Cigna Medical Coverage Policies – Musculoskeletal Lumbar Fusion (Arthrodesis) Guidelines

Effective November 1, 2024





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:

- 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.

CPT® (Current Procedural Terminology) is a registered trademark of the American Medical Association (AMA). CPT® five digit codes, nomenclature and other data are copyright 2024 American Medical Association. All Rights Reserved. No fee schedules, basic units, relative values or related listings are included in the CPT® book. AMA does not directly or indirectly practice medicine or dispense medical services. AMA assumes no liability for the data contained herein or not contained herein.

©Copyright 2024 eviCore healthcare

CMM-609: Lumbar Fusion (Arthrodesis)

CMM-609.1: General Guidelines

CMM-609.2: Osteotomy

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 Following Failed Lumbar Disc

Arthroplasty Surgery

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

CMM-609.9: Non-Indications

Procedure (CPT®) Codes (CMM-609)

References (CMM-609)

CMM-609.1: General Guidelines

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 <u>CMM-600.1: Prior</u> Authorization Requirements.

<u>Urgent/Emergent Indications/Conditions</u>

- ➤ The presence of <u>urgent/emergent indications/conditions</u> 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)
 - Timeframe 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

CMM-609.2: Osteotomy

<u>Posterior Column Osteotomy (PCO)</u>

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

- ➤ Correction of non-fixed deformity requiring 5° to 10° of correction (SPO) per spinal segment for **EITHER** of the following:
 - ◆ Lumbar <u>sagittal</u> plane deformities where sagittal vertical axis (SVA) is greater than 8cm or pelvic incidence-lumbar lordosis (PI-LL) is <15°
 - ◆ Larger <u>coronal</u> 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 <u>Scheuermann's Kyphosis</u> as this deformity is long, gradual, rounded, and amendable to more than 4 posterior column osteotomies.
- ➤ ALL of the criteria for lumbar fusion have been met per the applicable procedurespecific section(s) below:
 - **◆ 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 a fusion) when **ALL** of the following criteria are met:

- ➤ Performed for **EITHER** of the following:
 - ◆ Correction of fixed <u>sagittal</u> plane deformity requiring more than 30° of correction (PSO)
 - ◆ Large fixed <u>coronal</u> deformities greater than 60° that are amenable to asymmetric osteotomy
- ➤ ALL of the criteria for lumbar fusion have been met per the applicable procedurespecific section(s) below:
 - ◆ 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

CMM-609.3: Pediatric Spinal Deformity

Pediatric Lumbar Fusion

Lumbar fusion (arthrodesis) is considered **medically necessary** when the following criteria is 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 over 50° curve
 - ◆ Congenital scoliosis
 - ◆ Neuromuscular scoliosis
 - Infantile/juvenile scoliosis

Pediatric Osteotomy

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

<u>CMM-609.4: Lumbar Fusion (Arthrodesis) with Decompression (Indirect or Direct)</u>

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

Actual Instability

- ➤ The individual is a candidate for lumbar decompression or corpectomy per <u>CMM-608: Lumbar Decompression</u>.
- ➤ Imaging shows **ANY** of the following:
 - Degenerative spondylolisthesis <u>without spondylolysis</u> 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 greater than 3 mm between views
 - Meyerding Grade II or higher spondylolisthesis
 - Spondylolisthesis <u>with spondylolysis</u> (e.g. Isthmic Spondylolisthesis) with **ANY** of the following:
 - Meyerding Grade 1 or 2 spondylolisthesis (anterolisthesis) and plain X-rays support progression of anterolisthesis
 - Meyerding Grade 3 or higher spondylolisthesis (anterolisthesis) with 50% or more 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 exceeds 50% bilaterally or 75% or more of a single facet
- Pars fracture
- Previous lumbar 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 latrogenic Instability
- > 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 6 weeks prior to planned surgery as evidenced by blood cotinine lab results of ≤10 ng/mL

Anticipated latrogenic Instability

- ➤ The individual is a candidate for lumbar decompression or corpectomy per <u>CMM-608: Lumbar Decompression</u>.
- ➤ Anticipated iatrogenic instability with **ANY** of the following:
 - Created by disruption of the posterior elements due to facet joint excision that exceeds 50% bilaterally or 75% or more of a single facet during spinal decompression
 - Created by removal of the pars interarticularis is performed 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., <u>removal of at least one-third of the vertebral body</u> [not for resection of osteophytes alone])
 - For lumbar corpectomy, see <u>CMM-608.3: Corpectomy</u>.
- ➤ 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 6 weeks prior to planned surgery as evidenced by blood cotinine lab results of ≤10 ng/mL

