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Current Evaluation and Management of Vertebral Compression Fractures

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Abstract

Purpose of Review Vertebral compression fractures (VCFs) pose a significant burden of disease in an aging population. We aim to review current evidence for optimal management of this problem.

Recent Findings There is little high-quality evidence to guide treatment. While non-surgical management is the mainstay of treatment, there is no strong evidence to recommend bed rest, bracing, or opioid analgesics. Calcitonin may have a role in the management of acute pain. Cement augmentation may have a benefit in acute VCFs involving the thoracolumbar junction. Clinicians should maintain a high index of suspicion for underlying malignancy in the setting of VCFs.

Summary There is a lack of a clear consensus for the management of VCFs. Treatment should be individualized to each patient's overall clinical and functional status, with an aim of resolving acute pain and allowing early mobilization. Further high-quality studies are required to guide optimal treatment.

Keywords Vertebral compression fractures · Osteoporosis fractures · Spine fracture in elderly

Introduction

With the increasing age of the global population, the burden placed on our healthcare systems by fractures of fragility will inevitably continue to grow. There are currently an estimated 10 million individuals in the USA with a diagnosis of osteoporosis and a further 33 million with low bone mass [1]. This number is projected to continue to increase by a third by the year 2030 [2••]. By the age of 80, adults will have lost up to 50% of their axial bone mass, placing them at increased risk of fractures of fragility [3•] from minimal trauma. Of the 1.5 million osteoporotic fractures per year in the USA, 700,000 are due to vertebral compression fractures (VCFs) [4].

While many VCFs are asymptomatic, the majority of patients who do present to their primary care physicians or to a hospital have a chief complaint of back pain [3•, 5•]. Most patients will experience resolution of their pain over a course of 8–12 weeks with conservative treatment; however, not all fractures have a benign course [6]. Some studies have demonstrated a permanent deterioration in quality of life indicators following VCFs, which appears to correlate with severity of initial fracture deformation [7]. VCFs can also be associated with extended hospital stays, decreased mobility, sagittal deformity, and increased mortality [3•]. The association between mortality and VCFs is on par with hip fractures [8], with a mortality of 46.1% at 3 years and [9] 85.1% at 10 years [3•].

In 2001, the annual US medical cost for vertebral fracture management was estimated at $13.8 billion; however, this cost is likely to have increased given a growing elderly population [10]. In the year following a fracture, patients require an approximately 14 times greater rate of primary health care utilization compared to the general population [10]. This has led to a significant and increasing burden of disease for both primary care physicians and hospital practices [5•]. In Australia, 2 out of every 1000 general practitioner visits is related to the management of VCFs [5•]. Medicare claims data from the USA shows that vertebral fracture prevalence is 5.4% for patients of age less than 40 years, increasing to 18% for those aged over 80 [2••]. Although osteoporosis affects a greater proportion of females, males are also affected by this problem [5•].

With the advent of increasingly complex treatment modalities and advanced medical management strategies, there is a

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necessity to provide cost-effective and evidence-based treatment as well as appropriate preventative measures to allow the best care on a large population scale.

Evaluation

Despite the significant burden of disease posed by VCFs, there are still inconsistencies in the diagnosis and treatment of these fractures worldwide [3•]. It is important that treatment for VCFs is based on a sound evaluation of the structural characteristics of the fracture, careful evaluation of pain, identification of any neurologic changes or underlying pathologic processes and most importantly, the overall functional and medical state of the patient being treated.

A thorough medical and social history is essential to delineate history of osteoporosis, previous malignancy or infection and to evaluate the patient's functional state and usual level of independence. Although vertebral compression fractures are not typically associated with high energy injuries in an older population group, the mechanism of injury gives some idea as to the underlying bony and ligamentous damage that may have occurred [11]. Injuries resulting from falls from height are associated with higher energy fracture patterns and decreasing fracture stability. Injuries from low energy falls or without any antecedent history of trauma should bring into consideration the diagnosis of underlying osteoporosis, infection, or malignancy [11]. Newly diagnosed osteoporosis warrants specialist referral for detailed workup and medical optimization to prevent future fractures.

