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Percutaneous Vertebroplasty and Kyphoplasty (for Louisiana Only)

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[Instructions for Use](#)

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Application

This Medical Policy only applies to the state of Louisiana.

Coverage Rationale

Percutaneous vertebroplasty and kyphoplasty are proven and medically necessary for treating pain causing [Functional or Physical Impairment](#) in cervical, thoracic or lumbar vertebral bodies within 4 months of pain onset that has failed to respond to [eOptimal mMedical tTherapy](#) ~~optimal medical therapy~~ for the following indications:

- Osteoporotic vertebral compression fracture (VCF)
- Steroid-induced vertebral fracture
- Osteolytic metastatic disease involving a vertebral body
- Multiple myeloma involving a vertebral body
- Vertebral [Hemangioma](#) ~~hemangioma~~ with aggressive features
- Unstable fractures due to [Osteonecrosis](#) ~~osteonecrosis~~ (e.g., Kummel disease) and

Computed tomography (CT) or magnetic resonance imaging (MRI) has ruled out other causes of spinal pain, including but not limited to:

- Foraminal stenosis
- Facet arthropathy
- Herniated intervertebral disk
- Other spinal degenerative disease

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- Other significant coexistent spinal or bony pain generators and

The following are not present:

- Clinical evidence of spinal cord compression as confirmed by CT or MRI; or
- Significant vertebral collapse or destruction (e.g., vertebra reduced to less than one-third of its original height) as confirmed by CT or MRI; or
- Healed VCF as confirmed by CT or MRI; or
- Lesions of the sacrum or coccyx (see the Medical Policy titled [Surgical Treatment for Spine Pain \(for Louisiana Only\)](#) ~~Surgical Treatment for Spine Pain~~ for additional information on percutaneous sacral augmentation); or
- Asymptomatic vertebral compression fractures (VCFs); or
- VCFs responding appropriately to conservative therapy

Percutaneous vertebroplasty and kyphoplasty are unproven and not medically necessary for treating indications other than those listed above due to insufficient evidence of efficacy.

Definitions

Functional or Physical Impairment: A functional or physical or physiological impairment causes deviation from the normal function of a tissue or organ. This results in a significantly limited, impaired, or delayed capacity to move, coordinate actions, or perform physical activities and is exhibited by difficulties in one or more of the following areas: physical and motor tasks; independent movement; performing basic life functions.

Vertebral Hemangiomas: ~~Vertebral Hemangiomas are benign vascular tumors of the bony spine which are usually asymptomatic. A rare subset of them are characterized by extra-osseous extension, bone expansion, disturbance of blood flow, and occasionally compression fractures and thereby referred to as aggressive hemangiomas. Aggressive Vertebral Hemangiomas most often occur between T3 and T9 vertebral segments (Schrock, 2011).~~

Optimal Medical Therapy: ~~Treatments that are employed as first line before moving to more invasive, risky or complex procedures (Gibbons and Miller, 2017).~~

Osteonecrosis: ~~Osteonecrosis (also referred to as avascular necrosis, aseptic necrosis, pseudarthrosis, or Kummel disease) is a disease caused by reduced blood flow to bones in the joints. With decreased blood flow, the bone may break down. Known causes of Osteonecrosis are steroid medications, alcohol use, injury, and increased pressure inside the bone. Risk factors are radiation treatment, chemotherapy, kidney and other organ transplants. Nonsurgical treatments may relieve pain in the short term, but they do not cure the disease (National Institute of Arthritis and Musculoskeletal and Skin Diseases, 2014).~~

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Applicable Codes

The following list(s) of procedure and/or diagnosis codes is provided for reference purposes only and may not be all inclusive. Listing of a code in this policy does not imply that the service described by the code is a covered or non-covered health service. Benefit coverage for health services is determined by federal, state, or contractual requirements and applicable laws that may require coverage for a specific service. The inclusion of a code does not imply any right to reimbursement or guarantee claim payment. Other Policies and Guidelines may apply.

CPT Code	Description
22510	Percutaneous vertebroplasty (bone biopsy included when performed), 1 vertebral body, unilateral or bilateral injection, inclusive of all imaging guidance; cervicothoracic
22511	Percutaneous vertebroplasty (bone biopsy included when performed), 1 vertebral body, unilateral or bilateral injection, inclusive of all imaging guidance; lumbosacral
22512	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)
22513	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
22514	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
22515	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)

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Description of Services

Percutaneous vertebroplasty is a therapeutic, interventional radiologic procedure, which involves injection of an acrylic polymer, such as polymethylmethacrylate (PMMA) into a vertebral body fracture in an effort to relieve pain and provide stability. This procedure is used primarily for osteoporotic vertebral compression fractures or osteolytic vertebral lesions that are refractory to medical therapy. Medical management of vertebral body fractures can include analgesics, bed rest, and external bracing; however, despite these types of management, progressive kyphosis, prolonged pain, and disability still occur in some individuals. In these individuals, percutaneous vertebroplasty can be used to prevent further collapse of fractured vertebrae, and to augment osteoporotic vertebral bodies at risk for fracture.

Kyphoplasty (KP) (also known as balloon-assisted vertebroplasty or vertebral augmentation) is a modification of vertebroplasty. The procedure involves guided insertion of an inflatable bone tamp into the partially collapsed vertebral body. Once in place, the balloon is expanded to the desired height and removed. An acrylic polymer is then injected into the space, where it hardens and binds to the vertebral body. KP is intended to relieve pain and improve function and quality of life by restoring vertebral height and integrity.

The primary difference in the case of kyphoplasty is that the fracture itself is at least partially reduced by expanding the intrabody space by the use of inflatable bone tamps. Once the compression is reduced to an acceptable degree, the bone cement is then injected. In this way, some of the bony deformity and resulting kyphosis may be reduced, often significantly improving the individual's pain.

Painful vertebral compression fractures may cause a marked decline in physical activity and quality of life, leading to general physical deconditioning. This, in turn, may prompt further complications related to poor inspiratory effort (atelectasis and pneumonia) and venous stasis (deep venous thrombosis and pulmonary embolism). Successful management of painful vertebral compression fractures has the potential for improving quality of life, increasing the expectancy of an independent and/or productive life, and preventing superimposed medical complications (American College of Radiology, 2018).

~~Vertebral hemangiomas are benign vascular tumors of the bony spine which are usually asymptomatic. A rare subset of them are characterized by extra osseous extension, bone expansion, disturbance of blood flow, and occasionally compression fractures and thereby referred to as aggressive hemangiomas. Aggressive vertebral hemangiomas most often occur between T3 and T9 vertebral segments (Schrock, 2011).~~

~~Osteonecrosis (also referred to as avascular necrosis, aseptic necrosis, pseudarthrosis, or Kummel disease) is a disease caused by reduced blood flow to bones in the joints. With decreased blood flow, the bone may break down. Known causes of osteonecrosis are steroid medications, alcohol use, injury, and increased pressure inside the bone. Risk factors are radiation treatment, chemotherapy, kidney and other organ transplants. Nonsurgical treatments may relieve pain in the short term, but they do not cure the disease (National Institute of Arthritis and Musculoskeletal and Skin Diseases, 2014).~~

Clinical Evidence

There is a broad consensus based on the review of clinical literature and professional organization that percutaneous vertebral augmentation with the use of vertebroplasty or kyphoplasty (KP) is a safe, efficacious, and durable procedure in selected patients with symptomatic osteoporotic and neoplastic fractures. There is inadequate clinical evidence of safety and/or efficacy in published, peer-reviewed literature for treatment of other indications.

Percutaneous Vertebroplasty (PVP)

~~Sorensen et al. (2019) performed a systematic review evaluating the effectiveness and safety of vertebral augmentation for malignant vertebral compression fractures (VCFs). Studies on percutaneous vertebroplasty (PVP) or percutaneous kyphoplasty (KP) for vertebral compression fractures (VCFs) in patients with malignant spinal lesions were reviewed. The review identified two randomized controlled trials, 16 prospective studies, 44 retrospective studies, and 25 case series for a patient sample size of 3,426. At the earliest follow up, pain improved from 7.48 to 3.00 with PVP, and from 7.05 to 2.96 with~~

~~KP. ODI improved from 74.68 to 17.73 with PVP, and from 66.02 to 34.73 with KP. KPS improved from 66.99 to 80.28. Cement leakage was seen in 37.9% and 13.6% of patients treated with PVP and KP, respectively. Symptomatic complications (N= 43) were rare. The authors concluded that the review showed clinically relevant improvements in pain, ODI, and KPS in patients with VCFs due to malignancy treated with either PVP or KP. Cement leakage is common, but rarely symptomatic. The authors conclude that PVP and KP are safe and effective palliative procedures for painful VCFs in patients with malignant spinal lesions.~~

~~The authors concluded that clinical improvements were observed with both procedures over the 3-year period without significant inter-group differences, but the final mean EQ-5D index score was significantly in favor of the SJ group. Vertebral height restoration/kyphotic correction was still evident at 36 months with a greater mean correction of anterior and central height and a larger correction of the vertebral body angle for SJ group.~~

~~Pourtaheri et al. (2018) conducted a systematic review and meta analysis to (i) assess the clinical outcomes with and without vertebral augmentation (VA) for osteoporotic vertebral compression fractures (VCFs) with versus without correlating signs and symptoms; and (ii) acute (symptoms < 3 month duration) and subacute VCFs (3- 6 month duration) versus chronic VCFs (> 6 months). Thirteen studies totaling 1467 patients with minimum 6 month follow up were found. Pain reduction was greater with VA over conservative management for SVFs and equivalent for RVFs. Subanalysis for acute/subacute SVFs and chronic SVFs showed that VA was superior to nonoperative care. No difference was observed in outcomes between VA and nonoperative care for chronic RVF. The authors concluded that VA is superior to nonoperative care in reducing lower back pain for osteoporotic VCFs with correlating signs and symptoms. VA had no benefit over nonoperative care for chronic VCFs that lacked clinical correlation. The authors also note that lower back pain has many etiologies and patients should be clinically assessed before recommending VA.~~

~~A systematic review and network meta analysis was conducted by Zuo et al. (2018). Randomized controlled trials (RCTs) were compared percutaneous vertebroplasty (PVP), percutaneous kyphoplasty (PKP), nerve block (NB), or conservative treatment (CT) for treating osteoporotic vertebral compression fractures (OVCFs). A total of 18 trials among 1994 patients were included. PKP was first option in alleviating pain in the case of the acute/subacute OVCFs for long term, and chronic OVCFs for short term and long term, while PVP had the most superiority in the case of the acute/subacute OVCFs for short term. NB ranks higher probability than PKP and PVP on acute/subacute OVCFs in short and long term, respectively. The authors concluded that the results suggest that PVA (PVP/PKP) had better performance than CT in alleviating acute/subacute and chronic OVCFs pain for short and long term and that NB may be used as an alternative or before PVA, for pain relief. The findings are limited by the inherent indirectness of network meta analyses.~~

~~In the VERTOS IV study, Firanesescu et al. (2018) conducted a randomized, double blind, sham controlled clinical trial to assess whether PVP results in more pain relief than a sham procedure in patients with acute osteoporotic compression fractures of the vertebral body. Participants requiring treatment for acute osteoporotic vertebral compression fractures (OVCFs) were randomized to either vertebroplasty (n = 91) or a sham procedure (n = 89). Main outcome measure was mean reduction in visual analogue scale (VAS) scores at one day, one week, and one, three, six, and 12 months. Clinically significant pain relief was defined as a decrease of 1.5 points in VAS scores from baseline. Secondary outcome measures were the differences between groups for changes in the quality of life for osteoporosis and Roland-Morris disability questionnaire scores during 12 months' follow-~~

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~~up. The mean difference in VAS scores between groups was 0.20 (95% confidence interval -0.53 to 0.94) at baseline, -0.43 (-1.17 to 0.31) at one day, -0.11 (-0.85 to 0.63) at one week, 0.41 (-0.33 to 1.15) at one month, 0.21 (-0.54 to 0.96) at three months, 0.39 (-0.37 to 1.15) at six months, and 0.45 (-0.37 to 1.24) at 12 months. PVP did not result in statistically significantly greater pain relief than a sham procedure during 12 months' follow-up among patients with acute osteoporotic vertebral compression fractures.~~

~~Duchbinder et al. (2018) conducted a Cochrane review in order to update the clinical evidence on the benefits and harms of vertebroplasty for treatment of osteoporotic vertebral fractures. Randomized and quasi-RCTs of adults with painful osteoporotic vertebral fractures, comparing vertebroplasty with placebo (sham), usual care, or another intervention were included. As it is least prone to bias, vertebroplasty compared with placebo was the primary comparison. Major outcomes were mean overall pain, disability, disease specific and overall health related quality of life, patient reported treatment success, new symptomatic vertebral fractures and number of other serious adverse events. Based upon high to moderate quality evidence, the authors' updated review does not support a role for vertebroplasty for treating acute or subacute osteoporotic vertebral fractures in routine practice. The authors found no demonstrable clinically important benefits compared with placebo (sham procedure) and subgroup analyses indicated that the results did not differ according to duration of pain ≤ 6 weeks versus > 6 weeks. Sensitivity analyses confirmed that open trials comparing vertebroplasty with usual care are likely to have overestimated any benefit of vertebroplasty. Numerous serious adverse events have been observed following vertebroplasty. Due to the small number of events, they stated that they could not be certain about whether or not vertebroplasty results in a clinically important increased risk of new symptomatic vertebral fractures and/or other serious adverse events. In the authors' opinion, patients should be informed about both the high to moderate quality evidence that shows no important benefit of vertebroplasty and its potential for harm.~~

