



# CLINICAL GUIDELINES

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## CMM-601: Anterior Cervical Discectomy and Fusion Guidelines

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eviCore healthcare Clinical Decision Support Tool Diagnostic Strategies: This tool addresses common symptoms and symptom complexes. Requests for individuals with atypical symptoms or clinical presentations that are not specifically addressed will require physician review. Consultation with the referring physician, specialist and/or individual's Primary Care Physician (PCP) may provide additional insight.

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Clinical guidelines for medical necessity review of Comprehensive Musculoskeletal Management Services.

**CMM-601: Anterior Cervical Discectomy and Fusion**

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## **CMM-601.1: General Guidelines**

- The determination of medical necessity for the performance of cervical fusion with and without discectomy is always made on a case-by-case basis.
- For prior authorization requirements, see **CMM-600.1: Prior Authorization Requirements**.
- The presence of urgent/emergent indications/conditions warrants definitive surgical treatment. Confirmatory advanced imaging studies are required. The following criteria are **NOT** required for confirmed urgent/emergent conditions:
  - ◆ Provider-directed non-surgical management
  - ◆ Proof of smoking cessation
  - ◆ Recent (within 6 months) plain X-rays of the cervical spine
  - ◆ Absence of unmanaged significant mental and/or behavioral health disorders
- Urgent/emergent conditions for cervical fusion with and without discectomy include **ANY** of the following:
  - ◆ Acute/unstable traumatic spinal fractures or dislocations with neural compression
  - ◆ Central cord syndrome
  - ◆ Documentation of progressive neurological deficit on two separate physical examinations
  - ◆ **ANY** of the following due to a neurocompressive pathology:
    - Motor weakness of grade 3/5 or less of specified muscle(s)
    - Rapidly progressive symptoms of motor loss
    - Bowel incontinence
    - Bladder incontinence/retention
  - ◆ Epidural hematoma
  - ◆ Infection (e.g. discitis, epidural abscess, osteomyelitis)
  - ◆ Myelopathy or Cord signal changes on MRI due to cord compression
  - ◆ Occipitocervical and/or Atlantoaxial (C1-C2) instability (non-traumatic) due to **ANY** of the following:
    - Rheumatoid arthritis
    - Congenital abnormality of occipitocervical/C1-C2 vertebrae
    - Os odontoideum
  - ◆ Neoplasms of the spine
  - ◆ Primary or metastatic neoplastic disease causing pathologic fracture, cord compression or instability
  - ◆ Documentation of severe debilitating pain and/or dysfunction to the point of being incapacitated
  - ◆ Flexion-extension plain X-rays demonstrate instability and include **ANY** of the following:
    - >3.5 mm sagittal plane translation
    - >20% sagittal plane translation of vertebral body width
    - >11 degrees relative sagittal plane angulation

## **CMM-601.2: Initial Primary Anterior Cervical Discectomy and Fusion (ACDF)**

Initial primary anterior cervical discectomy and fusion (ACDF) is considered **medically necessary** when **ALL** of the following are met:

- Recent (within 6 months) plain X-rays of the cervical spine have been performed
- Absence of unmanaged significant mental and/or behavioral health disorders (e.g. major depressive disorder, chronic pain syndrome, secondary gain, opioid and alcohol use disorders)
- Performed for **EITHER** of the following conditions:
  - ◆ **Radiculopathy** when **ALL** of the following are met:
    - Subjective symptoms including **BOTH** of the following:
      - Significant level of pain on a daily basis defined as **EITHER** of the following:
        - Visual Analog Scale (VAS)/Numeric Rating Scale (NRS) as  $\geq 7$
        - Severe, disabling, crippling, or incapacitating pain
      - Unremitting radicular pain to shoulder girdle and/or upper extremity with or without concordant objective physical examination findings resulting in disability
    - Objective physical examination findings including **ANY** of the following:
      - Dermatomal sensory deficit
      - Motor deficit (e.g. biceps, triceps weakness)
      - Reflex changes
      - Shoulder Abduction Relief Sign
      - Nerve root tension sign (e.g. Spurling's maneuver)
      - Unremitting radicular pain to shoulder girdle and/or upper extremity without concordant objective physical examination findings
    - Less than clinically meaningful improvement with at least **TWO** of the following unless contraindicated:
      - Prescription strength analgesics, steroids, and/or NSAIDs for 6 weeks
      - Provider-directed exercise program prescribed by a physical therapist, chiropractic provider, osteopathic or allopathic physician for 6 weeks
      - Epidural steroid injection(s)/selective nerve root block(s)
    - Recent (within 6 months) MRI/CT identifies nerve root impingement caused by herniated disc(s) and/or osteophytes that is concordant with the patient's symptoms and physical examination findings
    - Documentation of nicotine-free status with **EITHER** of the following:
      - Patient is a never-smoker
      - Patient has refrained from smoking, use of smokeless tobacco products, and/or nicotine replacement therapy for at least 6 weeks prior to planned surgery as evidenced by blood cotinine lab results of  $\leq 10$  ng/mL

