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Pars interarticularis fracture in young athletes is an extension-stress fracture and initiates in the ventral-caudal region

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INTRODUCTION:
Lumbar spondylolysis is a defect of pars interarticularis and occurs in ~6% of the population in the United States. Based on clinical appearances, the pathogenesis of spondylolysis is considered to be a stress fracture. Spondylolysis commonly occurs to young athletes, Sairyo et al [1] reported that stresses during lumbar extension and axial rotation increase at the pars interarticularis. However, the region where the fracture initiates is not known. Our hypothesis is that fracture line of spondylolysis initiate from the ventral region of pars during extension because stresses are the highest during extension. In the present study, early-stage spondylolysis patient-cases were reviewed to identify the initiation of the fracture line. A biomechanical study was undertaken to corroborate the clinical observations with finite element model based stress predictions.

METHODS:
Four cases of early-stage spondylolysis patients in whom fracture line did not encompass the entire circumference were reviewed (Table 1). All patients were young athletes. There were three males and one female, 12 to 14 years old. All of them had L5 spondylolysis. Three cases were unilateral spondylolysis, and one case was bilateral spondylolysis. The fracture location/lines of pars interarticularis was examined using the sagittal and oblique axial CT views.

Using a finite element model of the intact ligamentous L3-S1 segment, stress distributions were analyzed in response to 400-N axial compression and 10.6-N.m moment in flexion, extension, lateral bending, and axial rotation. The stresses in the ventral and the dorsal aspects of the pars were compared to identify the regions where cracks could initiate.

<table>
<thead>
<tr>
<th>Case</th>
<th>Gender</th>
<th>Age</th>
<th>Level of spondylolysis</th>
<th>Sport</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Male</td>
<td>13</td>
<td>L5 bilateral</td>
<td>Football</td>
</tr>
<tr>
<td>2</td>
<td>Male</td>
<td>14</td>
<td>L5 rt,unilateral</td>
<td>Weight lifting</td>
</tr>
<tr>
<td>3</td>
<td>Male</td>
<td>14</td>
<td>L5 lt,unilateral</td>
<td>Basketball</td>
</tr>
<tr>
<td>4</td>
<td>Female</td>
<td>12</td>
<td>L5 lt,unilateral</td>
<td>Volleyball</td>
</tr>
</tbody>
</table>

Table 1: Spondylolysis in patients reporting to the sports clinic

RESULTS:
• Clinical study
According to the CT scans, 5 pars of 4 patients revealed early-stage spondylolysis and also had fracture lines. In axial view of CT, that fracture line did not encompass the entire circumference, confined only to ventral aspect of pars. In sagittal view, these pars defects were present along the caudal aspect of pars. Figure 1 shows the fracture line of a football player with bilateral L5 spondylolysis.

• Biomechanical study
The principal stresses in the pars of the intact model in the ventral and dorsal aspect are shown during all 6 lumbar motions (Figures 2 and 3). The highest increase in tensile principal stress was in the ventral-caudal region during extension, 2 times compared to the dorsal aspect. These results corroborate our clinical data.

DISCUSSION:
In the clinical part of the study, the fracture line of early-stage spondylolysis was located only in ventral-caudal region, while the highest stress was also in the same region in extension. The stress fractures in athletes with much extension maneuvers are likely to occur during extension. Further, the fracture of spondylolysis occurs so that ventral-caudal aspect is torn apart to start with. The fracture line then proceeds to the dorsal aspect with time. To further validate our findings, we need to increase our clinical sample size.

REFERENCE: