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# Osteoporotic vertebral fractures: current concepts of conservative care

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**Introduction**: Osteoporotic vertebral compression fractures (VCFs) are a growing public health problem with important socio-economic effects in western countries. In the USA, 10 million people over 50 suffer from osteoporosis. In these patients, 1.5 million annual fractures have been registered, and 50% of these are vertebral compression.

**Sources of data**: We performed a comprehensive search of PubMed, Medline, Cochrane, CINAHL and Embase databases using various combinations of the keywords 'osteoporosis', 'vertebral compression fractures', 'brace', 'bracing', 'orthosis', 'conservative management' and 'rehabilitation' over the years 1966–2011. All articles relevant to the subject were retrieved, and their bibliographies were hand searched for further references in the context of conservative management of osteoporotic vertebral fractures.

**Areas of agreement**: Conservative management for patients with osteoporotic vertebral fractures includes bed rest, pain medication, physiotherapy and bracing.

**Areas of controversy**: A conservative management for patients with osteoporotic VCFs s has not been standardized. The utility of vertebral augmentation techniques has been questioned by recent randomized controlled trials.

**Growing points**: Randomized controlled trials are being performed worldwide on vertebral augmentation techniques.

**Areas timely for developing research**: Although spinal orthoses are commonly used for the management of patients with osteoporotic vertebral fractures, in the literature there is only one randomized controlled trial on bracing for this condition. While the best conservative management for subjects with osteoporotic VCFs s is not defined and standardized, no conclusions on the superiority of vertebral augmentation techniques over conservative management can be drawn.

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## Introduction

In osteoporosis, low bone mass and microarchitectural deterioration of bone tissue lead to bone fragility and increased risk of fracture.[1] In the USA, 10 million people over 50 suffer from osteoporosis, while an additional 34 million people are at significant risk to develop the disorder. In the affected group, 1.5 million annual fractures have been registered and 50% of these are vertebral compression fractures (VCFs), twice the rate of hip fractures.[1]

Recent data from the European Vertebral Osteoporosis Study have shown that the overall prevalence of vertebral deformity in women is higher than in men, and it also increases with ageing (from 5% at 50 years to 25% at 75 years in women; from 10 to 18% in men).[2]

Osteoporosis usually remains silent and back pain arising from painful VCF could be the first symptom that patients report. However, just one-third of the patients with osteoporotic VCFs are symptomatic.[3] When a painful VCF occurs, symptoms should be treated and predictable complications should be avoided.[4] Both acute (i.e. spinal cord compression) and chronic complications (i.e. progressive kyphosis) have been described. Postural changes associated with kyphosis may limit activity, including bending and reaching. Moreover, restrictive lung disease may arise when multiple thoracic fractures occur.[5–7]

Because of increasing population's age and severe morbidity, VCFs represent a growing serious public health problem with important socio-economic effects in western countries. In the 1990s, in the USA, direct medical costs from VCFs were >$746 millions.[8] In the UK, the annual acute costs for the management of patients with VCFs has been estimated at around £12 millions.[9] The economic costs could be higher than reported, as it is often difficult to evaluate the associated long-term morbidities.

Vertebroplasty and kyphoplasty are two percutaneous minimally invasive vertebral augmentation methods for cement application into the vertebral body to manage symptomatic VCFs without neurological impairment.[10,11]

Vertebroplasty for the management of a painful aggressive haemangioma of a vertebral body was first reported in 1987.[12] Polymethylmethacrylate (PMMA) cement is injected percutaneously into a collapsed vertebral body under imaging guidance to strengthen it.

Kyphoplasty was introduced to manage the kyphotic deformity and help to realign the spine.[13] Kyphoplasty involves percutaneously inserting an inflatable bone tamp into a vertebral body. The inflation of the bone tamp with fluid allows restoration of vertebral height and correction of kyphosis. After deflation, the cavity which has been produced is filled by injection of PMMA.

The major problem when trying to perform a meta-analysis on the available studies for the use of vertebral augmentation in patients with VCF is that all the randomized controlled studies used different conservative modalities.

