Vertebral Compression Fractures

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Ankit Patel and Brent Page

Introduction

While many patients with acute osteoporotic VCFs achieve significant pain relief with conservative measures, there are some who continue to experience persistent pain. VCFs may contribute to symptoms of back pain, radiculopathy, and/or myelopathy. Patients with VCFs may also experience other medical co-morbidities, functional impairments, and overall reduction in quality of life. For some patients, VCFs can be an incidental finding on spine imaging. Therefore, it is important to identify if a patient has a symptomatic compression fracture as this significantly impacts the treatment plan.

This chapter aims to review the epidemiology and common etiologies of VCFs, as well as the global impact of these fractures on patients. The key points in the clinical and diagnostic imaging evaluation of patients with VCFs will also be highlighted. An evidence-based review will be provided on the various treatment options for acute and persistent pain associated with VCFs. The chapter will also emphasize the importance of a multidisciplinary approach to treatment and prevention of VCFs.

Epidemiology and Risk Factors

A vertebral compression fracture (VCF) is characterized by collapse of trabecular bone within the vertebral body. VCFs have a variety of causes, including osteoporosis, trauma, malignancy, and infection. Osteoporotic fractures are by far the most common, accounting for an estimated 700,000 new VCFs in the United States every year [1]. Osteoporosis is characterized by decreased bone mineral density (BMD).

A. Patel (✉) · B. Page
UT Southwestern Medical Center, Dallas, TX, USA
e-mail: Ankit.Patel@UTSouthwestern.edu

C. E. Noe (ed.), *Multidisciplinary Spine Care*,
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The World Health Organization defines osteoporosis as a BMD that lies 2.5 standard deviations (SD) or more below the average BMD of a healthy, premenopausal white female (T-score < −2.5 SD). Osteoporosis results in diminished structural support of the spinal column, increasing the risk of fracture. In 2010, approximately 10.2 million older adults in the United States had osteoporosis, placing them at substantially increased risk for VCF compared to their non-osteoporotic peers [2–4]. The rate of osteoporosis is expected to increase more than 30% by the year 2030 as the population ages [4].

Other VCF risk factors are similar to those for osteoporosis and include advanced age, female sex, Asian or Caucasian ethnicity, excessive alcohol consumption, tobacco use, estrogen deficiency, history of falls, lack of physical activity, use of systemic glucocorticoids, and deficiency of calcium and vitamin D [5, 6]. The prevalence of VCF increases with advancing age, affecting approximately 25% of all postmenopausal women [7]. By 80 years of age, the prevalence in women reaches 40% [8]. Elderly men are also at increased risk of VCF, though lifetime fracture risk in men is less than in women [7].

History of prior VCF is also an important risk factor for sustaining a new VCF. Having sustained 1 VCF increases the risk of a subsequent VCF by approximately five-fold in the first year following the initial fracture [9]. In patients with a history of 2 or more VCFs, the subsequent fracture risk increases up to 12-fold [10].

While osteoporosis is the most common cause of VCF in the elderly, any new compression fracture in a young and otherwise healthy patient should prompt further investigation. Again, it is important to assess bone health and to also evaluate for secondary causes of fracture, such as malignancy. Metastatic disease affecting the vertebral body can compromise bone stability and lead to pathologic VCF. Bone metastasis is common in a variety of advanced stage solid tumor malignancies including prostate, lung, renal, breast, and colorectal cancer. For example, bone metastasis is diagnosed in up to 45% of metastatic prostate cancer patients within 12 months of initial cancer diagnosis [11]. Pathologic fracture is also common in Multiple myeloma (MM), a plasma cell malignancy associated with osteolytic bone disease. VCF is the most common type of fracture in MM and is seen in up to 60% of patients at the onset of disease [12].

Global Effects of VCF

More than two-thirds of patients with VCFs are asymptomatic and only identified incidentally, often on standard radiographs of the chest and abdomen [13]. Symptomatic fractures, however, can cause significant acute and chronic back pain, impaired physical functioning, vertebral height loss, and progressive spinal kyphotic deformity [14–17]. Symptomatic VCF negatively impacts quality of life and mental health. Patients often report feelings of anxiety and depression following an acute VCF [18]. Additionally, the loss of ability to participate in recreational activities, secondary to fracture associated pain and debility, can lead to social isolation [18].

Patient perceived deterioration in overall health status is common and adds to dissatisfaction following acute fracture [19]. Not surprisingly, patients with a history of prior VCF have greater disability and worse quality of life after sustaining a subsequent VCF compared to those with a first-time fracture [20]. While VCFs are rarely fatal in the short term, they have been associated with a higher mortality rate which becomes more pronounced in the years following fracture [21].

The social and economic costs of VCFs are also substantial. Direct healthcare costs associated with VCFs were estimated to exceed $1 billion per year in 2005, with costs expected to increase more than 50% by the year 2025 as rates of osteoporosis continue to rise [22]. When patient and caregiver productivity loss is factored in, the costs associated with VCF are substantially higher. Direct economic costs to the patient are also high. In the first 12 months following an initial osteoporotic fracture, average all-cause healthcare costs more than double [23]. Also, in the first 12 months following a fracture, patients are 14 times more likely to require primary care physician services, as compared to the general population [24]. Approximately 10% of patients with acute VCF require hospitalization, with a 6-day length of stay on average [25]. Of those patients requiring hospitalization, approximately half require ongoing skilled care in a nursing facility following hospital discharge [25].

Given the substantial individual, societal, and growing economic burden associated with VCF, the identification and treatment of underlying fracture etiology is paramount. Unfortunately, studies suggest physicians often fail to evaluate bone health nor initiate osteoporosis directed treatment following acute osteoporotic VCF [26]. These missed opportunities, in addition to the known high rates of refracture, highlight the importance of addressing bone health in a timely manner following VCF.

