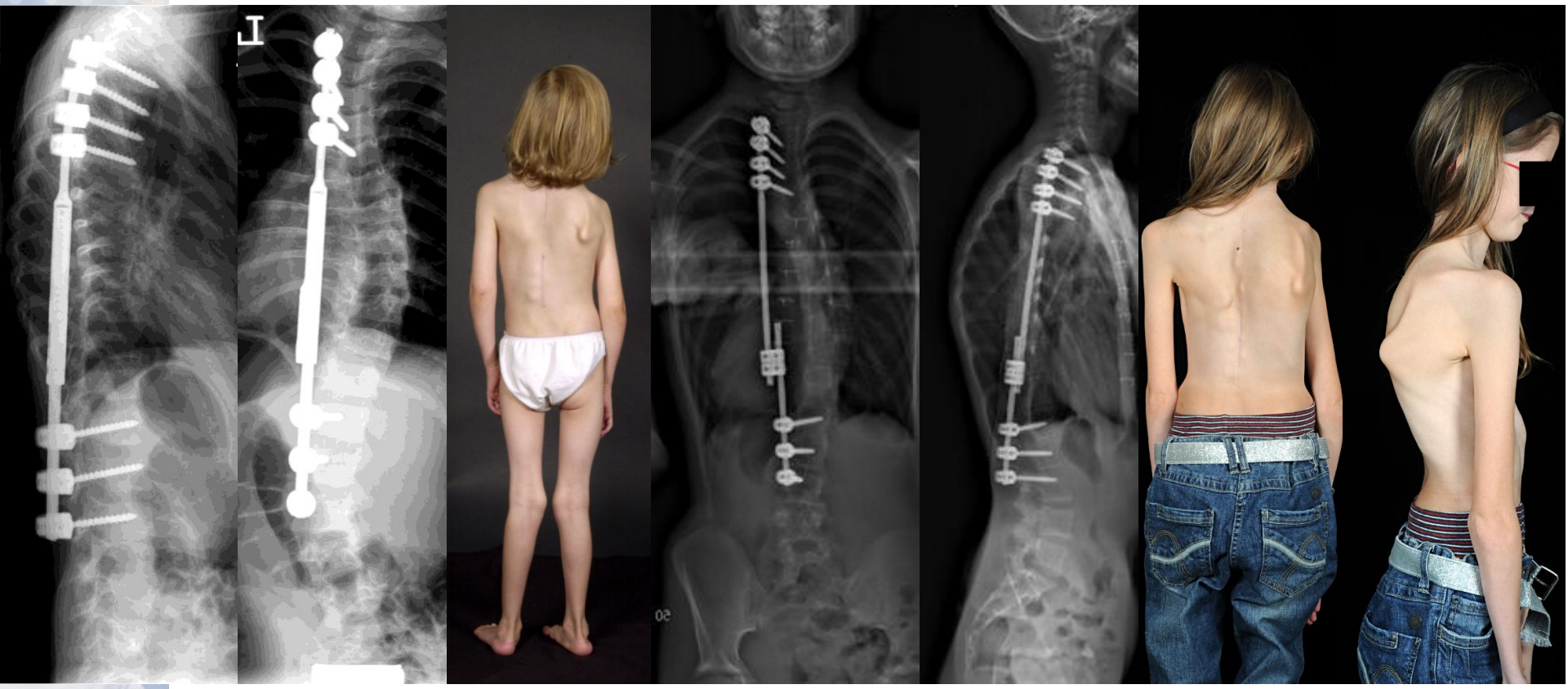


Fig. 2a. Radiographies of a 1-year-1-month-old girl with Marfan syndrome and right thoracic early onset scoliosis EOS (Cobb angle major curve 40 deg.) Syndrome included Pectus excavatum, dilatation of the proximal aorta and pseudarthrosis of the right clavicula. Brace treatment was applied first (1y3m). A quick progression of the major curve under conservative treatment was noted (1y6m Cobb 55 deg., 2y3m 72 deg., 2y11m 100 deg.)

Case



2y11m

10y

Fig. 2b. A single growing rod construct with pedicle screws and non-fusion technique at the foundation was implanted and repeated distraction was applied. An initial correction to 35 deg. Cobb angle was achieved. At the latest follow up (age 10 years) the Cobb angle of the major curve was 14 degrees.

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Discussion/ Conclusion

- Our data demonstrate that the growing rod technique and, if necessary, in conjunction with complementary surgical measures results in a satisfactory radiological and clinical outcome
- Total complication / revision rate is slightly higher compared to other studies due to more complex and multiple surgeries and broader pathologies in our series
- The growing rod construct itself with non-fusion fixation at the foundation sites exhibits a similarly high implant failure rate as in the literature
- Implant failures with a single growing rod or screw breakage have to be anticipated; the rod exchange is usually combined with another distraction or can be postponed if a dual rod construct is present
- Non-fusion rod fixation offers a superior potential for continuous spinal growth and leaves more options for the later determination of final fusion levels
- Further follow-up and data analysis will allow firmer conclusions regarding the longer-term outcome and total spinal growth