BIOMECHANICAL ALTERATION INITIATES INTERVERTEBRAL DISC DEGENERATION IN THE NEEDLE PUNCTURE MODEL

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INTRODUCTION:
The annular puncture or stab model is an experimental method of creating intervertebral disc degeneration. By using a scalpel or needle to puncture a hole through the annulus fibrosus and into the nucleus pulposus, a series of events take place to cause disc degeneration. While a number of stab model studies have been conducted\(^1,2,3\), the exact mode of disc degeneration is not completely understood.

Recently, a successful alternative stab model was performed by Masuda et al\(^2\). In this model, various sizes of needles were used to create slower, more progressive disc degeneration in rabbits. A similar study by Sobajima et al\(^3\) notes that no herniation had occurred after stabbing the disc. To date, the exact mode of disc degeneration due to needle stab is not understood. Our group hypothesizes that the puncture allows for a loss of nucleus material, including cells. In that case, the model would not be a true degeneration model, but would be classified as a herniation model. The present study shows that herniation and ensuing biomechanical alteration occurs when using the needle puncture type of stab model.

METHODS:
Eighteen fresh lumbar motion segments (L3-L4 or L5-L6) were obtained from NZW rabbits weighing 4 to 5 kg (~40 to 50 N). The spine segments were stripped of all musculature and excess tissue, leaving only ligamentous specimens. Both ends of the segments were potted in molds filled with plastic resin such that the segments were positioned vertically. The FSUs were then attached to a hydraulic loading machine (MTS) and prepared for axial compression testing.

The FSU’s were randomly assigned to 16, 18 and 20 gauge needle groups. Intact FSUs were loaded in axial compression until 2mm displacement. The discs were unloaded and a needle was selected for stab use. Each disc was then punctured to the center and was monitored for 5 minutes to witness any possible herniation under no load (Figure 1). The specimen was tested again and the load at which herniation occurred was recorded. The stiffnesses before and after the herniation load were compared to each other as well as the intact case.

RESULTS:
All FSU’s showed herniation during loading to 2mm displacement (Figure 1).

Figure 1. Multiple views of disc herniation after stab and axial loading.

The average force at the herniation was 7.8±2.64, 10.3±4.72, and 30.8±19.82 N for 16, 18 and 20 gauge needle groups, respectively; smaller the stab size higher the load value. This force at herniation was smaller than the rabbit’s body weight. Thus, the herniation of the disc material could occur during the normal activities following surgery, since compressive load on the disc is likely to increase compared to the anesthetized condition. Figure 2 shows the herniation loads in relation to body weight.

Figure 2. Amount of load required to cause herniation in discs stabbed with various gauge needles. Herniation loads are similar to those seen in normal activities.

The stiffness of the FSUs before and after stab was compared by looking at the slope of the force-displacement curves. The average stiffness after stab was 28.6±28.1%, 17.9±15.6%, and 37.3±31.9% of intact for 16, 18, and 20 gauge needle groups, respectively.

The average decrease in stiffness following stab and disc herniation was significant compared to intact values, although no significant difference existed among the three needle size groups. The average herniation forces for discs stabbed with 16 and 18 gauge needles were not significantly different. However, the force required for herniation from stab using a 20 gauge needle was significantly higher than both of the other groups. For statistical purposes, p value less than 0.05 (p<0.05) was taken as significant.

DISCUSSION:
The study shows that disc herniation could occur during normal activity following stab. Also, different needle sizes used in the stab or needle puncture model of disc degeneration have an effect on the amount of force needed to cause herniation. Any subsequent biochemical changes that would occur within the disc in an in vivo study are partially due to the biomechanical changes in the disc environment. Additionally, large amounts of cells would be lost as the nuclear material protrudes out of the disc. The loss of cells may compound the problems of disc degeneration.

REFERENCES: