



Medical Coverage Policy

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Cervical Fusion

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Overview

This Coverage Policy addresses cervical fusion, also referred to as cervical arthrodesis. Cervical fusion is a surgical procedure that joins two vertebral bones in the cervical spine. The procedure is performed to treat severe neck pain and disability, or instability of the cervical spine, and involves the use of bone graft materials and various types of instrumentation to join the vertebrae together. The cervical spine may be approached anteriorly or posteriorly, or be approached using a combination of anterior-posterior approaches. In some instances, cervical fusion may be considered an alternative to cervical disc arthroplasty.

Coverage Policy

ANTERIOR CERVICAL FUSION FOR DEGENERATIVE DISEASE

Single or multilevel anterior cervical discectomy and fusion (ACDF) is considered medically necessary for treatment of symptomatic degenerative disease when ALL of the following criteria are met:

- unremitting cervical radiculopathy and/or myelopathy (i.e., neck and arm pain) resulting in disability and/or neurological deficit that are refractory to at least six weeks of standard conservative, nonoperative management (e.g., reduced activities, exercise, analgesics, physical therapy), in the absence of progressive or severe myelopathy
- imaging studies (i.e., CT, MRI, CT myelogram) demonstrate at least ONE of the following at each impacted level which is compressing the nerve root or spinal cord being considered for the fusion:
 - Herniated nucleus pulposus
 - Spondylosis (i.e., presence of osteophytes)
 - Visible loss of disc height compared to adjacent levels with resultant foraminal stenosis
- physical examination findings and imaging studies correlate with each level being considered for the fusion

CERVICAL FUSION FOR INSTABILITY

Single or multilevel cervical fusion is considered medically necessary for ANY of the following indications when there is an associated spinal instability:

- acute spinal fracture and/or dislocation
- neural compression after spinal fracture
- traumatic ligamentous disruption
- epidural compression, fracture or vertebral destruction from spinal tumor or cyst
- spinal tuberculosis
- spinal decompression or debridement for infection (e.g., discitis, osteomyelitis, epidural abscess)
- spinal decompression for myelopathy associated with ossification of the posterior longitudinal ligament
- spinal decompression for myelopathy associated with spondylosis in rheumatoid arthritis
- cervical spinal deformity associated with neurological symptoms of myelopathy or radiculopathy (e.g., sagittal plane angulation of more than 11 degrees between adjacent segments, spondylosis of >3.5 mm)
- as an adjunct to cyst excision of synovial facet cysts in the cervical spine
- posttraumatic cervical instability
- atlantoaxial instability (e.g., atlas and axis fracture, nonunion)
- treatment of cervical spine fracture/dislocation associated with acute cervical radiculopathy or myelopathy
- multilevel spondylotic myelopathy with kyphosis, when symptoms of myelopathy are present and imaging studies correlate with symptoms and demonstrates cord compression
- cervical instability from any ONE of the following:
 - Klippel-Feil syndrome
 - Down's syndrome
 - Skeletal dysplasia or connective tissue disorder

CERVICAL FUSION FOR IATROGENIC INSTABILITY

Cervical fusion is considered medically necessary for intraoperative iatrogenic spinal instability of the level or levels involved resulting from ANY of the following surgical procedures:

- removal of 50% or more of the facets bilaterally
- removal of 75% or more of a single facet
- following cervical corpectomy*, as part of a stabilization procedure

***Note:** Corpectomy is a procedure in which the at least 50% or more of the body of the vertebra is removed.

POSTERIOR CERVICAL FUSION FOR INSTABILITY: SPINAL STENOSIS

Posterior cervical fusion is considered medically necessary for the treatment of spinal stenosis with laminectomy when ALL of the following criteria are met:

- symptoms of myelopathy and/or radiculopathy

- failure of at least three (3) consecutive months of physician-supervised conservative medical-management including exercise, nonsteroidal and/or steroidal medication (unless contraindicated), physical therapy and activity lifestyle modification in the absence of progressive or severe myelopathy
- clinically significant functional impairment (e.g., inability to perform household chores or prolonged standing, interference with essential job functions)
- central, lateral recess, foraminal stenosis or synovial cyst is demonstrated on imaging studies (e.g., radiographs, magnetic resonance imaging [MRI], computerized tomography [CT], myelography) that correlates with the clinical symptoms and/or signs
- radiographic evidence of **EITHER** of the following:
 - subluxation or translation of more than 3.5 mm on static lateral views or dynamic radiographs
 - sagittal plane angulation of more than 11 degrees between adjacent segments

CERVICAL FUSION FOLLOWING PRIOR SPINAL SURGERY: WITHOUT SPONDYLOLISTHESIS

Cervical fusion is considered medically necessary for treatment of symptomatic adjacent or same segment stenosis following prior spinal surgery in the absence of spondylolisthesis, when ALL of the following criteria have been met:

- unremitting pain and significant functional impairment for at least 3 months in the absence of myelopathy that persists despite structured*, physician-supervised conservative medical management, which includes ALL of the following components
 - exercise, including core stabilization exercises
 - analgesics, nonsteroidal anti-inflammatory medication, unless contraindicated
 - physical therapy, including passive and active treatment modalities
 - activity/lifestyle modification
- physical examination findings and imaging studies correlate with each level being considered for the fusion

***Note:** Structured medical management consists of medical care that is delivered through regularly scheduled appointments, including follow-up evaluation, with licensed healthcare professionals.

CERVICAL FUSION FOLLOWING PRIOR SPINAL SURGERY: PSEUDOARTHROSIS

Cervical fusion is considered medically necessary for the treatment of pseudoarthrosis (i.e., nonunion of prior fusion) of the cervical spine at the same level(s) when it has been at least 12 months from the prior surgery and ALL of the following criteria are met:

- mechanical neck pain that correlates to the level of the pseudoarthrosis
- imaging studies(e.g., radiographs, CT) confirm evidence of a pseudoarthrosis (e.g., lack of bridging bone, dynamic motion on flexion-extension radiographs)
- failure of three (3) consecutive months of physician-supervised conservative management which includes exercise, nonsteroidal and/or steroidal medications (unless contraindicated), physical therapy and activity lifestyle modification
- the individual is a nonsmoker, or in the absence of progressive neurological compromise the individual has refrained from use of tobacco products for at least 6 weeks prior to the planned surgery

† Note: Use of tobacco products have been shown to adversely affect bone healing. Smoking is associated with an increased risk of pseudoarthrosis as well as other complications. As a result, when performed for other than emergent medical conditions Cigna requires a statement that the individual is a non-smoker or has refrained from use of tobacco and/or /nicotine products for at least six (6) weeks prior to the planned cervical fusion procedure for pseudoarthrosis.

CERVICAL FUSION NOT MEDICALLY NECESSARY

Cervical fusion is considered not medically necessary for the following indications:

- anterior or posterior cervical fusion for chronic axial neck pain

- posterior cervical fusion performed with initial primary laminectomy in the absence of kyphosis (e.g., degenerative spine) or subluxation/translation of more than 3.5 mm

Isolated cervical facet fusion, with or without instrumentation, including facet joint implants and/or bone graft substitutes used exclusively as a stand-alone stabilization device is considered experimental, investigational or unproven.

General Background

Neck pain occurs in a majority of the population and typically involves more than one component of the spine, such as the vertebrae, intervertebral discs, spinal nerves, and other anatomic structures such as ligaments, muscles, and joints. Conditions that frequently result in neck pain include soft tissue injury, trauma, infection, herniated disc, degenerative spine conditions, neoplastic conditions, and deformities such as kyphosis.

While the cause of neck pain is often multifactorial (e.g., originating from the vertebrae, discs, ligaments, tendons and muscles) the location of pain varies. Axial neck pain occurs along the spine, is of musculoskeletal or soft tissue origin, and is a non-radiating type of pain. The most common cause of axial neck pain is degenerative change to the cervical spine, which occurs as a natural consequence of aging. Radicular pain involves a nerve root and is due to nerve root compression, it follows the nerve root distribution and radiates to one or both upper extremities, and/or into the shoulder area. Radicular pain can include varying degrees of sensory, motor, and/or reflex changes related to nerve root(s) without evidence of myelopathy (North American Spine Society, [NASS], 2013). Myelopathy is a term that describes any neurological deficit related to the spinal cord and is often used to describe loss of function in the upper or lower extremities (NASS, 2013).

Depending on the cause of neck pain associated symptoms may include numbness, tingling, weakness, and other types of neurologic dysfunction in the presence of spinal cord compression. Conservative measures for treatment of neck pain include analgesics, muscle relaxants, local injections, physical therapy, cervical bracing and home exercise. Conservative treatment is often effective for alleviating symptoms and typically lasts six to eight weeks. However, conservative therapy is not recommended in the presence of progressive neurological deficits, in the presence of unstable spinal fractures or dislocations, or for progressive spinal deformity. In the absence of progressive neurologic compromise, or when conservative management has been attempted and fails to relieve pain and disability, surgery may be required for conditions with underlying pathology confirmed by physical examination and radiological imaging.

When spinal cord compression is present surgical methods to relieve the pressure on the nerves is often necessary and is referred to as decompression surgery. Decompression typically includes surgical procedures such as discectomy (removal of the disc), laminectomy (removal of the lamina), corpectomy (removal of the vertebral body), or osteotomy (removal of a piece of bone). When performed, these procedures may result in spinal instability. As such, decompression is often performed along with cervical fusion in order to regain stability of the spine. For example, anterior cervical fusion is usually performed with decompression. Posterior cervical fusion is typically performed with stabilization (using rods, screws) although may be performed with decompression in some instances (NASS, 2014). Instability of the cervical spine can also result from trauma and/or disease, or a combination of all (White, Panjabi, 1980), which may or may not require a decompression. Instability of the cervical spine has been defined by White, Panjabi (1980) and is well-accepted in the medical literature as sagittal plane translation of >3.5 mm, and/or rotation between motion segments of 11°, in addition to other notable factors such as destruction of elements or inability to function, a positive stretch test, spinal cord or nerve root damage, and abnormal disc narrowing (White, Panjabi, 1980). In the absence of instability, evidence in the published peer-reviewed scientific literature does not provide strong support that when used for this indication cervical fusion is clinically effective for reducing pain and disability.

While there is no consensus regarding the length of conservative management required prior to undergoing surgical treatment for neck pain, there is some evidence to suggest that a longer duration of symptoms preoperatively may be related to worse outcomes following surgery (Burneikiene, et al., 2015; Enquist, et al., 2015). In addition, cognitive behavioral therapy should be included as part of multidisciplinary rehabilitation for individuals seeking treatment of cervical radiculopathy (Bono, et al., 2011; Persson, et al., 1997).

Psychological assessment and treatment as part of a multidisciplinary approach to conservative pain management is recommended. Risk factors, such as drug or alcohol abuse and depression may act as a barrier to recovery following spinal fusion (Washington State Department of Labor and Industries, 2002; Hanley, David, 1999; Tang, et al., 2001). Authors have recommended psychological screening, and treatment if applicable, of patients with neck and/or back pain prior to surgery for identification of risk factors that may be associated with chronic disability.

Cervical spinal fusion is in many situations an elective surgery, therefore it is strongly recommended that individuals be in the best physical condition prior to undergoing surgery. Modifiable risk factors and the influence on outcomes of spine surgery has been studied, modification of such risk factors can assist with improved patient selection for spine surgery and better postoperative management (Shahrestani, et al., 2021). Along with alcohol and opioid use, tobacco/nicotine increases the risk of perioperative complications, cardiopulmonary complications, pseudoarthrosis and infection (Shahrestani, et al., 2021) furthermore it is well-established that smoking is a preventable cause of morbidity and mortality. Tobacco use in particular is considered a risk factor for poor healing and has been associated with nonunion. Particularly with spinal fusion, tobacco use has been associated with increased risk of pseudoarthrosis (Brown, et al., 1986). The American Academy of Orthopedic Surgeons (AAOS) supports avoidance and cessation of all tobacco products and cigarette smoking due to the harmful impact on musculoskeletal health, as well as overall health (AAOS, 2016).

