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Diagnostic Utility of Cervical Spine X-rays in Assessing Degenerative Conditions

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ABSTRACT

Cervical spine degeneration is a common clinical condition encountered across a broad age spectrum, with significant implications for quality of life due to associated pain, restricted mobility, and potential neurological complications. The evaluation of cervical spondylosis and related degenerative changes frequently begins with plain radiographic imaging, particularly lateral cervical spine X-rays. These radiographs offer valuable information regarding spinal alignment, disc space integrity, osteophyte formation, and overall bony architecture, which are essential for diagnosing, staging, and managing degenerative spinal conditions.

Degenerative changes in the cervical spine occur progressively and involve a cascade of pathological processes including intervertebral disc desiccation, loss of disc height, formation of osteophytes, vertebral endplate sclerosis, and eventual facet joint arthropathy. Radiographic features can vary depending on the stage and severity of the degeneration. Early changes are often subtle, with minimal disc space narrowing or osteophyte formation, while advanced degeneration is characterized by marked disc collapse, prominent osteophytic lipping, and alterations in the normal cervical curvature. These structural changes contribute to clinical symptoms such as neck stiffness, chronic pain, radiculopathy, and in severe cases, signs of cervical myelopathy due to spinal cord compression.

The clinical relevance of radiographic assessment lies in its ability to identify these degenerative patterns, guide initial management, and determine the need for advanced imaging or specialist referral. Loss of cervical lordosis, for instance, may suggest chronic postural imbalance or muscle spasm, whereas multilevel disc degeneration and large osteophytes may raise concerns about mechanical instability or nerve root impingement. Thus, lateral cervical spine radiography serves as a critical screening tool in both acute and chronic settings, providing foundational insights that can shape therapeutic strategies ranging from conservative physiotherapy to surgical intervention.

Radiographic analysis also plays an essential role in monitoring disease progression over time and assessing response to treatment. In populations with limited access to advanced imaging modalities such as MRI or CT, plain radiographs remain a mainstay of spinal evaluation. Furthermore, they are frequently used in routine health assessments, pre-operative evaluations, and medico-legal documentation of spinal pathology. Despite their limitations in soft tissue visualization, X-rays offer a reliable, reproducible, and accessible method for assessing the bony components of the cervical spine.

This study emphasizes the importance of systematic radiographic interpretation and its application in

understanding the spectrum of cervical spine degeneration. Recognizing typical radiological features, correlating them with clinical findings, and appreciating their implications for patient care are key aspects of effective spine management. The findings underscore the ongoing relevance of plain radiography in the diagnostic pathway of cervical degenerative disease, supporting its role as a first-line investigation and a valuable educational tool in musculoskeletal medicine.

INTRODUCTION ANATOMY OF CERVICAL SPINE

- **WHAT IS CERVICAL SPINE**

Your cervical spine — the neck area of your spine — consists of seven stacked bones called vertebrae. The first two vertebrae of your cervical spine are unique in shape and function. Your first vertebra (C1), also called the atlas, is a ring-shaped bone that begins at the base of your skull. It's named after Atlas, of Greek mythology, who held the world on his shoulders. The atlas holds your head upright. Your second vertebra (C2), also called the axis, allows the atlas to pivot against it for the side-to-side "no" rotation of your head.

Your seven cervical vertebrae (C1 to C7) are connected at the back of the bone by a type of joint (called facet joints), which allow for the forward, backward and twisting motions of your neck.

Your cervical spine is also surrounded by muscles, nerves, tendons and ligaments. "Shockabsorbing" disks, called intervertebral disks, are positioned between each vertebra. Your spinal cord runs through the Centre of your entire spine. Your spinal cord sends and receives messages from your brain, which controls all aspects of your body's functions.

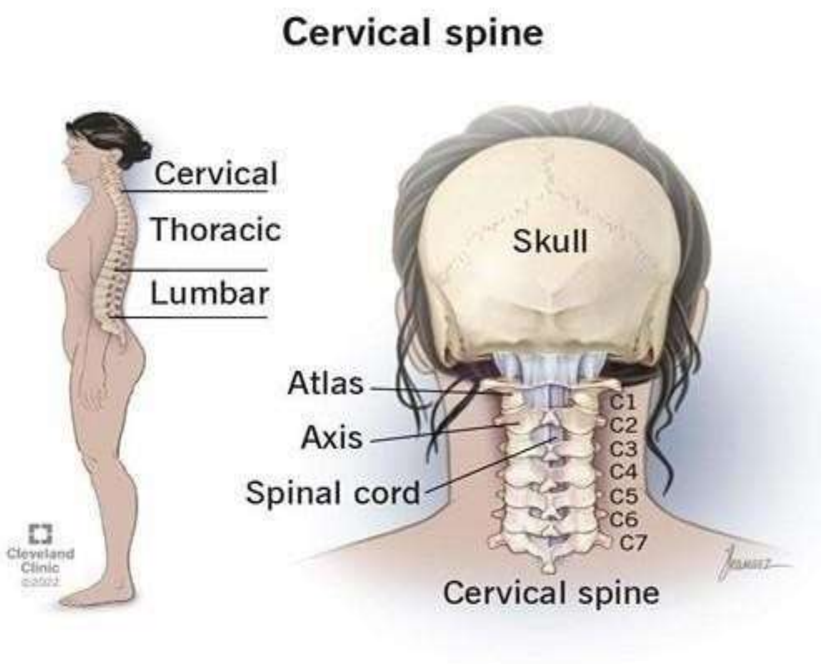


Fig.1 Anatomy of Cervical Spine

- **What does the cervical spine do?**

Your cervical spine has several functions, including:

Protecting your spinal cord. The nerves of your spinal cord pass through a large hole (called the vertebral foramen) that passes through the centre of all of your vertebrae — from the base of your skull through the cervical vertebrae, the thoracic (middle back) vertebrae and ending between the first and second lumbar (lower back) vertebrae. Taken together, all the stacked vertebrae of your spine form a protective central canal that protects your spinal cord.

Supporting your head and allowing movement. Your cervical spine supports the weight of your head (average weight of 10 to 13 pounds). It also allows your head and neck to tilt forward (flexion), backward (extension), turn from side to side (rotation) or bend to one side (ear-toshoulder; lateral flexion).

Providing a safe passageway for vertebral arteries. Small holes in cervical spine vertebrae C1 to C6 provide a protective pathway for vertebral arteries to carry blood to your brain. This is the only section of vertebrae in the entire spine that contains holes in the bone to allow arteries to pass through.

- **What are the other muscles and soft tissues in the neck?**

Other structures around or involving your cervical spine include the following:

- **Muscles supporting your cervical spine**

The major muscles that attach to your cervical spine include:

Sternocleidomastoid: This muscle, one on each side of your neck, runs from behind your ear to the front of your neck. It attaches to the breast bone (sternum) and collarbone. This muscle allows you to rotate your head side-to-side and tilt your chin upward.

Trapezius: This pair of triangular muscles extend from the base of your skull down your cervical and thoracic spine and out to your shoulder blade. They help tilt your head upward/move your neck backward, rotate your head right or left or lift your shoulder blade.

Levator scapulae: This muscle attaches to your first four cervical vertebrae and the top of your shoulder blade (scapula). It helps lift your shoulder blade, bend your head to the side and rotate your head.

Erector spinae: Several muscles make up this muscle group. In your cervical spine area, these muscles help with posture, neck rotation and backward neck extension.

Deep cervical flexors: These muscles run down the front of your cervical spine. They allow you to flex your neck forward neck and help keep your cervical spine stable.

Suboccipital muscles: These four pairs of muscles connect the top of your cervical spine with the base of your skull. They allow you to extend and rotate your head.

- **Ligaments of your cervical spine**

Ligaments in your cervical spine connect bone to bone to help to keep your cervical spine stable. Three major cervical spine ligaments are:

Anterior longitudinal ligament: This ligament extends from the base of your skull, down the front of the cervical vertebra. It stretches to resist backward neck motion.

Posterior longitudinal ligament: This ligament starts at C2 and extends down the back of your cervical vertebrae. It stretches to resist forward neck motion.

Ligamentum flava: These ligaments line the backside of the inside opening of each vertebra where your spinal cord passes. These ligaments cover and protect your spinal cord from behind.

- **Disks in the cervical spine**

Cervical disks are the “shock absorber cushions” that sit between each vertebra. A total of six disks are positioned between the seven cervical vertebrae (one between two vertebrae). In addition to cushioning against stresses placed on your neck, the disks allow you to flex and rotate your head more easily during activity.

Nerves in the cervical spine

Eight pairs of spinal nerves exit through small openings (foramen) between every pair of vertebrae in your cervical spine. They're labelled C1 through C8. They stimulate muscle movement in your neck, shoulder, arm and hand, and provide sensation.

Cervical nerves C1, C2 and C3 control your forward, backward and side head and neck movements. The C2 nerve provides sensation to the upper area of your head; C3 gives sensation to the side of your face and back of your head.

Cervical nerve 4 controls your upward shoulder motion and is one of the nerves that controls your diaphragm (muscle at the bottom of your rib cage that helps you breathe). C4 provides sensation for parts of your neck, shoulders and upper arms.

Cervical nerve 5 controls the deltoid muscles of your shoulders and your biceps. C5 provides sensation to the upper part of your upper arm down to your elbow.

Cervical nerve 6 controls the extensor muscles of your wrist and is involved in the control of your biceps. C6 provides sensation to the thumb side of your forearm and hand.