Evaluation

For patients who have back pain and for whom there is a high index of suspicion of a possible compression fracture, imaging can be useful in confirming or ruling out the presence of a vertebral compression deformity. It is imperative that clinical correlation is applied because some patients can have asymptomatic VCFs that are noted incidentally on spine imaging. Features in the patient's history that are suggestive of an acute compression fracture include an acute onset of severe pain in the region of the compression fracture. Acute compression fractures often occur spontaneously or as a result of trivial strain [27]. An accurate diagnosis of an acute VCF can be missed initially and can lead to a delay in appropriate care [27]. For benign acute compression fractures, the pain is typically worse with activity and relieved with rest. The pain can also be aggravated with coughing, sneezing, and activities that jar the body. Some patients may experience symptoms of early satiety and decreased exercise tolerance due to a compression of the abdominal and thoracic cavity from the spinal deformity associated with multiple VCFs [28]. The wide

spectrum of impact that compression fractures can have on patients highlights the importance of obtaining a thorough history of the patient's symptoms, as well as the impact of the fracture on the patient's function and quality of life.

The most common sites of VCFs include the thoracolumbar junction, the mid-thoracic spine, and the lumbar spine [29]. In patients with acute compression fractures, physical examination may reveal point tenderness over the symptomatic spinous process. Patients may have a positive "closed-fist percussion sign" or "supine sign" in the setting of an acute compression fracture. The closed-first percussion sign requires the examiner to percuss over the site of a suspected fracture with the hypothenar aspect of the fist. Reproduction of the back pain is considered to be a positive sign. In order to evaluate for the supine sign, the examiner observes the patient transition to a supine position on the examination table. This sign is considered positive if the patient is unable to lie supine due to severe back pain. The closed-fist percussion sign has been shown to have a sensitivity of 87.5% and a specificity of 90%, while the supine sign has a reported sensitivity of 81.25% and a specificity of 93.33% [30].

Depending on the location, severity, and height loss associated with VCF(s), patients may be noted have kyphosis or loss of lordosis on physical inspection. Some patients with VCFs in the upper back region can develop a rounded-appearing kyphotic deformity known as a dowager's hump [31]. A reduction in overall body height may also be present in patients with severe or multilevel compression fractures.

Neurological compromise due to a VCF is a rare but potentially catastrophic scenario [32]. A comprehensive clinical evaluation and neuromuscular examination is important to rule out radiculopathy, myelopathy, cauda equina, or spinal cord compression. Spinal canal compromise should be suspected in patients who develop lower extremity pain, neurologic signs or symptoms, or bowel or bladder incontinence after the initial diagnosis of acute back pain due to a VCF [32]. These "red-flag" signs and symptoms warrant urgent imaging and surgical consultation. According the American College of Radiology's appropriateness criteria for management of VCFs, surgical consultation should be considered in patients with spinal instability, neurologic deficits, or spinal deformity. Surgical consultation is recommended in the setting of patients with pathologic VCFs who have severe pain, neurologic deficits, spinal deformity, spinal instability, or pulmonary dysfunction [33].

Plain radiographs can be useful for evaluating the presence of a superior and/or inferior endplate compression deformity and to quantify the degree of vertebral body height loss (Figs. 11.1, 11.2, 11.3, and 11.4). Repeating plain radiographs upon patient follow up can be considered to monitor for fracture progression [34]. It should be noted that not all vertebral body deformities are a result of a VCF. Vertebral bodies may appear deformed from other conditions such as Schmorl's nodes, short vertebral height, Scheuermann's disease, and physiologic wedging [35].

Magnetic resonance imaging (MRI) can be useful to assess fracture acuity by evaluating for endplate edema (Figs. 11.5, and 11.6). In a patient with an acute compression fracture, the MRI would be expected to demonstrate marrow edema on

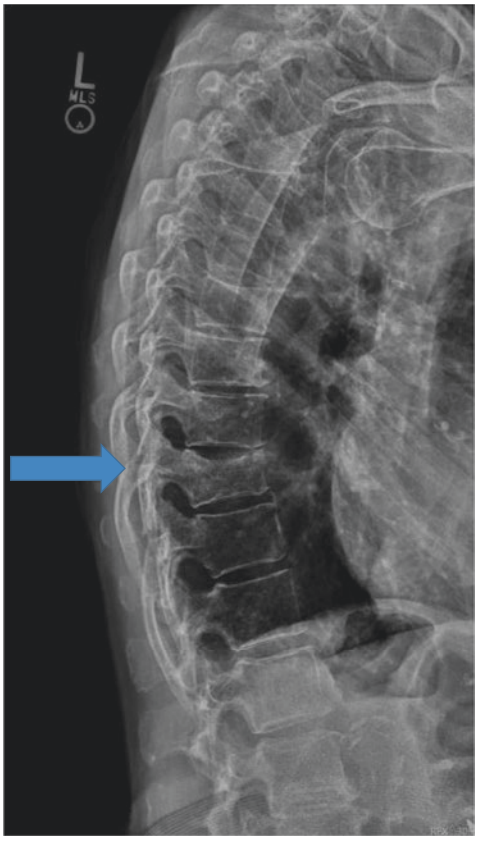

Fig. 11.1 Lateral X-ray demonstrating a T10 VCF

fat-suppressed short tau inversion recovery (STIR) sequences. In the setting of chronic compression fractures, the MRI would not demonstrate high T2, low T1, or STIR signal abnormality in the compression fracture (Fig. 11.7). MRI can be useful in procedural planning and in distinguishing acute versus chronic fractures in patients with multiple wedge deformities and conflicting physical examination findings [33]. MRI can also be considered in the evaluation of symptomatic patients who do not have significant height loss on plain radiographs.

Contrast-enhanced MRI studies can aid in differentiating between osteoporotic and malignant vertebral fracture. MRI features that could suggest the presence of a pathologic VCF include abnormal posterior element signal, epidural/paravertebral soft-tissue mass, expansion of posterior vertebral contour, abnormal enhancement, and replacement of normal marrow signal [36, 37] (Fig. 11.8).