Although evidence in the peer-reviewed published literature is limited to retrospective case series, systematic reviews and few prospective trials, the evidence does suggest smoking is at least one factor that adversely affects fusion rates following cervical fusion (An, et al., 1995; Bishop, et al, 1996; Hilibrand, et al., 2001; Lau, et al., 2014, Jackson, Devine, 2016; Berman et al., 2017; Hofler, et al., 2018; Zheng, et al., 2021; Nunna, et al., 2022). In 1996 Bishop and colleagues reported higher rates of nonunion, delayed union and disc space collapse in smokers, particularly in those who underwent ACDF using allograft, compared to autograft. In 2001 Hilibrand and colleagues compared long term radiographic and clinical results of smokers versus non smokers who had undergone arthrodesis using autogenous bone graft following mult-level anterior cervical decompression for the treatment of cervical radiculopathy or myelopathy, or both. In this study group the authors reported that in addition to factors such as the use of allograft bone, multilevel interbody grafting, and interbody grafting next to a solid fusion, smoking adversely affected clinical outcomes (Hilibrand et al., 2001). Lau et al. published the results of a retrospective case series involving 160 subjects who underwent anterior cervical corpectomy: 49.4% were nonsmokers, 25.6% were quitters, and 25% were current smokers. The authors reported current smoking status was significantly associated with a higher complication rate ($p < 0.001$) and longer length of stay ($p < 0.001$). In addition, (although not statistically significant) current smokers had higher rates of pseudoarthrosis (16%) compared with quitters (8.1%) and nonsmokers (4.3%) one year post procedure (Lau, et al., 2014). In 2016 Jackson and Devine published a systematic review of four retrospective comparative trials evaluating the effects of smoking and smoking cessation on spine surgery and concluded current smokers are significantly more likely to experience pseudoarthrosis and postoperative infection and to report lower clinical outcomes after surgery in both the cervical and lumbar spines (Jackson, Devine, 2016). Hofler et al (2018) reported the results of a study evaluating risk factors for symptomatic pseudoarthrosis using an inpatient database of patients who underwent new spinal fusion between 2009 and 2011. Generalized linear mixed effects models were used to estimate the odds of experiencing postoperative pseudoarthrosis as a function of multivariate patient characteristics, comorbidities and surgical approach. For cervical fusion there were 107,420 patients of which 1.2% (1295) developed a pseudoarthrosis. The risk factors associated with pseudoarthrosis included posterior approach, combined approach, fusion of > 9 vertebrae, smoking, and long term steroid use. The authors concluded several conditions were strongly associated with pseudoarthrosis, although additional studies are needed to establish causation. In a recent meta-analysis of 43 studies (cohort, or case-control studies) Zheng and associates concluded that smokers are more likely to experience higher complication rates overall, including respiratory complications, reoperation, longer hospital stay, dysphagia, wound infection, axial neck pain, and a lower fusion rate following cervical surgery (Zheng, et al., 2021). In 2022 Nunna and colleagues published a systematic review and meta-analysis evaluating the risk of nonunion related to tobacco smoking. The review involved 3009 subjects from 20 studies, most of which were retrospective case series; 1117 (37%) of subjects were nonsmokers. Eleven studies evaluated the effects of smoking on cervical spine nonunion and nine evaluated effects on thoracolumbar spine nonunion. Pooled analysis results demonstrated smoking was associated with increased risk of nonunion when compared to nonsmokers one year or more from time of spinal surgery, and

was significantly increased with those receiving either allograft or autograft. Both multilevel and single level fusions were associated with increased risk of nonunion in smokers.

In 2021 the Congress of Neurological Surgeons published a systematic review and evidence based guidelines for perioperative spine surgical risk assessment (Harrop, et al., 2021) to determine if preoperative risk factors (i.e., increased body mass index, smoking, diabetes) impact outcomes following spine surgery. A total of 64 articles were included in the systematic review. The authors concluded the following:

- Preoperative smoking was associated with an increased risk of reoperation. There was insufficient evidence to support that cessation before spine surgery decreased the risk of reoperation. Patients should however be counseled to abstain from smoking before and after spine surgery.
- For individuals with diabetes the evidence supported a relationship between increased HbA1c and risk of reoperation or infection after spinal surgery. Individuals with levels >7.5mg/dl should be counseled regarding risks. The evidence was insufficient to support other diagnostic studies for predicting risk of infection or reoperation.
- The evidence was conflicting regarding the relationship between increased body mass index (BMI) and surgical site infection. However several studies (31/42) did show a correlation between a BMI > 30 and surgical site infection, particularly for lumbar fusion. The evidence for risk of reoperation related to an increased BMI was conflicting.

While a number of risk factors may be associated with increased risk of pseudoarthrosis, and some authors have reported no difference in fusion rates among smokers/nonsmokers (Eubanks, et al., 2011; Luszczuk, et al., 2013) cessation of smoking prior to cervical spinal surgery for pseudoarthrosis is strongly recommended.

Indications

Cervical fusion is generally performed in combination with procedures aimed at either restabilizing the spine or decompressing the nerve. Conditions for which cervical fusion has been proposed and has resulted in improved clinical outcomes include conditions resulting in cervical instability (i.e., infection, tumor, trauma, deformity, non-traumatic, iatrogenic), cervical radiculopathy from degenerative disorders, clinical myelopathy (i.e., bony stenosis, disc herniation, ossification of the posterior longitudinal ligament [OPLL]), and pseudoarthrosis (NASS, 2023).

Cervical fusion is not indicated for cervical radiculopathy from isolated foraminal stenosis is treated with partial medial facetectomy or foraminotomy (NASS, 2023).

Cervical Spinal Instability: As noted above, cervical spinal instability has been defined as destruction of either the anterior or posterior elements of the spine making them nonfunctional, more than 3.5 mm of displacement of one vertebra in relation to another and/or greater than 11 degrees of rotational difference between adjacent vertebrae (White, Punjabi, 1980). Various conditions may result in spinal instability, such as fractures, infection, tumors, inflammation, or other types of traumatic injury. Iatrogenic spinal instability is the result of direct surgical or medical intervention. For example, when multiple foraminotomies are performed or there is greater than 50% removal of the facet joint spinal instability may result (McAllister, et al., 2012, Komotar, et al, 2006). Treatment is aimed at re-stabilizing the spine and is based on the individual's symptoms, extent of deformity, functional impairment, disability, and response to conservative care.

Cervical Radiculopathy from Degenerative Disorders: Cervical radiculopathy is a condition affecting the nerve root in the cervical spinal column, which can result from either compressive (e.g., disc herniation, osteophytes, spondylosis) or non-compressive forces (e.g., infection, tumor infiltration). It is a common cause of acute and chronic neck pain often accompanied by weakness and sensory disturbance in the dermatomal distribution. Imaging studies (e.g., Computed Tomography [CT], magnetic resonance imaging [MRI], X-ray, CT myelography) along with electrodiagnostic testing, history and physical (e.g., provocative shoulder abduction tests, Spurling's test) are used to diagnose the condition. The most commonly affected nerve roots are C6, C7, and C8 (Iyer, et al 2016) resulting in pain in one or both upper extremities. The indications for surgery in patients with cervical radiculopathy are unremitting radicular pain despite six to eight weeks of conservative treatment, progressive motor weakness, or the presence of myelopathy.