- ◆ **Myelopathy** when **ALL** of the following are met:
  - Subjective symptoms including **ANY** of the following:
    - Upper/lower extremity weakness, numbness, or pain
    - Fine motor dysfunction (buttoning, handwriting, clumsiness of hands)
    - Gait disturbance
    - New-onset bowel or bladder dysfunction
    - Frequent falls
  - Objective physical examination findings including at least **TWO** of the following:
    - Grip and release test
    - Ataxic gait
    - Hyperreflexia
    - Hoffmann sign
    - Pathologic Babinski sign
    - Tandem walking test demonstrating ataxia
    - Inverted brachial radial reflex
    - Increased muscle tone or spasticity
    - Clonus
    - Myelopathic hand
  - Recent (within 6 months) MRI/CT findings that are concordant with the patient's symptoms and physical examination findings including **EITHER** of the following:
    - MRI/CT demonstrates cervical spinal cord compression
    - MRI/CT identifies cervical spinal stenosis

### **CMM-601.3: Repeat Anterior Cervical Discectomy and Fusion (ACDF) at the Same Level**

Repeat anterior cervical discectomy and fusion (ACDF) at the same level is considered **medically necessary** for **ANY** of the following:

- Painful pseudarthrosis documented by confirmatory imaging that is unresponsive to 6 months of non-surgical treatment
- Recent (within 6 months) post-operative plain X-rays of the cervical spine including flexion/extension lateral views with radiographic evidence of implant/structural bone graft malposition or implant/structural bone graft failure
- Performed for **ANY** of the following conditions:
  - ◆ **Unremitting neck pain** when **ALL** of the following are met:
    - Significant level of pain on a daily basis defined as **EITHER** of the following:
      - Visual Analog Scale (VAS)/Numeric Rating Scale (NRS) as  $\geq 7$
      - Severe, disabling, crippling, or incapacitating pain
    - Greater than 6 months since prior anterior cervical discectomy and fusion (ACDF) procedure at the same level
    - Absence of unmanaged significant mental and/or behavioral health disorders (e.g. major depressive disorder, chronic pain syndrome, secondary gain, opioid and alcohol use disorders)

- Less than clinically meaningful improvement with **BOTH** of the following unless contraindicated:
  - Prescription strength analgesics, steroids, and/or NSAIDs for 6 weeks
  - Provider-directed exercise program prescribed by a physical therapist, chiropractic provider, osteopathic or allopathic physician for 6 weeks
- Recent (within 6 months) post-operative MRI/CT findings that are concordant with the patient's symptoms and/or physical examination findings presenting post-operatively
- Documentation of nicotine-free status including **EITHER** of the following:
  - Patient is a never-smoker
  - Patient has refrained from smoking, use of smokeless tobacco products, and/or nicotine replacement therapy for at least 6 weeks prior to planned surgery as evidenced by blood cotinine lab results of  $\leq 10$  ng/mL
- ◆ Radiculopathy secondary to herniated disc or osteophyte when **ALL** of the following are met:
  - Initial relief of symptoms following previous disc decompression procedure at the same level
  - Absence of unmanaged significant mental and/or behavioral health disorders (e.g. major depressive disorder, chronic pain syndrome, secondary gain, opioid and alcohol use disorders)
  - Greater than 6 weeks since the initial anterior cervical discectomy/fusion surgery
  - Subjective symptoms including **BOTH** of the following:
    - Significant level of pain on a daily basis defined as **EITHER** of the following:
      - Visual Analog Scale (VAS)/Numeric Rating Scale (NRS) as  $\geq 7$
      - Severe, disabling, crippling, or incapacitating pain
    - Unremitting radicular pain to shoulder girdle and/or upper extremity resulting in disability
  - Objective physical examination findings including **ANY** of the following:
    - Dermatomal sensory deficit
    - Motor deficit (e.g. biceps, triceps weakness)
    - Reflex changes
    - Shoulder Abduction Relief Sign
    - Nerve root tension sign (e.g. Spurling's maneuver)
    - Unremitting radicular pain to shoulder girdle and/or upper extremity without concordant objective physical examination findings
  - Less than clinically meaningful improvement with at least **TWO** of the following unless contraindicated:
    - Prescription strength analgesics, steroids, and/or NSAIDs for 6 weeks
    - Provider-directed exercise program prescribed by a physical therapist, chiropractic provider, osteopathic or allopathic physician for 6 weeks
    - Selective nerve root block(s) performed at the same level(s) as the requested ACDF or epidural steroid injection(s)