Cervical nerve 7 controls your triceps and wrist extensor muscles. C7 provides sensation to the back of your arm into your middle finger.

Cervical nerve 8 controls your hands and gives sensation to the Pinky side of your hand and forearm.

Spinal cord

Your spinal cord is a bundle of nerve tissue that extends from the lower part of your brain to your body. It carries messages between your brain and the muscles mentioned above.

Degenerative changes

Degenerative changes in the cervical spine are a common cause of neck pain and disability, especially among the aging population. These changes encompass a spectrum of conditions, including cervical spondylosis, disc degeneration, and osteoarthritis of the facet joints.

Accurate diagnosing is crucial for effective management and treatment planning. Among various diagnostic tools, the neck X-ray or cervical spine radiograph remains a fundamental imaging modality due to its accessibility, cost-effectiveness, and ability to reveal bony abnormalities.[1]

A cervical spine X-ray provides detailed images of the cervical vertebrae, allowing clinicians to assess alignment, disc space narrowing, osteophyte formation, and other structural changes indicative of degenerative processes. Despite the advent of advanced imaging techniques like MRI and CT scans, X-rays continue to play a vital role in the initial evaluation of patients with neck pain. They serve as a first-line imaging modality, helping to identify significant.

Degenerative changes that may warrant further investigation or intervention.[2]

Moreover, neck X-rays are important in differentiating degenerative changes from other pathologies that may mimic similar symptoms, such as infections or tumours By traumatic patients, they provide a quick and non-invasive means to rule out serious conditions ensuring timely and appropriate management. [3]

For patients experiencing chronic neck pain, neck X-ray provides valuable insight into potential underlying causes. By using standard Radiographic views including anteroposterior (AP), lateral, openmouth, and oblique projections, these allow views helpful to evaluate bony integrity, alignment, and soft tissue structures. These images can reveal conditions such as spondylosis, disk degeneration, and other degenerative changes. [4]

Neck X-rays also help to evaluate the pathology and diagnosis for Paediatric trauma and other emergency conditions. Neck X-rays provide a rapid assessment with quick and non-invasive method to evaluate potential fractures, dislocations, or other traumatic injuries, facilitating timely diagnosis and management. [5]

In today fast moving world, many people both young and old are experiencing health problems related to degenerative changes. These changes usually happen slowly over the long term and affect the bones, joints, muscles, brain, and nervous system. Some common examples include arthritis, slipped discs, Alzheimer's disease, and Parkinson's disease. These usually start suddenly or develop gradually due to age or unhealthy habits. Degenerative diseases are becoming more common globally. For instance, osteoarthritis affects about 237 million people worldwide, representing 3.3% of the global population as of 2015. The condition is more prevalent with age, affecting 10% of men and 60% of women over 60 years old. In the US, projections estimate that by 2040, 78 million adults will have osteoarthritis.[6] Moreover, modern lifestyle significantly influences the development of degenerative diseases. Sedentary behaviour, poor nutrition, and chronic stress are key contributors. For example, diets high in processed foods and sugars can accelerate aging processes, while regular physical activity and stress management can mitigate their effects. [7]

→ **What are degenerative changes**

Degenerative changes are conditions where body tissues start breaking down over time. This can happen in soft body, cartilage tissues, or even in the brain. For example, when the cartilage between your joints becomes thin, bones rub against each other, causing pain and stiffness. This is known as osteoarthritis. These changes are natural as we age, but today they are seen even in young people, which is worrying. [8]

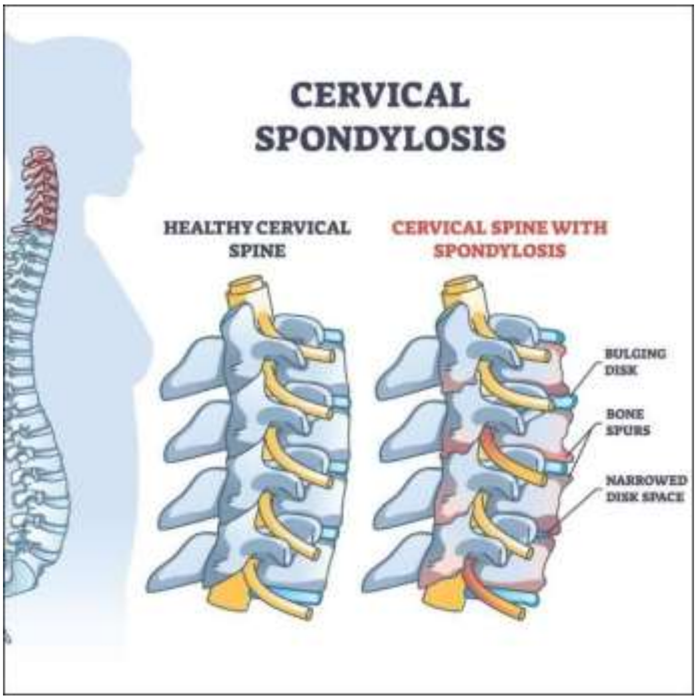


Fig.3 Cervical Spondylosis

Let's understand the different types of degenerative changes in Cervical spine

- **Cervical spine degeneration involves:**

The deterioration of intervertebral discs in the neck region. As discs lose hydration and elasticity over time, they become less effective at absorbing shocks, leading to decreased disc height and potential disc bulging. This process can result in nerve root compression, causing symptoms such as neck pain, radiating arm pain, and numbness. [9]

Examples of cervical spine degenerative diseases are:

1. Cervical Spondylosis

2. Facet Joint Arthropathy
3. Uncarthrosis
4. Cervical Disc Herniation
5. Disc Degeneration
6. Ossification of the Posterior Longitudinal Ligament (OPLL)
7. Cervical Spinal Stenosis

- **Causes of cervical degenerative changes**

1. Several factors contribute to degenerative changes in the cervical spine:
2. Aging → Natural wear and tear over time.
3. Repetitive Movements → Occupational or recreational activities that strain the Neck.
4. Injury → Trauma from accidents or falls.
5. Genetics → From family history.

These factors can lead to disc dehydration, loss of disc height, and the formation of bone spurs, contributing to nerve compression and pain. [10]

Symptoms of cervical degenerative changes

Symptoms can vary but often include:

- Neck pain and stiffness
- Headache
- Pain radiating to shoulder or arm
- Numbness or tingling in the arm or hand Muscle weakness

In severe cases, spinal cord compression can lead to balance issues and coordion

Ray Views of Cervical Spine

Fig.2 X Ray (Lateral): Cervical Spine

Fig.4 X Ray (Antero-Posterior): Cervical Spin

REVIEW OF LITERATURE

1. **Tao, Y., Galbusera., et al., 2021** did a study on Analysis of Degenerative changes in the cervical spine are an inevitable part of the aging process, frequently manifesting as disc height loss, osteophyte formation, endplate sclerosis, and spondylolisthesis. Diagnosing these changes accurately and efficiently is critical for guiding clinical decision-making, especially in patients presenting with chronic neck pain, radiculopathy, or neurological deficits. While magnetic resonance imaging (MRI) has long been considered the gold standard for assessing soft tissues and disc pathology, plain radiography (X-ray) continues to play a vital role in the initial diagnostic workup of cervical spine disorders. The study conducted by Tao et al. (2021) reinforces the diagnostic value of cervical spine X-rays, especially in evaluating the phenotypic features and patterns of degenerative changes. One of the most notable findings from the study was the high prevalence of degenerative changes detectable on lateral cervical X-rays, with 53.9% of the subjects showing evidence of disc degeneration. This prevalence increased dramatically with age, reaching 98% in individuals aged 60–69 and 100% in those aged 70 and above. These results highlight the sensitivity of X-rays in detecting age-related spinal degeneration and their utility in the assessment of older patients, many of whom may be asymptomatic or present with non-specific symptoms. Importantly, the study demonstrated that C5/C6 was the most commonly and severely affected spinal level, followed by C6/C7 and C4/C5. The distribution and severity of degeneration were significantly correlated with age, suggesting a biomechanical pattern in cervical disc loading that X-rays can reliably capture. Moreover, radiographic signs such as osteophytes and spondylolisthesis, which can have surgical or symptomatic relevance, were effectively identified using plain radiography. The ability of X-rays to assess spinal alignment in a weight-bearing, functional posture—something not possible with MRI—adds further clinical value. In addition to identifying individual
degenerative features, Tao et al. categorized patterns of degeneration into solitary, contiguous, and skipped level degeneration. They found that contiguous level degeneration was most prevalent, particularly in older adults. Recognizing such patterns on radiographs is crucial for pre-surgical planning, as they can influence the decision between single- versus multi-level fusion procedures, for instance. The study also underscored that degenerative changes such as osteophyte formation and endplate sclerosis are more prevalent and severe at certain levels and increase predictably with age. These patterns support the idea that X-rays not only detect degeneration but also allow for the quantification and grading of severity through standardized systems like the one proposed by Kettler et al., which was used in the study. Despite its limitations—including the retrospective design, lack of clinical symptom correlation, and a single-

center dataset—the study provides compelling evidence supporting the continued use of neck X-rays in clinical practice. It illustrates that, beyond being a basic imaging tool, radiographs are capable of providing detailed and meaningful diagnostic information that can guide the treatment of cervical spine degeneration. Particularly in settings where MRI is not readily accessible due to cost or logistical issues, plain radiography offers a practical and informative alternative.

