

# Cigna Medical Coverage Policies – Musculoskeletal Primary Vertebral Augmentation (Percutaneous Vertebroplasty-Kyphoplasty) and Sacroplasty



Effective February 25, 2026



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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.

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## **CMM-607: Primary Vertebral Augmentation (Percutaneous Vertebroplasty/Kyphoplasty) and Sacroplasty**

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## **CMM-607.1: General Guidelines**

### **Application of Guideline**

- The determination of medical necessity for the performance of vertebral augmentation (percutaneous vertebroplasty/kyphoplasty) and sacroplasty 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.**
  - ◆ Provider-directed non-surgical management is **NOT** required for confirmed urgent/emergent conditions.
- Urgent/emergent conditions for vertebral augmentation procedure include **EITHER** of the following:
  - ◆ Primary or metastatic neoplastic disease causing pathologic fracture
  - ◆ A condition otherwise meeting criteria listed in the applicable procedure section(s) with documentation of severe debilitating or crippling pain and/or dysfunction to the point of being incapacitated

### **Definitions**

- **Vertebral Augmentation:** a minimally invasive procedure for stabilization and restoration of a vertebra to treat painful, pathologic fractures. The more common techniques in current use are vertebroplasty, kyphoplasty. Sacroplasty or coccygeoplasty are the terms used when vertebroplasty or kyphoplasty is used to treat insufficiency fractures of the sacrum or coccyx, respectively.
  - ◆ **Vertebroplasty:** a percutaneous augmentation procedure that involves image-guided injection of polymethylmethacrylate [PMMA] cement.
  - ◆ **Kyphoplasty:** a percutaneous augmentation procedure that is a variant of vertebroplasty. This procedure uses instrumentation or a device to re-establish vertebral height. Kyphoplasty techniques include balloon kyphoplasty and mechanical kyphoplasty.
  - ◆ **Balloon Kyphoplasty:** a percutaneous augmentation technique that involves the use of a specialized balloon to expand collapsed vertebrae, which then allows injection of PMMA.
    - **Mechanical Kyphoplasty:** a percutaneous augmentation technique using a device other than a balloon to expand collapsed vertebrae. Types of mechanical kyphoplasty techniques include, but are not limited to, the following:

- **Radiofrequency Kyphoplasty:** a percutaneous kyphoplasty technique utilizing the StabiliT® Vertebral Augmentation System (StabiliT®). This technique uses radiofrequency energy to modify ultra-high viscosity cement to a desired consistency. This ultra-high viscosity cement is introduced into the vertebral body to expand the collapsed vertebrae.
- **Kiva® VCF System:** a percutaneous kyphoplasty technique using a cannula-deployed Kiva® coil to insert a spiral PolyEtherEtherKetone (PEEK) implant which serves as a conduit for PMMA cement placement.
- **SpineJack®:** a percutaneous kyphoplasty technique using an expandable intervertebral body implant to restore vertebral height followed by injection of PMMA cement to keep the implant in place.
- **Vertebral Body Stenting:** a percutaneous kyphoplasty technique using an expandable metal stent with PMMA cement resulting in a stent-reinforced cement implant that restores vertebral height.

## **CMM-607.2: Indications**

Vertebral augmentation (e.g., injection of polymethylmethacrylate [PMMA] cement under imaging guidance) is considered **medically necessary** for **ANY** of the following when **ALL** of the associated criteria are met:

### **Associated Surgical Procedure**

- Performed as a prophylactic vertebroplasty (including adjacent vertebrae if needed) to facilitate fusion surgery
- Performed at no more than 2 levels of the T5-L5 spine on the same date of service

### **Malignant Conditions**

- Imaging that is concordant with the individual's symptoms and physical exam findings and that shows **ANY** of the following:
  - ◆ Osteolytic metastases including destruction of a vertebral body by multiple myeloma
  - ◆ Primary malignant neoplasm of bone or bone marrow
- Subjective symptoms include significant level of pain on a daily basis defined clinically significant functional impairment (e.g., inability to perform household chores, prolonged standing, or essential job functions)

