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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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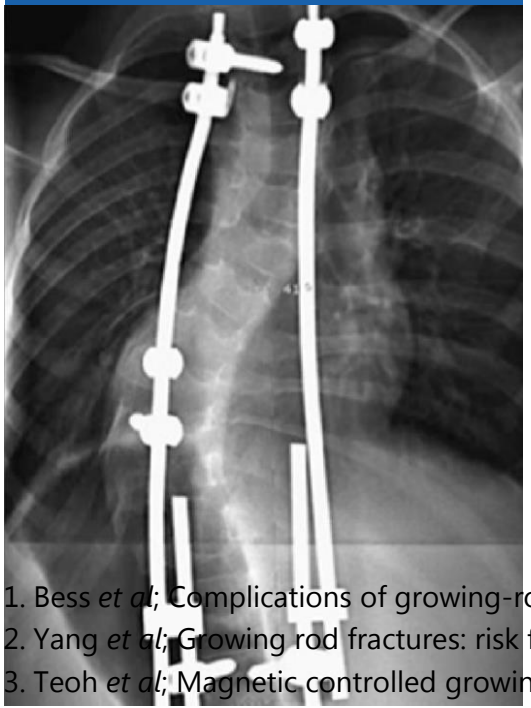
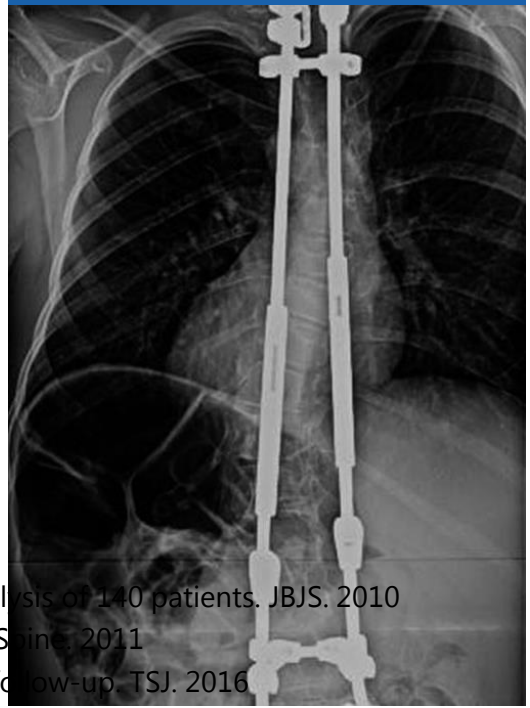
Disclosures

This study received funding from **K2M**

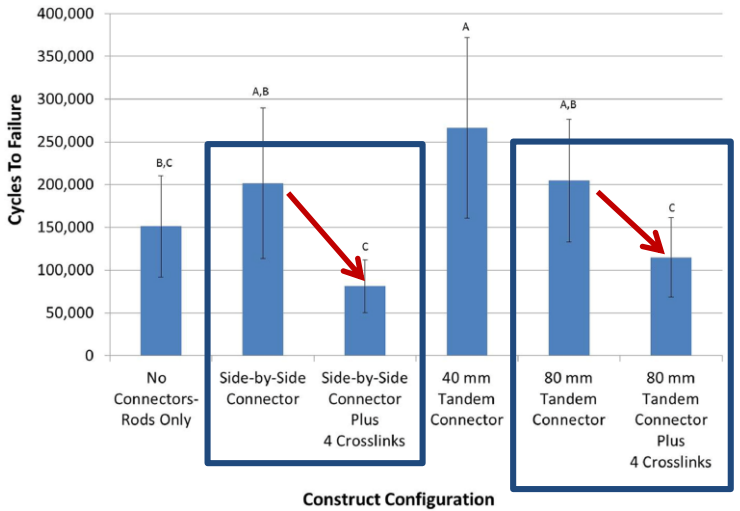
Growing Rod Failure

TGR	MCGR	Cross-links
		

1. Bess *et al*; Complications of growing-rod treatment for early-onset scoliosis: analysis of 140 patients. JBJS. 2010
2. Yang *et al*; Growing rod fractures: risk factors and opportunities for prevention. Spine. 2011
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