Adult Degenerative Spinal Deformity

➤ The individual is a candidate for lumbar decompression or corpectomy per <u>CMM-608: Lumbar Decompression</u>

- ➤ Imaging findings include **EITHER** of the following:
 - ◆ Coronal plane deformity which includes **ANY** of the following:
 - Cobb angle greater than 30°
 - Asymmetric disk collapse causing symptomatic foraminal narrowing
 - Coronal imbalance causing head and trunk shift off the midline
 - Sagittal imbalance which includes ANY of the following:
 - Sagittal vertebral axis measurement greater than 8 cm
 - Pelvic incidence-lumbar lordosis greater than 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 6 weeks prior to planned surgery as evidenced by blood cotinine lab results of ≤10 ng/mL

Initial Disc Herniation

- ➤ This individual is a candidate for an <u>initial</u> primary lumbar discectomy per the applicable section below:
 - ◆ For information related to excision of extradural lesion other than neoplasm, see CMM 606.1: General Guidelines.
 - ◆ For an initial primary lumbar discectomy, see CMM-606.2: Initial Primary Lumbar Microdiscectomy (Laminotomy, Laminectomy, or Hemilaminectomy).
- 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 tobacco products, and/or nicotine replacement therapy for at least 6 weeks prior to planned surgery as evidenced by blood cotinine lab results of ≤10 ng/mL

Recurrent Disc Herniation

- ➤ The individual is a candidate for <u>repeat</u> lumbar discectomy per <u>CMM 606.3: Repeat</u> <u>Lumbar Microdiscectomy (Laminotomy or Laminectomy) at the Same Level</u>.
- ➤ Imaging shows 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 greater than 3 mm 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 tobacco products, and/or nicotine replacement therapy for at least 6 weeks prior to planned surgery as evidenced by blood cotinine lab results of ≤10 ng/mL

Second or Greater Recurrent Disc Herniation

- ➤ Individual is a candidate for <u>repeat</u> lumbar discectomy per <u>CMM 606.3: Repeat</u> <u>Lumbar Microdiscectomy (Laminotomy or Laminectomy) at the Same Level</u>.
- ➤ Documentation of nicotine-free status with **EITHER** of the following:
 - ◆ Individual is a never-smoker
 - Individual has refrained from smoking, use of tobacco products, and/or nicotine replacement therapy for at least 6 weeks prior to planned surgery as evidenced by blood cotinine lab results of ≤10 ng/mL

CMM-609.5: Lumbar Fusion (Arthrodesis) without Decompression

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

Degenerative Spondylolisthesis without Spondylolysis

- ➤ Imaging at the requested level(s) shows **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 greater than 3 mm between views
 - Meyerding Grade II or higher spondylolisthesis
 - Subjective 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 <u>for at least</u> 3 consecutive months (unless contraindicated):
 - Prescription strength analgesics, steroids, gabapentinoids, and/or NSAIDs

- Provider-directed exercise program prescribed by a physical therapist, chiropractic provider, osteopathic or allopathic physician
- ➤ Absence of untreated, underlying mental and/or behavioral health disorders (e.g., depression, 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 tobacco products, and/or nicotine replacement therapy for at least 6 weeks prior to planned surgery as evidenced by blood cotinine lab results of ≤10 ng/mL

Spondylolisthesis with Spondylolysis (e.g. Isthmic Spondylolisthesis)

- ➤ Imaging at the requested level(s) shows **ANY** of the following:
 - Meyerding Grade 1 or 2 spondylolisthesis (anterolisthesis) with plain X-rays supporting progression of anterolisthesis
 - Meyerding Grade 3 or higher spondylolisthesis (anterolisthesis) identified on plain x-rays with 50% or more anterior slippage OR plain X-rays supporting progression of anterolisthesis
 - Progressive spinal pain without confirmatory imaging of progression of spondylolisthesis
 - Multi-level spondylolysis on plain X-rays
 - Subjective 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 for at least 3 consecutive months (unless contraindicated):
 - Prescription strength analgesics, steroids, gabapentinoids, and/or NSAIDs
 - ◆ Provider-directed exercise program prescribed by a physical therapist, chiropractic provider, osteopathic or allopathic physician
- ➤ Absence of untreated, underlying mental and/or behavioral health disorders (e.g., depression, 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 tobacco products, and/or nicotine replacement therapy for at least 6 weeks prior to planned surgery as evidenced by blood cotinine lab results of ≤10 ng/mL