### **Non-Malignant Conditions**

- Imaging that is concordant with the individual's symptoms and physical exam findings and that shows **ANY** of the following:
  - ◆ Osteoporotic vertebral compression fracture
  - ◆ Osteolytic vertebral compression fracture
  - ◆ Aggressive space occupying lesions of a vertebral body (hemangioma/eosinophilic granuloma)

- ◆ Osteonecrotic (i.e., Kummel disease) vertebral compression fracture
- ◆ Steroid-induced vertebral compression fracture
- Performed at no more than two (2) levels of the T5-L5 spine on the same date of service
- 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.)
- **EITHER** of the following:
  - ◆ Acute (0-6 weeks) axial pain in the thoracic/lumbar spine that persists at a level which prevents independent transfers and/or ambulation and correlates with the level of the fracture
  - ◆ Subacute (>6 weeks) axial pain in the thoracic/lumbar spine with less than clinically meaningful improvement with **BOTH** of the following (unless contraindicated):
    - Prescription strength analgesics, steroids, and/or NSAIDs for four (4) weeks
    - Provider-directed exercise program prescribed by a physical therapist, chiropractic provider, osteopathic or allopathic physician for four (4) weeks
- For osteoporotic compression fractures, the individual is enrolled in an osteoporosis treatment and prevention program after an osteoporotic vertebral compression fracture

### **CMM-607.3: Non-Indications**

#### **Not Medically Necessary**

- Vertebral Augmentation (Percutaneous Vertebroplasty/Kyphoplasty) performed without meeting the criteria in the **General Guidelines** (when applicable for urgent/emergent conditions) **and** the criteria in the applicable procedure-specific **Indications** section (associated surgical procedure; malignant conditions; non-malignant conditions) is considered **not medically necessary**.
- Vertebral Augmentation (Percutaneous Vertebroplasty/Kyphoplasty) is considered **not medically necessary** when there is presence of **ANY** of the following **alternative causes of axial back pain**:
  - ◆ Lumbar/thoracic radiculopathy or facet disease
  - ◆ Lumbar/thoracic/sacral trigger points
  - ◆ Insufficiency fractures or lesions of the sacrum or coccyx
- Sacroplasty and coccygeoplasty are considered **not medically necessary**.
- Primary Vertebral Augmentation (Percutaneous Vertebroplasty/Kyphoplasty) is considered **not medically necessary** for **ANY** of the following:
  - ◆ Non-painful/non-aggressive vertebral hemangioma
  - ◆ Vertebrae of the cervical spine and thoracic levels T1-T4

- ◆ Prophylactic treatment for osteoporosis of the spine
- ◆ Prophylactic treatment for chronic back pain of longstanding duration (>6 months), even if associated with old compression fracture(s)
- ◆ Spinoplasty (e.g., OptiMesh® 1500E Polyethylene Terephthalate (PET) mesh pouch)
- ◆ The use of any cement, cement products, or devices that are not FDA-approved for vertebral augmentation (e.g., Norian XR cement and Norian SRS cement products)
- ◆ Radiofrequency Kyphoplasty (e.g., StabiliT® System)
- ◆ Vertebral body stenting
- Vertebral Augmentation (Percutaneous Vertebroplasty/Kyphoplasty) considered **not medically necessary** when there is a presence of **ANY** of the following **contraindications**:
  - ◆ Allergy to materials used in the procedure
  - ◆ Uncorrected coagulation disorders or anticoagulation therapy
  - ◆ Myelopathy associated with a bone fragment in the spinal canal or cord compression from a tumor
  - ◆ Extensive vertebral destruction
  - ◆ Burst fracture associated with widened pedicles and/or retropulsed bone fragments
  - ◆ Potential space occupying lesions causing cord compression (tumor, bone fragment)
  - ◆ Collapse of vertebral body to less than the level of the vertebra plana
  - ◆ Radiculopathy from a herniated intervertebral disc
  - ◆ Untreated symptomatic foraminal or canal stenosis, facet arthropathy, or other significant coexistent spinal or bony pain generators
  - ◆ Unstable fracture or requirement for stabilization procedure in the same or adjacent spinal region
  - ◆ Septicemia and any active infection (including urinary tract infection [UTI])
  - ◆ Active osteomyelitis of the target vertebra
  - ◆ Severe cardiopulmonary disease

