

The effect of pedicle screw application on vertebral canal growth in young children: Controversy between animal studies and clinical applications

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Disclosure

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Pedicle screw

- Revolution in spinal surgery
 - Strong vertebral purchase
 - Improved control of the instrumented segments
 - Rigid internal immobilization with greater correction of the spinal deformity



Pedicle Screw @ immature spine

- Advantages

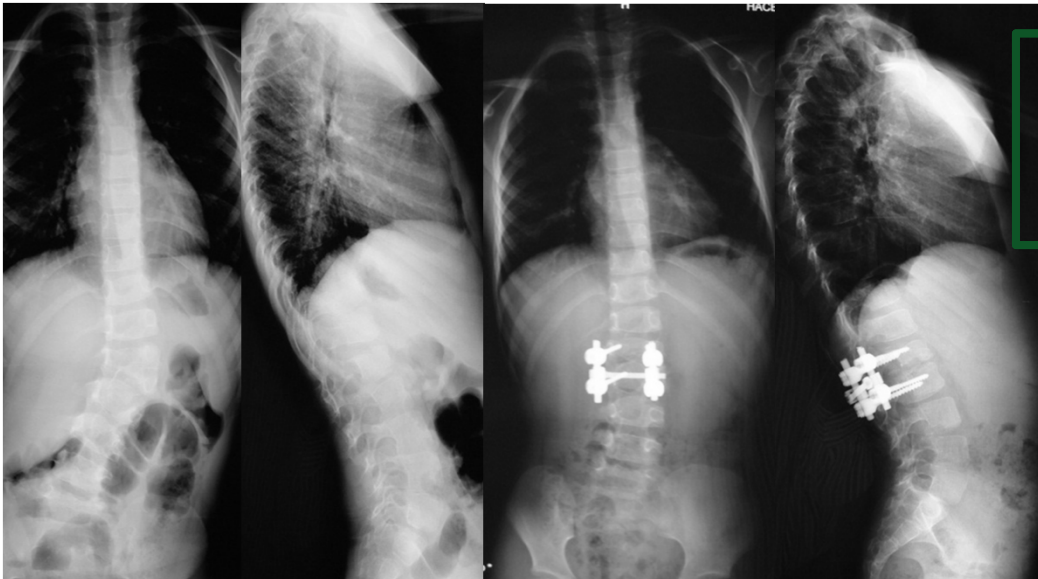
- Segment preservation
 - Growth potential
- Less indication for additional anterior
 - Crankshaft phenomenon

- Problems

- Dimension matching
 - Small pedicle diameter
- Insufficient bony purchase
 - Vertebral ossification ranges from 32% to 65%

- Growth arrest

- NCC damage
 - Iatrogenic spinal stenosis?



Neurocentral cartilage

- NCC
 - @ junction of the pedicle and body
 - Bipolar growth plate
 - Two separate cell blocks facing away from each other
 - Ottander, Acta Orthop Scand 1963
 - It contributes 1/3 of the growth of body and posterior arch
 - Not stationary structure, it moves posteriorly with growth



Growth arrest

- Physis and metallic implants
 - Type of the implants
 - Smooth vs. threaded pins
 - Size of the implant
 - % occupancy of the physis



Neurocentral cartilage as physis

- Asymmetrical NCC in deformed spine
- Growth asymmetry and deformity development?
 - Beguiristain et al, Int Orthop 1980
 - Slight rotatory scoliosis in pigs
 - Zhang et al, Spine 2008
 - Inhibition of growth at NCC leads to asymmetric growth at pedicle and resulting in scoliosis