Characterization of the patient's pain profile is essential for guiding treatment. While it is thought that only 25 to 33% of VCFs are thought to be clinically diagnosed, those presenting to medical services most often have a chief complaint of back pain [4]. A detailed history should be obtained to determine the presence of longstanding pre-existing back pain, as well as the duration and severity of any new pain, degree of improvement since injury, and functional loss associated with pain. It is important to clearly understand the patient's medical history and narcotic tolerance in order to allow for the appropriate management of analgesics.

A thorough neurologic examination is crucial to the workup of VCF. Both acute and delayed neurologic injury is possible with VCF, and repeat neurological examination should be standard during the follow up visits of any patient [8]. Delayed neurological injuries have been reported to occur between 1 and 18 months following VCFs and are due to fracture-related instability and progressive kyphotic deformity of the spinal column leading to dynamic compression of neural elements [8]. Cervical osteoporotic fractures are particularly at risk of neurological injury given the mobility of the spine and should be examined carefully for stability. The authors suggest that all cervical osteoporotic fractures should be referred to a spine surgeon.

It is important to tailor the neurologic examination to the level of injury. Injuries in the thoracic spine can lead to spinal cord dysfunction, thoracolumbar junction fractures having the potential of causing conus medullaris dysfunction and lumbar fractures can cause cauda equina syndrome. At all levels, there is the possibility of nerve root dysfunction, manifesting in radicular pain or root dysfunction. Any neurologic dysfunction in the setting of vertebral compression fracture necessitates advanced imaging and prompts spine surgical opinion. Early diagnosis or recognition of neurologic dysfunction can result in increased likelihood of functional return [8].

Figure 1a reveals the radiographs of a 67-year-old female who sustained T12 osteoporotic VCF secondary to a fall from standing. She initially presented with back pain and was found to be neurologically intact. Upright radiographs revealed 21 degrees of kyphosis and 60% anterior height loss. She was initially treated conservatively with oral analgesics and activity modification. Over the following 3 months, she complained of increasing bladder dysfunction, as well as gait disturbances. Repeat radiographs now revealed further height loss, involvement of the posterior wall, and retrolisthesis of the superior segment (Fig. 1b). An MRI was obtained demonstrating compression of the conus medullaris as well as T2 cord signal change (Fig. 1c). The patient was treated with a T12 vertebral column resection and T10 to L2 posterior instrumented fusion with augmentable screws (Fig. 1d, e).

Radiological Investigations

Radiologic examination of fractures should be aimed at identifying injury patterns, underlying pathologic process and any evidence of neural compromise. The use of advanced imaging should be guided by the patient's history and clinical examination.

The mainstay of fracture identification is the plain spine radiograph. Radiographs should be performed in an upright position whenever possible, ideally with full-length three-foot x-rays to allow for assessment of focal and global deformity in the sagittal and coronal planes. Comparison of these images with supine radiographs or CT/MRI scans allows for determination of dynamic instability.

Computed tomography (CT) imaging is useful for identification of fracture patterns and shows evidence of bone loss or neural element compromise. Involvement of posterior elements, a rounded posterior wall, an accompanying soft tissue mass, and destruction or erosion of cortical bone may suggest underlying malignancy. CT scan