Discogenic Lower Back Pain/Degenerative Disc Disease

- ➤ Plain X-rays **and** advanced diagnostic imaging studies (i.e., CT, MRI) at the requested level(s)show moderate to severe <u>single-level</u> disc degeneration
- ➤ 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
 - Subjective 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, non-operative 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 NSAIDs <u>for</u> at least 12 consecutive months
 - Provider-directed exercise program prescribed by a physical therapist, chiropractic provider, osteopathic or allopathic physician <u>for at least 12</u> consecutive months
 - Epidural steroid injection(s)/ or selective nerve root block(s)
 - Facet joint injection(s)/medial branch block(s)/radiofrequency ablation(s)
- ➤ Absence of untreated, underlying mental and/or behavioral health disorders (e.g., depression, 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 tobacco products, and/or nicotine replacement therapy for at least 6 weeks prior to planned surgery as evidenced by blood cotinine lab results of ≤10 ng/mL

Adult Degenerative Spinal Deformity

- Imaging shows EITHER of the following:
 - Coronal plane deformity which includes ANY of the following:
 - Cobb angle of greater than 30°
 - Asymmetric disk collapse causing symptomatic foraminal narrowing
 - Coronal imbalance causing head and trunk shift off the midline
 - ◆ Sagittal imbalance which includes **ANY** of the following:
 - Sagittal vertebral axis measurement greater than 8 cm
 - Pelvic incidence-lumbar lordosis greater than 15°
- Less than clinically meaningful improvement with **EITHER** of the following <u>for at least</u> 3 consecutive months (unless contraindicated):
 - Prescription strength analgesics, steroids, gabapentinoids, and/or 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 6 weeks prior to planned surgery as evidenced by blood cotinine lab results of ≤10 ng/mL

CMM-609.6: Adjacent Segment Disease

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

- ➤ The individual meets criteria for lumbar fusion per the applicable section below:
 - ◆ CMM-609.4: Lumbar Fusion with Decompression
 - ◆ CMM-609.5: Lumbar Fusion (Arthrodesis) without Decompression
- ➤ The prior adjacent-level lumbar fusion was performed at least 6 months prior
- ➤ Imaging at the requested level(s) shows evidence of anterolisthesis on plain X-rays resulting 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 greater than 3 mm between views
 - Meyerding Grade II or higher spondylolisthesis
- Significant initial relief of symptoms following prior lumbar spinal fusion(s)

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

Lumbar fusion (with or without decompression) following failed lumbar disc arthroplasty surgery is considered **medically necessary** when performed for **EITHER** of the following conditions when **ALL** of the associated criteria are 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 6 months since the prior lumbar disc arthroplasty surgery
- ➤ The individual meets criteria for lumbar fusion per the applicable section below:
 - ◆ 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)

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

Repeat lumbar fusion (arthrodesis) (with or without decompression) at the same level is considered **medically necessary** for **EITHER** of the following conditions when **ALL** of the associated criteria are 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 6 months since the prior lumbar fusion surgery
- ➤ Subjective 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 6 weeks of non-surgical treatment with **BOTH** of the following (unless contraindicated):
 - Prescription strength analgesics, steroids, gabapentinoids, and/or NSAIDs
 - Provider-directed exercise program prescribed by a physical therapist, chiropractic provider, osteopathic or allopathic physician
- ➤ Post-operative imaging (performed at no less than 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 including **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 6 weeks prior to planned surgery as evidenced by blood cotinine lab results of ≤ 10 ng/mL

CMM-609.9: Non-Indications

Not Medically Necessary

- ➤ Lumbar fusion performed without meeting the criteria in the <u>General Guidelines</u> section (when applicable for urgent/emergent conditions) and the criteria in the applicable procedure-specific section(s) (<u>pediatric spinal deformity</u>; <u>fusion with decompression</u>; <u>fusion without decompression</u>; <u>adjacent segment disease</u>; <u>fusion following failed disc arthroplasty</u>; or, <u>repeat fusion</u>) is considered **not medically necessary**.
- ➤ Lumbar osteotomy performed without meeting the criteria in the <u>General</u> <u>Guidelines</u> (when applicable for urgent/emergent conditions) and the criteria in the applicable procedure-specific section (<u>osteotomy</u>; <u>pediatric spinal deformity</u>; <u>fusion with decompression</u>; <u>fusion without decompression</u>; <u>adjacent segment disease</u>; <u>fusion following failed disc arthroplasty</u>; or, <u>repeat fusion</u> is considered **not medically necessary**.
- ➤ Lumbar fusion and/or osteotomy performed for ANY of the following <u>sole</u> <u>indications</u> is considered **not medically necessary**:
 - Disc herniation in the absence of 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)
 - Multi-level degenerative disc disease without instability
 - Neurocompressive pathology