NCC epiphysiodesis by pedicle screw and spinal canal growth

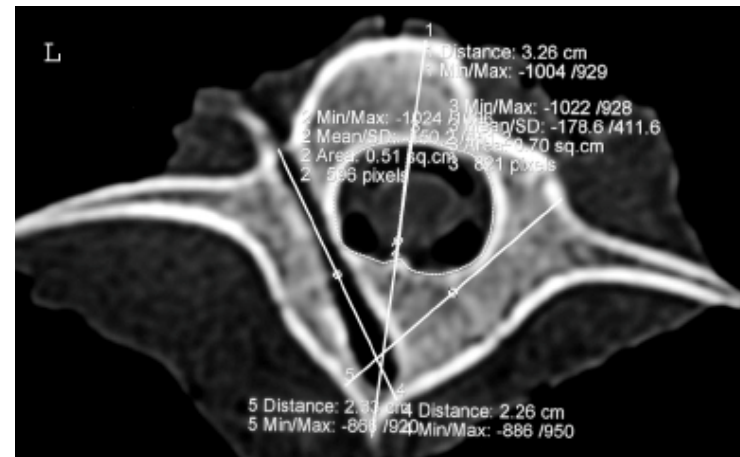
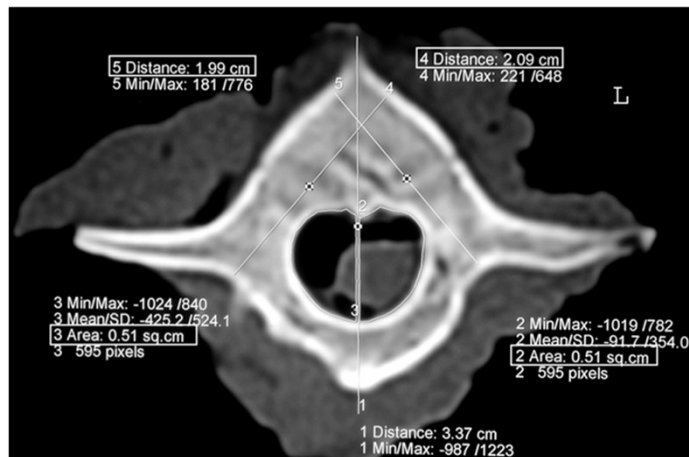
- Animal studies
 - Cil, Yazici, Spine 2005
 - Zhang, Sucato, JBJS 2008
 - Fekete, Jeszenszky, ESJ 2011



The Effect of Pedicle Screw Placement With or Without Application of Compression Across the Neurocentral Cartilage on the Morphology of the Spinal Canal and Pedicle in Immature Pigs

Akin Cil, MD,
Ahmet Alanay

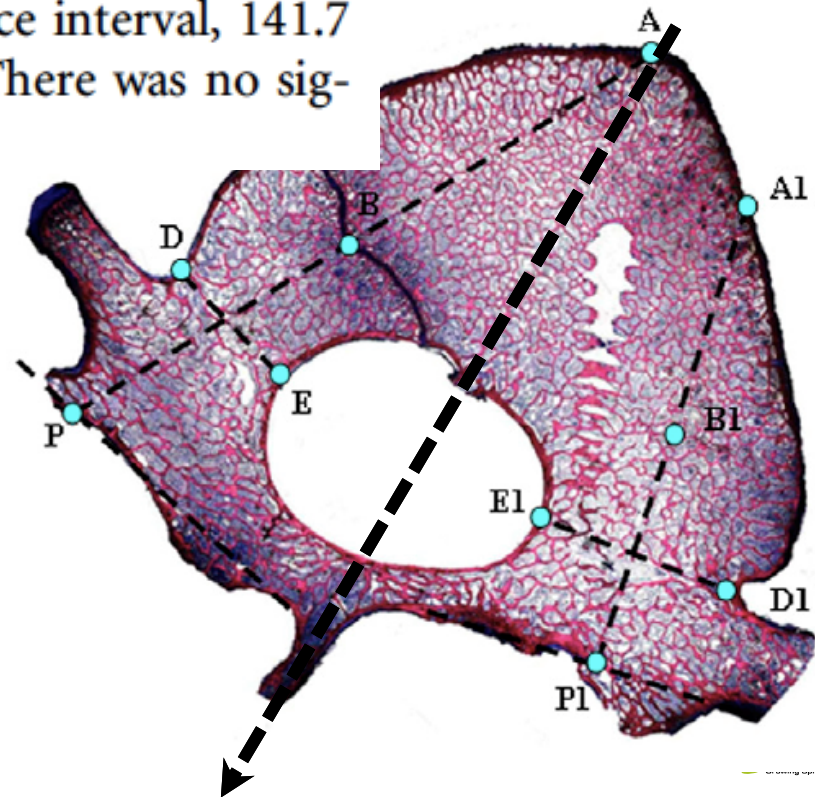
hemi-canal area and shorter pedicles at the operated side, respectively ($P = 0.008$, $P = 0.021$). Approximately 4% to 9% shortening of the pedicle lengths and 20% to 26% narrowing of the hemi-canal areas on the instrumented side occurred with transpedicular instrumentation (groups 2, 3).