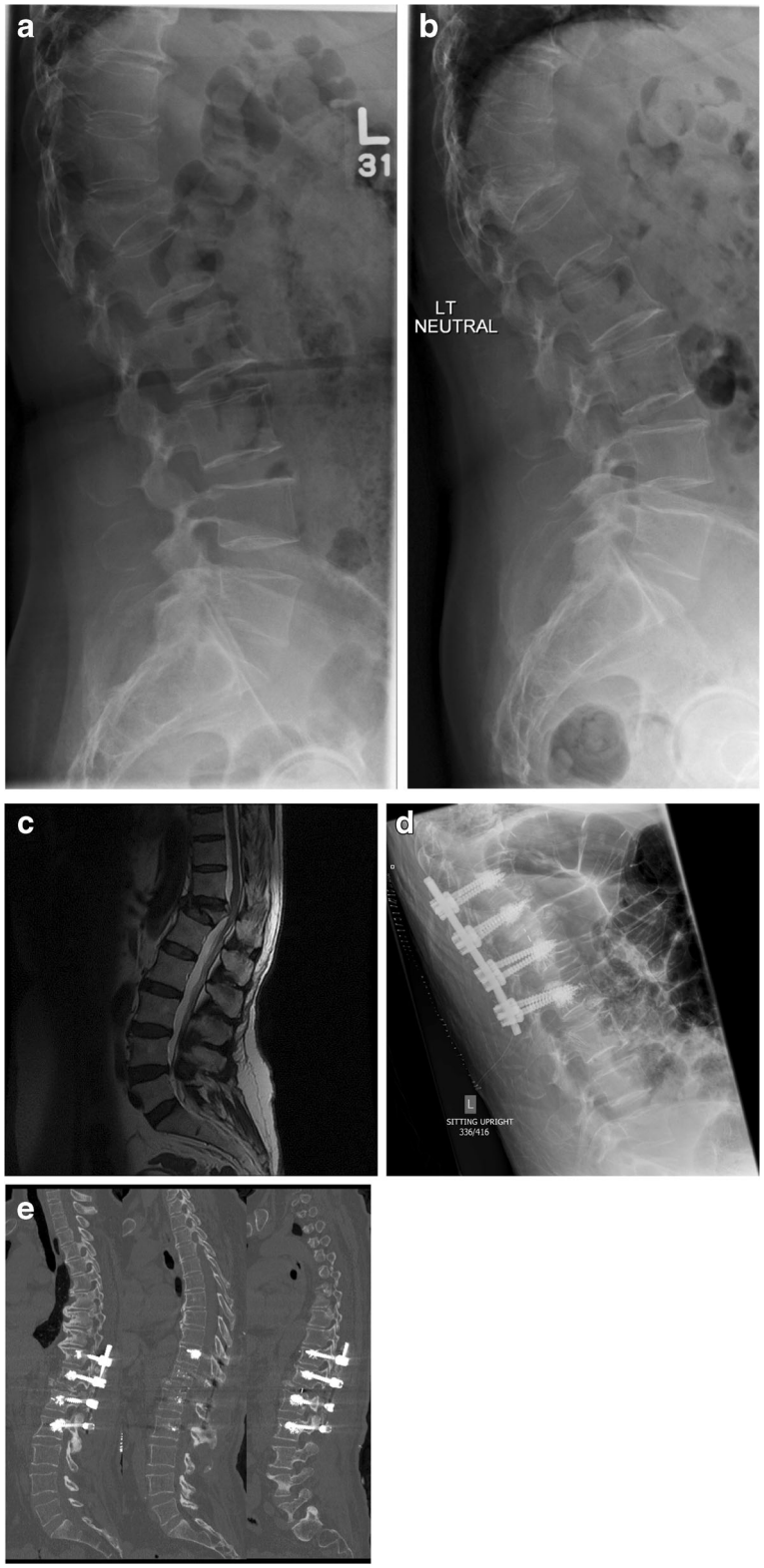

Fig. 1 **a** Radiographs of a 67-year-old female who sustained T12 osteoporotic VCF secondary to a fall from standing. **b** Repeat radiographs now revealed further height loss, involvement of the posterior wall, and retrolisthesis of the superior segment. **c** An MRI was obtained demonstrating compression of the conus medullaris as well as T2 cord signal change. **d**-**e** The patient was treated with a T12 vertebral column resection and T10 to L2 posterior instrumented fusion with augmentable screws

imaging may often reveal evidence of subtle, pre-existing vertebral compression fractures of indeterminate age [12]. Such injuries should be correlated to the patient's clinical history and where necessary can be examined with MRI scan to investigate for acuity of injuries. MRI imaging further can be helpful in determination of neural element compression by osseous or discoligamentous structures. It can also aid in the diagnosis of underlying malignancy.