- ◆ Facet joint disorders without instability
- Initial discectomy/laminectomy without instability
- An adjunct to primary decompression of central and/or lateral recess stenosis in the absence of instability, spondylolisthesis, or an actual or anticipated bony resection that will result in iatrogenic instability
- ◆ Spondylolysis without spondylolisthesis

Experimental, Investigational, or Unproven (EIU)

- ➤ ALL of the following devices/procedures are considered experimental, investigational, or unproven (EIU) (not an all-inclusive list):
 - Pre-sacral interbody fusion including AxiaLIF
 - Minimally invasive lumbar spinal fusions using direct visualization <u>via endoscopy</u> (endoscopic fusion) or indirect visualization (e.g., percutaneous 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, Stabilimax NZ)
 - 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, Aspen Spinous Process Fixation System, Coflex-F)
 - Personalized anterior and lateral body interbody cage (implantable) (e.g., Aprevo)
 - 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 [any level], NuFix[®] [any level])
 - Total facet arthroplasty

CMM-609: Lumbar Fusion (Athrodesis)

Procedure (CPT®) Codes (CMM-609)

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	
Osteotomy of spine, posterior or posterolateral approach, 3 columns	, 1
vertebral segment (e.g., Pedicle/vertebral body subtraction); lumbar	
Osteotomy of spine, posterior or posterolateral approach, 3 columns	, 1
+22208 vertebral segment (e.g., Pedicle/vertebral body subtraction); each	
additional vertebral segment (List separately in addition to code for	
primary procedure)	
Osteotomy of spine, posterior or posterolateral approach, 1 vertebra	
segment; lumbar	
Osteotomy of spine, posterior or posterolateral approach, 1 vertebra	
+22216 segment; each additional vertebral segment (List separately in additional vertebral segment)	on
to code for primary procedure)	
Osteotomy of spine, including discectomy, anterior approach, single	
vertebral segment; lumbar	
Osteotomy of spine, including discectomy, anterior approach, single	
+22226 vertebral segment, each additional vertebral segment (List separatel	y in
addition to code for primary procedure)	
Arthrodesis, lateral extracavitary technique, including minimal	
discectomy to prepare interspace (other than for decompression);	
lumbar	
Arthrodesis, lateral extracavitary technique, including minimal	
discectomy to prepare interspace (other than for decompression);	
tnoracic or lumbar, each additional vertebral segment (List separate)	y in
addition to code for primary procedure)	
Arthrodesis, anterior interbody technique, including minimal discector	my
to prepare interspace (other than for decompression); lumbar	
Arthrodesis, anterior interbody technique, including minimal discecto	
+22585 to prepare interspace (other than for decompression); each additional	
interspace (List separately in addition to code for primary procedure)	
Arthrodesis, pre-sacral interbody technique, including disc space	
22586 preparation, discectomy, with posterior instrumentation, with image	
guidance, includes bone graft when performed, L5-S1 interspace	
Arthrodesis, posterior or posterolateral technique, single interspace;	
iumbar (with lateral transverse technique, when performed)	
Arthrodesis, posterior or posterolateral technique, single interspace;	
+22614 each additional vertebral segment (List separately in addition to code	for
primary procedure)	
Arthrodesis, posterior interbody technique, including laminectomy ar	d/or
discectomy to prepare interspace (other than for decompression), sin	ngle
interspace; lumbar	
Arthrodesis, posterior interbody technique, including laminectomy ar	
discectomy to prepare interspace (other than for decompression), sin	ngle
interspace; each additional interspace (List separately in addition to	
code for primary procedure)	

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®	
CP I°	Code Description/Definition
22633	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
+22634	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)
22800	Arthrodesis, posterior, for spinal deformity, with or without cast; up to 6
	vertebral segments
22802	Arthrodesis, posterior, for spinal deformity, with or without cast; 7 to 12
	vertebral segments
22804	Arthrodesis, posterior, for spinal deformity, with or without cast; 13 or
	more vertebral segments
22808	Arthrodesis, anterior, for spinal deformity, with or without cast; 2 to 3
	vertebral segments
22040	Arthrodesis, anterior, for spinal deformity, with or without cast; 4 to 7
22810	vertebral segments
20040	Arthrodesis, anterior, for spinal deformity, with or without cast; 8 or more
22812	vertebral segments
	Posterior non-segmental instrumentation (e.g. Harrington rod technique,
+22840	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)
100044	Internal spinal fixation by wiring of spinous processes (List separately in
+22841	addition to code for primary procedure)
	Posterior segmental instrumentation (e.g., pedicle fixation, dual rods with
+22842	multiple hooks and sublaminar wires); 3 to 6 vertebral segments (List
	separately in addition to code for primary procedure)
	Posterior segmental instrumentation (e.g., pedicle fixation, dual rods with
+22843	multiple hooks and sublaminar wires); 7 to 12 vertebral segments (List
	separately in addition to code for primary procedure)
	Posterior segmental instrumentation (e.g., pedicle fixation, dual rods with
+22844	multiple hooks and sublaminar wires); 13 or more vertebral segments
	(List separately in addition to code for primary procedure)
.00045	Anterior instrumentation; 2 to 3 vertebral segments (List separately in
+22845	addition to code for primary procedure)
.000.10	Anterior instrumentation; 4 to 7 vertebral segments (List separately in
+22846	addition to code for primary procedure)
	Anterior instrumentation; 8 of more vertebral segments (List separately
+22847	in addition to code for primary procedure)
	Pelvic fixation (attachment of caudal end of instrumentation to pelvic
+22848	bony structures) other than sacrum (List separately in addition to code
	for primary procedure)
22849	Reinsertion of spinal fixation device
44043	Tremsertion of spillar hyanon device