Unilateral Pedicle Screw Epiphysiodesis of the Neurocentral Synchondrosis

Production of Idiopathic-Like Scoliosis in an Immature Animal Model

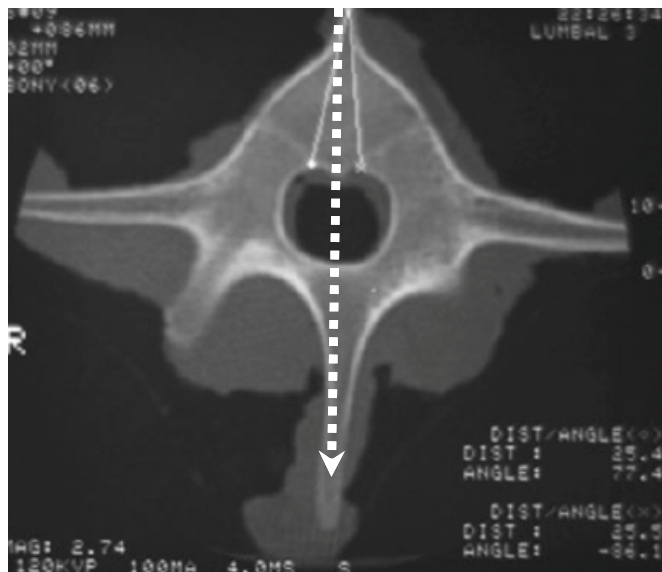
The mean spinal canal area, as measured in the intermediate-1 section of each vertebra, was 145.4 mm² (95% confidence interval, 141.6 to 149.2 mm²) in the control group, 146.9 mm² (95% confidence interval, 141.2 to 152.7 mm²) in the single-screw group, and 144.5 mm² (95% confidence interval, 141.7 to 147.4 mm²) in the double-screw group. There was no significant difference among the three groups.



Prospective study of the effect of pedicle screw placement on development of the porcine model

Tamás Fülöp Fekete · Frank S. Anne F. Mannion · Zsolt S. Ker

Conclusions Pedicle screws in the immature porcine spine have a significant effect on the development of the vertebral body. However, in the present study, no corresponding alteration of the morphology of the spinal canal was observed. Our results provide further support for the



Pedicle screw instrumentation at young age and spinal canal growth

- Ruf and Harms, *Spine 2002 and 2003, SRS 2010*
- Hamzaoglu et al, *IMAST 2011*
- Olgun and Yazici, *Spine 2012*

Pedicle screw and infantile deformities

Ruf M and Harms J,

– *Spine 2002 and 2003*

- 16 children, 91 transpedicular screws
- 1-2 years of age
- 3/16 were followed >6 years
- 2/3 had x-ray and 1/3 had MRI at FU
- No neurologic deficit and stenosis

– *SRS 2010*

- Axial MRI study at 10 years follow-up
- No stenosis

Does Pedicle Screw Fixation Under Age Five Disrupt Vertebral Growth? A Computerized Tomography Study

