

**American College of Radiology
ACR Appropriateness Criteria®
Management of Vertebral Compression Fractures**

Variant 1: **New symptomatic compression fracture identified on radiographs or CT. No known malignancy.**

| Procedure | Appropriateness Category |
|---|--------------------------|
| Medical management | Usually Appropriate |
| MRI spine area of interest without IV contrast | Usually Appropriate |
| CT spine area of interest without IV contrast | Usually Appropriate |
| Percutaneous vertebral augmentation | May Be Appropriate |
| Surgical consultation | May Be Appropriate |
| Tc-99m bone scan whole body | May Be Appropriate |
| Tc-99m SPECT/CT spine area of interest | May Be Appropriate |
| CT spine area of interest with IV contrast | Usually Not Appropriate |
| CT spine area of interest without and with IV contrast | Usually Not Appropriate |
| FDG-PET/CT skull base to mid-thigh | Usually Not Appropriate |
| MRI spine area of interest with IV contrast | Usually Not Appropriate |
| MRI spine area of interest without and with IV contrast | Usually Not Appropriate |
| Percutaneous thermal ablation | Usually Not Appropriate |
| Radiation oncology consultation | Usually Not Appropriate |

Variant 2: **Osteoporotic compression fracture, with or without edema on MRI and no “red flags”. With or without spinal deformity, worsening symptoms, or pulmonary dysfunction.**

| Procedure | Appropriateness Category |
|-------------------------------------|--------------------------|
| Medical management | Usually Appropriate |
| Percutaneous vertebral augmentation | Usually Appropriate |
| Surgical consultation | Usually Not Appropriate |
| Percutaneous thermal ablation | Usually Not Appropriate |
| Radiation oncology consultation | Usually Not Appropriate |

Variant 3: **Painful osteoporotic compression fracture with edema on MRI. Contraindication to vertebral augmentation or surgery (eg, fitness, pregnancy, infection, coagulation disorder, etc).**

| Procedure | Appropriateness Category |
|---------------------------------|--------------------------|
| Medical management | Usually Appropriate |
| Surgical consultation | May Be Appropriate |
| Radiation oncology consultation | Usually Not Appropriate |

Variant 4: Known malignancy and new back pain. Compression fracture identified on radiographs or CT.

| Procedure | Appropriateness Category |
|---|-----------------------------------|
| MRI spine area of interest without and with IV contrast | Usually Appropriate |
| Image-guided biopsy spine area of interest | Usually Appropriate |
| FDG-PET/CT skull base to mid-thigh | May Be Appropriate |
| MRI spine area of interest without IV contrast | May Be Appropriate (Disagreement) |
| Tc-99m bone scan whole body | May Be Appropriate |
| Tc-99m SPECT/CT spine area of interest | May Be Appropriate |
| MRI spine area of interest with IV contrast | May Be Appropriate |

Variant 5: Asymptomatic pathologic spinal fracture with or without edema on MRI.

| Procedure | Appropriateness Category |
|-------------------------------------|-----------------------------------|
| Radiation oncology consultation | Usually Appropriate |
| Medical management | Usually Appropriate |
| Percutaneous vertebral augmentation | May Be Appropriate |
| Percutaneous thermal ablation | May Be Appropriate |
| Surgical consultation | May Be Appropriate (Disagreement) |

Variant 6: Pathologic spinal fracture with severe and worsening pain.

| Procedure | Appropriateness Category |
|-------------------------------------|--------------------------|
| Radiation oncology consultation | Usually Appropriate |
| Percutaneous thermal ablation | Usually Appropriate |
| Percutaneous vertebral augmentation | Usually Appropriate |
| Surgical consultation | Usually Appropriate |
| Medical management | May Be Appropriate |
| Systemic radionuclide therapy | May Be Appropriate |

Variant 7: Pathologic spinal fracture with spinal deformity or pulmonary dysfunction.

| Procedure | Appropriateness Category |
|-------------------------------------|--------------------------|
| Radiation oncology consultation | Usually Appropriate |
| Surgical consultation | Usually Appropriate |
| Percutaneous vertebral augmentation | Usually Appropriate |
| Medical management | May Be Appropriate |
| Percutaneous thermal ablation | May Be Appropriate |

Variant 8:**Pathologic spinal fracture with neurologic deficits.**

| Procedure | Appropriateness Category |
|---------------------------------|---------------------------------|
| Surgical consultation | Usually Appropriate |
| Radiation oncology consultation | Usually Appropriate |
| Medical management | May Be Appropriate |

MANAGEMENT OF VERTEBRAL COMPRESSION FRACTURES

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Summary of Literature Review

Introduction/Background

Vertebral compression fractures (VCFs) can be caused by osteoporosis, neoplasms, metabolic disorders including renal osteodystrophies, congenital disorders such as osteogenesis imperfecta, infections, and acute trauma. Painful VCFs 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) [1] and venous stasis (deep venous thrombosis and pulmonary embolism) [2]. Successful management of painful VCFs has the potential for improving quality of life, increasing the expectancy of an independent and productive life, and preventing superimposed medical complications. Research has also suggested that management of painful VCFs may have a cost benefit for society as a whole; however, assessment of any potential societal benefits is difficult because of the inexactness of methods used for quantifying pain-related disability.

This document addresses the management of both osteoporotic and pathologic VCFs.

Thorough medical management involves appropriate osteoporosis screening and follow-up treatment (see the ACR Appropriateness Criteria[®] topic on “[Osteoporosis and Bone Mineral Density](#)” [3]). Postmenopausal women represent the majority of patients at risk for developing osteoporotic fractures of any type, and VCFs represent 25% of osteoporotic fractures [4-6]. In the setting of “red flags” (see Table 1), the initial evaluation of a painful VCF includes assessment of any neurologic deficits. Subsequently, imaging of the affected spinal segment will be important to characterize the fracture and to determine extent of disease.

