

# CIGNA MEDICAL COVERAGE POLICIES - MUSCULOSKELETAL CMM-609: Lumbar Fusion (Arthrodesis)

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**EviCore**  
By EVERNORTH

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## Instructions for use

The following coverage policy applies to health benefit plans administered by Cigna. Coverage policies are intended to provide guidance in interpreting certain standard Cigna benefit plans and are used by medical directors and other health care professionals in making medical necessity and other coverage determinations. Please note the terms of a customer's particular benefit plan document may differ significantly from the standard benefit plans upon which these coverage policies are based. For example, a customer's benefit plan document may contain a specific exclusion related to a topic addressed in a coverage policy.

In the event of a conflict, a customer's benefit plan document always supersedes the information in the coverage policy. In the absence of federal or state coverage mandates, benefits are ultimately determined by the terms of the applicable benefit plan document. Coverage determinations in each specific instance require consideration of:

1. The terms of the applicable benefit plan document in effect on the date of service
2. Any applicable laws and regulations
3. Any relevant collateral source materials including coverage policies
4. The specific facts of the particular situation

Coverage policies relate exclusively to the administration of health benefit plans. Coverage policies are not recommendations for treatment and should never be used as treatment guidelines.

This evidence-based medical coverage policy has been developed by EviCore, Inc. Some information in this coverage policy may not apply to all benefit plans administered by Cigna.

These guidelines include procedures EviCore does not review for Cigna. Please refer to the [Cigna CPT code list](#) for the current list of high-tech imaging procedures that EviCore reviews for Cigna.

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# CMM-609.1: General Guidelines

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# CMM-609.1: General Guidelines

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## Application of Guideline

- The determination of medical necessity for the performance of lumbar fusion (with or without osteotomy) is always made on a case-by-case basis.
- For additional timing and documentation requirements, see **CMM-600.1: Prior Authorization Requirements**.

## Urgent/Emergent Indications/Conditions

- The presence of urgent/emergent indications/conditions warrants definitive surgical treatment. **Imaging findings noted in the applicable procedure section(s) are required.**
  - The following criteria are NOT required for confirmed urgent/emergent conditions:
    - provider-directed non-surgical management
    - proof of smoking cessation
    - 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)
    - time frame for repeat procedure
  - Urgent/emergent conditions for lumbar fusion and/or osteotomy include ANY of the following:
    - traumatic spinal fractures or dislocations (with or without neural compression) when instability is present or decompression of the spinal canal is anticipated to result in iatrogenic instability
    - infection (e.g., discitis, epidural abscess, osteomyelitis) when instability is present or debridement and/or decompression is anticipated to result in iatrogenic instability
    - primary or metastatic neoplastic disease causing pathologic fracture, cord compression, when instability is present, or resection and/or decompression is anticipated to result in iatrogenic instability
    - a condition otherwise meeting criteria listed in the applicable procedure section(s) with documentation of severe debilitating pain and/or dysfunction to the point of being incapacitated

## Health Equity Considerations

Health equity is the highest level of health for all individuals; health inequity is the avoidable difference in health status or distribution of health resources due to the social conditions in which individuals are born, grow, live, work, and age. Social determinants of health are the conditions in the environment that affect a wide range of health, functioning, and quality of life outcomes and risks. Examples include the following: safe housing, transportation, and neighborhoods; racism, discrimination, and violence; education, job opportunities, and income; access to nutritious foods and physical activity opportunities; access to clean air and water; and language and literacy skills.

# CMM-609.2: Osteotomy

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# CMM-609.2: Osteotomy

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## Posterior Column Osteotomy (PCO)

Lumbar posterior column osteotomy (PCO) (i.e., Smith-Peterson osteotomy [SPO] or Ponte osteotomy) is considered **medically necessary** (in addition to fusion) when ALL of the following criteria have been met:

- Performed for non-fixed deformity requiring 5° to 10° of correction (SPO) per spinal segment with EITHER of the following:
  - lumbar sagittal plane deformities where sagittal vertical axis (SVA) is >8cm or pelvic incidence-lumbar lordosis (PI-LL) is >15°
  - larger coronal deformities where there is limited flexibility and the Cobb angle is >30°
- Posterior column osteotomy is limited to a maximum of four (4) posterior column osteotomies performed in the apex of the deformity per correction surgery.
  - **Criteria exception:** There is no limit to posterior column osteotomies for correction of Scheuermann's kyphosis as this deformity is long, gradual, rounded, and amendable to more than four (4) posterior column osteotomies
- Criteria have been met in the applicable procedure-specific section:
  - **CMM-609.3: Pediatric Spinal Deformity**
  - **CMM-609.4: Lumbar Fusion (Arthrodesis) with Decompression (Indirect or Direct)**
  - **CMM-609.5: Lumbar Fusion (Arthrodesis) without Decompression**
  - **CMM-609.6: Adjacent Segment Disease**
  - **CMM-609.7: Lumbar Fusion (with or without Decompression) Following Failed Disc Arthroplasty Surgery**
  - **CMM-609.8: Repeat Lumbar Fusion (Arthrodesis) at the Same Level**

## Three-Column Osteotomy

Lumbar three-column osteotomy (i.e., pedicle subtraction osteotomy (PSO) or vertebral column resection [VCR]) is considered **medically necessary** (in addition to fusion) when ALL of the following criteria have been met:

- Performed for EITHER of the following:
  - fixed sagittal plane deformity requiring >30° of correction (PSO)
  - large, fixed coronal deformities >60° that are amenable to asymmetric osteotomy
- Criteria have been met in the applicable procedure-specific section:

- **CMM-609.3: Pediatric Spinal Deformity**
- **CMM-609.4: Lumbar Fusion (Arthrodesis) with Decompression (Indirect or Direct)**
- **CMM-609.5: Lumbar Fusion (Arthrodesis) without Decompression**
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# CMM-609.3: Pediatric Spinal Deformity

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# CMM-609.3: Pediatric Spinal Deformity

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## Pediatric Lumbar Fusion

Lumbar fusion (arthrodesis) is considered **medically necessary** when the following criteria has been met:

- Imaging studies (advanced imaging or plain x-rays) show the presence of ANY of the following pediatric spinal deformities that warrant definitive surgical treatment:
  - adolescent idiopathic scoliosis with Cobb angle  $>50^\circ$
  - congenital scoliosis
  - neuromuscular scoliosis
  - infantile/juvenile scoliosis

## Pediatric Osteotomy

Lumbar osteotomy is considered **medically necessary** (in addition to fusion) when ALL of the criteria have been met in **CMM-609.2: Osteotomy**.

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# CMM-609.4: Lumbar Fusion (Arthrodesis) with Decompression (Indirect or Direct)

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# CMM-609.4: Lumbar Fusion (Arthrodesis) with Decompression (Indirect or Direct)

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Lumbar fusion with lumbar decompression (indirect or direct) is considered **medically necessary** when performed for ANY of the following conditions when ALL of the associated criteria have been met:

### Actual Instability

- The individual is a candidate for lumbar decompression or lumbar corpectomy per CMM-608: Lumbar Decompression.
- Imaging findings include ANY of the following:
  - degenerative spondylolisthesis **without spondylolysis** with EITHER of the following:
    - dynamic segmental instability on flexion-extension plain x-rays OR comparison of a supine and upright image, with a difference in translational alignment between vertebrae >3mm between views
    - Meyerding Grade II or higher spondylolisthesis
  - spondylolisthesis **with spondylolysis** (e.g., Isthmic Spondylolisthesis) with ANY of the following:
    - Meyerding Grade I or II spondylolisthesis (anterolisthesis) and plain x-rays support progression of anterolisthesis
    - Meyerding Grade III or higher spondylolisthesis (anterolisthesis) with ≥50% anterior slippage OR plain x-rays support progression of anterolisthesis
    - progressive spinal pain without confirmatory imaging showing progression of spondylolisthesis
    - multi-level spondylolysis on plain x-rays
  - post-operative instability created by the disruption of the posterior elements due to facet joint excision that exceeding 50% bilaterally or 75% or more of a single facet
  - pars fracture
  - previous spinal decompression that resulted in iatrogenic spondylolisthesis
  - **Criteria exception:** When instability is created and/or identified intra-operatively, the above imaging criteria are NOT required.
    - See **Anticipated Iatrogenic Instability**
- Documentation of nicotine-free status with EITHER of the following:
  - individual is a never-smoker

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- individual has refrained from smoking, use of smokeless tobacco products, and/or nicotine replacement therapy for at least six (6) weeks prior to planned surgery validated by objective cotinine testing methods (serum, urinary, or saliva) verified as within the normal range for the testing method and lab at which the test was performed

### **Anticipated Iatrogenic Instability**

- The individual is a candidate for lumbar decompression or lumbar corpectomy per CMM-608: Lumbar Decompression.
- Anticipated iatrogenic instability with ANY of the following:
  - created by disruption of the posterior elements due to facet joint excision exceeding 50% bilaterally or 75% or more of a single facet during spinal decompression
  - created by removal of the pars interarticularis that requires fusion to stabilize
  - created by decompression for Meyerding Grade I or higher spondylolisthesis with foraminal stenosis
  - created by complete or partial corpectomy (i.e., removal of at least one-third of the vertebral body [not for resection of osteophytes alone])
- Documentation of nicotine-free status with EITHER of the following:
  - individual is a never-smoker
  - individual has refrained from smoking, use of smokeless tobacco products, and/or nicotine replacement therapy for at least six (6) weeks prior to planned surgery validated by objective cotinine testing methods (serum, urinary, or saliva) verified as within the normal range for the testing method and lab at which the test was performed

### **Adult Symptomatic Degenerative Spinal Deformity**

- The individual is a candidate for lumbar decompression or lumbar corpectomy per CMM-608: Lumbar Decompression.
- Imaging findings include EITHER of the following:
  - coronal plane deformity which includes ANY of the following:
    - Cobb angle >30°
    - asymmetric disk collapse causing symptomatic foraminal narrowing
    - global coronal imbalance causing head and trunk shift off the midline
  - sagittal imbalance which includes ANY of the following:
    - sagittal vertebral axis measurement >8cm
    - pelvic incidence-lumbar lordosis >15°
- Documentation of nicotine-free status with EITHER of the following:
  - individual is a never-smoker

- individual has refrained from smoking, use of smokeless tobacco products, and/or nicotine replacement therapy for at least six (6) weeks prior to planned surgery validated by objective cotinine testing methods (serum, urinary, or saliva) verified as within the normal range for the testing method and lab at which the test was performed

### Initial Disc Herniation

- The individual is a candidate for an initial primary lumbar discectomy per the applicable section below:
  - For an initial primary lumbar discectomy, see **CMM-606.2: Initial Primary Lumbar Microdiscectomy (Laminotomy, Laminectomy, or Hemilaminectomy)**.
  - For information related to excision of extradural lesion other than neoplasm, see **CMM 606.1: General Guidelines**.
- Advanced imaging shows ANY of the following:
  - primary extraforaminal disc herniation at L5-S1, in which a far lateral approach is not feasible because of the presence of the iliac wings
  - primary foraminal disc herniation for which facet resection is necessary to retrieve the disc, which will result in iatrogenic instability
  - primary disc herniation in the lumbar spine that is at the level of the spinal cord (i.e., low lying conus medullaris)
- Documentation of nicotine-free status with EITHER of the following:
  - individual is a never-smoker
  - individual has refrained from smoking, use of smokeless tobacco products, and/or nicotine replacement therapy for at least six (6) weeks prior to planned surgery validated by objective cotinine testing methods (serum, urinary, or saliva) verified as within the normal range for the testing method and lab at which the test was performed

### Recurrent Disc Herniation

- The individual is a candidate for repeat lumbar discectomy per **CMM 606.3: Repeat Lumbar Microdiscectomy (Laminotomy or Laminectomy) at the Same Level**.
- Imaging findings include evidence of anterolisthesis at the requested level(s) that results in EITHER of the following:
  - dynamic segmental instability on flexion-extension plain x-rays OR comparison of a supine and upright image, with a difference in translational alignment between vertebrae >3mm between views
  - Meyerding Grade II or higher spondylolisthesis
- Documentation of nicotine-free status with EITHER of the following:
  - individual is a never-smoker

- individual has refrained from smoking, use of smokeless tobacco products, and/or nicotine replacement therapy for at least six (6) weeks prior to planned surgery validated by objective cotinine testing methods (serum, urinary, or saliva) verified as within the normal range for the testing method and lab at which the test was performed

### **Second or Greater Recurrent Disc Herniation**

- The individual is a candidate for repeat lumbar discectomy per **CMM 606.3: Repeat Lumbar Microdiscectomy (Laminotomy or Laminectomy) at the Same Level.**
- Documentation of nicotine-free status with EITHER of the following:
  - individual is a never-smoker
  - individual has refrained from smoking, use of smokeless tobacco products, and/or nicotine replacement therapy for at least six (6) weeks prior to planned surgery validated by objective cotinine testing methods (serum, urinary, or saliva) verified as within the normal range for the testing method and lab at which the test was performed

# CMM-609.5: Lumbar Fusion (Arthrodesis) without Decompression

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# CMM-609.5: Lumbar Fusion (Arthrodesis) without Decompression

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Lumbar fusion (arthrodesis) without decompression is considered **medically necessary** when performed for ANY of the following conditions when ALL of the associated criteria have been met:

## Degenerative Spondylolisthesis without Spondylolysis

- Imaging findings include EITHER of the following at the requested level(s):
  - dynamic segmental instability on flexion-extension plain x-rays OR comparison of a supine and upright image, with a difference in translational alignment between vertebrae >3mm between views
  - Meyerding Grade II or higher spondylolisthesis
- Symptoms include significant level of pain on a daily basis defined as clinically significant functional impairment (e.g., inability to perform household chores, prolonged standing, etc.)
- Less than clinically meaningful improvement with EITHER of the following (unless contraindicated) for at least three (3) consecutive months:
  - prescription strength analgesics, steroids, gabapentinoids, and/or nonsteroidal anti-inflammatory drugs (NSAIDs)
  - provider-directed exercise program (prescribed by a physical therapist, chiropractic provider, osteopathic or allopathic physician)
- 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)
- Documentation of nicotine-free status with EITHER of the following:
  - individual is a never-smoker
  - individual has refrained from smoking, use of smokeless tobacco products, and/or nicotine replacement therapy for at least six (6) weeks prior to planned surgery validated by objective cotinine testing methods (serum, urinary, or saliva) verified as within the normal range for the testing method and lab at which the test was performed

## Spondylolisthesis with Spondylolysis (e.g., Isthmic Spondylolisthesis)

- Imaging findings include ANY of the following at the requested level(s):

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- Meyerding Grade I or II spondylolisthesis (anterolisthesis) and plain x-rays support progression of anterolisthesis
- Meyerding Grade III or higher spondylolisthesis (anterolisthesis) with  $\geq 50\%$  anterior slippage OR plain x-rays support progression of anterolisthesis
- progressive spinal pain without confirmatory imaging showing progression of spondylolisthesis
- multi-level spondylolysis on plain x-rays
- Symptoms include significant level of pain on a daily basis defined as clinically significant functional impairment (e.g., inability to perform household chores, prolonged standing, etc.)
- Less than clinically meaningful improvement with EITHER of the following (unless contraindicated) for at least three (3) consecutive months:
  - prescription strength analgesics, steroids, gabapentinoids, and/or nonsteroidal anti-inflammatory drugs (NSAIDs)
  - provider-directed exercise program (prescribed by a physical therapist, chiropractic provider, osteopathic or allopathic physician)
- 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)
- Documentation of nicotine-free status with EITHER of the following:
  - individual is a never-smoker
  - individual has refrained from smoking, use of smokeless tobacco products, and/or nicotine replacement therapy for at least six (6) weeks prior to planned surgery validated by objective cotinine testing methods (serum, urinary, or saliva) verified as within the normal range for the testing method and lab at which the test was performed

### **Discogenic Lower Back Pain/Degenerative Disc Disease**

- Plain x-rays and advanced imaging (i.e., CT, MRI) show moderate to severe single-level disc degeneration at the requested level(s).
- Presence of chronic, unremitting, discogenic axial lower back pain and associated disability secondary to single-level degenerative lumbar disc disease (DDD) for at least one year
- Symptoms include significant level of pain on a daily basis defined as clinically significant functional impairment (e.g., inability to perform household chores, prolonged standing, etc.)
- Structured physician-supervised, multi-modal, nonoperative management of medical care with licensed healthcare professionals which includes ALL of the following:
  - regularly scheduled appointments
  - follow-up evaluation

- less than clinically meaningful improvement with at least TWO of the following (unless contraindicated):
  - prescription strength analgesics, steroids, gabapentinoids, and/or nonsteroidal anti-inflammatory drugs (NSAIDs) for at least 12 consecutive months
  - provider-directed exercise program (prescribed by a physical therapist, chiropractic provider, osteopathic or allopathic physician) for at least 12 consecutive months
  - epidural steroid injection(s) or selective nerve root block(s) performed at the same level(s) as the requested surgery
  - facet joint injection(s)/medial branch block(s)/radiofrequency ablation(s)
- 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)
- Documentation of nicotine-free status with EITHER of the following:
  - individual is a never-smoker
  - individual has refrained from smoking, use of smokeless tobacco products, and/or nicotine replacement therapy for at least six (6) weeks prior to planned surgery validated by objective cotinine testing methods (serum, urinary, or saliva) verified as within the normal range for the testing method and lab at which the test was performed

### **Adult Symptomatic Degenerative Spinal Deformity**

- Imaging findings include EITHER of the following:
  - coronal plane deformity which includes ANY of the following:
    - Cobb angle  $>30^{\circ}$
    - asymmetric disk collapse causing symptomatic foraminal narrowing
    - global coronal imbalance causing head and trunk shift off the midline
  - sagittal imbalance which includes ANY of the following:
    - sagittal vertebral axis measurement  $>8\text{cm}$
    - pelvic incidence-lumbar lordosis  $>15^{\circ}$
- Less than clinically meaningful improvement with EITHER of the following (unless contraindicated) for at least three (3) consecutive months:
  - prescription strength analgesics, steroids, gabapentinoids, and/or nonsteroidal anti-inflammatory drugs (NSAIDs)
  - provider-directed exercise program (prescribed by a physical therapist, chiropractic provider, osteopathic or allopathic physician)
- 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)
- Documentation of nicotine-free status with EITHER of the following:

- individual is a never-smoker
- individual has refrained from smoking, use of smokeless tobacco products, and/or nicotine replacement therapy for at least six (6) weeks prior to planned surgery validated by objective cotinine testing methods (serum, urinary, or saliva) verified as within the normal range for the testing method and lab at which the test was performed

# CMM-609.6: Adjacent Segment Disease

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# CMM-609.6: Adjacent Segment Disease

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Lumbar fusion (arthrodesis) for adjacent segment disease is considered **medically necessary** when ALL of the following criteria have been met:

- The prior adjacent-level lumbar fusion was performed at least 6 months prior
- Criteria have been met in the applicable procedure-specific section:
  - **CMM-609.4: Lumbar Fusion with Decompression**
  - **CMM-609.5: Lumbar Fusion (Arthrodesis) without Decompression**

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# CMM-609.7: Lumbar Fusion (with or without Decompression) Following Failed Lumbar Disc Arthroplasty Surgery

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# CMM-609.7: Lumbar Fusion (with or without Decompression) Following Failed Lumbar Disc Arthroplasty Surgery

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Lumbar fusion (with or without decompression) following a failed lumbar disc arthroplasty is considered **medically necessary** when performed for EITHER of the following conditions when ALL of the associated criteria have been met:

## Failed Lumbar Disc Arthroplasty Implant

- Post-operative imaging shows evidence of lumbar disc arthroplasty implant malposition or failure (e.g., subsidence, loosening, infection, dislocation, subluxation, vertebral body fracture, dislodgement)

## Evidence of Neural Structure Compression

- Greater than six (6) months since the prior lumbar total disc arthroplasty at the same level
- Criteria have been met in the applicable procedure-specific section:
  - **CMM-609.4 : Lumbar Fusion (Arthrodesis) with Decompression**
  - **CMM-609.5: Lumbar Fusion (Arthrodesis) without Decompression**
- Post-operative MRI /CT shows evidence of neural structure compression (e.g., either retained disc material or a recurrent disc herniation)

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# CMM-609.8: Repeat Lumbar Fusion (Arthrodesis) at the Same Level

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# CMM-609.8: Repeat Lumbar Fusion (Arthrodesis) at the Same Level

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Repeat lumbar fusion (arthrodesis) (with or without decompression) at the same level is considered **medically necessary** for when performed for EITHER of the following conditions when ALL of the associated criteria have been met:

## Malposition or Failure of Implant/Instrumentation or Structural Bone Graft

- Post-operative imaging shows evidence of malposition or failure of the implant/instrumentation or structural bone graft (e.g., migration, pedicle screw breakage, pedicle screw loosening, dislodged hooks, rod breakage, rod bending, rod loosening, loss of curve correction, decompensation, etc.)