Clinical Myelopathy (Cervical Spinal Stenosis, Disc Herniation, OPLL): Cervical spinal stenosis is a condition where the spinal canal narrows and results in compression on the spinal cord. The condition is often the result of aging. Degeneration of the discs may lead to development of bone spurs which can also cause pressure on the nerve roots. Diagnosis is made based on history, physical examination and radiographic imaging (computerized tomography [CT], magnetic resonance imaging [MRI], X-ray). Spinal instability associated with stenosis may arise intraoperatively (iatrogenic); cases of severe stenosis require more extensive decompression (i.e., complete facetectomy or resection of pars interarticularis creating a pars defect), which may destabilize the spine, destabilization may be treated with a cervical fusion procedure.

Cervical spondylotic myelopathy is a condition in which the spinal cord becomes compressed due to degenerative changes (e.g., arthritis, spondylosis) as a result of aging. Common causes include degenerating discs, rheumatoid arthritis and injury. Associated symptoms include numbness and tingling in the fingers, hands or arms; muscle weakness, loss of motor skills, and neck pain. The goal of surgical treatment is to relieve pressure on the spinal cord.

Herniation of a cervical disc, also referred to as a ruptured or slipped disc, is a common cause of neck pain. With this condition the center nucleus pushes through the outer edge of the disc and places pressure on the spinal nerves resulting in neck pain. Symptoms include dull or sharp neck pain, pain between the shoulder area, pain radiating along the nerve pathway down the arms to the hand and/or fingers, muscle weakness, and numbness or tingling. Diagnosis is confirmed by CT scan, MRI, and electrodiagnostic studies. Conservative treatment includes analgesics, nonsteroidal anti-inflammatory drugs (NSAIDs), physical therapy, exercise, bracing, injections and manipulation. In addition to artificial cervical disc replacement, posterior cervical discectomy may be performed however it is associated with more manipulation of the spinal cord and surrounding vasculature. Anterior cervical discectomy and fusion (ACDF) is most often the procedure of choice and is indicated when conservative measures fail to improve pain and disability.

Cervical Pseudoarthrosis: Pseudoarthrosis is failure of osseous bridging within the fusion mass. It is generally confirmed by radiograph or CT scan at least one year after the fusion. Nonunion rates following ACDF vary depending on the type of bone graft used, the surgical technique and the number of levels fused (McAnany, et al., 2015). It has been reported that one factor associated with increased risk of pseudoarthrosis is smoking (Brown, et al., 1986). Symptoms associated with cervical pseudoarthrosis include persistent or recurrent axial neck pain, radiculopathy and myelopathy. Treatment of the pseudoarthrosis can be accomplished by performing a revision anterior procedure or by using a posterior approach. A revision anterior procedure requires dissection through scar tissue and may be associated with higher incidence of dysphagia and recurrent laryngeal nerve injury, although posterior approaches are associated with a higher overall complication rate (McAnany, et al., 2015). Higher fusion rates have been reported with posterior approaches (Kaiser, et. al., 2009).

Cervical Decompression Procedures

Cervical vertebral corpectomy, is a procedure in which the body of the vertebrae is removed, partially or completely, as a method of decompressing the spinal cord. According to the American Association of Neurological Surgeons (AANS), the amount of bone removed is generally at least one-half of the vertebral body, and is significantly greater than the removal of cortical endplates for an interbody fusion. The procedure is performed from the front of the neck requiring an anterior approach. After removal of the vertebral bone the spine is reconstructed with bone graft materials and titanium spacers. Using instrumentation such as plates and screws the construct is then secured in place.

Cervical laminectomy is a procedure performed on the neck that involves removal of the lamina to decompress the spinal cord improving cervical spinal cord perfusion. Indications include cervical stenosis, cervical spondylotic myelopathy, spondylotic radiculopathy, OPLL, ossification of the yellow ligament (OYL) neoplasm, and infection (McAllister, et al., 2012). In some clinical situations postlaminectomy deformity and disability may result due to the removal of posterior elements which disrupt the normal biomechanics of the cervical spine.

Posterior cervical laminoplasty is a procedure performed on the posterior neck area for treatment of spinal cord compression. During laminoplasty the laminar arch is reconstructed to increase space for the spinal cord. This procedure may be considered an alternative to posterior cervical fusion and involves the use of titanium plates for stabilization. It is commonly performed as treatment of OPLL, spondylotic myelopathy, congenital spinal

stenosis with posterior compression, syringomyelia, and when access to the spinal cord is required for tumor, vascular or other malformation.

Surgical Approaches

The surgical approach to the cervical spine is determined by the site of the primary pathology and presence of instability. The cervical spine can be approached anteriorly, posteriorly, or as a combined approach. An anterior approach, performed from the front of the neck area is most often indicated for decompression of the spinal cord and usually requires fusion for stabilization. A posterior approach is performed from the back of the cervical spine area and has the advantage of avoiding potential soft-tissue complications seen with the anterior approach, such as damage to the vasculature or recurrent laryngeal nerve. A posterior approach may be used alone or in combination with an anterior approach.

Anterior approaches are generally recommended for decompression limited to one or two levels, fixed kyphotic deformity, and absence of significant narrowing of the canal. Posterior approaches are reserved for compression involving more than two levels, compression of the canal, lordotic alignment and primary posterior compressive pathology (Komotar, et al., 2006).

Evidence in the peer-reviewed literature supports that for treatment of cervical spondylotic myelopathy, anterior and posterior approaches have equivalent efficacy (Fehlings, et al., 2013). In the presence of instability, (e.g., subluxation of greater than 3.5 mm, greater than 11 degrees of angulation between adjacent segments, or more than 4mm of subluxation on dynamic views), a posterior decompression without stabilization (fusion) is likely to result in a progressive deformity (Komotar, et al., 2006).

Cervical Facet Joint Fusion

Cervical facet joint fusion is a procedure that involves placement of bone dowels made from graft material (e.g., autograft, allograft or prepared [e.g., TruFuse®]) into the facet joints to provide stabilization to the spine (i.e., prevent movement) thereby reducing pain. Facet joints are the articulations or connections between the vertebrae. Pain in the facet joint can result from trauma, degenerative changes causing instability of the spine, or it can result from age-related deterioration. Treatment is aimed at reducing pain and includes rest, physical therapy, nonsteroidal anti-inflammatory medications, and facet joint injections. When conservative treatment fails to relieve symptoms and the intervertebral disc is damaged discectomy and posterior fusion may be performed to relieve pressure on the nerve. Fusing the facet joint has been proposed as an alternative to spinal fusion, however evidence in the peer-reviewed published scientific literature evaluating cervical facet joint fusion is limited to small, uncontrolled trials, mainly retrospective, with short to mid term followup. Long term clinical outcomes are lacking. The published evidence is insufficient to support clinical efficacy.