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Table 1. Red Flags: Indications of a more complicated status include back pain/radiculopathy in the following settings (adapted from [7]).

| Red Flag | Potential Underlying Condition as Cause of LBP |
|---|--|
| <ul style="list-style-type: none"> • History of cancer • Unexplained weight loss • Immunosuppression • Urinary infection • Intravenous drug use • Prolonged use of corticosteroids • Back pain not improved with conservative management • Fever | <ul style="list-style-type: none"> • Cancer or infection |
| <ul style="list-style-type: none"> • History of significant trauma • Minor fall or heavy lift in a potentially osteoporotic or elderly individual • Prolonged use of steroids | <ul style="list-style-type: none"> • Spinal fracture |
| <ul style="list-style-type: none"> • Cauda equina syndrome <ul style="list-style-type: none"> ▪ Acute onset of urinary retention or overflow incontinence ▪ Loss of anal sphincter tone or fecal incontinence ▪ Saddle anesthesia • Global or progressive motor weakness in the lower limbs • Severe neurologic compromise | <ul style="list-style-type: none"> • Epidural spinal cord compression |

Neoplasms causing VCF include: (1) primary bone neoplasms, such as hemangioma or giant cell tumors [8], and tumor-like conditions causing bony and cellular remodeling, such as aneurysmal bone cysts, or Paget’s disease (osteitis deformans); (2) infiltrative neoplasms including and not limited to multiple myeloma and lymphoma, and (3) metastatic neoplasms [2,9,10]. As the literature has focused predominantly on VCFs that are due to metastatic disease, this document focuses on the management of pathological VCFs secondary to metastatic disease; however, it should be noted that treatment can vary depending on tumor type. VCF secondary to underlying malignant or metastatic disease can result in skeletal-related events (SREs), including bone pain, pathologic vertebral fractures, and epidural spinal cord compression. The pathologic vertebral fractures may also have associated mechanical instability. The Spine Oncology Study Group (SOSG) has developed the Spinal Instability Neoplastic Score (SINS) to evaluate spinal stability, and one of the categories within SINS is the presence of a pathologic VCF. The rating is a composite of clinical and radiographic data including: location, pain, bone quality, alignment, vertebral body collapse, and posterolateral involvement. The affected spinal segment can be classified as stable (0–6), potentially unstable (7–12), and unstable (13–18). The SINS is routinely used by spine oncologic surgeons and spine radiation oncologists, and has excellent interobserver and intraobserver reliability [11]. SINS has also been shown in clinical studies to be a tool enabling the prediction of VCF or progression of an existing VCF postradiation [12]. A radiographic grading system for metastatic epidural spinal cord compression developed by the SOSG can also be used to guide management [13].

Special Treatment Considerations

Vertebral augmentation (VA) is a generic term that includes percutaneous vertebroplasty (VP), balloon-assisted kyphoplasty (BK) [2] and other implantable methods of VA [14-17]. These procedures, the majority of which are described in the lumbar and thoracic spine, are used for the palliation of pain related to VCF and have been shown to be effective compared to medical management [10,18-20].

Many studies have compared VP versus BK [21-27] and the timing of when VA is appropriate [18-20,28-31]. A thorough description of the indications and contraindications to VA are detailed in the [ACR-ASNR-ASSR-SIR-SNIS Practice Parameter for the Performance of Vertebral Augmentation](#) [32]. Because the clinical outcome studies show essentially the same benefit of BK as VP for patient pain relief and mobility and similar

complication rates, a multisociety panel of spine interventionalist holds the position that BK or VP may be considered to be appropriate and generally interchangeable techniques for the performance of VA. The panel recognizes that performance of VP or BK may be related to operator experience or preference or additional factors, such as degree of compression deformity, age of fracture, and presence of neoplastic involvement [33].

Minimally invasive percutaneous image-guided techniques for the treatment of spine tumors include newer technologies, such as radiofrequency ablation (RFA) [34], cryoablation, microwave ablation, alcohol ablation, and laser photocoagulation. These modalities provide an alternative or adjunct therapeutic option for the treatment of spinal tumors beyond medical pain management, surgery, radiation therapy (RT), and standard VA. Curative ablation can be applied for the treatment of specific benign or in selected cases of malignant localized spinal tumors. Pain palliation of primary and secondary bone tumors is also possible with ablation (chemical, thermal, mechanical), cavitation (radiofrequency ionization), and consolidation (VP, BK) techniques performed separately or in combination.

Discussion of Procedures by Variant

Variant 1: New symptomatic compression fracture identified on radiographs or CT. No known malignancy.

The body regions covered in this clinical scenario are cervical, thoracic, and lumbar spine. These body regions might be evaluated separately or in combination as guided by physical examination findings, patient history, and other available information including prior imaging.

For some authors, focal tenderness upon palpation in correlation with radiographs of the vertebral column is a satisfactory indication for intervention. However, spine radiographs are often nonspecific with respect to the acuity or cause of the vertebral fracture [35].

CT Spine Area of Interest

CT provides osseous detail of fractures extending to the posterior column of the vertebra and for evaluating the integrity of pedicles and the posterior cortex prior to VP [9,36]. CT permits evaluation of vertebral body architecture and assessment of the posterior cortex and pedicles before augmentation, which is critical in patients with cortical disruption and epidural extension. Comparison to prior imaging is helpful to determine acuity. Dual-energy CT may show bone marrow edema with reasonably high sensitivity and specificity [37,38], with good concordance to MRI in thoracolumbar VCF patients [39], which is helpful in patients who cannot get an MRI. Contrast does not provide additional value in this circumstance.