The conservative modalities used in these trials included bed rest, pain medication, physiotherapy and bracing.[14] However, several studies did not specify the length of the period of bed rest, bracing and the type of brace used.[10,15] This introduces biases in all the publications in which either vertebroplasty or kyphoplasty was compared with a conservative management modality. In fact, to compare a vertebral augmentation technique to a conservative management modality with or without brace and bed rest makes dramatic difference to the patient in term of satisfaction, pain and ability to return to their daily life activities.

Farrokhi *et al.*[16] performed a randomized controlled trial to compare percutaneous vertebroplasty versus optimal medical management for the relief of pain and disability in acute osteoporotic VCFs. In the control group, all patients were managed with acetaminophen with codeine twice daily, ibuprofen twice a day, calcium daily, vitamin D daily, alendronate orally once weekly and calcitonin daily. No braces or bed rest were prescribed.

Braces are used in patients with vertebral fractures to reduce pain by decreasing postural flexion that causes increased load on the painful fractured vertebra and by helping in relieving paraspinal muscle spasm.[4] Braces can help to reduce motion of the fractured vertebra, facilitating bone healing.[4] Traditionally, three-point contact braces facilitate thoracic and lumbar neutral positioning while decreasing flexion.[4] Guidelines on the management of symptomatic osteoporotic spinal compression fractures have been recently published by the American Academy of Orthopaedic Surgeons. The authors were unable to recommend for or against treatment with a brace for patients with an osteoporotic spinal compression fracture on imaging, correlating with clinical signs and symptoms and who are neurologically intact.

Unfortunately, until a safe and effective conservative management will not be standardized, all the studies on the topic will have enormous limitations.

In this systematic review of the literature, we aimed to report the best evidence-based conservative management options for patients with osteoporotic VCF.

## Methods

We performed a comprehensive search of PubMed, Medline, Cochrane, CINAHL and Embase databases using various combinations of the keywords 'osteoporosis', 'vertebral compression fractures', 'brace', 'bracing', 'orthosis', 'conservative management' and 'rehabilitation' over the years 1966–2011. All articles relevant to the subject were retrieved, and their bibliographies were hand searched for further references in the context of conservative management of osteoporotic vertebral fractures. We considered publications in any language. Reviewers scanned the bibliographies of all retrieved studies and other relevant publications, including reviews and meta-analyses, for additional relevant articles.[14,17–43] Two reviewers (U.G.L. and M.L.) screened the titles and abstracts of identified citations independently and in duplicate and acquired the full text of any article that either judged potentially eligible. These reviewers independently applied eligibility criteria to the methods section of potentially eligible trials. Only articles published in peer-reviewed journals were included in this systematic review. We resolved disagreements by discussion.

Three reviewers (U.G.L., M.L. and L.D.) extracted data from each eligible study independently and in triplicate. Data included personal information, methodology, details on interventions and reported outcomes. We excluded studies on outcome of vertebral augmentation for the purpose of this study.

## Risk factor

Although osteoporotic VCF have a multifactorial aetiology, bone mineral density (BMD) is a central component of any management plan. Osteoporosis is defined by the World Health Organization (WHO) in terms of BMD measured with dual energy X-ray absorptiometry.[44] Osteopenia consists of mild-to-moderate bone deficiency and a BMD value ranging from 1 and 2.5 standard deviations below average peak bone mass. Osteoporosis is a marked bone deficiency status, defined with BMD measurements $>2.5$ standard deviations below average peak bone mass. Severe osteoporosis is defined as osteoporosis status associated with osteoporotic fragility fractures.[45]

Osteoporotic fragility fractures are defined as occurring at a site associated with low BMD; they have an increased incidence after the age of 50 years.[46]

Several risk factors have been associated with osteoporotic fragility fractures. However, few of them, including current age, family and personal history of fragility fractures, low body weight and a history of smoking, presents an evidence-based association with high risk of vertebral fracture, such as decreased BMD.

Evidence-based risk factors have been included in the WHO fracture risk model (Table 1). The included factors increase risk independently of BMD, and can be combined with BMD values to assess patient's risk of future fracture.

