**Problem**

- Scoliosis is a spinal deformity characterized by a 3D curvature of the coronal plane.
- Affecting ~9 million people in the US.
- 400,000 doctors visits annually.
- ~29,000 of them require surgical intervention.

**Current Spine Models**

- Sawbone models.
  - Anatomically realistic, but fail to represent the biomechanical properties of the spine.
  - Expensive, most do not have scoliosis, and mechanical properties of the body alter after death.

**Problem**

- Currently, there are no existing models that accurately replicate the anatomy and biomechanical properties of a spine during scoliosis surgery for adolescent patients.

**Proposed Solution**

A portable, reusable, cost-effective spinal model that accurately replicates the anatomy and biomechanics of the scoliotic adolescent spine

- **Anatomy**
  - 3D printed spinal vertebrae with snap fit features for easy assembly replacement.
  - Hook for attaching elastic bands.
  - Elastic bands connecting frame to vertebrae to simulate ligaments/tendons.

- **Frame**
  - Rail frame with acrylic plates to account for varying patient anatomy.
  - Spring loaded walls to allow for length variation during procedures.

- **Mold**
  - Foam mold to set spinal curvature and provide support.

- **Testing**
  - Polyurethane foam compression testing.
  - Elastic tensile testing.
  - Surgeon feedback.

**Market Analysis and Patents**

- **Figure** (right) identifies gap in current treatments/models.
- **Patients** with adolescent scoliosis account for around 29,000 surgeries per year.
- **Global medical simulation market** size is projected to reach $3.7 billion by 2025.
- **This solution** would be ~$400, while current models are between $500-5000.

- **Patent Search**
  - Two possible conflicting patents were identified.

**Conclusions**

- Determining best elastic material attachment points on model.
- Creating foam mold and molding the foam to sit underneath the vertebrae.
- Retrofitting better snap-fit attachment for a more secure connection around tubing.
- Hands-on testing and feedback with Medtronic consulting surgeons.
- Analyze ways to accurately model the effects of intervertebral disks.

**References**

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9. 1,3,4.

**Ongoing/Future Work**

- Determining best elastic material attachment points on model.
- Creating foam mold and molding the foam to sit underneath the vertebrae.
- Retrofitting better snap-fit attachment for a more secure connection around tubing.
- Hands-on testing and feedback with Medtronic consulting surgeons.
- Analyze ways to accurately model the effects of intervertebral disks.

**Acknowledgements**

Our team would like to thank Dr. Conrad Zapanta, as well as Nick Lee for their guidance and support throughout the year. We would also like to thank Medtronic for sponsoring this project as well as Medtronic Engineers, Drew Hall and Jerald Redmond, for their mentorship. The team would also like to thank Dr. Yanamadala, Dr. Cheng, and Dr. Bumpass for their expertise and guidance.

**Final Prototype**

**Market Analysis and Patents**

- **Material Modifications**
  - Thicker gooseneck tubing with frictional rubber coating.
  - 25lb latex resistance bands.
  - 5lb density flexible polyurethane foam mold with defined Lenke 1A curvature.

- **Mechanical Modifications**
  - Vertebrae with predrilled holes, elastic attachment features, and snap-fit geometry.
  - Spring loaded walls to allow for 1/3 length variation during procedure.
  - Adjustable and lockable frame.
  - Wooden 1/4" peg boards for attaching elastic bands with eye hooks.

**Results**

- Stiffness of spinal ligaments is roughly 1.5 MPa.
- Applied the best material from results of last years’ tensile tests.
- Chosen elastomer accurately represents the variable resistance behavior of spinal ligaments.

- **Polyurethane Foam Compression Testing**
  - Tested compressive properties of 4 different density PU foams.
  - Estimates from surgeon interviews were used as a comparison.
  - Survey with questions that rate our design against standards and experience.

- **Elastic Tensile Testing**
  - Tested 3 elastic bands with varying resistances, rubber bands, and Orthotape.

- **Surgeon Feedback**
  - Virtual demonstration of prototype with surgeons resulted in positive feedback regarding elasticity of vertebral column, stiffness of spine, and compressibility of ‘soft tissue’ when compared to typical adolescent spine.
  - Results help quantify feels right criteria.