Spring Distraction System for Early Onset Scoliosis Provides Continuous Distraction Without a Potential Increase in Rod Fractures, Compared to Traditional Growing Rods

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Disclosures

This study received funding from K2M
Growing Rod Failure

3. Teoh et al.; Magnetic controlled growing rods for early-onset scoliosis: a 4-year follow-up. TSJ. 2016
Construct stiffness

• Both TGR/MCGR are stiff constructs
• Earlier failure with increasing stiffness\(^1,2\)
• Stiffer ≠ better
Spring Distraction System (SDS)

- **Connector**
  - Mounted on the sliding rod
  - Spring distracts against buttress or distal side and connector on proximal side

- **Springs**
  - Ti6Al4V (UTS: 1050 MPa)
  - Fully compressed: 37.5mm, 75N
  - Fully relaxed: 72.0mm, 0N
  - Spring constant (k): 2.2 N/mm

- **Buttress**
SDS as Spinal Suspension?

TGR/MCGR?

SDS?

Stress peaks

Shocks absorbed

Study aim

To determine whether SDS can reduce von Mises stresses in the rod during spinal loading

- Finite element (FE) analysis with stress comparison
- Two versions of the same model (SDS vs. TGR)

Only difference between 2 models is spring and sliding connector
Methods

- Previously validated FE scoliotic spine model

1. Implantation of instrumentation (SDS vs. TGR)
2. Distraction to correct the curve
3. Introduce gravity and muscle forces (follower load)
4. Loading (1Nm FLE/EXT/BEN/ROT moments)

Only difference between 2 models is spring and sliding connector

Measure von Mises stress
1. Implantation

- Pedicle screw fixation
- 2 short 4.5mm Ti rods (proximal)
- 2 long 4.5mm Ti rods (distal)

2. Distraction

- S1 fixed in all degrees of freedom
- Fixed 20mm distraction
- Then: (1) Tie proximal and distal rods (TGR)
  (2) Introduction of 2 springs (SDS)
3. Follower load

- S1 fixed in all degrees of freedom
- Simulate gravity and muscle forces
- 14% body weight at T1 + 2.7% body weight at each subsequent level

4. Loading

- S1 fixed in all degrees of freedom
- 1Nm moment to the top of T1
- Flexion, extension, bending, rotations
Results

1. SDS springs compressed further following loading in SDS
2. Gravity load converted to spring energy
3. Rod stress SDS < TGR
## Results

<table>
<thead>
<tr>
<th></th>
<th>Follower load</th>
<th>Flexion</th>
<th>Extension</th>
<th>Left bending</th>
<th>Right bending</th>
<th>Left rotation</th>
<th>Right rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Top right rod (MPa)</strong></td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>TGR</td>
<td>151</td>
<td>156</td>
<td>147</td>
<td>153</td>
<td>149</td>
<td>153</td>
<td>148</td>
</tr>
<tr>
<td>SDS</td>
<td>134</td>
<td>130</td>
<td>139</td>
<td>133</td>
<td>142</td>
<td>134</td>
<td>134</td>
</tr>
<tr>
<td>SDS-TGR</td>
<td>-17 (-11%)</td>
<td>-26 (-17%)</td>
<td>-8 (-5%)</td>
<td>-20 (-13%)</td>
<td>-7 (-5%)</td>
<td>-19 (-12%)</td>
<td>-14 (-9%)</td>
</tr>
<tr>
<td><strong>Top left rod (MPa)</strong></td>
<td></td>
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</tr>
<tr>
<td>TGR</td>
<td>224</td>
<td>228</td>
<td>221</td>
<td>228</td>
<td>221</td>
<td>217</td>
<td>239</td>
</tr>
<tr>
<td>SDS</td>
<td>214</td>
<td>215</td>
<td>213</td>
<td>212</td>
<td>216</td>
<td>202</td>
<td>226</td>
</tr>
<tr>
<td>SDS-TGR</td>
<td>-10 (-4%)</td>
<td>-13 (-6%)</td>
<td>-8 (-4%)</td>
<td>-16 (-7%)</td>
<td>-5 (-2%)</td>
<td>-15 (-7%)</td>
<td>-13 (-5%)</td>
</tr>
</tbody>
</table>
Discussion

• Currently implanted in >40 patients, no rod fractures as of yet

Additional research will focus on:
1. Biomechanical validation of FE model
2. Unilateral vs. bilateral spring?
3. Optimal spring strength?
4. Optimal design of polyaxial connector
Conclusion

1. The spring in SDS converts loading forces into potential spring energy

2. This reduces von Mises stresses in rods between 2-18% depending on motion

3. This could reduce the incidence of rod fractures
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