- Recent (within 6 months) post-operative confirmatory imaging including **EITHER** of the following that is concordant with the patient's symptoms and physical examination findings:
  - MRI /CT confirms evidence of neural structure compression (e.g. either retained disc material or a recurrent disc herniation)
  - CT documenting pseudarthrosis, no less than 6 months after initial fusion
- Documentation of nicotine-free status including **EITHER** of the following:
  - Patient is a never-smoker
  - Patient has refrained from smoking, use of smokeless tobacco products, and/or nicotine replacement therapy for at least 6 weeks prior to planned surgery as evidenced by blood cotinine lab results of  $\leq 10$  ng/mL
- ◆ Myelopathy when **ALL** of the following are met:
  - Initial relief of symptoms following previous disc decompression procedure at the same level
  - Absence of unmanaged significant mental and/or behavioral health disorders (e.g. major depressive disorder, chronic pain syndrome, secondary gain, opioid and alcohol use disorders)
  - Subjective symptoms including **ANY** of the following:
    - Upper/lower extremity weakness, numbness, or pain
    - Fine motor dysfunction (buttoning, handwriting, clumsiness of hands)
    - Gait disturbance
    - New-onset bowel or bladder dysfunction
    - Frequent falls
  - Objective physical examination findings including at least **TWO** of the following:
    - Grip and release test
    - Ataxic gait
    - Hyperreflexia
    - Hoffmann sign
    - Pathologic Babinski sign
    - Tandem walking test demonstrating ataxia
    - Inverted brachial radial reflex
    - Increased muscle tone or spasticity
    - Clonus
    - Myelopathic hand
  - Recent (within 6 months) post-operative confirmatory MRI/CT findings including **ANY** of the following:
    - MRI /CT confirms evidence of neural structure compression
    - MRI /CT identifies stenosis
    - CT scan documenting pseudarthrosis, no less than 6 months after initial fusion

### **CMM-601.4: Adjacent Segment Disease**

Anterior cervical discectomy and fusion (ACDF) for a degenerative spinal segment adjacent to a previous decompression or fusion procedure is considered **medically necessary** when **ALL** of the following are met:

- Recent (within 6 months) plain X-rays of the cervical spine including flexion/extension lateral views and advanced diagnostic imaging demonstrating successful decompression and/or fusion at the adjacent level
- The prior decompression or fusion procedure at an adjacent level was performed at least 6 months prior.
- Absence of unmanaged significant mental and/or behavioral health disorders (e.g. major depressive disorder, chronic pain syndrome, secondary gain, opioid and alcohol use disorders)
- Performed for **EITHER** of the following conditions:
  - ◆ **Radiculopathy** when **ALL** of the following are met:
    - Subjective symptoms including **BOTH** of the following:
      - Significant level of pain on a daily basis defined as **EITHER** of the following:
        - Visual Analog Scale (VAS)/Numeric Rating Scale (NRS) as  $\geq 7$
        - Severe, disabling, crippling, or incapacitating pain
      - Unremitting radicular pain to shoulder girdle and/or upper extremity resulting in disability
    - Objective physical examination findings including **ANY** of the following:
      - Dermatomal sensory deficit
      - Motor deficit (e.g. biceps, triceps weakness)
      - Reflex changes
      - Shoulder Abduction Relief Sign
      - Nerve root tension sign (e.g. Spurling's maneuver)
      - Unremitting radicular pain to shoulder girdle and/or upper extremity without concordant objective physical examination findings
    - Less than clinically meaningful improvement with at least **TWO** of the following unless contraindicated:
      - Prescription strength analgesics, steroids, and/or NSAIDs for 6 weeks
      - Provider-directed exercise program prescribed by a physical therapist, chiropractic provider, osteopathic or allopathic physician for 6 weeks
      - Epidural steroid injection(s)/selective nerve root block(s)
    - Recent (within 6 months) MRI/CT identifies nerve root impingement caused by herniated disc(s) or osteophytes that is concordant with the patient's symptoms and physical examination findings
    - Documentation of nicotine-free status with **EITHER** of the following:
      - Patient is a never-smoker
      - Patient has refrained from smoking, use of smokeless tobacco products, and/or nicotine replacement therapy for at least 6 weeks prior to planned surgery as evidenced by blood cotinine lab results of  $\leq 10$  ng/mL