The benefits of an MRI over a computerized tomography (CT) scan or plain radiographs are more optimal soft tissue & bone marrow resolution, as well as avoidance of ionizing radiation. If there is a contraindication to MRI, a CT scan can be useful to evaluate for any bony retropulsion (Fig. 11.9). It should be noted that CT scans will expose the patient to ionized radiation. For assessment of specific

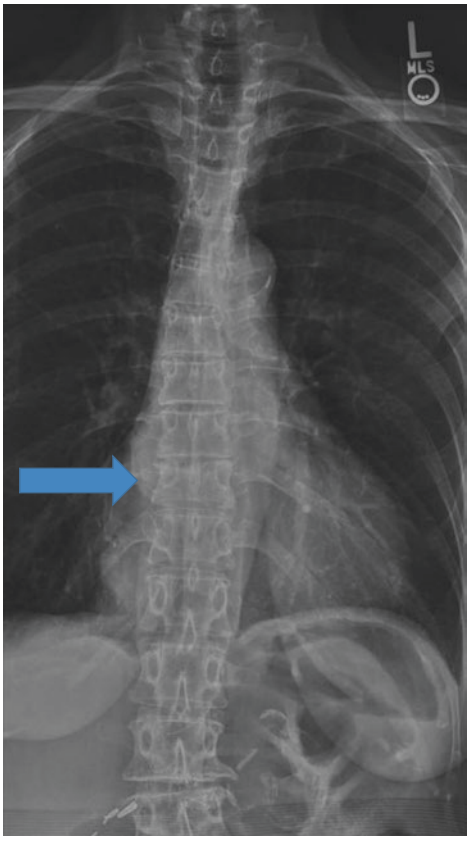

Fig. 11.2 AP X-ray demonstrating a T10 VCF

bony details such as the location and extent of fracture lines, thin-section CT with sagittal reconstructions can be a useful modality [38].

Bone scintigraphy, or bone scan, can be useful in patients who are unable to undergo MRI and in whom a CT scan or clinical history does not confirm the acuity of the compression fracture (Fig. 11.10). A bone scan may show elevated tracer uptake for up to 12 months following a fracture, therefore the results should be correlated clinically [38].

Management

Successful management of VCF often involves a graduated, multimodal approach. Most patients with acute VCF can be treated conservatively and pain typically resolves over a period of 4 to 6 weeks [39]. Comprehensive treatment strategies should address pain control and maintenance of physical functioning. It is also essential to address bone health, when the fracture is osteoporotic in nature, given the high likelihood of subsequent fracture.

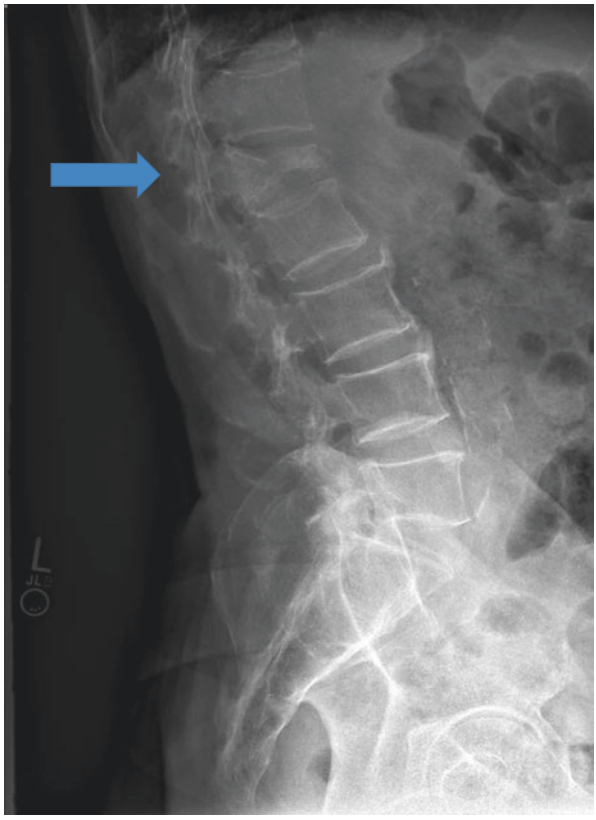

Fig. 11.3 Lateral X-ray of a L1 VCF

Medications for Pain Control

Adequate pain control is important to prevent immobility and associated comorbidities including decubitus ulcers, venous thromboembolism, pulmonary disease, and progressive functional decline. First-line analgesics used to manage acute pain from VCF include acetaminophen and nonsteroidal anti-inflammatory drugs (NSAIDs). Appropriate consideration should be taken when prescribing NSAIDs to patients with a history of gastric ulcers, gastrointestinal bleeding, cardiac and renal disease. Selective cyclooxygenase-2 (COX-2) inhibitors, which have a lower risk of gastrointestinal side effects as compared to traditional nonselective NSAIDs, may also be considered [40–42]. There is a theoretical risk of impaired bone healing with the use of NSAIDs, though this has not been confirmed and NSAIDs are commonly used for acute pain control in clinical practice [43, 44]. Other frequently used pharmacotherapies include muscle relaxants, transdermal lidocaine, and various neuropathic pain medications (e.g., gabapentin, pregabalin, and tricyclic antidepressants). Although generally well tolerated, appropriate caution should be taken when prescribing skeletal muscle relaxants and neuropathic pain medications, especially in the elderly. Dizziness, somnolence, and gait disturbance are all documented side

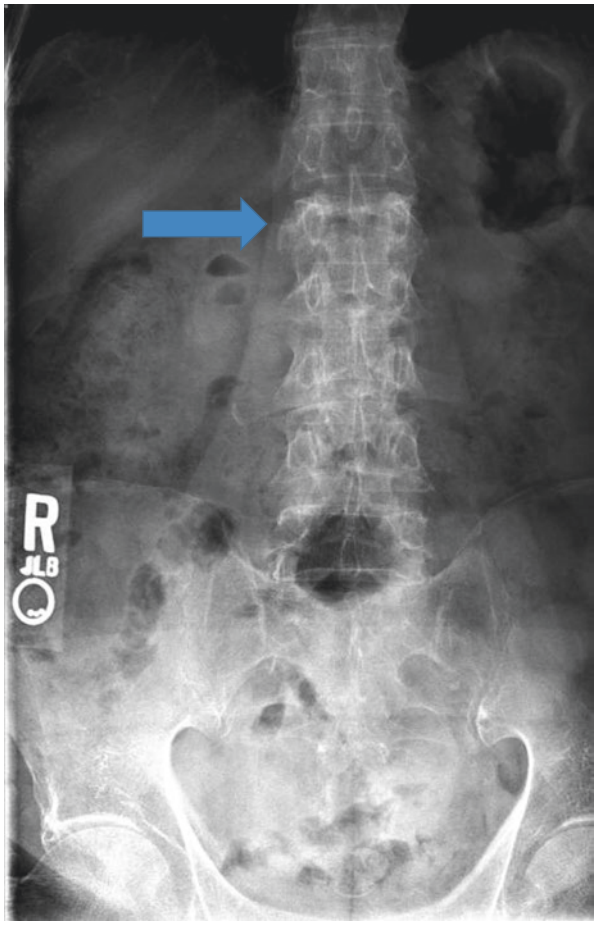

Fig. 11.4 AP X-ray of a L1 VCF

effects of gabapentin and the use of muscle relaxers has been shown to increase hospitalization rates in the elderly [45–47]. Tricyclic antidepressants, such as amitriptyline, reduce pain by inhibiting the reuptake of norepinephrine and serotonin. Tricyclics have demonstrated effectiveness in treating neuropathic pain but their common side effects including urinary retention, sedation, and postural hypotension may limit their use [48, 49].