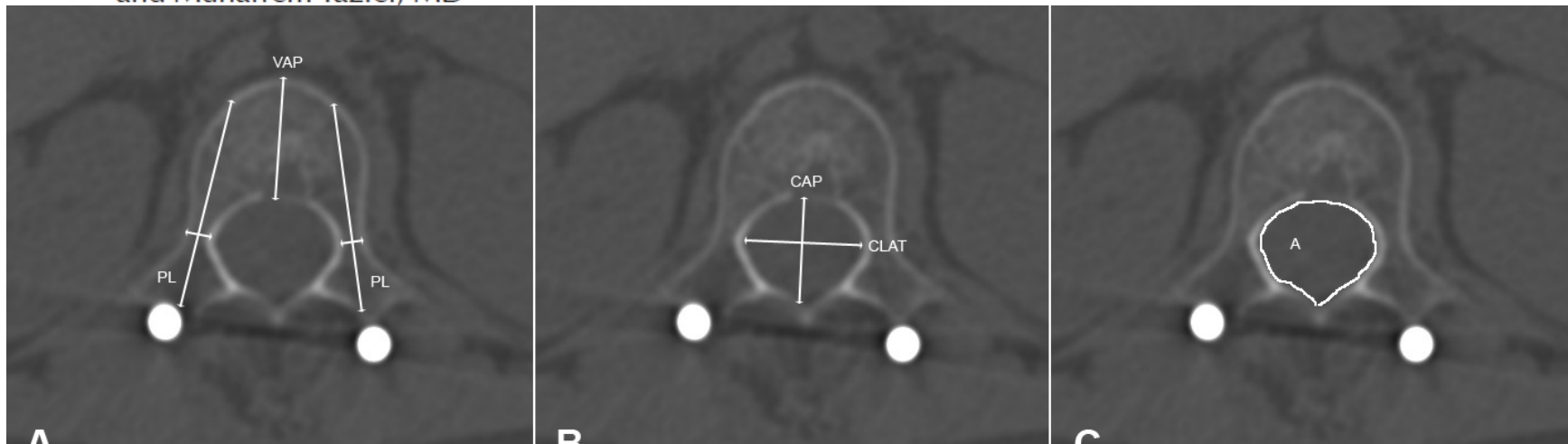
Hamzaoglu et.al., IMAST 2011

- Thirteen to spinal deformity patients who had been operated under age 5
- Preoperative and more than 2 years follow-up CT
- Age
 - 3 (range; 2 to 4)
- FU
 - 3.6 (range; 2 to 8) years
- Pedicle screw instrumentation before age 5 does not cause spinal canal narrowing

SURGERY

The Effect of Pedicle Screw Insertion at a Young Age on Pedicle and Canal Development

Zeynep Deniz Olgun, MD,* Gokhan Demirkiran, MD,* Mehmet Ayvaz, MD,* Emre Karadeniz, MD,†
and Muharrem Yazici, MD*

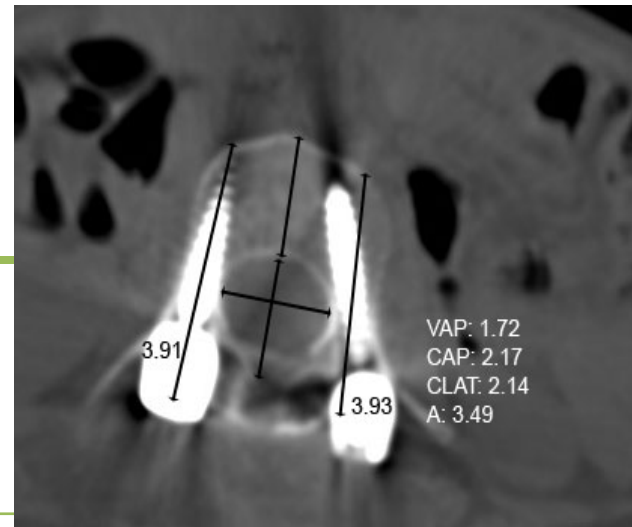
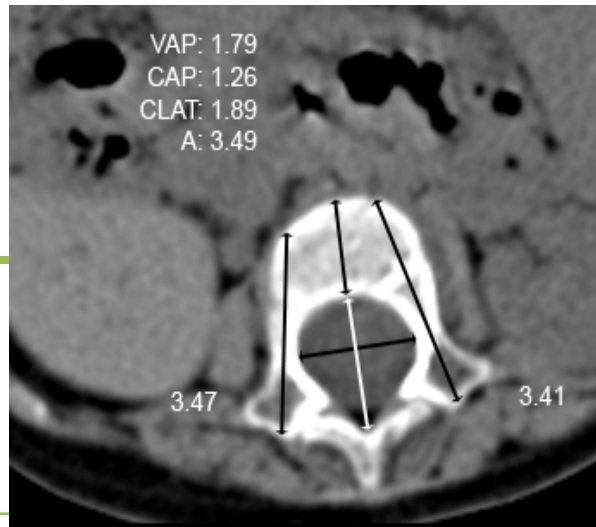


SURGERY

The Effect of Pedicle Screw Insertion at a Young Age on Pedicle and Canal Development