- ◆ **Myelopathy** when **ALL** of the following are met:
  - Subjective symptoms including **ANY** of the following:
    - Upper/lower extremity weakness, numbness, or pain
    - Fine motor dysfunction (buttoning, handwriting, clumsiness of hands)
    - Gait disturbance
    - New-onset bo due to a neurocompressive pathology
    - Frequent falls
  - Objective physical examination findings including at least **TWO** of the following:
    - Grip and release test
    - Ataxic gait
    - Hyperreflexia
    - Hoffmann sign
    - Pathologic Babinski sign
    - Tandem walking test demonstrating ataxia
    - Inverted brachial radial reflex
    - Increased muscle tone or spasticity
    - Clonus
    - Myelopathic hand
  - Recent (within 6 months) MRI/CT findings that is concordant with the patient's symptoms or physical examination findings including **EITHER** of the following:
    - MRI/CT demonstrates cervical spinal cord compression
    - MRI/CT identifies cervical spinal stenosis

### **CMM-601.5: Failed Cervical Disc Arthroplasty Implant**

Anterior cervical decompression and fusion following failed cervical disc arthroplasty implant is considered **medically necessary** for **EITHER** of the following:

- Recent (within 6 months) post-operative imaging studies demonstrating failure of a cervical disc arthroplasty implant (i.e. subsidence, loosening, infection, dislocation, subluxation, vertebral body fracture, dislodgement)
- Performed for **ANY** of the following conditions:
  - ◆ Unremitting neck pain when **ALL** of the following are met:
    - Significant level of pain on a daily basis defined as **EITHER** of the following:
      - Visual Analog Scale (VAS)/Numeric Rating Scale (NRS) as  $\geq 7$
      - Severe, disabling, crippling, or incapacitating pain
    - Greater than 6 months since prior since prior cervical disc arthroplasty procedure at the same level
    - Absence of unmanaged significant mental and/or behavioral health disorders (e.g. major depressive disorder, chronic pain syndrome, secondary gain, opioid and alcohol use disorders)
    - Less than clinically meaningful improvement with prescription strength analgesics, steroids, and/or NSAIDs for 6 weeks unless contraindicated
    - Recent (within 6 months) post-operative MRI/CT findings that are concordant with the patient's symptoms or physical examination findings

- Documentation of nicotine-free status including **EITHER** of the following:
  - Patient is a never-smoker
  - Patient has refrained from smoking, use of smokeless tobacco products, and/or nicotine replacement therapy for at least 6 weeks prior to planned surgery as evidenced by blood cotinine lab results of  $\leq 10$  ng/mL
- ◆ **Radiculopathy** when **ALL** of the following are met:
  - Greater than 6 months since the prior cervical disc arthroplasty procedure
  - Absence of unmanaged significant mental and/or behavioral health disorders (e.g. major depressive disorder, chronic pain syndrome, secondary gain, opioid and alcohol use disorders)
  - Subjective symptoms including **BOTH** of the following:
    - Significant level of pain on a daily basis defined as **EITHER** of the following:
      - Visual Analog Scale (VAS)/Numeric Rating Scale (NRS) as  $\geq 7$
      - Severe, disabling, crippling, or incapacitating pain
    - Unremitting radicular pain to shoulder girdle and/or upper extremity resulting in disability
  - Objective physical examination findings including **ANY** of the following:
    - Dermatomal sensory deficit
    - Motor deficit (e.g. biceps, triceps weakness)
    - Reflex changes
    - Shoulder Abduction Relief Sign
    - Nerve root tension sign (e.g. Spurling's maneuver)
    - Unremitting radicular pain to shoulder girdle and/or upper extremity without concordant objective physical examination findings
  - Less than clinically meaningful improvement with any **TWO** of the following unless contraindicated:
    - Prescription strength analgesics, steroids, and/or NSAIDs for 6 weeks
    - Provider-directed exercise program prescribed by a physical therapist, chiropractic provider, osteopathic or allopathic physician for 6 weeks
    - Epidural steroid injection(s)/selective nerve root block(s)
  - Recent (within 6 months) post-operative MRI/CT identifies nerve root impingement caused by herniated disc(s) or osteophytes that is concordant with the patient's symptoms or physical examination findings
  - Documentation of nicotine-free status including **EITHER** of the following:
    - Patient is a never-smoker
    - Patient has refrained from smoking, use of smokeless tobacco products, and/or nicotine replacement therapy for at least 6 weeks prior to planned surgery as evidenced by blood cotinine lab results of  $\leq 10$  ng/mL