Opioid pain medications may be required when patients fail to obtain adequate pain control with first-line analgesics and activity modification. Special consideration when prescribing opioids in the elderly include risk of reduced gastrointestinal motility, urinary retention, cognitive slowing, loss of balance, and increased risk of falls [50, 51]. However, a short course of opioid treatment can be an effective means of providing analgesia and preventing immobility secondary to uncontrolled, acute pain. When opioid medications are required a laxative can also be given to prevent constipation as straining with deification can acutely exacerbate VCF pain. As pain subsides, opioids should be tapered gradually while closely monitoring the patient's

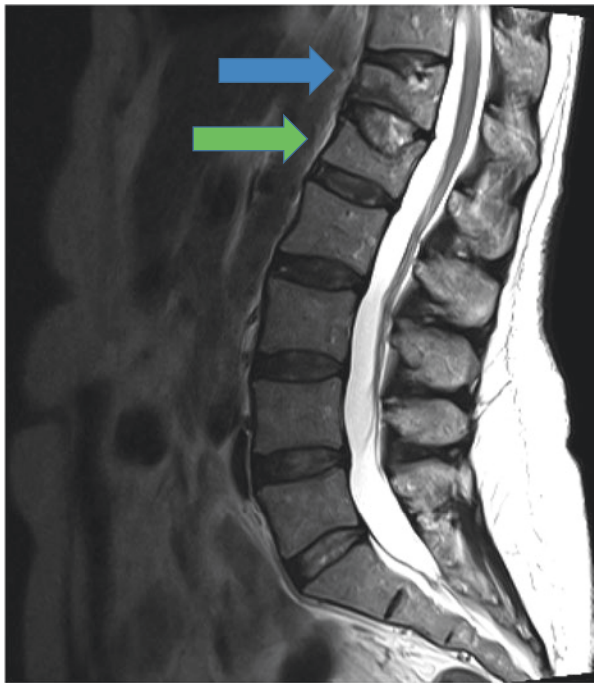

Fig. 11.5 T2-weighted MRI demonstrating an acute T12 VCF (blue arrow) and a chronic L1 VCF (green arrow)

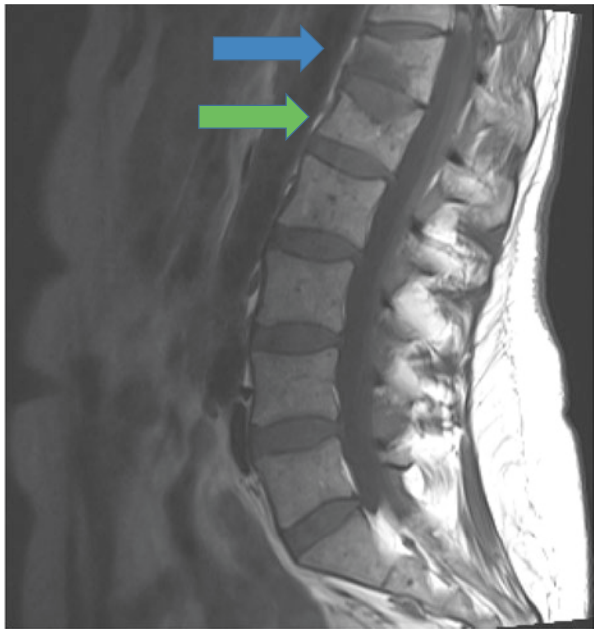

Fig. 11.6 T1-weighted MRI demonstrating an acute T12 VCF (blue arrow) and a chronic L1 VCF (green arrow)

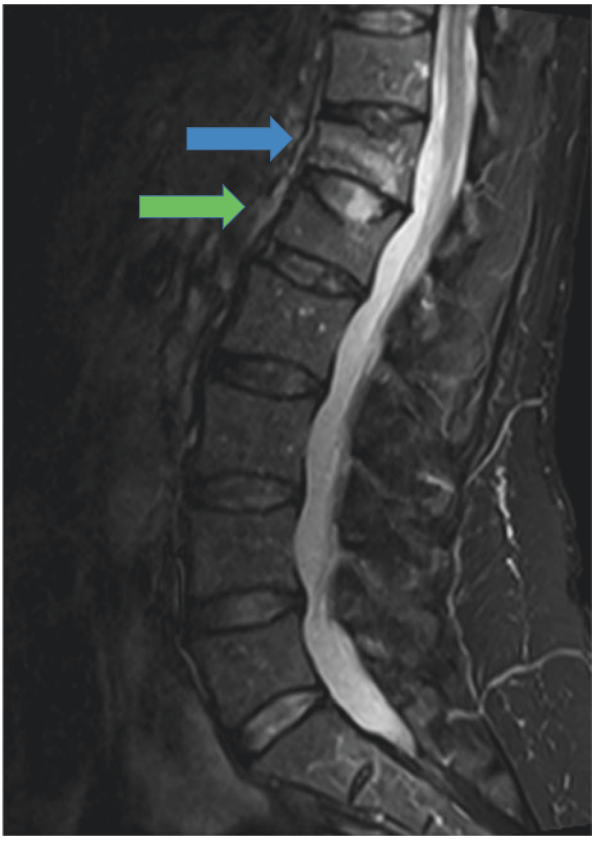

Fig. 11.7 STIR MRI sequence demonstrating increased STIR signal in an acute T12 VCF and normal signal in a chronic L1 VCF

response to dose reduction, including residual pain and functional status. Re-evaluation and optimization of non-opioid analgesics may also be appropriate as opioid analgesics are weaned. The risks and benefits of opioid medications should be carefully considered on a case-by-case basis.

