INTRODUCTION: Abnormal loading of cartilage has been related to osteoarthritis of articular joints, including the facet joints of the spine. Facet joint degeneration is considered an important cause of disabling low back pain. Previous studies have shown that degenerative changes of the facet joints in the canine lumbar spine can be induced by alteration of the corresponding intervertebral disc from either chymopapain injection or discectomy. This animal model of OA is unique since the affected facet capsule could remain intact while loads were being measured.

The purpose of this study is to measure segment motion and forces on ipsilateral facet, using the method of Kahmann et. al, before and after partial and complete facetectomy of the human lumbar spine.

Methods: Four fresh human cadaver specimens of the L1,2 motion segment were divided in open discectomy, with the remaining segment extensively debridged of nuclear material. Strain gages were mounted on the (L1) inferior articular process and the ISL ends. Pneumatic actuators were used to apply different loads to the specimens. At each of these load states, data from the strain gages and the ISL were collected. After the normal specimen had been tested, a contralateral hemi-facetectomy was performed on the specimen, and the same load was reapplied. A complete contralateral facetectomy was then performed on the specimen, and the same load was reapplied. After testing was complete, the facet strain gages and ISL were calibrated. The load in the ipsilateral facet, and the motion of the segment were computed from the stored data.

Results: At small extension moments the contact site did not vary between the normal, hemi-facetectomy, and complete facetectomy groups. The facet load and contact site remained constant for all loads for the normal and hemi-facetectomy specimens. The complete facetectomy specimen, the contact site moved medially with increasing load. Facet loads produced by right lateral bending moments remained the same in all three specimen groups. Left lateral bending moments generated an average increased load of 53 percent between the normal and complete facetectomy groups. The facet load and contact site did not vary between the normal and complete facetectomy groups. No significant motion changes were observed when their respective loads were being applied. Some small secondary rotations were observed after the complete facetectomy was performed. Under applied extension moments, axial, and lateral bend rotations were found to increase on an average of 21 degrees.

Discussion/Conclusions: Three aspects of the biomechanics of a motion segment were observed for each motion segment status. The changes in facet load resultant site in the facet joint indicates that, as the extension moment is increased, the specimen rotates axially. This may be due to the missing contralateral facet joint. The loads on the ipsilateral facet joint (after partial facetectomy) corresponded with extension and axial load. The small amount of nuclear material contributing to the facet joint remained intact and uninvaded. The authors developed a method which is robust.
The facet joint which allows measurement of facet loads and resultant contact location obtained in vivo and in vitro has been significantly increased in vitro to compressive strains. The aim of the current study is to measure facet loads in the living animal during various functional activities and strain baseline data for animals with normal intervertebral discs prior to future studies on facet load changes with degeneration of facet joint and/or disc alterations.

METHODS: The technique entails measuring the strain of the cortical bone on the aspect of the craniocaudal joint process at three or more locations simultaneously in response to loading of the facet joint. Strain measurements obtained during testing were compared to strains obtained at subsequent absolute loading of the caudal facet; this determines resultant facet load contact locations and magnitudes. Four mature, male mongrel dogs (26-31 kg) had five encapsulated strain-gages imbedded on the right L3 cranial articular process via a paraspinal muscle-splitting approach. Reliable strain-gage to bone bonding with cyanoacrylate cement required preparing the surface of the articular process by degreasing, wet-sanding and drying, as well as applying an adhesive. Each loaded sector was identified by the sensing of muscle forces from direct contact with the strain-gages. X-rays of the lumbar spine were obtained preoperatively to rule out pre-existing facet or disc pathology, and postoperatively to verify the level of the instrumented facet joint. All animals walked normally by post-op day 1. At post-op day 9, simultaneous strain recordings were made at each gauge for various static and dynamic activities. Multiple tests of standing and walking were performed to determine in vivo repeatability. Tests for facet unloading included right horizontal and vertical traction unanesthetized with paralyzation. After completion of testing, the lumbar spine was excised, and in-vitro tests of the L2-3 motion segment were performed on a previously described micro-dissection apparatus. Calibration of the strain-gages involved disarticulation at the L2-3 level, and dividing the articular surface of the craniocaudal facet joint in all 14 dogs into 30 to 40 sectors. A ramp load was applied to the center point of each sector and strain at each gage was calculated yielding strain ratio contours for every possible pair of gages. Comparing in-vivo test strain ratios to the calibration strain ratio contours identified the resultant facet contact load location point. The magnitude of the strain for each gage at the load location point was determined by the load projected through that gage. The facet load was the average of the calculated loads for the five gages.

