REVIEW ARTICLE

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Degenerative Cervical Spondylosis

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N Engl J Med 2020;383:159-68.
DOI: 10.1056/NEJMra2003558
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Degenerative cervical spondylosis is a chronic, progressive deterioration of osseocartilaginous components of the cervical spine that is most often related to aging. Radiographic evidence of degeneration of the cervical spine occurs in virtually all persons as they age; however, not all persons have the typical symptoms of neck pain or neurologic deficits that correspond to the mechanical compression of neural elements. Symptomatic cervical spondylosis is initially managed with nonsurgical treatment options, which usually result in abatement of symptoms. Surgical intervention may be indicated if there is clinically significant neurologic dysfunction or progressive instability or deformity of the cervical spine. No currently approved therapy addresses the cause of degenerative cervical spondylosis or reverses the deterioration. In select patients, surgical intervention can lead to favorable outcomes.

TERMINOLOGY AND EPIDEMIOLOGY

Degeneration of the cervical spine has acquired many equivalent names, including degenerative cervical spondylosis, cervical degenerative disease, cervical spondylosis, cervical osteoarthritis, and neck arthritis. The term spondylosis comes from the Greek word *spóndylos*, meaning vertebra. In general, these terms refer to age-related wear and tear that affect elements of the cervical spine over time, including the intervertebral disks, facet joints, and other connective-tissue structures (e.g., cervical spinal ligaments). However, cervical spine degeneration may also have immune inflammatory components.[1,2] The disorder may be associated with generalized neck pain, mechanical or axial neck pain, compression and inflammation of the cervical nerve roots exiting the cervical spine (cervical radiculopathy), and compression and inflammation of the adjacent cervical spinal cord (cervical myelopathy).[3]

Although age-related degenerative changes of the spine are almost universal, they may begin as early as in the first decade of life.[4] Population-based studies have shown that approximately 80 to 90% of people have disk degeneration on magnetic resonance imaging (MRI) by the age of 50 years.[5,6] A review of the global burden of low back and neck pain estimated that in 2015, more than a third of a billion people worldwide had mechanical neck pain of at least 3 months' duration,[7] underscoring the global health implications of degenerative cervical spondylosis.[8] A much smaller number of people have cervical radiculopathy (estimated annual incidence, approximately 83 cases per 100,000 persons)[9] and myelopathy (approximately 4 per 100,000)[10] as a result of cervical spondylosis. Clinical features of spondylosis are more common in men than in women, with a peak incidence between the ages of 40 and 60 years for both men and women.[11,12]

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PATHOGENESIS AND PATHOPHYSIOLOGY

Although degenerative cervical spondylosis can affect any component of the cervical spine, such as bone quality and joint structures,[13] the most clinically significant changes occur in the intervertebral disks and facet joints. The intervertebral disk consists of the annulus fibrosus on the exterior border of the disk and the nucleus pulposus in the interior.[14] Like most dense connective tissue (e.g., ligaments), the intervertebral disk is essentially avascular.[15,16] Nutrient and waste exchange occur primarily through diffusion across the capillary beds in the adjacent superior and inferior vertebral end plates.[17] The intervertebral disks are metabolically active tissues, and cells deep within the disk, where oxygen is scarce, have adopted mechanisms to compensate for the relative hypoxia, including the up-regulation of hypoxia-inducible factors (e.g., HIF-1α).[18,19] Inner intervertebral disk cells (nucleopulpocytes) exist in a precarious state and may die in the presence of age-related changes such as vertebral bony end-plate calcification that decrease the limited exchange of nutrient and waste products.[17]

The loss of intervertebral disk cells is thought to contribute to a shift from tissue homeostasis toward net catabolism, leading to intervertebral disk deterioration.[20] However, the events triggering catabolic processes within the intervertebral disk have not been clearly defined. Such events may have a genetic basis or may be related to previous spinal trauma, including subclinical and unnoticed injuries.[21,22] Up-regulation of proinflammatory cytokines within the disk, including tumor necrosis factor α, interleukin-1β, and interleukin-6, occurs concomitantly with the loss of matrix-producing cells, further promoting the loss or senescence of native matrix-producing cells and subsequent replacement with fibroblast-like cells.[20] As a result, the production of hydrophilic proteoglycans is decreased, leading to gradual desiccation of the disk and the transfer of biomechanical loads from the nucleus pulposus to the surrounding annulus.[13] Furthermore, this degenerative process is accompanied by the secondary up-regulation of matrix metalloproteinases by resident disk cells, which lowers the yield strength of the annulus.[23] The combination of increased load sharing by the annulus and decreased yield strength predisposes the annulus to fissuring, with resultant herniation of the nucleus pulposus (the common condition of disk herniation), which impinges on the spinal cord or nerve roots.