MRI Spine Area of Interest

MRI may provide valuable information to determine the need for intervention and for procedural guidance. The benefits of MRI for preprocedural planning and guiding the puncture site have been reported [40-42]. Minimally deforming fractures that are overlooked by conventional radiographs may be detected on preprocedure MRI, particularly if the imaging evaluation is >3 months old or if there is a change in symptoms from the initial workup [40,43]. Fluid-sensitive MRI sequences (short tau inversion recovery or fat-saturated T2-weighted imaging), are helpful for detecting acute fractures, identifying fracture clefts, and differentiating synchronous fractures [43,44]. MRI is also useful in distinguishing recent from chronic vertebral fractures in patients with multiple deformities and confusing clinical examinations [45,46]. However, vertebral body edema is not a precise measure of compression fracture age because the duration after an osteoporotic compression fracture is often not known with certainty. Bone marrow edema typically resolves within 1 to 3 months [47,48]. Contrast is not indicated, as it does not add information in the setting of osteoporotic VCF.

Tc-99m Bone Scan Whole Body

Technetium-99m (Tc-99m) whole-body bone scan (bone scintigraphy) may be helpful to determine the painful vertebrae [49], particularly the causative level [50,51]. Bone scan and MRI have higher concordance with single-level fractures as compared to multiple level involvements [52]. When more than one area of increased activity is detected, bone scans may overestimate the number of acute fractures; as such, multiple hot spots should be interpreted cautiously [53]. The utilization of bone scans may be based on institutional preference.

Tc-99m SPECT/CT Spine Area of Interest

Single-photon emission computed tomography (SPECT) coupled with CT provides complementary information because sites of abnormal radiopharmaceutical uptake on the spine are of interest. SPECT images can be anatomically localized on the CT, and anatomic abnormalities on CT images can draw attention to subtle areas of

SPECT tracer uptake. SPECT/CT has been shown to more precisely localize abnormalities in the vertebra compared to SPECT imaging alone, particularly in complicated cases, such as multiple collapsed vertebrae of different ages [54]. Studies have demonstrated a 63% to 80% agreement between SPECT/CT and MRI in detection of acute VCF [55,56].

FDG-PET/CT Skull Base to Mid-Thigh

PET using the tracer fluorine-18-2-fluoro-2-deoxy-D-glucose (FDG) combined with morphologic CT imaging can noninvasively localize metabolic activity in areas of spinal infection [57-59]. Vertebral osteomyelitis may present as a compression fracture [60] and may be difficult to distinguish from noninfectious, osteoporotic VCF. Vertebral osteomyelitis may be considered in the setting of severe back pain, persistent unexplained fever, elevated inflammatory markers (ie, erythrocyte sedimentation rate), or bacteremia without a known extravertebral focus of infection, particularly if the patient is immunocompromised.

Medical Management

The traditional first-line treatment of painful VCFs has been nonoperative or conservative management [61,62]. This may depend on the severity of the VCF as recent studies have found VA to be superior to placebo intervention for pain reduction in patients with acute osteoporotic VCF of <6 weeks' duration [19]. Medical management is often complementary to other treatment strategies. Medications include nonsteroidal anti-inflammatory drugs and narcotics. Narcotics have to be used with caution given the associated effects of sedation, nausea, further decrease in physical conditioning, and fall risks. Most patients with osteoporotic VCF have spontaneous resolution of pain, even without medication, in over 6 to 8 weeks [62-65]. Immobilization with bed rest and bracing are also part of conservative treatment.

Percutaneous Vertebral Augmentation

VA, in the form of VP and BK, may be offered to patients who have failed conservative therapy for 3 months [31]. Failure can be defined as pain refractory to oral medications (nonsteroidal anti-inflammatory drugs or narcotics) [66-69]. Failure can also be defined as a contraindication to such medications or a requirement for parenteral narcotics and hospital admission.

Two randomized controlled trials that reported no statistically significant advantage for VA versus sham therapy raised discussions and controversial editorials, particularly regarding the inclusion criteria and other methodological issues [63,70]. Several studies have shown the benefit of VA versus conservative treatment in acute osteoporotic VCF [20,62,71-73], with benefits persisting through 1 year after intervention, although others demonstrated that VA procedures may have no effect on global spinal alignment [74]. A meta-analysis found improvements in pain intensity, vertebral height, sagittal alignment, functional capacity, and quality of life with BK as compared with conventional medical management [75]. Multiple other studies demonstrated the benefit of VA for alignment with improvement in pain relief [19,76-78], and respiratory function [79-81]. In a multisociety position statement, it was concluded that VA of osteoporotic VCF is clearly beneficial in the short term and likely beneficial also in the long term [33]. Given the evidence that VA has been shown to be more effective than prolonged medical treatment in achieving analgesia, improving function in patients with painful VCFs [73,82], and avoiding the complications of narcotic use, the threshold for performing VA has declined.

The timing of when VA is appropriate has been debated. Studies found VA to be superior to placebo intervention for pain reduction in patients with acute osteoporotic VCF of <6 weeks' duration [19]. In the study by Syed et al [30], patients with VCF >12 weeks compared to those with VCFs <12 weeks had equivalent benefit suggesting that the age of the fracture does not independently affect the outcomes of VP.

Biopsy can be performed as a part of the VA procedure [83,84], as it can verify the etiology of a VCF and has been shown to detect unsuspected malignancy [85].

Percutaneous Thermal Ablation

Percutaneous thermal ablation procedures are reserved for symptomatic spinal metastatic disease [86].

