A Nanocomposite Sensor Neck Sleeve for Tracking in Vivo Spine Kinematics in the Alpaca

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Introduction: Chronic low back pain in the United States is a pervasive problem with tremendous economic and social implications and is often attributed to intervertebral disc degeneration. Current techniques for treatment have low patient satisfaction. Camelids, particularly alpacas, pose a potential model for spinal treatment due to similarity of the spinal structure and vertical loading. In recent work, our lab has discovered that alpacas also exhibit a very high rate of natural disc degeneration (up to 90% in elderly alpacas). In order to gain more understanding about how disc degeneration is caused in alpacas it is necessary to understand the loading and motion of the alpaca cervical spine. The goal of the present work was to incorporate novel nanocomposite sensors into a custom-designed neck sleeve in order to track the daily in vivo neck motion of an alpaca in its natural environment.

Materials and Methods: Neck strains of an alpaca at maximal range were acquired from live alpaca specimens and ranged from 20-100%. Nanocomposite strain sensors comprised of nickel nanostrands (11% by volume) embedded in a silicone matrix (Ecoflex 00-30 silicone), with nickel-coated carbon fibers (2% by volume) were created. These gauges were developed in previous work and exhibit a massive change in electrical resistance during finite deformations up to 100% strain. A structured design process was used to develop a custom-designed spandex sleeve that could easily be positioned tightly against the skin of a shaved alpaca neck. The nanocomposite strain gauges were incorporated into the sleeve design, and the locations of the embedded gauges were based on preliminary marker tracking studies and can be seen in Figure 1. Changes in the electrical resistance of the embedded gauges were measured using a connected multimeter as seen in Figure 3.

Results: Preliminary results demonstrated that the sleeve fit well on the alpaca and did not disturb the natural motion of the animal or provide any obvious discomfort as seen in figure 2. Electrical resistance changes were easily observed during cervical flexion-extension, lateral bending, and axial rotation motion of the animal and ranged from 3 M-ohm to 300 M-ohm depending on the specific neck positioning of the animal.

Figure 1.   Figure 2.   Figure 3.

Figure 1: Preliminary marker tracking study on alpaca neck
Figure 2: Nanocomposite sensor neck sleeve for tracking in vivo spine kinematics of the alpaca.
Figure 3: Embedded gauges on the alpaca sleeve

Conclusion: The nanocomposite sensor neck sleeve design works as anticipated and is now being connected to a microcontroller with integrated Bluetooth transmission capabilities to provide a self-contained alpaca kinematics tracking device. Future work will use this design to track alpaca motion over an extended period of time (up to a week), providing a unique look at alpaca biomechanics and potentially yielding insights as to why this animal experiences disc degeneration rates similar to elderly humans.