~~Park et al. (2018) assess vertebral height restoration, re-collapse and change of back pain in osteoporotic vertebral compression fracture (OVCF) patients with or without intra-vertebral cleft (IVC) through a retrospective review. The records of 108 patients with IVC (group I) and 233 patients without IVC (group II) were included. The heights of the anterior, middle, and posterior columns, as well as the wedge angle (WA) of the fractured vertebral body were measured. The overall incidence of IVC in OVCF patients who underwent vertebroplasty was 20.8% (127/611 patients). Group I showed significantly higher CR over the entire follow-up period, with the exception of CR for the anterior column at final follow-up, and CR for the posterior column throughout the follow-up. The mean restoration rates at the anterior and middle column immediately after vertebroplasty were also significantly larger in group I. Re-collapse rate in all columns was similar for groups I and II. The mean wedge angle was significantly larger in group I over the entire follow-up period. The groups did not differ in terms of NRS score at final follow-up. The authors concluded that vertebroplasty restores vertebral body heights and WA more effectively in OVCF patients with IVC and provides satisfactory radiographic and clinical outcomes regardless of the presence of IVC. The findings are limited by the observational nature of the study design.~~

~~A meta-analysis of randomized controlled trials (RCTs) by Xie et al. (2017) aimed to evaluate the efficacy and safety in percutaneous vertebroplasty (PVP) and conservative treatment (CT) for osteoporotic vertebral compression fractures (OVCFs). Twelve RCTs with a total 1231 patients (623 in the PVP and 608 in the CT) were included. Patients were followed up for at least 2 weeks in all the studies. Statistical differences were found between pain relief and Quality of Life Questionnaires. No statistical differences were~~

~~found between pain relief and the rate of adjacent vertebral fracture. PVP is associated with higher pain relief than CT in the early period. PVP did not increase the rate of adjacent vertebral fracture. The authors concluded that the results indicate that PVP is a safe and effective treatment for OVCFs.~~

~~Semaan et al. (2017) conducted a retrospective observational study to evaluate the clinical outcome and subsequent sequelae of cement extravasation after percutaneous KP (n = 223) and vertebroplasty (N = 0188) and found that the most common site of cement extravasation was in paravertebral soft tissues for vertebroplasty (n= 33, 40.7%) and for KP (n= 30, 30%). In the subgroup where cement leaked into the intradiscal space, adjacent vertebral body fractures occurred in 3/26 vertebrae (11.5%) in the PVP group and in 2/18 vertebrae (11.1%) in the KP group. Both groups showed a statistically significant decrease in both VAS (P < 0.001) and ODI scores (P < 0.001). The authors concluded that although KP has an advantage in terms of cement extravasation, this factor did not reflect on subsequent sequelae or final clinical outcomes.~~

~~Park et al. (2017) conducted a retrospective case series to evaluate the radiographic and clinical outcomes of percutaneous vertebroplasty (PVP) in patients with Kümmell's disease (N = 18). The mean VAS score significantly decreased after PVP and the decrease was maintained through to the final follow-up (p < 0.05). However, the regional and global kyphotic angle, LL, and TLJ angle were not improved. Cement leakage was observed in 5 cases (26.3%); however, there were no cases of cement leakage into the spinal canal. No neurological deterioration was observed, even among patients with cement leakage. Adjacent level fractures were detected in 3 cases (15.8%). In the authors' opinion, PVP can be considered as an effective treatment option for pain relief and maintenance of sagittal balance in patients with Kümmell's disease. The findings are limited by the lack of comparison group.~~

~~A 2016 Hayes report, updated in 2020, indicated there is moderate-quality evidence that VP may offer benefit as a treatment in some patients with VCF due to osteoporosis. Evidence regarding the benefit of VP compared with sham treatment and CTx was inconsistent, and may be due to variation in factors such as length of follow-up and age of the fracture at treatment. Evidence was consistent that VP offers comparable benefit as kyphoplasty on measures of pain, disability, and QOL. There was insufficient evidence to evaluate comparative outcomes for VP versus facet block. There appear to be unresolved questions regarding the safety of VP. Large database analyses of fair quality offer limited but consistent evidence of higher mortality risk for VP than kyphoplasty. In addition, limited evidence from these database studies suggested that VP was associated with a higher risk for some postoperative complications (pulmonary embolism, deep vein thrombosis, and pneumonia). The clinical relevance of these risk differences is unclear.~~

~~Qi et al. (2016) conducted a meta-analysis to evaluate the function of percutaneous vertebroplasty (PVP) treatment to pain relief and life quality for patients with spinal tumors. Twenty-six studies involving 1351 patients met selection criteria. Meta-analysis results among 10 case-control studies showed that the combined hazard ratio was 2.83 [95% confidence interval (CI) 2.92, 2.73; P < .0001], indicating a 2.83-fold decrease of pain in PVP group. For 12 single-arm studies, a significantly decrease of pain after PVP treatment (HR = -4.79, 95% CI -5.00, -4.57, P < .0001) was also found in PVP group. In addition, for KPS analysis, the combined HR was 16.31 (95% CI 14.31, 18.31; P < .0001), which indicated that PVP treatment was associated with a 16.31-fold increase of KPS. The combined hazard ratio was 0.58 (95% CI 0.35, 0.96; P = .04) for complication analysis. The authors concluded that PVP treatment of spinal tumor is significantly associated with~~

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~~better pain relief and life quality, which could improve the outcome in metastatic spinal tumor patients. The findings are limited by the observational design of some of the included studies.~~

~~Yuan et al. (2016) conducted a meta-analysis to examine vertebroplasty BKP for osteoporotic compression fractures compared to conservative treatment. The authors' review determined that overall vertebroplasty and KP reduce pain and improve function and quality of life as compared with conservative treatment. However, analysis by surgery type indicated that pain relief of kyphoplasty was similar to that of conservative management, but pain relief of vertebroplasty was greater than that of conservative management. Both procedures improved functional outcomes to a greater degree than conservative treatment, and that while KP improved quality of life to a greater degree than conservative treatment, there was no difference in quality of life improvement between vertebroplasty and conservative treatment. These results need to be interpreted with caution however, as only 2 studies examined KP and only 1 of these studies examined function and quality of life.~~

~~In a systematic review, Health Quality Ontario (2016) evaluated the effectiveness and safety of percutaneous image guided vertebral augmentation techniques, vertebroplasty and KP, for palliation of cancer related vertebral compression fractures. Owing to the heterogeneity of the clinical reports, the authors performed a narrative synthesis based on an analytical framework constructed for the type of cancer related vertebral fractures and the diversity of the vertebral augmentation interventions. 111 clinical reports (4,235 patients) were evaluated to determine the effectiveness of vertebroplasty (78 reports, 2,545 patients) or KP (33 reports, 1,690 patients) for patients with mixed primary spinal metastatic cancers, multiple myeloma, or hemangiomas. Overall the mean pain intensity scores often reported within 48 hours of vertebral augmentation (kyphoplasty or vertebroplasty), were significantly reduced. Analgesic use, although variably reported, usually involved parallel decreases, particularly in opioids, and mean pain related disability scores were also significantly improved. In a randomized controlled trial comparing KP with usual care, improvements in pain scores, pain related disability, and health related quality of life were significantly better in the kyphoplasty group than in the usual care group. Bone cement leakage, mostly asymptomatic, was commonly reported after vertebroplasty and KP. Major adverse events, however, were uncommon. The authors concluded that both vertebroplasty and KP significantly and rapidly reduced pain intensity in cancer patients with vertebral compression fractures. The procedures also significantly decreased the need for opioid pain medication, and functional disabilities related to back and neck pain. Pain palliative improvements and low complication rates were consistent across the various cancer populations and vertebral fractures that were investigated.~~

~~Mattie et al. (2016) compared the degree and duration of pain relief following percutaneous vertebroplasty (PVP) with that following conservative treatment and/or sham for osteoporotic compression fractures by means of meta analysis of randomized controlled trials. Based on their analysis, up to 1 year postoperatively, the effect of PVP exceeded the effect of conservative therapy with respect to pain relief in patients with osteoporotic compression fractures. The effect size was significant and close to the minimal clinically important difference. Those receiving PVP (531 out of 1,048 patients) had a significantly lower pain level compared with the control group at 1 to 2 weeks, 2 to 3 months, and 12 months. Based on their observations, the authors concluded that the effect of PVP exceeded the effect of conservative therapy up to 1 year postoperatively with respect to pain relief in patients with osteoporotic compression fractures. The effect size was significant and close to the minimal clinically important difference.~~

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~~Wang et al. (2016) compared the clinical and radiological outcomes of patients undergoing percutaneous vertebroplasty (PVP) versus those undergoing facet blocking (FB) for severe pain due to osteoporotic vertebral compression fractures (OVCFs). 206 patients who had OVCFs on spine radiography and intractable back pain for ≤ 8 weeks were randomly assigned to the PVP group (100 patients) or the FB group (106 patients). Significantly lower VAS, ODI, Roland Morris disability (RMD) scores for patients in the PVP group compared to those in the FB group were observed at follow-up of 1 day and 1 week ($p < 0.05$). However, differences in the VAS, ODI, RMD and SPC/MCS (SF-36) scores between the two groups at follow-ups of more than 1 month were statistically insignificant ($p > 0.05$). Difference in numbers of new fractures in the two groups at the follow-up of 12 months was also statistically insignificant. The authors concluded that PVP produced better pain relief than FB in the short term (≤ 1 week). However, the difference in pain-relief between these two techniques was insignificant in the long term (follow-up between 1 month and 12 months).~~

~~In a case series of surgical treatments for aggressive vertebral hemangiomas, Vasudeva et al. (2016) report on five patients who underwent surgery for treatment of aggressive vertebral hemangiomas during the specified time period. Intraoperative vertebroplasty was used in 3 cases to augment the anterior column or to obliterate residual tumor. The authors conclude that despite the variety of available treatment options, the optimal management strategy is unclear because aggressive vertebral hemangiomas are uncommon lesions, making it difficult to perform large trials. In their opinion, vertebroplasty provides hemostatic embolization and improves the load bearing capacity of the anterior column; however, either kyphoplasty or vertebroplasty may also be used intraoperatively in conjunction with decompressive surgery.~~

~~Tan et al. (2015) conducted a prospective study of percutaneous vertebroplasty (PVP) for chronic painful osteoporotic vertebral compression fracture. Sixty-two consecutive patients with chronic painful osteoporotic VCFs for ≥ 3 months underwent PVP on 92 vertebrae in 73 procedures three to five days after referral. All procedures were performed under local anesthesia. The outcomes were pain relief at one week, one month, three months, six months and one year, as measured by visual analogue scale, Oswestry Disability Index, Quality of Life Questionnaire of the European Foundation for Osteoporosis (QUALEFFO) and Roland Morris Disability Questionnaire scores. According to the authors, the PVP procedures were technically successful and well tolerated in all patients. Compared with baseline scores, improvement in visual analogue scale, Oswestry Disability Index, QUALEFFO and Roland Morris Disability Questionnaire scores was significantly greater after PVP at one week ($P < 0.001$), one month ($P < 0.001$), three months ($P < 0.001$), six months ($P < 0.001$) and one year ($P < 0.001$), and the number of patients using drugs for pain treatment was significantly reduced. Five new fractures were reported in five of 62 patients treated with PVP during follow up. The authors concluded that PVP is effective in patients with chronic painful osteoporotic VCFs due to immediate pain relief that was sustained for one year and may be an important factor for reducing persistent pain. The findings are however limited by the lack of comparison group.~~

~~In a systematic review, Stevenson et al. (2014) evaluated the clinical effectiveness of percutaneous vertebroplasty (PVP) and balloon kyphoplasty (BKP) in reducing pain and disability in people with osteoporotic vertebral compression fractures (VCFs). Inclusion criteria were randomized controlled trials for VCFs treated with their PVP or BKP. Primary outcomes were health related quality of life, back specific functional status/mobility, pain/analgesic use, vertebral body height and angular deformity,~~

~~incidence of new vertebral fractures and progression of treated fracture. A total of nine RCTs were identified and included in the review of clinical effectiveness. This body of literature was of variable quality, with the two double blind, OPLA controlled trials being at the least risk of bias. The most significant methodological issue among the remaining trials was lack of blinding for both study participants and outcome assessors. According to the authors, broadly speaking, the literature suggests that both PVP and BKP provide substantially greater benefits than OPM in open label trials. However, in double blinded trials PVP was shown to have no more benefit than local anesthetic; no trials of BKP compared with local anesthesia have been conducted. The authors concluded that for people with painful osteoporotic VCFs refractory to analgesic treatment, PVP and BKP perform significantly better in unblinded trials than OPM in terms of improving quality of life and reducing pain and disability. However, there is as yet no convincing evidence that either procedure performs better than OPLA. They further commented that data on key parameters were uncertain and/or potentially confounded, making definitive conclusions difficult to make.~~

~~Narayana et al. (2014) evaluated percutaneous vertebroplasty (PVP) in the treatment of painful vertebral hemangiomas refractory to medical management. In this case series, our teen patients (four thoracic and ten lumbar vertebra) with painful vertebral hemangiomas presenting with severe back pain for more than 6 months not responding to medical therapy were treated by PVP. Cross sectional imaging of the spine with magnetic resonance was done. The pain intensity numeric rating scale (PI NRS 11) of these patients was in the range of 7-10 (Severe Pain). After vertebroplasty 8 patients were completely free of pain (PI NRS Score 0) while 6 were significantly relieved (PI NRS Score 1-3). No complications were observed. Two patients with associated radicular pain had good pain relief following PVP. No recurrence was found during 36 months of postoperative follow up. The authors concluded that PVP is a safe and effective procedure in patients with painful vertebral hemangiomas refractory to medical management. The findings are however limited by lack of comparison group.~~