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
+22853	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)
+22854	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)
+22859	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)
0202T	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
0221T	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
+0222T	Placement of a posterior intrafacet implant(s), unilateral or bilateral, including imaging and placement of bone graft(s) or synthetic device(s), single level; each additional vertebral segment (List separately in addition to code for primary procedure)

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.

References (CMM-609)

- 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.
- 2. Abdu RW, Abdu WA, Pearson AM, Zhao W, Lurie JD, Weinstein JN. Reoperation for Recurrent Intervertebral Disc Herniation in the Spine Patient Coutcomes Research Trial. *Spine*. 2017:42(14)1106-1114.
- 3. Agency for Healthcare Research and Quality (AHRQ). Treatment of degenerative lumbar spinal stenosis: summary, Evidence report/technology assessment: number 32. AHRQ publication No. 01-E047. Archived. Rockville, MD: Agency for Healthcare Research and Quality; 2001 Mar.
- 4. American Academy of Orthopaedic Surgeons (AAOS). Position statement: The effects of tobacco exposure on the musculoskeletal system. 2011.
- 5. American Academy of Orthopedic Surgeons (AAOS). Surgery and smoking. July 2007.
- 6. American Association of Neurological Surgeons. J Neurosurg Spine. 2014:21:48-53.
- 7. American College of Occupational and Environmental Medicine (ACOEM). CH 12: Low back complaints. In: ACOEM Practice Guidelines. 2nd ed. ©2008 by the American College of Occupational and Environmental Medicine.
- 8. American College of Occupational and Environmental Medicine (ACOEM). *Low back disorders*. Occupational medicine practice guidelines: evaluation and management of common health problems and functional recovery in workers. 2nd ed. 2007.
- 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, Ernst C, Fruensgaard S, Ostergaard J, Andersen JL, Rasmussen S, Niedermann B, Høy K, Helmig P, Holm R, Lindblad BE, Hansen ES, Egund N, Bünger C. 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. 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.
- 18. 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.
- 19. 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.
- 20. 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.
- 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.
- 22. 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.
- 23. Brox JI, Nygaard ØP, Holm I, Keller Á, 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. Epub 2009 Jul 26.
- 24. 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. Epub 2006 Mar 20.
- 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.

- 26. 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.
- 27. Canale: Arthrodesis. Lumbar spine. Campbell's Operative Orthopaedics. 10th ed. Mosby, Inc. 2003:1704-1712.
- 28. Canale and Beaty: Degenerative spondylolisthesis and scoliosis. *Campbells Operative Orthopaedics*, 11th ed. ©2007. Mosby.
- 29. 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.
- 30. 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.
- 31. Chaput C, Padon D, Rush J, Lenehan E, Rahm M. The significance of increased fluid signal on magnetic resonance imaging in lumbar facts in relationship to degenerative spondylolisthesis. *Spine*. 2007;32(17):1883-1887.
- 32. 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.
- 33. 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.
- 34. Choma TJ, Śchuster 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.
- 35. Chou R, Loeser JD, Owens DK, Rosenquist RW, Atlas SJ, Baisden J, Carragee EJ, Grabois M, Murphy DR, Resnick DK, Stanos SP, Shaffer WO, Wall EM; 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.
- 36. Chung SK, Lee SH, Lim SR, Kim DY, Jang JS, Nam KS, Lee HY. 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
- 37. Clinicaltrials.gov, NCT01019057. An evaluation of interlaminar instrumented lumbar fusion.
- 38. 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. Published 2015 Apr 16. doi:10.1136/bmj.h1748.
- 39. 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;discussion 15-20.
- 40. 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.
- 41. 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.
- 42. Devereaux MW. Low back pain. Prim Care. 2004;31(1):33-51. doi:10.1016/S0095-4543(03)00114-3.
- 43. 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.
- 44. 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.
- 45. 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.
- 46. 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.
- 47. Durrani A, Mistur R, Shanti N: Presacral Approach for L5-S1 Fusion. *Techniques in Orthopaedics*. 2011 Sept;26(3): SC. Minimally invasive lumbar spinal fusion. *J Am Acad Orthop Surg*. 2007;15(6):321-329.
- 48. Eck JC, Sharan A, Ghogawala Z, et al. Guideline update for the performance of fusion proedures for degenerative disease of the lumbar spine. Part 7: Lumbar fusion for intractable low-back pain without stensos or spondylolisthesis. *J Neurosurg Spine*. 2014:21:42-47.
- 49. ECRI Institute. Hotline Response [database online]. Plymouth Meeting (PA): ECRI Institute. 2009. *Dynamic pedicle-and screw-based stabilization systems for chronic back pain*.
- 50. ECRI Institute. Hotline Response [database online]. Plymouth Meeting (PA): ECRI Institute. 2010. *iFuse Implant system for sacroiliac joint arthrodesis*.
- 51. 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.
- 52. 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.