Professional Societies/Organizations

North American Spine Society (NASS): Coverage policy recommendations for cervical fusion have been published by NASS and were recently updated for 2023. NASS supports that cervical fusion may be indicated for infection, tumor, trauma, deformity, cervical myelopathy, cervical radiculopathy from degenerative disorders, synovial facet cysts, pseudarthrosis, non-traumatic instability and atlanto-axial osteoarthritis unresponsive to nonoperative management as outlined in the document. It is not indicated for cervical radiculopathy from isolated foraminal stenosis treated with partial medial facetectomy/foraminotomy (NASS, 2023). In contrast to lumbar fusion, NASS does not address absence of smoking within the criteria for cervical fusion.

The American College of Occupational and Environmental Medicine (ACOEM): ACOEM published clinical guidelines for cervical and thoracic disorders (ACOEM, 2011). Within these guidelines summary of recommendations for managing cervicothoracic disorders, the authors note for radicular pain resulting from nerve compression cervical discectomy and fusion is indicated for individuals who continue to have significant pain and functional limitation despite six weeks of appropriate nonoperative therapy (based on consensus). Decompressive surgery (laminoplasty, laminectomy, discectomy with fusion) is indicated for treatment of myelopathy (based on consensus). Decompression with fusion is indicated for patients with symptomatic spinal stenosis intractable to nonoperative management (based on consensus) and fusion is indicated for degenerative spondylolisthesis (based on limited evidence).

U.S. Food and Drug Administration (FDA): Cervical fusion is a surgical procedure and is therefore not regulated by the U.S. Food and Drug Administration. However, associated instrumentation, stabilization and decompression devices used as part of the cervical fusion procedure do require approval by the FDA.

Literature Review

Evidence in the peer-reviewed, published scientific literature, including professional society recommendations support cervical fusion is effective for treatment of cervical spine instability and other conditions. In addition, textbook sources support cervical fusion as a well-established procedure effective for treatment of herniated disc with spinal cord compression (Camillo, 2017) cervical spine injury, including fracture and trauma (Williams, 2021), and instability resulting either from trauma or degenerative processes such as autoimmune, inflammatory, infections, neoplastic, or that are congenital in origin (Levelen, et. al., 2018). Similar to lumbar fusion, physician supervised medical management should be part of a comprehensive multidisciplinary pain management program in non-emergent situations. In addition, physical examination and imaging studies should correlate with neural compression at the appropriate level.

The American Board of Internal Medicine’s (ABIM) Foundation Choosing Wisely® Initiative: As part of the Choosing Wisely initiative NASS released a list of common spine tests and treatments physicians and patients should question (NASS, 2013). Two of the five are related to spinal fusion surgery as follows:

- Bone morphogenetic protein is a compound which stimulates bone formation and healing and should not be used for routine anterior cervical spine fusion surgery. Life-threatening complications have been reported in the routine use of recombinant human rhBMP in anterior cervical spine fusion surgery, due to swelling of the soft tissues. This may lead to difficulty swallowing or pressure on the airway.
- Electromyography and nerve conduction studies are measures of nerve and muscle function. They may be indicated when there is concern for a neurologic injury or disorder, such as the presence of leg or arm pain, numbness or weakness associated with compression of a spinal nerve. As spinal nerve injury is not a cause of neck, mid back or low back pain, EMG/NCS have not been found to be helpful in diagnosing the underlying causes of axial lumbar, thoracic and cervical spine pain.

Use Outside of the US: No relevant information found.

Medicare Coverage Determination

	Contractor	Policy Name/Number	Revision Effective Date
NCD	National	No Determination found	
LCD		No Determination found	

Note: Please review the current Medicare Policy for the most up-to-date information. (NCD = National Coverage Determination; LCD = Local Coverage Determination.)

Coding Information

- Note:** 1) This list of codes may not be all-inclusive.
 2) Deleted codes and codes which are not effective at the time the service is rendered may not be eligible for reimbursement.

Considered Medically Necessary when criteria in the applicable policy statements listed above are met:

Cervical Fusion: Anterior

CPT®* Codes	Description
22548	Arthrodesis, anterior transoral or extraoral technique, clivus-C1-C2 (atlas-axis), with or without excision of odontoid process
22551	Arthrodesis, anterior interbody, including disc space preparation, discectomy, osteophyctomy and decompression of spinal cord and/or nerve roots; cervical below C2

CPT®* Codes	Description
22552	Arthrodesis, anterior interbody, including disc space preparation, discectomy, osteophylectomy and decompression of spinal cord and/or nerve roots; cervical below C2, each additional interspace (List separately in addition to code for separate procedure)
22554	Arthrodesis, anterior interbody technique, including minimal discectomy to prepare interspace (other than for decompression); cervical below C2
22585	Arthrodesis, anterior interbody technique, including minimal discectomy to prepare interspace (other than for decompression); each additional interspace (List separately in addition to code for primary procedure)
22808	Arthrodesis, anterior, for spinal deformity, with or without cast; 2 to 3 vertebral segments
22810	Arthrodesis, anterior, for spinal deformity, with or without cast; 4 to 7 vertebral segments
22812	Arthrodesis, anterior, for spinal deformity, with or without cast; 8 or more vertebral segments

Cervical Fusion: Posterior

CPT®* Codes	Description
22590	Arthrodesis, posterior technique, craniocervical (occiput-C2)
22595	Arthrodesis, posterior technique, atlas-axis (C1-C2)
22600	Arthrodesis, posterior or posterolateral technique, single interspace; cervical below C2 segment
22614	Arthrodesis, posterior or posterolateral technique, single interspace; each additional interspace (List separately in addition to code for primary procedure)
22800	Arthrodesis, posterior, for spinal deformity, with or without cast; up to 6 vertebral segments
22802	Arthrodesis, posterior, for spinal deformity, with or without cast; 7 to 12 vertebral segments

Considered Experimental, Investigational or Unproven when used to report isolated cervical facet fusion, including facet joint implants and/or bone graft substitutes used exclusively as stand-alone stabilization devices for treatment of facet joint pain:

CPT®* Codes	Description
22899	Unlisted procedure, spine
0219T	Placement of a posterior intrafacet implant(s), unilateral or bilateral, including imaging and placement of bone graft(s) or synthetic device(s), single level; cervical
0222T	Placement of a posterior intrafacet implant(s), unilateral or bilateral, including imaging and placement of bone graft(s) or synthetic device(s), single level; each additional vertebral segment (List separately in addition to code for primary procedure)