## Symptomatic Pseudoarthrosis

- Greater than six (6) months since the prior lumbar fusion
- Symptoms include significant level of pain on a daily basis defined as clinically significant functional impairment (e.g., inability to perform household chores, prolonged standing, etc.)
- Post-operative physical exam findings are concordant with the individual's symptoms
- Less than clinically meaningful improvement with BOTH of the following (unless contraindicated):
  - prescription strength analgesics, steroids, gabapentinoids, and/or nonsteroidal anti-inflammatory drugs (NSAIDs) for six (6) weeks
  - provider-directed exercise program (prescribed by a physical therapist, chiropractic provider, osteopathic or allopathic physician) for six (6) weeks
- Post-operative imaging (performed at no less than six (6) months after the prior lumbar fusion) shows pseudoarthrosis at the requested level(s)
- Post-operative MRI/CT findings are concordant with the individual's symptoms
- 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)
- Documentation of nicotine-free status with EITHER of the following:
  - individual is a never-smoker
  - individual has refrained from smoking, use of smokeless tobacco products, and/or nicotine replacement therapy for at least six (6) weeks prior to planned surgery validated by objective cotinine testing methods (serum, urinary, or saliva) verified

as within the normal range for the testing method and lab at which the test was performed

# CMM-609.9: Non-Indications

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# CMM-609.9: Non-Indications

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## Not Medically Necessary

- Lumbar fusion performed without meeting the criteria in the **General Guidelines** (when applicable for urgent/emergent conditions) and the criteria in the applicable procedure-specific section(s) (**pediatric spinal deformity; fusion with decompression; fusion without decompression; adjacent segment disease; fusion following failed disc arthroplasty**; or, **repeat fusion**) is considered **not medically necessary**.
- Lumbar osteotomy performed without meeting the criteria in **General Guidelines** (when applicable for urgent/emergent conditions) and the criteria in the applicable procedure-specific section (**osteotomy; pediatric spinal deformity; fusion with decompression; fusion without decompression; adjacent segment disease; fusion following failed disc arthroplasty**; or, **repeat fusion**) is considered **not medically necessary**.

## Experimental, Investigational, or Unproven (EIU)

ALL of the following devices/procedures are considered **experimental, investigational, or unproven** (not an all-inclusive list):

- pre-sacral interbody fusion including AxiaLIF
- percutaneous lumbar spinal fusion (i.e., performed with indirect visualization of the spine)
- endoscopic lumbar spinal fusion
- anterior interbody fusion or implantation of intervertebral body fusion devices using laparoscopic approach
- device/implant not FDA approved
- dynamic (intervertebral) stabilization (e.g., Dynesys<sup>®</sup>, Stabilimax NZ<sup>®</sup>)
- interlaminar lumbar instrumented fusion (e.g., ILIF)
- interspinous and interlaminar distraction devices
- interspinous fixation/posterior non-pedicle supplemental fixation devices for spinal fusion (e.g., Affix<sup>®</sup>, Aspen<sup>®</sup> Spinous Process Fixation System, Coflex<sup>®</sup>-F)
- personalized anterior and lateral body interbody cage (implantable) (e.g., Aprevo<sup>®</sup>)
- least invasive lumbar decompression interbody fusion (e.g., LINDIF)
- isolated facet fusion (with or without instrumentation) including allograft bone graft substitutes used exclusively as stand-alone stabilization devices (e.g., TruFuse<sup>®</sup> [any level], NuFix<sup>®</sup> [any level])

- total facet arthroplasty

# Codes (CMM-609)

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CMM-609: Lumbar Fusion (Arthrodesis)

## Codes (CMM-609)

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The inclusion of any code in this table does not imply that the code is under management or requires prior authorization. Refer to the applicable health plan for management details. Prior authorization of a code listed in this table is not a guarantee of payment. The Certificate of Coverage or Evidence of Coverage policy outlines the terms and conditions of the member's health insurance policy.

Code	Code Description/Definition
<b>22207</b>	Osteotomy of spine, posterior or posterolateral approach, 3 columns, 1 vertebral segment (e.g., Pedicle/vertebral body subtraction); lumbar
<b>+22208</b>	Osteotomy of spine, posterior or posterolateral approach, 3 columns, 1 vertebral segment (e.g., Pedicle/vertebral body subtraction); each additional vertebral segment (List separately in addition to code for primary procedure)
<b>22214</b>	Osteotomy of spine, posterior or posterolateral approach, 1 vertebral segment; lumbar
<b>+22216</b>	Osteotomy of spine, posterior or posterolateral approach, 1 vertebral segment; each additional vertebral segment (List separately in addition to code for primary procedure)
<b>22224</b>	Osteotomy of spine, including discectomy, anterior approach, single vertebral segment; lumbar
<b>+22226</b>	Osteotomy of spine, including discectomy, anterior approach, single vertebral segment, each additional vertebral segment (List separately in addition to code for primary procedure)
<b>22533</b>	Arthrodesis, lateral extracavitary technique, including minimal discectomy to prepare interspace (other than for decompression); lumbar

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Code	Code Description/Definition
<b>+22534</b>	Arthrodesis, lateral extracavitary technique, including minimal discectomy to prepare interspace (other than for decompression); thoracic or lumbar, each additional vertebral segment (List separately in addition to code for primary procedure)
<b>22558</b>	Arthrodesis, anterior interbody technique, including minimal discectomy to prepare interspace (other than for decompression); lumbar
<b>+22585</b>	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)
<b>22586</b>	Arthrodesis, pre-sacral interbody technique, including disc space preparation, discectomy, with posterior instrumentation, with image guidance, includes bone graft when performed, L5-S1 interspace
<b>22612</b>	Arthrodesis, posterior or posterolateral technique, single interspace; lumbar (with lateral transverse technique, when performed)
<b>+22614</b>	Arthrodesis, posterior or posterolateral technique, single interspace; each additional vertebral segment (List separately in addition to code for primary procedure)
<b>22630</b>	Arthrodesis, posterior interbody technique, including laminectomy and/or discectomy to prepare interspace (other than for decompression), single interspace; lumbar
<b>+22632</b>	Arthrodesis, posterior interbody technique, including laminectomy and/or discectomy to prepare interspace (other than for decompression), single interspace; each additional interspace (List separately in addition to code for primary procedure)
<b>22633</b>	Arthrodesis, combined posterior or posterolateral technique with posterior interbody technique including laminectomy and/or discectomy sufficient to prepare interspace (other than for decompression), single interspace; lumbar

Code	Code Description/Definition
<b>+22634</b>	Arthrodesis, combined posterior or posterolateral technique with posterior interbody technique including laminectomy and/or discectomy sufficient to prepare interspace (other than for decompression); each additional interspace (List separately in addition to code for primary procedure)
<b>22800</b>	Arthrodesis, posterior, for spinal deformity, with or without cast; up to 6 vertebral segments
<b>22802</b>	Arthrodesis, posterior, for spinal deformity, with or without cast; 7 to 12 vertebral segments
<b>22804</b>	Arthrodesis, posterior, for spinal deformity, with or without cast; 13 or more vertebral segments
<b>22808</b>	Arthrodesis, anterior, for spinal deformity, with or without cast; 2 to 3 vertebral segments
<b>22810</b>	Arthrodesis, anterior, for spinal deformity, with or without cast; 4 to 7 vertebral segments
<b>22812</b>	Arthrodesis, anterior, for spinal deformity, with or without cast; 8 or more vertebral segments
<b>+22840</b>	Posterior non-segmental instrumentation (e.g. 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)
<b>+22841</b>	Internal spinal fixation by wiring of spinous processes (List separately in addition to code for primary procedure)
<b>+22842</b>	Posterior segmental instrumentation (e.g., pedicle fixation, dual rods with multiple hooks and sublaminar wires); 3 to 6 vertebral segments (List separately in addition to code for primary procedure)

Code	Code Description/Definition
<b>+22843</b>	Posterior segmental instrumentation (e.g., pedicle fixation, dual rods with multiple hooks and sublaminar wires); 7 to 12 vertebral segments (List separately in addition to code for primary procedure)
<b>+22844</b>	Posterior segmental instrumentation (e.g., pedicle fixation, dual rods with multiple hooks and sublaminar wires); 13 or more vertebral segments (List separately in addition to code for primary procedure)
<b>+22845</b>	Anterior instrumentation; 2 to 3 vertebral segments (List separately in addition to code for primary procedure)
<b>+22846</b>	Anterior instrumentation; 4 to 7 vertebral segments (List separately in addition to code for primary procedure)
<b>+22847</b>	Anterior instrumentation; 8 or more vertebral segments (List separately in addition to code for primary procedure)
<b>+22848</b>	Pelvic fixation (attachment of caudal end of instrumentation to pelvic bony structures) other than sacrum (List separately in addition to code for primary procedure)
<b>22849</b>	Reinsertion of spinal fixation device
<b>+22853</b>	Insertion of interbody biomechanical device(s) (e.g., 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)
<b>+22854</b>	Insertion of intervertebral biomechanical device(s) (e.g., 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)

Code	Code Description/Definition
<b>+22859</b>	Insertion of intervertebral biomechanical device(s) (e.g., 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)
<b>0202T</b>	Posterior vertebral joint(s) arthroplasty (e.g., facet joint[s] replacement), including facetectomy, laminectomy, foraminotomy, and vertebral column fixation, injection of bone cement, when performed, including fluoroscopy, single level, lumbar spine
<b>0221T</b>	Placement of a posterior intrafacet implant(s), unilateral or bilateral, including imaging and placement of bone graft(s) or synthetic device(s), single level; lumbar
<b>+0222T</b>	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)

# Evidence Discussion (CMM-609)

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CMM-609: Lumbar Fusion (Arthrodesis)

# Evidence Discussion (CMM-609)

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## Lumbar Fusion (Arthrodesis)

Risks of lumbar fusion surgery include, but are not limited to, the following: infection; neurovascular injury; persistent or incomplete relief of symptoms; pseudoarthrosis; hardware failure; possible need for more surgery; dural tear; deep vein thrombosis; pulmonary embolus; paralysis; and death.<sup>34,66,91,159,185</sup> Given the potential possibility for significant complications, proper surgical candidacy selection is critical to minimize the risk benefit ratio.

As recommended by the North American Spine Society (NASS) *Coverage Policy Recommendations: Lumbar Fusion*, there are multiple indications for fusion, including the following: infection; tumor; traumatic injuries; deformity; stenosis; disc herniation; synovial facet cysts; discogenic low back pain; and pseudoarthrosis.<sup>142</sup>

In the cases of infection, tumor, and traumatic injuries there will be underlying instability or anticipated instability from the appropriate debridement, resection, or decompression. In the cases of stenosis, disc herniation, and synovial cysts there needs to be documented instability or anticipated iatrogenic instability from the approach or need for removal of greater than 50 percent of facets.<sup>120,221</sup>

For discogenic low back pain and pseudoarthrosis, there is need for a longer presence of pain and failed conservative measures. More complex revision surgeries are required for the treatment of pseudoarthrosis and persistent pseudoarthrosis is not uncommon.<sup>49</sup> Regarding fusion surgery for discogenic low back pain, studies have noted no significant differences in outcomes between fusion and non-surgical conservative measures.<sup>26,27</sup> Multiple studies support spinal fusion for spinal stenosis associated with degenerative spondylolisthesis graded of at least Meyerding Grade II.<sup>68,75,91,144,213</sup>

It has been shown in the literature that individuals with psychosocial disorders or with a smoking history undergoing fusion have poorer outcomes and higher complication rates.<sup>45,100</sup> Proper identification and treatment of these conditions prior to surgery may significantly improve many outcome measures.