The BMD and risk for vertebral fracture are inversely related, with 2.3-fold increase in risk for each standard deviation decrease in spine BMD.[47] Age is another factor that contributes to risk independently of BMD. The risk of osteoporotic fracture increases significantly with age for both men and women. In addition, for each value of BMD, the fracture risk is much higher in elderly than in young people. In women, the risk of osteoporotic VCF increases 6-fold from menopause to age 85.[48,49] A previous VCF is an important risk factor for subsequent vertebral fracture. The relative risk to develop a new fracture in a female population with one pre-existing vertebral deformity is 5.4. Moreover, the risk is increased by a combination of low BMD and history of previous VCF, with a reported 25-fold higher risk.[50]

The identification of low values of BMD with any of the aforementioned risk factors provides a significantly greater risk of fragility fracture. Remarkably, patients with low risk of future fractures should be periodically reassessed, by reviewing risk factors for osteoporosis and measuring BMD, as the risk could increase over their remaining lifetime years.

**Table 1** WHO fracture risk assessment model: risk factors.

| |
|---|
| Current age |
| Gender |
| A prior osteoporotic fracture (including morphometric vertebral fracture) |
| Parental history of hip fracture |
| Femoral neck BMD |
| Low body mass index (kg/m$^2$) |
| Alcohol intake (3 or more drinks/day) |
| Current smoking |
| Oral glucocorticoids $\geq$5 mg/day of prednisone for $\geq$3 months (ever) |
| Rheumatoid arthritis |
| Secondary osteoporosis |

## Classification

Several classification systems of vertebral fractures have been proposed. In 1991, Eastell *et al.*[51] suggested an easy classification system including three types of fracture, based on deformity shape of vertebrae: (i) vertebral fracture with 'wedge deformity', in which there was a decrease in the anterior height of vertebral body without any involvement of the posterior height; (ii) vertebral fracture with 'biconcavity deformity', in which there was a reduction in the middle height without involvement of the anterior and posterior wall of vertebral body; (iii) vertebral fracture with 'compression deformity', in which any part of the vertebral body has been involved with reduction in anterior, posterior and middle heights.

Recently, the two most commonly used classifications for VCF in clinical practice were described by Sugita *et al.*[52] and Wu *et al.*[53]

Sugita *et al.*[52] developed a classification system including five types of fracture identified on lateral radiographic views: (i) the 'swelled front', in which >50% of the anterior wall is convex anteriorly; (ii) the 'bows haped', in which the anterior wall is pinched inward and the upper endplate is collapsed; (iii) the 'projecting', in which <50% of the anterior wall is convex anteriorly; (iv) the 'concave', in which the upper endplate is collapsed without any fracture of the anterior wall and (v) the 'dented', in which the anterior wall is interrupted by fracture line (Fig. 1). This classification system allows to distinguish fractures with different prognosis. Both concave and dented types present a good prognosis with a short painful period and rapid healing. The remaining types present a poor prognosis because of significant bone loss, leading to high rates of collapse and vacuum cleft formation with subsequent slow healing.

Wu *et al.*[53] described a classification system, based on lateral radiographic views, consisting of two types of fracture: in a type I fracture, compression involves only the anterior column; in type II, the fracture involves both the anterior and middle columns. Each of them is subdivided into two groups: 'non-union' group, characterized by vacuum cleft within injured vertebra and kyphotic angle changes in standing dynamic radiographs and 'union' group, characterized by healed fracture.

## Diagnosis

The incidence of osteoporotic VCFs is difficult to estimate, because most patients are asymptomatic at the time of diagnosis and only