Zeynep Deniz Olgun, MD,* Gokhan Demirkiran, MD,* Mehmet Ayvaz, MD,* Emre Karadeniz, MD,†
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- 15 patients (7M, 8F)
- Average age at surgery: 29-60 (45.9) months
- Average duration of follow-up: 24-82 (48.7) months



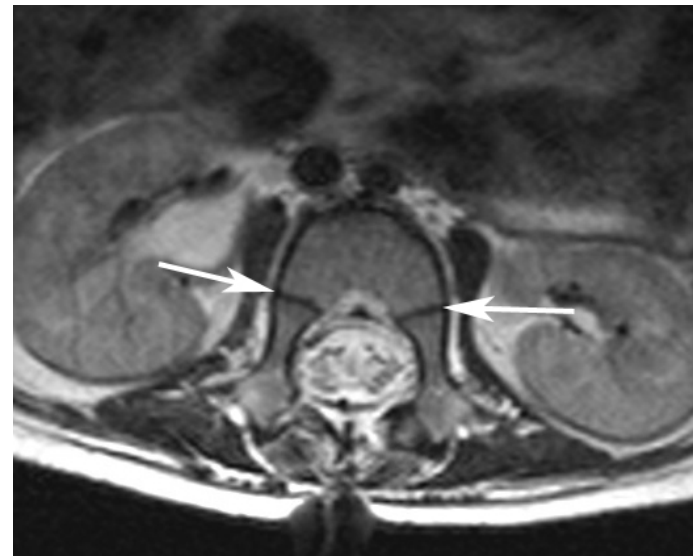
| Measurem. | Preop (av.) | | Last follow-up (av.) | | Δ (av.) | | p (Δ) |
|---------------------|-------------|-------|----------------------|-------|----------------|-------|----------------|
| | S(-) | S(++) | S(-) | S(++) | S(-) | S(++) | |
| PL(cm) | 2.92 | 2.91 | 3.40 | 3.45 | 0.47 | 0.53 | 0.303 |
| VAP(cm) | 1.62 | 1.60 | 1.87 | 1.79 | 0.25 | 0.19 | 0.369 |
| CAP(cm) | 1.46 | 1.40 | 1.71 | 1.75 | 0.25 | 0.35 | 0.140 |
| CLAT(cm) | 1.72 | 1.69 | 1.97 | 1.88 | 0.24 | 0.19 | 0.551 |
| A(cm ²) | 2.59 | 2.55 | 2.67 | 2.71 | 0.08 | 0.16 | 0.440 |

Clinical series

- Pedicle screws do not affect growth, no stenosis
- No detectable shortening of the pedicle
- Discrepancy between animal studies and clinical applications
 - WHY?

Neurocentral cartilage

- NCC can be discerned in its location up to the age of 16, but its functionality after early is called into question
 - Yamazaki et.al., JPO 1998
 - Ginsburg and Schwend, 4th ICEOS
- NCC starts to fuse in lumbar segments around the age of 3, in thoracic part around the age of 5
 - Zhang et.al. Spine 2010



Vertebral canal development and NCC

Zindrick MR et.al., *Spine* 2000

- Fully mature midsagittal diameter and canal area @ 4 years of age
- Interpedicular diameter, 87% of adult
- Vertebral body size dramatically increases until adulthood
 - Apositional growth?
- Growth of the pedicle in relation to the canal
 - Increase in pedicle size is lateral to the canal!

