1. Proposal Abstract

Purpose: Chronic low back pain (LBP) is a common musculoskeletal disorder that significantly impacts public health. However the mechanism of chronic LBP is still not fully understood. From a biomechanical point of view, it is believed that chronic LBP is related to spinal instability (abnormal motion), abnormal load transmission, or both in the degenerated motion segment. But the relationship between these factors and back pain is again not clear. There remains a need for more effective biomechanical measures that are able to characterize spine motion and load transmission, and clarify how these factors relate to pain generation. The ***long term goal*** of this study is to find effective biomechanical measures for characterizing spinal motion and load transmission, and use these measures to elucidate the biomechanical mechanism of chronic low back pain. The ***objective*** of this research is to validate *in vitro* that instantaneous axis of rotation (IAR) is an effective measure to define abnormal spinal motion (spinal instability), and intra-discal pressure profile (IDPP) an effective measure to define abnormal load-transmission; and further to understand the relationship between IAR and IDPP.

Hypotheses:1) Instantaneous axis of rotation (IAR) trace patters are different between normal and degenerated discs. 2) The load transmission across the disc space, as measured using intra-discal pressure profile (IDPP), is different between normal and degenerated discs. 3) There is a relationship between IAR and the load-transmission across the disc space.

Methods: An *in vitro* study of lumbar spine kinematics and load transmission is proposed to achieve our study aims. Ten human cadaver lumbar spine specimens will be procured. MRI scans of these spines will be performed to determine the degree of disc degeneration. Lateral radiographs of the specimens will be obtained to measure disc height, lordosis, listhesis, endplate sclerosis, etc. The specimens will then be potted with two motion segments in each potting for load-deformation tests on a six-degrees-of-freedom (6-DOF) spine tester. IAR will be determined from motion tracking data and hundreds of instances of IAR locations (continuous tracking of the locations of the IAR) will be calculated during one flexion-extension cycle. Disc pressures will be determined using two methods, with IDPP as the primary approach, to identify any abnormal load-transmission across the disc space. The two methods for measuring disc pressures are: 1)IDPP, as a continuous pressure profile across the disc space with the specimens held statically in flexion, extension and neutral posture under load-bearing; and 2)disc pressure graph, which is determined during dynamic flexion-extension motion from the center of the disc space. Finally, both qualitative and statistical comparison of IAR and IDPP will be performed based on degree of disc degeneration to understand their relationships.

2. Findings

2.1. Project summary

We have conducted tests on 40 discs from 14 spine specimens. Before tests, MRI was conducted on specimens and degenerated discs were graded using a clinical disc degeneration grading system as described by Pfirrmann et al (2001). Discs were divided into five groups: normal (grade I), minor (grade II), mild (grade III), moderate (grade IV), and severe degeneration (grade V). **Table 1** summarizes degeneration grade distribution of tested discs.

The majority of tested discs were normal (grade I), and only one grade V disc was available. It was found obtaining higher degeneration grade discs (Grade V) was difficult, because of their low availability and the frequent spontaneous fusion of such motion segments. However, we obtained sufficient numbers of discs for Grade I~IV. Clinically, symptomatic discs with degeneration equal or greater than grade III are surgically treated, therefore our tested Grade III and IV discs should be sufficient to answer our research question.

In the following sections, IAR, ROM, NZ, IDPP, and disc pressure graph (IDP) data are presented.