In addition, disk desiccation is associated with loss of disk height, which is one reason that people "shrink" with age. Loss of disk height also narrows the foramina, through which nerve roots exit the spinal column, and leads to circumferential bulging of the annulus.

Finally, nociceptive nerve fibers that are present in the annulus and nucleus pulposus become sensitized by the cytokine milieu of the degenerative disk, putatively leading to a syndrome of pure diskogenic pain.[24,25] Mechanical neck pain is more often due to the distortion of surrounding soft tissues, including muscles and ligaments, and the cause of pain in patients with degenerative cervical spondylosis is often difficult to determine. It has been suggested that the central nervous system may become sensitized and perpetuate neck discomfort in patients with chronic spinal pain.[26,27]

Degeneration of the cervical facet joints, a set of two synovial joints that stabilize adjacent vertebrae at every spinal level below C1, may occur as a result of — or independent of — degeneration of the intervertebral disk. Such degeneration leads to pain and radiculopathy.

Myelopathy occurs if vertebral bodies are displaced, a condition termed spondylolisthesis.[4] This process is the result of damage to several elements of the spinal architecture. Normally, the cervical facet joints provide load-bearing support alongside the intervertebral disk and stabilize the neck during flexion, extension, and rotation. In the context of disk degeneration, the facet joints may be subjected to increased load bearing, which leads to osseocartilaginous alterations and destabilizes the joints.[13] Degeneration of the facet joints is similar to degeneration seen in other diarthrodial joints, such as the knee, and may be characterized by joint-space narrowing, subchondral sclerosis, and osteophyte formation. These changes narrow the spinal canal and neural foramina and decrease neck mobility. Like the intervertebral disk, the facet joints are innervated by nociceptive nerve fibers and may be sources of cervical spine pain.[28] Cervical facet joint syndrome, which is focal pain caused by degeneration of a cervical

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Table 1. Worrisome Signs and Symptoms in the Evaluation of Patients with Degenerative Cervical Spondylosis.*

Signs and Symptoms	Cause	Physical Examination
History of cancer (especially breast, prostate, or lung), weight loss, night sweats, fever, nocturnal neck pain	Cancer	Variable findings, neurologic deficit, exquisite tenderness over vertebral body
History of intravenous drug use, immunocompromised status, fever, diabetes, recent sepsis	Spinal abscess	Usually severe local pain
Decreased dexterity in hands or feet, gait and balance instability, increased urinary frequency and urgency	Spondylitic myelopathy	Hyperreflexia, clonus, ataxia, Romberg's sign, atrophy of intrinsic hand muscles

* The information is from Childress and Becker.[31]

facet joint, is recognized by some clinicians as a subcategory of degenerative cervical spondylosis that calls for distinct treatment.[29,30]

CLINICAL PRESENTATION AND DIAGNOSIS

Patients with degenerative cervical spondylosis may present with mechanical neck pain, radiculopathy, myelopathy, or a combination of these symptoms. Mechanical neck pain may be isolated to the neck or may radiate broadly, such as to the shoulders, head, chest, and back. The source of the pain is often difficult for patients to pinpoint. This complicates management, since the pain could stem from the degenerated intervertebral disk (pure diskogenic pain), the degenerated facet joints, or the muscular and ligamentous structures. The pain is often worsened by neck motion and relieved by rest and immobilization. However, neck pain is relatively common in the general population, affecting an estimated 15% of people at any time, and is not specific to degenerative cervical spondylosis.[3] A patient presenting with neck pain may be asked about red-flag signs and symptoms, such as a history of cancer, gait instability or sensory loss associated with myelopathy, and fever with nocturnal pain suggestive of spinal abscess — all of which require rapid evaluation (Table 1).