Evidence supports that the various methods of cotinine testing (serum, saliva, urinary) are sufficiently equivalent in accuracy to confirm nicotine abstinence. Serum testing cutoff values ranged from 3.0ng/mL to 20ng/mL. Salivary testing cutoff values ranged from 10ng/mL to 44ng/mL. Urinary testing cutoff is 10ng/mL.<sup>2,20,42,107</sup>

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1. Abdu RW, Abdu WA, Pearson AM, Zhao W, Lurie JD, Weinstein JN. Reoperation for recurrent intervertebral disc herniation in the Spine Patient Outcomes Research Trial. *Spine*. 2017;42(14):1106-1114.
2. Achilihu H, Feng J, Wang L, Bernert JT. Tobacco use classification by inexpensive urinary cotinine immunoassay test strips. *J Anal Toxicol*. 2019;43(2):149-153. doi:10.1093/jat/bky075.
3. Ahn Y, Youn M, Heo D. Endoscopic transforaminal lumbar interbody fusion: a comprehensive review. *Expert Rev Med Devices*. 2019;16(5):373-380. doi:10.1080/17434440.2019.1610388.
4. Agency for Healthcare Research and Quality (AHRQ). *Evidence Report/Technology Assessment No. 32: Treatment of Degenerative Lumbar Spinal Stenosis Summary (AHRQ publication No. 01-E047)*. March 2001. Rockville, MD. Agency for Healthcare Research and Quality. Available at: <https://archive.ahrq.gov/clinic/epcsums/stenosum.htm>.
5. American Academy of Orthopaedic Surgeons (AAOS®). *Information Statement 1047: The effects of tobacco exposure on the musculoskeletal system*. Feb 2016. © American Academy of Orthopaedic Surgeons (AAOS). Available at: <https://www.aaos.org/globalassets/about/bylaws-library/information-statements/1047-tobacco-use-and-orthopaedic-surgery-3.pdf>.
6. American Academy of Orthopaedic Surgeons (AAOS®). *OrthoInfo: Orthopaedic Surgery and Smoking*. May 2024. © American Academy of Orthopaedic Surgeons (AAOS®). Available at: <https://orthoinfo.aaos.org/en/treatment/surgery-and-smoking>.
7. American College of Occupational and Environmental Medicine (ACOEM). CH 12: Low back complaints. In: *ACOEM Practice Guidelines*. 2<sup>nd</sup> ed. 2008. © American College of Occupational and Environmental Medicine.
8. American College of Occupational and Environmental Medicine (ACOEM). Low back disorders. In: *Occupational Medicine Practice Guidelines: Evaluation and Management of Common Health Problems and Functional Recovery in Workers*. 2<sup>nd</sup> ed. 2007. © American College of Occupational and Environmental Medicine.
9. Anand N, Baron EM, Thaiyananthan G, Khalsa K, Goldstein TB. Minimally invasive multilevel percutaneous correction and fusion for adult lumbar degenerative scoliosis: a technique feasibility study. *J Spinal Disord Tech*. 2008;21(7):459-467.
10. Anand N, Rosemann R, Khalsa B, Baron EM. Mid-term to long-term clinical and functional outcomes of minimally invasive correction and fusion for adults with scoliosis. *Neurosurg Focus*. 2010;28(3):E6.
11. Anderson DG, Samartzis D, Shen FH, Tannoury C. Percutaneous instrumentation of the thoracic and lumbar spine. *Orthop Clin North Am*. 2007;38(3):401-408, vii.
12. Andersen T, Christensen FB, Langdahl BL, et al. Fusion mass bone quality after uninstrumented spinal fusion in older patients. *Eur Spine J*. 2010;19(12):2200-2208.
13. Appaduray SP, Lo P. Effects of diabetes and smoking on lumbar spine surgery outcomes. *J Clin Neurosci*. 2013;20:1713-1717.
14. Applied Spine Technologies, Inc. Stabilimax NZ® Dynamic spine stabilization system. Study enrollment criteria.
15. Aryan HE, Newman CB, Gold JJ, Acosta FL Jr, Coover C, Ames CP. Percutaneous axial lumbar interbody fusion (AxiaLIF) of the L5-S1 segment: initial clinical and radiographic experience. *Minim Invasive Neurosurg*. 2008;51(4):225-230.
16. Audat Z, Moutasem O, Yousef K, Mohammad B. Comparison of clinical and radiological results of posterolateral fusion, posterior lumbar interbody fusion and transforaminal lumbar interbody fusion techniques in the treatment of degenerative lumbar spine. *Singapore Med J*. 2012;53(3):183-187.
17. Bae H. A Prospective, Non-randomized, Multi-Center Evaluation of Interlaminar Lumbar Instrumented (ILF™). Clinicaltrials.gov Identifier: NCT01019057. Available at: <https://clinicaltrials.gov/study/NCT01019057>.
18. Bartynski WS, Lin L. Lumbar root compression in the lateral recess: MR imaging, conventional myelography, and CT myelography comparison with surgical confirmation. *AJNR*. 2003;24(3):348-360.

19. Beastall J, Karadimas E, Siddiqui M, Nicol M, Hughes J, Smith F, Wardlaw D. The Dynesys lumbar spinal stabilization system: a preliminary report on positional magnetic resonance imaging findings. *Spine*. 2007;32(6):685-690.
20. Benowitz NL, Bernert JT, Foulds J, et al. Biochemical verification of tobacco use and abstinence: 2019 update. *Nicotine Tob Res*. 2020;22(7):1086-1097. doi:10.1093/ntr/ntz132.
21. Bothmann M, Kast E, Boldt GJ, Oberle J. Dynesys fixation for lumbar spine degeneration. *Neurosurg Rev*. 2008;31(2):189-196. Epub 2007 Sep 29.
22. Bohinski R, Jain V, Tobler W. Presacral retroperitoneal approach to axial lumbar interbody fusion—a new, minimally invasive technique at L5-S1: clinical outcomes, complications and rates in 50 patients at 1-year follow up. *SAS J*. 2010;(4):54-62.
23. Boonstra AM, Schiphorst Preuper HR, Balk GA, Stewart RE. Cut-off points for mild, moderate, and severe pain on the visual analogue scale for pain in patients with chronic musculoskeletal pain. *Pain*. 2014;155(12):2545-2550. doi:10.1016/j.pain.2014.09.014.
24. Botolin S, Agudelo J, Dwyer A, Patel V, Burger E. High rectal injury during trans-1 axial lumbar interbody fusion L5-S1 fixation. *Spine (Phila Pa 1976)*. 2010;35(4):E144-E148.
25. Brau SA, Delamarter RB, Schiffman ML, Williams LA, Watkins RG. Vascular injury during anterior lumbar surgery. *Spine J*. 2004;4(4):409-412. doi:10.1016/j.spinee.2003.12.003.
26. Brox JI, Nygaard ØP, Holm I, Keller A, Ingebrigtsen T, Reikerås O. Four-year follow-up of surgical versus non-surgical therapy for chronic low back pain. *Ann Rheum Dis*. 2010;69(9):1643-1648. doi:10.1136/ard.2009.108902.
27. Brox JI, Reikerås O, Nygaard Ø, et al. Lumbar instrumented fusion compared with cognitive intervention and exercises in patients with chronic back pain after previous surgery for disc herniation: a prospective randomized controlled study. *Pain*. 2006;122(1-2):145-155. doi:10.1016/j.pain.2006.01.027.
28. Brox JI, Sorensen R, Friis A, et al. Randomized clinical trial of lumbar instrumented fusion and cognitive intervention and exercises in patients with chronic low back pain and disc degeneration. *Spine*. 2003;28(17):1913-1921.
29. Cakir B, Carazzo C, Schmidt R, Mattes T, Reichel H, Käfer W. Adjacent segment mobility after rigid and semirigid instrumentation of the lumbar spine. *Spine*. 2009;34(12):1287-1291.
30. Canale: *Arthrodesis. Lumbar spine*. Campbell's Operative Orthopaedics. 10<sup>th</sup> ed. Mosby, Inc. 2003:1704-1712.
31. Canale and Beaty: Degenerative spondylolisthesis and scoliosis. *Campbells Operative Orthopaedics*. 11<sup>th</sup> ed. 2007. Mosby, Inc.
32. Carragee EJ, Lincoln T, Parmar VS, Alamin T. A gold standard evaluation of the "discogenic pain" diagnosis as determined by provocative discography. *Spine*. 2006;31(18):2115-2123.
33. Carreon LY, Glassman SD, Howard J. Fusion and nonsurgical treatment for symptomatic lumbar degenerative disease: a systematic review of Oswestry Disability Index and MOS Short Form-36 outcomes. *Spine J*. 2008;8(5):747-755.
34. Chang R, Reddy RP, Coutinho DV, et al. Diagnostic accuracy of SSEP changes during lumbar spine surgery for predicting postoperative neurological deficit: a systematic review and meta-analysis. *Spine (Phila Pa 1976)*. 2021;46(24):E1343-E1352. doi:10.1097/BRS.0000000000004099.
35. Chaput C, Padon D, Rush J, Lenehan E, Rahm M. The significance of increased fluid signal on magnetic resonance imaging in lumbar facets in relationship to degenerative spondylolisthesis. *Spine*. 2007;32(17):1883-1887.
36. Cheung JPY. The importance of sagittal balance in adult scoliosis surgery. *Ann Transl Med*. 2020;8(2):35. doi:10.21037/atm.2019.10.19.
37. Choi JH, Ochoa JK, Lubinus A, Timon S, Lee Y, Bhatia NN. Management of lumbar spondylolysis in the adolescent athlete: a review of over 200 cases. *Spine J*. 2022;22(10):1628-1633. doi:10.1016/j.spinee.2022.04.011.
38. Choma TJ, Schuster JM, Norvell DC, Dettori JR, Chutkan NB. Fusion versus nonoperative management for chronic low back pain: do comorbid diseases or general health factors affect outcome? *Spine (Phila Pa 1976)*. 2011;36(21 Suppl):S87-S95.
39. Chou R, Loeser JD, Owens DK, et al; American Pain Society Low Back Pain Guideline Panel. Interventional therapies, surgery, and interdisciplinary rehabilitation for low back pain: an evidence-based clinical practice guideline from the American Pain Society. *Spine (Phila Pa 1976)*. 2009;34(10):1066-1077.

