Are Serum Ion Levels Elevated in Pediatric Patients with Growing Spine Implants versus Controls?

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Supported by: T. Denny Sanford Pediatric Collaborative Research Fund
Disclosures

• I (and/or my co-authors) have something to disclose.

• Refer to the ICEOS Annual Meeting program for more detailed disclosure information.
Introduction

Children with spinal fusion – elevated serum Ti levels.

Serum titanium, niobium, and aluminum levels after instrumented spinal arthrodesis in children.
Cundy TP, Antoniou G, Sutherland LM, Freeman BJ, Cundy PJ.

Serum titanium, niobium and aluminium levels two years following instrumented spinal fusion in children: does implant surface area predict serum metal ion levels?
Cundy TP, Cundy WJ, Antoniou G, Sutherland LM, Freeman BJ, Cundy PJ.
Introduction

- Children with spinal fusion – elevated serum Ti levels.
- Corrosion $\rightarrow$ metal debris $\rightarrow$ increased Ti ions
Introduction

• What about **Cobalt** and **Chromium**?
Hypothesis

- Serum ion levels will be elevated in pediatric patients with spinal implants, particularly growing spine devices compared to patients with implants in the extremities.
Methods

Pediatric patients

I: Spine implant placement

II: Spine implant revision/ removal

III: Extremity implant removal (control group)

• Serum Ti, Co, Cr at the time of surgery
• Intra-op waste tissue specimens: metal debris + macrophage activity
Tissue biopsies were obtained from the site of metal debris adjacent to the implant.
Study Population

• Patients were enrolled at two centers prior to surgery.
Study Population

Pediatric patients undergoing surgery

N = 51
Pediatric patients undergoing surgery
N = 51

I: Spine implantation (DeNovo)
N = 10

MCGR
N = 1

Fusion
N = 9
Study Population

Pediatric patients undergoing surgery
N = 51

I: Spine implantation (DeNovo)
N = 10

MCGR
N = 1
Fusion
N = 9
VEPTR: 5
TGR: 6
Fusion
N = 4

II: Spine implants (Revision or Removal)
N = 15
Study Population

Pediatric patients undergoing surgery
N = 51

I: Spine implantation (DeNovo)
N = 10

MCGR
N = 1

Fusion
N = 9

VEPTR: 5
TGR: 6

II: Spine implants (Revision or Removal)
N = 15

Fusion
N = 4

III: Extremity implants (Removal)
N = 26
Results – *Do ion levels change?*
# Results

## Before and after spine instrumentation (DeNovo) (N = 8)

<table>
<thead>
<tr>
<th>Metal</th>
<th>Before implantation</th>
<th>After implantation</th>
<th>p values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt</td>
<td>0.3 ng/ml</td>
<td>1.0 ng/ml</td>
<td>0.06</td>
</tr>
<tr>
<td>(N = 0-0.9 ng/ml)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chromium</td>
<td>0.2 ng/ml</td>
<td>0.3 ng/ml</td>
<td>0.28</td>
</tr>
<tr>
<td>(N &lt; 0.3 ng/ml)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Titanium</td>
<td>0.91 ng/ml</td>
<td>3.3 ng/ml</td>
<td>0.02</td>
</tr>
<tr>
<td>(N &lt; 1 ng/ml)</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
# Results

Growing spine implants vs Fusion + Controls

<table>
<thead>
<tr>
<th>Metal</th>
<th>Growing spine implants (N = 11)</th>
<th>Others (Fusion + Controls) (N = 30)</th>
<th>p values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt</td>
<td>0.63 ng/ml</td>
<td>0.32 ng/ml</td>
<td>0.052</td>
</tr>
<tr>
<td>Chromium</td>
<td>1.2 ng/ml</td>
<td>0.27 ng/ml</td>
<td>0.01</td>
</tr>
<tr>
<td>Titanium</td>
<td>3.3 ng/ml</td>
<td>1.9 ng/ml</td>
<td>0.01</td>
</tr>
</tbody>
</table>
## Results

### Growing spine implants vs Extremity Implants (Controls)

<table>
<thead>
<tr>
<th>Metal</th>
<th>Growing spine implants (N = 12)</th>
<th>Extremity implants (Controls) (N = 26)</th>
<th>p values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt</td>
<td>0.63 ng/ml</td>
<td>0.275 ng/ml</td>
<td>0.023</td>
</tr>
<tr>
<td>(N = 0-0.9 ng/ml)</td>
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</tr>
<tr>
<td>Chromium</td>
<td>1.018 ng/ml</td>
<td>0.27 ng/ml</td>
<td>0.008</td>
</tr>
<tr>
<td>(N &lt; 0.3 ng/ml)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Titanium</td>
<td>3.1 ng/ml</td>
<td>1.1 ng/ml</td>
<td>0.007</td>
</tr>
<tr>
<td>(N &lt; 1 ng/ml)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Histology – H&E stain (10X)

Flexible Ti Nail

Growing Rod
Histology – SEM (10 μM)
Growing Rod
Immunohistochemistry – CD68 (macrophage marker)

Flexible Ti Nail

Growing Rod
Immunofluorescence – Growing Rod

IgG (control) 40x

CD68 (macrophage marker) 40x
IL-6 (inflammatory marker) 40x

TNF-α (inflammatory marker)
Conclusion

• Growing spine implants create an *increase in serum levels of titanium, chromium, and cobalt ions compared to controls.*

• Tissue evaluation reveals *high macrophage activity and intracellular metal particles.*
Discussion

• Previous series
  • Patients with GR and MCGR vs controls (non operated patients)
  • Elevated serum Ti metal ions

Metal Ion Release During Growth-Friendly Instrumentation for Early-Onset Scoliosis: A Preliminary Study.

Yilgor C1, Efendiye A2, Akbıyık F3, Demirkiran G2, Senköylü A4, Alanay A1, Yazıcı M5
Discussion

• Previous series
  • Patients with VEPTR and MCGR
  • Elevated serum Ti metal ions (VEPTR > MCGR)
  • No control group


Elevated Serum Titanium Levels in Children With Early Onset Scoliosis Treated With Growth-friendly Instrumentation.

Li Y¹, Graham CK, Robbins C, Caird MS, Farley FA.
Discussion

• Reasonable to consider growing spine implant removal and converting to a fusion surgery at maturity.
  • Retaining an implant → lifetime exposure to serum metal ions → consequences??
THANK YOU!