Calcitonin may be used as an adjunct to traditional oral analgesics for pain control in acute VCF. It is also an option for patients with uncontrolled pain who cannot tolerate NSAIDs or opioids. Calcitonin is typically administered intranasally for a two to four-week course. Ideally, treatment should be initiated within 5 days following acute fracture [52, 53]. Although the exact mechanism of analgesia is unknown, calcitonin appears to exert a pain-relieving effect independent of its antiresorptive properties, possibly via a direct central nervous system mechanism involving calcitonin-binding receptors, modulation of peripheral prostaglandin levels, or by increasing plasma β-endorphin release [54, 55]. A meta-analysis by Knopp-Sihota et al., examining the combined results of 13 trials, demonstrated significant pain reduction with calcitonin administration following acute osteoporotic VCF. However, results from the analysis did not show any convincing evidence when calcitonin was used for chronic pain associated with older fractures [56]. Recently, there has been some concern that the long-term use of calcitonin may increase various cancer rates.

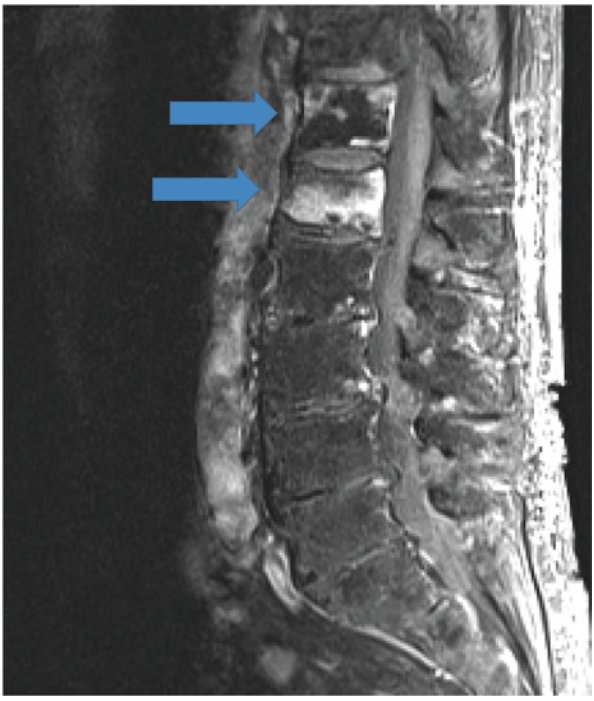

Fig. 11.8 MRI with contrast demonstrating abnormal marrow signal & post-contrast enhancement in pathologic T12 and L1 VCFs

Although a direct causal relationship has not been established there does appear to be a weak association with long-term use [57].

In summary, successful pharmacotherapy for the management of pain in VCF requires an individualized approach based on the intensity, quality, and duration of pain. A thorough understanding of the indications and potential side effects for each medication is also important. Medication indications and dosing regimens should be frequently reviewed as the natural course of pain associated with acute VCF typically improves over subsequent weeks.

Spinal Bracing

Spinal orthoses can also be used to reduce pain in patients following acute VCF. In general, braces are used to limit spinal flexion, thereby decreasing load on the fractured and painful anterior vertebral column [58]. Although high-quality evidence is lacking, bracing may also aid in limiting motion about the injured vertebrae to reduce pain, facilitate bone healing, prevent further vertebral body collapse, and decrease adjacent paraspinal muscle spasm by providing axial support [44, 53, 59–62]. Several bracing options are available for stable fractures including the Jewitt and CASH (Cruciform Anterior Spinal Hyperextension) orthoses. These braces provide a ridged 3-point contact system to promote neutral spine posture and limit flexion of the thoracic spine and thoracolumbar junction [61, 63]. Semi-ridged or flexible orthoses may also be appropriate for some patients and have been shown to

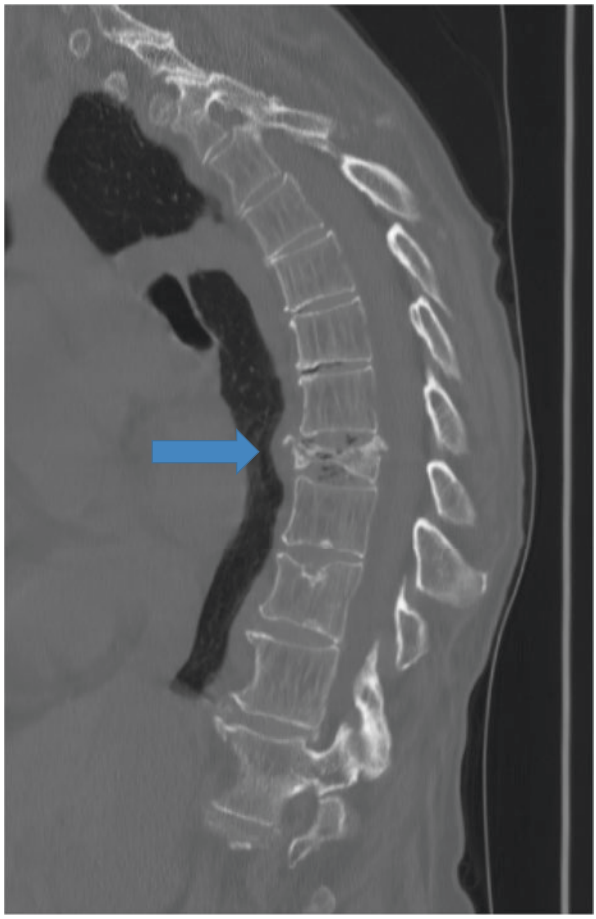

Fig. 11.9 Sagittal CT scan demonstrating a severe T9 VCF with mild posterior retropulsion

provide equivalent outcomes when compared to rigid bracing [58]. As pain subsides, braces should be weaned to avoid weakening of the axial musculature. Though some patients do find benefit from bracing, the most recent American Association of Orthopedic Surgeons guideline was unable to recommend for or against spinal bracing in patients with osteoporotic VCF, citing an overall lack of high-quality evidence [53].