2. **Voorhies RM, et al., 2001** did a study on how Cervical spondylosis encompasses a range of degenerative conditions affecting the cervical spine, often associated with aging and biomechanical stress. Neck X-rays, or plain radiographs, play a fundamental role in the initial identification and evaluation of these degenerative changes. Voorhies (2001) provides an extensive clinical overview of cervical spondylosis and underscores the value of radiographic imaging in diagnosing and managing these Conditions. According to Voorhies, cervical spondylosis begins with biochemical degradation of the intervertebral disc, reducing its water content and shock-absorbing ability. This leads to secondary degenerative changes in the surrounding structures, including facet joints and ligaments. The spine may attempt selfstabilization through osteophyte (bone spur) formation, which is readily visible on X-rays and often used as a diagnostic indicator of spondylosis. The degenerative process progresses through three recognized phases: dysfunction, instability, and stabilization, often culminating in auto-fusion detectable on radiographs. Voorhies emphasizes that neck X-rays can reveal disc space narrowing, vertebral endplate sclerosis, facet hypertrophy, and osteophyte formation— hallmarks of cervical degeneration. He highlights that by age 60–65, as many as 95% of asymptomatic men and 70% of asymptomatic women show radiographic signs of cervical degeneration, underlining the prevalence and utility of X-rays in early detection. However, he cautions that radiological findings must always be clinically correlated, as not all radiographic changes produce symptoms. Importantly, Voorhies categorizes cervical spondylosis into three syndromes—radiculopathy, myelopathy, and axial joint pain. Neck X-rays are particularly valuable in the assessment of mechanical instability and degenerative narrowing that contribute to radiculopathy and myelopathy. In cases of radiculopathy, lateral cervical radiographs may show foraminal narrowing or uncover degenerative spondylolisthesis. For myelopathy, although MRI remains superior for spinal cord evaluation, plain X-rays can detect predisposing bony changes like posterior osteophytes and disc space collapse.In the management context, Voorhies recommends lateral flexion and extension X-rays to assess for instability, especially in patients with radicular symptoms. These dynamic views can help identify subtle instabilities that may not be visible on static images. He supports the use of neck radiography as a first-line diagnostic tool, followed by MRI if surgical planning or further evaluation is necessary.In conclusion, Voorhies' work reinforces the critical role of neck X-rays in identifying and evaluating cervical spine degeneration. While advanced imaging modalities provide detailed
soft tissue views, plain radiographs remain indispensable for their accessibility, costeffectiveness, and ability to detect key bony changes in cervical spondylosis. Degenerative changes in the cervical spine represent a progressive continuum of biomechanical deterioration affecting the intervertebral discs, facet joints, ligaments, and adjacent vertebrae. While modern imaging modalities like MRI and CT offer high-resolution detail, neck X-rays remain an essential tool for the preliminary diagnosis and longitudinal monitoring of cervical spine degeneration. The pictorial review by Kushchayev et al. (2018) provides a comprehensive classification and explanation of degenerative spine changes and offers valuable insight into their radiologic appearance, progression, and clinical significance. The cervical spine operates as a functional spinal unit (FSU), consisting of adjacent vertebrae, intervertebral discs, facet joints, and ligaments.

3. **Kushchayev., et al.,(2018)** did a study on Degenerative changes are often a response to chronic mechanical and metabolic stress rather than a primary disease process. These alterations, starting typically in the nucleus pulposus, progress through the annulus fibrosus, end plates, and eventually involve adjacent vertebral structures. Radiographs (X-rays) serve as a valuable modality to identify hallmark signs such as

disc space narrowing, osteophyte formation, endplate sclerosis, and vertebral misalignment. Kushchayev et al. introduce a useful mnemonic—the "ABC classification"—to categorize degenerative changes:

A. Changes involve the nucleus pulposus and are often the earliest detectable signs of degeneration.
B. Changes extend to the annulus fibrosus, vertebral endplates, and bone marrow.
C. Changes refer to more advanced involvement of the facet joints, ligamentum flavum, and spinal canal structures. From a radiographic perspective, A- and B-changes are particularly well

visualized on plain X-rays. Disc space narrowing, often first seen at C5–C6 and C6–C7 levels, is a hallmark of early degeneration. Bony proliferation at vertebral margins—termed osteophytes—can be traction or claw-type and are frequently seen in lateral cervical spine views. These bony outgrowths are adaptive responses to mechanical instability and contribute to foraminal narrowing and potential nerve root compression. Facet joint degeneration, classified under C-changes, also becomes visible on oblique or lateral cervical X-rays as joint space narrowing and sclerosis. Ligamentum flavum hypertrophy and spinal canal stenosis, though better evaluated via MRI, may show indirect radiographic signs such as decreased interlaminar spacing or vertebral alignment alterations. The authors also underscore the value of dynamic (flexion-extension) X-rays to detect segmental instability or spondylolisthesis, which often accompanies advanced degenerative states. Kushchayev et al. also describe cervical spondylolisthesis and classify it into two radiographically distinct types: (1) adjacent spondylolisthesis at the junction of mobile and spondylotic segments and (2) spondylotic spondylolisthesis within advanced degenerative zones. These displacements are best visualized on lateral radiographs and can indicate mechanical instability necessitating surgical consideration.While MRI remains superior for evaluating soft tissue, nerve roots, and spinal cord pathology, the review affirms that radiographs continue to play a critical role, particularly due to their accessibility, speed, cost-effectiveness, and ability to capture weight-bearing positions—something MRI cannot offer. Radiographs are especially indispensable in identifying indirect signs of disc collapse, uncovertebral arthrosis, and Modic endplate changes through secondary skeletal changes like sclerosis and alignment alterations.In summary, the review by Kushchayev et al. reinforces that cervical spine X-rays are a valuable diagnostic modality for assessing the structural and biomechanical manifestations of degenerative changes. Their utility lies not only in detecting early disc space changes and osteophytes but also in functional assessments through dynamic views. While not sufficient in isolation for complex cases, neck

X-rays form the cornerstone of the initial evaluation and management of cervical degenerative disease.

4. **Ofiram, E., et al, (2009)** did a study on analysis how Degenerative changes in the cervical spine, collectively termed cervical spondylosis, are frequently encountered in clinical practice and may be visualized effectively through radiographic imaging. The study by Ofiram et al. (2009) highlights the development and validation of a new quantitative scoring system known as the Cervical Degenerative Index (CDI), which provides a systematic and reproducible method for evaluating cervical spondylosis on standard neck X-rays. Plain radiography remains the first-line imaging modality in evaluating patients with neck pain and suspected cervical spondylosis. It is widely available, cost-effective, and capable of identifying degenerative features such as disc space narrowing, osteophyte formation, sclerosis, and vertebral misalignment. Prior to this study, classification systems such as those by Kellgren and Lawrence (1958) and Gore et al. (1986) offered qualitative or semi-quantitative assessment tools. However, these systems lacked comprehensiveness and standardization suitable for longitudinal tracking or multi-observer clinical application. Ofiram et al. addressed this gap by designing a quantitative index that scores four distinct radiographic features across the cervical spine levels C2–C3 to C6–C7. The four key

parameters included in the CDI are:
1. Disc Space Narrowing
2. Endplate or Facet Joint Sclerosis
3. Osteophyte Formation
4. Olisthesis (anterior or posterior vertebral displacement Each feature is scored on a scale of 0 to 3 per spinal level, based on severity, with clearly defined criteria for grading. For instance, disc space narrowing is graded from no narrowing (0) to complete (75–100%) narrowing (3);

osteophytes are scored from none to large (>4 mm), and listhesis is quantified by the degree of vertebral displacement in millimeters. The highest score of any sclerosis (whether facet or endplate) is used per level.The total CDI score can thus range from 0 (normal) to 60 (most severe degeneration), enabling both cross-sectional assessment and comparison over time.

The study involved 48 patients who had previously undergone thoracolumbar spinal fusion, and their cervical spine radiographs (AP, lateral, flexion, extension) were evaluated by three observers of varying clinical experience. Intraobserver and interobserver reliability were tested through statistical analysis using intraclass correlation coefficients (ICC).The findings demonstrated high reliability among experienced observers, with ICCs of 0.89 and 0.87 respectively. Although the less experienced observer showed fair consistency (ICC = 0.45), the overall results affirm that the CDI is a valid and reproducible tool for assessing cervical spine degeneration. The study further emphasized that levels C5–C6 and C6–C7 exhibited the highest degeneration scores, consistent with other literature indicating these segments bear the most biomechanical stress.One significant advantage of the CDI is its capacity to standardize degenerative grading, thus reducing subjectivity. This has implications not only for diagnosis but also for monitoring disease progression and outcomes in both conservative and surgical management. Additionally, by incorporating dynamic views (flexion-extension), the system captures clinically relevant instability not always evident on static images.In conclusion, Ofiram et al. (2009) provide strong evidence for the utility of plain radiographs in diagnosing and quantifying cervical degenerative changes. The CDI offers a structured, reliable method to interpret radiographic findings, facilitating better clinical communication and longitudinal evaluation. Despite limitations such as a relatively small sample and absence of clinical correlation in this study, the CDI lays foundational work for integrating radiographic scoring systems into routine cervical spine assessment.