- 53. ECRI Institute. Spinal fusion and discography for chronic low back pain and uncomplicated lumber degenerative disc disease (Washington HTA). Plymouth Meeting (PA): ECRI Institute Health Technology Assessment Information Service: 2007;(Evidence Report).
- 54. Fairbank J, Frost H, Wilson-MacDonald J, Yu LM, Barker K, Collins R; Spine Stabilisation Trial Group. 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. *BMJ*. 2005;330(7502):1233.
- 55. 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.
- 56. 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.
- 57. 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.
- 58. 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.
- 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.
- 60. 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 Techn*. Epub ahead of print September 29, 2011.
- 61. 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.
- 62. 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.
- 63. Ghogawala Z, Dziura J, Butler W, et al. Laminectomy plus Fusion versus Laminectomy Alone for Lumbar Spondylolisthesis. *NEJM*. 2016;374(15):1424-1434. doi:10.1056/nejmoa1508788.
- 64. 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.
- 65. 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.
- 66. Glassman SD, Carreon LY, Djurasovic M, Dimar JR, Johnson JR, Puno RM, Campbell MJ. Lumbar fusion outcomes stratified by specific diagnostic indication. *Spine J.* 2009;9(1):13-21. doi:10.1016/j.spinee.2008.08.011.
- 67. Graham RB, Sugrue PA, Koski TR. Adult degenerative scoliosis. *Clin Spine Surg.* 2016; 29(3):95-107. doi:10.1097/BSD.000000000000367.
- 68. 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.
- 69. Gundanna M, Miller L, Block J: Complications with Axial Presacral Lumbar Interbody Fusion: A FiveYear Postmarket Surveillance Experience. *SAS J*. 2011;5:90-94.
- 70. Guyton JL, Perez EA. Ch 53: *Fractures of Acetabulum and Pelvis*. In: Canale & Beaty: Campbell's Operative Orthopaedics, 11th ed. ©2007.
- 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.
- 72. 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.
- 73. Hansen H, Manchikanti L, Simopoulos TT, Christo PJ, Gupta S, Smith HS, Hameed H, Cohen SP. A systematic evaluation of the therapeutic effectiveness of sacroiliac joint interventions. *Pain Physician*. 2012;15(3):E247-F278
- 74. 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.
- 75. Heim SE, Altimari A. Laparoscopic approaches to fusion of the lumbosacral spine: latest techniques. *Orthop Clin North Am.* 2002;33(2):413-420.
- 76. Heindel P, Tuchman A, Hsieh PC, Pham MH, D'Oro A, Patel NN, Jakoi AM, Hah R, Liu JC, Buser Z, Wang JC. Reoperation Rates After Single-level Lumbar Discectomy. *Spine*. 2017;42(8);E496-E501.
- 77. 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.
- 78. Herkowitz HN. Spine update. Degenerative lumbar spondylolisthesis. Spine. 1995;20(9):1084-1090.
- 79. 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.

