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Degenerative Changes in Spine: A Morphological Study in Dried Vertebrae

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Abstract:
BACKGROUND*: Lumbar backache is one of the most common causes of chronic disability. In majority of cases the backache is associated with degeneration of intervertebral disc in the lower lumbar spine. This is an age related phenomenon that occurs in 80% of people who live for more than 50 years. The unrelenting changes associated with aging, progressively affect all the structures of spinal unit. The degenerative process starts early during the first decade of life at the disc level, finally affecting all the surrounding structures including vertebral bodies, facet joints and ligaments.* ***OBJECTIVE****: To study comprehensively the morphological changes occurring in spine due to the natural process of degeneration associated with aging.* ***METHOD****: This study was an observational study done on dried vertebrae. We included a total of 3250 number of dried vertebrae collected from osteology section of S.C.B. Medical college, Cuttack and VIMSAR, Burla and did a morphological study to see the observable changes in vertebral body, facet joints and ligaments of spine and made a comprehensive analysis of our findings.* ***RESULTS****: Significant changes like, growth of osteophytes along the margins of vertebral bodies and facet joints was a common finding. It affected all vertebrae but most commonly lumbar vertebrae. Other changes were thickening and ossification of anterior longitudinal ligament and ligamentum flavum.* ***CONCLUSION****: All the components of motion segment of spine are affected by degenerative changes which occurs secondary to degeneration of intervertebral disc. The changes were more marked in the vertebral bodies and articular facets of lumbar vertebrae compared to that of cervical and thoracic vertebrae. Out of all the ligaments, ligamentum flavum was more commonly affected by thickening and calcification. This change was most common in thoracic spine. Our findings are consistent with that of earlier studies which were done mostly in X-ray and MRI. As observable gross anatomical changes appear very late, this study will not be of much help to know the progress of the degenerative changes, rather this can only help in establishing the findings of radiological studies.*

Key words*: Facet Joints, Ligamentum flavum, Osteophytes, Spinal degeneration*

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I. Introduction

1.1 APPLIED ANATOMY OF SPINE:

The spine acts as a crane to transmit the weight. Any weight carried anteriorly is counterbalanced by contraction of paravertebral muscles posteriorly. The resultant force passes through the nucleus pulposus of lower lumbar disc. So the lumbar spine is always loaded even at rest. Each segment of vertebral column transmits weight through the vertebral body anteriorly and facet joints posteriorly. The intervertebral disc between adjacent vertebral bodies acts like a compressible cushion and surrounding ligaments and muscles act like shock absorbers. If they degenerate or become weak their ability to absorb some of the force is diminished and bones and joints suffer from secondary degenerative changes.[1]

1.2 AGE CHANGES IN SPINE

Spinal degeneration is a sequence of biochemical, biomechanical and physiological changes, starting in intervertebral disc and finally affecting all the surrounding structures including vertebral bodies, facet joints and ligaments. It occurs as a part of normal aging process affecting everybody[2]. Spinal degeneration process is initiated in intervertebral disc resulting in secondary changes in facet joints, vertebral bodies and ligaments. This concept is supported by many studies.[3-7]The process of spinal degeneration is divided into three phases by

Kirkaldy- Willis.[8] The first stage is known as stage of dysfunction during which there occurs biochemical, biomechanical and physiological changes in intervertebral disc resulting in clinical symptoms. The second stage is known as stage of instability when mostly osteoarthritic changes appear in facet joints. The third stage is known as stage of re-stabilisation during which different elements of motion segment are stabilised by osteophyte formation and calcification of ligaments. Discal degeneration is associated with biochemical changes followed by macroscopic alterations including tears and fissures, which may lead to discal herniation. Facet joint changes occur secondary to discal degeneration. They include subluxation, cartilage alteration and osteophytosis. Kirkaldy-Willis had conceptualised the three joint complexes, comprising of the intervertebral disc and facets. Degeneration of the disc, therefore affects the facets as well as the ligaments and vertebral bodies. Degeneration of facet joints resembles osteoarthritis of other synovial joints. Facet degeneration is secondary to disc degeneration. Due to loss of disc height, instability and altered biomechanics, there is an increase in load borne by the facets, generating cartilage damage and subluxation of the facet joints. The process starts with synovitis, progressive cartilage loss, followed by capsular laxity and marginal hypertrophy. The anterior and posterior longitudinal ligaments contribute to spinal stability and also act as buttress to the anterior and posterior annulus. These ligaments become redundant with loss of disc height and may even undergo calcification. Ligamentum flavum, rich in elastin, spans the adjacent vertebrae, allowing contraction and elongation during flexion and extension. With aging they undergo chemical and macroscopic changes which include rise in elastin concentration and decrease in tensile properties, resulting in weakening. Additionally there is increased thickness and buckling of the ligamentum flavum. [2, 8]

II. Materials And Method

Vertebrae preserved in the osteology section of S.C.B. Medical college, Cuttack and VIMSAR, Burla were taken as study material. All the damaged vertebrae, vertebrae with incomplete ossification and those having congenital malformation were excluded from our study. This was an observational study done on 3250 individual vertebrae which included 764 cervical, 1786 thoracic and 700 lumbar vertebrae. We examined all the components of spine which suffer from degenerative changes, namely, vertebral body, facet joints and ligaments and did a comprehensive analysis on them with reference to earlier studies.

