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Review Article **Radiological anatomy**

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AGE RELATED CHANGES IN CERVICAL SPINE

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ABSTRACT

There is great uncertainty regarding the relation between degenerative changes and age. This article aimed to summarize and quantify association between age and degenerative changes in the cervical spine by using the common imaging techniques. A structured literature search was conducted on medline (PubMed), Google Scholar and other databases. The search had no period or language restrictions. We searched PubMed and Embase from their inception till November, 2014 for population-based studies reporting the association between age and degenerative changes in the cervical spine**.** Degenerative changes in the cervical spine should be considered a biological phenomenon that begins in teenagers and progresses with a clear age association. In old age, everybody will have them. Cervical spondylosis is very common and worsens with age. There also appears to be a genetic component involved because some families will have more of these changes over time, while other families will develop less. The speed with which it develops is probably strongly genetically determined. However the severity and specific of the degenerative changes differ between the individuals. It has been found that degenerative changes in the cervical spine are normal phenomena that inevitably develop during life and advance with age.

KEYWORDS: Cervical spine – Age Changes – Spondylosis

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INTRODUCTION

Cervical anatomy

The vertebral column in general is formed by alternating vertebrae and intervertebral discs that are metamerically arranged along the anterior–posterior body axis. Each vertebra can be divided into ventral and dorsal regions. The ventral region is composed of vertebra bodies and the underlying intervertebral discs. Dorsally, the neural arches, which are subdivided into ventral pedicles and dorsal laminae, enclose the spinal cord. In the thoracic region, ribs are associated with vertebrae [40]. The cervical vertebrae are seven, which may be divided into two groups that are distinct both anatomically and functionally: the upper pair (C1 and C2, the atlas and axis) and the lower five (C3–C7).The upper cervical spine has the first and second vertebrae – the atlas and axis – and forms a unit with the occiput [40]. The lower cervical spine is composed of the third to the seventh vertebrae, which are all very similar. Each vertebral body is quite small. Its height is greater posteriorly than anteriorly and it is concave on its upper aspect and convex on its lower. [40].The upper surface of a typical cervical vertebral body is concave from side to side and convex in an anterior posterior direction. The upper projection of the lateral superior surface is known as the uncus and articulates with the vertebral body above at the unco-vertebral joint of Luschka. The pedicle is attached below the unco-vertebral joint on the body of the vertebra. Thus an inter vertebral foramen is bounded in front by vertebral bodies, the uncovertebral joint, and the lateral disc. Posteriorly the foramen is bounded by the facet joint. Root compression may occur secondary to osteophyte formation arising from unco-vertebral joint medial to the root or from facet joint lateral to the root. These bony abnormalities are particularly well seen on computed tomography (CT). A lateral disc prolapse may also compress the root. The laminae enclose a relatively large spinal canal which is triangular in cross section and nicely defined on axial MRI. Cord compression may occur anteriorly, secondary to midline disc prolapse, osteophyte or more rarely ossified posterior longitudinal ligament. The cord may be compressed posteriorly by a hypertrophied ligamentum flavum [34]. The main joint between two cervical vertebrae is made up by a large spongy mass, the intervertebral disc. This disc sits between the two broad flat surfaces of the vertebral bodies. The disc is made up of specialized materials that act as a soft “glue” between the bones, while still allowing them to move. The disc is extremely important to spinal stability. However, it is a frequent site of degeneration or breakdown [34]. Normally, the neck is very flexible. It allows the head to rotate from side to side to nearly 180˚, to flex forward to touch the chin to the chest and extend backwards to almost touch the back of the head to upper back. It also allows bending of head toward shoulder and all ranges in between these basic movements. These movements are afforded by various joints of the cervical spine [21]. The cervical spine does not carry the same burden as the lumbar spine, but is designed for higher mobility in exchange of less stability [26, 32]. It is a complex system with seven vertebrae, discs between them, 37 synovial joints, ligaments and muscles. The two top vertebrae, atlas and axis, are highly specialized for large mobility. The second most mobile areas are between the fifth and sixth vertebra (C5/C6) followed by C4/C5 and C6/C7. The disc is an avascular tissue with cells (chondrocytes) in a structurally intricate matrix. It consists of three distinct components, the circumferential annulus fibrosus, the central gelatinous nucleus pulposus, and the two cartilaginous endplates adhering to the nearby vertebral bodies. For a long time it has been known that degenerative changes in the spine are products of lifelong tissue processes [25]. In spite of the term “degenerative” (according to Webster’s dictionary “falling below a normal or desirable level”), disintegrating or degrading processes seem closely interlinked with processes of adaptive remodelling and healing involving cell proliferation [2,9].

