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Synthetic Soft Tissue Characterization of the Mechanical Analogue Lumbar Spine

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Evaluation of spinal implants is limited by difficulties in testing biological structures. Soft tissues primarily control spinal biomechanical responses. The objective of this study is to show controllability of the synthetic soft tissue properties of the mechanical analogue lumber spine. The development of an analogue spine would answer a multitude of clinical questions and improve implant design. Polyester fibers in a wave pattern were embedded in a shore-A F55 polyurethane matrix to mimic the nonlinear properties of human ligaments. Ligaments with four different volume fractions (Vf) of fibers were tested to failure in tension using specially designed jigs in a MTS MiniBionix. Polyester fibers oriented at +/−30 degrees were embedded in F55 polyurethane to simulate the annulus fibrosis (AF). Discs with three different Vf's and F5 polyurethane for the nucleus pulposus were tested in compression to 1.25 mm using a self-aligning jig. Displacement control was used for all specimens at a rate of 0.04230 mm/sec. For the ligaments, the initial stiffness and strain at toe was similar and the mean secondary stiffness in MPa was $187 \pm 5\%$, $307 \pm 5\%$, $422 \pm 2\%$, and $511 \pm 3\%$ as the Vf increased. For the discs, the mean initial and (secondary) stiffness in N/mm was $158 \pm 14\%$ ($658 \pm 6\%$), $150 \pm 5\%$ ($666 \pm 8\%$), and $74 \pm 3\%$ ($1230 \pm 2\%$) as the AF Vf increased. The results showed that synthetic soft tissue properties are controllable and properties measured fall within the range of human cadaveric literature values. A wide variety of analogue models can be developed utilizing the control of soft tissues.