~~In a prospective randomized study, Chen et al. (2014) compared the efficacy of percutaneous vertebroplasty (PV) and conservative treatment (CT) for pain relief and functional outcome in patients with chronic compression fractures and persistent pain. Ninety-six patients with chronic compression fractures confirmed by MRI and persistent severe pain for 3 months or longer were prospectively randomly assigned to undergo PVP (n = 46, Group A) or CT (n = 50, Group B). The primary outcome was pain relief and functional outcome at 1 week, 1 month, 3 months, 6 months and 1 year. A total of 89 patients (46 in Group A and 43 in Group B) completed the 1-year follow-up assessment. Pain relief and functional outcomes were significantly better in Group A than in Group B, as determined by visual analogue scale scores, Oswestry Disability Index scores, and Roland Morris Disability scores at 1 week, 1 month, 3 months, 6 months and 1 year (all p < 0.001). The final clinical follow-up assessment indicated complete pain relief in 39 Group A patients and 15 Group B patients (p < 0.001). PVP for patients with chronic compression fractures and persistent severe pain was associated with better pain relief and improved functional outcomes at 1 year compared to CT.~~

~~Sun et al. (2014) conducted a retrospective case series to evaluate the safety and efficacy of percutaneous vertebroplasty (PVP) in patients with painful spinal metastasis and encroachment of epidural space. Patients (n = 43) with spinal metastasis underwent PVP, for a total of 69 affected levels. All patients had at least 1 level associated with epidural encroachment related to metastasis. Among these patients, 14 had signs of spinal cord or cauda equina compression. Pain intensity was scored on a visual-analog scale (VAS). The analgesic efficacy was defined as at least 50% improvement in pain score as~~

~~compared with the pre-procedure baseline and post-procedure. Clinical improvement of neurological compressive symptoms was defined as a decrease in ASIA impairment scale from baseline of 1 point or more. The authors reported that analgesic efficacy was achieved in 89.7% of survival patients at 1 month, 87.5% at 3 months, 86.9% at 6 months, and 84.6% at 1 year. No deterioration of spinal cord or cauda equina compression symptoms was observed after a PVP in any patients. The different grade of epidural encroachment of the lesions was not correlated with filling volume or extraosseous leakage ($P > 0.05$). The treated levels with epidural encroachment showed a statistically significant relationship to spinal-canal leakage ($P < 0.05$). The authors concluded that PVP can be performed safely and effectively in patients with painful spinal metastasis and epidural encroachment. The findings are however limited by lack of comparison group.~~

~~In a meta analysis of randomized controlled trials, Liu et al. (2013) compared the amount of pain reduction measured using the visual analog scale (VAS) when osteoporotic vertebral compression fractures are treated with percutaneous vertebroplasty (PVP) or conservatively. They also assessed the clinical utility of PVP. Five randomized controlled trials met the analysis criteria; conservative treatments used as comparators in these trials were different. There was no difference in pain relief in the PVP group at 2 weeks and one month when compared with the conservatively managed group. Pool results from the 5 studies showed that pain relief in the PVP group was greater than that of the conservative group at 3 months, 6 months, and 12 months. However, after subgroup analysis, pain scores were similar between the PVP group and the sham injection group from 2 weeks to 6 months. Compared with non operative therapy, PVP reduced pain at all times studied. The authors concluded that PVP has some value for relieving pain; however, the possibility of a placebo effect should be considered. They recommend more large scale, double blinded, controlled trials in order to quantify the pain relief afforded by PVP more precisely.~~

~~Shi et al. (2012) performed a meta analysis to determine whether, when compared to non-operative management or sham procedures, percutaneous vertebroplasty (PVP) provided greater improvement in pain and pain related disability for patients with vertebral compression fractures. Using a random effects model, the authors calculated the weighted mean differences to evaluate the pain reduction at different times as the primary outcome. Pain related disability was assessed by a quality of life (QOL) measure. Improvement of QOL and recurrence of vertebral fractures were the secondary outcomes. The authors used subgroup analysis to reinvestigate pain relief and function improvement of PVP based on two different controls: nonoperative therapy and sham injection. The total number of patients was 886. Based on the outcome of their review, pain scoring was similar between the PVP group and the sham injection group at 1 to 29 days and 90 days. However, compared with nonoperative therapy, PVP reduced pain at all times studied. QOL in the PVP group was improved or tended to be improved compared with QOL for both control groups. The risk of new fractures was similar between the PVP groups and both control groups. They noted that different control groups may have accounted for the different conclusions in the literature regarding the ability of PVP to relieve pain and restore function recovery. Compared with nonoperative treatment PVP relieved pain better and improved QOL. PVP did not increase the risk of new fractures.~~

~~Blasco et al. (2012) conducted a prospective, controlled, randomized single-center trial to compare the effects of percutaneous vertebroplasty (VP) versus conservative treatment on the quality of life and pain in patients with painful osteoporotic vertebral fractures, new fractures and secondary adverse effects were also analyzed during a 12-month follow-up period. Patients (n = 125) were randomly assigned to receive conservative treatment or VP. The primary end point was to compare the evolution of the quality of~~

life (Quality of Life Questionnaire of the European Foundation for Osteoporosis [Qualeffo-41] and pain (Visual Analogue Scale [VAS]) during a 12-month follow-up. Secondary outcomes included comparison of analgesic consumption, clinical complications, and radiological vertebral fractures at the same time points. The authors reported that both arms showed significant improvement in VAS scores at all time points, with greater improvement ($p = 0.035$) in the VP group at the 2-month follow-up. In addition, significant improvement in Qualeffo total score was seen in the VP group throughout the study, whereas this was not seen in the conservative treatment arm until the 6-month follow-up. VP treatment was associated with a significantly increased incidence of vertebral fractures (odds ratio [OR], 2.78; 95% confidence interval [CI], 1.02-7.62, $p = 0.0462$). The authors observed that VP and conservative treatment are both associated with significant improvement in pain and quality of life in patients with painful osteoporotic vertebral fractures over a 1-year follow-up period. They concluded that VP achieved faster pain relief with significant improvement in the pain score at the 2-month follow-up but was associated with a higher incidence in vertebral fractures.

In a prospective case series, Farrokhi et al. (2012) evaluated the efficacy of percutaneous vertebroplasty (PVP) in pain relief in patients with spinal fractures due to metastatic spinal tumors. Patients ($n = 25$) consisted of 11 males and 14 females with mean age of 53.5 (range 37 to 70 years). Severe pain was the main presenting symptom in these patients that had decreased their quality of life. The authors reported that the original pain was improved. VAS scores of the patients were compared before and after the procedure and meaningful P-value of 0.00 was obtained 24 hours and 2 months after PVP ($P \leq 0.05$) that was considered statistically significant. Mean VAS pain degree of these patients was 8.23 before PVP that was decreased to 2.12 and 1 in 24 hours and 2 months afterwards. The authors concluded that PVP is a safe, effective and minimally invasive surgical technique with decreased overall surgical complications which is successful at improving pain and contributes to spinal stabilization. The findings are however limited by the lack of comparison group.

Anselmetti et al. (2012) prospectively evaluated the safety and efficacy of percutaneous vertebroplasty (PV) in the treatment of vertebral compression fractures (VCFs) resulting from multiple myeloma (MM). PV was performed in a case series of 106 consecutive MM patients who had back pain due to VCFs, the treatment of which had failed conservative therapies. Follow-up (28.2 ± 12.1 months) was evaluated at 7 and 15 days as well as at 1, 3, 6, 12, 18, and every 6 months after PV. Visual analog scale (VAS) pain score, opioid use, external brace support, and Oswestry Disability Index (ODI) score were recorded. The median pretreatment VAS score of 9 (range 4-10) significantly ($P < 0.001$) decreased to 1 (range 0-9) after PV. Median pre-ODI values of 82% (range 36-89%) significantly improved to 7% (range 0-82%) ($P < 0.001$). Differences in pretreatment and posttreatment use of analgesic drug were statistically significant ($P < 0.001$). The majority of patients (70 of 81; 86%) did not use an external brace after PV ($P < 0.001$). The authors concluded that PV is a safe, effective, and long-lasting procedure for the treatment of vertebral compression pain resulting from MM. The findings are however limited by the lack of comparison group.

Doochi et al. (2012) studied in this case series treatment with vertebroplasty in patients with painful vertebral hemangiomas to determine its validity for this usage. Patients ($n = 24$) were treated by percutaneous vertebroplasty: 16 thoracic, 8 lumbar. The average age at the time of surgery was 48 years. All the patients complained of a pain syndrome resistant to continuing medication. Preprocedure imaging was conducted for confirmation. The mean follow-up was 5.8 years. In all the patients, the authors observed a successful outcome with a complete resolution of pain symptom. Clinical and

~~radiological follow up showed stability of the treatment and absence of pain in all patients. They concluded that percutaneous treatment with vertebroplasty for symptomatic vertebral hemangiomas is a valuable, less-invasive, and a quick method that allows a complete and enduring resolution of the painful vertebral symptoms without findings of the vertebral body's fracture. The findings are however limited by the lack of comparison group.~~

~~Farrokhi et al. (2011) conducted a randomized controlled trial that compared the efficacy of percutaneous vertebroplasty (PV) versus optimal medical therapy (OMT) in controlling pain and improving the quality of life (QOL) in patients with vertebral compression fractures. Efficacy was measured as the incidence of new vertebral fractures after PV, restoration of vertebral body height (VBH), and correction of deformity. Forty patients underwent PV and 42 received OMT. Primary outcomes were control of pain and improvement in QOL before treatment, and these were measured at 1 week and at 2, 6, 12, 24, and 36 months after the beginning of the treatment. Radiological evaluation to measure VBH and sagittal index was performed before and after treatment in both groups and after 36 months of follow-up. The authors found a statistically significant improvement in pain in the PV group compared with the OMT group at 1 week (difference -3.1, 95% CI -3.72 to -2.28; $p < 0.001$). The QOL improved significantly in the PV group (difference -14, 95% CI -15 to -12.82; $p < 0.028$). One week after PV, the average VBH restoration was 8 mm and the correction of deformity was 8°. The incidence of new fractures in the OMT group (13.3%) was higher than in the PV group (2.2%; $p < 0.01$). The authors observed that the PV group had statistically significant improvements in visual analog scale and QOL scores maintained over 24 months, improved VBH maintained over 36 months, and fewer adjacent-level fractures compared with the OMT group.~~

~~Klazen et al. (2010) conducted an open-label prospective randomized trial (VERTOS II) from the radiology departments of six hospitals in the Netherlands and Belgium. Patients were aged 50 years or older, had vertebral compression fractures on spine radiograph (minimum 15% height loss; level of fracture at Th5 or lower; bone edema on MRI), with back pain for 6 weeks or less, and a visual analogue scale (VAS) score of 5 or more. Patients (n = 202) were randomly allocated to percutaneous vertebroplasty (101) or conservative treatment (101) by computer-generated randomization codes with a block size of six. Masking was not possible for participants, physicians, and outcome assessors. The primary outcome was pain relief at 1 month and 1 year as measured by VAS score. Vertebroplasty resulted in greater pain relief than did conservative treatment; difference in mean VAS score between baseline and 1 month was -5.2 (95% CI -5.88 to -4.72) after vertebroplasty and -2.7 (-3.22 to -1.98) after conservative treatment, and between baseline and 1 year was -5.7 (-6.22 to -4.98) after vertebroplasty and -3.7 (-4.35 to -3.05) after conservative treatment. The difference between groups in reduction of mean VAS score from baseline was 2.6 (95% CI 1.74-3.37, $p < 0.0001$) at 1 month and 2.0 (1.13-2.80, $p < 0.0001$) at 1 year. No serious complications or adverse events were reported. The authors concluded that in a subgroup of patients with acute osteoporotic vertebral compression fractures and persistent pain, percutaneous vertebroplasty is effective and safe as pain relief was immediate, is sustained for at least a year, and is significantly greater than that achieved with conservative treatment. The findings are however limited by the lack of masking to treatment assignment, which could have resulted in biases.~~

Kallmes et al. Osteoporotic Vertebral Compression Fractures (VCFs)

An updated 2021 Hayes Health Technology Assessment reported on percutaneous kyphoplasty (KP) for osteoporotic vertebral compression fractures. The report included 10 studies: 6 randomized controlled trials (RCTs) (8 publications), 1 quasi-RCT, and 3 database

studies. The sample size was 59 to 1,038,956 patients with VCFs due to osteoporosis with a 6 month to 4 years follow-up. The authors concluded that (2010) conducted a multicenter, randomized control trial for patients (n = 131) with 1-3 painful, osteoporotic vertebral compression fractures who were assigned to vertebroplasty or to a simulated vertebroplasty without cement. The primary outcomes were modified Roland-Morris Disability Questionnaire (RDQ) scores (range, 0-23) and patient ratings of average pain intensity in the preceding 24 hours (0-10 numerical rating scale) at one month. Patients were allowed to cross over after one month. The baseline characteristics were similar in the two groups. At one month, the vertebroplasty and control groups did not differ significantly on either the RDQ (treatment difference: 0.7; 95% CI: -1.3, 2.8; P = 0.49) or the pain rating (treatment difference: 0.7; 95% CI: -0.3, 1.7; P = 0.19). Both groups showed immediate improvement in disability and pain after the intervention. Although the groups did not differ significantly on any secondary outcome at one month, there was a trend toward a higher rate of clinically meaningful improvement in pain (30% decrease from baseline) in the vertebroplasty group (64% versus 48%, P = 0.06). At three months, there was a higher crossover rate in the control group (43% versus 12%, P < 0.001)). There was one serious adverse event in each group. The authors concluded that improvement in osteoporotic compression fracture pain and pain-related disability was similar in patients treated with vertebroplasty and patients treated with simulated vertebroplasty without cement.