- ◆ Myelopathy when **ALL** of the following are met:
  - Greater than 6 months since the prior cervical disc arthroplasty procedure
  - Absence of unmanaged significant mental and/or behavioral health disorders (e.g. major depressive disorder, chronic pain syndrome, secondary gain, opioid and alcohol use disorders)
  - Subjective symptoms including **ANY** of the following:
    - Upper/lower extremity weakness, numbness, or pain
    - Fine motor dysfunction (buttoning, handwriting, clumsiness of hands)
    - Gait disturbance
    - New-onset bowel or bladder dysfunction
    - Frequent falls
  - Objective physical examination findings including at least **TWO** of the following:
    - Grip and release test
    - Ataxic gait
    - Hyperreflexia
    - Hoffmann sign
    - Pathologic Babinski sign
    - Tandem walking test demonstrating ataxia
    - Inverted brachial radial reflex
    - Increased muscle tone or spasticity
    - Clonus
    - Myelopathic hand
  - Recent (within 6 months) post-operative MRI/CT findings that are concordant with the patient's symptoms or physical examination findings including **ANY** of the following:
    - MRI/CT demonstrates cervical spinal cord compression
    - MRI/CT identifies cervical spinal stenosis

### CMM-601.6: Non-Indications

#### **Not medically Necessary**

- Anterior cervical discectomy and fusion (ACDF) is **not medically necessary** for **EITHER** of the following:
  - ◆ Chronic non-specific neck or arm pain of unknown etiology
  - ◆ Cervical degenerative disc disease without radiculopathy or myelopathy

**CMM-601.7: Procedure (CPT®) Codes**

This guideline relates to the CPT® code set below. Codes are displayed for informational purposes only. Any given code’s inclusion on this list does not necessarily indicate prior authorization is required.

CPT®	Code Description/Definition
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, osteophytectomy and decompression of spinal cord and/or nerve roots; cervical below C2
+22552	Arthrodesis, anterior interbody, including disc space preparation, discectomy, osteophytectomy 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)
+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)
+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)
+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)
63075	Discectomy, anterior, with decompression of spinal cord and/or nerve root(s), including osteophytectomy; cervical, single interspace
+63076	Discectomy, anterior, with decompression of spinal cord and/or nerve root(s), including osteophytectomy; cervical, each additional interspace (List separately in addition to code for primary procedure)
63081	Vertebral corpectomy (vertebral body resection), partial or complete, anterior approach with decompression of spinal cord and/or nerve roots(s); cervical, single segment
+63082	Vertebral corpectomy (vertebral body resection), partial or complete, anterior approach with decompression of spinal cord and/or nerve roots(s); cervical, single segment; cervical, each additional segment (List separately in addition to code for primary procedure)
This list may not be all inclusive and is not intended to be used for coding/billing purposes. The final determination of reimbursement for services is the decision of the health plan and is based on the individual’s policy or benefit entitlement structure as well as claims processing rules.	