## Codes (CMM-607)

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/Definitions  |
|---------------|---|
| <b>22510</b>  | Percutaneous vertebroplasty (bone biopsy included when performed), 1 vertebral body, unilateral or bilateral injection, inclusive of all imaging guidance; cervicothoracic  |
| <b>22511</b>  | Percutaneous vertebroplasty (bone biopsy included when performed), 1 vertebral body, unilateral or bilateral injection, inclusive of all imaging guidance; lumbosacral  |
| <b>+22512</b> | Percutaneous vertebroplasty (bone biopsy included when performed), 1 vertebral body, unilateral or bilateral injection, inclusive of all imaging guidance; each additional cervicothoracic or lumbosacral vertebral body (List separately in addition to code for primary procedure)  |
| <b>22513</b>  | Percutaneous vertebral augmentation, including cavity creation (fracture reduction and bone biopsy included when performed) using mechanical device, (e.g., kyphoplasty); 1 vertebral body, unilateral or bilateral cannulation, inclusive of all imaging guidance; thoracic  |
| <b>22514</b>  | Percutaneous vertebral augmentation, including cavity creation (fracture reduction and bone biopsy included when performed) using mechanical device, (e.g., kyphoplasty); 1 vertebral body, unilateral or bilateral cannulation, inclusive of all imaging guidance; lumbar  |
| <b>+22515</b> | Percutaneous vertebral augmentation, including cavity creation (fracture reduction and bone biopsy included when performed) using mechanical device, (e.g., kyphoplasty); 1 vertebral body, unilateral or bilateral cannulation, inclusive of all imaging guidance; each additional thoracic or lumbar vertebral body (list separately in addition to code for primary procedure) |
| <b>0200T</b>  | Percutaneous sacral augmentation (sacroplasty), unilateral injection(s), including the use of a balloon or mechanical device, when used, one or more needles, includes imaging guidance and bone biopsy, when performed   |
| <b>0201T</b>  | Percutaneous sacral augmentation (sacroplasty), bilateral injections, including the use of a balloon or mechanical device, when used, two or more needles, includes imaging guidance and bone biopsy, when performed  |