Kyphoplasty (KP)

A ~~Hayes~~ report on percutaneous kyphoplasty for osteoporotic vertebral compression fractures states there is moderate-quality evidence that KP may be beneficial to some patients with a VCF due to osteoporosis that have ~~has~~ not responded to conservative treatment (CT). ~~CT~~. There is consistent evidence that KP and VP provide similar improvements in pain, disability, and QOL from baseline. There is limited evidence that KP is favored over CT ~~CT~~ for pain relief., ~~although additional studies evaluating this comparison are needed. There is remaining uncertainty regarding the comparative safety of KP, VP, and CT.~~ Large fair-quality database analyses offer limited but consistent evidence of lower mortality risk in patients treated with KP compared with those treated with VP. In addition, limited evidence from these database studies suggested ~~suggests~~ that VP is associated with a higher risk for some postoperative complications (e.g., pulmonary embolism, deep vein thrombosis, and pneumonia)- (Hayes, The clinical relevance of these risk differences is unclear and requires further analysis. (2017; updated 2021 2020).

Otsuka et al. (2021) completed a single-center retrospective analysis to identify predictors of outcome after balloon kyphoplasty (BKP) in patients with osteoporotic vertebral compression fracture (OVCF). Between January 2001 and December 2019, 152 patients underwent BKP for painful OVCFs at the National Cerebral and Cardiovascular Center Hospital in Osaka, Japan. This study included 115 patients who were followed for >12 months, and their data were retrospectively analyzed. Regarding the degree of independent living 1 year after BKP, patients were divided into a good outcome group (composed of patients who could independently go indoors) and a poor outcome group. The authors analyzed factors associated with outcome and subsequent OVCF. Mean age of patients was 77.9 years, 58.2% were female, 81% had a good outcome, and 19% had a poor outcome. Univariable analysis revealed significant differences in age, bone mineral density, preoperative vertebral body decompression rate, body mass index (BMI), pre-operative Japanese Orthopaedic Association score, pre-operative modified Rankin Scale score, and subsequent OVCF. Multivariable logistic analysis showed that low BMI (odds ratio 1.415, 95% confidence interval 1.06 - 1.87, P = 0.046) and subsequent OVCF (odds ratio 0.13, 95% confidence interval 0.02 - 0.69, P = 0.044) were independent risk

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factors. The incidence of subsequent OVCF was also lower among patients with higher BMI (odds ratio 0.83, 95% confidence interval 0.72 - 0.95, P = 0.001). Body mass index (BMI) and subsequent OVCF are the most influential predictors of independent living 1 year after BKP for OVCF.

A 2016 Hayes Health Technology Assessment, updated in 2021, reviewed comparative effectiveness of percutaneous vertebroplasty versus sham, conservative treatment, or kyphoplasty for osteoporotic vertebral compression fractures. The evidence comprised 19 studies: 15 RCTs, 1 quasi-RCT, and 3 database studies. The sample sizes were 49 to 1,038,956 patients with VCFs due to osteoporosis with a follow-up of 6 months to 4 years. The authors reported that moderate-quality evidence found that for patients with acute pain, pain relief was better for VP versus sham or CT in 4 of 10 studies, and was similar to comparators (sham, facet block, kyphoplasty) in 6 of 10 studies. For patients with chronic pain, VP was favored over CT in 3 of 5 studies, was equivocal relative to sham in 1 study, and was similar to kyphoplasty in 1 of 5 studies. Findings were generally similar for disability and QOL. The most reported adverse events across studies were the occurrence of additional VCFs following treatment and cement leakage. The 2021 annual review included two new key studies with no change to the evidence or conclusion.

Li, Cai & Cong (2021) performed a systematic review and meta-analysis comparing the safety and efficacy of vertebral augmentation (VA) with non-surgical management (NSM) for treatment of osteoporotic OVCFs. The study included 20 randomized controlled trials involving 2,566 patients with painful OVCFs. There were no significant differences between PVP and sham procedure VAS scores at most time points during follow-up period. In a subgroup analysis based on fracture type and fracture location, significant differences of VAS were found between PVP and CT and were not found between PVP and sham procedure. In a subgroup analysis of duration of back pain, significant differences were found between PVP and CT in VAS at 1 week, 3 months and 1 year. The differences of VAS were not significant between PVP and CT at 1 month and 6 months. The authors concluded that VA is safe and effective for treatment of painful OVCFs with good clinical outcomes compared to patients undergoing conservative NSM. (Authors Berenson et al. (2011), Boonen et al. (2011), Blasco et al. (2012), Chen et al. (2014), Farrokhi et al. (2011), Firanescu et al. (2018), Kallmes et al. (2009), and Klazen et al. (2010), which were previously cited in this policy are included in this systematic and meta-analysis review).

Hinde et al. (2020) performed a systematic review and meta-analysis comparing mortality benefits of individuals with osteoporotic vertebral compression fractures (OVCFs) who have undergone VA versus those who received non-surgical management (NSM). A total of 16 studies including more than 2 million patients with OVCF (VA = 382 070, NSM = 1 707 874) were included in the review. Only 7 studies were included in the meta-analysis. Results showed hazard ratios (HRs) for mortality benefit for VA versus NSM over a two- and five-year period as 0.78 (P < .001) and 0.79 (P = .05). Pooled hazard ratio for mortality comparing VA with conservative management was 0.78 (P = .003) at up to 10 years. Balloon kyphoplasty provided a mortality benefit over VA with a hazard ratio of 0.77 versus 8.87 (P < .001). The authors concluded that VA offers survival benefits when treating OVCFs and should be offered in carefully selected patients as a best clinical practice. Osteoporotic vertebral compression fractures who underwent vertebral augmentation were 22% less likely to die at up to 10 years after treatment than those who received nonsurgical treatment.

Wei et al. (2020) performed a systematic review and meta-analysis to compare clinical outcomes of PVP versus PKP for treatment of osteoporotic vertebral compression fractures (OVCFs) with intravertebral cleft (IVC). The review included 688 patients in nine

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studies: 378 patients were treated with PVP and 310 patients with PKP. The authors stated the results indicated no significant differences between the two groups in the short-and long-term VAS, ODI, LKA, or VH% (P> 0.05). PKP was associated with significantly longer operation time, higher cost, and more injected cement volume. PKP had a lower risk of cement leakage. There was no significant difference in adjacent-level fracture rates. The authors concluded that both PVP and PKP are safe and effective minimally invasive options for treatment of OVCFs.

~~Astur and Anzi conducted a systematic review (2019) of randomized controlled trials to assess the efficacy of kyphoplasty (KP) in controlling pain and improving quality of life in oncologic patients with metastatic spinal disease and pathologic compression fractures of the spine. After a literature search through medical databases, two studies with a combined total of 181 patients, met inclusion criteria. A meta analysis was not possible due to data heterogeneity and individual analysis of studies was performed. There was moderate evidence that patient treated with balloon kyphoplasty (BKP) displayed better scores for pain (Numeric Rating Scale), disability (Roland Morris Disability Questionnaire), quality of life (Short Form 36 Health Survey), and functional status (Karnofsky Performance Status) compared with those undergoing conventional treatment. Patients treated with KP also had better recovery of vertebral height. The authors concluded that although balloon kyphoplasty (KP) could be considered as an early treatment option for patients with symptomatic neoplastic spinal disease, further randomized clinical trials should be performed for improvement of the quality of evidence.~~

Liu et al. (2019) performed a randomized controlled trial to assess the effect of BKP on elderly patients with multiple osteoporotic vertebral fractures. The observation group was treated with BKP, and the control group was managed with conservative treatment. Image indices, pain degree, daily life disturbance, and occurrences of complications were compared between the two groups. One hundred sixteen elderly patients with multiple osteoporotic vertebral fracture divided randomly into observation (n = 58) and control groups (n = 58). The observation group showed a significantly higher trailing edge, leading edge, and midcourt line and larger upper thoracic kyphosis compared with the control group. Before the treatment, no statistically significant differences were observed between the two groups in terms of visual analog scale (VAS) score and daily life disturbance score. The VAS score and the daily life disturbance score of the two groups decreased sharply after the treatment. Moreover, the VAS score and the daily life disturbance score of the observation group were significantly lower than those of the control group. The observation group showed lower occurrence rate of complications compared with the control group. The authors concluded that BKP can significantly improve the image indices of patients with multiple osteoporotic vertebral fractures and relieve their pain degree and daily life disturbance. BKP exhibited a low occurrence rate of complications and high safety.

A pilot monocenter prospective study (Noriega et al., 2019) in 30 patients with painful osteoporotic vertebral compression fractures compared two vertebral augmentation procedures. Patients were randomized to SpineJack® (SJ) (n=15) or balloon kyphoplasty (BKP) (n=15). Clinical endpoints were analgesic consumption, back pain intensity (visual analog scale (VAS)), the Oswestry Disability Index (ODI), and quality of life (EQ-VAS score). They were recorded preoperatively, at 5 days (except EQ-VAS), 1, 3, 6, 12, and 36 months post-surgery. Spine X-rays were taken 48 hours prior to the procedure and 5 days, 6, 12, and 36 months after. Over a 3-year post-surgery follow-up, pain/disability/quality of life remained significantly improved with both BKP and SpineJack® techniques, but the latter allowed better vertebral body height

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restoration/kyphosis correction. Preliminary results showed that SJ resulted in a better restoration of vertebral heights and angles, maintained over 12 months.

~~A systematic review was conducted by Sadeghi Naini et al. (2018) to assess the effects of vertebroplasty (VP) and kyphoplasty (KP) compared with each other, usual care, or other treatments on pain, disability, and quality of life following metastatic spinal lesions (MSL). Nine trials were included in the qualitative analysis. In total, there were 622 patients enrolled in the trials and of them 432 were in the surgical treatment group (92 received KP, 97 received VP, 134 received VP and chemotherapy, 68 received VP and radiotherapy, and 41 received Kiva implant) and 190 were in the nonsurgical treatment group (83 received chemotherapy, 46 received radiotherapy, and 61 received other treatment). Using the grading of recommendations assessment, development and evaluation approach, pain (low quality evidence) and functional scores (very low quality evidence) improved more with VP plus chemotherapy than with chemotherapy alone. KP seemed to lead to significantly greater improvement in pain, disability, and health related quality of life (HRQoL) compared with nonsurgical management. VP plus Iodine 125 seemed to lead to significantly greater improvement in pain and disability in comparison with VP alone. VP plus radiochemotherapy resulted in better pain relief and HRQoL postoperatively in comparison with routine radiochemotherapy. The authors concluded that there was low quality evidence to prove that surgical treatment significantly decreases pain and improves functional score and HRQoL following MSL in comparison with nonsurgical management. On the basis of the analysis of currently published trial data, it is unclear whether VP for MSL provides benefits over KP.~~

Buchbinder et al. (2018) conducted a Cochrane review in order to update the clinical evidence on the benefits and harms of vertebroplasty for treatment of osteoporotic vertebral fractures. Randomized and quasi- RCTs of adults with painful osteoporotic vertebral fractures, comparing vertebroplasty with placebo (sham), usual care, or another intervention were included. As it is least prone to bias, vertebroplasty compared with placebo was the primary comparison. Major outcomes were mean overall pain, disability, disease-specific and overall health-related quality of life, patient-reported treatment success, new symptomatic vertebral fractures, and number of other serious adverse events. Based upon high- to moderate-quality evidence, the authors' updated review does not support a role for vertebroplasty for treating acute or subacute osteoporotic vertebral fractures in routine practice. The authors found no demonstrable clinically important benefits compared with placebo (sham procedure) and subgroup analyses indicated that the results did not differ according to duration of pain ≤ 6 weeks versus > 6 weeks. Sensitivity analyses confirmed that open trials comparing vertebroplasty with usual care are likely to have overestimated any benefit of vertebroplasty. Numerous serious adverse events have been observed following vertebroplasty. Due to the small number of events, they stated that they could not be certain about whether or not vertebroplasty results in a clinically important increased risk of new symptomatic vertebral fractures and/or other serious adverse events. In the authors' opinion, patients should be informed about both the high- to moderate-quality evidence that shows no important benefit of vertebroplasty and its potential for harm.

Pourtaheri et al. (2018) conducted a systematic review and meta-analysis to (i) assess the clinical outcomes with and without vertebral augmentation (VA) for osteoporotic vertebral compression fractures (VCFs) with versus without correlating signs and symptoms; and (ii) acute (symptoms <3 -month duration) and subacute VCFs (3- 6 month duration) versus chronic VCFs (>6 months). Thirteen studies totaling 1467 patients with minimum 6-month follow-up were found. Pain reduction was greater with VA over conservative management for SVFs and equivalent for RVFs. Sub analysis for acute/subacute

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SVFs and chronic SVFs showed that VA was superior to nonoperative care. No difference was observed in outcomes between VA and nonoperative care for chronic RVF. The authors concluded that VA is superior to nonoperative care in reducing lower back pain for osteoporotic VCFs with correlating signs and symptoms. VA had no benefit over nonoperative care for chronic VCFs that lacked clinical correlation. The authors also note that lower back pain has many etiologies and patients should be clinically assessed before recommending VA.

