**INTRODUCTION:**

The lumbar spondylolisthesis is clinically benign and usually the symptoms can be managed with non-operative treatment. In patients with radiculopathy caused by the impingement of nerve root at the pars defect, decompression of the affected nerve root by removal of loose lamina for nerve root is essential (1). There is a significant risk of further instability after Gill’s laminectomy, therefore, concomitant intervertebral fusion has been recommended to prevent further slippage following Gill’s procedure. Most recently, Sairyo et al. (3) established an endoscopic technique to decompress the impinged nerve root. Since this technique is considered to be minimally invasive, the additional arthrodesis may not be essential. However, there are no studies evaluating the biomechanics of lumbar spondylolytic spine before and after the endoscopic decompression surgery or the Gill’s procedure. In this study, we analyzed the biomechanical changes following Gill’s laminectomy and endoscopic decompressive procedure for the spondylolytic spine using three-dimensional finite element method (FEM) to support the hypothesis that endoscopic based surgery is minimally invasive and does not lead to further instability, as compared to Gill’s procedure.

**METHODS**

**Finite element model**

For the biomechanical study, an experimentally validated 3-dimensional non-linear FEM of the intact ligamentous L3-5 segment was used (2,3). The intact model was modified to simulate bilateral spondylolisthesis at L4. Cracks of 1.0 (mm) were created at both of the pars interarticularis to simulate bilateral spondylolisthesis. Figure 1 demonstrates the FEM simulating endoscopic decompression procedure (center), and Gill’s laminectomy (right). The surgical method of the endoscopic decompression involves fenestration at the left L3/4 level: i.e. L3 and L4 laminotomy, partial medial facetectomy at L3/4, and curettage around the pars defect. On the other hand, in the Gill’s procedure, the loose lamina of L4 is removed. Simultaneously all surrounding ligaments such as ligamentum flavum, interspinous and supraspinous, are also removed.

![Spondylolysis](Image1.png)  
![Endoscopic](Image2.png)  
![Gill's procedure](Image3.png)  

**Figure 1. Posterior view of three kinds of finite element models**

**Analysis**

Von Mises stress distributions in various structures of contralateral pedicle and pars interarticularis and changes in the intradiscal pressure (IDP) were analyzed in flexion, extension, lateral bending and axial rotation in response to 400 N of axial compression and 10.6 Nm moment. The IDP and stresses were compared between the models simulating spondylolisthesis and two surgical procedures.

**RESULTS:**

**Stress distribution (Table 1):**

The stresses and intradiscal pressure during flexion motion showed differences among the models. During the flexion motion, the pressure at L4/5 nucleus pulposus was 0.09, 0.09 and 0.16 MPa for spondylolysis, endoscopic decompression and Gill’s procedure, respectively.

<table>
<thead>
<tr>
<th></th>
<th>Ant-L4 endplate</th>
<th>Post-L4 endplate</th>
<th>Ant-AF</th>
<th>NP</th>
<th>Post-AF</th>
<th>Ant-L5 endplate</th>
<th>Post-L5 endplate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spondylolysis</td>
<td>14.8</td>
<td>4.1</td>
<td>0.7</td>
<td>0.09</td>
<td>0.6</td>
<td>12.8</td>
<td>8.5</td>
</tr>
<tr>
<td>Gill</td>
<td>23.1</td>
<td>13.6</td>
<td>1.2</td>
<td>0.16</td>
<td>1.3</td>
<td>18.1</td>
<td>18.6</td>
</tr>
<tr>
<td>Scope</td>
<td>14.9</td>
<td>4.1</td>
<td>0.7</td>
<td>0.09</td>
<td>0.6</td>
<td>12.8</td>
<td>8.6</td>
</tr>
</tbody>
</table>

The stresses at adjoining endplates showed about 2-fold increase in the Gill’s procedure compared to the other two models; while these stresses for the endoscopic and spondylolisthesis models were similar. In the other motions, i.e. extension, lateral bending, or axial rotation, the results were similar among the models.

**DISCUSSION:**

As for the surgical treatment of spondylolisthesis to relieve radiculopathy, Gill et al. (1) described a lesser invasive technique compared to fusion, removal of loose lamina and curettage around the impinged nerve roots. However, long-term follow up studies of this procedure revealed further slippage post surgery in some patients. Thus, at present patients undergoing this procedure usually receive additional inter-segmental fusion. We feel this additional surgery becomes essential because of the unfavorable biomechanics following the procedure. To test this hypothesis we undertook the present study comparing the Gill’s procedure with spondylolisthesis model. The analyses reveal approximately a two-fold increase in the stresses at the anterior spinal column such as endplates of L4 and L5, and annulus fibrosus, and intradiscal pressure across L4/5 during the flexion motion after the Gill’s laminectomy. This 2-fold increase, at the disc and surrounding tissues, may facilitate disc degeneration, causing forward slippage over time following surgery using Gill’s procedure.

On the other hand, the present FEM study showed that the endoscopic procedure does not lead to any increase in stresses in various spinal elements and intradiscal pressure, as compared to pre-surgery. In this technique, the supra- and inter-spinous ligaments are left intact as well as the para-vertebral muscles. This surgical invasiveness contributed the biomechanical results. In conclusion, the present biomechanical study using FEM supports the concept that endoscopic decompression of the spondylolisthesis is a minimally invasive method to relieve radicular pain without further destabilizing the spine.

**REFERENCES:**

2) Goel VK et al. Spine 1955; 20: 689- 698  