Cervical radiculopathy from spondylosis is caused by mechanical compression and inflammation of a cervical nerve root, most commonly C6 or C7.[31,32] The compression may be acute (e.g., caused by an abruptly herniated disk) or chronic (e.g., the result of hypertrophied facet joints). Pain arising from the compressed and inflamed nerve root, mainly radiating from the shoulder or upper back to the proximal arm, is the most common symptom of cervical degenerative radiculopathy.[9] Radicular neck pain may also be accompanied by painful neck spasms. Patients with cervical degenerative radiculopathy may have paresthesia, numbness, or weakness that often — but not always — corresponds to dermatomal distributions of the affected cervical nerve root.[31] Diminished deep-tendon reflexes, such as those of the biceps (C6 nerve root) or triceps (C7 nerve root), are corroborative of nerve-root compression.

Provocative tests used to aid in the diagnosis of cervical degenerative radiculopathy include the Spurling test, the shoulder-abduction test, and the cervical-traction test.[33,34] In the typical application of the Spurling test, the patient's neck is turned to the side of the radicular pain and is then slightly extended. Downward pressure is applied to the top of the patient's head, which narrows the neural foramina on the affected side. If the pain is elicited or worsened, it can be attributed to radiculopathy. The test may be repeated by turning the patient's head to the side opposite the pain; if the pain is worsened by this maneuver, a musculoskeletal cause is suggested. The shoulder-abduction test is another useful diagnostic tool. This test is performed by placing the palm or forearm of the affected arm on top of the patient's head. If the radicular pain is relieved, radiculopathy is the likely source of the pain. Manual cervical traction may be used as a test to expand the neural foramina; if radicular pain is relieved in this way, then radiculopathy is suggested.

Cervical degenerative myelopathy is the least common but most worrisome presentation of degenerative cervical spondylosis. It is caused by

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Table 2. Differential Diagnosis for Cervical Degenerative Spondylosis.*

Clinical Feature	Acute Conditions	Chronic Conditions
Neck pain	Cervical strain or sprain, painful intervertebral disk, painful facet joint	Fibromyalgia, failed surgical fusion, referred visceral pain, hypochondriasis and somatoform disorders
Radiculopathy	Intervertebral disk herniation, brachial plexitis	Intervertebral disk herniation, shoulder disorder, entrapment neuropathy, focal facet hypertrophy
Myelopathy	Intervertebral disk herniation, pathologic fracture, Guillain–Barré syndrome	Intervertebral disk herniation, spinal instability, central canal stenosis, multiple sclerosis, neoplasm, infection, myopathies, syringomyelia, arteriovenous malformation, vitamin B_{12} deficiency

* The information is from Voorhies.[3]

mechanical compression and is associated with inflammation and edema of the spinal cord; inflammation and edema lead to slow, progressive deterioration of neurologic function as a result of narrowing of the spinal canal and compression of the long tracts and local segmental elements of the spinal cord.[35] Both static (at rest) and dynamic (repetitive motion) compressive factors contribute to deterioration.[36,37] For example, an already compressed spinal cord may sustain further compression on neck flexion, which increases tension on the spinal cord because of its relatively fixed longitudinal position, maintained by the dentate ligaments and cervical nerve roots. Patients with myelopathy may present with a variety of subtle neurologic findings, which they may attribute to natural loss of function with age. These include loss of manual dexterity; gait and balance disturbances, especially in the absence of visual cues (Romberg's sign); sensory loss in the hands or feet; arm or hand weakness; and defecatory or urinary frequency, urgency, or hesitancy. There may be upper-motor-neuron signs, including clonus, hyperreflexia, Hoffmann's sign, and Babinski's sign.[38] Patients with symptoms of myelopathy almost always have associated neck pain and stiffness and may have pain in the arms or shoulders. Radicular features, mentioned above, are also common in the context of cervical degenerative myelopathy. Some persons have Lhermitte's sign (electrical sensations radiating down the spine or across the shoulders) on neck flexion, and other signs and symptoms that are occasionally attributable to cervical myelopathy but have many alternative causes.[38]

Table 2 outlines the differential diagnosis for the main presentations of cervical spondylosis, with or without myelopathy.[3,31,39] In evaluating patients with neck pain, it is useful to recognize that virtually all patients older than 50 years of age have cervical degenerative changes on one or more forms of imaging, and many findings are not specific. For these reasons, diagnostic imaging is often not recommended for patients who initially present with nontraumatic neck pain without neurologic symptoms or signs or red flags.