40. Chung SK, Lee SH, Lim SR, et al. Comparative study of laparoscopic L5-S1 fusion versus open mini-ALIF, with a minimum 2-year follow-up. *Eur Spine J*. 2003;12(6):613-617. Epub 2003 Oct 17.
41. Cohen SP, Hanling S, Bicket MC, et al. Epidural steroid injections compared with gabapentin for lumbosacral radicular pain: multicenter randomized double blind comparative efficacy study. *BMJ*. 2015;350:h1748. doi: 10.1136/bmj.h1748.
42. Cooke F, Bullen C, Whittaker R, McRobbie H, Chen MH, Walker N. Diagnostic accuracy of NicAlert cotinine test strips in saliva for verifying smoking status. *Nicotine Tob Res*. 2008;10(4):607-612. doi:10.1080/14622200801978680.
43. Cowan JA Jr, Dimick JB, Wainess R, Upchurch GR Jr, Chandler WF, La Marca F. Changes in the utilization of spinal fusion in the United States. *Neurosurgery*. 2006;59(1):15-20.
44. Dakwar E, Cardona RF, Smith DA, Uribe JS. Early outcomes and safety of the minimally invasive, lateral retroperitoneal transpsoas approach for adult degenerative scoliosis. *Neurosurg Focus*. 2010;28(3):E8.
45. Daniell JR, Osti OL. Failed back surgery syndrome: a review article. *Asian Spine J*. 2018;12(2):372-379. doi:10.4184/asj.2018.12.2.372.
46. Danielsson, A. Natural history of adolescent idiopathic scoliosis: a tool for guidance in decision of surgery of curves above 50°. *J Child Orthop*. 2013;7:37-41. doi:10.1007/s11832-012-0462-7.
47. Davis R, Auerbach JD, Bae H, Errico TJ. Can low-grade spondylolisthesis be effectively treated by either coflex interlaminar stabilization or laminectomy and posterior spinal fusion? Two-year clinical and radiographic results from the randomized, prospective, multicenter US investigational device exemption trial: clinical article. *J Neurosurg Spine*. 2013;19(2):174-184. doi:10.3171/2013.4.SPINE12636.
48. Davis RJ, Errico TJ, Bae H, et al. Decompression and coflex interlaminar stabilization compared with decompression and instrumented spinal fusion for spinal stenosis and low-grade degenerative spondylolisthesis: two-year results from the prospective, randomized, multicenter, Food and Drug Administration Investigational Device Exemption trial. *Spine (Phila Pa 1976)*. 2013;38(18):1529-1539. doi:10.1097/BRS.0b013e31829a6d0a.
49. Derman PB, Singh K. Surgical Strategies for the Treatment of Lumbar Pseudarthrosis in Degenerative Spine Surgery: A Literature Review and Case Study. *HSS J*. 2020;16(2):183-187. doi:10.1007/s11420-019-09732-9.
50. Devereaux MW. Low back pain. *Prim Care*. 2004;31(1):33-51. doi:10.1016/S0095-4543(03)00114-3.
51. Deyo RA, Mirza SK, Martin BI, Kreuter W, Goodman DC, Jarvik JG. Trends, major medical complications, and charges associated with surgery for lumbar spinal stenosis in older adults. *JAMA*. 2010;303(13):1259-1265.
52. Diebo BG, Varghese JJ, Lafage R, Schwab FJ, Lafage V. Sagittal alignment of the spine: What do you need to know? *Clin Neurol Neurosurg*. 2015;139:295-301. doi:10.1016/j.clineuro.2015.10.024.
53. Donnally C, Patel P, Canseco J, et al. Current incidence of adjacent segment pathology following lumbar fusion versus motion-preserving procedures: a systematic review and meta-analysis of recent projections. *Spine J*. 2020;20(10):1554-1565. doi:10.1016/j.spinee.2020.05.100.
54. Dorward IG, Lenke LG. Osteotomies in the posterior-only treatment of complex adult spinal deformity: a comparative review. *Neurosurg Focus*. 2010;28(3):E4. doi:10.3171/2009.12.focus09259.
55. Du MR, Wei FL, Zhu KL, et al. Coflex interspinous process dynamic stabilization for lumbar spinal stenosis: Long-term follow-up. *J Clin Neurosci*. 2020;81:462-468. doi:10.1016/j.jocn.2020.09.040.
56. Durrani A, Mistur R, Shanti N. Presacral Approach for L5-S1 Fusion. *Techniques in Orthopaedics*. 2011;26(3):166-172. doi:10.1097/BTO.0b013e31822ce192.
57. Eck JC, Hodges S, Humphreys SC. Minimally invasive lumbar spinal fusion. *J Am Acad Orthop Surg*. 2007;15(6):321-329. doi:10.5435/00124635-200706000-00001.
58. Eck JC, Sharan A, Ghogawala Z, et al. Guideline update for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 7: Lumbar fusion for intractable low-back pain without stenosis or spondylolisthesis. *J Neurosurg Spine*. 2014;21:42-47.
59. ECRI Institute. Hotline Response [database online]. Plymouth Meeting (PA): ECRI Institute. 2009. *Dynamic pedicle-and screw-based stabilization systems for chronic back pain*.
60. ECRI Institute. Hotline Response [database online]. Plymouth Meeting (PA): ECRI Institute. 2010. *iFuse Implant system for sacroiliac joint arthrodesis*.
61. ECRI Institute. Hotline Response [database online]. Plymouth Meeting (PA): ECRI Institute. *Minimally Invasive Spinal Fusion Surgery Using eXtreme Lateral Interbody Fusion OR Axial Lumbar Interbody Fusion for Low-back Pain*. 2009.

62. ECRI Institute. Hotline Response [database online]. Plymouth Meeting (PA): ECRI Institute. *Semi-rigid spinal stabilization systems for use in non-cervical spinal fusion surgery*. 2006.
63. ECRI Institute. *Spinal fusion and discography for chronic low back pain and uncomplicated lumbar degenerative disc disease (Washington HTA)*. Plymouth Meeting (PA): ECRI Institute Health Technology Assessment Information Service; 2007;(Evidence Report).
64. Fairbank J, Frost H, Wilson-MacDonald J, et al. Randomised controlled trial to compare surgical stabilization of the lumbar spine with an intensive rehabilitation programme for patients with chronic low back pain: the MRC spine stabilisation trial [published correction appears in *BMJ*. 2005 Jun 25;330(7506):1485]. *BMJ*. 2005;330(7502):1233. doi:10.1136/bmj.38441.620417.8F.I.
65. 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):1089-1094.
66. Fineberg SJ, Oglesby M, Patel AA, Pelton MA, Singh K. The Incidence and Mortality of Thromboembolic Events in Lumbar Spine Surgery. *Spine*. 2013;38(13):1154-1159. doi:10.1097/brs.0b013e318286b7c0.
67. Forbin W, Brinckmann P, Leivseth G, Biggemann, Reikerås O. Precision measurement of segmental motion from flexion-extension radiographs of the lumbar spine. *Clin Biomech*. 1996;11(8):457-465. doi:10.1016/s0268-0033(96)00039-3.
68. Försth P, Ólafsson G, Carlsson T, et al. A randomized, controlled trial of fusion surgery for lumbar spinal stenosis. *N Engl J Med*. 2016;374(15):1413-1423. doi:10.1056/NEJMoa1513721.
69. Fu TS, Lai PL, Tsai TT, Niu CC, Chen LH, Chen WJ. Long term results of disc excision for recurrent lumbar disc herniation with or without posterolateral fusion. *Spine*. 2005;30(24):2830-2834.
70. Fujibayashi S, Neo M, Takemoto M, Ota M, Nakamura T. Paraspinal-approach transforaminal lumbar interbody fusion for the treatment of lumbar foraminal stenosis. *J Neurosurg Spine*. 2010;13(4):500-508.
71. Gelalis ID, Kang JD. Thoracic and lumbar fusions for degenerative disorders: rationale for selecting the appropriate fusion techniques. *Orthop Clin North Am*. 1998;29(4):829-842.
72. Gerszten PC, Tobler W, Raley TJ, Miller LE, Block JE, Nasca RJ. Axial Presacral Lumbar Interbody Fusion and Percutaneous Posterior Fixation for Stabilization of Lumbosacral Isthmic Spondylolisthesis. *J Spinal Disord Tech*. 2012;25(2):E36-E40. doi:10.1097/BSD.0b013e318233725e.
73. Ghiselli G, Wang JC, Bhatia NN, Hsu WK, Dawson EG. Adjacent segment degeneration in the lumbar spine. *J Bone Joint Surg Am*. 2004;86-A(7):1497-1503.
74. Ghogawala Z, Benzel EC, Amin-Hanjani S, et al. Prospective outcomes evaluation after decompression with or without instrumented fusion for lumbar stenosis and degenerative Grade I spondylolisthesis. *J Neurosurg Spine*. 2004;1(3):267-272.
75. Ghogawala Z, Dziura J, Butler W, et al. Laminectomy plus fusion versus laminectomy alone for lumbar spondylolisthesis. *N Engl J Med*. 2016;374(15):1424-1434. doi:10.1056/nejmoa1508788.
76. Gibson JNA, Waddell G. Surgery for degenerative lumbar spondylosis. *Cochrane Database Syst Rev*. 1999;Issue 1. Updated 2005. In: The Cochrane Library. ©2007 The Cochrane Collaboration.
77. 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):2608-2615.
78. Glassman SD, Carreon LY, Djurasovic M, et al. Lumbar fusion outcomes stratified by specific diagnostic indication. *Spine J*. 2009;9(1):13-21. doi:10.1016/j.spinee.2008.08.011.
79. Graham RB, Sugrue PA, Koski TR. Adult degenerative scoliosis. *Clin Spine Surg*. 2016;29(3):95-107. doi:10.1097/BSD.0000000000000367.
80. Grob D, Benini A, Junge A, Mannion AM. Clinical experience with the dynesys semirigid fixation system for the lumbar spine. Surgical and patient-oriented outcome in 50 cases after an average of 2 years. *Spine*. 2005;30(3):324-331.
81. Gundanna M, Miller L, Block J. Complications with axial presacral lumbar interbody fusion: a five year postmarket surveillance experience. *SAS J*. 2011;5:90-94.
82. Guyton JL, Perez EA. Ch 53: Fractures of Acetabulum and Pelvis. In: *Canale & Beaty: Campbell's Operative Orthopaedics*. 11<sup>th</sup> ed. ©2007.
83. Halanski MA, Cassidy JA. Do multilevel Ponte osteotomies in thoracic idiopathic scoliosis surgery improve curve correction and restore thoracic kyphosis?. *J Spinal Disord Tech*. 2013;26(5):252-255. doi:10.1097/BSD.0b013e318241e3cf.