Wang and colleagues (2018) completed a systematic review and meta-analysis which included a total of 16 studies and was aimed at exploring the overall safety and efficacy of BKP versus PVP for osteoporotic vertebral compression fracture (OVCF). The qualified studies included randomized controlled trials ($n=1$), prospective or retrospective comparative studies, and cohort studies. The results indicated that KP significantly decreased the kyphotic wedge angle (SMD, 0.98; 95% CI 0.40-1.57), increased the postoperative vertebral body height (SMD, - 1.27; 95% CI - 1.86 to - 0.67), and decreased the risk of cement leakage (RR, 0.62; 95% CI 0.47-0.80) in comparison with vertebroplasty. However, there was no statistical difference in visual analog scale (VAS) scores (WMD, 0.04; 95% CI - 0.28-0.36) and Oswestry Disability Index (ODI) scores (WMD, - 1.30; 95% CI - 3.34-0.74) between the two groups. The authors concluded that KP contributes especially to decreasing the mean difference of kyphotic wedge angle and risk of cement leakage and increasing the vertebral body height when compared with vertebroplasty. But radiographic differences did not significantly influence the clinical results (no significant difference was observed in VAS scores and ODI scores between the two groups); thus, KP and PVP are equally effective in the clinical outcomes of OVCF. Furthermore, the authors indicated that more high-quality multi-center RCTs with a larger sample size and longer follow-up are warranted to confirm the current findings. The findings are limited by inclusion of mostly observational studies.

~~Zhang et al. (2017) conducted a meta analysis to evaluate whether PVP or BKP for osteoporotic vertebral compression fractures increase the incidence of new vertebral fractures. Twelve studies and 1,328 patients were included; 768 underwent a surgical procedure, and 560 received non operative treatments. For new level vertebral fractures, the meta analysis found no significant difference between the 2 methods, including total new fractures ($P = 0.55$) and adjacent fractures ($P = 0.5$). For pre-existing vertebral fractures, there was no significant difference between the 2 groups (operative and non-operative groups) ($P = 0.24$). Additionally, there was no significant difference in bone mineral density, both in the lumbar ($P = 0.13$) and femoral neck regions ($P = 0.37$), between the 2 interventions. The analysis did not reveal evidence of an increased risk of fracture of vertebral bodies, especially those adjacent to the treated vertebrae, following augmentation with either method compared with conservative treatment.~~

~~A retrospective, observational study (Lee et al., 2018) was conducted to investigate the clinical and radiological outcomes of percutaneous balloon kyphoplasty (PBK) for the treatment of very severe osteoporotic vertebral compression fractures (vsOVCF) compared with those of non-vsOVCF. A total of 167 consecutive patients (210 vertebral bodies) who underwent PBK for OVCF between March 2010 and January 2015 were assessed. Visual analog scale (VAS) scores for back pain, Korean Oswestry disability index (K-ODI) scores, vertebral body height variations, and kyphotic angles were evaluated preoperatively, postoperatively, and 1 year after treatment. Patients in the non-vsOVCF group (anterior vertebral compression of more than two-thirds on plain radiograph) who had undergone PBK were compared with those in the non-vsOVCF group (compression between 30% and two-thirds). Clinical and radiological outcomes were compared. In addition, complications were evaluated. In total, 31 patients (33 vertebrae) in the vsOVCF group and 136 patients~~

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~~(177 vertebrae) in the non-vsOVCF group were treated with PBK. Both groups had significant postoperative improvements in the clinical and radiological outcomes. There was no difference regarding the VAS score and the K-ODI score between the two groups at the final follow-up. The cement leakage occurred frequently in the vsOVCF group (26 vertebrae, 78.8%) than in the non-vsOVCF group (92 vertebrae, 52.0%), the difference was statistically significant. But there was no case that showed neurologic complication or pulmonary embolism caused by cement leakage. The incidence of recollapse was significantly higher in the vsOVCF group (five vertebrae, 15.2%) than in the non-vsOVCF group (seven vertebrae, 4.0%). The incidence of an adjacent segment fracture (vsOVCF group, 6 vertebrae, 18.2%; non-vsOVCF group, 21 vertebrae, 11.9%) was not significantly different. The authors concluded that PBK is a safe and effective procedure for the treatment of vsOVCF. The findings are limited by the observational design of the study.~~

~~Zhao et al. (2017) performed a network meta analysis to assess the efficacy and safety of vertebroplasty (VP), kyphoplasty (KP), and conservative treatment (CT) for the treatment of osteoporotic vertebral compression fractures (OVCFs). Sixteen RCTs with 2046 participants were included. Compared with CT, patients treated with VP had improved pain relief, daily function, and quality of life; however, no significant differences were found between VP and KP for these 3 outcomes. All treatment options were associated with comparable risk of new fractures. VP was the most effective treatment for pain relief, followed by KP and CT; conversely, KP was the most effective in improving daily function and quality of life and decreasing the incidence of new fractures, followed by VP and CT. The authors concluded that VP might be the best option when pain relief is the principle aim of therapy, but KP was associated with the lowest risk of new fractures and might offer better outcomes in terms of daily function and quality of life. The findings are limited by the inherent indirectness of network meta analyses.~~

~~In the KAST trial, Beall et al. (2017) assessed the effect of 2 different augmentation procedures (balloon kyphoplasty and implant-based approach) on unplanned readmission rates due to significant adverse effects. Forty (27.8%) patients with implants had 69 SAEs associated with readmission compared to 44 (31.2%) patients with BK having 103 events. The risk for all SAEs leading to readmission was 34.4% lower with the implant than for BK (95% confidence interval = 11.1%, 51.7%; $P < 0.01$). Multivariate analysis showed that the risk of SAEs associated with readmission was decreased in subjects treated with the implant compared to BK and increased in patients with prior histories of vertebral compression fractures (VCFs) or significant osteoporosis. The augmentation approaches compared in this study have similar pain relief and quality of life effects; the implant showed a lower risk of readmissions. The authors noted that the sample size is underpowered, although the results remain significant.~~

A systematic review and network meta-analysis was conducted by Zuo et al. (2018). Randomized controlled trials (RCTs) were compared percutaneous vertebroplasty (PVP), percutaneous kyphoplasty (PKP), nerve block (NB), or conservative treatment (CT) for treating osteoporotic vertebral compression fractures (OVCFs). A total of 18 trials among 1994 patients were included. PKP was first option in alleviating pain in the case of the acute/subacute OVCFs for long term, and chronic OVCFs for short term and long term, while PVP had the most superiority in the case of the acute/subacute OVCFs for short term. NB ranks higher probability than PKP and PVP on acute/subacute OVCFs in short and long-term, respectively. The authors concluded that the results suggest that PVA (PVP/PKP) had better performance than CT in alleviating acute/subacute and chronic OVCFs pain for short and long-term and that NB may be used as an alternative or before PVA, for pain relief. The findings are limited by the inherent indirectness of network meta-analyses. (Authors Evans et al. (2016), Farrokhi et al. (2011), Klazen et al. (2010), and Wang (2016) which were previously cited in this policy are included in this systematic review).

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In a systematic review of pain, quality of life and safety outcomes of BKP compared to other surgical techniques and non-surgical management for vertebral compression fractures (VCF), a task force of the American Society of Bone and Mineral Research (ASBMR) evaluated ten unique trials (1,837 participants). BKP in comparison to non-surgical management, was associated with greater reductions in pain, back-related disability, and better quality of life that appeared to lessen over time but were less than minimally clinically important differences. Risk of new VCF at 3 and 12 months was not significantly different. Individuals with painful VCF experienced symptomatic improvement compared with baseline with all interventions. There were no significant differences between BKP and PVP in back pain, back disability, quality of life, risk of new VCF or any adverse events. Limitations of the studies included lack of a balloon kyphoplasty versus sham comparison, availability of only one randomized controlled trial of BKP versus non-surgical management, and lack of study blinding. The Task Force recommends well-conducted randomized trials comparing BKP with sham to help resolve remaining uncertainty about the relative benefits and harms of this procedure (Rodriguez et al., 2017). (Author Boonen et al. (2011) which was previously cited in this policy is included in this systematic review).

A meta-analysis of randomized controlled trials (RCTs) by Xie et al. (2017) aimed to evaluate the efficacy and safety in percutaneous vertebroplasty (PVP) and conservative treatment (CT) for osteoporotic vertebral compression fractures (OVCFs). Twelve RCTs with a total 1231 patients (623 in the PVP and 608 in the CT) were included. Patients were followed up for at least 2 weeks in all the studies. Statistical differences were found between pain relief and Quality of Life Questionnaires. No statistical differences were found between pain relief and the rate of adjacent vertebral fracture. PVP is associated with higher pain relief than CT in the early period. PVP did not increase the rate of adjacent vertebral fracture. The authors concluded that the results indicate that PVP is a safe and effective treatment for OVCFs. (Authors Blasco et al. (2012), Chen et al. (2014), Farrokhi et al. (2011), and Klazen et al. (2010), which were previously cited in this policy are included in this meta-analysis review).

Zhang et al. (2017) conducted a meta-analysis to evaluate whether PVP or BKP for osteoporotic vertebral compression fractures increase the incidence of new vertebral fractures. Twelve studies and 1,328 patients were included; 768 underwent a surgical procedure, and 560 received non-operative treatments. For new-level vertebral fractures, the meta-analysis found no significant difference between the 2 methods, including total new fractures ($P = 0.55$) and adjacent fractures ($P=0.5$). For pre-existing vertebral fractures, there was no significant difference between the 2 groups (operative and non-operative groups) ($P=0.24$). Additionally, there was no significant difference in bone mineral density, both in the lumbar ($P=0.13$) and femoral neck regions ($P=0.37$), between the 2 interventions. The analysis did not reveal evidence of an increased risk of fracture of vertebral bodies, especially those adjacent to the treated vertebrae, following augmentation with either method compared with conservative treatment. (Author Klazen et al. (2010), which was previously cited in this policy is included in this meta-analysis review).

Zhao et al. (2017) performed a network meta-analysis to assess the efficacy and safety of vertebroplasty (VP), kyphoplasty (KP), and conservative treatment (CT) for the treatment of osteoporotic vertebral compression fractures (OVCFs). Sixteen RCTs with 2046 participants were included. Compared with CT, patients treated with VP had improved pain relief, daily function, and quality of life; however, no significant differences were

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found between VP and KP for these 3 outcomes. All treatment options were associated with comparable risk of new fractures. VP was the most effective treatment for pain relief, followed by KP and CT; conversely, KP was the most effective in improving daily function and quality of life and decreasing the incidence of new fractures, followed by VP and CT. The authors concluded that VP might be the best option when pain relief is the principle aim of therapy, but KP was associated with the lowest risk of new fractures and might offer better outcomes in terms of daily function and quality of life. The findings are limited by the inherent indirectness of network meta-analyses. (Authors Blasco et al. (2012), Boonen et al. (2011), Farrokhi et al. (2011), and Klazen et al. (2010), which were previously cited in this policy are included in this meta-analysis review).

Mattie et al. (2016) compared the degree and duration of pain relief following percutaneous vertebroplasty (PVP) with that following conservative treatment and/or sham for osteoporotic compression fractures by means of meta-analysis of randomized controlled trials. Based on their analysis, up to 1 year postoperatively, the effect of PVP exceeded the effect of conservative therapy with respect to pain relief in patients with osteoporotic compression fractures. The effect size was significant and close to the minimal clinically important difference. Those receiving PVP (531 out of 1,048 patients) had a significantly lower pain level compared with the control group at 1 to 2 weeks, 2 to 3 months, and 12 months. Based on their observations, the authors concluded that the effect of PVP exceeded the effect of conservative therapy up to 1 year postoperatively with respect to pain relief in patients with osteoporotic compression fractures. The effect size was significant and close to the minimal clinically important difference.

Gu et al. (2016) performed a systematic review and meta-analysis of studies comparing the outcomes of PVP and KP in the treatment of vertebral compression fractures, which included prospective non-randomized, retrospective, comparative and randomized studies. No significant difference was found between PVP and KP in short- and long-term pain and disability outcomes. The authors concluded that further studies are needed to better determine if any particular subgroups of patients would benefit more from PVP or KP in the treatment of vertebral body compression fractures. The findings are limited by inclusion of observational studies.

~~Deibert et al. (2016) conducted a case series investigation of the development of symptomatic adjacent level compression fractures following balloon-assisted kyphoplasty (BAK). Seventy-seven of 726 patients (10.6%) underwent a second BAK procedure on average 350 days following the initial procedure (range 21 to 2,691 days). Third and fourth procedures were less common, treated in 11 and 3 patients, respectively. Forty-eight of 77 patients (62%) suffered a fracture at a level immediately adjacent to the index level at mean time of 256 days. Remote level fractures were treated at a mean time of 489 days, but no statistical difference was noted. There was no statistically significant difference between tobacco use, BMI, and chronic steroid use between patients suffering from remote and adjacent level VCFs. Specific risk factors for remote versus adjacent level fractures could not be determined. This was not a population-based study and the true incidence of subsequent fractures after BAK might be underestimated by this analysis.~~

~~In a randomized clinical trial of 115 subjects, Evans et al. (2016) found KP and PVP equally effective in substantially reducing pain and disability in patients with vertebral body compression fractures.~~

~~In a retrospective observational study Zhang et al. (2015) evaluated a total of 73 patients who underwent PVP (n = 38) or kyphoplasty (n = 35) for the management of Kummel~~

disease. Visual analogue score (VAS) was used to evaluate pain. The anterior vertebral height was measured. The operative time, the incidence of cement leakage and the costs were recorded. In both the PVP and KP group, the VAS and anterior vertebral height significantly improved at 1-day postoperatively ($P < 0.05$), and the improvement sustained at the final follow-up ($P > 0.05$). Between the PVP and PKP groups, there were no significant differences in VAS and the anterior vertebral height at 1-day postoperatively and at the final follow-up ($P > 0.05$). The operating time and expense in the PKP group were higher than the PVP group ($P < 0.001$). Cement leakages in the PKP group were fewer than PVP group ($P < 0.05$). The authors concluded that PVP is a faster, less expensive option that still provides a comparable pain relief and restoration of vertebral height to PKP for the treatment of Kummel disease. PKP has a significant advantage over PVP in term of the fewer cement leakages. The findings are however limited by the observational design of the study.