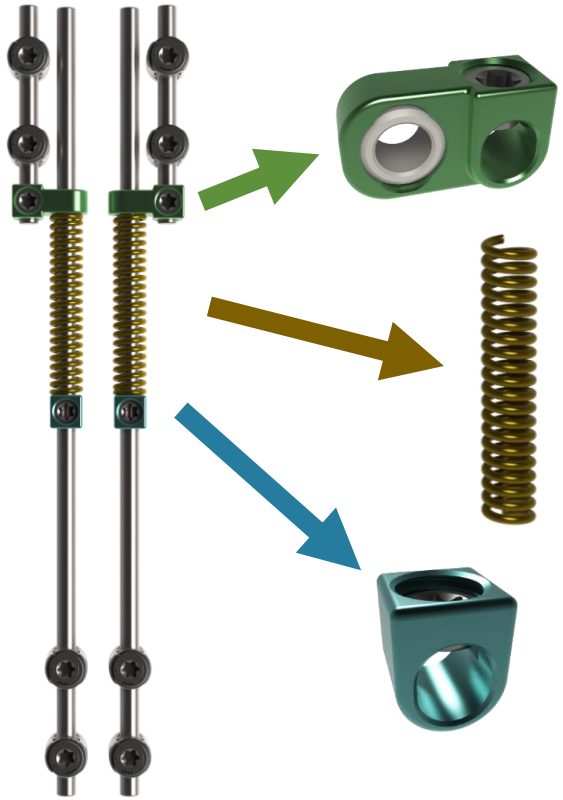


1. Hill *et al*; Mechanical Performance of Traditional Distraction-Based Dual Growing Rod Constructs. TSJ. 2018
2. Hill *et al*; Retrieval and clinical analysis of distraction-based dual growing rod constructs for EOS. TSJ. 2017

Spring Distraction System (SDS)

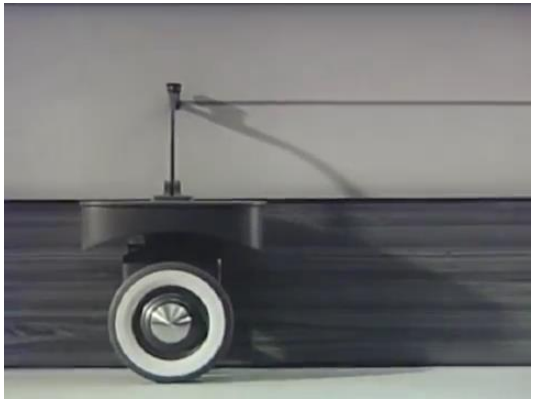
Connector | Springs | Buttress

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



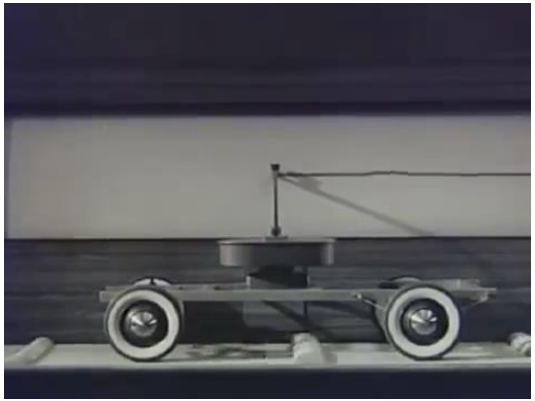
SDS as Spinal Suspension?

TGR/MCGR?



Stress peaks

SDS?