Surgical Consultation

Surgical intervention is reserved for patients with neurologic deficits, spinal deformity (eg, junctional kyphosis, retropulsion), or spinal instability. Surgical consultation is helpful for prescribing and supervising immobilization devices. When the etiology of the VCF is questionable, an open biopsy may be necessary if percutaneous access is not feasible.

Radiation Oncology Consultation

There is no role for RT in a patient without a cancer diagnosis and in a nonpathologic VCF. In the event that cancer is thought to be the cause of a VCF, a biopsy is needed to confirm a cancer diagnosis. RT is reserved for spinal metastatic disease and typically for those spinal metastases causing pain, neurologic compromise, or those asymptomatic lesions with radiologic features suggesting that there is a risk of neurologic compromise or VCF.

Variant 2: Osteoporotic compression fracture, with or without edema on MRI and no “red flags”. With or without spinal deformity, worsening symptoms, or pulmonary dysfunction.

Most VCFs show gradual improvement in pain over 2 to 12 weeks, with variable return of function [64,65]. Bone marrow edema associated with acute fractures on MRI typically resolves within 1 to 3 months [47,48].

As conservative medical treatment does not prevent further collapse and does not prevent kyphosis, the timing of intervention has been an issue of debate. The VERTOS II randomized control trial comparing VA with medical management revealed that 40% of conservatively treated patients had no significant pain relief after 1 year in spite of higher class prescription medication [31]. Approximately 1 in 5 patients with osteoporotic VCFs will develop chronic back pain as a result of the fracture [87,88]. Additionally, spinal deformity associated with VCF can contribute to impaired mobility and physical functioning. Spinal deformity may be defined as $\geq 15\%$ kyphosis, $\geq 10\%$ scoliosis, $\geq 10\%$ dorsal wall height reduction, or vertebral body height loss $\geq 20\%$ [61].

Medical Management

The natural history of most healing VCF is that of gradual improvement in pain over 2 to 12 weeks, with variable return of function [64,65]. Conservative management includes medical management with or without methods of immobility and is the initial treatment of painful VCFs [33,61,62]. If there is failure of medical management with worsening of symptoms to medications [66-69] or in the setting of spinal deformity or pulmonary dysfunction, alternatives other than medical management should be implemented.

Percutaneous Vertebral Augmentation

VA may be a treatment option [33,61] for osteoporotic VCFs, as there is evidence that VA is associated with better pain relief and improved functional outcomes compared to conservative therapy [18,20,29,31]. VA has shown immediate and considerable improvement in pain and patient mobility. This supports consideration of VA to abate the secondary sequelae of VCFs, such as decreased bone mineral density and muscle strength with immobility [89,90], increased risk of deep venous thrombosis [89], and deconditioning of cardiovascular and respiratory muscles [1,90]. VA, because of improved alignment and decreased pain, has been shown to improve pulmonary function in patients with VCF [79-81,91]. Certain newer variants of VA are shown to be comparable to standard methods, such as BK, for decreased pain score, functional improvement, and height restoration [14,92].

The timing of when VA is appropriate has been debated. In the VERTOS II trial, of the patients who had significant pain relief on medical management, the majority achieved this level by 3 months; this study suggested that patients who had not received sufficient pain relief by 3 months with conservative treatment may be candidates for VA [31]. Studies have found VA to be superior to placebo intervention for pain reduction in patients with acute osteoporotic VCF of < 6 weeks' duration [19]. As noted in Variant 1 in the study by Syed et al [30], patients with VCF > 12 weeks compared to VCF < 12 weeks had equivalent benefit suggesting that the age of the fracture does not independently affect the outcomes of VP, although there is evidence for treatment of subacute and chronic, painful compression fractures [18,20,28,29].

Many studies have compared VP versus BK. A randomized control trial to evaluate the efficacy of VP versus BK in the treatment of VCF by Evans et al [24] found that VP and BK are equally effective in substantially reducing pain and disability in such patients. Others have corroborated these findings with improvements in vertebral deformity and less cement leakage with BK [22,23]. This comparable effectiveness between VA techniques in clinical outcomes has been shown to persist from 2 years [23] to 5 years [25] after the procedure. The improvement in spinal deformity with extension of the kyphotic angle and increased vertebral body height with BK has been shown to provide superior functional recovery compared with VP [27]. Unilateral versus bilateral VP techniques have shown no statistical difference in visual analog scale score, Oswestry disability index, Short Form-36, cement leakage rate, or vertebral height restoration [21,26]. Because clinical outcome studies show essentially the same benefit of BK as VP for patient pain relief and mobility and similar complication rates, a multisociety (ACR-ASNR-ASSR-SIR-SNIS) panel of spine interventionalists holds the position that BK or VP may be considered to be appropriate and generally interchangeable techniques for the performance of VA [33].

Percutaneous Thermal Ablation

Percutaneous thermal ablation procedures are reserved for symptomatic spinal metastatic disease [86].

Surgical Consultation

Surgical intervention is reserved for patients with neurologic deficits or spinal instability. When the etiology of the VCF is questionable, an open biopsy may be necessary if percutaneous access is not feasible. Surgical consultation will be helpful for prescribing and supervising immobilization devices.

Radiation Oncology Consultation

There is no role for RT in a patient without a cancer diagnoses and in a nonpathologic VCF. In the event that cancer is thought to be the cause of a VCF, then a biopsy is needed to confirm a cancer diagnosis. RT is reserved for spinal metastatic disease and typically for those spinal metastases causing pain, neurologic compromise, or those asymptomatic lesions with radiologic features suggesting that there is a risk of neurologic compromise or VCF.