The National Institute for Health and Care Excellence (NICE) 2013 (reviewed and confirmed 2016) technology guidance appraisal on percutaneous vertebroplasty and percutaneous balloon kyphoplasty for treating osteoporotic vertebral compression fractures recommends percutaneous vertebroplasty, and percutaneous balloon kyphoplasty without stenting, as options for treating osteoporotic vertebral compression fractures only in people who: have severe ongoing pain after a recent, unhealed vertebral fracture despite optimal pain management, and in whom the pain has been confirmed to be at the level of the fracture by physical examination and imaging.

Doonen et al. (2011) compared the efficacy and safety of BKP to nonsurgical therapy over 24 months in patients with acute painful fractures. Adults with one to three vertebral fractures were randomized within 3 months from onset of pain to undergo KP ($n = 149$) or nonsurgical therapy ($n = 151$). Quality of life, function, disability, and pain were assessed over 24 months. The authors reported that KP was associated with greater improvements in Short-Form 36 (SF-36) Physical Component Summary (PCS) scores when averaged across the 24-month follow-up period compared with nonsurgical therapy [overall treatment effect 3.24 points, 95% confidence interval (CI) 1.47-5.01, $p = .0004$]; the treatment difference remained statistically significant at 6 months (3.39 points, 95% CI 1.13-5.64, $p = .003$) but not at 12 months (1.70 points, 95% CI -0.59 to 3.98, $p = .15$) or 24 months (1.68 points, 95% CI -0.63 to 3.99, $p = .15$). Greater improvement in back pain was observed over 24 months for kyphoplasty (overall treatment effect -1.49 points, 95% CI -1.88 to -1.10, $p < .0001$); the difference between groups remained statistically significant at 24 months (-0.80 points, 95% CI -1.39 to -0.20, $p = .009$). There was no statistically significant difference between groups in the number of patients (47.5% for kyphoplasty, 44.1% for control) with new radiographic vertebral fractures; fewer fractures occurred (~18%) within the second year. The authors commented that compared with nonsurgical management, kyphoplasty rapidly reduced pain and improved function, disability, and quality of life without increasing the risk of additional vertebral fractures. They concluded that the differences from nonsurgical management are statistically significant when averaged across 24 months; most outcomes are not statistically different at 24 months, but the reduction in back pain remains statistically significant at all time points.

In a multicenter, randomized controlled trial (Cancer Patient Fracture Evaluation [CAFÉ] study), Berenson et al. (2011) evaluated the efficacy and safety of BKP compared with non-surgical management for patients with cancer who have painful vertebral compression fractures. Patients ($n = 134$) aged 21 and over with cancer and painful vertebral compression fractures were randomly assigned by a computer-generated minimization randomization algorithm to kyphoplasty ($n = 70$) or non-surgical management ($n = 64$).

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~~Investigators and patients were not masked to treatment allocation. The primary endpoint was back-specific functional status measured by the Roland-Morris disability questionnaire (RDQ) score at 1 month. Outcomes at 1 month were analyzed by modified intention to treat, including all patients with data available at baseline and at 1-month follow-up. Patients in the non-surgical management group (control) were allowed to crossover to receive KP after 1 month. The mean RDQ score in the KP group changed from 17.6 at baseline to 9.1 at 1 month (mean change -8.3 points, 95% CI -6.4 to -10.2; $p < 0.0001$). The mean score in the control group changed from 18.2 to 18.0 (mean change 0.1 points; 95% CI -0.8 to 1.0; $p = 0.83$). At 1 month, the KP treatment effect for RDQ was -8.4 points (95% CI -7.6 to -9.2; $p < 0.0001$). The authors concluded that for painful VCFs in patients with cancer, KP is an effective and safe treatment that rapidly reduces pain and improves function.~~

Yuan et al. (2016) conducted a meta-analysis to examine vertebroplasty or BKP for osteoporotic compression fractures compared to conservative treatment. The authors' review determined that overall vertebroplasty and KP reduce pain and improve function and quality of life as compared with conservative treatment. However, analysis by surgery type indicated that pain relief of kyphoplasty was similar to that of conservative management, but pain relief of vertebroplasty was greater than that of conservative management. Both procedures improved functional outcomes to a greater degree than conservative treatment, and that while KP improved quality of life to a greater degree than conservative treatment, there was no difference in quality-of-life improvement between vertebroplasty and conservative treatment. These results need to be interpreted with caution however, as only 2 studies examined KP and only 1 of these studies examined function and quality of life. (Authors Blasco et al. (2012), Chen et al. (2014), Boonen et al. (2011), Farrokhi et al. (2011), and Klazen et al. (2010) which were previously cited in this policy are included in this meta-analysis review).

Tan et al. (2015) conducted a prospective study of percutaneous vertebroplasty (PVP) for chronic painful osteoporotic vertebral compression fracture. Sixty-two consecutive patients with chronic painful osteoporotic VCFs for ≥ 3 months underwent PVP on 92 vertebrae in 73 procedures three to five days after referral. All procedures were performed under local anesthesia. The outcomes were pain relief at one week, one month, three months, six months and one year, as measured by visual analogue scale, Oswestry Disability Index, Quality of Life Questionnaire of the European Foundation for Osteoporosis (QUALEFFO) and Roland Morris Disability Questionnaire scores. According to the authors, the PVP procedures were technically successful and well tolerated in all patients. Compared with baseline scores, improvement in visual analogue scale, Oswestry Disability Index, QUALEFFO and Roland Morris Disability Questionnaire scores was significantly greater after PVP at one week ($P < 0.001$), one month ($P < 0.001$), three months ($P < 0.001$), six months ($P < 0.001$) and one year ($P < 0.001$), and the number of patients using drugs for pain treatment was significantly reduced. Five new fractures were reported in five of 62 patients treated with PVP during follow-up. The authors concluded that PVP is effective in patients with chronic painful osteoporotic VCFs due to immediate pain relief that was sustained for one year and may be an important factor for reducing persistent pain. The findings are however limited by the lack of comparison group.

In a systematic review, Stevenson et al. (2014) evaluated the clinical effectiveness of percutaneous vertebroplasty (PVP) and balloon kyphoplasty (BKP) in reducing pain and disability in people with osteoporotic vertebral compression fractures (VCFs). Inclusion criteria were randomized controlled trials for VCFs treated with their PVP or BKP. Primary outcomes were health-related quality of life; back-specific functional status/mobility; pain/analgesic use; vertebral body height and angular deformity;

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incidence of new vertebral fractures and progression of treated fracture. A total of nine RCTs were identified and included in the review of clinical effectiveness. This body of literature was of variable quality, with the two double-blind, OPLA-controlled trials being at the least risk of bias. The most significant methodological issue among the remaining trials was lack of blinding for both study participants and outcome assessors. According to the authors, broadly speaking, the literature suggests that both PVP and BKP provide substantially greater benefits than OPM in open-label trials. However, in double-blinded trials PVP was shown to have no more benefit than local anesthetic; no trials of BKP compared with local anesthesia have been conducted. The authors concluded that for people with painful osteoporotic VCFs refractory to analgesic treatment, PVP and BKP perform significantly better in unblinded trials than OPM in terms of improving quality of life and reducing pain and disability. However, there is as yet no convincing evidence that either procedure performs better than OPLA. They further commented that data on key parameters were uncertain and/or potentially confounded, making definitive conclusions difficult to make. (Authors Blasco et al. (2012), Farrokhi et al. (2011), and Boonen et al. (2011), which were previously cited in this policy are included in this systematic review).

In a meta-analysis of randomized controlled trials, Liu et al. (2013) compared the amount of pain reduction measured using the visual analog scale (VAS) when osteoporotic vertebral compression fractures are treated with percutaneous vertebroplasty (PVP) or conservatively. They also assessed the clinical utility of PVP. Five randomized controlled trials met the analysis criteria; conservative treatments used as comparators in these trials were different. There was no difference in pain relief in the PVP group at 2 weeks and one month when compared with the conservatively managed group. Pool results from the 5 studies showed that pain relief in the PVP group was greater than that of the conservative group at 3 months, 6 months, and 12 months. However, after subgroup analysis, pain scores were similar between the PVP group and the sham injection group from 2 weeks to 6 months. Compared with non-operative therapy, PVP reduced pain at all times studied. The authors concluded that PVP has some value for relieving pain; however, the possibility of a placebo effect should be considered. They recommend more large scale, double blinded, controlled trials in order to quantify the pain relief afforded by PVP more precisely. (Authors Blasco et al. (2012), Chen et al. (2014), Farrokhi et al. (2011), & Klazen et al. (2010), which were previously cited in this policy are included in this meta-analysis).

Shi et al. (2012) performed a meta-analysis to determine whether, when compared to non-operative management or sham procedures, percutaneous vertebroplasty (PVP) provided greater improvement in pain and pain-related disability for patients with vertebral compression fractures. Using a random effects model, the authors calculated the weighted mean differences to evaluate the pain reduction at different times as the primary outcome. Pain-related disability was assessed by a quality of life (QOL) measure. Improvement of QOL and recurrence of vertebral fractures were the secondary outcomes. The authors used subgroup analysis to reinvestigate pain relief and function improvement of PVP based on two different controls: nonoperative therapy and sham injection. The total number of patients was 886. Based on the outcome of their review, pain scoring was similar between the PVP group and the sham injection group at 1 to 29 days and 90 days. However, compared with nonoperative therapy, PVP reduced pain at all times studied. QOL in the PVP group was improved or tended to be improved compared with QOL for both control groups. The risk of new fractures was similar between the PVP groups and both control groups. They noted that different control groups may have accounted for the different conclusions in the literature regarding the ability of PVP to relieve pain and restore function recovery. Compared with nonoperative treatment PVP relieved pain better and

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improved QOL. PVP did not increase the risk of new fractures. (Authors Kallmes et al. (2010), Farrokhi et al. (2011), and Klazen et al. (2010) which were previously cited in this policy are included in this meta-analysis review).

Osteolytic Metastatic Disease Involving a Vertebral Body

Shamhoo et al. (2022) performed a retrospective clinical case series study to evaluate the outcome of percutaneous vertebroplasty of more than two multi-level osteoporotic and malignant fractures. This study was conducted on 30 patients. Visual analogue scale (VAS) was used to evaluate the functional outcome. All patients were treated using percutaneous vertebroplasty. They were followed for 6 months postoperatively. The functional state of all patients improved after percutaneous vertebroplasty. According to the visual analogue scale (VAS), the preoperative VAS score was (8.43 ± 1.19) . Immediate postoperative VAS was (3.07 ± 1.20) and after six months it dropped to (1.13 ± 0.67) . There was noted improvement of pain ($p < 0.001$). Asymptomatic leakage in the disc space was reported in two patients. A single case of pulmonary embolism was reported who complained of dyspnea. This patient was admitted to ICU and managed with proper medications with satisfactory results. The authors concluded that multilevel PV is proved to be a safe, cost effective and successful procedure that could reduce pain and improve patient's mobility.

Wu et al. (2022) completed a retrospective study. From February 2017 to January 2020, a total of 31 patients with 58 osteoblastic-related metastatic vertebral lesions who underwent PKP were enrolled in this retrospective study. Among them, 12 were pure osteoblastic lesions and 19 were mixed lesions. The clinical efficacy was assessed based on parameters including visual analogue scale, Oswestry Disability Index, vertebral body height variation and quality of life. Major and minor complications were systematically evaluated to assess the safety of the procedure. Average follow-up period was 22.5 ± 11.1 months (range, 3 to 46 months). The procedure duration time ranged from 50 to 180 minutes (average 96.8 ± 36.9 minutes). Mean visual analogue scale scores decreased significantly from 6.1 ± 1.8 pre-operatively to 2.7 ± 1.5 at 3 days after PKP ($p < 0.001$), and remained largely immutable at 1 month (2.0 ± 0.7 ; 31 patients; $p < 0.001$), 3 months (2.4 ± 1.2 ; 30 patients; $p < 0.001$) and 1 year (3.0 ± 1.0 ; 27 patients; $p < 0.001$). Oswestry Disability Index scores and vertebral body height variation also changed after the procedure, with significant differences between pre-operative scores and at each follow-up examination ($p < 0.001$). Mean quality of life scores was 90.8 ± 12.9 pre-operatively and improved to 99.5 ± 12.1 (27 patients, $p < 0.001$) at 1 year after PKP. The only minor encountered complication was bone cement leakage, which was seen in 6.5% (2 of 31) of patients. None of the patients experienced major complications. The authors concluded that PKP is a safe and effective treatment strategy for osteoblastic-related metastatic vertebral lesions from a variety of tumor etiologies.