Table 1. Degeneration distribution of tested discs

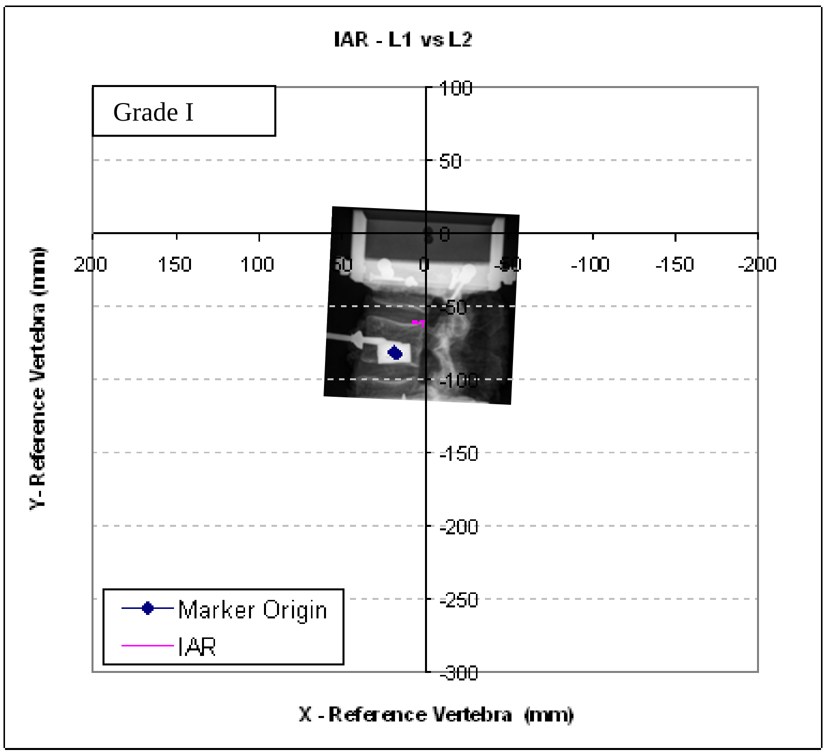
	Grade I	Grade II	Grade III	Grade IV	Grade V
# of discs tested	13	9	12	5	1

2.2. Instantaneous Axis of Rotation (IAR)

Potted specimens were loaded onto a 6-DOF spine tester for load-deformation tests in flexion-extension direction. During tests, motion was captured with a motion tracking system and IAR was calculated from the continuous motion tracking data. After tests, lateral X-ray radiograph of the specimen was obtained to record the reference positions of motion tracking markers. IAR was then superimposed to the radiographs to reveal anatomic location of the IAR relative to the motion segment.

Figure 1 and **Figure 2** are IAR for two typical normal discs (Grade I). **Figure 3** and **Figure 4** are IAR for two typical Grade II disc. **Figure 5** and **Figure 6** are IAR for two typical Grade III discs. **Figure 7** and **Figure 8** are IAR for two typical Grade IV disc. **Figure 9** is the IAR result for one Grade V disc.

In summary, extensive tests have been conducted and IAR of 40 motion segments with various degrees of degeneration have been obtained. Baseline of IAR patterns of normal discs has been established. The IAR results of degenerated discs will be analyzed and compared with normal IAR. Further results will be submitted in the final report this project.



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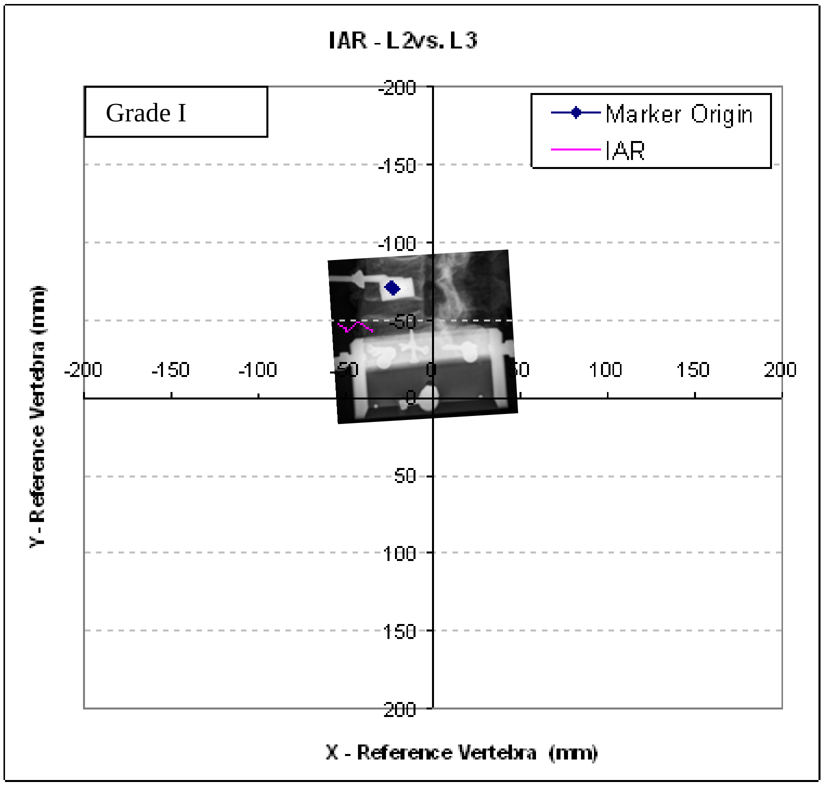