Variant 3: Painful osteoporotic compression fracture with edema on MRI. Contraindication to vertebral augmentation or surgery (eg, fitness, pregnancy, infection, coagulation disorder, etc).

Patients may not be candidates for percutaneous or surgical intervention because of factors related to fitness, pregnancy, infection, or coagulation disorders, among others. Clinical decision making must account for the ability and time necessary to resolve the underlying contraindication and the overall risk and benefit to the patient's health and well-being.

Medical Management

In scenarios when a patient with a painful osteoporotic VCF cannot undergo VA or surgery, the main treatment option is medical management. Conservative management includes medical management with or without methods of immobility. In patients with contraindication to VA, medical management is the main treatment option for painful VCFs.

Radiation Oncology Consultation

There is no role for RT in a patient without a cancer diagnoses and in a nonpathologic VCF. In the event that cancer is thought to be the cause of a VCF, then a biopsy is needed to confirm a cancer diagnosis. RT is reserved for spinal metastatic disease and typically for those spinal metastases causing pain, neurologic compromise, or those asymptomatic lesions with radiologic features suggesting that there is a risk of neurologic compromise or VCF.

Surgical Consultation

Surgical consultation will be helpful for prescribing and supervising immobilization devices.

Variant 4: Known malignancy and new back pain. Compression fracture identified on radiographs or CT.

The body regions covered in this clinical scenario are cervical, thoracic, and lumbar spine. These body regions might be evaluated separately or in combination as guided by physical examination findings, patient history, and other available information including prior imaging.

The associated pain and neurologic deficits of pathologic VCF can result in impaired mobility, decreased quality of life and loss of functional independence [93]. Algorithms for patient selection and VCF management have been proposed by multidisciplinary groups that include oncology, surgery, and interventional radiology, based on evidence and expert opinion for managing metastatic spinal disease [94]. Medical therapy, including bisphosphonates for osteoclast inhibition [95-97] and osteoclast regulating agents [98-100], can be used to prevent SREs.

The SOSG has developed the SINS to evaluate spinal stability in the patients with metastatic spinal disease, and presence of VCF is within the SINS classification system. The rating is a composite of clinical and radiographic data that includes: location, pain, bone quality, alignment, presence and degree of VCF, and posterolateral involvement. The affected spinal segment can be classified as stable (0–6), potentially unstable (7–12), and unstable (13–18). The SINS is routinely used by spine oncologic surgeons and spine radiation oncologists and has excellent interobserver and intraobserver reliability [11]. A radiographic grading system for metastatic epidural spinal cord compression developed by the SOSG can also be used to guide management [13].

MRI Spine Area of Interest

MRI is imperative for assessing VCFs in patients with a history of malignancy or atypical clinical features. In addition to detecting early metastases that are localized completely in the bone marrow cavity, MRI can be used to differentiate benign from malignant fractures, as osteoporotic VCFs can occur in patients with malignancy [81,101-104]. MRI allows assessment of the degree of thecal sac or cord compression, epidural extension [13], paraspinal extension, presence of other lesions, and vascularity. Intraosseous disease is best delineated on noncontrast MRI sequences (T1-weighted and short tau inversion recovery). Contrast-enhanced MRI is helpful to delineate epidural, foraminal, paraspinal, and intrathecal disease extension, including intramedullary disease, when compared to sequences without contrast. It is most helpful to compare precontrast and contrast MRI sequences. With tumor involvement of the marrow in a vertebral body, edema may not be detected on conventional MRI sequences [105]. Diffusion-weighted [102] and MR perfusion techniques [106] may also be able to differentiate benign from pathological fractures; however, such advanced MRI techniques remain investigational. MRI is also important for further treatment planning, such as VA, percutaneous ablation, RT (stereotactic body radiation therapy [SBRT] or conventional palliative radiation), or systemic chemotherapy [107-110].

Tc-99m Bone Scan Whole Body

Tc-99m bone scan (bone scintigraphy) of the whole body is often used for initial detection of metastases, as well as the staging of patients with cancer. Bone scans may be performed based on institutional preference.

Tc-99m SPECT/CT Spine Area of Interest

SPECT/CT has been shown to precisely localize abnormalities in the vertebra, particularly in complicated cases, such as multiple collapsed vertebrae of different ages [54]. However, MRI has greater sensitivity and specificity for metastasis in certain locations of the spine [111] and for certain primaries, such as prostate cancer [112].

FDG-PET/CT Skull Base to Mid-Thigh

FDG-PET/CT may demonstrate localized metabolic activity in a neoplastic VCF and in areas of spinal infection [57-59]. MRI features coupled with clinical symptoms may help discern the etiology of a VCF with increased FDG uptake. VA augmentation is contraindicated in spinal infection [113]. Other potential radiotracers have been described for the early detection of marrow-based metastases, such as ¹⁸F-NaF PET/CT, which indicates areas of increased bone turnover and is generally used in the assessment of primary and secondary osseous malignancies, the evaluation of response to treatment, and the clarification of abnormalities on other imaging modalities or clinical data. However, ¹⁸F-NaF PET/CT is a highly sensitive method in the evaluation of bone metastases (eg, prostate cancer), but it can be problematic because of low specificity as tracer accumulates in degenerative and inflammatory bone diseases. ¹⁸F-fluorocholine may be able to differentiate between degenerative and malignant osseous abnormalities because degenerative changes are not choline-avid [114].

Image-Guided Biopsy Spine Area of Interest

If the imaging features are ambiguous and not definitely in keeping with a pathologic VCF, a biopsy can and should be performed to verify the etiology. A biopsy of the spine region of interest may be important for staging when isolated spine involvement is the first presentation of metastatic disease.