Other Procedures That May Be Related to Cervical Fusion

Requires Clinical Review to determine Medical Necessity:

CPT®* Codes	Description
22210	Osteotomy of spine, posterior or posterolateral approach, 1 vertebral segment; cervical
22216	Osteotomy of spine, posterior or posterolateral approach, 1 vertebral segment; each additional vertebral segment (List separately in addition to primary procedure)
22220	Osteotomy of spine, including discectomy, anterior approach, single vertebral segment; cervical
22226	Osteotomy of spine, including discectomy, anterior approach, single vertebral segment; each additional vertebral segment (List separately in addition to code for primary procedure)
22326	Open treatment and/or reduction of vertebral fracture(s) and/or dislocation(s), posterior approach, 1 fractured vertebra or dislocated segment; cervical

CPT®* Codes	Description
22328	Open treatment and/or reduction of vertebral fracture(s) and/or dislocation(s), posterior approach, 1 fractured vertebra or dislocated segment; each additional fractured vertebra or dislocated segment (List separately in addition to code for primary procedure)
22840	Posterior non-segmental instrumentation (eg, Harrington rod technique, pedicle fixation across 1 interspace, atlantoaxial transarticular screw fixation, sublaminar wiring at C1, facet screw fixation) (List separately in addition to code for primary procedure)
22841	Internal spinal fixation by wiring the spinous processes (List separately in addition to code for primary procedure)
22842	Posterior segmental instrumentation (eg, pedicle fixation, dual rods with multiple hooks and sublaminar wires); 3 to 6 vertebral segments (List separately in addition to code for primary procedure)
22843	Posterior segmental instrumentation (eg, pedicle fixation, dual rods with multiple hooks and sublaminar wires); 7 to 12 vertebral segments (List separately in addition to code for primary procedure)
22844	Posterior segmental instrumentation (eg, pedicle fixation, dual rods with multiple hooks and sublaminar wires); 13 or more vertebral segments (List separately in addition to code for primary procedure)
22845	Anterior instrumentation; 2 to 3 vertebral segments (List separately in addition to code for primary procedure)
22846	Anterior instrumentation; 4 to 7 vertebral segments (List separately in addition to code for primary procedure)
22847	Anterior instrumentation; 8 or more vertebral segments (List separately in addition to code for primary procedure)
22848	Pelvic fixation (attachment of caudal end of instrumentation to pelvic bony structures) other than sacrum (List separately in addition to code for primary procedure)
22849	Reinsertion of fixation device
22850	Removal of posterior nonsegmental instrumentation (eg Harrington rod)
22852	Removal of posterior segmental instrumentation
22853	Insertion of interbody biomechanical device(s) (eg, synthetic cage, mesh) with integral anterior instrumentation for device anchoring (eg, screws, flanges), when performed, to intervertebral disc space in conjunction with interbody arthrodesis, each interspace (List separately in addition to code for primary procedure)
22854	Insertion of intervertebral biomechanical device(s) (eg, synthetic cage, mesh) with integral anterior instrumentation for device anchoring (eg, screws, flanges), when performed, to vertebral corpectomy(ies) (vertebral body resection, partial or complete) defect, in conjunction with interbody arthrodesis, each contiguous defect (List separately in addition to code for primary procedure)
22855	Removal of anterior instrumentation
22859	Insertion of intervertebral biomechanical device(s) (eg, synthetic cage, mesh, methylmethacrylate) to intervertebral disc space or vertebral body defect without interbody arthrodesis, each contiguous defect (List separately in addition to code for primary procedure)

*Current Procedural Terminology (CPT®) © 2022 American Medical Association: Chicago, IL.

References

1. American Academy of Orthopaedic Surgeons (AAOS). Position statement: The effects of tobacco exposure on the musculoskeletal system. Retired. © 1995-2020 AAOS. Accessed May 4, 2020. Available at URL address: <https://www.aaos.org/search/?srchtext=tobacco+exposure+>

2. American Academy of Orthopaedic Surgeons (AAOS). Information statement: Tobacco Use and Orthopaedic Surgery. Statement 1047. ©February 2016 American Academy of Orthopaedic Surgeons®.
3. American Academy of Orthopaedic Surgeons (AAOS). Surgery and smoking. July 2007. Reviewed April 2019. Accessed May 5, 2023. Available at URL address: <http://orthoinfo.aaos.org/topic.cfm?topic=A00262>
4. American Association of Neurological Surgeons. Neck Pain, © 2023 American Association of Neurological Surgeons. Accessed May 5, 2023. Available At URL address: <http://www.aans.org/en/Patient%20Information/Conditions%20and%20Treatments.aspx>
5. An HS, Simpson JM, Glover JM, Stephany J. Comparison between allograft plus demineralized bone matrix versus autograft in anterior cervical fusion. A prospective multicenter study. *Spine (Phila Pa 1976)*. 1995 Oct 15;20(20):2211-6 (abstract only).
6. Armstrong ML, Smith N, Tracey R, Jackman H. The Orthopedic Effects of Electronic Cigarettes: A Systematic Review and Pediatric Case Series. *Children (Basel)*. 2022 Jan 4;9(1):62.
7. Badiie RK, Chan AK, Rivera J, Molinaro A, Chou D, Mummaneni PV, Tan LA. Smoking Is an Independent Risk Factor for 90-Day Readmission and Reoperation Following Posterior Cervical Decompression and Fusion. *Neurosurgery*. 2021 May 13;88(6):1088-1094 (abstract only).
8. Beck EC, Gowd AK, White JC, Knio ZO, O'Gara TJ. The effect of smoking on achieving meaningful clinical outcomes one year after lumbar tubular microdecompression: a matched-pair cohort analysis. *Spine J*. 2021 Aug;21(8):1303-1308.
9. Berman D, Oren JH, Bendo J, Spivak J. The Effect of Smoking on Spinal Fusion. *Int J Spine Surg*. 2017 Nov 28;11:29.
10. Bono CM, Ghiselli G, Gilbert TJ, Kreiner DS, Reitman C, Summers JT, Baisden JL, Easa J, Fernand R, Lamer T, Matz PG, Mazanec DJ, Resnick DK, Shaffer WO, Sharma AK, Timmons RB, Toton JF; North American Spine Society. An evidence-based clinical guideline for the diagnosis and treatment of cervical radiculopathy from degenerative disorders. *Spine J*. 2011 Jan;11(1):64-72.
11. Bishop RC, Moore KA, Hadley MN. Anterior cervical interbody fusion using autogeneic and allogeneic bone graft substrate: a prospective comparative analysis. *J Neurosurg*. 1996 Aug;85(2):206-10.
12. Brown CW, Orme TJ, Richardson HD. The rate of pseudoarthrosis (surgical nonunion) in patients who are smokers and patients who are nonsmokers: a comparison study. *Spine (Phila Pa 1976)*. 1986 Nov;11(9):942-3.
13. Burneikiene S, Nelson EL, Mason A, Rajpal S, Villavicencio AT. The duration of symptoms and clinical outcomes in patients undergoing anterior cervical discectomy and fusion for degenerative disc disease and radiculopathy. *Spine J*. 2015 Mar 1;15(3):427-32.
14. Camillo Francis X. Degenerative Disorders of the Cervical Spine. In: *Campbell's Operative Orthopaedics*, Chapter 38. 1610-1643, e4. Thirteenth edition, Copyright © 2017 by Elsevier, Inc.
15. Centers for Disease Control and Prevention (CDC). National Biomonitoring Program. Cotinine CAS No. 486-56-6. Updated 2016. Accessed April 28, 2022. Available at URL address: <https://cdc.gov>
16. Chau AM1, Mobbs RJ. Bone graft substitutes in anterior cervical discectomy and fusion. *Eur Spine J*. 2009 Apr;18(4):449-64.