TERMINOLOGY

There are no commonly accepted definitions of the different degenerative changes exist. The bony changes in the vertebral bodies are often mentioned under the collective names spondylosis, spondylosis deformans or sometimes osteochondrosis [44]. Conceptual vagueness is regularly met in the literature. The term spondylosis is used synonymously for both disc degeneration and the formation of osteophytes only. Osteoarthrosis in the facet joints is normally distinguished from the concepts of disc and vertebral body degeneration with the terms spondylarthrosis, facet joint arthrosis, uncovertebral arthrosis, spondylarthritis or facet joint arthritis. [44]

Cervical spondylosis

Cervical spondylosis is a general term for age-related wear and tear or changes affecting the spine at back of neck. With age Progress occur degeneration, bone spurs and the disks slowly shrink. It tends to start sometime after the age of about 30. One feature of the degeneration is that the edges of the vertebrae often develop small, rough areas of bone called osteophytes. The pathoanatomy of cervical spondylosis as we mentioned earlier results from the sequelae of the aging process in the spine, specifically, disk degeneration with hypertrophic osseous and ligamentous changes [13]. These changes may affect in the ligaments and in the stability of the spine.This could cause pressure on the spine and associated nerves and blood vessels which will lead to cervical radiculopathy and cervical spondylotic myelopathy. Approximately 25% of individuals younger than forty years of age, 50% of individuals over forty years of age, and 85% of individuals over sixty years of age have some degree of disc degeneration [18]. Neck pain is almost as common in the general population as low back pain. Today, however, there is great uncertainty regarding the relation between spinal degenerative changes and symptoms. Another question is whether the degenerative processes may be caused, accelerated or worsened by certain physical activities, postures or other factors. According to this literature review, there is insufficient evidence to determine whether any external exposures increase cervical spinal degeneration. The only factors we found to be of obvious significance were age and genetic disposition. Visualized cervical degenerative spinal changes (abbreviated CDSC) include reduced disc height, osteophytes, sclerosis of the vertebral endplates, anular tear, disc intensity alterations, disc bulging, disc herniation (prolapsed disc), spondylolisthesis, Modic changes, bony changes of the vertebral bodies and facet joint arthrosis. For a long time it has been known that degenerative changes in the spine are products of lifelong tissue processes. Degenerative changes in the disc started already in late childhood and increase with age. However, the severity and specifics of the degenerative changes differ between individuals. [4] Most studies showed a clear association between age and degenerative changes. In general, age was found to be positively associated with CDSC; indeed, sometimes it turned out to be the only variable having an influence in an almost linear fashion. A twin study of very high quality showed a strong heritability for degeneration with estimates around 70 %. Degenerative changes in the disc start already in late childhood with progressive desiccation and decompression of the gelatinous nucleus, primarily due to declining content of the water-binding proteoglycans [4,12,33]. Later in the degenerative process, the nucleus becomes increasingly fibrotic and disintegrated, often divided in several lumps by intranuclear clefts and separated from the cartilaginous endplate by softer material [1,48]. Also in the cartilaginous endplate, degenerative changes commence early in life, including erosions and cracking and later calcification [11,41]. In the annulus fibrosus degenerative changes have also been shown from late childhood. This includes, apart from some desiccation, disorganization of the annular microarchitecture which leave the anulus increasingly stiffer and weaker [17,49] with progression to development of fissures or tears of different types [49]. It is a relative new knowledge that degeneration of lumbar discs with disrupted cartilaginous endplates often is accompanied by oedema in the surrounding bone marrow of the adjoining vertebral bodies, with formation of fibrovascular tissue between the thickened