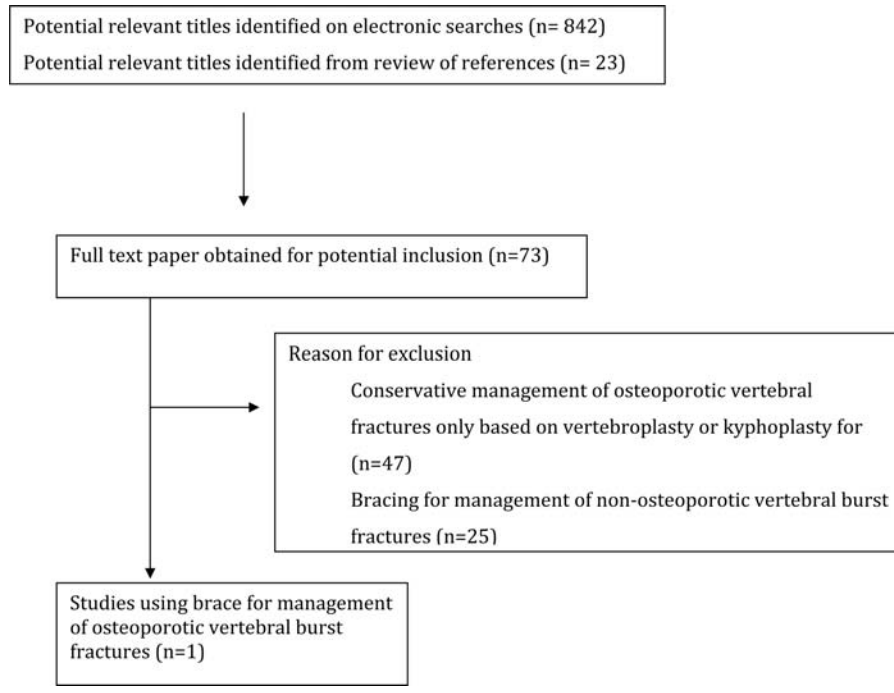


**Fig. 1** Flow chart of the available studies on orthoses.

one-third of them complain of an acute painful event.[54] For this reason, osteoporotic VCF should be suspected in any old or osteoporotic patient who complains of new-onset back pain, even with no history of trauma. The onset of pain is usually related to atraumatic activities such as bending forward, standing from a seated position, coughing or sneezing.[55]

The first step of diagnosis includes history and physical examination. The latter, typically, does not reveal any specific finding. However, in patients with multiple osteoporotic VCF, postural changes (i.e. focal kyphosis and lumbar lordosis reduction) or evident loss of height may be present at clinical examination. On physical examination, it is also possible to diagnose compression of a nerve root caused by a retropulsed bony fragment or neural foraminal narrowing. Radicular pain is revealed by a positive straight leg raise test, even when strength and reflex testing are negative.

Anteroposterior and lateral radiographs of the lumbar or thoracic spine are the first investigation to be performed. Dynamic flexion and extension views can add useful information.

Static radiographs allow to identify the type of fracture, documenting the vertebral loss of body height. VCF is defined as a decrease in anterior, middle or posterior height of at least 20%, or a decrease of at least

4 mm compared with baseline height (estimated basing on vertebral body high of upper or lower vertebra).[51] When a fracture with less marked collapse occurs, magnetic resonance imaging (MRI) may be helpful to confirm the diagnosis.

Static radiographs are also important to evaluate the posterior vertebral line. If the posterior column is involved, retropulsion of body vertebral fragment may occur with potentially dramatic consequences. When retropulsion is suspected, MRI or CT scan is recommended to assess the posterior column integrity, intervertebral discs collapse and nerve roots.

Dynamic radiographs (flexion–extension views) allow to measure dynamic vertebral translation, defined as the change in relative position of vertebra from hyperflexion to hyperextension.[56] When a vertebral fracture occurs, dynamic radiographs changing posture from maximum flexion to maximum extension show vacuum clefts (as a gas-like area of radiolucency) into the collapsed vertebral body[57] and changing of kyphotic angle.[53] Detection of unstable vertebral fractures is important because they could be complicated by retropulsion of bony fragment with subsequent neurological impairment.

Bone scan or MRI is helpful to determine the age of a compression fracture, especially when history is negative for trauma or fall. However, bone scan may not show a fracture for up to 10 days after an acute injury.[54] MRI usually shows decreased signal on T1 sequences and marrow oedema on T2 fat-saturation sequences at the fracture site.

When a VCF has been diagnosed, it is important to discriminate between osteoporotic and tumour-associated fractures. To rule out the malignant nature of a fracture, MRI can be helpful because the presence of a soft-tissue mass or pedicle involvement is suggestive of tumour. Instead of gadolinium enhancement, multiple level involvement and posterior vertebral expansion are not useful specifics for tumour fractures or lesions.[58] Bone scan can also suggest malignant nature of fracture by showing multiple areas of increased radionuclide uptake due to metastatic lesions. In addition, positron emission tomography with fluorine-18 deoxyglucose (FDG-PET) has been proposed to differentiate osteoporotic from pathological vertebral fractures, because malignant and inflammatory processes are characterized by high FDG uptake, whereas it is absent or slightly increased in osteoporotic fractures.[59]

## Management of acute osteoporotic vertebral fractures

To date, the best management of acute painful vertebral fractures is unclear. Although a controversial topic, very few level I studies are available. The conservative care of a patient with an acute painful

vertebral fracture focuses on two issues. The first goal is pain relief and rehabilitation, traditionally with analgesics, bed rest, orthotic support such as brace or corset and gradual mobilization, depending on pain. The second goal consists of assessment and management of the underlying osteoporosis.

