INTRODUCTION:
Knowledge of motion patterns of the lumbar vertebrae in discogenic low back pain (LBP) patients is important for improving the surgical treatment. However, few data has been reported on 6DOF vertebral motion of these patients under physiological loading conditions. Recently, we validated a combined dual fluoroscopic and MRI/CT imaging system (DFIS) to investigate in vivo lumbar spine kinematics in human subjects [1, 2]. In this paper, we applied this technique to study a cohort of patients with discogenic LBP immediately prior to undergoing spinal fusion procedures. The results were compared to previously published data on asymptomatic subjects without evidence of degenerative changes. We hypothesized that the lumbar vertebrae at different levels, particularly at the levels immediately adjacent to those that were symptomatic, would demonstrate distinct motion characters during active in-vivo spine motion.

METHODS:
Patient recruitment: Ten symptomatic subjects of 50-60 years old were recruited under IRB approval and informed consent. Their symptoms were deemed to be discogenic and originate from the L4-5 level. Radiographic confirmation of discogenic LBP was confirmed by both the treating surgeon and a neuroradiologist. The degree of degeneration was graded using the Pfirrmann [3] scales (Table 1). L3-4 was the adjacent level to the degenerated levels L4-5 and L5-S1 with Pfirrmann grade of 1.6 ± 0.8.

Vertebral Kinematics: Spine motions were reproduced using combined DFIS and MR imaging technique [2] during flexion-extension left-right (LR) bending and LR twisting of the body. From the local coordinate system at the endplate (Fig 1), the relative motions of the proximal vertebrae with respect to the distal vertebrae were calculated at 4 vertebral levels: L2-3, L3-4, L4-5 and L5-S1.Ranges of motion (ROM) of both the primary rotations and coupled translations and rotations were determined. ANOVA was used to compare the ROMs between the different levels and between patients and normal subjects. Significance was set at p<0.05.

RESULTS:
Primary rotations: Interestingly, during all 3 movements, the greatest ROM were observed at the L3-4 level (Fig 2), which was the adjacent level to the degenerated levels L4-5 and L5-1. L3-4 had a significantly larger ROM than L2-3 in LR bend and LR twist movements, but not in flexion-extension (p = 0.24). The lowest range occurred at the L5-1 level (significantly smaller than L3-4) for all 3 principal movements.

Comparison with Normal Subjects: The ROM during bend LR and twist LR at L3-4 was significant larger in the DDD group than the normal group (Fig 2). During flexion, it is also larger but not significant (p = 0.43). The ROM during flexion at L4-5 was significantly larger in the DDD group than the normal group. However, it is smaller than normal (P = 0.21) during bend LR and similar to normal (p = 0.91) during twist LR.

DISCUSSION:
This study quantified aberrant motion patterns in 6DOF in patients with LBP specifically of a clinically confirmed discogenic etiology. The data revealed several interesting biomechanical findings. During all 3 movements the greatest ROMs were observed at the L3-4 level, which were also larger than normal subjects. This led us to believe that superior adjacent levels developed segmental hypomobility prior to undergoing surgical fusion. During all three movements L5-S1 had the lowest ROM, and significantly less motion than L3-4. Given that this was the level at which all patients had confirmed DDD, this leads us to believe that with severe DDD that progresses to the point of requiring surgical intervention, segmental hypomobility ensues.

In the future, this data can be used to study the effects of spinal arthrodesis on motion characteristic after operation and to further define the mechanical component of adjacent segment degeneration. Furthermore, knowledge of motion patterns of the lumbar vertebrae in DDD patients is important for improving the surgical treatment of intervertebral disc diseases using dynamic stabilization techniques, such as dynamic fusion and total disc arthroplasty (TDA).

Reference:

Table 1: Pfirrmann scores (average ± standard deviation) at different disc levels and a typical MR image.

<table>
<thead>
<tr>
<th>Level</th>
<th>Pfirrmann Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>L3-4</td>
<td>1.6 ± 0.8</td>
</tr>
<tr>
<td>L4-5</td>
<td>4.2 ± 0.6</td>
</tr>
<tr>
<td>L5-S1</td>
<td>4.5 ± 0.5</td>
</tr>
</tbody>
</table>

Figure 2: Primary rotation of DDD and normal subjects at different levels during: a) Flexion-extension. b) Bend LR. c) Twist LR. *: statistical different within DDD group, #: statistical different compare DDD with normal group.