Establishing fracture acuity by MRI has historically been thought to correlate to signal intensity on STIR sequences. In a recent study, Takahashi et al. challenged this notion and followed prospectively 153 consecutive patients with VCFs using repeat MRIs at enrolment, 1-month, 3-month, 6-month, and 1-year time intervals [13]. They found that STIR signal changes persisted in 64% of fracture a year after they were first diagnosed. Similarly, T2 signal changes were still evident in 56.1% of fractures at the same timeline. This has led the authors to conclude that it is difficult to determine the age of a VCR by MRI alone, and that ongoing microfracture may play a role in sustaining signal abnormality for a prolonged period of time. In another study, Muratore et al. found that the presence of intravertebral cleft, fluid within the fracture or posterior wall involvement on MRI scan was associated with conservative treatment failure [14].

Classification of Fractures

The AOSpine Thoracolumbar Classification System (AOTLCS) serves as a comprehensive guide for classifying thoracolumbar fractures based upon the integrity of bony and discoligamentous structures [15]. This in turn can help physicians determine the management of specific fractures. A basic understanding of the grading scheme can help provide a basis for determining the stability of the spine following fracture. In this system, higher alphabetical and numerical gradings are related to decreasing stability for fractures. Type A injuries involve a compression mechanism, which includes most VCFs. This category is further divided into numerical subtypes denoting progressively more complex fracture patterns. Type B injuries involve a distraction mechanism with damage to the anterior or posterior tension band. Type C fractures are associated with high -energy trauma and represent translational injuries often accompanied with neurologic dysfunction and spinal cord injury.

Vorlat et al. studied the outcomes from the non-operative management of type A injuries. They followed 48 consecutive patients with VCF prospectively for 1 year [16]. They found that increasing fracture severity type from AOTLCS Type A1 to A3 was responsible for greater pain [16], with each grade transferring a further 8% of disability on the Oswestry Disability Index. Interestingly, they also found that smokers were on average 13% more disabled for a given fracture type.

Treatment

The treatment of VCF has to be individualized to each patient based upon pain, presence neurologic dysfunction, fracture stability, and deformity. Although uncommon, any neurological change associated with the injury requires prompt review by a spine surgical service for consideration of operative management [8]. The goal of all treatment should be to allow the rapid return of the patient to their previous level of functioning with control of pain and minimization of deformity. Parreira et al. recently performed a review of guidelines for the management of VCFs between 2010 and 2013 [3•]. They found inconsistent recommendations for all treatment modalities, with many being based solely on expert opinion. Half of all guidelines recommended the use of bed rest and braces, and almost all guidelines had inconsistent recommendations for pharmacologic agents and preventative treatments in order to minimize the risk of future fractures [3•].

Interventions for the management of VCF are broadly divided into non-operative, interventional, and surgical treatments. These are explored in more detail below in light of recent evidence.

Bed Rest and Exercise

Many rehabilitation protocols using non-operative management for the treatment of VCFs use a short period of bed rest [3•, 16]. There is little recommendation on the duration of bed rest, with longer periods of bed rest being associated with increasing incidence of gastrointestinal disturbance (constipation and diarrhea), disuse muscle atrophy, and thromboembolic disease [17, 18].

Giangregorio et al. reviewed the literature to determine the role which exercise plays in the improvement of outcomes after osteoporotic vertebral fractures [19]. They found that overall, substantial variability in the treatment prescribed prevented pooling of the data to allow for a stronger analysis. There was some evidence of benefit of exercise in regard to pain, physical function, and quality of life outcomes, although other trials did not confirm these findings [19]. There does not exist any evidence at this time that exercise helps prevent future VCFs after a sentinel event.

The authors do not recommend a prescribed period of bed rest for patients with osteoporotic vertebral compression fractures. We recommend that all patients be encouraged to mobilize immediately following injury with appropriate pain control, use of walking aids, and allied health intervention as necessary. While routine use of exercise programs is not

supported by the literature, we feel that simple exercise prescriptions can be beneficial to patients for improving their return to function.