### *Pain medication*

The acute pain arising from a new vertebral fracture usually resolves over a period of 6–12 weeks.[60] During this time, analgesia should be prescribed to reduce pain and encourage mobilization. Analgesia should begin with acetaminophen or salicylates[61] and non-steroidal anti-inflammatory drugs (NSAIDs). Because traditional NSAIDs are related to the risk of gastrointestinal bleeding and renal insufficiency, agents such as COX2 inhibitors could be considered.[62] A recent meta-analysis of case–control and cohort studies assessed the impairment of bone healing, with subsequent risk of non-union and NSAID exposure: the risk of non-union with NSAID was not confirmed by the highest-quality studies assessed.[63] Opioids should be administered to patients failing to obtain adequate relief with the first-line medications and activity modification. Opioids such as oxycodone can be used in combination with acetaminophen. However, narcotics have significant side effects, including reduced gastrointestinal motility, urinary retention, reduced respiratory drive and cognitive deficits, with loss of balance, increase of falls and depression.[64]

In addition, muscle relaxants may be helpful in the management of painful paravertebral muscle spasms. Although their efficacy has been evaluated in non-specific acute back pain conditions, they could stop the cycle of pain and muscle spasms following the vertebral fracture.[65] Muscle relaxants are most beneficial in the first 1 or 2 weeks of treatment. Moreover, the treatment should not be prolonged because of their potential side effects, such as drowsiness, dizziness, abuse and dependence in some cases.[66]

Osteoporosis active medications have been also used to obtain pain relief in acute vertebral fractures. A recent systematic review and meta-analysis on the use of calcitonin agents for patients with pain from recent osteoporotic vertebral fractures identified five randomized double-blind placebo-controlled trials involving a total of 246 patients and supported the use of calcitonin as an effective analgesic for acute pain in both men and women with recent osteoporotic vertebral fractures.[67]

Farrokhi *et al.*[16] recently performed a randomized controlled trial to compare percutaneous vertebroplasty versus optimal medical

management for the relief of pain and disability in acute osteoporotic VCFs. In the control group, all patients were managed with acetaminophen with codeine twice daily, ibuprofen twice a day, calcium daily, vitamin D daily, alendronate orally once weekly and calcitonin daily. The authors found statistically significant improvements in the visual analogue scale and the quality-of-life scores maintained over 24 months, improved vertebral body height maintained over 36 months and fewer adjacent-level fractures compared with the conservative group.

The bisphosphonates have been also used in the management of back pain associated with acute vertebral fracture. Rovetta *et al.* compared the efficacy of intravenous disodium clodronate with paracetamol. They found higher pain relief rate at the end of treatment[68] and better physical conditions after discontinuation of treatment in patients receiving disodium clodronate.[69] In a randomized, double-blind, controlled clinical trial comparing intravenous pamidronate and placebo, a rapid and sustained pain relief in patients with acute painful osteoporotic vertebral fracture treated with bisphosphonate was found.[70]

Two recent meta-analyses showed a role of teriparatide for pain management in patients with osteoporotic VCFs. Patients randomized to teriparatide had a reduced risk of new or worsening back pain compared with placebo, hormone replacement therapy or alendronate during the clinical trial period[71] and during 30 months of post-treatment observation.[72]

### *Bracing*

Bracing can represent a landmark step in conservative care of selected patients affected by compression vertebral fractures. The primary goal of bracing osteoporosis-related vertebral fractures is to prevent pain from movement by stabilization of the spine obtained with any kind of brace.[54] Moreover, bracing reduces back fatigue and it provides an opportunity for early mobilization with reduction of the bed rest period after an acute VCF. Bracing is typically necessary during the initial 6–8 weeks after the fracture, until the acute pain resolves.[73]

To date, the application of bracing is still largely opinion based. Although several types of brace are commonly used in patients with VCFs, only one randomized prospective, placebo, controlled trial has been performed on this topic.[74]

An ideal brace should be light weight, easy to put on, ensure comfort for high patients' compliance and prevent respiratory impairment. The type of brace for each patient may be chosen according to the patient's

need for comfort and function, clinical status, type and level of fractures.