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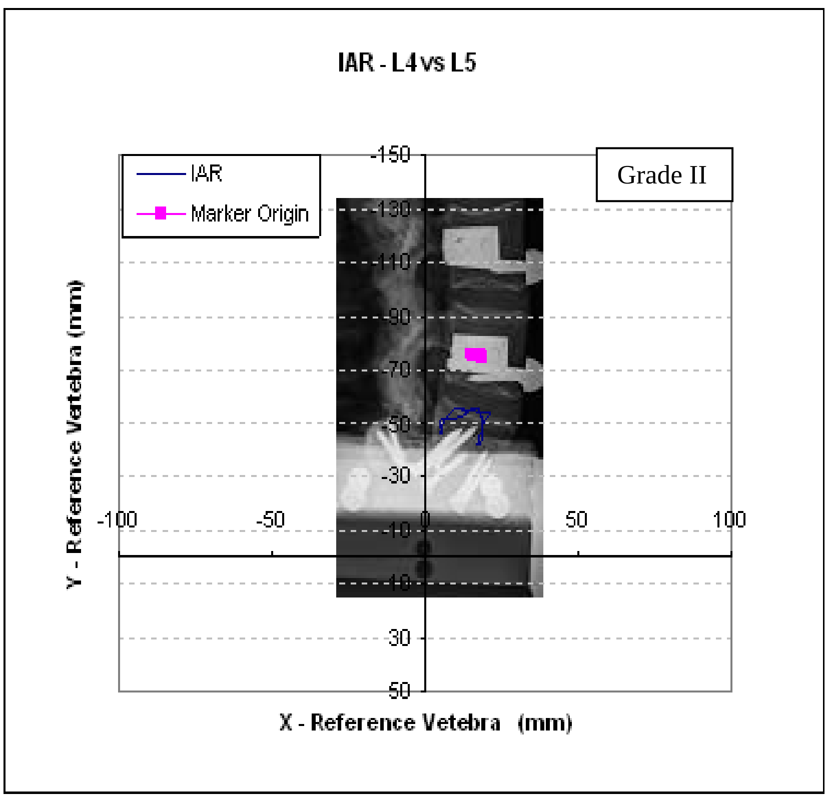

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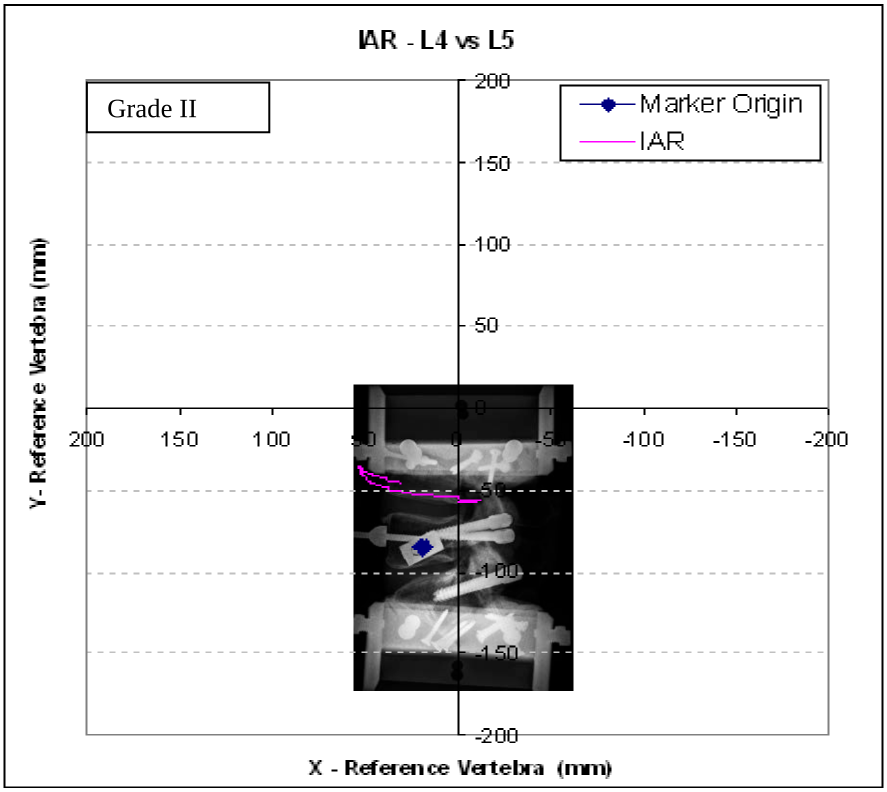