For patients with persistent neck, shoulder, or arm pain and suspected radiculopathy, an initial radiographic evaluation may be performed, with the use of anteroposterior, lateral, and oblique radiographs, which are relatively inexpensive and provide information pertaining to degenerative changes and alignment.[40] Lateral flexion or extension views may also be obtained during the initial evaluation and may disclose cervical instability, limited range of motion, and fused cervical spine segments.[41] For patients with progressive neurologic impairments or any feature that suggests myelopathy, cervical spine MRI without the administration of contrast material is the preferred imaging technique, since it provides information about osseous, soft-tissue, and spinal cord structures (Fig. 1).[42] The presence of an abnormal signal within the cervical cord or adjacent to the level of compression by spondylosis is considered a serious finding, which may signify a less satisfactory outcome with surgical decompression than would otherwise be expected. On the other hand, in some cases the spinal cord seems able to withstand a substantial degree of deformation, with few resulting symptoms, if the deformation develops slowly. The decision to surgically decompress the spinal canal in cases of cervical spondylosis incorporates, but does not entirely depend on, such factors as the degree of disability (e.g., impairment of activities of daily living) and the rapidity of symptom progression. If MRI is con-

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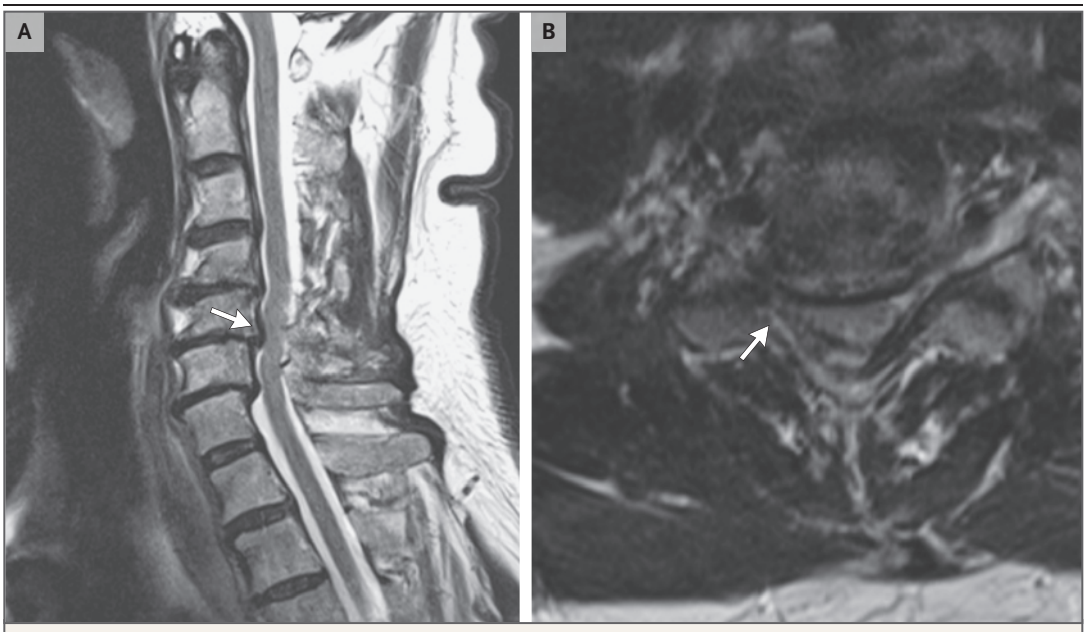

Figure 1. MRI Scans of the Cervical Spine in a Patient with Cervical Spondylosis.

A 75-year-old man presented with a 2-year history of progressive upper-extremity paresthesias and radicular pain. He reported having dropped items recently from both hands and noted dexterity and balance deficits but no bowel or bladder incontinence. A sagittal T2-weighted MRI scan shows stenosis of the central spinal canal at C4–C7, with an osteophyte, deformation of the cord, disk material, and spondylolisthesis at C5–C6 (Panel A, arrow). An axial T2-weighted image shows severe foraminal stenosis (Panel B, arrow) and severe encroachment on the spinal canal by osteophyte, ligamentous, and facet hypertrophy.

traindicated or unavailable, a computed tomographic (CT) study or CT myelography of the cervical spine (Fig. 2) is an alternative imaging approach.[43,44] Electrodiagnostic testing may be helpful in evaluating cervical radiculopathy by showing denervation in muscles specifically referable to a single cervical nerve root.[45,46] Guidelines for the use of injections and other approaches, including advanced imaging studies such as single-photon emission CT to identify "pain generators," are ill defined and lack evidence-based support.[3,47,48]