CMM-601: Anterior Cervical Discectomy and Fusion

## **CMM-601.8: References**

1. Albert TJ, Murrell SE. Surgical management of cervical radiculopathy. *J Am Acad Orthop Surg*. Nov-Dec 1999;7(6):368-376.
2. American Academy of Orthopaedic Surgeons (AAOS). Position statement: The effects of tobacco exposure on the musculoskeletal system.
3. American Academy of Orthopedic Surgeons (AAOS). Surgery and smoking. Last Reviewed Dec 2013.
4. An HS, Simpson HM, Glover JM, et al. Comparison between allograft plus demineralized bone matrix versus autograft in anterior cervical fusion: a prospective multicenter study. *Spine*. 1995; 20(20): 2211-16.
5. Anderson PA, Subach BR, Riw KD. Predictors of outcome after anterior cervical discectomy and fusion: a multivariate analysis. *Spine* 2009; 34: 161-6.
6. Bishop RC, Moore KA, Hadley MN. Anterior cervical interbody fusion using autogeneic and allogeneic bone graft substrate: a prospective comparative analysis. *J Neurosurg* 1996; 85: 206-10.
7. Bohlman HH, Emery SE, Goodfellow DB, et al. Robinson anterior cervical discectomy and arthrodesis for cervical radiculopathy. Long-term followup of one hundred and twenty-two patients. *J Bone Joint Surg Am* 1993; 75: 1298-307.
8. Bond M, McIntosh G, Fisher C et al. Treatment of Mild Cervical Myelopathy. *Spine (Phila Pa 1976)*. 2019;44(22):1606-1612. doi:10.1097/brs.00000000000003124.
9. Brown MD, Malinin TI, Davis PB. A roentgenographic evaluation of frozen allografts versus autografts in anterior cervical spine fusions. *Clin Orthop Relat Res* 1976; 119: 231-6.
10. Butterman, GR. Anterior Cervical Discectomy and Fusion Outcomes over 10 Years. *SPINE* 2018; 43(3): 207-214.
11. Carrier CS, Bono CM, Lebl DR. Evidence-based analysis of adjacent segment degeneration and disease after ACDF: a systematic review. *Spine J* 2013; 13: 1370-8.
12. Cauthen JC, Kinard RE, Vogler JB, et al. Outcome analysis of noninstrumented anterior cervical discectomy and interbody fusion in 348 patients. *Spine* 1998; 23: 188-92.
13. Chatley A, Kumar R, Jain V, Behari S, Sahu R. Effect of spinal cord signal intensity changes on clinical outcome after surgery for cervical spondylotic myelopathy. *J Neurosurg Spine*. 2009;11(5):562-567. doi:10.3171/2009.6.spine091.
14. Daniels AH, et al. Adverse events associated with anterior cervical spine surgery. *Journal of the American Academy of Orthopedic Surgeons* 2008;16(12):729-738.
15. Eck JC, Humphreys SC, Hodges SD, et al. A comparison of outcomes of anterior cervical discectomy and fusion in patients with and without radicular symptoms. *J Surg Orthop Adv* 2006; 15: 24-6.
16. Emery SE, Bohlman HH, Bolesta MJ, et al. Anterior cervical decompression and arthrodesis for the treatment of cervical spondylotic myelopathy. Two to seventeen year follow-up. *J Bone Joint Surg Am* 1998; 80: 941-51.
17. Emery SE, Fisher JR, Bohlman HH. Three-level anterior cervical discectomy and fusion: radiographic and clinical results. *Spine* 1997; 22: 2622-4.
18. Epstein NE. Iliac Crest Autograft Versus Alternative Constructs for Anterior Cervical Spine Surgery: Pros, Cons and Costs. *Surg Neurol Int*. 2012; 3(Suppl3): S143-S156
19. Eubanks JD, Thorpe SW, Cheruvu VK, et al. Does smoking influence fusion rates in posterior cervical arthrodesis with lateral mass instrumentation? *Clinical Orthop Relat Res*. 2011; 469(3): 696-701.
20. Farshad M, Burgstaller JM, Held U, et al. Do preoperative corticosteroid injections increase the risk for infections or wound healing problems after spine surgery? *Spine*. 2018;43(15): 1089-94.
21. Floyd T, Ohnmeiss D. A meta-analysis of autograft versus allograft in anterior cervical fusion. *Eur Spine J* 2000; 9: 398-403.
22. Fountas KN, et al. Anterior cervical discectomy and fusion associated complications. *Spine* 2007;32(21):2310-7.
23. Harris A, Marrache M, Puvanesarajah V et al. Are preoperative depression and anxiety associated with patient-reported outcomes, health care payments, and opioid use after anterior discectomy and fusion?. *Spine J*. 2020;20(8):1167-1175. doi:10.1016/j.spinee.2020.03.004.
24. Hills BB, Kasliwal MK. Cervical Radiographic Parameters in the Management of Cervical Spine Disorders: The Minimum that Needs to Be Measured. *SpineLine*. 2019 September/October; 12-16.
25. Garringer SM, Sasso RC. Safety of anterior cervical discectomy and fusion performed as outpatient surgery. *Journal of Spinal Disorders and Techniques* 2010;23(7):439-43.
26. Garvey TA, Transfeldt EE, Malcolm JR, et al. Outcome of anterior cervical discectomy and fusion as perceived by patients treated for dominant axial-mechanical cervical spine pain. *Spine* 2002; 27: 1887-95.
27. Glassman SD, Anagnost SC, Parker A, et al. The effect of cigarette smoking and smoking cessation on spinal fusion. *Spine (Phila Pa 1976)*. 2000;25(20):2608-15.
28. Goffin J, Geusens E, Vantomme N, et al. Long-term follow-up after interbody fusion of the cervical spin. *J Spinal Disord Tech* 2004; 17: 79-85.
29. Gore DR, Sepic SB. Anterior cervical fusion for degenerated or protruded discs. A review of one hundred and forty-six patients. *Spine* 1984; 9: 667-71.