## References (CMM-607)

1. Abeloff MD, Armitage JO, Niederhuber JE, Kastan MB, Gillies McKenna W. *Abeloff's Clinical Oncology E-Book*. 4<sup>th</sup> ed. Churchill Livingstone, an imprint of Elsevier 2008.
2. American College of Radiology. *ACR-ASNR-ASSR-SIR-SNIS Practice Parameter for the Performance of Vertebral Augmentation*. Revised 2022 (Resolution 19). Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/vertebraaug.pdf>.
3. Astur N, Avanzi O. Balloon Kyphoplasty in the Treatment of Neoplastic Spine Lesions: A Systematic Review. *Global Spine J*. 2019;9(3):348-356. doi:10.1177/2192568218768774.
4. Bayley E, Srinivas S, Boszyk. Clinical outcomes of sacroplasty in sacral insufficiency fractures: a review of the literature. *Eur Spine J*. 2009;18(9):1266–1271. doi:10.1007/s00586-009-1048-z.
5. Berenson J, Pflugmacher R, Jarzem P, et al. Cancer Patient Fracture Evaluation (CAFE) Investigators. Balloon kyphoplasty versus non-surgical fracture management for treatment of painful vertebral body compression fractures in patients with cancer: a multicentre, randomised controlled trial. *Lancet Oncol*. 2011;12(3):225-235. doi:10.1016/S1470-2045(11)70008-0.
6. BlueCross BlueShield Association (BCBSA) Technology Evaluation Center (TEC) TEC Assessment Program. *Percutaneous vertebroplasty or kyphoplasty for vertebral fractures caused by osteoporosis*.
7. Boonen S, Van Meirhaeghe J, Bastian L, et al. Balloon kyphoplasty for the treatment of acute vertebral compression fractures: 2-year results from a randomized trial. *J Bone Miner Res*. 2011;26(7):1627-1637.
8. 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.
9. Bouza C, Lopez T, Magro A, Navalpotro L, Amate JM. Efficacy and safety of balloon kyphoplasty in the treatment of vertebral compression fractures: a systematic review. *Eur Spine J*. 2006;1-18.
10. Buchbinder R, Osborne RH, Ebeling PR, et al. randomized trial of vertebroplasty for painful osteoporotic vertebral fractures. *N Engl J Med*. 2009;361(6):557-568. doi:10.1056/NEJMoa0900429.
11. Chou R, Qaseem, A, Snow, V, et al. Diagnosis and treatment of low back pain: a joint clinical practice guideline from the American College of Physicians and the American Pain Society. *Ann Intern Med*. 2007;147(7):478-491.
12. Clark W, Bird P, Gonski T, et al. Safety and efficacy of vertebroplasty for acute painful osteoporotic fractures (VAPOUR): a multicenter, randomized, double-blind, placebo-controlled trial. *Lancet*. 2016;388:1408-1416.
13. Coumans JVCE, Reinhardt MK, Lieberman IH. Kyphoplasty for vertebral compression fractures: 1-year clinical outcomes from a prospective study. *J Neurosurg*. 2003;99(1 Suppl):44-50.
14. De Negri P, Tirri T, Paternoster G, Modano P. Treatment of painful osteoporotic or traumatic vertebral compression fractures by percutaneous vertebral augmentation procedures: a nonrandomized comparison between vertebroplasty and kyphoplasty. *Clin J Pain*. 2007;23(5):425-430.
15. Deramond H, Saliou G, Aveillan M, Lehmann P, Vallee JN. Respective contributions of vertebroplasty and kyphoplasty to the management of osteoporotic vertebral fractures. *Joint Bone Spine*. 2006;73(6):610-613. doi:10.1016/j.jbspin.2006.09.00.
16. Eck JC, Nachtigall D, Humphreys SC, Hodges SD. Comparison of vertebroplasty and balloon kyphoplasty for treatment of vertebral compression fractures: a meta-analysis of the literature. *Spine J*. 2008;8(3):488-497.
17. ECRI Institute. *Percutaneous kyphoplasty for the treatment of vertebral fractures*. Plymouth Meeting (PA): ECRI Institute Health Technology Assessment Information Service. Mar 2006:75. (Windows on Medical Technology™, no. 132).
18. ECRI Institute. *Percutaneous vertebroplasty for the treatment of vertebral fractures*. Plymouth Meeting (PA): ECRI Institute Health Technology Assessment Information Service. Dec 2008.
19. Eichholz KM, O'Toole JE, Christie SD, Fessler RG. Vertebroplasty and kyphoplasty. *Neurosurg Clin North Am*. 2006;17(4):507-518.
20. Esses SI, McGuire R, Jenkins J, et al. AAOS Clinical Practice Guideline: The Treatment of Symptomatic Osteoporotic Spinal Compression Fractures. *J Am Acad Orthop Surg*. 2011;19(3):183-184.
21. Farrokhi MR, Alibai E, Maghami Z. Randomized controlled trial of percutaneous vertebroplasty versus optimal medical management for the relief of pain and disability in acute osteoporotic vertebral compression fractures. *J Neurosurg Spine*. 2011;14(5):561-569. doi:10.3171/2010.12.SPINE10286.
22. Feng L, Shen JM, Feng C, et al. Comparison of radiofrequency kyphoplasty (RFK) and balloon kyphoplasty (BKP) in the treatment of vertebral compression fractures: a meta-analysis. *Medicine*. 2017;96(25):e7150. doi:10.1097/md.00000000000007150.
23. Frey ME, Depalma MJ, Cifu DX, Bhagia SM, Carne W, Daitch JS. Percutaneous sacroplasty for osteoporotic sacral insufficiency fractures: a prospective, multicenter, observational pilot study. *Spine J*. 2008;8(2):367-373. doi:10.1016/j.spinee.2007.05.011.
24. Frey ME, DePalma MJ, Cifu DX, Bhagia SM, Daitch JS. Efficacy and safety of percutaneous sacroplasty for painful osteoporotic sacral insufficiency fractures. a prospective multi-center trial. *Spine*. 2007;32(15):1635–1640. doi:10.1097/BRS.0b013e318074d4e1.