TREATMENT APPROACHES AND OUTCOMES

Various treatment algorithms have been created for managing degenerative cervical spondylosis and mechanical neck pain, radiculopathy, or myelopathy.[31,49-51] The management of degenerative neck pain in patients who have no neurologic deficit is typically a "tincture of time," along with analgesics and other conservative options, including physical therapy.[3] Some patients have worsening or chronic pain, even in the absence of signs of nerve-root or spinal cord compression. The care of patients with chronic, degenerative neck pain can be challenging and frustrating for both patient and health care provider, especially given the difficulty in identifying the cause. Many patients benefit from a referral to a specialist in chronic pain management, and many have improvement when coexisting psychiatric disorders, including anxiety and depression, are treated.[52-54] In general, surgical outcomes for patients with chronic neck pain are limited, especially when the source of the pain cannot be identified.

Most patients with degenerative cervical radiculopathy have reduced pain and improved neurologic function with nonsurgical care, including oral analgesics, epidural glucocorticoid injections, physical therapy, cervical traction or brief immobilization in a cervical orthosis, and other options, such as massage.[9,31,55] Few high-quality studies have evaluated these conservative therapies to provide a recommendation, and the various approaches may offer similar rates of symptomatic improvement.

The severity and rate of progression of neuro-

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logic deficits are the main aspects of the evaluation of patients with degenerative cervical radiculopathy, since clinically significant motor weakness or worsening neurologic symptoms usually indicate the need for surgical evaluation. The timing for surgical evaluation is not clear, although advancing nerve-root compression in association with weakness, atrophy, or sensory loss, in addition to deteriorating neurologic status at any time, generally prompts referral to a spine surgeon. In patients with identifiable causes of nerve-root compression — for example, a herniated disk — surgical outcomes are often good.[56]

Patients with degenerative cervical myelopathy are also typically referred to a spine surgeon.

Figure 3 (facing page). Cervical Spine Decompression and Fusion.

Anterior cervical diskectomies at C3–C4 and C4–C5, with the placement of bone-graft spacers where disks were removed and stabilizing screw–plate instrumentation, are shown schematically in Panel A and in a lateral radiograph in Panel C. Posterior laminectomies and lateral mass screw–rod instrumentation and fusion at C3–C6 are shown schematically in Panel B and in an anteroposterior radiograph in Panel D.

In view of the progressive natural history of nerve-root or spinal cord compression or pain in most patients, surgical treatment for degenerative cervical myelopathy can be a good option.[35,36] For patients with moderate-to-severe