bone trabeculae. These changes, radiologically exclusively detectable with MRI, are called "Modic changes" [16,39]. They have also been described in the cervical spine, especially at the C5/C6 level [42]. Histologically, they constitute an inflammatory "discovertebritis" which probably represent a mechanical and/or chemical tissue reaction to the degenerated endplate and disc. Usually, two types of Modic changes are encountered, "Type 1" and "Type 2", the latter probably being regenerative. Another common proliferative change is the subchondral osteosclerosis of the vertebral endplates [30]. "Osteophytes" gradually proliferate from the vertebral margins. They can eventually fuse with osteophytes from neighbouring segments to form bony bridges. This makes the spine more rigid. The disc degeneration is regularly accompanied by osteoarthrosis in the adjacent synovial joints, "spondylarthrosis" [19]. Advanced bony proliferative changes, posteriorly located osteophytes and gross facet joint deterioration can lead to secondary stenosis of the intervertebral foramina, the nerve root canals or the spinal canal. The subsequent mechanical or chemical irritation of spinal nerve roots can give rise to brachial radiculopathy, or, when the medulla is affected, to myelopathy [16,19,20,29,30,42,43,47].

RADIOLOGICAL ASSESSMENT

The common imaging techniques in detecting degenerative spinal changes are conventional radiography (X-ray imaging), computed tomography (CT) and magnetic resonance imaging (MRI). X-ray visualises soft tissues poorly and cannot display the disc tissue as such, but secondary phenomena of the disc degradation can be seen, primarily disc space narrowing, and sometimes also disc calcification and gas accumulation (vacuum phenomenon) in the disc(fig1).

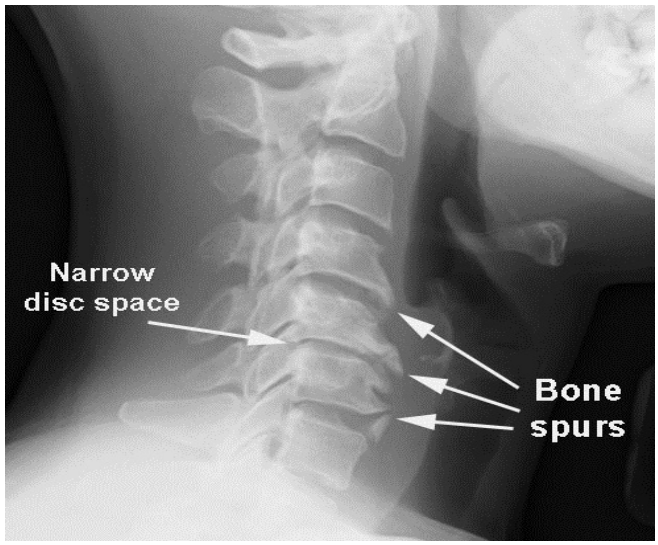

Figure 1
Lateral cervical spine x ray in patient with cervical spondylosis showing loss of disc height, anterior osteophytosis, and narrowing of the foramina [24]

With MRI, and in minor degree also with CT, soft tissue changes are substantially better visualised, and MRI is at present the method of choice in visualizing discs, ligaments and the other spinal soft-tissues. More detailed information can also be visualized with MRI including disc bulging, disc protrusion, disc herniation, fissures and clefts in the nucleus and "high intensity zones" in the anulus representing tears. Also finer disc tissue details can be displayed, such as scarring and calcification and defects in the endplates (fig3,4). However, histological features, i.e. tears, rim lesions and prolapse of nucleus material, may be poorly recognized [14]. The Modic changes of the vertebral bodies are described earlier.