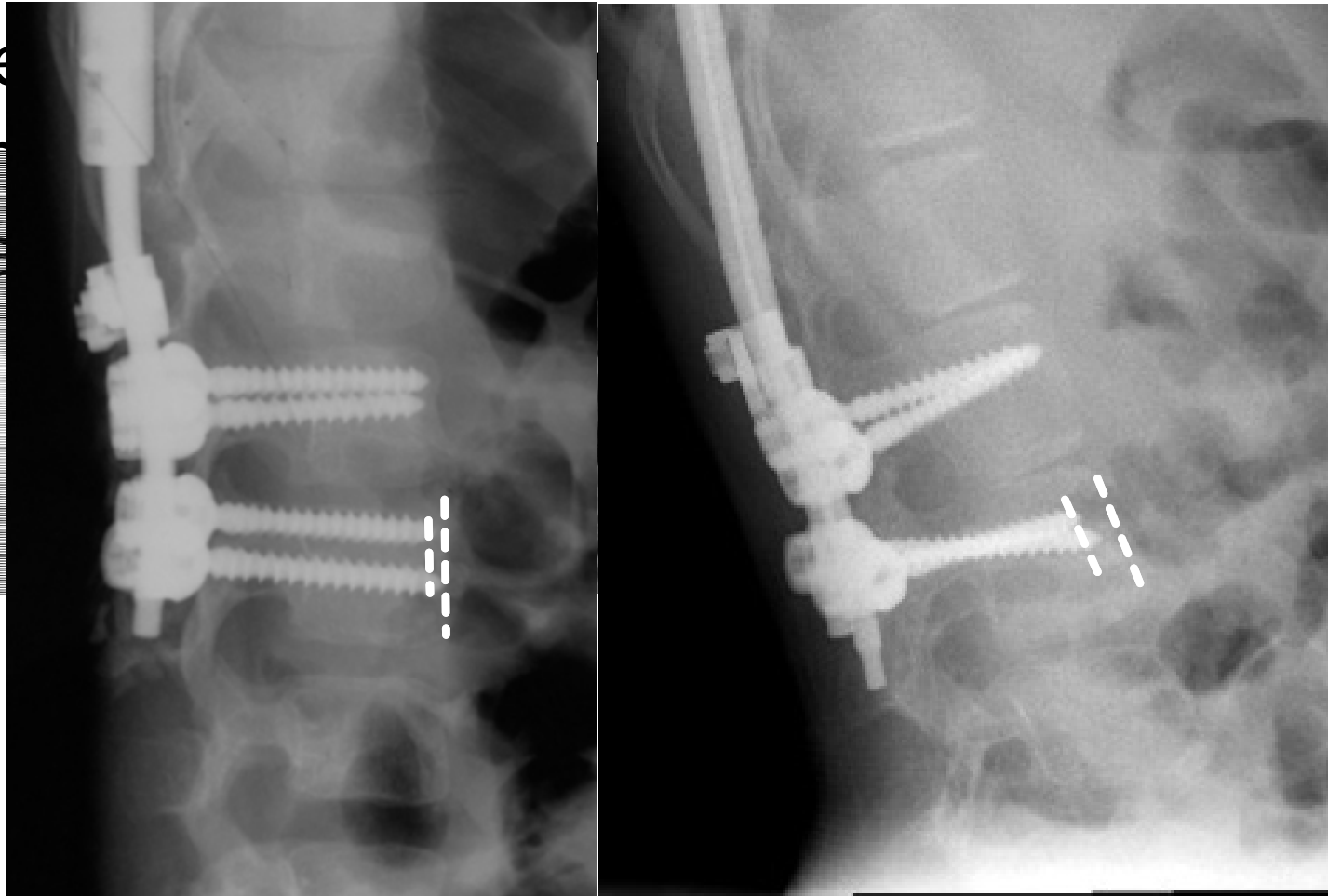
Morphometric Analysis of Vertebral Growth Using Magnetic Resonance Imaging in the Normal Skeletally Immature Spine

Hong Zhang, MD, Daniel J. Sucato, MD, MS, Pamela Nurenberg, MD, and Anna McClung, RN

| | Spinal Canal Area (mm ²) | | |
|---------|--------------------------------------|--------------|--------------|
| | Infantile* | Juv-Young† | Juv-Old‡ |
| T1–T3 | 175.0 ± 36.3§ | 224.6 ± 31.9 | 228.9 ± 28.3 |
| T4–T6 | 166.9 ± 35.0§ | 206.4 ± 26.6 | 211.0 ± 28.6 |
| T7–T9 | 176.9 ± 38.9§ | 209.2 ± 34.5 | 213.7 ± 26.8 |
| T10–T12 | 206.7 ± 50.7§ | 244.4 ± 44.7 | 242.2 ± 37.7 |
| L1–L5 | 280.2 ± 63.5§ | 321.8 ± 48.4 | 322.7 ± 41.8 |

Vertebral height and width after pedicle screw application

- Pedicle screw application should be careful



Conclusion

- Pedicle screws do not cause a negative effect on the growth of pedicles, the transverse plane of the vertebral body, or the spinal canal even when placed before the age of 5 years