III. Observation

3.1 Changes found in articular facets (table no. 1 & figure no. 1)

In some of the vertebrae we observed growth of osteophytes along the margins of superior and inferior articular facets. Though observed in vertebrae of all types, osteophytic changes affected mostly the lumbar vertebrae. 14 out of 764 cervical vertebrae (1.8%), 71 out of 1786 thoracic vertebrae (3.97%) and 37 out of 700 lumbar vertebrae(5.28%) showed degenerative changes of articular facets.

3.2 Changes found in vertebral body (table no. 2 & figure no. 2)

Growth of osteophytes along the margins of vertebral bodies was found to be the major degenerative change. Though lumbar vertebrae were most commonly affected, vertebrae from other regions also showed this type of changes. Out of 764 cervical vertebrae studied, 46 vertebrae (6%) found to have developed osteophytes along the margins of vertebral bodies. 125 out of 1786 thoracic vertebrae (7%) and 52 out of 700 lumbar vertebrae (7.5%) showed similar changes along the margins of vertebral bodies.

3.3 Changes found in ligaments (table no. 3 & figure no. 3)

Thickening and calcification of ligamentum flavum was observed in all types of vertebrae but the thoracic vertebrae were more commonly affected than cervical and lumbar vertebrae. In 50 out of 764 cervical vertebrae (6.5%), 220 out of 1786 thoracic vertebrae (12.3%) and 17 out of 700 lumbar vertebrae (2.4%) ligamentum flavum was ossified. The anterior longitudinal ligament was ossified In 7 cases from lumbar region and 2cases from thoracic region leading to fusion of adjacent vertebrae. Posterior longitudinal ligament was thickened and ossified only in one vertebra which was 7th cervical vertebra.

Table no. 1 Changes found in facet joints

VERTEBRAE	No. Of vertebrae studied	Osteophytes along the margins of facet joints	Percentage (%)
CERVICAL	764	14	1.8
THORACIC	1786	71	3.97
LUMBAR	700	37	5.28

Table no. 2 Changes found in vertebral body

VERTEBRAE	No. Of vertebrae studied	Osteophytes along the margins of bodies	Percentage (%)
CERVICAL	764	46	6
THORACIC	1786	125	7

LUMBAR	700	52	7.5

Table no. 3 (ossification of ligamentum flavum)

VERTEBRAE	No. Of vertebrae studied	Vertebrae with ossification of LF	Percentage (%)
CERVICAL	764	50	6.5
THORACIC	1786	220	12.3
LUMBAR	700	17	2.4

FIGURE-1: OSTEOPHYTES ALONG THE MARGINS OF ARTICULAR FACETS.

FIGURE-2: OSTEOPHYTES ALONG THE MARGINS OF VERTEBRAL BODIES

FIGURE-3: OSSIFICATION OF LIGAMENTS

ALL-ANTERIOR LONGITUDINAL LIGAMENT

PLL- POSTERIOR LONGITUDINAL LIGAMENT

LF- LIGAMENTUM FLAVUM

IV. Discussion:

Disc degeneration is universal in the aging spine and it is usually predominant in the lumbar spine due to its anatomical predisposition to mechanical stresses compared to other higher levels of spine. Degenerative changes in the surrounding structures appear secondary to degeneration of disc. Development of osteophytes around facet joints and margins of vertebral bodies followed by hypertrophy and calcification of ligamentum flavum are the usual morphological changes found in the third phase of re-stabilisation according to Kirkaldy-Willis degenerative cascade concept.[8] Osteophytic growth along the margins of vertebral bodies and articular facets was the most recognisable finding in our study and it was more prominent in lumbar region compared to

thoracic and cervical spine. Vishram Singh et al in their study on lumbar spinal stenosis and facet joint arthrosis have reported that lumbar facet degeneration increases with age and the severity of degeneration gradually increases caudally.[9] R. Sethi et al in a MRI study have shown a statistically significant relationship between disc degeneration and degenerative changes in facet joints.[10]

Calcification of ligamentum flavum was also a prominent finding in our study but this predominantly affected the thoracic spine in sharp contrast to lumbar region (12.3% in contrast to 2.4%). Vishram singh et al have reported buckling and hypertrophy of ligamentum flavum and have explained that, degenerative process causes proliferation of type II collagen fibres along with deposition of calcium crystals.[9] Meigne JY et al and Sato T et al have reported that, ossification of ligamentum flavum affects thoracic spine most frequently and authors have suggested that hypermobility of thoracic spine could be responsible for this.[11,12]

Loss of disc height causes buckling of anterior and posterior longitudinal ligament because of which they may also undergo calcification. In our study we did not observe any change in posterior longitudinal ligament except one case confined to the posterior surface of 7th cervical vertebra. Anterior longitudinal ligament was ossified leading to fusion of adjacent vertebrae in 7 cases from lumbar region and 2 cases from thoracic region.

V. Conclusion

Most of the earlier studies on degenerative changes of spine were done in X-ray and MRI. As morphological studies are not available, we have made this attempt to do a morphological study on spine including cervical, thoracic and lumbar vertebrae with a comprehensive analysis on the degenerative changes taking place during natural process of aging.

As our study is conducted to observe the gross anatomical changes in dried vertebrae we could not study changes in intervertebral disc, which forms an important component of spine involved in degeneration process. We studied the degenerative changes of surrounding structures which included vertebral bodies, facet joints and ligaments. As observable gross anatomical changes appear mostly in 3rd phase of degeneration or the phase of re-stabilisation this study will not be of much help to know the gradual progress of the degeneration of spine. Rather this morphological study will help to re-establish the findings of radiological studies.

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