84. Hanley EN, David SM. Current concepts review—lumbar arthrodesis for the treatment of back pain. *J Bone Joint Surg Am*. 1999;81-A(5):716-730.
85. Hansen H, Manchikanti L, Simopoulos TT, et al. A systematic evaluation of the therapeutic effectiveness of sacroiliac joint interventions. *Pain Physician*. 2012;15(3):E247-E278.
86. Harris EB, Massey P, Lawrence J, Rihn J, Vaccaro A, Anderson DG. Percutaneous techniques for minimally invasive posterior lumbar fusion. *Neurosurg Focus*. 2008;25(2):E12.
87. Heim SE, Altimari A. Laparoscopic approaches to fusion of the lumbosacral spine: latest techniques. *Orthop Clin North Am*. 2002;33(2):413-420.
88. Heindel P, Tuchman A, Hsieh PC, et al. Reoperation rates after single-level lumbar discectomy. *Spine*. 2017;42(8):E496-E501.
89. Heo D, Son S, Eum J, Park C. Fully endoscopic lumbar interbody fusion using a percutaneous unilateral biportal endoscopic technique: technical note and preliminary clinical results. *Neurosurg Focus*. 2017;43(2):E8. doi:10.3171/2017.5.focus17146.
90. Herkowitz HN. Spine update. Degenerative lumbar spondylolisthesis. *Spine*. 1995;20(9):1084-1090. doi:10.1097/00007632-199505000-00018.
91. Herkowitz HN, Kurz LT. Degenerative lumbar spondylolisthesis with spinal stenosis. A prospective study comparing decompression with decompression and intertransverse process arthrodesis. *J Bone Joint Surg Am*. 1991;73(6):802-808.
92. Hsu CJ, Chou WY, Chang WN, Wong CY. Clinical follow up after instrumentation-augmented lumbar spinal surgery in patients with unsatisfactory outcomes. *J Neurosurg Spine*. 2006;5(4):281-286.
93. Hu Y, Gu YJ, Xu RM, Zhou LJ, Ma WH. Short-term clinical observation of the Dynesys neutralization system for the treatment of degenerative disease of the lumbar vertebrae. *Orthop Surg*. 2011;3(3):167-175. doi:10.1111/j.1757-7861.2011.00142.x.
94. Huarn KF, Chen TY. Clinical results of single central interbody fusion case and transpedicle screws fixation for recurrent herniated lumbar disc and low-grade spondylolisthesis. *Chang Gung Med J*. 2003;26:170-177.
95. Ibrahim T, Tleyjeh IM, Gabbar O. Surgical versus non-surgical treatment of chronic low back pain: a meta-analysis of randomised trials. *Int Orthop*. 2008;32(1):107-113.
96. Inamasu J, Guiot BH. Laparoscopic anterior lumbar interbody fusion: a review of outcome studies. *Minim Invasive Neurosurg*. 2005;48(6):340-347.
97. Institute for Clinical Systems Improvement (ICSI). *Adult Acute and Subacute Low Back Pain*. 16<sup>th</sup> ed. Mar 2018. Bloomington, MN. © Institute for Clinical Systems Improvement. Available at: <https://www.icsi.org/guideline/low-back-pain/>.
98. International Society for Advancement of Spine Surgery (ISASS). *Policy Statement on Lumbar Spinal Fusion Surgery*. July 2011. Available at: <https://isass.org/isass-policy-statement-on-lumbar-spinal-fusion-surgery/>.
99. Jackson KL, Devine JG. The effects of smoking and smoking cessation on spine surgery: a systemic review of the literature. *Global Spine J*. 2016; 6(7):695-701. doi:10.1055/s-0036-1571285.
100. Jackson KL, Rumley J, Griffith M, Agochukwu U, DeVine J. Correlating psychological comorbidities and outcomes after spine surgery. *Global Spine J*. 2020;10(7):929-939. doi:10.1177/2192568219886595.
101. 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.
102. Kalakoti P, Sciubba DM, Pugely AJ, et al. Impact of psychiatric comorbidities on short-term outcomes following intervention for lumbar degenerative disc disease. *Spine*. 2018;43(19):1363-1371. doi:10.1097/BRS.0000000000002616.
103. Kamson S, Lu D, Sampson P, Zhang Y. Full-endoscopic lumbar fusion outcomes in patients with minimal deformities: a retrospective study of data collected between 2011 and 2015. *Pain Physician*. 2019;1(22;1):75-88. doi:10.36076/ppj/2019.22.75.
104. Kelly DM, McCarthy RE, McCullough FL, Kelly HR. Long-term outcomes of anterior spinal fusion with instrumentation for thoracolumbar and lumbar curves in adolescent idiopathic scoliosis. *Spine*. 2010;35(2):194-198. doi:10.1097/BRS.0b013e3181bc948e.
105. Kelly MP, Mok JM, Berven S. Dynamic constructs for spinal fusion: an evidence-based review. *Orthop Clin North Am*. 2010;41(2):203-215.

106. Kim S. Overview of cotinine cutoff values for smoking status classification. *Int J Environ Res Public Health*. 2016;13(12):1236. Published 2016 Dec 14. doi:10.3390/ijerph13121236.
107. Kim J, Yoo H, Choi D, Park E, Jee S. Comparison of minimal invasive versus biportal endoscopic transforaminal lumbar interbody fusion for single-level lumbar disease. *Clin Spine Surg*. 2020;34(2):E64-E71. doi:10.1097/bsd.0000000000001024.
108. Kleimeyer JP, Cheng I, Alamin TF, et al. Selective anterior lumbar interbody fusion for low back pain associated with degenerative disc disease versus nonsurgical management. *Spine*. 2018;43(19):1372-1380. doi:10.1097/BRS.0000000000002630.
109. Kong CB, Jeon DW, Chang BS, Lee JH, Suk KS, Park JB. Outcome of spinal fusion for lumbar degenerative disease: a cross-sectional study in Korea. *Spine (Phila Pa 1976)*. 2010;35(15):1489-1494.
110. Knight RQ, Schwaegler P, Hanscom D, Roh J. Direct lateral lumbar interbody fusion for degenerative conditions: early complication profile. *J Spinal Disord Tech*. 2009;22(1):34-37.
111. Koslosky E, Gendelberg D. Classification in Brief. *Clin Orthop Relat Res*. 2020;478(5):1125-1130. doi:10.1097/corr.0000000000001153.
112. Kreiner DS, Shaffer WO, Baisden JL, et al. NASS. An evidence-based clinical guideline for the diagnosis and treatment of degenerative lumbar spinal stenosis (update). *Spine J*. 2013;13(7):734-743.
113. Kuhns BD, Kouk S, Buchanan C, et al. Sensitivity of magnetic resonance imaging in the diagnosis of mobile and non-mobile L4-5 degenerative spondylolisthesis. *Spine J*. 2014. doi: 10.1016/j.spinee.2014.08.006.
114. Kumar A, Beastall J, Hughes J, et al. Disc changes in the bridged and adjacent segments after Dynesys dynamic stabilization system after two years. *Spine*. 2008;33(26):2909-2914.
115. 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):892-896.
116. Kwon B, Kim DH. Review article: lateral lumbar interbody fusion: indications, outcomes and complications. *J Am Acad Orthop Surgery*. 2016;24:96-105.
117. La Marca F, Brumblay H, Smith-Petersen osteotomy in thoracolumbar deformity surgery. *Neurosurgery*. 2008;63(3):A163-A170. doi:10.1227/01.neu.0000320428.67620.4f.
118. Lambrechts ML, D'Antonio ND, Karamian BA, et al. What is the role of dynamic cervical spine radiographs in predicting pseudarthrosis revision following anterior cervical discectomy and fusion? *Spine J*. 2022; 22(10):1610-1621. doi:10.1016/j.spinee.2022.04.020.
119. Lee BS, Nault R, Grabowski M, et al. Utility of repeat magnetic resonance imaging in surgical patients with lumbar stenosis without disc herniation. *Spine J*. 2019;19(2):191-198. doi:10.1016/j.spinee.2018.06.357.
120. Lee KK, Teo EC. Effects of laminectomy and facetectomy on the stability of the lumbar motion segment. *Med Eng Phys*. 2004;26(3):183-192. doi:10.1016/j.medengphy.2003.11.006.
121. Li AM, Li X, Yang Z. Decompression and coflex interlaminar stabilisation compared with conventional surgical procedures for lumbar spinal stenosis: A systematic review and meta-analysis. *Int J Surg*. 2017;40:60-67. doi:10.1016/j.ijssu.2017.02.056.
122. Li T, Yan J, Ren Q, Hu J, Wang F, Liu X. Efficacy and safety of lumbar dynamic stabilization device Coflex for lumbar spinal stenosis: a systematic review and meta-analysis. *World Neurosurg*. 2023;170:7-20. doi:10.1016/j.wneu.2022.11.141.
123. Lindley EM, McCullough MA, Burger EL, Brown CW, Patel VV. Complications of axial lumbar interbody fusion. *J Neurosurg Spine*. 2011;15(3):273-279. doi:10.3171/2011.3.SPINE10373.
124. Lindstrom D, Azodi OS, Wladis A, et al. Effects of a perioperative smoking cessation intervention on postoperative complications: a randomized trial. *Ann Surg*. 2008;248:739-745.
125. Lubelski D, Williams SK, O'Rourke C, et al. Differences in the surgical treatment of lower back pain among spine surgeons in the United States. *Spine*. 2016;41(11):978-986.
126. Lurie JD, Tosteson AN, Tosteson TD, et al. Reliability of magnetic resonance imaging readings for lumbar disc herniation in patients with symptomatic lumbar spine disc herniations in the spine outcomes research trial (SPORT). *Spine*. 2008;33:991-998.
127. Lurie JD, Doman DM, Spratt KF, et al. Patients with symptomatic lumbar spine disc herniations. *Spine*. 2009;34:701-705.
128. Mamisch N, Brumann M, Hodler J, Held U, Brunner F, Steurer J. Radiologic criteria for the diagnosis of spinal stenosis. *Radiology*. 2012;264 (1):174-179.