25. Gaitanis IN, Hadjipavlou AG, Katonis PG, Tzermiadianos MN, Pasku DS, Patwardhan AG. Balloon kyphoplasty for the treatment of pathological vertebral compressive fractures. *Eur Spine J*. 2005;14(3):250-260. doi:10.1007/s00586-004-0767-4.
26. Garfin SR, Buckley RA, Ledlie J, Balloon Kyphoplasty Outcomes Group. Balloon kyphoplasty for symptomatic vertebral body compression fractures results in rapid, significant, and sustained improvements in back pain, function, and quality of life for elderly patients. *Spine*. 2006;31(19):2213-2220.
27. Grohs JG, Matzner M, Trieb K, Krepler P. Minimal invasive stabilization of osteoporotic vertebral fractures: a prospective nonrandomized comparison of vertebroplasty and balloon kyphoplasty. *J Spinal Disord Tech*. 2005;18(3):238-242.
28. Hadjipavlou AG, Tzermiadianos MN, Katonis PG, Szpalski M. Percutaneous vertebroplasty and balloon kyphoplasty for the treatment of osteoporotic vertebral compression fractures and osteolytic tumours. *J Bone Joint Surg Br*. 2005;87(12):1595-1604.
29. Haig AJ, Colwell M, eds. *Back Pain*. ACP Press. 2005. ISBN-10: 1-930513-59-3.
30. Han S, Wan S, Ning L, Tong Y, Zhang J, Fan S. Percutaneous vertebroplasty versus balloon kyphoplasty for treatment of osteoporotic vertebral compression fracture: a meta-analysis of randomised and non-randomised controlled trials. *Int Orthop*. 2011;35(9):1349-1358. doi:10.1007/s00264-011-1283-x.
31. He Z, Zhai Q, Hu M, et al. Bone cements for percutaneous vertebroplasty and balloon kyphoplasty: Current status and future developments. *J Orthop Translat*. 2014;3(1):1-11. doi:10.1016/j.jot.2014.11.002.
32. Hirsch JA, Beall DP, Chambers MR, et al. Management of vertebral fragility fractures: A clinical care pathway developed by a multispecialty panel using the RAND/UCLA Appropriateness Method. *Spine J*. 2018;18(11):2152-2161. doi:10.1016/j.spinee.2018.07.025.
33. Hoffmann J, Preston G, Whaley J, Khalil JG. Vertebral Augmentation in Spine Surgery. *JAAOS*. 2023;31(10):477-489. doi:10.5435/jaaos-d-22-00958.
34. Hulme PA, Krebs J, Ferguson SJ, Berlemann U. Vertebroplasty and kyphoplasty: a systematic review of clinical studies. *Spine*. 2006;31(17):1983-2001.
35. Institute for Clinical Systems Improvement (ICSI). Health Care Guideline: *Adult Acute and Subacute Low Back Pain*. 15<sup>th</sup> ed. Bloomington (MN): Institute for Clinical Systems Improvement. Jan 2012. Accessed October 17, 2012.
36. Institute for Clinical Systems Improvement (ICSI). *Vertebroplasty and balloon-assisted vertebroplasty for the treatment of osteoporotic compression fractures*. Technology Assessment Report #79. Jan 2004. Bloomington (MN): Institute for Clinical Systems Improvement.