- 80. 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.
- 81. 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.
- 82. Ibrahim T, Tleyjeh IM, Gabbar O. Surgical versus non-surgical treatment of chronic low back pain: a metaanalysis of randomised trials. *Int Orthop*. 2008;32(1):107-113.
- 83. Inamasu J, Guiot BH. Laparoscopic anterior lumbar interbody fusion: a review of outcome studies. *Minim Invasive Neurosurg*. 2005;48(6):340-347.
- 84. Institute for Clinical Systems Improvement (ICSI). *Adult low back pain*. 15th ed Jan 2012; Bloomington (MN): Institute for Clinical Systems Improvement (ICSI). 2005:64.
- 85. International Society for Advancement of Spine Surgery (ISASS). Policy Statement on Lumbar Spinal Fusion Surgery. July 2011.
- 86. 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.
- 87. 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.
- 88. 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.
- 89. 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.
- 90. 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.
- 91. Kelly MP, Mok JM, Berven S. Dynamic constructs for spinal fusion: an evidence-based review. *Orthop Clin North Am.* 2010;41(2):203-215.
- 92. 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.000000000001024.
- 93. 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.000000000002630.
- 94. 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.
- 95. 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.
- 96. Koslosky E, Gendelberg D. Classification in Brief. *Clin Orthop Relat Res.* 2020;478(5):1125-1130. doi:10.1097/corr.000000000001153.
- 97. Kreiner DS, Shaffer WO, Baisden JL, et al. NASS. An evidence-based clinical guidline for the diagnosis and treatment of degenerative lumbar spinal stenosis (update). *Spine J.* 2013;13(7):734-743.
- 98. 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.
- 99. 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.
- 100.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.
- 101.Kwon B, Kim DH. Review Article: Lateral Lumbar Interbody Fusion: Indications, Outcomes and Complications. *J Am Acad Orthop Surgery*. 2016;24:96-105.
- 102.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.
- 103.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;19:191-198. doi:10.1016/j.spinee.2018.06.357.
- 104.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.
- 105.Lindley EM, McCullough MA, Burger EL, Brown CW, Patel VV. Complications of axial lumbar interbody fusion. *J Neurosurg Spine*. 2011;15(3):273-279. Epub 2011 May 20.
- 106.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.

- 107. 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.
- 108. 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 Ourcomes Research Trial (SPORT). Spine. 2008;33:991-998
- 109.Lurie JD, Doman DM, Spratt KF, et al. Patients with Symptomatic Lumbar Spine Disc Herniations. *Spine*. 2009:34:701-705.
- 110. 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.
- 111. Marchi L, Oliveira L, Coutinho E, Pimenta L. Results and complications after 2-level axial lumbarinterbody fusion with a minimum 2-year follow-up. *J Neurosurg Spine*. 2012;17:187–192.
- 112.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.
- 113. 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.
- 114. 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.
- 115.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.
- 116.Miller DJ, Cahill PJ, Vitale MG, Shah SA. Posterior Correction Techniques for Adolescent Idiopathic Scoliosis. *JAAOS*. Published online October 2019:1. doi:10.5435/jaaos-d-18-00399.
- 117. 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.
- 118.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.
- 119.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.
- 120.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.
- 121.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.
- 122. 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.
- 123.North American Spine Society (NASS) Evidence-Based Clinical Guidelines for Multidisciplinary Spine Care. *Diagnosis and treatment of degenerative lumbar spondylolisthesis*. 2nd ed. 2014; Burr Ridge, IL. North American Spine Society (NASS). Available at: https://www.spine.org.
- 124.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.
- 125.North American Spine Society (NASS) Coverage Policy Recommendations. *Lumbar Fusion*. 2021. Burr Ridge, IL. North American Spine Society. Available at: https://www.spine.org.
- 126.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-Clinical-Care/Quality-Improvement/Appropriate-Use-Criteria.
- 127.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.
- 128.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.0000000000003485.
- 129.Oster BA, Kikanloo SR, Levine NL, Lian J, Cho W. Systematic Review of Outcomes Following 10-Year Mark of Spine Patient Outcomes Research Trial for Intervertebral Disc Herniation. *Spine*. 2020;45(12):825-831. doi:10.1097/brs.00000000000003400.
- 130.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.0000000000003323.
- 131.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.
- 132. 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.

- 133. 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.
- 134. 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.
- 135.Patil SS, Lindley EM, Patel VV, Burger EL. Clinical and radiological outcomes of axial lumbar interbody fusion. *Orthopedics*. 2010;33(12):883.
- 136.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.000000000000004291.
- 137. 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.
- 138.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.
- 139.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.
- 140. 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.
- 141.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.
- 142.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.
- 143.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.
- 144. 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.
- 145.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 Jun;2(6):679-685.
- 146.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.
- 147.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.
- 148.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.
- 149.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
- 150.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*. Published online Nov 2018. 2019;30(2):228-223. doi:10.3171/2018.8.spine18586.
- 151.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.
- 152.Rodgers WBV, 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.
- 153. 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.
- 154. 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.
- 155.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.
- 156. Schwarzenbach O, Berlemann U, Stoll TM, Dubois G. Posterior dynamic stabilization systems: DYNESYS. *Orthop Clin North Am.* 2005;36(3):363-372.
- 157. 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.