Variant 5: Asymptomatic pathologic spinal fracture with or without edema on MRI.

Adjuvant therapies to achieve local tumor control in asymptomatic patients depend on patient-specific factors, including life expectancy, performance status, and tumor burden, which are often evaluated using the Tokuhashi and Tomita systems [115]. In general, observation and medical management may be supplemented by therapies to prevent an SRE without a local intervention if the patient is asymptomatic. If there is a high risk for spinal instability despite being asymptomatic (eg, SINS potentially unstable or unstable), then a local intervention (surgery or RT) may be of benefit, in particular for those patients with a longer life expectancy (>3 months). There is variability in practice patterns depending on different regional, institutional, and subspecialty practices. The data on this patient population are continuing to grow, and such treatment decisions may be made on a case-by-case basis [94].

Medical Management

The treatment regimen for VCF that is due to spinal metastasis is generally palliative and consists of a combination of medical therapy (steroids, pain medication, chemotherapy, or targeted immunotherapy), RT, and surgery. Observation is recommended for patients with asymptomatic spinal metastases and life expectancy <3 months, poor performance status, or widespread visceral metastatic disease as, in these circumstances, therapy is

unlikely to improve survival [94]. VCFs with high-risk features for neurologic compromise may warrant therapy in patients with a <3-month life expectancy, despite being asymptomatic. Decisions should be made on a case-by-case basis.

Percutaneous Vertebral Augmentation

For neoplastic VCFs, VA is a safe and effective treatment for vertebrae weakened by metastatic neoplastic disease [116]. Multidisciplinary case discussion should be performed prior to intervention. VA provides structural reinforcement more rapidly than other treatment measures [117]. VA may be considered as fracture prophylaxis after RT or percutaneous ablation. Although the rate of pathologic VCF at sites treated with external-beam RT (EBRT) is approximately 3% [118] and 11% to 39% after SBRT with median times to fracture of 2 to 25 months [119], the benefits of prophylactic VA before or after RT have not been validated. In addition, there is a debate as to the timing of VA as there is a small risk of tumor extravasation [120].

Percutaneous Thermal Ablation

Percutaneous thermal ablation procedures are considerations when spinal metastases do not respond to RT, the cumulative tolerance of the spinal cord to radiation has been reached, or inclusion criteria in clinical trials preclude RT [121-125]. RFA and VA may also be an effective alternative for patients who cannot be offered or cannot tolerate RT [126]. Such procedures, including RFA and laser-induced thermotherapy, with VA have been shown to decrease pain scores [121,127-130]. A retrospective study of RFA and VA has demonstrated the possibility of percutaneous thermal ablation to provide local disease control, although most of the cases were performed for pain alleviation [126]. Although ablation is not contraindicated when the posterior vertebral body cortex is eroded by tumor, it cannot be performed safely when epidural tumor abuts or surrounds the spinal cord [130].

Radiation Oncology Consultation

The current standard of care for the management of spinal osseous metastases is EBRT [131] or SBRT [132], particularly if there is local pain. Radiation oncology consultation may also be appropriate in asymptomatic patients. The data on this patient population are evolving with gains in knowledge, hence treatment decisions may be made on a case-by-case basis. RT typically does not provide spinal stabilization, and the abnormal biomechanics remain. EBRT may be considered for patients with pain, radiographic progression of tumor into the epidural space, and sufficiently long life expectancy to be at risk for spinal cord compression [93]. SBRT may provide greater local tumor control [133-135] and is frequently used to treat patients with isolated spinal metastases. Furthermore, SBRT is increasingly being applied to asymptomatic patients with oligometastases as it is suggested that these patients have a long life expectancy, with potential cure if treated with an ablative dose [132].

Surgical Consultation

Treatment decisions must be made on a case-by-case basis and in a multidisciplinary forum. Surgical intervention may be of limited value in patients with spinal metastases, owing to its morbidity, often poor functional status, and the short life span of the patients. Surgery is typically reserved for lesions with consequent neurologic compromise from spinal instability or from spinal cord compression that is due to epidural disease or retracted bone fragments.

Variant 6: Pathologic spinal fracture with severe and worsening pain.

With painful pathologic VCFs, management strategies include medications to affect bone turnover, RT, and interventions such as VA and percutaneous thermal ablation to alleviate symptoms. A multidisciplinary approach is necessary for the management of painful pathologic VCFs.

Medical Management

Although conservative medical management may be performed for a pathological fracture, severe and worsening pain warrants alternative measures. Bisphosphonates, which inhibit osteoclasts and other agents that regulate osteoclasts, can help with pain palliation and decrease the risk of SREs [95,97,136]. Medical management can be performed concurrently with other procedures.

Percutaneous Vertebral Augmentation

VA is a safe and effective treatment for vertebrae weakened by neoplasia [116]. VA provides analgesia and structural reinforcement more rapidly than other treatment measures [117]. Certain newer variants of VA have

been shown to be comparable to standard methods, such as BK, in decreasing pain scores and functional improvement [14]. VCFs following SBRT are also amenable to VA [110,137].

Percutaneous Thermal Ablation

Percutaneous thermal ablation procedures with VA can provide pain relief for symptomatic spinal metastatic disease [86], particularly when RT cannot be offered or is ineffective [121-123,127-130,138,139]. Such procedures, including RFA and laser-induced thermotherapy, with VA have shown decreased pain scores [121,127-130]. In addition, local tumor control may be achieved with RFA, VA [126], and cryoablation [122]. RFA and VA may be an effective alternative for patients who cannot be offered or cannot tolerate RT [126]. In patients with radiation-resistant tumor, concurrent percutaneous thermal ablation and RT have been shown to be safe and effective in palliating painful spinal metastases [140].