37. Jacobson RE, Palea O, Granville M. Progression of vertebral compression fractures after previous vertebral augmentation: technical reasons for recurrent fractures in a previously treated vertebra. *Cureus*. 2017;9(10):e1776. doi:10.7759/cureus.1776.
38. Kallmes DF, Comstock BA, Heagerty PJ, et al. A randomized trial of vertebroplasty for osteoporotic spinal fractures. *N Engl J Med*. 2009;361(6):569-579.
39. Kasperk C, Grafe IA, Schmitt S, et al. Three-year outcomes after kyphoplasty in patients with osteoporosis with painful vertebral fractures. *J Vasc Interv Radiol*. 2010;21(5):701-709. doi:10.1016/j.jvir.2010.01.003.
40. Kasperk C, Hillmeier J, Noldge G, et al. Treatment of painful vertebral fractures by kyphoplasty in patients with primary osteoporosis: a prospective nonrandomized controlled study. *J Bone Miner Res*. 2005;20(4):604-612. doi:10.1359/JBMR.041203.
41. Kathuria S. Post-Vertebral Augmentation Spine Imaging. *Neuroimag Clin N Am*. 2014;24(2):337-347. doi:10.1016/j.nic.2014.01.007.
42. Kim YJ, Lee JW, Park KW, et al. Pulmonary cement embolism after percutaneous vertebroplasty in osteoporotic vertebral compression fractures: incidence, characteristics, and risk factors. *Radiology*. 2009;251(1):250-259.
43. Klazen CA, Lohle PN, de Vries J, et al. Vertebroplasty versus conservative treatment in acute osteoporotic vertebral compression fractures (Vertos II): an open-label randomised trial. *Lancet*. 2010;376(9746):1085-1092. doi:10.1016/S0140-6736(10)60954-3.
44. Lavelle W, Carl A, Lavelle ED, Khaleel MA. Vertebroplasty and kyphoplasty. *Med Clin North Am*. 200;91(2):299-314.
45. Ledlie JT, Renfro M. Balloon kyphoplasty: one-year outcomes in vertebral body height restoration, chronic pain, and activity levels. *J Neurosurg*. 2003;98(1):36-42. doi:10.3171/spi.2003.98.1.0036.
46. Ledlie JT, Renfro MB. Kyphoplasty treatment of vertebral fractures: 2-year outcomes show sustained benefits. *Spine*. 2006;31(1):57-64.
47. 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.
48. Lee MJ, Dumonski M, Cahill P, et al. Percutaneous treatment of vertebral compression fractures: a meta-analysis of complications. *Spine (Phila Pa 1976)*. 2009;34(11):1228-1232.
49. Lehman RA, Kang DG, Wagner SC. Management of Osteoporosis in Spine Surgery. *JAAOS*. 2015;23(4):253-263. doi:10.5435/jaaos-d-14-00042.
50. Luo Y, Yang DM, Yang HM, Wu D, Xie FY. Innovative minimally invasive implants for osteoporosis vertebral compression fractures. *Front Med (Lausanne)*. 2023;10:1161174. doi:10.3389/fmed.2023.1161174.