30. Gore DR, Sepsic SB. Anterior discectomy and fusion for painful cervical disc disease. A report of 50 patients with an average follow-up of 21 years. *Spine* 1998; 23: 2047-51.
31. Hermansen A, Hedlund R, Vavruch L, et al. A comparison between the carbon fiber cage and the cloward procedure in cervical spine surgery: a ten to thirteen year follow-up of a prospective randomized study. *Spine* 2011; 36: 919-25.
32. Hilibrand AS, Fye MA, Emery SE, et al. Impact of smoking on the outcome of anterior cervical arthrodesis with interbody or strut-grafting. *J Bone Joint Surg Am* 2001; 83-A: 668-73.
33. Hashimoto M, et al. C5 palsy following anterior decompression and spinal fusion for cervical degenerative diseases. *European Spine Journal* 2010;19(10):1702-10.
34. Ishihara H, Kanamori M, Kawaguchi Y, et al. Adjacent segment disease after anterior cervical interbody fusion. *Spine J* 2004; 4: 624-8.
35. Jiménez-Almonte J, Hautala G, Abbenhaus E et al. Spine patients demystified: what are the predictive factors of poor surgical outcome in patients after elective cervical and lumbar spine surgery?. *Spine J (Phila Pa 1976)*. 2020;20(10):1529-1534. doi:10.1016/j.spinee.2020.05.550.
36. Jung A, Schramm J. How to reduce recurrent laryngeal nerve palsy in anterior cervical spine surgery: a prospective observational study. *Neurosurgery* 2010;67(1):10-5; discussion 15.
37. Kalsi-Ryan, S, et al. Ancillary Outcomes Measures for Assessment of Individuals with Cervical Spondylotic Myelopathy. *Spine*, 38 (22S) Supplement 1, October 2013, p.S111-122.
38. Klein GR, Vaccaro AR, Albert TJ. Health outcome assessment before and after anterior cervical discectomy and fusion for radiculopathy: a prospective analysis. *Spine* 2000; 25: 801-3.
39. Kuri M, Nakagawa M, Tanaka H, et al. Determination of the duration of preoperative smoking cessation to improve wound healing after head and neck surgery. *Anesthesiology*. 2005;102(5): 892-96.
40. Kwon B, Kim Dh, Marvin A, et al. Outcomes following anterior cervical discectomy and fusion: the role of interbody disc height, angulation, and spinous process distance. *J Spinal Disord Tech* 2005; 18: 304-8.
41. Lau D, Chou D, Ziewacz JE, et al. The effects of smoking on perioperative outcomes and pseudarthrosis following anterior cervical corpectomy: clinical article. *J Neurosurg Spine*. 2014; 21(4): 547-58.
42. Lawrence BD, Hilibrand AS, Brodt ED, et al. Predicting the risk of adjacent segment pathology in the cervical spine: a systematic review. *Spine* 2012; 37 (22 suppl): S52-64.
43. Lee JC, Lee SH, Peters C, et al. Adjacent segment pathology requiring reoperation after anterior cervical arthrodesis: the influence of smoking, sex and number of operated levels. *Spine* 2015; 40: E571-7.
44. Liu JT, Briner RP, Friedman JA. Comparison of inpatient vs. outpatient anterior cervical discectomy and fusion: a retrospective case series. *BMC Surgery* 2009;9:3.
45. Luszczk M, Smith JS, Fischgrund JS, et al. Does smoking have an impact on fusion rate in single-level anterior cervical discectomy and fusion with allograft and rigid plate fixation?: clinical article. *J Neurosurg Spine*. 2013; 19(5): 527-31.
46. Malloy KM, Hilibrand AS. Autograft versus allograft in degenerative cervical disease. *Clin Orthop Relat Res* 2002; 394: 27-38.
47. Matsumoto M, Okada E, Ichihara D, et al. Anterior cervical decompression and fusion accelerates adjacent segment degeneration: comparison with asymptomatic volunteers in a ten-year magnetic resonance imaging follow-up study. *Spine* 2010; 35: 36-43.
48. Matz PG, et al. Anterior cervical surgery for the treatment of cervical degenerative myelopathy. *Journal of Neurosurgery: Spine* 2009;11(2):170-3.
49. Matz PG, et al. Indications for anterior cervical decompression for the treatment of cervical degenerative radiculopathy. *Journal of Neurosurgery: Spine* 2009;11(2):174-82.
50. Matz PG, et al. Techniques for anterior cervical decompression for radiculopathy. *Journal of Neurosurgery: Spine* 2009;11(2):183-97.
51. Mills E, Eyawo O, Lockhart I, et al. Smoking cessation reduces postoperative complications: a systematic review and meta-analysis. *Am J Med*. 2011;124(2):144-54.
52. North American Spine Society (NASS). Evidence-Based Clinical Guidelines for Multidisciplinary Spine Care. Diagnosis and Treatment of Cervical Radiculopathy from Degenerative Disorders. 2014.
53. Palit M, Schofferman J, Goldthwaite N, et al. Anterior discectomy and fusion for the management of neck pain. *Spine* 1999; 24: 2224-8.
54. Papadopoulos EC, Huang RC, Girardi FP, et al. Three-level anterior cervical discectomy and fusion with plate fixation: radiographic and clinical results. *Spine* 2006; 31: 897-902.
55. Patel CK, Fischgrund JS. Complications of anterior cervical spine surgery. *Instr Course Lect*. 2003;52:465-469.
56. Peolsson A, Peolsson M. Predictive factors for long-term outcome of anterior cervical decompression and fusion: a multivariate data analysis. *Eur Spine J* 2008; 17: 406-14.
57. Raoi RD, Gore DR, Tang SJ, et al. Radiographic changes in the cervical spine following anterior arthrodesis: a long term analysis of 166 patients. *J Bone Joint Surg* 2016; 98: 1606-13.
58. Raja M, Garg A, Yadav P, et al. Diagnostic Methods for Detection of Cotinine Level in Tobacco Users: A Review. *J Clin Diagn Res*. 2016 Mar; 10(3): ZE04–ZE06.