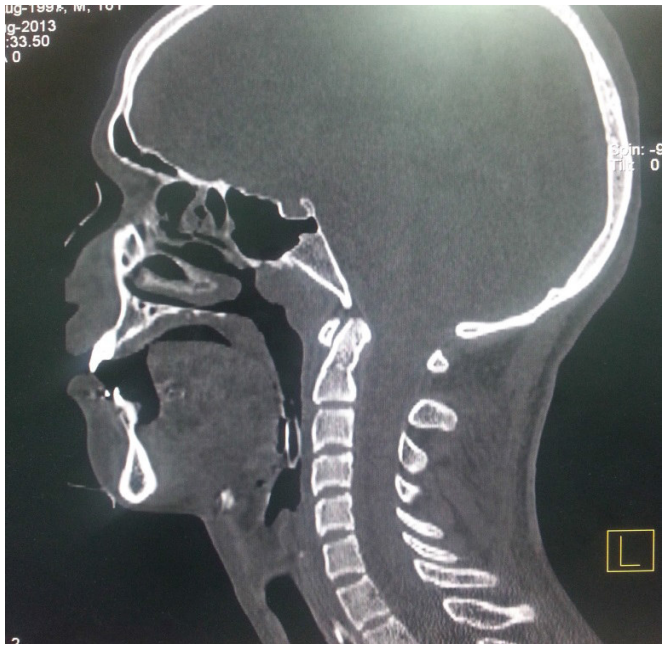

Figure 2
A sagittal Computed tomographic (CT) scanning cervical spine image of an 18years male showing normal alignment of vertebrae, normal lordotic cervical spine curvature, No disc space narrowing and normal vertebral body heights.[3]

Bony changes of the vertebrae, including spondylosis and facet joint arthrosis are visible with all three main imaging modalities. However, CT-scan is (followed by MRI) superior in demonstrating osseous structures (fig2). In the facet joints a typical osteoarthrosis is revealed for example as subchondral sclerosis and cysts, osteophytosis, joint space narrowing, and sometimes also as intra-articular vacuum, increased joint fluid or ligamentous thickening [20]. Natural course of cervical degenerative spinal changes CDSC increases with age. However, the severity and specifics of the degenerative changes differ between individuals [20, 31]. Degenerative spinal changes are normally expected to assume a slowly progressing, chronic course. However, at least as far as disc degeneration is concerned, the picture appears more complicated, since recent observations indicate that annular fissures and even disc height narrowing can “recover” spontaneously [46] just as it is known for disc protrusions. A number of risk factors for lumbar disc degeneration related to life style and constitution have been suspected to contribute including age, smoking habits, gender, body height, weight and body mass index [6,8,50].

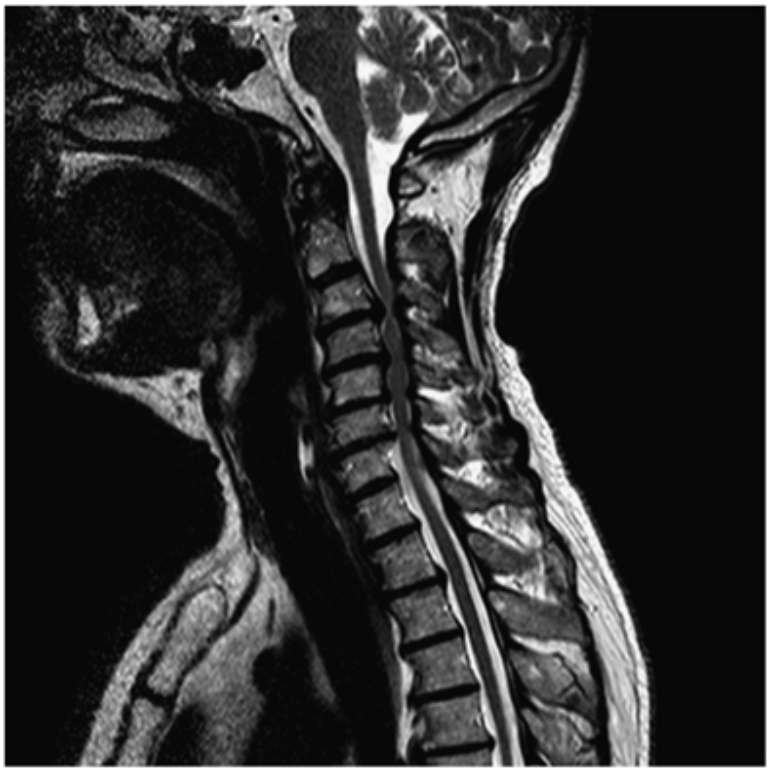

Figure 3
MRI spine showing severe degenerative change between C3/4 and C6/7 with compression of the cord (cervical spondylosis with myelopathy). [28]

