INTRODUCTION

Disc degeneration leads to many spinal disorders like spondylolisthesis, and osteophyte formation. Previous studies stipulate that osteoporosis leads to compression fracture of the vertebral body and causes spinal instability. Biomechanical investigation of stress changes in the lumbar vertebrae and intervertebral disc caused by disc degeneration has been performed using mathematical models and cadaveric studies [1]. Osteoporosis has also been studied following same mathematical and experimental procedures [2]. However, very little is known of the combined effects of osteoporosis and disc degeneration in the lumbar spine and how it may affect the treatment planning. This paper presents our findings on the sensitivity of stresses in annulus ground substance, endplate and pedicle, and the stiffness of motion segment to both disc degeneration and osteoporosis under flexion, extension, lateral bending and torsional moments using detailed validated finite element model of human L4-L5 motion segment.

METHODS

Six 3D Finite Element models of L4–L5 FSU were developed. They are as follows

1. Intact disc with normal Bone
2. Intact disc with osteoporotic bone
3. Stage (I) degenerated disc with normal bone
4. Stage (I) degenerated disc with osteoporotic bone
5. Stage (II) degenerated disc with normal bone
6. Stage (II) degenerated disc with osteoporotic bone

These finite element models were analyzed using ANSYS- v.5.7. Geometric data of the vertebral body, facet joint and intervertebral disc were based on recent studies [3][4]. Cortical bone, cancellous bone, annulus ground substance and posterior elements were modeled as 3D Isoparametric 8 node hexahedral elements. The intervertebral disc was modeled similar to recent studies [5]. Facet contact was modeled as 3D point-to-point contact elements. All ligaments were modeled as tension only spar element and all material properties are based on recent studies [5]. The model was validated with experimental studies [6]. Stage (I) Disc degeneration (Dehydrated nucleus) was simulated by using stiffer solid elements for the nucleus with Young’s modulus twice that of annulus ground substance. Stage (II) Disc degeneration was simulated by doubling the young’s modulus of annulus ground substance and reducing the annulus fiber volume by 25% [7] and including stage (I) changes. Stage (II) Disc degeneration. This severe stage of degeneration was represented by a 25% reduction in disc height along with stage I and stage II changes. Osteoporosis of the vertebral body was simulated by reducing the young’s modulus of cancellous bone by 30%.

DISCUSSION

(Tables -1) - Maximum % change of the parameters due to disc degeneration (Intact disc to Grade III degenerated disc)

As the degeneration progressed, the stiffness of the segment, annulus stress and endplate stress increased irrespective of the bone and loading condition. In contrast the pedicle stress decreased as the degeneration progressed. Maximum percentage change of parameters due to degeneration is given in (Table-1) for both normal and osteoporotic bone. It was observed that except for the stiffness all other parameters were more sensitive to degeneration under extension moment loading. From the results shown in (Table-1) it seems that the behavior of osteoporotic bone model was similar to that of normal bone model.

From the results shown in (Table-2) it seems that the behavior of osteoporotic bone model was similar to that of normal bone model.

REFERENCES