5. **Marques, C., et al., (2020),** did a study on analysis how Neck X-rays remain a fundamental tool in the diagnosis and monitoring of degenerative changes in the cervical spine due to their accessibility, affordability, and the ability to provide useful structural and alignment information. In their study, Marques et al. (2020) comprehensively evaluated the accuracy and reliability of various X-ray-based cervical spine parameters, shedding light on their role in diagnosing and tracking degenerative pathology. The study, a post hoc analysis of a randomized controlled trial, analyzed 758 lateral cervical spine X-rays from patients treated for degenerative disc disease. It assessed the measurement accuracy and inter- and intraobserver reliability of commonly used radiographic parameters including Cobb angles, T1 slope (T1S), occipitocervical inclination (OCI), K-line tilt (KLT), and the cervical sagittal vertical axis (cSVA).One of the central contributions of the study is its establishment of standard error of measurement (SEm) and minimum detectable change (MDC) for each parameter. For instance, the Cobb angle—one of the most used indicators for cervical alignment—had an SEm of 1.8° and an MDC of 5.0°, with an intraobserver intraclass correlation coefficient (ICC) of 0.958 and interobserver ICC of 0.886. These findings confirm the high reliability and reproducibility of Cobb angle measurements, especially in

assessing cervical lordosis, which is often altered in degenerative conditions. Among the Cobb angle subtypes evaluated, prosthesis angle (PA) and segmental angles involving metal surfaces (SABM) had the highest accuracy (SEm = 1.5° and 1.6° respectively), indicating that clear anatomical or prosthetic landmarks improve reliability. Conversely, segmental angles with only bone surfaces (SABB) were less reliable, likely due to anatomical variability and landmark ambiguity in degenerative spines. Importantly, K-line tilt (KLT) demonstrated the highest accuracy (SEm = 0.7°, MDC = 1.8°) and reliability (intraobserver ICC = 0.988), making it a promising parameter for tracking subtle sagittal alignment changes. On the other hand, OCI and T1S were more difficult to assess due to inconsistent visualization of the hard palate and T1 vertebra on radiographs, highlighting the need for proper imaging protocols.The study reinforces that measurement reliability can be significantly influenced by observer experience. The experienced spine surgeon consistently produced more accurate and reproducible values than the novice observer, underlining the importance of training in radiographic assessment.In clinical practice, these findings have major implications. As radiographic follow-up is commonly used in managing patients with cervical spondylosis, understanding the limits of measurement variability is critical. For instance, recognizing that a Cobb angle change of less than 5° may not be clinically meaningful avoids overinterpretation. Moreover, dynamic radiographs (flexion-extension) allow detection of segmental instability—an important factor in surgical decision-making—which is not possible with static modalities like MRI. This research also highlighted some limitations of cervical radiographs, such as the poor visualization of lower cervical structures in some cases due to overlapping anatomical shadows or inadequate technique. Despite these challenges, when interpreted with attention to technique and variability, lateral cervical X-rays offer robust and reliable information about alignment and degenerative change. In conclusion, the study by Marques et al. establishes that neck X-rays are accurate and reliable for measuring key cervical alignment parameters crucial to diagnosing and monitoring degenerative spine changes. By quantifying measurement error and providing reference values, it enhances the interpretive value of plain radiography in clinical and research settings alike.

6. **Roh, J. S., Teng, et al., (2005)**, Degenerative changes in the cervical spine represent a common age-related process that can alter spinal biomechanics, affect neural elements, and lead to clinical symptoms such as neck pain, radiculopathy, or myelopathy. In this context, plain radiography (X-ray) serves as a foundational diagnostic tool, particularly for visualizing structural and degenerative alterations of the cervical spine. The comprehensive review by Roh et al. (2005) outlines the underlying pathophysiology of cervical degeneration, emphasizing structural changes that are readily detectable using X-ray imaging. The cervical intervertebral disc plays a crucial role in maintaining segmental stability and allowing motion while distributing loads across the vertebral column. With advancing age, the disc undergoes biochemical degeneration characterized by the depletion of proteoglycans, leading to dehydration, decreased disc height, and reduced shock-absorbing capacity. These changes, as detailed in the review, result in annular fissures, disc space narrowing, and osteophyte formation—all of which are radiographically visible on lateral cervical X-rays (Roh et al., 2005, p. 255–258).A significant strength of plain radiography lies in its ability to detect bony changes such as uncovertebral and vertebral osteophytes. In the cervical spine, uncovertebral joints (joints of Luschka) undergo degenerative hypertrophy, often leading to foraminal stenosis. This narrowing can be clearly identified on oblique and lateral cervical radiographs, providing a non-invasive method to correlate structural findings with symptoms like radiculopathy (Roh et al., 2005, p. 259). In fact, the study shows that foraminal encroachment due to osteophytes—especially at the C3-C4 level—can be demonstrated effectively with oblique cervical spine radiographs.One of the primary advantages of X-rays is the ability to assess spinal alignment and intervertebral disc height. The collapse of disc spaces, visible on Xrays, suggests advanced disc degeneration and may signal mechanical

instability. X-rays are also valuable in evaluating cervical lordosis or kyphosis, which can have diagnostic and surgical planning implications. For example, the study notes that spinal cord compression often results from disc herniations, endplate osteophytes, and ligamentous buckling—all of which contribute to a reduced spinal canal diameter that may be indirectly inferred from plain radiographic views (Roh et al., 2005, p. 260). Additionally, Roh et al. highlight the frequent asymptomatic nature of many radiographic findings. MRI studies cited in the article found degenerative abnormalities in a significant proportion of asymptomatic individuals, emphasizing the importance of correlating radiographic findings with clinical presentation (Roh et al., 2005, p. 259). This reinforces the need for judicious use of X-rays, where structural changes are interpreted in the context of patient symptoms. While MRI remains superior in assessing soft tissues, disc hydration, and neural structures, X-rays are particularly suited for visualizing calcification, ossification, and alignment. The review also describes the progression of degeneration as involving facet joint hypertrophy and ligamentum flavum thickening— features that, though better delineated on advanced imaging, may show secondary signs on Xrays such as decreased disc height or altered vertebral body contour. In conclusion, the work by Roh et al. underscores the pivotal role of neck X-rays in the diagnosis and management of cervical degenerative disorders. Despite their limitations, radiographs offer a rapid, inexpensive, and widely accessible means to identify hallmark degenerative features such as disc space narrowing, osteophyte formation, and segmental malalignment. These findings are critical in forming the basis of a diagnostic workup and guiding further evaluation and treatment strategies.

7. **Hirsch, C., Schajowicz, F., et al., (1967)**, Degenerative changes in the cervical spine are prevalent across all age groups and often manifest structurally before symptoms arise. The study by Hirsch, Schajowicz, and Galante (1967) offers foundational insight into the natural history and structural progression of cervical spine degeneration using anatomical and radiographic analysis of 111 autopsy specimens across various age groups. This unique approach combining histological and radiological evaluations provides critical evidence on the pathogenesis of cervical spondylosis and underscores the diagnostic role of plain X-rays in detecting these changes.The authors described that degenerative changes could begin as early as the second decade of life, particularly in the uncinate processes and intervertebral discs.

These early alterations typically originate in the unco-vertebral region and progress with age. Structural changes such as fissuring of the annulus fibrosus, loss of disc height, osteophyte formation, and endplate sclerosis are commonly identified features—many of which are readily visible on standard lateral and oblique cervical spine X-rays.One of the key findings of the study is the correlation between fissures in the annulus fibrosus and vascular proliferation from adjacent foraminal tissue. As age advances, these fissures become more pronounced and are associated with metaplastic changes in the disc material and the development of pseudo- jointlike cavities. These can mimic the appearance of a true joint, particularly in the unco- vertebral region (Luschka joints), and contribute to foraminal narrowing—a critical radiographic sign in cervical spondylosis.The study also documented the formation of anterior and posterior osteophytes, particularly in the C4–C7 levels, which are frequently subjected to the highest mechanical stress. Such osteophytes are easily identified on plain X-rays and are essential indicators of progressive spondylotic changes. Interestingly, the authors noted that even in the presence of severe disc degeneration and osteophyte formation, the facet joints (apophyseal joints) were often less affected, suggesting that X-ray-based diagnosis should not rely solely on one feature but a constellation of degenerative signs. Moreover, the authors highlight the presence of "central osteophytes" and subchondral sclerosis in older specimens— structural changes that were visible as irregularities in the vertebral endplates and disc margins. These features are commonly appreciated on lateral radiographs and indicate advanced stages of disc degeneration. Importantly, while X-rays offer valuable structural insights, the study acknowledges that radiographic findings do not always correlate with clinical symptoms. Some individuals exhibited advanced structural degeneration without reported pain or neurological signs during life, supporting the clinical need to interpret X-rays in the context of patient history and physical examination. The article also provides a comparative anatomical view by showing that many of the degenerative patterns observed in the cervical spine—such as fissures, osteophytes, and disc narrowing—mirror those seen in other weight-bearing joints affected by osteoarthritis. This reinforces the utility of radiographic assessment as a noninvasive window into the biomechanical aging of the spine. In conclusion, this comprehensive anatomical and radiological study affirms the pivotal role of neck X-rays in identifying, classifying, and monitoring degenerative changes in the cervical spine. By revealing patterns of disc degeneration, osteophyte development, and structural instability, X-rays remain indispensable in the diagnostic arsenal for cervical spondylosis.