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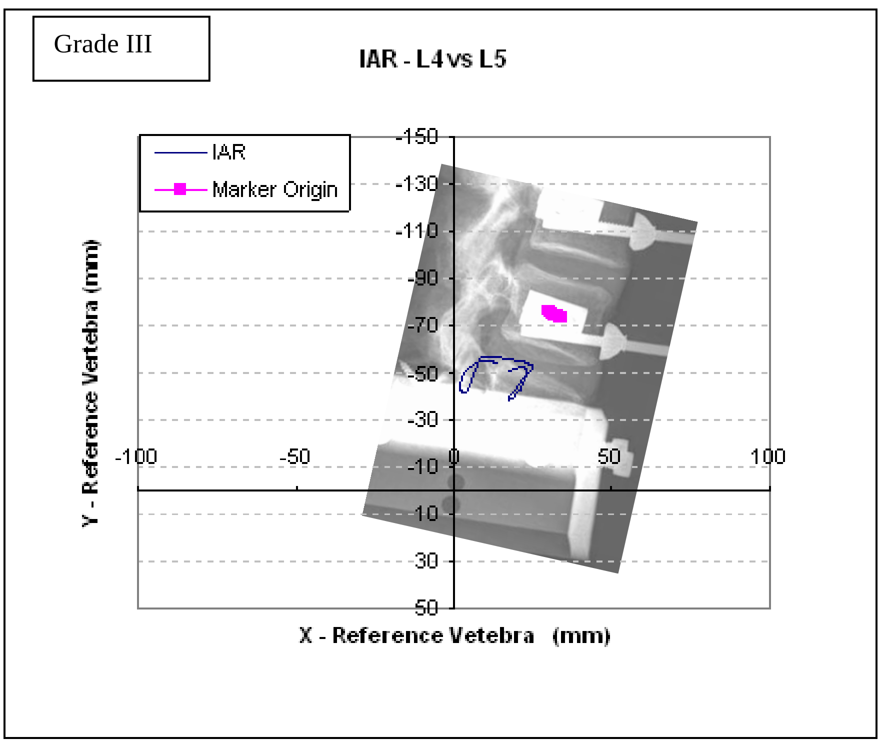

