Development of An Osteoporotic Bone Model

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Osteoporosis is a disease that incorporates diminished bone mass and structural deterioration of bone tissue. Under these conditions bone becomes fragile and is more susceptible toward fracture, specifically hip, vertebral and pelvic fractures. Nearly 44 million Americans have or are in serious danger of being affected by osteoporosis (10 million individuals have the disease and almost 34 million more are estimated to have low bone mass, high risk for osteoporosis). One in two women, and one in four men, over age 50, will have an osteoporosis-related fracture in his/her remaining lifetime. 14 billion dollars per year in health care costs are attributed to osteoporosis and the resultant fractures (1.5 million annually) from the disease. 500,000 individuals are affected by vertebral compression fractures.

While research has been done concerning the causes, prevention and treatment of osteoporosis in general, relatively little has been done to determine potential differences in orthopedic treatment for patients suffering from the disease. Cadavers are used for biomechanical fracture testing. Problems that exist in cadaver research include obtaining osteoporotic cadavers for testing and the variations in degree of osteoporosis among different cadavers. Sheep cadavers are used in place of human cadavers, as they are more obtainable and less expensive. A consistent, repeatable, and reliable bone model containing the appropriate value of bone density corresponding to the degrees of osteoporosis would be a significant help in treatment and prevention of osteoporosis.

The primary goal of this study is to obtain a consistent, reliable, and repeatable bone model of osteoporosis. Treating sheep vertebral bodies with formic acid will cause the necessary bone density demineralization values corresponding to the degrees of osteoporosis in human vertebral bone.

PRELIMINARY STUDIES

Studies have been done which show that bovine vertebral bodies can be degraded using formic acid in very high concentrations achieving a state of bone density loss beyond that of osteoporosis. Another existing study related the values in specimens of sheep vertebral bodies compared to human vertebral bodies. This study conveyed the ranges that the bone must be demineralized in order to achieve an osteoporotic state in comparison to a sample of human osteoporotic bone. No research has been done that uses entire vertebral bodies along with the degradation capability of formic acid in a controlled, vacuum/pressure system that will cause comparable and repeatable osteoporotic bone for further testing.

MATERIALS & METHODS

The University of Utah institutional animal care and use committee reviewed and approved this study. Twelve frozen sheep vertebral bodies were extracted from 3 sheep cadavers. The specimens were disarticulated while frozen. Using a 4 mm drill bit and a power drill, holes were drilled through the center of the vertebral body, with the vertebral body oriented in anatomical position and the hole drilled down the longitudinal axis, completely through the vertebral body. The specimens were analyzed using Dual-Energy X-ray Absorptiometry (DEXA) for imaging and calculation of the bone mineral density (BMD).

Figure 1 - Dual-Energy X-ray Absorptiometry (DEXA)

Because of the specificity in programs of the DEXA in obtaining images of the body, and because the specimens were not of complete spines, the right-hand X-ray program was employed. The DEXA measurements have previously been calculated to provide the acceptable ranges of BMD that correspond to osteoporosis. Twelve of the vertebral bodies were then subjected to chemical treatment by organic acid, injection of a solution of 25% formic