Analgesics

There is little comparative evidence on the ideal analgesic management of patients with osteoporotic vertebral compression fracture. Opioid analgesics are often prescribed without good data for their benefit [5•]. They have a significant side effect profile particularly in the geriatric population, including constipation, nausea, decreased cognition, dependence, and overdose [6, 11]. They may play some role in the acute management of severe pain, but have a less well-defined role for the management of chronic pain [6].

Non-steroidal anti-inflammatory medications are often used in younger population groups for acute pain management. There is a reluctance to prescribe these medications in an older group given their increased side effect profile including gastrointestinal bleeding, renal impairment, and myocardial or cerebrovascular ischemia [5•, 6]. Calcitonin has been shown to be efficacious in reducing pain in acute VCFs, reducing resting pain at 1 week, with sustained effect through to 4 weeks post-initiation of treatment [20]. This treatment has not shown to be efficacious in the treatment of chronic back pain from older fractures [20]. Studies have mainly focused on salmon calcitonin, which has been associated with increased cancer risk, though this is still unclear [21•].

Bracing

Many study protocols in the literature describe the use of brace treatment [3•, 16]. There are many types of braces, from rigid and semi rigid braces including those which aim to increase muscular activation. Braces should theoretically be donned while supine and worn anytime the patient is sitting or standing upright. The duration of bracing is variable but is generally prescribed to be between 6 and 12 weeks. Bracing has been associated with numerous complications in the geriatric population, which includes skin breakdown, muscle decondition, and issues with fit due to body habitus [22, 23].

Jin and Lee reviewed the literature published on the use of braces in osteoporotic vertebral compression fractures [23]. They found that all studies included were of low methodological quality with high risk of bias. They concluded that there is low to very low evidence of effect of braces in reducing pain and preventing kyphotic deformities. Other studies looking at all types of thoracolumbar fractures have found no evidence that bracing prevents kyphosis [24].

It has been the authors' experience that the use of braces in the hospital setting often contribute to difficulties in patient discharge due to inability to manage the brace, difficulties in mobilization, skin integrity, and that overall, these are often poorly applied. In the absence of high-quality evidence for their use, we only recommend braces in patients who are unable to be discharged home secondary to pain in an attempt to mobilize them. Given the lack of evidence for one brace over another, we typically use an off-the-shelf brace which requires little customization and is inexpensive.

Use of Cement Augmentation

The use of cement augmentation in VCFs has been a controversial issue in the literature [2••]. US Medicare data shows a peak of cement augmentation procedures in 2007–2008 of 24% of VCFs, with the rate declining by 2014 to 14% [2••]. This was associated with a 4% increase in mortality for the cohort of patients with VCFs over the same time period, with overall 10-year mortality remaining high (85.1%) [2••].

The decline in this period was thought to be related to the publication of two well-known randomized control trials in the New England Journal of Medicine by Buchbinder et al. and Kallmes et al. [25, 26] showing no benefit of vertebroplasty in pain or functional improvement over a sham procedure. This finding was maintained in the Cochrane review of 2015 [27] showing that from moderate quality evidence, there was no effect of vertebroplasty for the treatment of VCFs. Smaller studies were thought to be likely to overestimate the treatment effect of cement augmentation [27].

The safety and efficacy of vertebroplasty for osteoporotic fractures (VAPOR) trial was published in 2016 and was a randomized control trial specifically looking at the benefit of vertebroplasty in 120 patients with acute VCF of < 6 weeks duration [28••]. They found a benefit towards vertebroplasty in reduction of pain scores at 2 weeks, which was sustained throughout the 6-month follow-up period. Sub-group analysis showed a significant difference towards vertebroplasty for those patients with thoracolumbar junction injuries (T11-L2), but not for thoracic or lumbar injuries [28••, 29]. Analgesic use was also decreased in the vertebroplasty group in the previous 24 h at the 3 and 6 month follow-ups [28••].

For those patients who do go on to require a cement augmentation procedure, Nowak et al. in their series showed that there was a 3.1% incidence of previously unidentified lymphatic malignancy in patients who were biopsied at the time of kyphoplasty [30•]. These patients had no history of malignancy and no features on MRI imaging of malignancy. This has prompted a change in their practice to routinely perform a biopsy at the time of cement augmentation [30•].