Physical Therapy and Exercise

Physical therapy and directed exercise may also be employed as part of the multimodal treatment plan. Goals should include developing an individualized program focused on axial strengthening, balance, proper mechanics, and pain provoking activity modification. In addition to the positive impact of progressive resistance training on bone mineral density, exercise can also improve quality of life and reduce the risk of falls and fracture recurrence in patients with VCF [64–66]. A

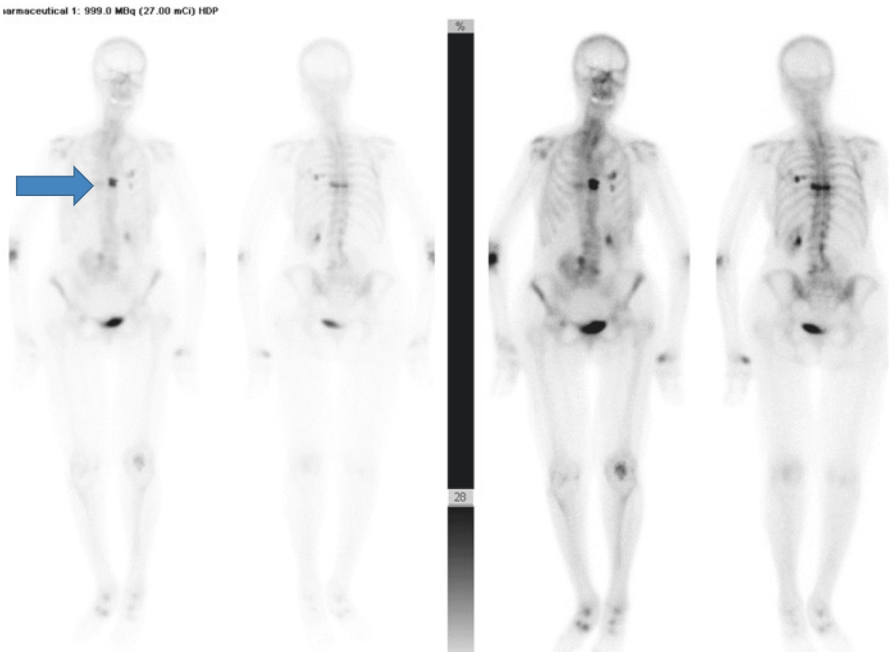

Fig. 11.10 Bone scan demonstrating increased radiotracer activity in a patient with several fractures, including a T9 VCF

retrospective review by Huntoon et al. concluded that a program of isometric back extensor strengthening in combination with proprioceptive postural retraining following osteoporotic VCF significantly decreased fracture recurrence following percutaneous vertebroplasty when compared to percutaneous vertebroplasty alone (4.5 vs. 20.4 months to re-fracture) [67]. Sinaki et al. examined the long-term effects of a 2-year resisted back extension program in healthy postmenopausal women without VCF. At 8-year follow-up, they found participants had a significant reduction in VCF risk and improved bone density compared to controls [66].

While several studies highlight the benefits of therapeutic exercise, a recent Cochran review examining exercise for improving outcomes following VCF, both alone or as part of a structured physical therapy intervention, drew no clinically relevant definitive conclusions [68]. The review included nine trials (749 participants). While some studies were positive and demonstrated improved pain, physical functioning, and quality of life, the overall quality of evidence was deemed weak. Additionally, there is no high-quality data regarding the safety of exercise following VCF or the effect on subsequent fracture risk. However, in general, safe therapeutic exercise programs can be developed based on the patient's current musculoskeletal status and individualized goals. Specific recommendations compiled by an expert consensus panel include limiting physical activity to moderate intensity, incorporating daily balance training, and development of spinal extensor muscle endurance [69]. Additional consensus recommendations included educating patients on proper posture and body mechanics during activities of daily living and stretching muscles

that prevent proper spinal alignment (e.g., tight pectoralis muscles causing exaggerated thoracic kyphosis) [69]. Finally, formal consultation with a physical therapist may be beneficial in patients with significant pain or debility to develop an individualized and graduated exercise plan [69].

Preventative Medicine & Bone Health

Interventions aimed at improving bone quality should also be addressed following an acute osteoporotic VCF. Treatment measures for osteoporosis include nutrition and lifestyle modification and pharmacologic therapy [70]. Lifestyle measures include exercise, smoking cessation, avoidance of excessive alcohol consumption, and fall prevention. Ensuring adequate calcium and vitamin D intake is also essential to bone health. The National Osteoporosis Foundation recommends a total calcium intake of 1200 milligrams per day for women over the age of 50 and men over the age of 70 and 800–1000 IU of vitamin D per day for men and women age 50 and older. Total calcium intake per day should include both dietary and supplemental forms taken in divided doses with meals. Consideration for initiation of pharmacotherapy is also appropriate following osteoporotic VCF [71]. A variety of medications are currently approved for the treatment of osteoporosis, including the bisphosphonates (alendronate, ibandronate, risedronate, and zoledronic acid), recombinant parathyroid hormone (teriparatide), receptor activator of nuclear factor kappa-B (RANK) ligand inhibitor (denosumab), and others. All agents act through either antiresorptive or osteogenic mechanisms. Choice of agent should be individualized and based on efficacy, safety, cost, and patient convenience [70, 72]. Referral to an endocrinologist, osteoporosis specialist, or to a dedicated osteoporosis coordinated care team should be considered to ensure patients who suffer a fracture receive appropriate diagnosis, treatment, education, and follow-up [73–75].

Spinal Injections

A hypothesis of facet-mediated pain following VCFs has been proposed. The posterior elements are thought to be strained biomechanically following a vertebral deformity [76]. A retrospective study evaluating the difference between vertebroplasty and facet medial branch blocks for pain associated with one-level VCFs found similar pain relief between the two groups at 2 years, and more cost-effectiveness in the medial branch block group [77].

Wang, et al., evaluated the difference in clinical outcomes of 206 patients that were randomized to undergo vertebroplasty versus facet blocks for back pain due to VCFs. The results demonstrated significantly better pain relief and functional outcomes a 1 week in the vertebroplasty group compared to the facet block group, however there were no significant differences between the two groups from 1 month to 12 months after the interventions [78]. These studies underscore the need for larger prospective randomized controlled trials evaluating facet blocks versus sham blocks and facet blocks versus vertebral augmentation in this patient population.

For some patients with VCFs, the kyphosis can lead to narrowing of the neural foramina at the level of the fractures. This can cause acute radicular pain symptoms in the distribution of the affected exiting nerve root. Consideration can be given to an epidural steroid injection for persistent or disabling radicular pain, however the potential adverse impact of repeat epidural steroid injections on bone mineral density should be taken into account [79].