The thoracolumbar orthoses (TLOs) are usually prescribed for thoracic fractures. Although several TLOs are available, the Jewitt and cruciform anterior spinal hyperextension (CASH) orthoses have been most commonly used because of their hyperextension design.[54] The Jewett brace is a three -point pressure system with two anterior pads, which place pressure over the sternum and pubic symphysis, and one posterior pad to produce an opposing pressure in the mid-thoracic region. The CASH brace consists of two anterior pads (sternal and pubic pads), attached to a metal, cross-shaped bar, one posterior pad (to produce force opposed by anterior pads) and strap around the thoracolumbar region.

In our experience, the Cheneau brace represents a good hyperextension brace. It is a thermoplastic brace modelled on a hyper-corrected positive plaster mould of the patient. It is fabricated in polypropylene and has an anterior opening with velcro straps for fastening.

Another hyperextension back brace is the Taylor brace that consists of two posterior paraspinal bars attached inferiorly to a pelvic band, an interscapular band stabilizing paraspinal bars, axillary straps attached posteriorly to an interscapular band and an anterior corset connected to the paraspinal bars. The Knight-Taylor brace consists of a corset-type front with lateral and posterior bands and shoulder straps. The anterior corset is fastened to the lateral bars. The posterior portion of the brace includes a cross band below the inferior angle of the scapula and a pelvic band fitted at the sacrococcygeal junction.

When the brace extends to the sacral segments, it is called a thoracolumbarsacral orthosis (TLSOs) and consists of a custom-moulded plastic body jacket in polypropylene or plastic.

For lower lumbar fractures, a rigid lumbosacral orthosis (LSO) is frequently adequate. It is a custom-made orthosis moulded over the iliac crest. It consists of plastic anterior and posterior overlapped shells, with multiple holes for aeration, and a velcro strap frontally. Some authors propose for these fractures a standard lumbosacral corset.[75]

For patients with multiple fractures, custom-made braces may be useful, although they may be uncomfortable because they are hot to wear.[76]

The ideal spinal orthoses provide an adequate stabilization of the spine, reducing gross spinal motion, segmental motion at the injured segment and it may be able to provide sagittal plane hyperextension, if required. The effect of spinal orthoses on segmental and overall motion of the trunk and the effect on the myoelectric activity of trunk muscles have been assessed in several biomechanical studies.

Bracing allows to restrict gross spinal motion, based on the specific design of brace.[77–79] Although LSO braces reduce gross trunk range of motion on the sagittal plane,[80,81] their effect on intervertebral motion is related to the vertebral level considered: intervertebral motion is reduced at the upper segments (Ll–L3) and increased at the lower levels (L4–S1).[82,83] Moreover, they restrict the axial rotation at the lumbosacral level, as observed in subjects wearing a chairback brace.[84] The rigidity of material used to fabricate the brace represents an important feature influencing the effectiveness of the orthosis. Cholewicki *et al.*[85] showed that a non-extensible LSOs (made of polyester and nylon) increased trunk stiffness and limited trunk motion, while the extensible LSOs (made of neoprene and lycra) did not have any such significant effects.

When hyperextension of the spine must be obtained, the Jewett brace is the standard, although recently the CASH brace has become an acceptable alternative.[86] However, although the Jewett and CASH braces provide excellent sagittal hyperextension-limiting flexion–extension motion, they are not able to reduce efficaciously motion on the coronal and transverse planes. The Knight-Taylor brace is effective in lateral bending, fair in flexion–extension, but it provides ineffective restriction of axial rotation.[87] Moreover, the Knight-Taylor spinal brace allows patients to maintain static and dynamic motor balance.[88]

In the non-operative management of severe compression fractures, an orthosis which provides sagittal three-point hyperextension and gross trunk and segmental motion reduction in all three planes is required. Buchalter *et al.*[77] compared moulded polypropylene TLSO with other types of braces, showing that it provides the greatest overall restriction of trunk motion in flexion–extension, lateral bending and axial rotation. This observation has been also confirmed by Lantz and Schultz,[89] who compared a moulded plastic TLSO with lumbosacral corset and chairback brace. According to previous data, the best brace to manage a severe compression vertebral fracture is a custom-moulded TLSO, fitted in hyperextension.