Verebroplasty Vs Balloon Kyphoplasty

Kyphoplasty has a number of theoretical benefits over vertebroplasty, including better restoration of vertebral height and less cement leakage. Shawky et al. showed that balloon kyphoplasty (BKP) was safe to use in patients with posterior wall defects with none of the 98 vertebrae showing leak into the spinal canal despite some leak into other areas [2••]. Although BKP is associated with better restoration of vertebral height on radiographs, this did not correlate with any clinical improvement [31]. Flippiadis et al. performed a review of the literature surrounding the two procedures they were unable to find any clear superiority of BKP over vertebroplasty [32].

Complications Related to Cement Augmentation

Cement augmentation procedures are subject to a number of complications. Cement leakage is present in up to 81% of cases, mostly subclinical [33]. The rate of cement embolization to the lungs was estimated to be between 2 and 26% depending on the diagnostic method employed [31]. Embolization has the potential to lead to acute hemodynamic changes, respiratory failure, or death; however, most cases are asymptomatic. Neurological complications are present in < 1% and comprise radiculopathy or spinal cord injury [31, 34]. The use of high-viscosity cement has the potential to reduce the rate of cement leakage [35]. Although cement augmentation is often associated with adjacent segment fracture, this increased with or without the use of cement augmentation in an osteoporotic patient population and is not specifically related to cement augmentation alone [32].

It is the authors' opinion that cement augmentation cannot be recommended as routine management of all VCFs. However, in patients with acute (< 6 week) VCFs with high pain scores not responsive to other methods of treatment, vertebroplasty/kyphoplasty is a reasonable option to consider.

Surgical Stabilization

Patients presenting with acute or delayed neurologic injury associated with VCFs or unstable fracture patterns need consideration of surgical stabilization and possibly decompression. These procedures can be challenging particularly in the setting of poor bone quality, predisposing the patient to increased rate of construct failure [26]. Techniques such as cement augmentation and undertapping of screws can be used safely to increase the strength of fixation [8, 36]. In addition, vertebroplasty or kyphoplasty can be used in any unstable intravertebral clefts at compressed levels, and potentially as a means of reducing junctional stiffness between the end of a construct and the adjacent level [8, 36]. Time to fusion may be delayed in this population group; however, the rate of fusion is not significantly affected [8].

In the authors' experience, the overall number of patients requiring surgical stabilization following VCFs is quite low. We recommend that all patients who present with a new neurological finding, in particular motor weakness, significant sensory change, or bowel/bladder disturbance be referred to a spine surgeon for urgent assessment. Overall, the potential benefit in the surgical management of these patients should be carefully weighed against the increased risk associated with surgical fixation in osteoporotic bone.

Conclusions

Vertebral compression fractures are a widespread problem in patients with decreased bone mineral density and are expected to become significantly more prevalent in the near future. While most go clinically undetected, they can present a large source of disability for patients and a significant cost to the healthcare system.

A careful history and physical examination is required to determine the level of debility caused by the current fracture, and if any neurological injury is present. Given the progressive nature of most VCFs, there can exist a significant delay in the presentation of neurological abnormality; therefore, close follow up is required. While upright thoracolumbar radiographs are the standard by which VCFs should be diagnosed and followed, advanced imaging is required in the setting of neurological abnormality, or if suspicious features of neoplasm or infection are present.

Most VCRs can be treated safely with oral analgesics and early mobilization. Bracing has limited evidence to support its practice and can be considered in patients who are unable to mobilize despite appropriate pain control. While cement augmentation has historically been overused, more recent evidence suggests that it may play a role in pain management in a subset of acute fractures, particularly as an alternative to hospitalization. All patients who sustain a VCR should be evaluated for osteoporosis and treated accordingly.

Compliance with Ethical Standards

Conflict of Interest Vinay Kulkarni, Maheswara Akula, and Jeremie Larouche declare no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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- •• Of major importance

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