Vertebral Augmentation

When conservative management fails to provide adequate pain relief, surgical intervention may be considered. Vertebroplasty and kyphoplasty are minimally invasive, percutaneous vertebral augmentation procedures frequently used to treat refractory pain secondary to osteoporotic and malignant VCF [80]. After a trial of conservative management, patients with persistent, severe back pain and physical exam and advanced imaging findings consistent with acute VCF (tenderness on palpation; vertebral end plate and/or marrow edema on MRI or increased radiotracer uptake on bone scintigraphy) are typically considered for treatment.

Vertebroplasty is a fluoroscopically guided procedure involving the percutaneous infusion of polymethylmethacrylate (PMMA) bone cement into the fractured vertebral body via a transpedicular approach. The objective is to reduce pain, stabilize the fractured elements, and provide structural support to the compromised trabecular bone. Kyphoplasty adds the additional step of inflating a balloon in the vertebral body in order to create a cavity for PMMA injection and to attempt restoration of vertebral height (Figs. 11.11, 11.12, 11.13, and 11.14). Both procedures

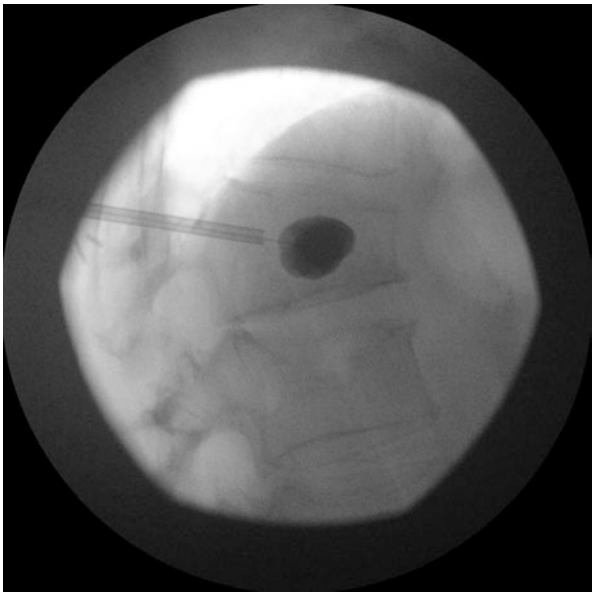

Fig. 11.11 Lateral fluoroscopy image demonstrating transpedicular kyphoplasty balloon inflation

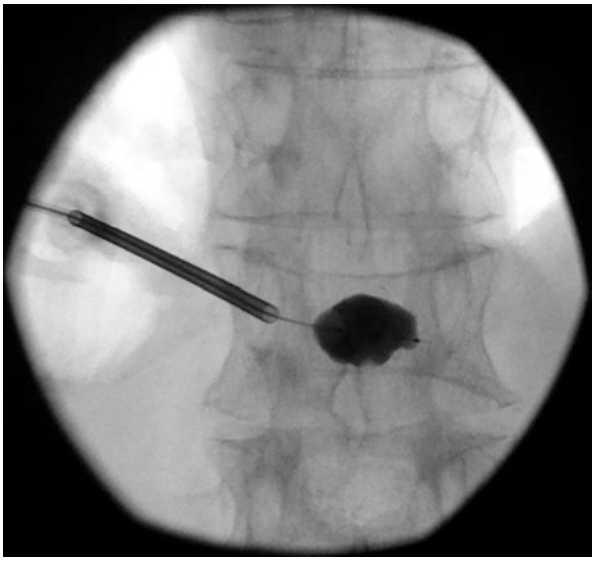

Fig. 11.12 AP fluoroscopy image demonstrating transpedicular kyphoplasty balloon inflation

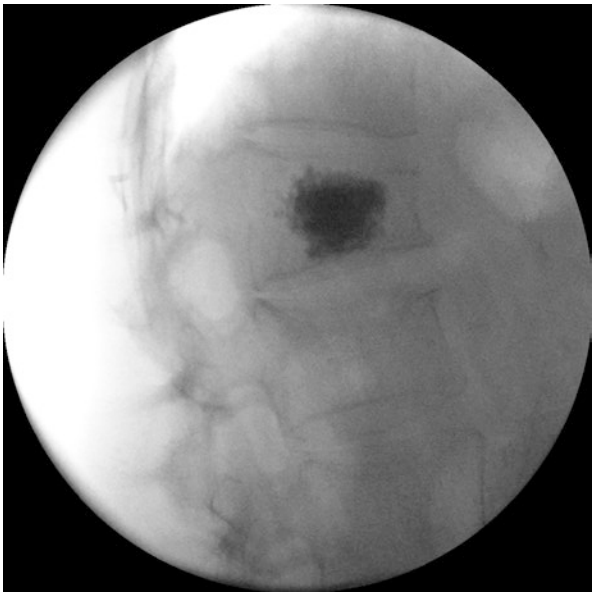

Fig. 11.13 Lateral fluoroscopy image demonstrating successful PMMA injection into a VCF

are typically preformed on an outpatient basis, under light sedation or general anesthesia. Procedural complications are rare, with major complications occurring in <1% of patients [81, 82]. Major complications include hemorrhage, osteomyelitis, cement pulmonary embolism, new procedure-related fractures, and permanent neurologic deficits [81]. Absolute contraindications to vertebral augmentation include

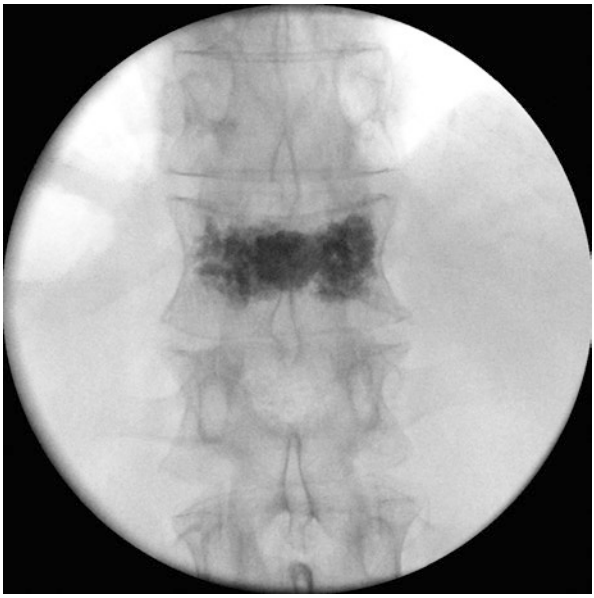

Fig. 11.14 AP fluoroscopy image demonstrating successful PMMA injection into a VCF

asymptomatic VCF, uncontrollable coagulopathy, unstable spinal fracture, active infection, or allergy to bone cement or opacification agents [83].

