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262. Direct Measure of Cervical Interbody Forces in Vivo: Load Reversal after Plating

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BACKGROUND CONTEXT: Biomechanics play an important role in spine fusion, but the in vivo biomechanics of the cervical spine are not well characterized and the in vivo biomechanics after spinal arthrodesis have never been studied. Load sharing facilitates fusion, but overloading of interbody implants can lead to subsidence and failure. In vitro studies have demonstrated that anterior plating significantly alters mechanical loading in the cervical spine. The instantaneous axis of rotation is shifted anteriorly and loading is reversed relative to an uninstrumented spine; the interbody space is compressed during extension and unloaded during flexion. However, this has never been tested in vivo and the magnitude of loads in the instrumented and uninstrumented cervical spine are unknown.

PURPOSE: The purpose of this study was to use a novel force-sensing implant to directly measure interbody loading in the cervical spine in real time in vivo in a large animal model following instrumented or uninstrumented arthrodesis.

STUDY DESIGN/SETTING: In vivo biomechanical loading following anterior cervical discectomy and fusion (ACDF) in goats.

OUTCOME MEASURES: Real time in vivo interbody forces and kinematic motion data during flexion/extension exercises after interbody arthrodesis in the goat cervical spine.

METHODS: A custom interbody implant/load cell was developed to measure real time forces in the interbody space of the goat cervical spine. The implants incorporated a wired button load cell (Futek, Irvine, CA) between implant endplates. The implant/load cells were calibrated and sterilized. After IACUC

approval, under general anesthesia, and using standard clinical technique, a discectomy was performed at C4-5 in three skeletally mature goats. In each animal, an interbody implant/load cell was placed in the disc space and the lead wires were tunneled submuscularly to exit percutaneously on the dorsal surface of the neck. In two animals, a PEEK washer was attached to the inferior vertebra with a bone screw to serve as a kick plate to prevent ventral migration of the implant. In the third animal, a static plate was used to instrument the fusion using a standard ACDF technique with two screws per vertebra. After recovery, animals were trained to perform repeatable flexion/extension exercises for food incentives. Real time in vivo interbody loads were measured weekly up to 6 weeks while head and neck kinematics were monitored via video. Loads were compared between instrumented and uninstrumented animals.

RESULTS: Results from more than 175 replicates of flexion/extension demonstrate that the magnitude of cervical interbody forces is dependent on head and neck position and motion. In uninstrumented animals, interbody forces ranged from 50–160 N during flexion/extension. The minimum interbody force always occurred in full extension when the flexor muscles were not engaged. The maximum force always occurred either just prior to the end of motion at full flexion when the extensors were firing to decelerate the head or at full flexion when the flexors were firing to achieve maximum flexion. In the instrumented animals, the pattern was reversed. Minimum interbody forces always occurred in full flexion and maximum forces were recorded in full extension for every cycle of motion. In the instrumented motion segments, interbody forces (load sharing) during flexion/extension exercises ranged from a minimum of 40 N to a maximum of 110 N.

CONCLUSIONS: Our results show for the first time the magnitudes of interbody loading in vivo in the cervical spine following instrumented and uninstrumented arthrodesis. Relative to neutral, normal flexion/extension causes interbody loads that can exceed 110 N. In an instrumented spine, loading is reversed relative to an uninstrumented spine and maximum loads are in extension.

FDA DEVICE/DRUG STATUS: This abstract does not discuss or include any applicable devices or drugs.