129. Marchi L, Oliveira L, Coutinho E, Pimenta L. Results and complications after 2-level axial lumbar interbody fusion with a minimum 2-year follow-up. *J Neurosurg Spine*. 2012;17:187–192.
130. Marotta N, Cosar M, Pimenta L, Khoo LT. A novel minimally invasive presacral approach and instrumentation technique for anterior L5-S1 intervertebral discectomy and fusion: technical description and case presentations. *Neurosurg Focus*. 2006;20(1):E9.
131. Martin CT, Gao Y, Duchman KR, Pugely AJ. The impact of current smoking and smoking cessation on short-term morbidity risk after lumbar spine surgery. *Spine*. 2016;41(7):577-584.
132. Matz PG, Meagher RJ, Lamer T, et al. Guideline summary review: An evidence-based clinical guideline for the diagnosis and treatment of degenerative lumbar spondylolisthesis. *Spine J*. 2016;16(3):439-448.
133. McAfee P, Khoo LT, Pimenta L, et al. Treatment of lumbar spinal stenosis with a total posterior arthroplasty prosthesis: implant description, surgical technique, and a prospective report on 29 patients. *Neurosurg Focus*. 2007;22(1):E13. doi:10.3171/foc.2007.22.1.13.
134. Miller DJ, Cahill PJ, Vitale MG, Shah SA. Posterior correction techniques for adolescent idiopathic scoliosis. *JAAOS*. 2020;28(9):e363-e373. doi:10.5435/jaaos-d-18-00399.
135. 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):144-154.
136. Mirza SK, Deyo RA. Systematic review of randomized trials comparing lumbar fusion surgery to nonoperative care for treatment of chronic back pain. *Spine (Phila Pa 1976)*. 2007;32(7):816-823.
137. Moojen WA, Arts MP, Bartels RH, Jacobs WC, Peul WC. Effectiveness of interspinous implant surgery in patients with intermittent neurogenic claudication: a systematic review and meta-analysis. *Eur Spine J*. 2011;20(10):1596-1606.
138. Moller AM, Villebro N, Pedersen T, et al. Effect of preoperative smoking intervention on postoperative complications: a randomized clinical trial. *Lancet*. 2002;359:114-117.
139. Musacchio MJ, Lauryssen C, Davis RJ, et al. Evaluation of decompression and interlaminar stabilization compared with decompression and fusion for the treatment of lumbar spinal stenosis: 5-year follow-up of a prospective, randomized, controlled trial. *Int J Spine Surg*. 2016;10(6). doi:10.14444/3006.
140. Myers K, Hajek P, Hinds C, et al. Stopping smoking shortly before surgery and postoperative complications: a systematic review and meta-analysis. *Arch Intern Med*. 2011;171:983-989.
141. North American Spine Society (NASS). *Appropriate Use Criteria: Degenerative Lumbar Spondylolisthesis*. 2020. Burr Ridge, IL. © North American Spine Society (NASS). Available at: <https://www.spine.org/Research/Appropriate-Use-Criteria>.
142. North American Spine Society (NASS). *Coverage Policy Recommendations: Lumbar Discectomy*. Dec 2019. Burr Ridge, IL. © North American Spine Society (NASS). Available at: <https://www.spine.org/coverage>.
143. North American Spine Society (NASS). *Coverage Policy Recommendations: Lumbar Fusion*. 2021. Burr Ridge, IL. © North American Spine Society (NASS). Available at: <https://www.spine.org>.
144. North American Spine Society (NASS). *Evidence-Based Clinical Guidelines for Multidisciplinary Spine Care: Diagnosis and Treatment of Degenerative Lumbar Spinal Stenosis*. Revised 2014. Burr Ridge, IL. © North American Spine Society (NASS). Available at: <https://www.spine.org>.
145. North American Spine Society (NASS). *Evidence-Based Clinical Guidelines for Multidisciplinary Spine Care: Diagnosis and Treatment of Degenerative Lumbar Spondylolisthesis*. Revised 2014. Burr Ridge, IL. © North American Spine Society (NASS). Available at: <https://www.spine.org>.
146. North American Spine Society (NASS). *Public Education Series: Bone Graft Alternatives*. 2006. Burr Ridge, IL. © North American Spine Society (NASS). Available at [www.knowyourback.org](http://www.knowyourback.org).
147. O'Donnell JA, Anderson JT, Haas AR, Percy R, Woods ST, Ahn UM, Ahn NU. Treatment of recurrent lumbar disc herniation with or without fusion in workers' compensation subjects. *Spine*. 2017;42(14):E864-E870.
148. Oster BA, Kikanloo SR, Levine NL, Lian J, Cho W. Systematic review of outcomes following 10-year mark of spine patient outcomes research trial (SPORT) for degenerative spondylolisthesis. *Spine*. 2020;45(12):820-824. doi:10.1097/brs.00000000000003485.
149. Oster BA, Kikanloo SR, Levine NL, Lian J, Cho W. Systematic review of outcomes following 10-year mark of spine patient outcomes research trial (SPORT) for intervertebral disc herniation. *Spine*. 2020;45(12):825-831. doi:10.1097/brs.00000000000003400.
150. Oster BA, Kikanloo SR, Levine NL, Lian J, Cho W. Systematic review of outcomes following 10-year mark of spine patient outcomes research trial (SPORT) for spinal stenosis. *Spine*. 2019;45(12):832-836. doi:10.1097/brs.00000000000003323.

151. Ozgur BM, Aryan HE, Pimenta L, Taylor WR. Extreme lateral interbody fusion (XLIF): a novel surgical technique for anterior lumbar interbody fusion. *Spine J.* 2006;6(4):435-443.
152. Panagopoulos J, Hush J, Steffens D, et al. Do MRI findings change over a period of up to 1 year in patients with low back pain and/or sciatica? *Spine.* 2017;42:504-512.
153. Park P, Foley KT. Minimally invasive transforaminal lumbar interbody fusion with reduction of spondylolisthesis: technique and outcomes after a minimum of 2 years' follow-up. *Neurosurg Focus.* 2008;25(2):E16.
154. Park Y, Ha JW. Comparison of one-level posterior lumbar interbody fusion performed with a minimally invasive approach or a traditional open approach. *Spine.* 2007;32(5):537-543.
155. Patil SS, Lindley EM, Patel VV, Burger EL. Clinical and radiological outcomes of axial lumbar interbody fusion. *Orthopedics.* 2010;33(12):883. doi: 10.3928/01477447-20101021-05.
156. Pazarlis K, Frost A, Försth P. Lumbar spinal stenosis with degenerative spondylolisthesis treated with decompression alone. a cohort of 346 patients at a large spine unit. clinical outcome, complications and subsequent surgery. *Spine (Phila Pa 1976).* 2021;47(6):470-475. doi:10.1097/brs.0000000000004291.
157. Phillips FM, Tzermiadianos MN, Voronov LI, et al. Effect of the total facet arthroplasty system after complete laminectomy-facetectomy on the biomechanics of implanted and adjacent segments. *Spine J.* 2009;9(1):96-102.
158. Poorman GW, Moon JY, Wang C, et al. Rates of mortality in lumbar spine surgery and factors associated with its occurrence over a 10-year period: a study of 803,949 patients in the nationwide inpatient sample. *Int J Spine Surg.* 2018;12(5):617-623. doi:10.14444/5076.
159. Raizman NM, O'Brien JR, Poehling-Monaghan KL, Yu WD. Pseudarthrosis of the spine. *JAAOS.* 2009;17(8):494-503. doi:10.5435/00124635-200908000-00003.
160. 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;10(3):ZE04-ZE06.
161. Resnick DK, Choudhri TF, Dailey AT, et al. Guidelines for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 4: radiographic assessment of fusion. *J Neurosurg Spine.* 2005;2(6):653-657.
162. Resnick DK, Choudhri TF, Dailey AT, et al. Guidelines for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 5: correlation between radiographic and functional outcome. *J Neurosurg Spine.* 2005;2(6):658-661.
163. Resnick DK, Choudhri TF, Dailey AT, et al. Guidelines for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 6: magnetic resonance imaging and discography for patient selection for lumbar fusion. *J Neurosurg Spine.* 2005;2(6):662-669.
164. Resnick DK, Choudhri TF, Dailey AT, et al. Guidelines for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 7: intractable low-back pain without stenosis or spondylolisthesis. *J Neurosurg Spine.* 2005;2(6):670-672.
165. Resnick DK, Choudhri TF, Dailey AT, et al. Guidelines for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 8: lumbar fusion for disc herniation and radiculopathy. *J Neurosurg Spine.* 2005;2(6):673-678.
166. Resnick DK, Choudhri TF, Dailey AT, et al. Guidelines for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 9: fusion in patients with stenosis and spondylolisthesis. *J Neurosurg Spine.* 2005;2(6):679-685.
167. Resnick DK, Choudhri TF, Dailey AT, et al. Guidelines for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 10: fusion following decompression in patients with stenosis without spondylolisthesis. *J Neurosurg Spine.* 2005;2(6):686-691.
168. Resnick DK, Choudhri TF, Dailey AT, et al. Guidelines for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 11: interbody techniques for lumbar fusion. *J Neurosurg Spine.* 2005;2(6):692-699.
169. Resnick DK, Choudhri TF, Dailey AT, et al. Guidelines for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 12: pedicle screw fixation as an adjunct to posterolateral fusion for low-back pain. *J Neurosurg Spine.* 2005;2(6):700-706.
170. Resnick DK, Choudhri TF, Dailey AT, et al. Guidelines for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 16: bone graft extenders and substitutes. *J Neurosurg Spine.* 2005;2(6):733-736.
171. Ries ZG, Glassman SD, Vasilyev I, Metcalfe L, Carreon LY. Updated imaging does not affect revision rates in adults undergoing spine surgery for lumbar degenerative disease. *J Neurosurg Spine.* 2019;30(2):228-223. doi:10.3171/2018.8.spine18586.