- 158. Sengupta DK, Herkowitz HN. Lumbar spinal stenosis: treatment strategies and indications for surgery. *Orthop Clin North Am.* 2003;34(2):281-295.
- 159. 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.000000000001320.
- 160. 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.
- 161. 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.
- 162. 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.
- 163. 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.
- 164. 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.
- 165.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.
- 166. Society for Minimally Invasive Spine Surgery (SMISS). Position statement on presacral lumbar interbody fusion. February 29, 2012.
- 167. Sonntag VKH, Marciano FF. Is fusion indicated for lumbar spinal disorders? *Spine*. 1995;20(24 Supp):138S-142S.
- 168. 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.
- 169. Spinellil J, Rainville J. CH 45. Lumbar spondylolysis and spondylolisthesis. In: Frontera: Essentials of Physical Medicine and Rehabilitation. 2nd ed. ©2008. Saunders.
- 170. Tajima N, Chosa E, Watanabe S. Posterolateral lumbar fusion. J Orthop Sci. 2004;9(3):327-333.
- 171.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.
- 172. 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.
- 173. Theadom A, Cropley 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.
- 174.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.
- 175. 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.
- 176.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.
- 177.Torg JS. CH 16: Spinal Injuries. In DeLee: DeLee and Drez's Orthopaedic Sports Medicine. 3rd ed. ©2009.
- 178.TruFUSE® Facet Fusion. minSURG Corporation. minSURG™ Corporation. 2008.
- 179. 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.
- 180.U.S. Food and Drug Administration (FDA). Centerpulse Spine-Tech, Inc. Dynesys Spinal System. 510(k) summary. K031511. March 5, 2004.
- 181.U.S. Food and Drug Administration (FDA). Satellite Spinal System. 510(k) summary K060415. February 2006.
- 182.U.S. Food and Drug Administration (FDA). Trans1 AxiaLif™ System.510 (k) Summary K050965. 4/15/2005.
- 183.U.S. National Institutes of Health. Clinicaltrials.gov. Dynamic Stabilization for Lumbar Spinal Stenosis With Stabilimax NZ® Dynamic Spine Stabilization System. Updated Aug 11, 2010. Suspended.
- 184. Van Loon P, Kuhn S, Hofmann A, Hessmann MH, Rommens PM. Van Loon P, Kuhn S, Hofmann A, Hessmann MH, Rommens PM. *Injury*. 2011;42(10):1012-1019.
- 185. Villavicencio AT, Burneikiene S, Roeca CM, Nelson EL, Mason A. Minimally invasive versus open transforaminal lumbar interbody fusion. *Surg Neurol Int.* 2010;1:12.
- 186. Vinas FC. Lumbar spine fractures and dislocations. eMedicine 2003 Jan. Updated Nov 2017.
- 187. Vokshoor A, Keenan MA. Spondylolisthesis, spondylolysis, and spondylosis. *eMedicine*. Jan 2009. Updated February 2017.

- 188.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
- 189. Washington State Department of Labor and Industries. *Guidelines for lumbar fusion (Arthrodesis)*. Olympia, WA: Washington State Department of Labor and Industries; 2002:5.
- 190. Washington State Health Care Authority. *Health technology Assessment. Spinal Fusion and Discography. For chronic low back pain and uncomplicated lumbar degenerative disc disease*. 2007.
- 191. 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.
- 192. Weinstein JN, Lurie JD, Tosteson TD, et al. Surgical versus nonsurgical treatment for lumbar degenerative spondylolisthesis. *NEJM*. 2007;356(22):2257-2270.
- 193. Welch WC, Cheng BC, Awad TE, et al. Clinical outcomes of the Dynesys dynamic neutralization system: 1-year preliminaryresults. *Neurosurg Focus*. 2007;22(1):E8.
- 194. Williams KD, Park AL. CH 39: Degenerative disc disease and internal disc derangement. In: Canale & Beaty: Campbell's Operative Orthopaedics. 11th ed. ©2007. Mosby.
- 195. 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.
- 196.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.
- 197. 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.
- 198. 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.
- 199. 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.
- 200.Zdeblick TA. Minimally invasive fusion techniques. Laparoscopic spinal fusion. *Orthop Clin North Am.* 1998;29(4):635-645.
- 201.Zhu Q, Larson CR, Sjovold SG, Rosler DM, Keynan O, Wilson DR, Cripton PA, Oxland TR. Biomechanical evaluation of the Total Facet Arthroplasty System: 3-dimensional kinematics. *Spine (Phila Pa 1976)*. 2007;32(1):55-62.
- 202. 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.