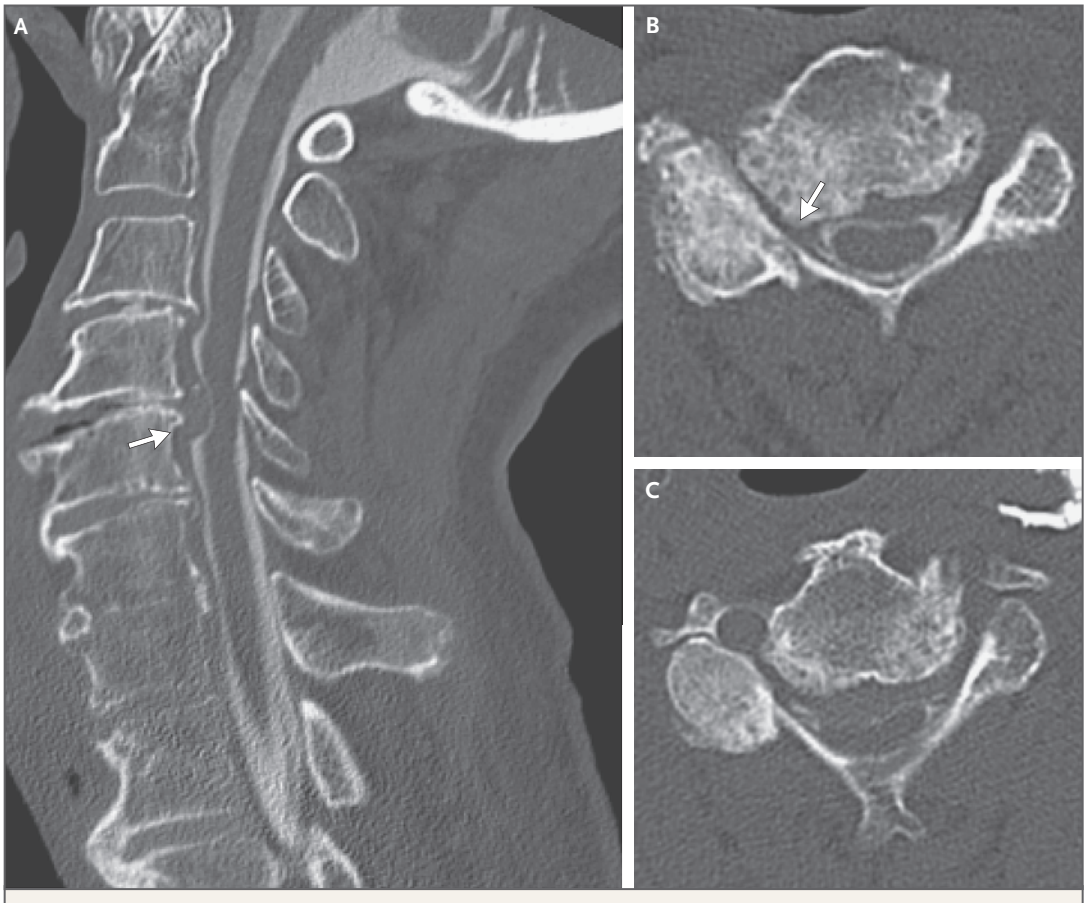

Figure 2. Postmyelography CT Scans of the Cervical Spine.

A 68-year-old woman had increasing hand weakness, intrinsic hand-muscle atrophy, and hand numbness. She had begun falling and had Romberg's sign. She was unable to undergo MRI. A midsagittal CT myelogram (Panel A) shows multilevel cervical spondylosis with osteophytes, disk protrusion, and cord compression at C4–C5 (arrow). An axial image at the C3–C4 disk space shows a right lateral osteophyte (Panel B, arrow) encroaching on the neural foramen, and a similar image at the C4–C5 disk space shows marked cord compression (Panel C).

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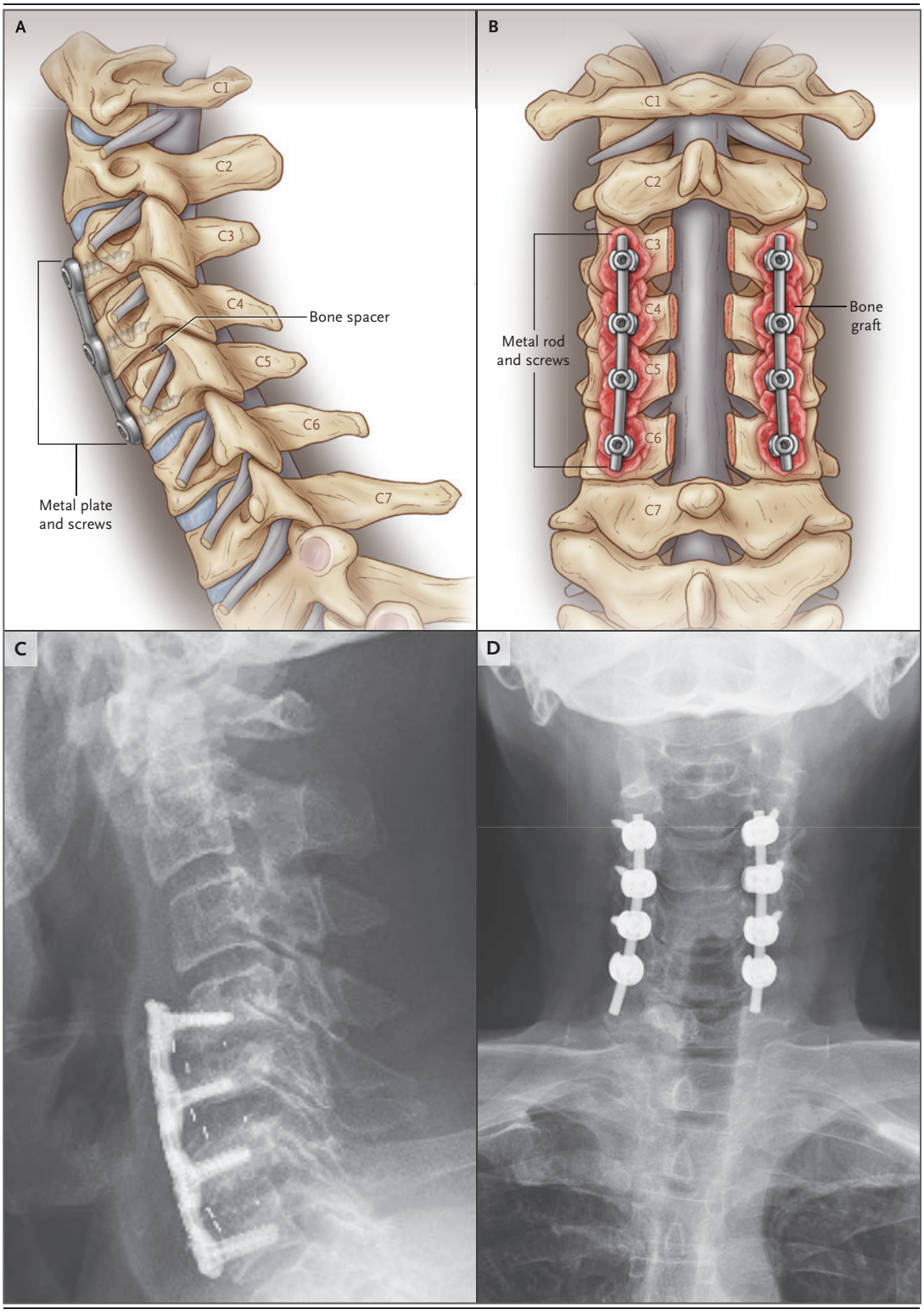