Surgical Consultation

Surgery is typically reserved for lesions causing neurologic compromise or spinal instability because of the inherent morbidity and the often poor functional status and short life span of the patients. Observational studies suggest that surgical decompression, tumor excision, and stabilization improve neurological status from nonambulatory to ambulatory as well as pain relief [93]. In patients with severe and worsening pain and who meet clinical criteria, spine-stabilization surgery with adjuvant RT helps manage axial pain and aides in neurologic recovery [141,142]. Surgical consultation can be performed concurrently with other procedures.

Radiation Oncology Consultation

The current standard of care for the management of painful osseous metastases is EBRT [131], but there is often a delay in symptom relief [143]. Generally, EBRT achieves at least partial pain palliation [143]. SBRT, using advanced radiation dose delivery systems, maximizes the likelihood of achieving local tumor control in addition to pain relief [135]. SBRT has the potential to produce more durable pain relief and local control of spinal metastases, including tumor histologies thought to be historically resistant to radiation [135].

Systemic Radionuclide Therapy

Systemic radionuclide therapy may be an option for palliation of multifocal osteoblastic metastases, particularly hormone-resistant prostate and breast cancer. The radionuclides are incorporated into the bone matrix at sites of increased osteoblastic activity and emit radioactive alpha or beta particles that reduce tumor volume and decrease production of pain-sensitizing cytokines [144]. Radioisotopes are effective in providing pain relief 1 to 4 weeks after initiation, with response rates of between 40% and 95% that can continue for up to 18 months. For example, prospective studies on the palliative efficacy of strontium-89 showed an overall response rate of 76% and complete response rate of 32% [145]. Repeat doses are effective in providing pain relief in many patients. The combination with chemotherapeutic agents, such as cisplatin, can increase the effectiveness of radioisotopes. Radionuclides may also be used for the prevention of SREs, as in the use of radium-223 for patients with multiple spinal metastases from castration-resistant prostate cancer.

Variant 7: Pathologic spinal fracture with spinal deformity or pulmonary dysfunction.

The pain, spinal deformity, and neurologic deficits associated with pathologic VCFs can result in impaired mobility and physical functioning, decreased quality of life, and loss of functional independence [93].

The pain and decreased mobility from pathologic VCFs can also result in a decrease in muscle strength, which includes the respiratory muscles. This results in decreased respiratory capacity by 25% to 50% [16]. Multiple studies have demonstrated the benefit of VA for alignment with improvement in pain relief [19,76-78] and respiratory function [79-81]. Multidisciplinary case discussion is warranted prior to intervention.

Medical Management

Although conservative medical management may be performed for a pathological fracture, spinal deformity or pulmonary dysfunction warrants other treatments. Medical management can be performed as an adjunct to other therapies.

Percutaneous Vertebral Augmentation

VA is a safe and effective treatment for vertebrae weakened by neoplasia [116]. VA provides analgesia and structural reinforcement more rapidly than other treatment measures [117]. VA has been shown to improve pulmonary function in patients with VCF [79-81,91]. VA is also recommended for patients with spinal instability, who are not surgical candidates. VA may not entirely restore spinal instability [116]. VCFs following SBRT are also amenable to VA [110,137].

BK and VP appear equally effective in substantially reducing pain and disability [24]; however, BK may have advantages in complex cases in which it could offer a better angular and fracture correction [146]. Certain newer variants of VA have been shown to be comparable to standard methods, such as BK, for decreased pain score and functional improvement [14].

Percutaneous Thermal Ablation

Percutaneous thermal ablation procedures with VA can be performed as an adjunct to other therapies, providing pain relief for symptomatic spinal metastatic disease [86]. RFA and VA may be an effective alternative for patients who cannot be offered or cannot tolerate RT or have tumors historically shown to be resistant to radiation [126]. RFA with BK may provide vertebral height restoration in the short term; however, this has not been shown to correlate with pain relief [147]. In certain types of spinal metastases when tumor has eroded through the posterior vertebral body cortex, ablation may be considered for cavity creation prior to VA because cement instillation can displace the tumor into the epidural space [108,120,130]. In patients with radiation-resistant tumor, concurrent percutaneous thermal ablation and RT have been shown to be safe and effective in palliating painful spinal metastases [140].

Surgical Consultation

Surgery is typically reserved for lesions causing neurologic compromise or spinal instability. Observational studies suggest that surgical decompression, tumor excision, and stabilization improve neurological status from nonambulatory to ambulatory as well as pain relief [93]. In patients with spinal deformity or pulmonary dysfunction, if they can undergo surgery, spine-stabilization surgery with adjuvant RT may aid in neurologic recovery as well as decreased axial pain [141,142]. Surgical referral is recommended with SINS ≥ 7 [11,148].

Radiation Oncology Consultation

The patient's clinical status determines the role of RT. For patients with life expectancy of <6 months, poor performance status, or visceral metastatic disease, EBRT is recommended when painful stable fractures are incompletely palliated with VA or to attenuate tumor progression in the setting of impending epidural spinal cord compression [93]. For patients with life expectancy >6 months, good performance status, and few visceral metastases, adjuvant combination RT and ablation are recommended to maximize the likelihood of local tumor control [140]. Compared to RT alone, the combination of RFA and RT has also been shown to be as safe and to produce a more complete response of pain relief at 12 weeks [149]. However, there are no comparative prospective randomized trials to determine if the combination ablation and RT achieves better local tumor control than RT alone in this population.

Generally, EBRT achieves at least partial pain palliation [143], which may be delayed up to 2 weeks following treatment [150]. Because the radiation does not correct the existing biomechanical abnormalities, surgical stabilization/VA with adjuvant RT may be necessary.