51. Lovi A, Teli M, Ortolina A, et al. Vertebroplasty and kyphoplasty: complementary techniques for the treatment of painful osteoporotic vertebral compression fractures. A prospective non-randomised study on 154 patients. *Eur Spine J*. 2009;18(1):95-101.
52. Martín-López JE, Pavón-Gómez MJ, Romero-Tabares A, Molina-López T. Stentoplasty effectiveness and safety for the treatment of osteoporotic vertebral fractures: a systematic review. *Orthop Traumatol Surg Res*. 2015;101(5):627-632. doi:10.1016/j.otsr.2015.06.002.
53. Mattie R, Brar N, Tram J, et al. Vertebral Augmentation of Cancer-Related Spinal Compression Fractures. *Spine*. 2021;46(24):1729-1737.
54. Mattie R, Laimi K, Yu S, Saltychev M. Comparing Percutaneous Vertebroplasty and Conservative Therapy for Treating Osteoporotic Compression Fractures in the Thoracic and Lumbar Spine. *JBJS*. 2016;98:1041-1051.
55. McGuire R. AAOS® Clinical Practice Guideline: *The treatment of symptomatic osteoporotic spinal compression fractures*. *J Am Acad Orthop Surg*. 2011;19(3):183-184. doi:10.5435/00124635-201103000-00008.
56. National Institute for Clinical Excellence (NICE). *Balloon kyphoplasty for vertebral compression fractures*. Interventional procedure guidance 166. London, UK: NICE. 2006 Apr. Revised 2008 Jan.
57. National Institute for Clinical Excellence (NICE). *Percutaneous vertebroplasty*. Interventional procedure guidance 12. London, UK: NICE; 2003 Sept. Revised 2008 Nov.
58. Noriega D, Maestretti G, Renaud C, et al. Clinical Performance and Safety of 108 SpineJack Implantations: 1-Year Results of a Prospective Multicentre Single-Arm Registry Study. *BioMed Res Int*. 2015;2015:1-10. doi:10.1155/2015/173872.
59. Noriega D, Marcia S, Theumann N, et al. A prospective, international, randomized, noninferiority study comparing an implantable titanium vertebral augmentation device versus balloon kyphoplasty in the reduction of vertebral compression fractures (SAKOS study). *Spine J*. 2019;19(11):1782-1795. doi:10.1016/j.spinee.2019.07.009.
60. Otten LA, Bornemann R, Jansen TR, et al. Comparison of balloon kyphoplasty with the new KIVA® VCF system for the treatment of vertebral compression fractures. *Pain Physician*. 2013;16:E505-E512.
61. Panagopoulos J, Hush J, Steffens D, Hancock MJ. Do MRI Findings Change Over a Period of Up to 1 Year in Patients with Low Back Pain and/or Sciatica? *Spine*. 2017;42(7):504-512. doi:10.1097/brs.0000000000001790.
62. Pateder DB, Khanna AJ, Lieberman IH. Vertebroplasty and kyphoplasty for the management of osteoporotic vertebral compression fractures. *Orthop Clin North Am*. 2007;38(3):409-18; abstract vii.
63. Rahmani R, Sanda M, Sheffels E, et al. The efficacy of prophylactic vertebroplasty for preventing proximal junctional complications after spinal fusion: a systematic review. *Spine J*. 2022;22(12):2050-2058. doi:10.1016/j.spinee.2022.07.104.
64. 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.
65. Rosales Olivarez LM, Dipp JM, Escamilla RF, et al. Vertebral augmentation treatment of painful osteoporotic compression fractures with the Kiva VCF Treatment System. *SAS J*. 2011;5(4):114-119. doi:10.1016/j.esas.2011.06.001.
66. Rousing R, Andersen MO, Jespersen SM, et al. Percutaneous vertebroplasty compared to conservative treatment in patients with painful acute or subacute osteoporotic vertebral fractures. *Spine*. 2009;34(13):1349-1354.
67. Rousing R, Hansen KL, Andersen MO, et al. Twelve-months follow-up in forty-nine patients with acute/semiacute osteoporotic vertebral fractures treated conservatively or with percutaneous vertebroplasty: a clinical randomized study. *Spine*. 2010;35(5):478-482.
68. Savage JW, Schroeder GD, Anderson PA. Review Article: Vertebroplasty and Kyphoplasty for the Treatment of Osteoporotic Vertebral Compression Fractures. *J Am Acad Orthop Surg*. 2014;22:653-664.
69. 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.
70. Shi G, Fang Feng, Chen H, Jia P, Bao L. Multilevel percutaneous kyphoplasty in painful osteolytic vertebral metastases: a study of the efficacy and safety. *J Pain Res*. 2019;Volume 12:1053-1060. doi:10.2147/jpr.s193564.
71. Sorensen ST, Kirkegaard AO, Carreon L, et al. Vertebroplasty or kyphoplasty as palliative treatment for cancer-related vertebral compression fractures: a systematic review. *Spine J*. 2019;19:1067-1075.
72. Spivak JM, Johnson MG. Percutaneous treatment of vertebral body pathology. *J Am Acad Orthop Surg*. 2005;13(1):6-17.
73. Staples MP, Kallmes DF, Comstock BA, Jarvik JG, Osborne RH, Heagerty PJ, Buchbinder R. Effectiveness of vertebroplasty using individual patient data from two randomised placebo controlled trials: meta-analysis. *BMJ*. 2011;343:d3952.
74. Taylor R. S., Fritzell P., Taylor, R. J. Balloon kyphoplasty in the management of vertebral compression fractures: an updated systematic review and meta-analysis. *Eur Spine J*. 2007;16(8):1085-1100.