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neurologic deficits, consensus statements have suggested that nonsurgical management, as compared with surgery, leads to inferior clinical outcomes. However, data from well-performed randomized trials, such as those that have been conducted for lumbar spine disease, are lacking, and so this suggestion is driven largely by clinical experience.[57]

Surgical approaches to the treatment of degenerative cervical radiculopathy, myelopathy, or both include anterior, posterior, and anteroposterior techniques (Fig. 3).[58-60] Each technique has its proponents and inherent drawbacks, related mainly to the adequacy of decompression of the spinal cord and nerve roots, maintenance of stability of the spinal column, duration of the procedure and blood loss, and time required to recover from surgery and be discharged from the hospital. In some instances, the surgeon's facility and experience with a certain procedure are considerations in choosing the approach. The goals of surgery are to decompress the nerve roots or spinal cord and stabilize the spine, while attempting to restore or maintain relatively normal spinal alignment. Outcomes depend on the severity and duration of the neurologic deficit at the time of surgery. Advanced age, smoking, and coexisting conditions such as obesity and diabetes mellitus have been shown to negatively affect outcomes.[61]

PREVENTION

In general, virtually all people have some degree of cervical degeneration with age, including intervertebral disk desiccation, neural foraminal narrowing, osteophyte formation, and facet joint hypertrophy. Why only some patients have symptoms after these changes occur is unclear. Certain anatomical configurations, such as a congenitally narrow spinal canal, short pedicles, and small neural foramina, are almost certainly contributors to the development of symptoms for a given degree of spondylosis. Staying physically active, maintaining good posture, and preventing neck injuries may all help prevent symptomatic degenerative cervical spondylosis. In addition, smoking and obesity have been found to be associated with spondylosis; therefore, managing these risk factors may offer benefits.[62]

CONCLUSIONS AND RECOMMENDATIONS

Degenerative cervical spondylosis is caused by arthritic changes in the osseocartilaginous components of the cervical spine, which may compress spinal nerve roots, the spinal cord, or both, causing neck pain, radiculopathy, or myelopathy. Treatment is generally nonsurgical, especially for pain and mild radiculopathy, which are typically self-limiting. However, surgery is generally indicated to treat myelopathy and may be indicated for persistent and severe nerve-root compression.

Dr. Theodore reports receiving royalties and consulting fees from Globus Medical and royalties from Depuy Synthes; and holding patent US20130345718A10 on a surgical robot platform, licensed to Globus Medical, for which royalties are received, and holding patent US 2019/0090907 A1 on a revision connector for spinal constructs, licensed to Depuy Synthes, for which royalties are received. No other potential conflict of interest relevant to this article was reported.

Disclosure forms provided by the author are available with the full text of this article at NEJM.org.

I thank Dr. Ethan Cottrill for assistance with the literature review and preparation of an earlier version of the manuscript.

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