Although numerous studies have been published on the subject, the efficacy of vertebral augmentation remains controversial. Several early prospective randomized controlled trials (RCT) demonstrated positive results. The Vertebroplasty for Painful Chronic Osteoporotic Vertebral Fractures (VERTOS) trial, published in 2007, was the first prospective RCT comparing vertebroplasty to sham procedure [84]. Subacute and chronic (6–24 weeks) VCFs were included in the analysis. This study found significant improvement in pain scores at 24 hours post-vertebroplasty, but the effect was lost by 2 weeks. VERTOS II followed in 2010 and compared early vertebroplasty with medical management [85]. Inclusion criteria were moderate to severe back pain, fracture age <6 weeks, focal tenderness, and bone edema on MR imaging. At 1 month, there was significant improvement in visual analog scale (VAS) scores in the vertebroplasty group with durability at 1-year follow-up.

The Fracture Reduction Evaluation (FREE) trial, published in 2009, was the first RCT to compare kyphoplasty with medical management for acute and subacute (<3 months) VCFs causing moderate to severe back pain (numeric rating scale [NRS] ≥4/10) [86]. The primary end point, Short-Form-36 physical component summary scores, significantly improved following kyphoplasty at 1 and 6 months but the effect was lost at 24-month follow-up. This study also demonstrated a durable improvement in vertebral height restoration (27%) and kyphosis correction (3.3 degrees) at 24-month follow-up. Studies comparing vertebroplasty to kyphoplasty have generally shown comparable efficacy in reducing pain and disability in VCF [87–89].

While these early studies were overall encouraging, several trials produced negative results. For example, the 2009 Investigational Vertebroplasty Safety and Efficacy Trial (INVEST), designed to compare vertebroplasty with a sham procedure, demonstrated no difference in back pain between the two groups at 1 month [90]. Each of these early trials had limitations including lack of blinding (VERTOS II, FREE), inclusion of chronic fractures (VERTOS, INVEST), and enrollment of patients with moderate pain (VERTOS, VERTOS II, FREE, INVEST). Thus, debate continued regarding the efficacy of vertebral augmentation for painful VCF.

In 2016, the double blinded Vertebroplasty for Acute Painful Osteoporotic Fractures (VAPOUR) trial was designed to compare early vertebroplasty with sham procedure [91]. Patient selection was much more stringent and attempted to control for the limitations identified in prior studies. Inclusion criteria were 60 years of age or older, severe back pain, fracture age <6 weeks, and MR imaging with edema or SPECT CT uptake. One hundred twenty patients were enrolled and randomly assigned to treatment or sham. The primary end point was conversion of pain from severe (NRS ≥7) to mild (NRS <4) at 2-week follow-up. Significantly more patients had an NRS <4 at 2-week follow-up in the vertebroplasty compared to sham group (44% vs. 21%; $p = 0.01$), which was durable to 6 months. Mean NRS scores were also significantly decreased in the vertebroplasty compared to sham group at all time points up to 6 months. Additionally, vertebroplasty resulted in significantly improved disease-specific quality of life and significantly less analgesic use at 3 and 6 months.

Finally, VERTOS IV, published in 2018, is the most recent double-blinded RCT comparing vertebroplasty to sham procedure in VCF [92]. Inclusion criteria included fracture age <6 weeks, VAS score ≥5, focal back pain, and edema on MRI. Due to slow recruitment, inclusion of fractures up to 9 weeks was ultimately allowed. One hundred and eighty patients were randomized to vertebroplasty or sham. Results revealed VAS scores, the primary end point, did not differ between the two groups at any time point from 1-day to 1-year follow-up. Notably, pain in both groups significantly improved at all time points. By 12-month follow-up, mean VAS scores had declined by 5.00 in the vertebroplasty group and 4.75 in the sham group.

Interpretation of the available evidence is challenging given the heterogeneity of study inclusion criteria, open vs. blinded design, and variable use of sham procedure. Questions remain regarding the optimal timing of intervention and which patient characteristics indicate favorable outcome. Overall, evidence has shown that those with acute fractures (<6 weeks) and severe pain may benefit from vertebral augmentation. This statement is consistent with the recommendations of a multisociety interventional spine panel which found vertebral augmentation to be a safe and valid treatment option for painful VCF refractory to medical management [82]. Further high-quality studies may also aid in defining the long-term impact of vertebral augmentation on other important outcome measures such as fall risk, adjacent fracture risk, future vertebral height loss and kyphosis.

In summary, a multimodal approach to the management of painful VCF is often necessary. While most patients achieve adequate pain controlled with conservative measures alone, vertebral augmentation may be considered for those with severe,

refractory pain following acute VCF. In addition to controlling pain and promoting function, timely evaluation and treatment of bone health is of high importance. Successful management may also necessitate coordination across a multidisciplinary team, including the primary care physician, endocrinologist or osteoporosis specialist, oncologist and radiation oncologist when malignancy is known or suspected, and interventional spine specialist [33]. Further high-quality studies are needed to better inform individualized management strategies.

Conclusion

VCFs are a common cause of back pain and disability, especially in the elderly. While osteoporosis in the most likely etiology, other causes, such as malignancy, must not be overlooked. Although most VCFs are asymptomatic, some patients may experience significant fracture-related pain and functional deficits resulting in poor quality of life and high socioeconomic costs. Diagnostic studies may include plain film radiographs or more advanced imagining, such as MRI. The patient history and physical exam are important and often aid in establishing the diagnosis and fracture acuity. Timely evaluation and optimization of bone health following an osteoporotic VCF is important in reducing the risk of new fractures. When indicated, treatment of osteoporosis should be initiated given the high risk of subsequent fracture. Most patients who suffer an acute VCF respond to conservative management, with pain gradually resolving over several weeks. Successful conservative treatment is often multimodal and may include medications for pain control, physical therapy, and spinal bracing. For those patients with an acute fracture who continue to experience significant pain, despite a trial of conservative therapy, vertebral augmentation can be considered.

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