75. Taylor RS, Fritzell P, Taylor RJ. Balloon kyphoplasty in the management of vertebral compression fractures: an updated systematic review and meta-analysis. *Eur Spine J*. 2007;16(8):1085-1100. doi:10.1007/s00586-007-0308-z.
76. Taylor RS, Taylor RJ, Fritzell P. Balloon kyphoplasty and vertebroplasty for vertebral compression fractures: a comparative systematic review of efficacy and safety. *Spine*. 2006;31(23):2747-2755.
77. Therapeutic Neuroradiology, Society of Interventional Radiology, American Association of Neurological Surgeons/Congress of Neurological Surgeons, and American Society of Spine Radiology. *Vasc Interv Radiol*. 2009;20(7):S326-S331.
78. Trout AT, Kallmes DF, Kaufmann TJ. New fractures after vertebroplasty: adjacent fractures occur significantly sooner. *AJNR*. 2006;27(1):217-223.
79. Tutton SM, Pflugmacher R, Davidian M, et al. KAST Study: the Kiva system as a vertebral augmentation treatment – a safety and effectiveness trial: a randomized, noninferiority trial comparing the Kiva system with balloon kyphoplasty in treatment of osteoporotic vertebral compression fractures. *Spine*. 2015;40(12):865-875. doi:10.1097/BRS.0000000000000906.
80. U.S. Department of Health and Human Services. FDA Public Health Notification\*: *Complications Related to the Use of Bone Cement and Bone Void Fillers in Treating Compression Fractures of the Spine*. 2002 Oct 31; Updated May 7, 2004.
81. Wardlaw D, Cummings SR, Van Meirhaeghe J, et al. Efficacy and safety of balloon kyphoplasty compared with non-surgical care for vertebral compression fracture (FREE): a randomised controlled trial. *Lancet*. 2009;373(9668):1016-1024. doi:10.1016/S0140-6736(09)60010-6.
82. Washington State Health Care Authority. *Vertebroplasty, kyphoplasty and Sacroplasty Health Technology Assessment*. Olympia WA: Health Technology Assessment Program. Nov 2010.
83. Yaltirik K, Ashour AM, Reis CR, Özdoğan S, Atalay B. Vertebral augmentation by kyphoplasty and vertebroplasty: 8 years experience outcomes and complications. *J Craniovertebr Junction Spine*. 2016;7(3):153-160. doi:10.4103/0974-8237.188413.
84. Yang E, Xu J, Huang G, Xiao W, Liu X, Zeng B, Lian, X. Percutaneous Vertebroplasty versus Conservative Treatment in Aged Patients With Acute Osteoporotic Vertebral Compression Fractures. *Spine*. 2016;41(8):653-660.