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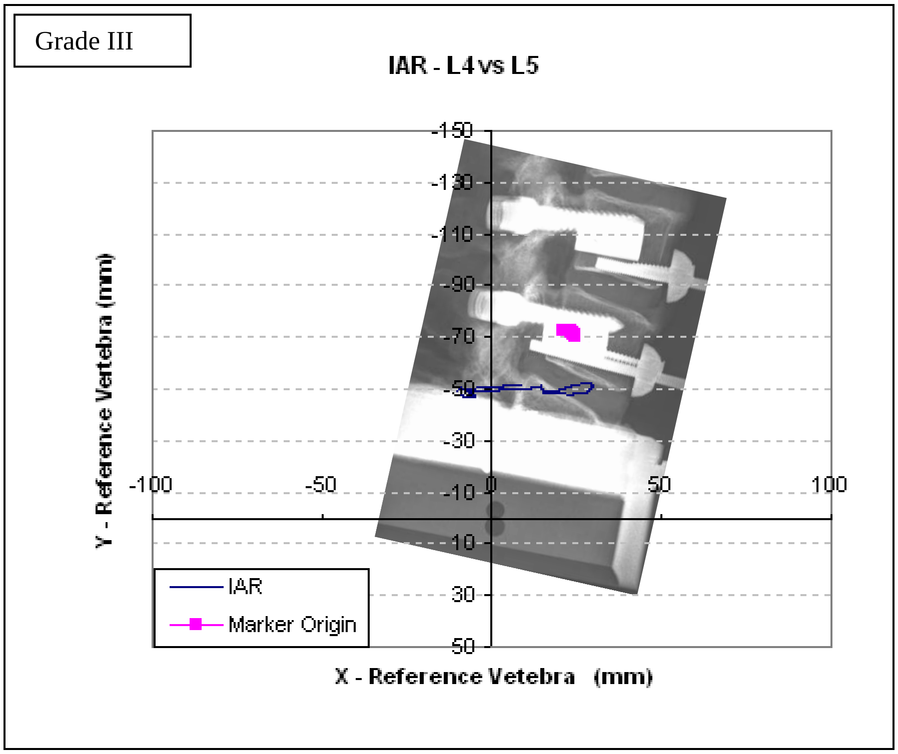

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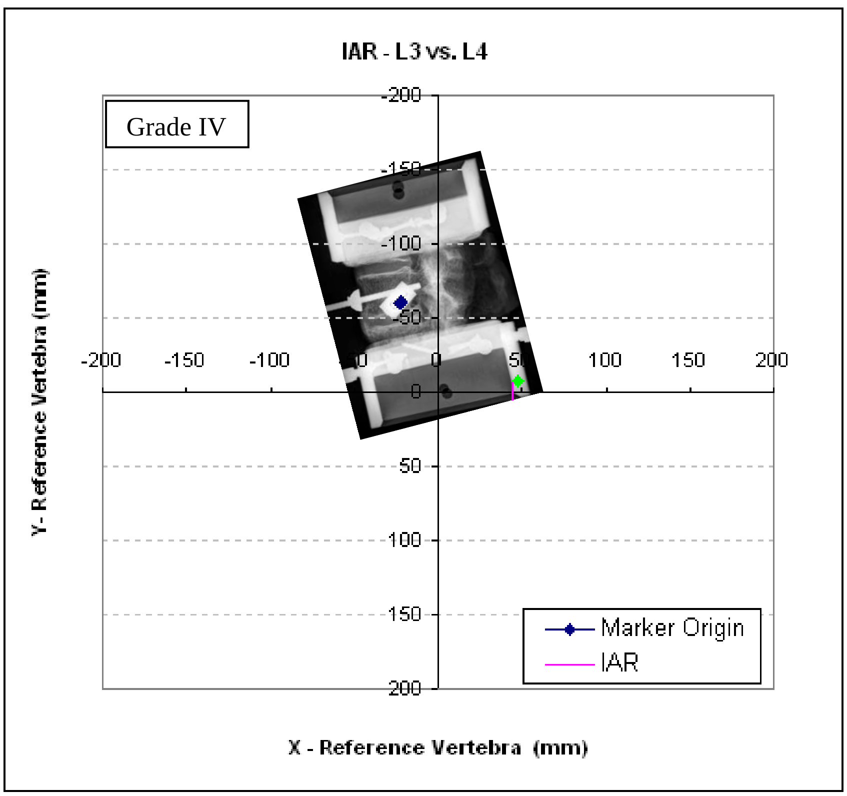