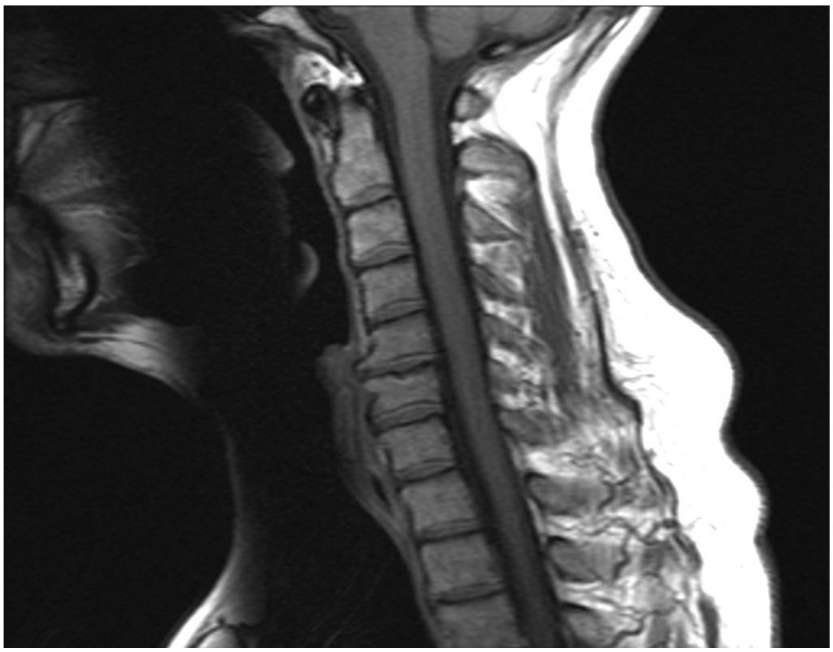

Figure 4
T1 weighted sagittal cervical spine MRI showing degenerative disc disease, osteophytes, and osteoarthritis of C5-C6[23]

DISCUSSION

In summary, we conclude that so called "degenerative changes" in the cervical spine should be considered a biological phenomenon that begins in teenagers and progresses with a clear age association. In old age, everybody will have them. Further, the speed with which it develops is probably strongly genetically determined. The asymptomatic degenerative CT scan findings of the cervical spine are probably normal age-related changes[36]. There is no generally accepted definition of degeneration morphologically, biochemically, or radiologically. Previous cross sectional studies have demonstrated that age related changes in cervical spine are widely present even in asymptomatic healthy individuals. Reference [10] conducted MRI of cervical spine in such subjects and reported degenerative changes in 40 years of age and older subjects. Reference [10] conducted MRI of cervical spine in 89 healthy subjects using a 0.1 MRI imager. Abnormal findings were recognized in 62% of the cases 40 years of age and older whereas the abnormal findings were rare in subjects younger than 40 years of age. In another study of cervical spine MRI from 497 asymptomatic volunteers, Reference [38] also found that degenerative changes in cervical intervertebral discs were more frequent in older populations. Reference [22] performed a 10 year long follow up study of healthy subjects without cervical spine related symptoms using plain x-ray. They recognized degenerative changes in 63% of individuals. This longitudinal study also revealed that the degenerative changes progressed in 81.1% of the initially asymptomatic subjects. 15%of the subjects however developed neck pain during follow up. According to them the progression of disc space narrowing and foraminal stenosis was more frequently observed in people 50 years and older while anterior compression of dura and spinal cord and posterior disc protrusion (PDP) were higher in people between 20 – 49years of age. The differences in degree of progression in different age groups may reflect the presence of different stages in the degeneration process of intervertebral discs. Tandem degenerative lumbar and cervical spine changes have been noted in clinical, anatomical, and genetic studies [5,15,27,35,37,45]. Reference [27] evaluated lumbar and cervical spine MRI images from 174 monozygotic and154 dizygotic twins and reported intervertebral disc degeneration to be present in 74% individuals at lumber spine and 73 % at cervical spine and concluded that genetic factors had a greater influence than environmental factors in these cases. Reference [7] conducted a longitudinal study of twins in multiple countries, including Canada, Finland and USA, the Twin Spine Study, and reported that genetic factors were more closely associated with disc degeneration than the conventionally known environmental factors, such as smoking, vibration, and automobile driving. Reference [35] found degenerative changes in both the lumbar and cervical spine in 80 % of 234 cadaveric specimens studied, with more severe degeneration in the lumbar spine. Reference [3] suggest that early changes of the disc degeneration represented by anterior dural compression and posterior disc protrusion occur in younger age groups (20 - 50 years) where as more advanced structural changes in intervertebral disc such as disc space narrowing and foramina stenosis occur in older age groups (>50 years of age).

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CONFLICT OF INTEREST

No actual or potential conflict of interest exists.

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