Astur and Aanzi conducted a systematic review (2019) of randomized controlled trials to assess the efficacy of kyphoplasty (KP) in controlling pain and improving quality of life in oncologic patients with metastatic spinal disease and pathologic compression fractures of the spine. After a literature search through medical databases, two studies with a combined total of 181 patients, met inclusion criteria. A meta-analysis was not possible due to data heterogeneity and individual analysis of studies was performed. There was moderate evidence that patient treated with balloon kyphoplasty (BKP) displayed better scores for pain (Numeric Rating Scale), disability (Roland-Morris Disability Questionnaire), quality of life (Short Form-36-Health Survey), and functional status (Karnofsky Performance Status) compared with those undergoing conventional treatment. Patients treated with KP also had better recovery of vertebral height. The authors concluded that although balloon kyphoplasty (KP) could be considered as an early

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treatment option for patients with symptomatic neoplastic spinal disease, further randomized clinical trials should be performed for improvement of the quality of evidence, (Author Berenson et al. (2011) which was previously cited in this policy is included in this systematic review).

Sorensen et al. (2019) performed a systematic review evaluating the effectiveness and safety of vertebral augmentation for malignant vertebral compression fractures (VCFs). Studies on percutaneous vertebroplasty (PVP) or percutaneous kyphoplasty (KP) for vertebral compression fractures (VCFs) in patients with malignant spinal lesions were reviewed. The review identified two randomized controlled trials, 16 prospective studies, 44 retrospective studies, and 25 case series for a patient sample size of 3,426. At the earliest follow-up, pain improved from 7.48 to 3.00 with PVP, and from 7.05 to 2.96 with KP. ODI improved from 74.68 to 17.73 with PVP, and from 66.02 to 34.73 with KP. KPS improved from 66.99 to 80.28. Cement leakage was seen in 37.9% and 13.6% of patients treated with PVP and KP, respectively. Symptomatic complications (N=43) were rare. The authors concluded that the review showed clinically relevant improvements in pain, ODI, and KPS in patients with VCFs due to malignancy treated with either PVP or KP. Cement leakage is common, but rarely symptomatic. The authors conclude that PVP and KP are safe and effective palliative procedures for painful VCFs in patients with malignant spinal lesions. (Authors Anselmetti et al. (2012), Berenson et al. (2011), Farrokhi et al. (2012) and Sun et al. (2014) which were previously cited in this policy are included in this systematic review).

A systematic review was conducted by Sadeghi-Naini et al. (2018) to assess the effects of vertebroplasty (VP) and kyphoplasty (KP) compared with each other, usual care, or other treatments on pain, disability, and quality of life following metastatic spinal lesions (MSL). Nine trials were included in the qualitative analysis. In total, there were 622 patients enrolled in the trials and of them 432 were in the surgical treatment group (92 received KP, 97 received VP, 134 received VP and chemotherapy, 68 received VP and radiotherapy, and 41 received Kiva implant) and 190 were in the nonsurgical treatment group (83 received chemotherapy, 46 received radiotherapy, and 61 received other treatment). Using the grading of recommendations assessment, development and evaluation approach, pain (low-quality evidence) and functional scores (very low-quality evidence) improved more with VP plus chemotherapy than with chemotherapy alone. KP seemed to lead to significantly greater improvement in pain, disability, and health-related quality of life (HRQoL) compared with nonsurgical management. VP plus Iodine-125 seemed to lead to significantly greater improvement in pain and disability in comparison with VP alone. VP plus radio chemotherapy resulted in better pain relief and HRQoL postoperatively in comparison with routine radio chemotherapy. The authors concluded that there was low-quality evidence to prove that surgical treatment significantly decreases pain and improves functional score and HRQoL following MSL in comparison with nonsurgical management. Based on the analysis of currently published trial data, it is unclear whether VP for MSL provides benefits over KP.

Qi et al. (2016) conducted a meta-analysis to evaluate the function of percutaneous vertebroplasty (PVP) treatment to pain relief and life quality for patients with spinal tumors. Twenty-six studies involving 1351 patients met selection criteria. Meta-analysis results among 10 case-control studies showed that the combined hazard ratio was -2.83 [95% confidence interval (CI) -2.92, -2.73; P<.0001], indicating a 2.83-fold decrease of pain in PVP group. For 12 single-arm studies, a significantly decrease of pain after PVP treatment (HR=-4.79, 95% CI -5.00, -4.57, P<.0001) was also found in PVP group. In addition, for KPS analysis, the combined HR was 16.31 (95% CI 14.31, 18.31; P<.0001), which indicated that PVP treatment was associated with a 16.31-fold increase of KPS. The

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combined hazard ratio was 0.58 (95% CI 0.35, 0.96; P=.04) for complication analysis. The authors concluded that PVP treatment of spinal tumor is significantly associated with better pain relief and life quality, which could improve the outcome in metastatic spinal tumor patients.

Multiple Myeloma Involving a Vertebral Body

In a systematic review, Health Quality Ontario (2016) evaluated the effectiveness and safety of percutaneous image-guided vertebral augmentation techniques, vertebroplasty and KP, for palliation of cancer-related vertebral compression fractures. Owing to the heterogeneity of the clinical reports, the authors performed a narrative synthesis based on an analytical framework constructed for the type of cancer-related vertebral fractures and the diversity of the vertebral augmentation interventions. One hundred and eleven clinical reports (4,235 patients) were evaluated to determine the effectiveness of vertebroplasty (78 reports, 2,545 patients) or KP (33 reports, 1,690 patients) for patients with mixed primary spinal metastatic cancers, multiple myeloma, or hemangiomas. Overall, the mean pain intensity scores often reported within 48 hours of vertebral augmentation (kyphoplasty or vertebroplasty), were significantly reduced. Analgesic use, although variably reported, usually involved parallel decreases, particularly in opioids, and mean pain-related disability scores were also significantly improved. In a randomized controlled trial comparing KP with usual care, improvements in pain scores, pain-related disability, and health-related quality of life were significantly better in the kyphoplasty group than in the usual care group. Bone cement leakage, mostly asymptomatic, was commonly reported after vertebroplasty and KP. Major adverse events, however, were uncommon. The authors concluded that both vertebroplasty and KP significantly and rapidly reduced pain intensity in cancer patients with vertebral compression fractures. The procedures also significantly decreased the need for opioid pain medication, and functional disabilities related to back and neck pain. Pain palliative improvements and low complication rates were consistent across the various cancer populations and vertebral fractures that were investigated.

In a retrospective observational study, Burton et al. (2011) evaluated outcomes of cancer patients with painful vertebral compression fractures treated with either PVP or KP. A total of 407 cancer patients had 1,156 fractures that had been treated with PVP or KP; the majority of patients had pathological fractures due to multiple myeloma, or osteoporotic fractures. The authors reported that surgery provided significant relief from pain and several related symptoms. Surgery provided significant relief from pain and several related symptoms. Symptomatic, serious complications requiring open surgery occurred in two cases (<0.01%). The authors concluded that the use of VP or KP in treating painful VCFs in cancer patients has good efficacy and an acceptably low complication rate. The findings are limited by lack of comparison group without surgical ~~intervention~~ and the observational design of the study.

Vertebral Hemangioma with Aggressive Features

Nambiar et al. (2020) conducted a retrospective multi-center cohort study to evaluate PVP for the treatment of symptomatic vertebral hemangioma. The study included 50 patients with painful vertebral hemangiomas and treated with PVP by a single provider over a 14-year period (March 1999 to April 2013). There was a minimum one-year follow-up. Two patients had recurrent symptoms and repeat vertebroplasty. Pre-intervention VAS score was 7.0 and mean post-intervention VAS at one year was 0.3. The mean reduction in VAS score was 6.8 points. All patients experienced pain relief following PVP, with 39 cases (74%) reporting complete pain relief. There were no cases of symptomatic cement leak, and no

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cases of procedural morbidity or mortality. The authors concluded that PVP is a safe and effective treatment of symptomatic vertebral hemangioma with low risk of complication.

In a case series of surgical treatments for aggressive vertebral hemangiomas, Vasudeva et al. (2016) report on five patients who underwent surgery for treatment of aggressive vertebral hemangiomas during the specified time period. Intraoperative vertebroplasty was used in 3 cases to augment the anterior column or to obliterate residual tumor. The authors conclude that despite the variety of available treatment options, the optimal management strategy is unclear because aggressive vertebral hemangiomas are uncommon lesions, making it difficult to perform large trials. In their opinion, vertebroplasty provides hemostatic embolization and improves the load-bearing capacity of the anterior column; however, either kyphoplasty or vertebroplasty may also be used intraoperatively in conjunction with decompressive surgery.

Narayana et al. (2014) evaluated percutaneous vertebroplasty (PVP) in the treatment of painful vertebral hemangiomas refractory to medical management. In this case series, fourteen patients (four thoracic and ten lumbar vertebra) with painful vertebral hemangiomas presenting with severe back pain for more than 6 months not responding to medical therapy were treated by PVP. Cross sectional imaging of the spine with magnetic resonance was done. The pain intensity numeric rating scale (PI-NRS-11) of these patients was in the range of 7-10 (Severe Pain). After vertebroplasty 8 patients were completely free of pain (PI NRS Score 0) while 6 were significantly relieved (PI-NRS Score 1-3). No complications were observed. Two patients with associated radicular pain had good pain relief following PVP. No recurrence was found during 36 months of postoperative follow-up. The authors concluded that PVP is a safe and effective procedure in patients with painful vertebral hemangiomas refractory to medical management. The findings are however limited by lack of comparison group.

Boschi et al. (2012) studied in this case series treatment with vertebroplasty in patients with painful vertebral hemangiomas to determine its validity for this usage. Patients (n=24) were treated by percutaneous vertebroplasty: 16 thoracic, 8 lumbar. The average age at the time of surgery was 48 years. All the patients complained of a pain syndrome resistant to continuing medication. Pre-procedure imaging was conducted for confirmation. The mean follow-up was 5.8 years. In all the patients, the authors observed a successful outcome with a complete resolution of pain symptom. Clinical and radiological follow-up showed stability of the treatment and absence of pain in all patients. They concluded that percutaneous treatment with vertebroplasty for symptomatic vertebral hemangiomas is a valuable, less invasive, and a quick method that allows a complete and enduring resolution of the painful vertebral symptoms without findings of the vertebral body's fracture. The findings are however limited by the lack of comparison group.

Unstable Fractures due to Osteonecrosis (e.g., Kümmell's Disease)

Wang et al. (2022) performed a systematic review and meta-analysis to compare the efficacy of percutaneous vertebroplasty (PVP), percutaneous kyphoplasty (PKP), and bone-filling mesh containers (BFC), three viable, minimally invasive techniques that have been used to treat Kümmell's disease (KD). This study summarized the pros and cons of the three techniques in the treatment of KD through network meta-analysis (NMA). All eligible published clinical control studies comparing PVP, PKP, and BFC for KD up to December 2021 were collected by online search of Cochrane Library, PubMed, Embase, CNKI, Wanfang Database, and Chinese biomedical literature database. Data were extracted after screening, and Stata 16.0 software was used to perform the network meta-analysis. Four randomized controlled trials (RCTs) and 16 retrospective case-control studies (CCTs) with

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a total of 1,114 patients were included. The NMA results showed no statistical difference between the 3 procedures in terms of improving patients' clinical symptoms. PKP was most likely to be the most effective in correcting kyphosis, while BFC was likely to be the most effective in managing the occurrence of cement leakage. No statistical differences were found in the incidence of new vertebral fractures in adjacent segments. The authors concluded ranking analysis showed that BFC has the highest likelihood of being the optimal procedure for the treatment of KD, based on a combined assessment of effectiveness in improving patients' symptoms and safety in the occurrence of adverse events (authors Chang et al. (2020), Dai et al. (2021), Wang et al. (2018), and Zhang et al. (2018) who were previously cited in this policy are included in this systematic review).

Zhang et al. (2022) performed a systematic review and meta-analysis to evaluate the clinical outcomes, imaging improvements, perioperative complications and intraoperative resource consumption associated with percutaneous vertebroplasty (PVP) and percutaneous kyphoplasty (PKP) for the treatment of neurologically intact osteoporotic Kümmell's disease (KD). Six databases were searched for all relevant studies based on the PRISMA guidelines. Two investigators independently conducted a quality assessment, extracted the data and performed all statistical analyses. Results: Eight studies encompassing 438 neurologically intact osteoporotic KD patients met the inclusion criteria. Compared to PVP, PKP was associated with greater improvement in the short- and long-term Cobb angle [SMD = -0.37, P = 0.007; SMD = -0.34, P = 0.012], short-term anterior vertebral height [SMD = 0.43, P = 0.003] and long-term middle vertebral height [SMD = 0.57, P = 0.012] and a lower cement leakage rate [SMD = 0.50, P = 0.003] but produced more consumption (cement injection volume, operative time, fluoroscopy times, intraoperative blood loss and operation cost). However, there were no differences between the 2 procedures in the short- and long-term VAS and ODI scores, long-term anterior vertebral height, overall complications or new vertebral fractures. The authors concluded that both procedures are equally effective for neurologically intact KD in terms of the clinical outcomes, except for a lower cement leakage risk and better radiographic improvement for PKP but greater resource consumption. Based on the evidence available, good clinical judgment should be exercised in the selection of patients for these procedures (authors Chang et al. (2020), and Zhang et al. (2015) who were previously cited in this policy are included in this systematic review).