172. Rodgers WB, Cox CS, Gerber EJ. Early complications of extreme lateral interbody fusion in the obese. *J Spinal Disord Tech*. 2010;23(6):393-397. doi:10.1097/BSD.0b013e3181b31729.
173. Rodgers WB, Gerber EJ, Patterson JR. Fusion after minimally disruptive anterior lumbar interbody fusion: Analysis of extreme lateral interbody fusion by computed tomography. *SAS J*. 2010;4(2):63-66. doi:10.1016/j.esas.2010.03.001.
174. Saifi C, Laratta JL, Petridis P, Shillingford JN, Lehman RA, Lenke LG. Vertebral column resection for rigid spinal deformity. *Global Spine J*. 2017;7(3):280-290. doi:10.1177/2192568217699203.
175. Schaeren S, Broger I, Jeanneret B. Minimum four-year follow-up of spinal stenosis with degenerative spondylolisthesis treated with decompression and dynamic stabilization. *Spine*. 2008;33(18):E636-E642.
176. Schnake KJ, Schaeren S, Jeanneret B. Dynamic stabilization in addition to decompression for lumbar spinal stenosis with degenerative spondylolisthesis. *Spine*. 2006;31(4):442-449.
177. Schwarzenbach O, Berlemann U, Stoll TM, Dubois G. Posterior dynamic stabilization systems: DYNESYS. *Orthop Clin North Am*. 2005;36(3):363-372.
178. Sengupta D. Dynamic stabilization devices in the treatment of low back pain. *Orthop Clin North Am*. 2004;35(10):43-56. doi:10.1016/S0030-5898(03)00087-7.
179. Sengupta DK, Herkowitz HN. Lumbar spinal stenosis: treatment strategies and indications for surgery. *Orthop Clin North Am*. 2003;34(2):281-295.
180. Shafshak TS, Elnemr R. The visual analogue scale versus numerical rating scale in measuring pain severity and predicting disability in low back pain. *J Clin Rheumatol*. 2020;27(7):1. doi:10.1097/rhu.0000000000001320.
181. Siecean A, Seicean S, Alan N, et al. Effect of smoking on the perioperative outcomes of patients who undergo elective spine surgery. *Spine*. 2013;38:1294-1302. doi:10.1097/BRS.0b013e31828e2747.
182. Simpson A, Lightsey H, Xiong G, Crawford A, Minamide A, Schoenfeld A. Spinal endoscopy: evidence, techniques, global trends, and future projections. *Spine J*. 2022;22(1):64-74. doi:10.1016/j.spinee.2021.07.004.
183. 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.
184. Sivaganesan A, Kim HJ. A review of indications, surgical technique, and outcomes for the cervical pedicle subtraction osteotomy. *JAAOS*. 2022;30(3):e295-e300. doi:10.5435/jaaos-d-21-00177.
185. Smith JS, Saulle D, Chen CJ, et al. Rates and causes of mortality associated with spine surgery based on 108,419 procedures: a review of the Scoliosis Research Society Morbidity and Mortality Database. *Spine (Phila Pa 1976)*. 2012;37(23):1975-1982. doi:10.1097/BRS.0b013e318257fada.
186. Smith JS, Shaffrey CI, Glassman SD, et al. Risk-benefits assessment of surgery for adult scoliosis: An analysis based on patient age. *Spine*. 2011;36(10):817-824.
187. Smith JS, Shaffrey CI, Lafage V, et al. Comparison of best versus worst clinical outcomes for adult spinal deformity surgery: A retrospective review of a prospectively collected, multicenter database with 2-year follow-up. *J Neurosurg Spine*. 2015;23(3):349-59.
188. Society for Minimally Invasive Spine Surgery (SMISS). Position statement on presacral lumbar interbody fusion. February 29, 2012.
189. Sonntag VKH, Marciano FF. Is fusion indicated for lumbar spinal disorders? *Spine*. 1995;20(24 Supp):138S-142S.
190. Sorensen LT. Wound healing and infection in surgery: the pathophysiological impact of smoking, smoking cessation, and nicotine replacement therapy: a systemic review. *Ann Surg*. 2012;255:1069-1079. doi:10.1097/SLA.0b013e31824f632d.
191. Spinelli J, Rainville J. CH 45. Lumbar spondylolysis and spondylolisthesis. In: Frontera WR, Silver JK, Rizzo TD Jr, eds. *Essentials of Physical Medicine and Rehabilitation*. 2<sup>nd</sup> ed. ©2008. Saunders Elsevier. ISBN 978-1-4160-4007-1.
192. Tajima N, Chosa E, Watanabe S. Posterolateral lumbar fusion. *J Orthop Sci*. 2004;9(3):327-333.
193. Tang G, Rodts G, Haid RW Jr. CH 2: Patient selection in lumbar arthrodesis for low back pain. In: Haid RW Jr., Resnick DK, eds. *Surgical management of low back pain*. Rolling Meadow, IL. American Association of Neurological Surgeons. 2001.
194. Thayer L, Tiffany E, Carreira D. Addressing Smoking in Musculoskeletal Specialty Care. *J Bone Joint Surg Am*. 2021;103(22):2145-2152. doi:10.2106/jbjs.21.00108.

195. Theadom A, Croypley M. Effects of preoperative smoking cessation on the incidence and risk of intraoperative and postoperative complications in adults smokers: a systematic review. *Tobacco Control*. 2006;15:352-358.
196. Tobler WD, Ferrara LA. The presacral retroperitoneal approach for axial lumbar interbody fusion: a prospective study of clinical outcomes, complications and fusion rates at a follow-up of two years in 26 patients. *J Bone Joint Surg Br*. 2011;93(7):955-960.
197. Tobler W, Gerszten P, Bradley W, Raley T, Nasca R, Block J. Minimally-invasive axial pre-sacral L5-S1 interbody fusion: two year clinical and radiographic outcomes. *Spine*. 2011; 36(20): E1296-E1301.
198. Tormenti MJ, Maserati MB, Bonfield CM, Okonkwo DO, Kanter AS. Complications and radiographic correction in adult scoliosis following combined transpsoas extreme lateral interbody fusion and posterior pedicle screw instrumentation. *Neurosurg Focus*. 2010;28(3):E7.
199. Torg JS. CH 16: Spinal Injuries. In: DeLee JC, Drez D Jr, Miller MD, eds. *DeLee and Drez's Orthopaedic Sports Medicine: Principles and Practice*. 3<sup>rd</sup> ed. ©2009. Saunders Elsevier. ISBN 141603143X, 9781416031437.
200. TruFUSE® Facet Fusion. minSURG Corporation. minSURG™ Corporation. 2008.
201. Urakawa H, Jones T, Samuel A, et al. The necessity and risk factors of subsequent fusion after decompression alone for lumbar spinal stenosis with lumbar spondylolisthesis: 5 years follow-up in two different large populations. *Spine J*. 2020;20(10):1566-1572. doi:10.1016/j.spinee.2020.04.026.
202. U.S. Food & Drug Administration (FDA). 510(k) Summary K031511: *DYNESYS® Spinal System*. Available at: [https://www.accessdata.fda.gov/cdrh\\_docs/pdf3/K031511.pdf](https://www.accessdata.fda.gov/cdrh_docs/pdf3/K031511.pdf).
203. U.S. Food & Drug Administration (FDA). 510(k) Summary K060415: *Satellite™ Spinal System*. Available at: [https://www.accessdata.fda.gov/cdrh\\_docs/pdf6/K060415.pdf](https://www.accessdata.fda.gov/cdrh_docs/pdf6/K060415.pdf).
204. U.S. Food & Drug Administration (FDA). 510 (k) Summary K050965: *TranS1® AxiaLIF™ System*. Available at: [https://www.accessdata.fda.gov/cdrh\\_docs/pdf5/K050965.pdf](https://www.accessdata.fda.gov/cdrh_docs/pdf5/K050965.pdf).
205. U.S. National Institutes of Health. Clinicaltrials.gov ID NCT00529997: *Dynamic Stabilization for Lumbar Spinal Stenosis with Stabilimax NZ® Dynamic Spine Stabilization System*. Available at: <https://clinicaltrials.gov/study/NCT00529997?tab=history&a=14>.
206. Van Loon P, Kuhn S, Hofmann A, Hessmann MH, Rommens PM. Radiological analysis, operative management and functional outcome of open book pelvic lesions: a 13-year cohort study. *Injury*. 2011;42(10):1012-1019. doi:10.1016/j.injury.2010.11.057.
207. Villavicencio AT, Burneikiene S, Roeca CM, Nelson EL, Mason A. Minimally invasive versus open transforaminal lumbar interbody fusion. *Surg Neurol Int*. 2010;1:12.
208. Wan SH, Wong DL, To SC, Meng N, Zhang T, Cheung JP. Patient and surgical predictors of 3D correction in posterior spinal fusion: a systematic review. *Eur Spine J*. 2023;32(6):1927-1946. doi:10.1007/s00586-023-07708-2.
209. Wang JC, Dailey AT, Mummaneni PV, et al. Guideline update for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 8: lumbar fusion for disc herniation and radiculopathy. *J Neurosurg Spine*. 2014;21(1):48-53. doi:10.3171/2014.4.SPINE14271.
210. Washington State Department of Labor and Industries. *Guidelines for lumbar fusion (Arthrodesis)*. Olympia, WA: Washington State Department of Labor and Industries; 2002:5.
211. Washington State Health Care Authority. *Health Technology Assessment. Spinal Fusion and Discography. For chronic low back pain and uncomplicated lumbar degenerative disc disease*. 2007.
212. Watters WC, Bono CM, Gilbert TJ, et al. An evidence-based clinical guidelines for the diagnosis and treatment of degenerative lumbar spondylolisthesis. *Spine J*. 2009;9(7):609-614.
213. Weinstein JN, Lurie JD, Tosteson TD, et al. Surgical versus nonsurgical treatment for lumbar degenerative spondylolisthesis. *N Engl J Med*. 2007;356(22):2257-2270. doi:10.1056/NEJMoa070302.
214. Welch WC, Cheng BC, Awad TE, et al. Clinical outcomes of the Dynesys dynamic neutralization system: 1-year preliminary results. *Neurosurg Focus*. 2007;22(1):E8.
215. Williams KD, Park AL. CH 39: *Degenerative disc disease and internal disc derangement*. In: Canale & Beaty: *Campbell's Operative Orthopaedics*. 11<sup>th</sup> ed. ©2007. Mosby.
216. 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):268-279.
217. Wu RH, Fraser JF, Härtl R. Minimal access versus open transforaminal lumbar interbody fusion: meta-analysis of fusion rates. *Spine (Phila Pa 1976)*. 2010;35(26):2273-2281. doi:10.1097/BRS.0b013e3181cd42cc.

218. Yaksi A, Özgönenel L, Özgönenel B. The efficiency of gabapentin therapy in patients with lumbar spinal stenosis. *Spine*. 2007;32(9):939-942. doi:10.1097/01.brs.0000261029.29170.e6.
219. Yue JJ, Timm JP, Panjabi MM, Jaramillo-de la Torre J. Clinical application of the Panjabi neutral zone hypothesis: the Stabilimax NZ posterior lumbar dynamic stabilization system. *Neurosurg Focus*. 2007;22(1):E12.
220. Yuan PS, Day TF, Albert TJ, et al. Anatomy of the percutaneous presacral space for a novel fusion technique. *J Spinal Disord Tech*. 2006;19(4):237-241.
221. Yue Z, Gang L, Tongwei C, et al. Biomechanical change of lumbar unilateral graded facetectomy and strategies of its microsurgical reconstruction: report of 23 cases. *J Medical Coll PLA*. 2008;23(2):98-105. doi:10.1016/s1000-1948(08)60030-1.
222. Zdeblick TA. Minimally invasive fusion techniques. Laparoscopic spinal fusion. *Orthop Clin North Am*. 1998;29(4):635-645.
223. Zhong J, O'Connell B, Balouch E, et al. Patient outcomes after single-level Coflex interspinous implants versus single-level laminectomy. *Spine (Phila Pa 1976)*. 2021;46(13):893-900. doi:10.1097/BRS.0000000000003924.
224. Zhu Q, Larson CR, Sjøvold SG, et al. Biomechanical evaluation of the total facet arthroplasty system: 3-dimensional kinematics. *Spine (Phila Pa 1976)*. 2007;32(1):55-62.
225. 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.