SBRT is more frequently being applied to patients with spinal metastases for local tumor control. SBRT provides higher total radiation doses compared to palliative EBRT. Although there may be greater rates of complete pain relief and tumor control as compared to EBRT, the risk of VCF is significantly greater with SBRT, ranging from 11% to 39% with median times to VCF ranging from 2 to 25 months [119]. A dose-complication relationship has been reported with high rates of $\sim 40\%$ with 24 Gy in 1 fraction as opposed to $\sim 10\%$ when fractionating with 24 Gy in 2 fractions or using lower dose single-fraction doses (16–18 Gy in 1 fraction) [110]. Baseline VCF is a risk factor for subsequent VCF following SBRT. Randomized trials are ongoing to evaluate the proposed benefits of SBRT as compared to EBRT (NCT00922974 and NCT02512965).

Variant 8: Pathologic spinal fracture with neurologic deficits.

Medical Management

Conservative medical management may be the only option for patients who are not radiation or surgical candidates. Upon presentation with neurological deficits, the patient should be treated with corticosteroid therapy and surgery should be performed as soon as possible to prevent further neurological deterioration [151]. Medical management is complementary to other therapies.

Surgical Consultation

Surgery is the standard of care for pathologic VCF complicated by frank spinal instability and/or neurologic deficits. The SINS can be used to categorize the metastatic spinal segment as stable, potentially unstable, or unstable based on anatomic and clinical factors [148]. Surgical referral can be guided by this classification

[11,148]. In the setting of metastatic spinal cord compression, particularly because of osseous compression, surgery is more likely to allow recovery compared to RT alone [152]. Observational studies suggest that surgical decompression, tumor excision, and stabilization improve neurological status from nonambulatory to ambulatory as well as providing pain relief [93]. Decompressive surgery followed by RT may benefit symptomatic spinal cord compression in patients who are <65 years of age, in the setting of a single level of compression, in patients with neurologic deficits for <48 hours, and in those patients with a predicted survival of at least 3 months [153]. The combination of a spine-stabilization procedure and RT may also help manage axial pain and aides in neurologic recovery [141].

Radiation Oncology Consultation

Therapeutic radiation is generally the only preferred option for patients who have radiosensitive tumors (hematologic primary, seminoma, small-cell lung cancer), cannot tolerate surgery, or have a poor survival prognosis (<3 months). The current standard of care for the management of painful osseous metastases is EBRT [131] for at least partial pain palliation [143]. Some studies have demonstrated success rates of 70% in neurologic improvement [150,154]. SBRT is increasingly being applied to patients with spinal metastases for local tumor control with doses that represent 2 to 6 times the dose of palliative EBRT. Postoperative SBRT has also been increasingly used with promising results [155].

Summary of Recommendations

- **Variation 1:** For patients, without known malignancy, with new symptomatic compression fracture identified on radiographs or CT, medical management and MRI spine area of interest without IV contrast or CT spine area of interest without IV contrast is usually appropriate.
- **Variation 2:** For patients with osteoporotic compression fractures, with or without edema on MRI or no “red flags”, with or without spinal deformity, worsening symptoms or pulmonary dysfunction, medical management is usually appropriate for the first 3 months. In those patients with spinal deformity, worsening symptoms or pulmonary dysfunction, percutaneous VA is usually appropriate.
- **Variation 3:** For patients with painful osteoporotic compression fracture with edema on MRI and contraindication to VA or surgery, medical management is usually appropriate.
- **Variation 4:** For patients with known malignancy and new back pain and compression fraction identified on radiographs or CT, MRI of the complete spine without and with IV contrast is usually appropriate. Image-guided biopsy spine area of interest is appropriate when the imaging findings are ambiguous.
- **Variation 5:** For patients with asymptomatic pathologic spinal fracture with or without edema on MRI, radiation oncology consultation or medical management is usually appropriate.
- **Variation 6:** For patients with pathologic spinal fracture with severe and worsening pain, a multidisciplinary approach including interventional radiology, surgery, and radiation oncology consultation is recommended. Percutaneous thermal ablation or percutaneous VAs is usually appropriate.
- **Variation 7:** For patients with pathologic spinal fracture with spinal deformity or pulmonary dysfunction, a multidisciplinary approach including interventional radiology, surgery and radiation oncology consultation is recommended. Percutaneous VA is usually appropriate.
- **Variation 8:** For patients with pathologic spinal fracture with neurologic effects, surgical consultation and radiation oncology consultation are usually appropriate.

Summary of Evidence

Of the 155 references cited in the *ACR Appropriateness Criteria® Management of Vertebral Compression Fractures* document, 30 are categorized as therapeutic references including 12 well-designed studies and 3 good-quality studies. Additionally, 117 references are categorized as diagnostic references including 12 well-designed studies, 40 good-quality studies, and 22 quality studies that may have design limitations. There are 58 references that may not be useful as primary evidence. There are 8 references that are meta-analysis studies.

The 155 references cited in the *ACR Appropriateness Criteria® Management of Vertebral Compression Fractures* document were published from 1982 to 2017.

Although there are references that report on studies with design limitations, 67 well-designed or good-quality studies provide good evidence.

Appropriateness Category Names and Definitions

| Appropriateness Category Name | Appropriateness Rating | Appropriateness Category Definition |
|-----------------------------------|------------------------|--|
| Usually Appropriate | 7, 8, or 9 | The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients. |
| May Be Appropriate | 4, 5, or 6 | The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal. |
| May Be Appropriate (Disagreement) | 5 | The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned. |
| Usually Not Appropriate | 1, 2, or 3 | The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable. |

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

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The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.