RESULTS: In general, there were significantly greater facet loads during peak phases of all dynamic tests relative to static tests. The facet was found to be unloaded under all the activities and under spinal traction or right traction. All strain changes, and thus loads, were applied relative to these unloaded states. For the group of four dogs, static tests of sitting, lying, prone, lying in a lateral decubitus position, and flexion-extension demonstrated facet load magnitudes and their contact locations as standard deviations. For the group of four dogs, static tests of sitting, lying, prone, lying in a lateral decubitus position, and flexion-extension demonstrated facet load magnitudes and their contact locations as standard deviations.

DISCUSSION: A recently developed technique for non-invasive measurement of facet load was applied to an in vivo canine model. Results obtained indicated that facet loading and resultant gage strains were determined to be significant for static and dynamic activities. Facet loading during active use of the back muscles was greater than when the animal was in a passive static posture. The facet load magnitudes were in the range of loads determined from previous in vitro and in vivo studies on applied load states. Assumptions that the loads are distributed over at least one-third of the joint surface, our results suggest that the facet cartilage may experience contact pressures up to 2MPa during peak loading. Estimates for thicker human articular cartilage range from 1 to 10 MPa. The importance of measuring facet loads in the joint is not only for improved understanding of spine biomechanics, but also for identifying load changes with degeneration of the facet joint and/or disc. The interrelationship of facet degeneration to disc alteration which has been found in dogs and in humans will be the focus of future research. Studies have found an increase in facet load and a change in loading sites with disc alteration, whereas others found only a change in loading sites. In order to address this issue, quantification of in vivo facet joint loads is essential. The current technique has been found to be adequate for short term in vivo studies to establish baseline data for a group of animals with unaltered discs. Currently, the technique is being modified in order to attempt to monitor facet load changes with alteration of the disc over extended periods.

CONDUCTION VELOCITIES OF PYRAMIDAL TRACT FIBRES AND LUMBAR MOTOR NERVE ROOTS: NORMAL VALUES

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Nerve tissue might be subjected to compression at various onset rates. For instance the onset rate of a trauma is far more rapid than that of a degenerative disorder or tumor. The importance of the onset rate of a mechanical deformation for the degree of nerve injury has only just recently been noted, but the basic mechanisms are not fully understood. In the present study, conduction velocities of the L5 segment was 48.1 m/sec. The conduction velocity of the motor root between its exit from the spinal cord and its exit from the intervertebral foramen was 78.8 m/sec. The overall conduction velocities between motor cortex and exit of the nerve roots from the intervertebral foramen were L4: 50.6 and L5: 54.0, i.e. 53.6 m/sec. It was 36.5 m/sec to the S3 root. The spinal cord motor conduction velocity between C7 and L5 segments (34.1 cm) was 57.8 m/sec.

Discussion: These results are in accord with reports on intra-operative epidural measurements and conduction velocities calculated from surface neurography. Critical interpretation, however, has to take account of the fact that conduction velocities were performed on cadavers whereas neurophysiological recordings were obtained from healthy subjects. Nevertheless our results emphasize the validity of magnetic stimulation for the evaluation of pyramidal tract and motor root conduction times.

INTRODUCTION: To date, pyramidal tract and motor root conduction velocities in man have been determined by indirect surface measurements or by intrathecal epidural recordings. Conduction velocities based on precise anatomical and neurophysiological measurements in awake subjects is not obtained, neither in the neurophysiological nor in the anatomical literature. We performed measurements of spinal cord and individual lumbar nerve root lengths in 20 dissected cadavers and correlated these data with the results of pyramidal tract and motor root conduction time studies by means of motor evoked potentials in 46 healthy subjects.

The aim of our study was to obtain normal values of the length of different segments of the central and proximal peripheral motor pathway. The spinal cord, anterior horn cells of the L5 segment was 48.1 m/sec. The conduction velocity of the motor root between its exit from the spinal cord and its exit from the intervertebral foramen was 78.4 m/sec. The overall conduction velocities between motor cortex and exit of the nerve roots from the intervertebral foramen were L4: 50.6 and L5: 54.0, i.e. 53.6 m/sec. It was 36.5 m/sec to the S3 root. The spinal cord motor conduction velocity between C7 and L5 segments (34.1 cm) was 57.8 m/sec.

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IMPORTANCE OF ONSET RATE FOR THE DEGREE OF INJURY IN NERVE COMPRESSION SYNDROMES.

An experimental study on the porcine cauda equina}

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