59. Riley LH, Vaccaro AR, Dettori JR, Hashimoto R. Postoperative dysphagia in anterior cervical spine surgery. *Spine* 2010;35(9 Suppl):S76-85.
60. Samartzis D, Shen FH, Lyon C, et al. Does rigid instrumentation increase the fusion rate in on-level anterior cervical discectomy and fusion. *Spine J* 2004; 4: 636-43.
61. Shen FH, Samartzis D, Khanna N, et al. Comparison of clinical and radiographic outcome in instrumented anterior cervical discectomy and fusion with or without direct uncovertebral joint decompression. *Spine J* 2004; 4: 629-35.
62. Sivaganesan A, Khan I, Pennings J et al. Why are patients dissatisfied after spine surgery when improvements in disability and pain are clinically meaningful?. *Spine J (Phila Pa 1976)*. 2020;20(10):1535-1543. doi:10.1016/j.spinee.2020.06.008.
63. Sorensen LT. Wound healing and infection in surgery: the pathophysiological impact of smoking, smoking cessation, and nicotine replacement therapy: a systematic review. *Ann Surg*. 2012;255(6): 1069-79.
64. Stieber JR, Brown K, Donald GD, Cohen JD. Anterior cervical decompression and fusion with plate fixation as an outpatient procedure. *Spine Journal* 2005;5(5):503-7.
65. Suchomel P, Barsa P, Buchavald P, et al. Autogenous versus allogenic bone grafts in instrumented anterior cervical discectomy and fusion: A prospective study with respect to bone union pattern. *Eur Spine J* 2004; 13: 510-5.
66. Tetreault, et al. The Practical Application of Clinical Prediction Rules: A Commentary Using Case Examples in Surgical Patients with Degenerative Cervical Myelopathy. *Global Spine Journal*. J 2015;5:457-465.
67. Tumialan LM, Gluf WM. Progressive vertebral body osteolysis after cervicomedial disc arthroplasty. *Spine (Phila Pa 1976)*. Jun 15 2011;36(14):E973-978.
68. Van Eck CF, Regan C, Donaldson WF, et al. The revisions rate and occurrence of adjacent segment disease after anterior cervical discectomy and fusion: a study of 672 consecutive patients. *Spine* 2014; 39: 2143-7.
69. Villavicencio AT, Pushchak E, Burneikiene S, Thramann JJ. The safety of instrumented outpatient anterior cervical discectomy and fusion. *Spine Journal* 2007;7(2):148-53.
70. Wang JC, McDonough PW, Endow KK, et al. Increase fusion rates with cervical plating for two-level anterior cervical discectomy and fusion. *Spine* 2000; 25: 41-5.
71. Weinberg D, Chugh AJ, Gebhart JJ, et al. Magnetic resonance imaging of the cervical spine under-represents sagittal plane deformity in degenerative myelopathy patients. *Int J Spine Surg*. 2016;10:32. doi: 10.14444/3032.
72. White AA 3<sup>rd</sup>, Southwick WO, et al. Relief of pain by anterior cervical-spine fusion for spondylosis. A report of sixty-five patients. *J Bone Joint Surg Am* 1973; 55: 525-34.
73. Wong J, Lam DP, Abrishami A, et al. Short-term preoperative smoking cessation and postoperative complications: a systematic review and meta-analysis. *Can J Anaesth*. 2012;59(3): 268-79.
74. Yin L, Zhang J, Wu Y, Li J, Yang Q. Increased signal intensity of spinal cord on T2W magnetic resonance imaging for cervical spondylotic myelopathy patients. *Medicine (Baltimore)*. 2020;99(49):e23098. doi:10.1097/md.00000000000023098.
75. Yue WM, Brodner W, Highland TR. Long-term results after anterior cervical discectomy and fusion with allograft and plating: a 5 to 11 year radiologic and clinical follow-up study. *Spine* 2005; 30: 2138-44.
76. Zhuang T, Ku S, Shapiro L, Hu S, Cabell A, Kamal R. A Cost-Effectiveness Analysis of Smoking-Cessation Interventions Prior to Posterolateral Lumbar Fusion. *J Bone Joint Surg*. 2020;102(23):2032-2042. doi:10.2106/jbjs.20.00393.