Interpretation and Application of Energy Dissipation Measurements in Biomechanical Spine Studies

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Introduction

The measurement of the hysteresis phenomenon during in vitro biomechanical testing in spinal investigations can provide parameters related to viscoelasticity. Various studies quantify spine biomechanics with Range of Motion and stiffness measurements. However, other studies included an energy dissipation/hysteresis area to increase the resolution of the analysis. The intent of this manuscript is to explore this area of biomechanics.

Methods

The study analyzed the energy dissipation of three previously published biomechanical investigations. The studies used ten L2-L3, nine L3-L4 or twelve L4-S1 intact spines. Injury conditions included full discectomy and partial annulotomy; laminotomy with partial discectomy and annulotomy; and bilateral facetectomy. Simulated fusion conditions included expandable lateral cages, static lateral cages with and without pedicle screws, interspinous spacers, bilateral expandable posterior cages with interspinous spacers or bilateral pedicle screws and a transdiscal screw system. All studies implemented a torque-controlled protocol of dynamic axial rotation (AR), quasi-static flexion/extension (FE) and lateral bending (LB).

Results

The disc injuries increased the energy dissipation in all motions ($P<0.05$) and facetectomy increased the energy dissipation in AR ($P<0.05$). The majority of fusion conditions had minimal energy dissipation. Interspinous spacers are more stable in FE. A strong correlation ($R2>0.99$) of energy dissipation was observed in all motions between 3.0Nm vs. 7.5Nm loading protocols (n=24).

Conclusions

The intervertebral disc is the main contributor to energy dissipation. Rigid replacement of the disc reduces energy dissipation. The disc has the most creep in a spine segment followed by the ligaments then vertebral body. The analysis of energy dissipation could potentially provide more depth to biomechanical investigations.

Learning Objectives

By the conclusion of this session, participants should be able to:

1) Describe what the area contained within the hysteresis loop is

2) Discuss the biomechanical significance of energy dissipation and its application to clinical models

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