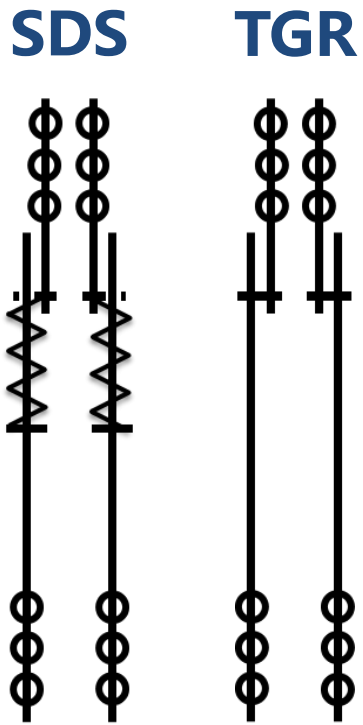
Shocks absorbed

1. Video source: Over the Waves (1938) Chevrolet Suspension – www.YouTube.com

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

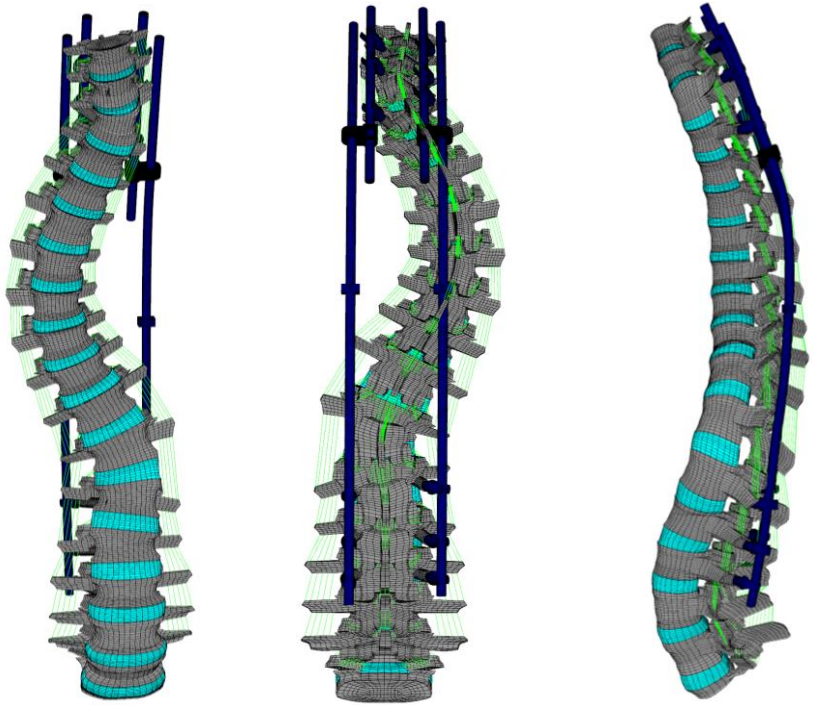
1. Implantation of instrumentation (**SDS** vs. **TGR**)
2. Distraction to correct the curve
3. Introduce gravity and muscle forces (follower load)
4. Loading (**1Nm** FLE/EXT/BEN/ROT moments)