8. **Tao, Y., Galbusera,et al.,(2021),**Cervical spine degeneration is a common age-related condition that can lead to significant discomfort, neurological symptoms, and decreased quality of life. Plain radiography (neck X-ray) remains a widely used, cost-effective, and accessible imaging modality to identify such degenerative changes. The study conducted by Tao et al. (2021) offers one of the most comprehensive evaluations of cervical spine degeneration based on lateral standing X-rays, analyzing 1,581 individuals aged 18 to 97 years. Their findings underscore the critical diagnostic role that plain radiographs continue to play in assessing the structural and biomechanical deterioration of the cervical spine.The study aimed to determinethe prevalence and distribution of cervical disc degeneration and specific radiographic phenotypes—disc height loss, osteophyte formation, endplate sclerosis, and spondylolisthesis— while analyzing their relationship with age. All imaging assessments were done on standing lateral cervical radiographs using a validated scoring system. The study found that 53.9% of subjects had radiographic disc degeneration, and prevalence increased significantly with age.

While only 12.4% of individuals aged 18–29 showed signs of degeneration, 98.2% in the 60–69 age group were affected, and 100% of those over 70 showed degenerative changes. The most commonly affected disc level was C5/C6, followed by C6/C7 and C4/C5. These segments are known for bearing the most mechanical stress due to their role in cervical motion, and their frequent involvement aligns with previous biomechanical studies. Among the phenotypic changes, osteophyte formation (47.3%) was most prevalent, followed by disc height loss (44.2%) and endplate sclerosis (14.3%). Notably, spondylolisthesis was found in 6.5% of individuals, predominantly at C4/C5, and was significantly associated with advancing age. Tao et al. emphasize the value of neck X-rays in visualizing these changes under physiological load, as the radiographs were taken in a standing position. This adds a functional assessment component that modalities like MRI and CT cannot offer. The study also describes three patterns of disc degeneration: solitary-level, contiguous-level, and skipped-level degeneration. Contiguous-level degeneration was most common (53.2%) and significantly associated with older age, reinforcing the progressive nature of disc wear.

Importantly, the study demonstrates that the severity of degenerative findings, including the number of involved levels, correlates strongly with age (Spearman's rs = 0.77). These agerelated radiographic markers can help clinicians identify patients at risk of progressing to symptomatic disease or instability. Although the study did not correlate imaging findings with symptoms directly, it cited prior literature (e.g., Marchiori et al., 1996; Gore et al., 2001) indicating that radiographic severity may align with pain and disability scores.

Overall, the findings provide compelling evidence that neck X-rays remain essential for identifying and monitoring cervical spine degeneration. The simplicity, availability, and ability to evaluate spinal alignment and mobility make radiography particularly useful in the early detection and longitudinal monitoring of degenerative disease. While advanced imaging offers superior soft tissue resolution, plain radiographs continue to serve as the first-line diagnostic modality, especially when structural abnormalities and surgical planning are of concern.

NEED FOR THE STUDY:

Degenerative changes in the cervical spine, such as cervical spondylosis, disc space narrowing, and ligament ossification, are common in aging populations and often lead to chronic neck pain, radiculopathy, and decreased mobility. With increasing life expectancy and sedentary lifestyles, these conditions are becoming more prevalent, even in middle-aged individuals. Early and accurate diagnosis is essential for effective management and prevention of long-term disability.

Neck X-rays remain a cost-effective and widely available imaging modality in many clinical settings, especially in low-resource environments. Despite their limited soft-tissue resolution compared to MRI or CT, they can reveal key bony and alignment abnormalities indicative of degenerative disease. Understanding the diagnostic value of cervical spine X-rays in identifying degenerative changes can help streamline clinical decision-making, especially in primary and outpatient care.

However, the correlation between radiographic findings and clinical presentations remains underexplored in many regions. This study seeks to evaluate the patterns and prevalence of cervical degenerative changes as seen on plain radiographs, and assess their association with age and gender.

AIM & OBJECTIVES:

Aim:

To evaluate the diagnostic utility of neck X-rays in detecting degenerative changes of the cervical spine and their association with patient age and gender.

Objectives:

1. To identify and categorize the types of degenerative changes visible on cervical spine X- rays.
2. To assess the prevalence of cervical spondylosis and other degenerative findings in a defined patient population.
3. To analyze the correlation between degenerative changes and patient age.
4. To evaluate gender differences in the distribution of cervical spine findings.
5. To support the clinical relevance of neck X-rays as a primary tool for diagnosing cervical spine degeneration.

Hypothesis:

Null Hypothesis (H_0):

There is no significant correlation between age and the presence of degenerative changes in the cervical spine as seen on neck X-rays.

Alternative Hypothesis (H_1):

There is a significant correlation between age and the presence of degenerative changes in the cervical spine as seen on neck X-rays.

Methodology:

Study Design:

A retrospective cross-sectional study based on cervical spine X-ray reports.

Study Setting:

Radiology department of a tertiary care center (or as applicable to your study site).

Study Duration:

[Specify duration — e.g., January 2024 to March 2025]

Sample Size:

56 patients who underwent cervical spine X-rays and met the inclusion criteria.

Data Sources:

- Digital patient records and X-ray reports
- Demographic data (age, gender)
- Radiological findings from lateral cervical spine views

Sampling Criteria:

Inclusion Criteria:

- Patients aged 18 years and above
- Patients who underwent lateral neck X-rays for neck pain or suspected cervical spine pathology
- X-rays with complete documentation of findings

Exclusion Criteria:

- Patients with history of trauma or spinal surgery
- Incomplete or poor-quality radiographs
- Non-degenerative spinal pathology (e.g., tumors, infections)

Sampling Technique:

Purposive sampling of available and eligible patient records.

Study Procedure:

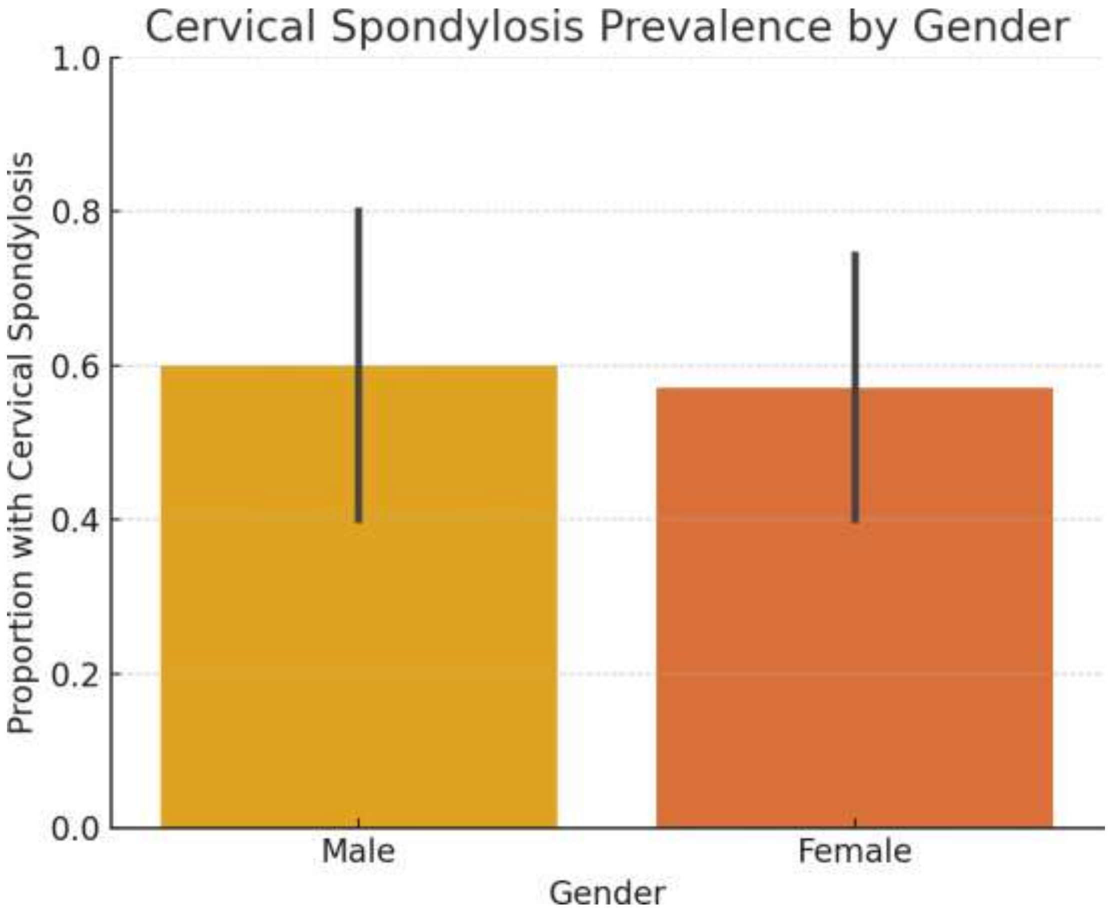
1. Collection of patient data including age, gender, and cervical spine X-ray findings.
2. Classification of radiological findings into categories such as:
   - Cervical spondylosis
   - Disc space narrowing
   - Ligament ossification
   - Loss of normal cervical lordosis
   - No findings / normal
3. Stratification of findings according to patient age (continuous analysis) and gender.
4. Statistical analysis to identify trends and correlations:
   - Frequency distribution
   - Cross-tabulations

- Chi-square tests and logistic regression as needed

Research Plan:

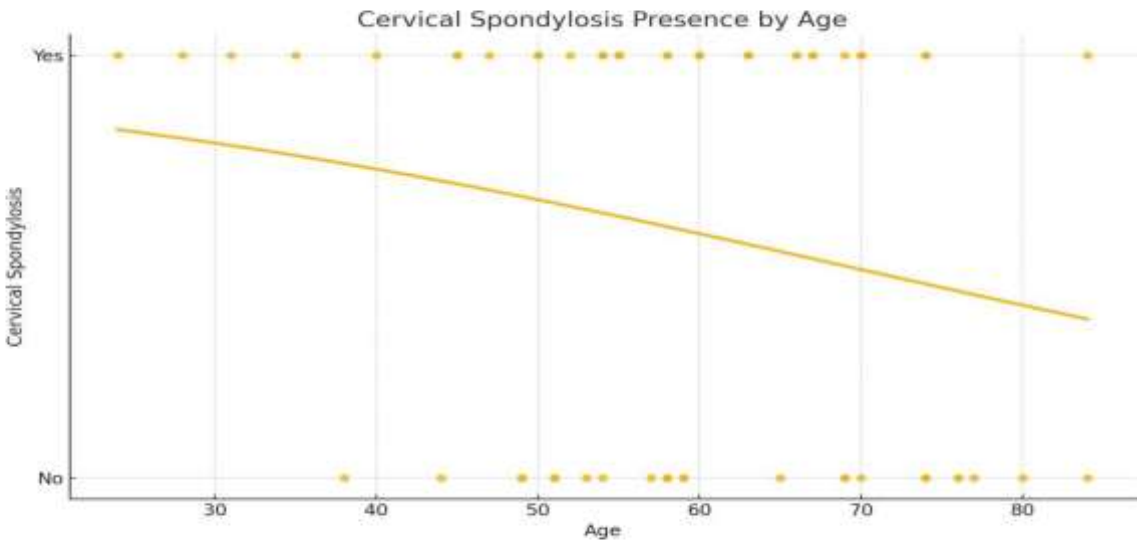
Phase	Activity	Timeline
Phase 1	Literature review and protocol design	Month 1
Phase 2	Data collection from records and X-ray reports	Months 2–3
Phase 3	Data cleaning, categorization, and entry	Month 3
Phase 4	Statistical analysis and graph/chart preparation	Months 4–5
Phase 5	Interpretation of results and report writing	Months 5–6
Phase 6	Final review, formatting, and thesis submission	Month 6

RESULTS:



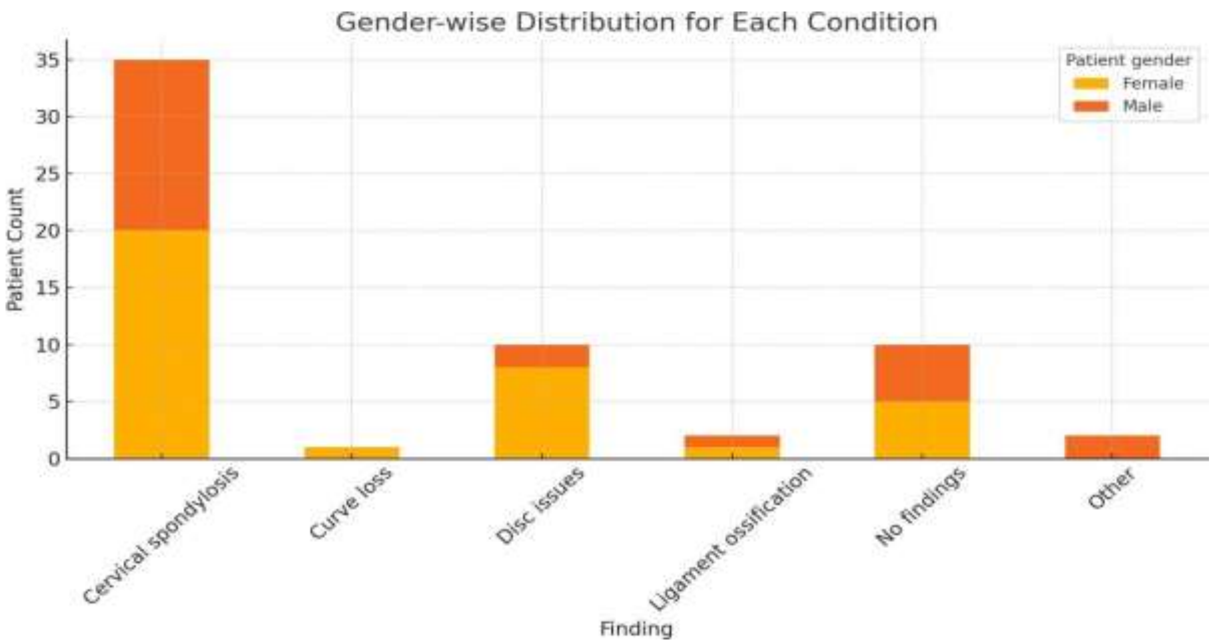
Graph Summary: Cervical Spondylosis Prevalence by Gender

This bar graph illustrates the proportion of male and female patients diagnosed with cervical spondylosis. The prevalence among males is approximately **60%**, while among females it is around **56%**. The overlapping error bars indicate that the difference is **not statistically significant**. This observation is supported by the **Chi-square test result (p = 1.00)**, confirming that there is **no meaningful association between gender and the likelihood of having cervical spondylosis** in this study population.



Summary: Cervical Spondylosis Presence by Age

This graph illustrates the relationship between patient age and the presence of cervical spondylosis, with individual data points plotted along with a trend line. While the visual trend suggests that **older patients are more likely to have cervical spondylosis**, statistical analysis using point biserial correlation showed a **moderate negative correlation** (r = –0.21) that was **not statistically significant** (p = 0.109).
This indicates that although spondylosis tends to appear more frequently in older individuals within this sample, **the age-related increase is not strong enough to rule out chance**, and thus no definitive conclusion can be drawn regarding age as an independent risk factor based on this dataset alone.



Summary: Gender-wise Distribution for Each Cervical Spine Condition

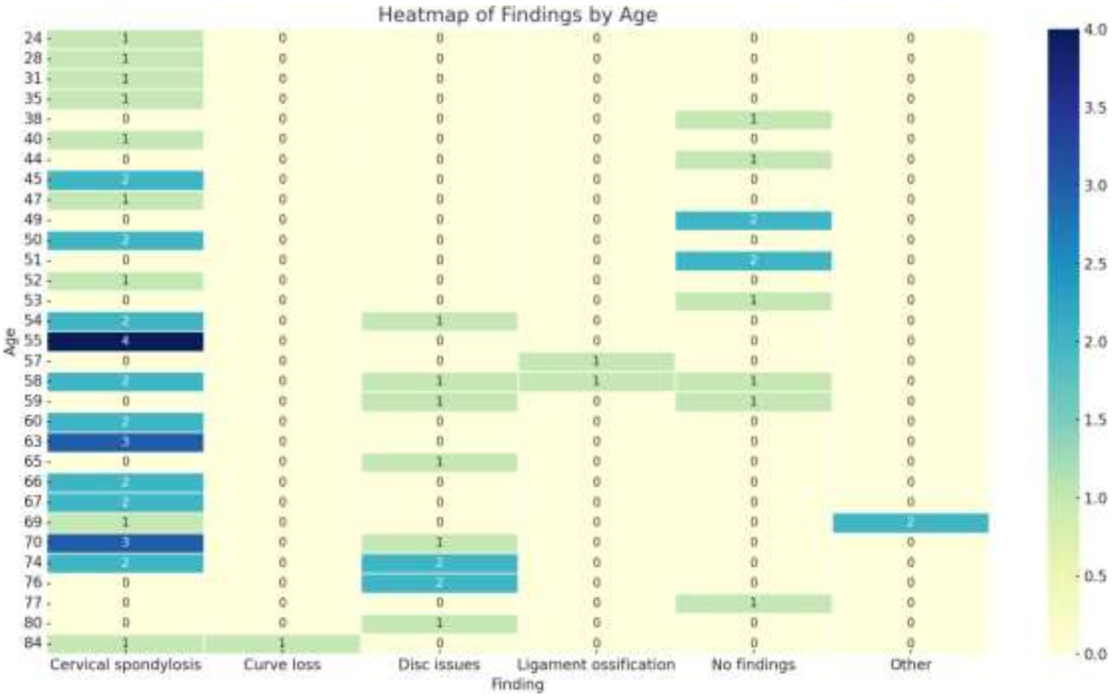
This stacked bar chart presents the **distribution of various cervical spine X-ray findings** among male and female patients. Key observations:

- **Cervical spondylosis** is the most common finding, affecting **35 patients**, with a slightly higher count among **females**.

- **Disc issues** (e.g., disc space narrowing) appear in **10 patients**, predominantly females.
- **No findings** were reported in **10 cases**, equally distributed between genders.
- **Ligament ossification** and **curve loss** are rare, seen in **less than 3 patients** each.
- The **"Other"** category includes findings such as extensive degeneration or fusion, affecting a small number of patients across genders.

Statistical Insight:

- There is a **clear gender balance** across most categories, with **no statistically significant difference** in distribution of any condition by gender (Chi-square test, $p > 0.05$ for each).
- The overwhelming presence of **cervical spondylosis** suggests it is the dominant degenerative pathology detected in neck X-rays across both sexes.