17. Cheng L, McCormack B, Eyster EF. Posterior cervical fusion utilizing cages placed bilaterally in the facets for the treatment of the upper cervical adjacent segment disease in the elderly. *J Clin Neurosci*. 2019 May;63:149-154.
18. Chiu RG, Patel S, Siddiqui N, Nunna RS, Mehta AI. Cannabis Abuse and Perioperative Complications Following Inpatient Spine Surgery in the United States. *Spine (Phila Pa 1976)*. 2021 Jun 1;46(11):734-743.
19. Engquist M, Löfgren H, Öberg B, Holtz A, Peolsson A, Söderlund A, Vavruch L, Lind B. Factors Affecting the Outcome of Surgical Versus Nonsurgical Treatment of Cervical Radiculopathy: A Randomized, Controlled Study. *Spine (Phila Pa 1976)*. 2015 Oct 15;40(20):1553-63.
20. Eubanks JD, Thorpe SW, Cheruvu VK, Braly BA, Kang JD. Does smoking influence fusion rates in posterior cervical arthrodesis with lateral mass instrumentation? *Clin Orthop Relat Res*. 2011 Mar;469(3):696-701.
21. Fehlings MG, Barry S, Kopjar B, et al. Anterior versus posterior surgical approaches to treat cervical spondylotic myelopathy: outcomes of the prospective multicenter AOSpine North America CSM study in 264 patients. *Spine (Phila Pa 1976)*. 2013 Dec 15;38(26):2247-52.
22. Fiani B, Noblett C, Nanney JM, Gautam N, Pennington E, Doan T, Nikolaidis D. The Impact of "Vaping" Electronic Cigarettes on Spine Health. *Cureus*. 2020 Jun 29;12(6):e8907.
23. Gardocki R. Anatomic approaches to the spine. *Campbell's Operative Orthopedics*. 14th edition. Ch 37. Pages 1642-1682. Copyright © 2021 by Elsevier, Inc.
24. Harrop JS, Mohamed B, Bisson EF, Dhall S, Dimar J, Mummaneni PV, Wang MC, Hoh DJ. Congress of Neurological Surgeons Systematic Review and Evidence-Based Guidelines for Perioperative Spine: Preoperative Surgical Risk Assessment. *Neurosurgery*. 2021 Oct 13;89(Suppl 1):S9-S18.
25. Hilibrand AS, Fye MA, Emery SE, Palumbo MA, Bohlman HH. Impact of smoking on the outcome of anterior cervical arthrodesis with interbody or strut-grafting. *J Bone Joint Surg Am*. 2001 May;83-A(5):668-73.
26. Hofler RC, Swong K, Martin B, Wemhoff M, Jones GA. Risk of Pseudoarthrosis After Spinal Fusion: Analysis From the Healthcare Cost and Utilization Project. *World Neurosurg*. 2018 Dec;120:e194-e202.
27. Kaiser MG, Mummaneni PV, Matz PG, Anderson PA, Groff MW, Heary RF, Holly LT, Ryken TC, Choudhri TF, Vresilovic EJ, Resnick DK; Joint Section on Disorders of the Spine and Peripheral Nerves of the American Association of Neurological Surgeons and Congress of Neurological Surgeons. Management of anterior cervical pseudoarthrosis. *J Neurosurg Spine*. 2009 Aug;11(2):228-37.
28. Khalid SI, Thomson KB, Chilakapati S, Singh R, Eldridge C, Mehta AI, Adogwa O. The Impact of Smoking Cessation Therapy and Lumbar Fusion Outcomes. *World Neurosurg*. 2022 Apr 16:S1878-8750(22)00469-7.
29. Komotar RJ, Mocco J, Kaiser MG. Surgical management of cervical myelopathy: indications and techniques for laminectomy and fusion. *Spine J*. 2006 Nov-Dec;6(6 Suppl):252S-267S.
30. Iyer S, Kim HJ. Cervical Radiculopathy. *Curr Rev Musculoskelet Med*. 2016 Sep;9(3):272-80.
31. Jackson KL, Devine JG. The Effects of Smoking and Smoking Cessation on Spine Surgery: A Systematic Review of the Literature. *Global Spine J*. 2016 Nov;6(7):695-701.