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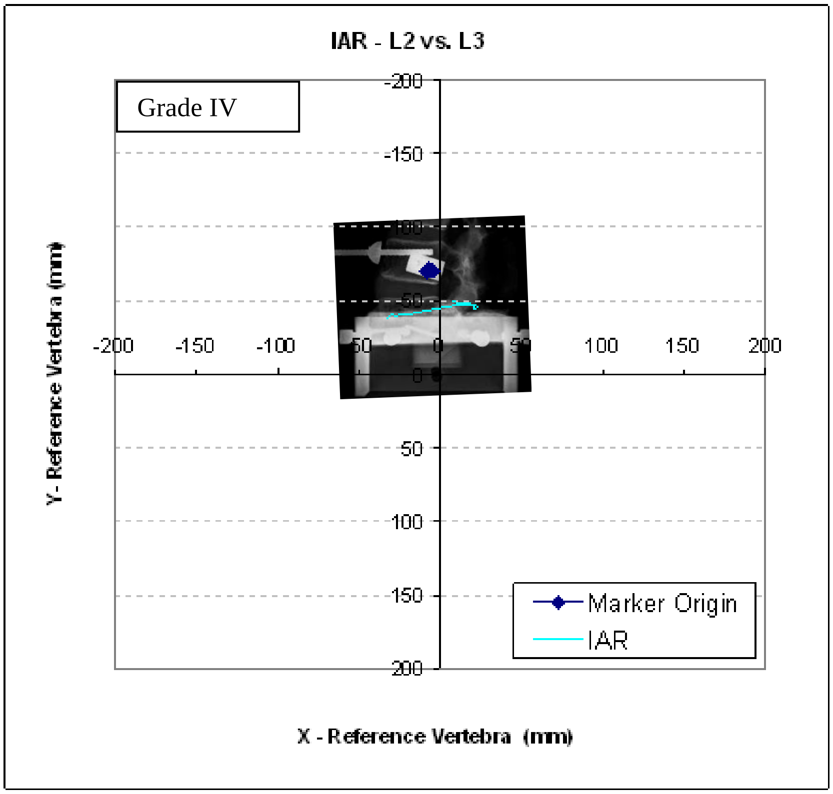

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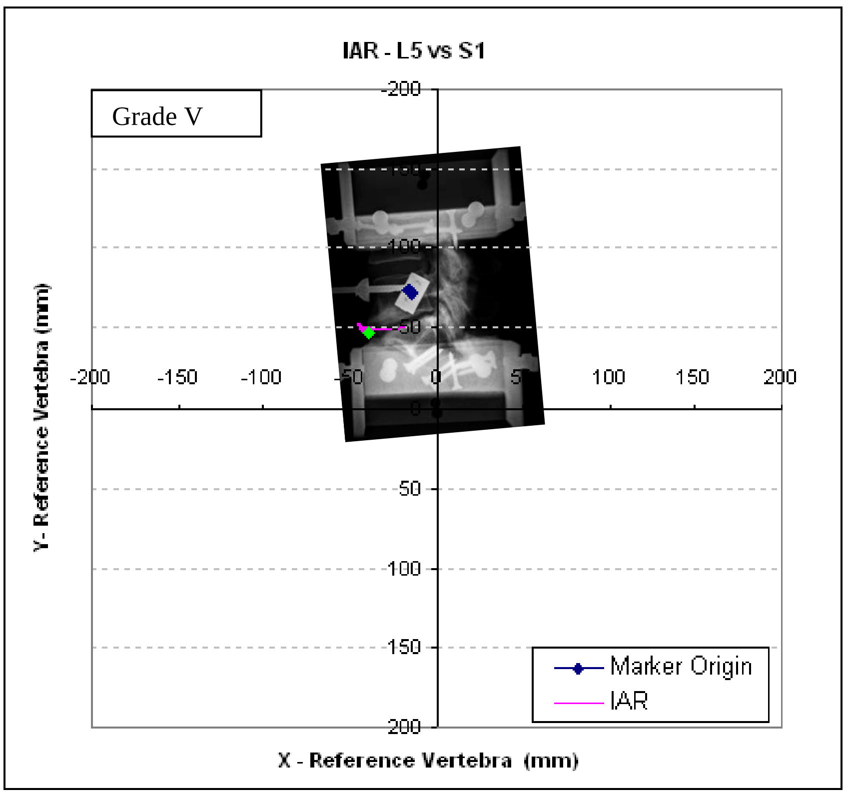

Figure 9, (spec #62109)