→ Measure von Mises stress

Only difference between 2 models is spring and sliding connector

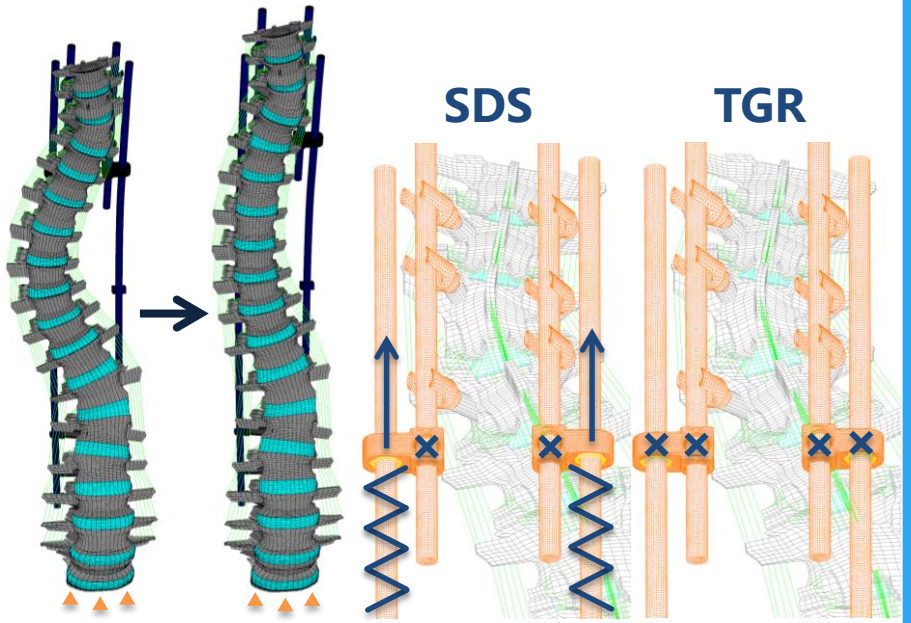
1. Implantation

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



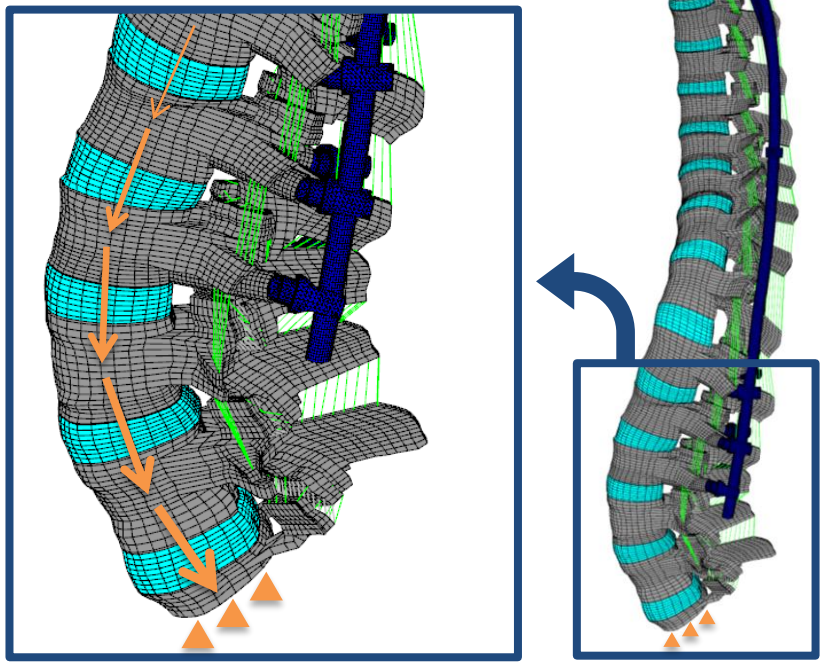
2. Distraction

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



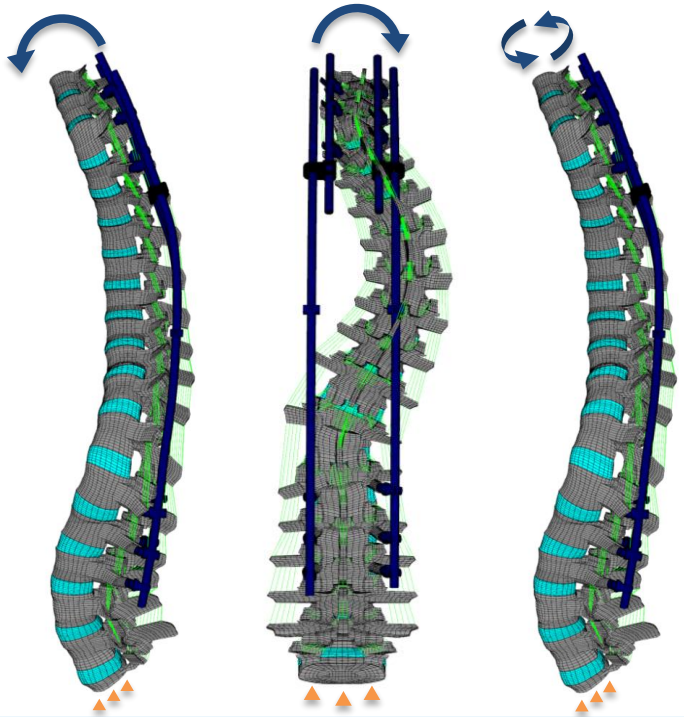
