**Introduction**

**Background**
- Scoliosis - spinal deformity with coronal plane curvature greater than 10° [1-12] (Figure 1)
- Degenerative scoliosis is painful and often requires surgery [1]
- 38,000 surgeries/year in the US [1]

**Problem**
- No devices exist to realistically model deformed spine for surgical preparation

**Needs Statement**
- “A cost-effective, reusable, and portable way to give engineers and healthcare providers the ability to model varying Cobb angles in preparation for spinal surgery.” [12]

**Testing Results**

**Ligament testing**
- Native ligaments - 1.5MPa [5]
- Tensile testing performed on elastic bands; example trial in Figure 2 and results in Table 1

**Disc testing**
- Native discs - 5.8 -42.7MPa [5]
- Compression testing performed on rubber sheets; results in Table 1

**Proposed Solution: Mechanical & Anatomical Synthetic Scoliosis Simulator**

**Final model includes following elements**
- User-friendly frame design (Figure 3)
- ABS 3D printed vertebrae w/ infill modeling cortical and cancellous bone (Figure 4)
- Snap-fit vertebrae (Figure 5)
- Torsional springs to model discs (Figure 6)
- Elastic bands as ligaments (Figure 7)

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**Figure 1:** Example of Scoliotic Spine [12]

**Figure 2:** Load vs. extension curve in tensile testing

<table>
<thead>
<tr>
<th>Elastic Moduli (MPa)</th>
<th>Average SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow (Light)</td>
<td>0.075 0.109</td>
</tr>
<tr>
<td>Red (Medium)</td>
<td>1.240 0.180</td>
</tr>
<tr>
<td>Blue (Strong)</td>
<td>1.444 0.096</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Compressive Moduli (MPa)</th>
<th>Average SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 Duro</td>
<td>99.107 3.509</td>
</tr>
<tr>
<td>40 Duro</td>
<td>52.917 6.052</td>
</tr>
</tbody>
</table>

**Table 1:** Summary of disc and ligament testing with selected materials highlighted

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**Discussion**

**Market Analysis and Patent Search**

**Market Analysis**
- Medical simulation ~ $2.58 Billion industry in 2022 [15]
- Table 2 and Figure 8 show market landscape for reusable spinal model

| Sawbone Models (one-time use) | $500+ |
| Cadavers (one-time use)       | $3000-5000 |
| Proposed Solution (reusable)  | $275  |

**Table 2:** Cost of existing & proposed models

**Results of Patent Search**
- Patent search yielded two spinal models (Figure 9), 3D printing infill method, disc prosthesis with springs, & artificial ligaments [13, 14]
- Risk of infringement is low

**Future Work**
- Quantitative testing on drillability of 3D printed vertebrae
- Verification of robustness of snap fit
- Quantitative testing on mechanical properties of the model to match forces used in correction surgeries

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**References**

10. "Dr. Boyle Cheng," for their support and guidance.