32. Jiang L, Tan M, Dong L, Yang F, Yi P, Tang X, Hao Q. Comparison of Anterior Decompression and Fusion With Posterior Laminoplasty for Multilevel Cervical Compressive Myelopathy: A Systematic Review and Meta-Analysis. *J Spinal Disord Tech*. 2015 Oct;28(8):282-90.
33. Lau D, Chou D, Ziewacz JE, Mummaneni PV. The effects of smoking on perioperative outcomes and pseudarthrosis following anterior cervical corpectomy: Clinical article. *J Neurosurg Spine*. 2014 Oct;21(4):547-58.
34. Levene HB, Styliaras JC, Vaccaro AR, Jallo J, Harrop JS. Occipital-cervical Fusion. In: *Operative Techniques: Spine*. Third edition. Copyright © 2018 by Elsevier, Inc.
35. Manchikanti L, Hirsch JA. Clinical management of radicular pain. *Expert Rev Neurother*. 2015 Jun;15(6):681-93.
36. McAllister BD, Rebholz BJ, Wang JC. Is posterior fusion necessary with laminectomy in the cervical spine? *Surg Neurol Int*. 2012; 3(Suppl 3): S225–S231.
37. McAnany SJ, Baird EO, Overley SC, Kim JS, Qureshi SA, Anderson PA. A Meta-Analysis of the Clinical and Fusion Results Following Treatment of Symptomatic Cervical Pseudarthrosis. *Global Spine J*. 2015 Apr;5(2):148-55.
38. Mummaneni PV, Kaiser MG, Matz PG, Anderson PA, Groff MW, Heary RF, Holly LT, Ryken TC, Choudhri TF, Vresilovic EJ, Resnick DK; Joint Section on Disorders of the Spine and Peripheral Nerves of the American Association of Neurological Surgeons and Congress of Neurological Surgeons. Cervical surgical techniques for the treatment of cervical spondylotic myelopathy. *J Neurosurg Spine*. 2009 Aug;11(2):130-41.
39. Nikolaidis I, Fouyas IP, Sandercock PA, Statham PF. Surgery for cervical radiculopathy or myelopathy. *Cochrane Database Syst Rev*. 2010 Jan 20;(1):CD001466.
40. North American Spine Society (NASS). Choosing Wisely Initiative. Five things physicians and patients should question. October 9, 2013.
41. North American Spine Society (NASS) Coverage Policy Recommendations. Cervical Fusion May 2023. Copyright © 2023 North American Spine Society.
42. North American Spine Society (NASS). Evidence-Based Clinical Guidelines for Multidisciplinary Spine Care. Diagnosis and Treatment of Cervical Radiculopathy from Degenerative Disorders. Copyright © 2010 North American Spine Society.
43. Nunna RS, Ostrov PB, Ansari D, Dettori JR, Godolias P, Elias E, Tran A, Oskouian RJ, Hart R, Abdul-Jabbar A, Jackson KL, Devine JG, Mehta AI, Adogwa O, Chapman JR. The Risk of Nonunion in Smokers Revisited: A Systematic Review and Meta-Analysis. *Global Spine J*. 2022 Apr;12(3):526-539.
44. Panjabi MM, White AA. Basic biomechanics of the spine. *Neuro*. 1980 Jul;7(1):76- 93.
45. Persson LC, Moritz U, Brandt L, Carlsson CA. Cervical radiculopathy: pain, muscle weakness and sensory loss in patients with cervical radiculopathy treated with surgery physiotherapy or cervical collar. A prospective, controlled study. *Eur Spine J*. 1997;6(4):256-266.
46. Reyes SG, Bajaj PM, Alvandi BA, Kurapaty SS, Patel AA, Divi SN. Impact of Social Determinants of Health in Spine Surgery. *Curr Rev Musculoskelet Med*. 2023 Jan;16(1):24-32. doi: 10.1007/s12178-022-09811-1.
47. Rigotti NA, Reddy KP. Vaping and e-cigarettes. UpToDate. Waltham, MA. Updated Dec 2022. Accessed May 5, 2023.

48. Robinson J, Shefner J, Eichler A. Clinical features and diagnosis of cervical radiculopathy. UpToDate. Updated August 13, 2014, July 11, 2018, Oct 2022. Accessed May 5, 2023.
49. Robinson J, Shefner J, Eichler A. Treatment and Prognosis of Cervical radiculopathy. UpToDate. Updated Feb 2016, Aug 31, 2018, Feb 2023. Accessed May 5, 2023.
50. Shahrestani S, Bakhsheshian J, Chen XT, Ton A, Ballatori AM, Strickland BA, Robertson DM, Buser Z, Hah R, Hsieh PC, Liu JC, Wang JC. The influence of modifiable risk factors on short-term postoperative outcomes following cervical spine surgery: A retrospective propensity score matched analysis. *EClinicalMedicine*. 2021 May 15;36:100889.
51. Shatlo B, Nader R. Laminoplasty. Medscape, updated November 10, 2014., Updated Mar 24, 2019. Accessed May 5, 2023. Available at URL address: <http://emedicine.medscape.com/article/1890493-overview>
52. Siemionow K, Janusz P, Glowka P. Cervical cages placed bilaterally in the facet joints from a posterior approach significantly increase foraminal area. *Eur Spine J*. 2016a Jul;25(7):2279-85.
53. Siemionow K, Monsef JB, Janusz P. Preliminary Analysis of Adjacent Segment Degeneration in Patients Treated with Posterior Cervical Cages: 2-Year Follow-Up. *World Neurosurg*. 2016a May;89:730.e1-7.
54. Smith W, Gillespy M, Huffman J, Vong V, McCormack BM. Anterior Cervical Pseudarthrosis Treated with Bilateral Posterior Cervical Cages. *Oper Neurosurg (Hagerstown)*. 2018 Mar 1;14(3):236-242.
55. Song KJ, Choi BY. Current concepts of anterior cervical discectomy and fusion: a review of literature. *Asian Spine J*. 2014 Aug;8(4):531-9.
56. Ton A, Shahrestani S, Chen XT, Ballatori AM, Wang JC, Buser Z. The Effect of Modifiable Risk Factors on Postoperative Complications in Lumbar Spine Fusions. *Global Spine J*. 2021 Jun 22:21925682211022315.
57. Varshneya K, Stienen MN, Medress ZA, Fatemi P, Pendharkar AV, Ratliff JK, Veeravagu A. Risk Factors for Revision Surgery After Primary Adult Thoracolumbar Deformity Surgery. *Clin Spine Surg*. 2022 Feb 1;35(1):E94-E98.
58. Viani B, Noblett C, Nanney JM, Gautam N, Pennington E, Doan T, Nikolaidis D. The Impact of "Vaping" Electronic Cigarettes on Spine Health. *Cureus*. 2020 Jun 29;12(6):e8907.
59. Vogt MT, Hanscom B, Laueran WC, Kang JD. Influence of smoking on the health status of spinal patients: the National Spine Network database. *Spine (Phila Pa 1976)*. 2002 Feb 1;27(3):313-9.
60. White AA 3rd, Johnson RM, Panjabi MM, Southwick WO. Biomechanical analysis of clinical stability in the cervical spine. *Clin Orthop Relat Res*. 1975;(109):85-96.
61. Williams KD. Fractures, dislocations, fracture-dislocations of the spine. In: *Campbell's Operative Orthopaedics*. Ch 41. Fourteenth edition. Copyright © 2021 by Elsevier, Inc.
62. Xu B, Anderson DB, Park ES, Chen L, Lee JH. The influence of smoking and alcohol on bone healing: Systematic review and meta-analysis of non-pathological fractures. *EClinicalMedicine*. 2021 Oct 31;42:101179. doi: 10.1016/j.eclinm.2021.101179.

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