3. Follower load

- 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



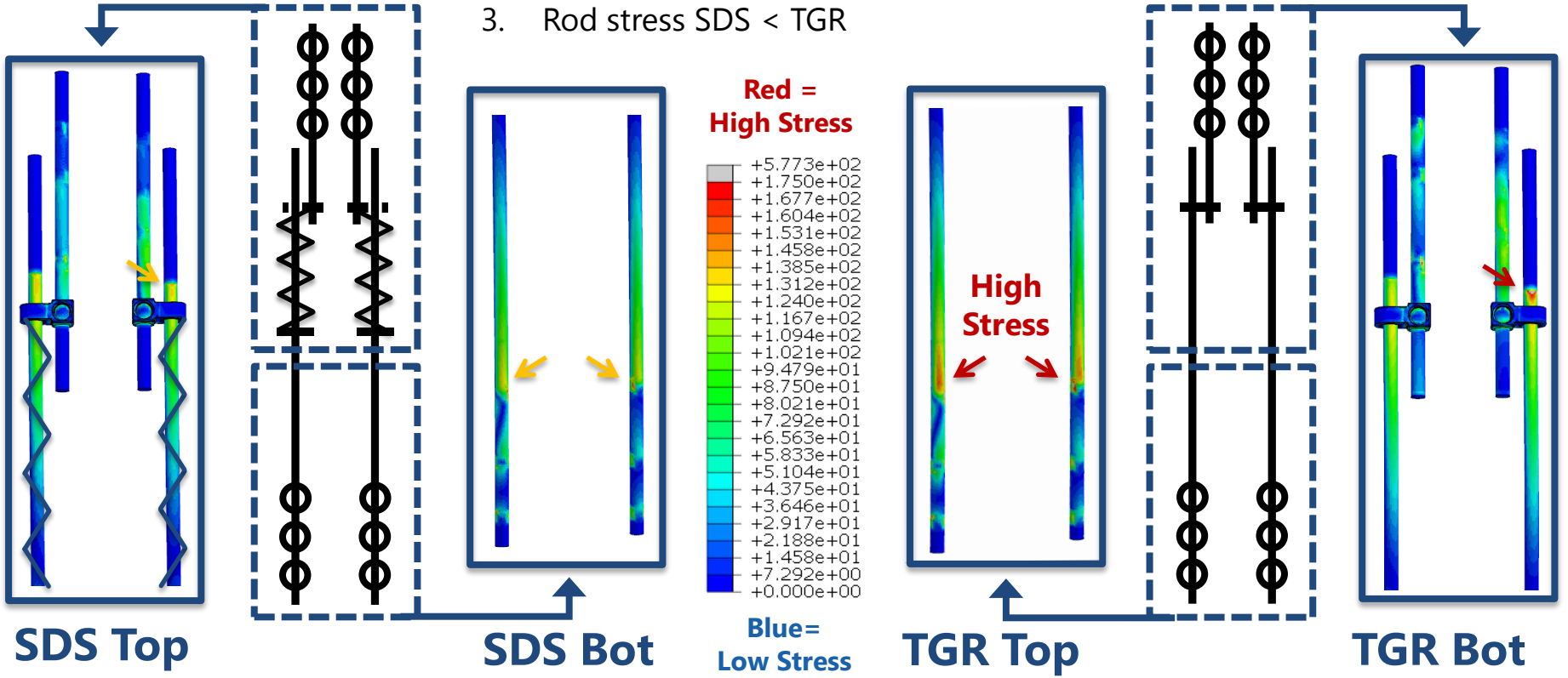
4. Loading

- 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

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

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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