The effect of bracing on the myoelectric activity of trunk muscles has been investigated. Morris and Lucas[90] showed a decrease in myoelectric activity in the abdominal muscles with brace wearing, not associated with an increase in the intra-abdominal pressure. Lantz and Schultz[89] assessed lumbosacral orthoses and a moulded plastic TLSO, describing an increased electrical activity of back muscles when braces are worn. However, a chairback brace was the most effective to reduce muscle electrical activity in anterior weight-holding tasks, whereas a moulded plastic TLSO was more effective in lateral bending tasks. Waters and Morris[91] evaluated myoelectric activity during walking. There was no significant effect of LSO orthoses on abdominal and

back muscles during a low-speed walking. When high-speed walking has been assessed, the back muscle activity was increased. Therefore, the efficacy of lumbar orthoses to reduce myoelectric activity is controversial. Moreover, electric signals are often increased with orthosis wearing.

Only one study evaluated non-operative spinal orthosis for osteoporotic VCF (Fig. 1). Pfeifer *et al.*[74] performed a prospective, randomized, crossover study using a TLO to manage osteoporotic vertebral fractures in women with postmenopausal osteoporosis. Increased trunk muscle strength and subsequent improvement in posture and body height in patients treated with an orthosis was found. Moreover, patients experienced pain reduction with increased quality of life and restoration of ability to perform daily living tasks. The efficacy of conservative spinal orthosis for the management of patients with VCF fractures can be supposed based on the evidences arising from studies on patients with non-osteoporotic vertebral burst fractures.[92–116]

Braces can be an option in patients who tolerate them. However, some patients are unable to wear them. This is particularly relevant in elderly patients with thin skin overlying bony prominences or impaired respiratory function.

### *Rehabilitation*

After a short period of bed rest, patients should begin early mobilization with rehabilitation exercise programmes. The goals of rehabilitation are prevention of fall and subsequent new fractures, reduction of kyphosis, enhancing axial muscle strength and providing correct spine alignment.

Sinaki *et al.*[117] demonstrated that a spinal extensor strengthening programme and a dynamic proprioceptive programme[118,119] increase bone density and reduce the risk of VCFs. Moreover, the incidence of new fractures associated with back extension exercises is lower than the incidence related to abdominal flexion exercises (16% versus 89%).[120]

Hyperkyphosis is common following osteoporotic vertebral fractures. Severe kyphosis is associated with reduction in the space between the lower ribs and the iliac crest, flank pain and compromission of breathing.[121] Back extensor exercises improve back strength, providing a better dynamic-static posturing and reducing the kyphotic deformity.[122] Correction of kyphois also results in pain relief, mobility increase and improvement in the patient's quality of life.

Papaioannou *et al.*[123] performed a randomized, controlled trial, showing an improvement in the quality of life over a 6-month period,

following a home exercise programme in patients affected by vertebral fractures. Malmros *et al.*[124] assessed a 10-week exercise programme focusing on balance, strength and lumbar stabilization and confirmed these findings. Bennell *et al.*[125] performed a single-blind randomized controlled pilot trial in which a 10-week multimodal physiotherapy programme was evaluated. This is the first study proposing a multimodal approach, associating manual therapy and exercise. The authors demonstrated the efficacy of the programme in reducing pain and improving physical function and back muscle endurance in patients with a history of painful vertebral fracture. According to previous data, physiotherapy, including several approaches such as manual techniques and exercises, has an important role in individuals affected by osteoporotic vertebral fractures because it provides pain relief and improvement in physical function.[125]

## Conclusions

Current knowledge regarding the best conservative management for patients with osteoporotic VCF is inconclusive.[126] Clearly, studies of higher levels of evidence should be conducted to help answer these questions. Until the best conservative management for patients with VCF is defined and standardized, no conclusions on the superiority of vertebral augmentation techniques over conservative management can be drawn.

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