Dai et al. (2021) performed a prospective study to compare the safety and efficacy of percutaneous vertebroplasty (PVP) versus percutaneous kyphoplasty (PKP) as treatment for osteoporotic Kümmell's disease. The study included 64 patients: 30 patients in the PVP group and 34 patients in the PKP group. Patients were followed for 24 months. Statistical results were insignificant with visual analogue scale (VAS) and Oswestry disability index (ODI) scores showing comparative results ($p > 0.05$) among PVP and PKP groups at all postoperative time points. The authors concluded that both PVP and PKP are safe and efficient procedures for eliminating pain and achieving kyphosis correction in the treatment of osteoporotic Kümmell's disease. The volume of bone cement injection, intraoperative blood loss, occurrence of bone cement leakage, transient fever, and re-fracture between two groups showed no significant difference. The surgical time, the operation cost and fluoroscopy times of the PKP group was significantly higher than that of the PVP group. The post-operative VAS, ODI scores, the height of the anterior edge of the injured vertebrae and kyphosis deformity were significantly improved in both groups compared with the pre-operation. The improvement of vertebral height and kyphosis deformity in PKP group was significantly better than that in the PVP group at every same time point during the follow-up periods, but the VAS and ODI scores between the two groups showed no significant difference. The authors concluded that PVP and PKP can both

significantly alleviate the pain of patients with KD and obtain good clinical efficacy and safety. By contrast, PKP can achieve better imaging height and kyphosis correction, while PVP has the advantages of shorter operation time, less radiation volume and operation cost.

Zhang et al. (2021) performed a systematic review and meta-analysis to compare clinical outcomes and efficacy of PVP with those of PKP for treatment of neurologically intact osteoporotic Kümmell's disease. The study included eight nonrandomized observational studies; 2 prospective and 5 retrospective case-control studies. Four hundred and thirty-eight patients were included with 195 patients treated with PKP and 243 patients treated with PVP. There were no statistically significant differences in the short-term and long-term VAS and ODI scores between the two groups. PKP provided better short-term and long-term kyphosis correction than did PVP. There were no differences in most of the vertebral height measurements, except for greater restoration of short-term anterior vertebral height and long-term middle vertebral height for the PKP group. The authors concluded that both PVP and PKP are safe and effective treatment options for treatment of neurologically intact Kümmell's disease with comparable clinical outcomes including improved functional status, quality of life, and pain relief.

Chang et al. (2020) performed a prospective study to compare clinical outcomes of percutaneous vertebroplasty (PVP) and percutaneous kyphoplasty (PKP) for Kümmell's disease. The study included 56 patients: 28 patients received PVP, and 28 patients received PKP treatment. Visual analogue scale (VAS) was used to evaluate degree of low back pain and the ODI to evaluate the severity of dysfunction. At two years post-surgery, VAS scores decreased from 8.0 ± 0.77 to 2.5 ± 0.70 in the PVP group, and from 8.0 ± 0.75 to 2.5 ± 0.84 in the PKP group. ODI scores decreased from 84.5 ± 5.94 to 29.9 ± 7.11 in the PVP group, and from 84.9 ± 8.23 to 31.0 ± 7.56 in the PKP group. The authors concluded that PVP and PKP are effective treatment options in Kümmell's disease, as both treatments achieve similar results. Follow-up time, incidence of bone cement leakage, refracture rate of adjacent vertebra and intraoperative amount of bone cement injection between the two groups was not statistical difference. Both groups significantly relieved patients' pain of low back, recovered the height of vertebral body and kyphosis angle and improved their quality of life, but PVP was associated with less surgical time, blood loss, and radiation exposure than those of PKP.

Clinical Practice Guidelines

American Academy of Family Physicians (AAFP)

A 2016 AAFP Practice Management for vertebral compression fractures lists the following clinical recommendations:

- A trial of conservative therapy should be offered to patients with vertebral compression fractures
- Percutaneous vertebral augmentation can be considered in patients who have inadequate pain relief with nonsurgical care or when persistent pain substantially affects quality of life
- Patients with vertebral compression fractures should be evaluated for osteoporosis, and preventive therapy should be initiated if necessary (McCarthy and Davis, 2016)

American Academy of Orthopaedic Surgeons (AAOS)

In its 2010 guidance and evidence report on the treatment of symptomatic osteoporotic spinal compression fractures, the AAOS recommends against vertebroplasty for patients who present with an osteoporotic spinal compression fracture on imaging with correlating clinical signs and symptoms and who are neurologically intact. This recommendation is

based on strong evidence regarding Level II studies that compare vertebroplasty to a sham procedure in which there was no statistically significant difference between the two procedures in pain using the VAS and function using the Roland Morris Disability scale (up to one month and six months respectively).

In the same 2010 guidance and evidence report, the AAOS considers kyphoplasty as an option for patients who present with an osteoporotic spinal compression fracture on imaging on imaging with correlating clinical signs and symptoms and who are neurologically intact. This is based on limited evidence regarding two Level II studies that examined the use of kyphoplasty compared to conservative treatment. In the study of patients with subacute fractures, clinically important benefits in pain were found at 1 week and 1 month, with possibly important effects at 3 and 6 months. There was no clinically important benefit in pain at 12 months. The study also found possibly clinically important benefits in physical function (at 1 and 3 months only) and the SF-36 physical component score (at 1, 3, and 6 months only). Clinically important improvement in quality of life was present at 1 month, and it was possibly clinically important at 3, 6, and 12 months (AAOS, 2010).

American Association of Clinical Endocrinologists (AACE), and American College of Endocrinology (ACE)

In a clinical practice guideline for the diagnosis and treatment of postmenopausal osteoporosis, the AACE and ACE (Camacho et al., 2016; Updated 2020) do not recommend vertebroplasty and kyphoplasty as first-line treatment of vertebral fractures given the unclear benefit on overall pain and the potential increased risk of vertebral fractures in adjacent vertebrae (R44. Grade BA, BEL 1; downgraded due to limitations of published studies).

American Association of Neurological Surgeons (AANS)

In a patient guideline on vertebral compression fracture (VCF), the AANS recommended that patients with the following criteria may be considered candidates for vertebroplasty or kyphoplasty:

- Osteoporotic VCFs in any area of the spine that have been present for more than two weeks, causing moderate to severe pain and unresponsive to conservative therapy
- Painful metastases and multiple myelomas
- Painful vertebral hemangiomas (benign, malformed vascular tumors composed of newly formed blood vessels)
- Vertebral osteonecrosis (a condition resulting from poor blood supply to an area of bone, which causes bone death)
- Reinforcement of a pathologically weak vertebral body before a surgical stabilization procedure

Patients with any of the following criteria should **not** undergo these procedures:

- A VCF that is completely healed or is responding effectively to conservative therapy
- A VCF that has been present for more than one year
- Greater than 80-90% collapse of the vertebral body
- Spinal curvature, such as scoliosis or kyphosis, that is due to causes other than osteoporosis
- Spinal stenosis or herniated discs with nerve or spinal cord compression and loss of neurological function not associated with a VCF
- Untreated coagulopathy (a disease or condition affecting the blood's ability to coagulate)

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- Osteomyelitis (an inflammation of the bone and bone marrow, usually caused by bacterial infection)
- Discitis (nonbacterial inflammation of an intervertebral disc or disc space)
- Significant compromise of the spinal canal caused by impeding bone fragment or tumor (AANS, 2021)

American College of Radiology (ACR)

The ACR appropriateness criteria for the management of vertebral compression fractures (2018) notes that conservative management (medical management with or without methods of immobility) is the initial first-line treatment of painful vertebral compression fractures. The ACR defines failure of conservative therapy as pain refractory to oral medications (NSAIDs and/or narcotics) or a contraindication to such medications or a requirement for parenteral narcotics and hospital admission. The ACR observes that the ideal preprocedural imaging has not been identified. The following variants were noted:

Percutaneous vertebral augmentation may be appropriate for the following:

- Asymptomatic pathologic spinal fracture with or without edema on MRI
- New symptomatic compression fracture identified on radiographs or CT. No known malignancy

Percutaneous vertebral augmentation is usually appropriate for the following:

- Osteoporotic compression fracture, with or without edema on MRI and no "red flags", with or without spinal deformity, worsening symptoms, or pulmonary dysfunction
- Pathologic spinal fracture with severe and worsening pain
- Pathologic spinal fracture with spinal deformity or pulmonary dysfunction (ACR, 2018)

American College of Radiology (ACR), American Society of Neuroradiology (ASNR), American Society of Spine Radiology (ASSR), Society of Interventional Radiology (SIR), Society of NeuroInterventional Surgery (SNIS)

The ACR, ASNR, ASSR, SIR and SNIS 2017 practice parameter for the performance of vertebral augmentation states that the major indication for vertebral augmentation is the treatment of symptomatic osteoporotic vertebral body fracture(s) refractory to medical therapy or vertebral bodies weakened due to neoplasia. They comment that although most fractures heal within a few weeks or months, a minority of patients continue to suffer pain that does not respond to conservative therapy. They note that there is no indication for the use of vertebral augmentation for prophylaxis against future fracture.

International Society for the Advancement of Spine Surgery (ISASS)

The ISASS 2019 policy statement on vertebral augmentation states that vertebral augmentation procedures (vertebroplasty and kyphoplasty) are safe and effective procedures. The level 1 evidence is in favor of vertebral augmentation when compared to conservative management. Failure to treat patients with painful VCFs has been associated with an increased mortality and morbidity. ISASS endorses the early treatment of painful VCFs with vertebral augmentation procedures (vertebroplasty and preferentially kyphoplasty) (Clerk-Lamallice et al. [2019]).

National Institute for Health and Care Excellence (NICE)

A NICE 2013 (reviewed and confirmed 2016) technology appraisal appraisal on percutaneous vertebroplasty and percutaneous balloon kyphoplasty for treating osteoporotic vertebral compression fractures recommends percutaneous vertebroplasty, and percutaneous balloon

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kyphoplasty without stenting, as options for treating osteoporotic vertebral compression fractures only in people who:

- Have severe ongoing pain after a recent, unhealed vertebral fracture despite optimal pain management, and
- In whom the pain has been confirmed to be at the level of the fracture by physical examination and imaging.

Society of Interventional Radiology (SIR), American Association of Neurological Surgeons (AANS) and the Congress of Neurological Surgeons (CNS), American College of Radiology (ACR), American Society of Neuroradiology (ASNR), American Society of Spine Radiology (ASSR), Canadian Interventional Radiology Association (CIRA), and Society of NeuroInterventional Surgery (SNIS)

The 2014 SIR, AANS, CNS, ACR, ASNR, ASSR, CIRA and the SNIS consensus statement on percutaneous vertebral augmentation states that percutaneous vertebral augmentation with the use of vertebroplasty or kyphoplasty is a safe, efficacious, and durable procedure in appropriate ~~inappropriate~~ patients with symptomatic osteoporotic and neoplastic fractures when performed in a manner in accordance with published standards. They further comment that these procedures are offered only when non-operative medical therapy has not provided adequate pain relief or pain is significantly altering the patient's quality of life.

Currently, there is no indication for the use of vertebral augmentation for prophylaxis against future fracture. The indications and contraindications for vertebral augmentation may change in the future as more research and information become available (Barr, 2017).

Society of NeuroInterventional Surgery (SNIS)

In a 2014 report, the Standards and Guidelines Committee of the Society of NeuroInterventional Surgery on vertebral augmentation concluded that:

- Kyphoplasty in selected patients is superior to conservative medical therapy in reducing back pain, disability and improving Karnofsky performance status and quality of life for patients with cancer and disabling back pain from a vertebral fracture (AHA Class IIA, Level of Evidence B).
- Vertebroplasty and kyphoplasty are reasonable therapeutic options in selected patients with cancer and severe back pain from a vertebral fracture that is refractory to conservative medical therapy (AHA Class IIA, Level of Evidence B).
- Vertebroplasty and kyphoplasty are reasonable therapeutic options in selected patients with severe back pain from an osteoporotic vertebral fracture that is refractory to conservative medical therapy (AHA Class IIA, Level of Evidence B).

U.S. Food and Drug Administration (FDA)

This section is to be used for informational purposes only. FDA approval alone is not a basis for coverage.

Percutaneous vertebroplasty and kyphoplasty are procedures and not regulated by the FDA.

A number of bone cement products have been approved for marketing by the FDA as Class II devices. See the following website for more information (use product codes NDN, LOD): <http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfpmn/pmn.cfm>. (Accessed ~~July 19, 2021~~ **August 2, 2022**)

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Polymethylmethacrylate (PMMA) bone cement is a device intended to be implanted that is made from ~~methacrylate~~ ~~methacrylate~~, polymethylmethacrylate, esters of methacrylic acid, or copolymers containing polymethylmethacrylate and polystyrene. These bone cement products are intended for use in arthroplastic procedures of the hip, knee, and other joints for the fixation of polymer or metallic prosthetic implants to living bone.

The FDA has approved bone tamps for the creation of a void in cancellous bone in the spine (including use during a balloon kyphoplasty procedure with a PMMA-based bone cement that is cleared for use in kyphoplasty procedures). Bone tamps are categorized by the FDA as Class II devices. See the following website for more information (use product codes HRX, HXG): <http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfpmn/pmn.cfm>. (Accessed ~~August 2, 2022~~ ~~July 19, 2021~~)

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Policy History/Revision Information

Date	Summary of Changes
<u>TBD</u>	<u>Definitions</u> <ul style="list-style-type: none">• <u>Added definition of:</u><ul style="list-style-type: none">○ <u>Optimal Medical Therapy</u>○ <u>Osteonecrosis</u>○ <u>Vertebral Hemangiomas</u> <u>Supporting Information</u> <ul style="list-style-type: none">• <u>Updated Clinical Evidence and References sections to reflect the most current information</u>• <u>Archived previous policy version CS330IA.A</u>

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