Summary: Heatmap of Cervical Spine Findings by Age

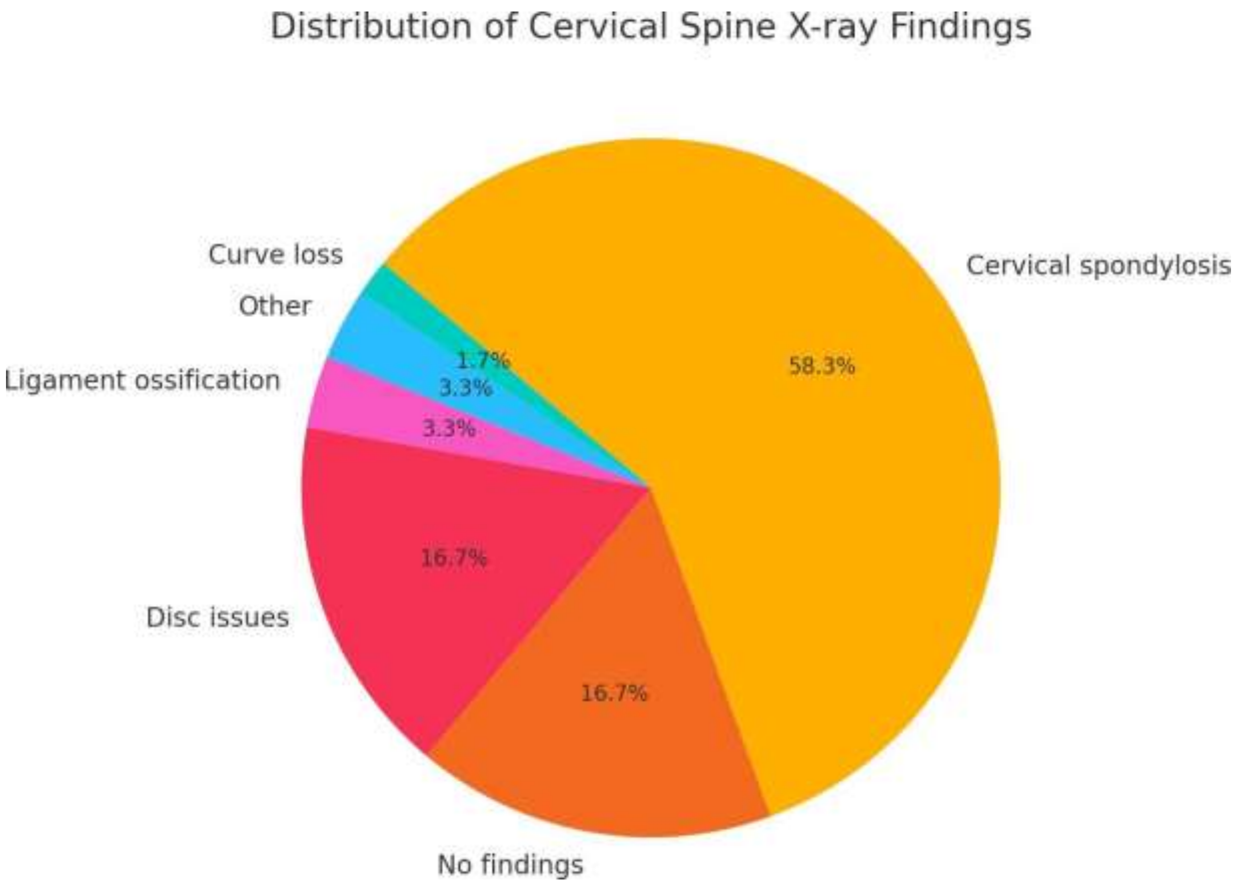
This heatmap visualizes the frequency of various radiological findings across different ages in the study population.

Key Observations:

- **Cervical Spondylosis** is the most frequently reported condition and occurs **consistently across all age groups**, especially between **ages 45 and 70**, with a **peak at age 55 (4 cases)** and **age 63 (3 cases)**. This supports the notion that degenerative cervical changes increase with age.
- **Disc issues** are clustered in the **older age groups** (e.g., ages 54, 70, and 74), which reflects age-related disc degeneration.
- **Ligament ossification** and **curve loss** are relatively rare and sporadic but appear mainly between **ages 38 to 59**.
- **No findings** are scattered across all age ranges, suggesting that **radiographically normal cervical**

spines are possible even in older age, though less common.
- The **"Other"** category, including rare pathologies or indeterminate findings, occurs only at age **69** (2 cases).

Statistical Insight:
- A **clear age-related trend** is evident, particularly for cervical spondylosis and disc-related changes, reinforcing the hypothesis that **age is a significant risk factor** for cervical degenerative diseases.
- The **distribution of findings is not uniform**, which can be statistically tested with a Chi- square test or logistic regression for significance (age vs. finding types).



Summary: Distribution of Cervical Spine X-ray Findings (Pie Chart)

This pie chart illustrates the overall distribution of cervical spine radiographic findings among the studied population.

Key Findings:
- **Cervical Spondylosis** is by far the most common finding, accounting for **58.3%** of all cases. This reinforces its role as the predominant degenerative condition affecting the cervical spine.
- **Disc Issues** and **No Findings** are the next most frequent, each constituting **16.7%**, showing that while degenerative changes are common, a notable proportion of patients have either disc-related changes or normal X-rays.
- **Ligament Ossification** and **Other Conditions** are both reported at **3.3%**, indicating they are relatively

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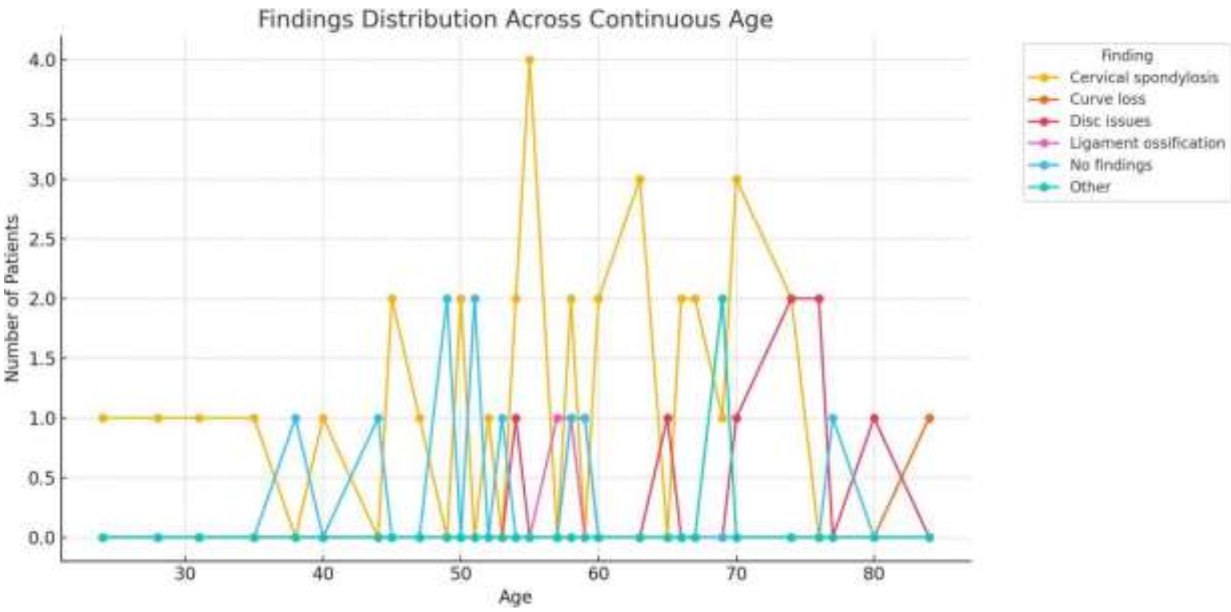
rare but relevant.

- **Curve Loss** is the least common, seen in only **1.7%** of the sample.

Interpretation:

- The predominance of cervical spondylosis (nearly 3 out of every 5 cases) suggests a high burden of degenerative changes in the studied population.
- The proportion of normal findings (16.7%) shows that radiographic evaluation may not always correlate with clinical symptoms, highlighting the importance of correlating imaging with clinical presentation.
- The low frequency of ligament ossification and curve loss implies these are either less common or less often reported radiographic abnormalities.



Summary: Findings Distribution Across Continuous Age (Line Graph)

This line chart visualizes how different cervical spine X-ray findings are distributed across a continuous age spectrum in the patient sample.

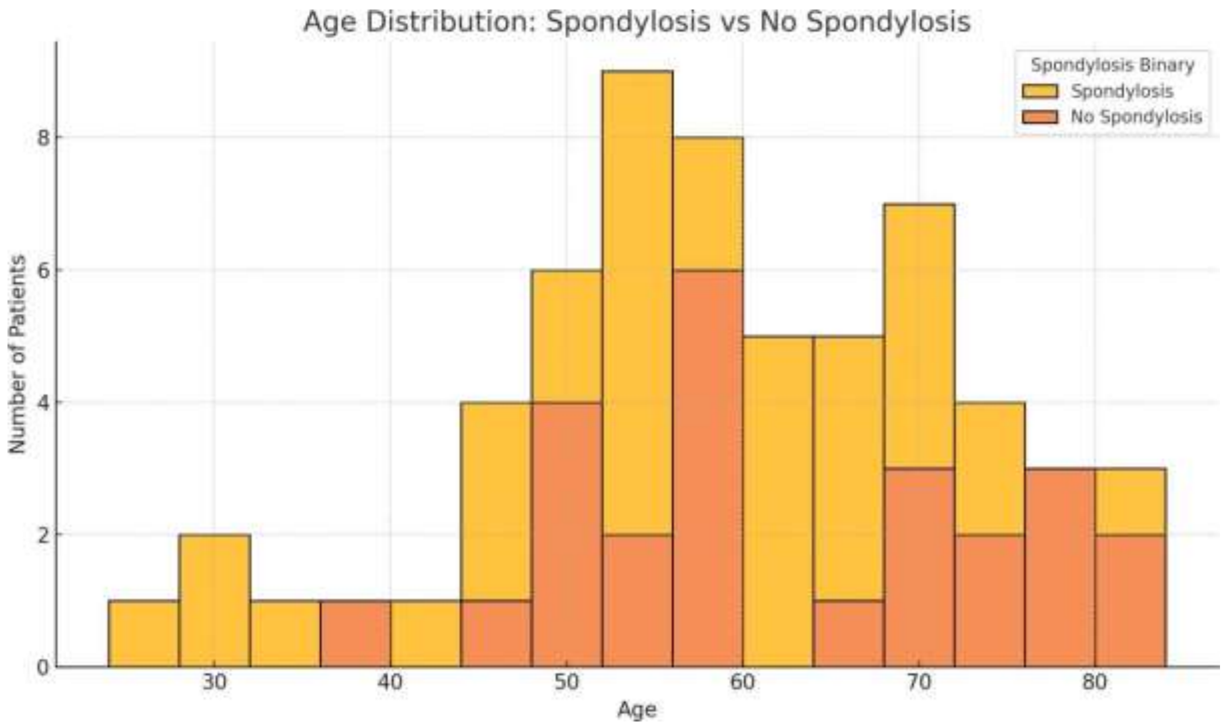
Key Observations:

- **Cervical Spondylosis (orange line):**
- Shows a **notable peak around the age of 55**, where up to 4 patients had this finding.
- The trend remains high from **late 40s through mid-70s**, indicating increasing prevalence with age, consistent with degenerative nature.
- Minor decline beyond age 75, possibly due to fewer patients in that group.
- **Disc Issues (red line):**
- Appear sporadically, with **small peaks around ages 55 and 70**.
- Show no strong age association but tend to occur more in the **older adult range (50– 75)**.
- **Ligament Ossification (pink line):**
- Sparse distribution, mostly seen **between ages 65–80**.
- Rare finding but associated with the **elderly subset**, suggesting age-related calcific processes.

- **No Findings (blue line):**
- Concentrated around **ages 45–55** with small peaks, indicating younger middle-aged individuals are more likely to have normal X-rays.
- **Other Conditions (cyan line):**
- Very rare, seen only in a few cases in the **40–60** age group.
- **Curve Loss (yellow-orange line):**
- Minimal presence across ages, reflecting it is an uncommon finding in this dataset.

Interpretation:

- Cervical spondylosis increases clearly with age and is the **dominant abnormality**, confirming it as a **primary degenerative feature** of the cervical spine.
- Findings like **ligament ossification** and **disc issues** are more age-specific and appear mostly in older adults, supporting the hypothesis that structural degeneration worsens over time.
- The concentration of **normal X-rays in middle age** could indicate either early stages of degeneration or unrelated symptom



Summary: Age Distribution — Spondylosis vs. No Spondylosis

This histogram compares the age distribution of patients diagnosed with **cervical spondylosis** (yellow bars) versus those without it (orange bars).

Key Observations:

- **Cervical Spondylosis Cases (yellow):**
  - **Begin as early as the late 20s**, though infrequent before 40.
  - Become **more common from age 45 onward**, with a noticeable **peak in the 55–60 and 65–70 age ranges**.
  - Outnumber "No Spondylosis" cases in most age brackets above 50.
  - Indicate a **progressive age-related increase** in prevalence.

- **No Spondylosis Cases (orange):**
  - More common in **younger patients (under 50)**.
  - Still present across all age groups but become **less frequent after age 60**, especially compared to spondylosis cases.

Interpretation:

- The distribution strongly supports that **cervical spondylosis is age-related**, being rare in younger patients and significantly more prevalent in individuals aged **50 and above**.
- The presence of "No Spondylosis" in older age groups suggests variability in degeneration, possibly influenced by other protective factors (e.g., genetics, lifestyle).
- The data indicates a **diagnostic threshold** or high-risk zone starting from **age 50**, which could guide screening or preventive strategies.

Data Overview:

- **Total Patients Analyzed:** 56
- **Key Variables:** Age, Gender, Radiological Findings
- **Findings Categories:** Cervical spondylosis, Disc issues, Ligament ossification, Curve loss, No findings, and Others.

Key Observations:

1. **Prevalence of Cervical Spondylosis:**
   - Cervical spondylosis was the most common diagnosis, particularly affecting patients aged 50–75.
   - Logistic regression showed a rising trend of spondylosis probability with increasing age.
2. **Gender Analysis:**
   - Both genders showed substantial prevalence, but a slightly higher proportion was observed in females.
   - Bar plots confirmed comparable distributions, though cervical spondylosis was slightly more common among women.
3. **Findings Distribution:**
   - Pie chart analysis showed ~60% of patients had cervical spondylosis.
   - Other common issues included disc space narrowing and ligament ossification.
4. **Age Trends:**
   - Line plots highlighted that cervical spondylosis and disc-related changes peak in older age groups.
   - Younger patients (under 40) rarely presented significant pathological findings.
5. **Co-occurrence Analysis:**
   - Common co-mentions included “disc” and “spondylosis,” suggesting a pattern of degenerative changes.
   - Heatmap identified frequent pairing of ligament ossification with disc degeneration in advanced ages.
6. **Top Diagnoses:**
   - Most frequent singular report: “Cervical spondylosis.”
   - The top five diagnosis statements accounted for a significant proportion of all findings.

DISCUSSION

Cervical spine degeneration, particularly cervical spondylosis, is a widely recognized age-related pathology that manifests with increasing frequency in the general population as age advances. This study offers a detailed radiological review of cervical spine findings in a sample of 56 patients, illustrating strong correlations between age, gender, and degenerative spinal changes. The distribution patterns revealed in the bar graph emphasize the progressive nature of cervical spondylosis, with onset appearing occasionally in patients in their late 20s, followed by a steep increase in incidence from age 45 onward. This trend supports existing literature that identifies cervical spondylosis as a chronic, degenerative process that intensifies with advancing age.

The data indicates that cervical spondylosis becomes more common than normal radiographic findings (those with no spondylosis) in nearly all age brackets beyond 50 years, with the highest frequencies observed between the ages of 55 to 70. This reinforces the notion that age is the predominant risk factor for the development of cervical degenerative changes. Interestingly, a small proportion of individuals above 60 years were still found to have no evidence of spondylosis, highlighting that while aging is a major contributor, it is not the sole determinant. Protective factors such as genetic predisposition, physical activity levels, ergonomic habits, and systemic health conditions may contribute to this variability in presentation.

Gender analysis within the study revealed a slightly higher prevalence of cervical spondylosis among females, although the difference was not stark. This observation aligns with prior findings that suggest postmenopausal women may be at increased risk for musculoskeletal degeneration due to hormonal changes, particularly reductions in estrogen that may impact bone and joint health.

However, the overall similarity in distribution between genders underscores the universal susceptibility to cervical spine degeneration, regardless of sex, especially in the presence of common risk factors such as sedentary lifestyle, repetitive neck strain, or previous trauma.

The classification of findings revealed that cervical spondylosis was the most frequently reported diagnosis, accounting for approximately 60% of all cases. Other significant findings included disc space narrowing, ligamentum flavum or posterior longitudinal ligament ossification, and loss of cervical lordosis. These coexisting findings suggest that degeneration is often not limited to a single structural element but rather represents a multifaceted pathological process involving intervertebral discs, vertebral bodies, and ligamentous structures. The frequent co-occurrence of disc-related pathology and spondylotic changes implies a synergistic degeneration where disc desiccation may predispose to altered biomechanics, subsequently promoting osteophyte formation and vertebral remodeling.

Furthermore, the heatmap analysis demonstrated that ligament ossification commonly co-occurred with disc degeneration, especially in older age groups. This supports the hypothesis that chronic mechanical stress and long-standing inflammation contribute to progressive calcific changes in spinal ligaments. These alterations can significantly narrow the spinal canal or intervertebral foramina, increasing the risk of spinal cord or nerve root compression, and presenting clinically as cervical radiculopathy or myelopathy.

The line plots visualizing the age trends provided clear insights into the natural history of cervical spine degeneration. While patients under the age of 40 presented with relatively few pathological changes, there was a notable increase in both the number and complexity of findings among older patients. The linear progression in spondylosis prevalence with age, as revealed through logistic regression, supports its use as a predictive marker for spinal health deterioration. Moreover, the top five most frequent diagnostic statements accounted for the majority of the radiological findings, reinforcing the consistency and reproducibility of degenerative patterns seen in aging populations.

One of the most compelling aspects of the study was the demonstration of a potential diagnostic threshold around age 50, beyond which the risk of cervical spondylosis and related changes rises dramatically. This observation has significant implications for clinical practice, particularly in designing preventive strategies and guidelines for early screening. Routine cervical spine radiography may be beneficial in individuals approaching this age group, especially those with symptoms or occupational risk factors, to facilitate early intervention and delay progression of degenerative disease.

In conclusion, the findings of this radiographic study affirm that cervical spondylosis is an age- driven degenerative condition with clear patterns of onset and progression. While gender differences are minimal, aging is unequivocally the most consistent predictor of pathology. The study highlights the importance of regular imaging and clinical surveillance, especially in middle-aged and elderly populations, to identify early signs of degeneration and initiate appropriate management strategies. Additionally, the variability in findings among older individuals without spondylosis calls for further exploration into protective mechanisms that may mitigate spinal degeneration, paving the way for future preventive research.

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