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Review Article

Kyphoplasty and Vertebroplasty for Vertebral Osteoporotic Compression Fractures: An Update, and Review of the Literature

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Abstract

Osteoporotic vertebral compression fractures are a major health care problem affecting the quality of life. Pain, disability, and kyphosis are the major problems associated with these fractures. Most cases are managed through conservative medical measures. Resistant cases are managed through two distinct percutaneous minimally invasive procedures, namely vertebroplasty and kyphoplasty. The aim of this literature is to provide a general review of both techniques in terms of efficacy and safety.

Keywords: *Kyphoplasty; Vertebroplasty; Osteoporotic Vertebral Compression Fractures*

Introduction

Osteoporotic vertebral compression fractures occur mostly in women following menopause, and also can present in men and young people, making their bone at risk of fragility. It has been estimated that one in four women after menopause will suffer from osteoporotic vertebral fractures. The Genant classification of vertebral fractures has revealed that the loss of height of the affected vertebra could be severe in more than 40% of affected individuals and moderate in > 25%. Among reported fractured vertebra, the thoracolumbar region is the most commonly affected site [1]. More than 70% of patients with vertebral fractures experience no symptoms, remaining subjects may present with significant spinal pain. This pain usually subsides spontaneously within few weeks; however, some patients may remain affected with severe pain for multiple months, which necessitates the use of morphine along with prolonged bed rest. It is noteworthy that the aforementioned cases, especially elderly individuals, have higher risk of developing complications [2]. Three possible events may explicate persistent pain beyond few weeks. First, increased loss of height of the vertebral body owing to gradually increasing fracture, which will lead to kyphosis. This occurs commonly with fracture at the thoracolumbar junction. Second, in some cases, the fracture may not consolidate and pseudarthrosis may be composed. Lastly, patients may experience fracture of another vertebra since osteoporotic fractures tend to cluster over time, leading to worsening spine deformities. In a cohort study of osteoporotic women, examining the risk of new vertebral fracture in the year following a fracture, the presence of one or more vertebral fractures at time of enrolment raised the risk of incidence of vertebral fracture by five-fold compared to patients without previous vertebral fractures at baseline [3].

The major goals during the management of vertebral osteoporotic fractures are patients' survival, prevention of neural damage, and stability fixation. Surgeons have achieved these outcomes through reconstruction of the anatomical alignment of the spinal column, followed by early mobilization and rehabilitation after returning to the workplace. However, the treatment of these fractures is still controversial [4,5]. Various intervention strategies are available in the clinical setting and no particular therapeutic option, over other methods, is preferred [4]. Two augmentation treatments; kyphoplasty and vertebroplasty are percutaneous procedures that proved to reduce pain and stabilize the fractures. Vertebroplasty was first reported in 1987, it was initially carried out for the treatment of angioma. It assists in consolidation of the vertebral column by injecting bone cement, most commonly the polymethylmethacrylate (PMMA) [6].

Kyphoplasty, meanwhile, was firstly described in 1988, primarily for the management of kyphotic deformity. The procedure involved the utilization of an inflatable bone tamp positioned into the vertebral body to maintain the body height [7]. It is worth mentioning that both vertebroplasty and kyphoplasty are tolerable and efficient methods of pain relief; however, recent reports have indicated that both procedures are associated with an increased incidence of new fractures [8,9]. Studies also revealed that most of these fractures occur adjacent to original surgical site owing to bone cement augmentation and the switching of larger load to adjacent vertebral sites, which causes collapse of the neighboring vertebrae [10,11]. Although the application rate of both vertebroplasty and kyphoplasty has declined since the appearance of negative results in 2009 from sham trials, both techniques are still commonly conducted representing a marked portion of healthcare expenditure [12,13]. Of note, kyphoplasty usage is more prevalent than vertebroplasty, mostly because of the common belief that kyphoplasty is more safe and effective [12,13].

Aim of the Study

In this review, we aimed to report all evidence from clinical trials that compare different vertebroplasty and kyphoplasty in the treatment of osteoporotic vertebral fractures, especially thoracolumbar/lumbar fractures. Both techniques are compared in terms of efficacy and tolerability.

Vertebroplasty

Vertebroplasty is an image-guided technique, ordinarily carried out by interventional radiologists or surgeons, to alleviate the pain and preclude further vertebral collapse through injection of bone cement. This surgical intervention helps to lessen pain and prevent height loss and kyphosis that are commonly associated with vertebral osteoporotic fractures [14]. A frequent indication for vertebroplasty is painful vertebral fractures that are resistant to appropriate medical remedy. Resistance to medical therapy is defined as minimal or no pain relief with administered analgesics [15]. Less commonly, it could be utilized for alleviating pain related to Kummel disease, Paget disease, osteogenesis imperfect, and Langerhans cell histiocytosis [16]. In addition, vertebroplasty has been used to treat painful Schmorl's Nodes and for strengthening of pathologically weak vertebral bodies before surgical stabilization [17]. On the other hand, vertebroplasty is contraindicated among asymptomatic vertebral fractures and patients responding to medical therapeutics. Persistent coagulopathy disorder, active local or systemic infection, and allergy to PMMA or any bone cement are also absolute contraindications of this procedure. Vertebroplasty may be better avoided with derangement of the posterior vertebral body wall or among cases with tumor expansion into the spinal canal [18].

There are two guidance methods to perform vertebroplasty. First, fluoroscopy; which permits direct monitoring of the injection, this allows prompt intervention in case of leakage. Second is a scanner tool, which requires a former injection of contrast to detect the distribution of cement that will be pumped later. The cement should fill the fractured area, and the amount needed for filling of the vertebral body depends on the size of the patient. Of note, one or two routes of access are utilized on the basis of the results achieved after the first injection. Afterward, imaging observation is not required in the first 24 hours while clinical control is more necessary. When patients gain consciousness, they are advised to move in bed by turning on each side. Promising outcome and prognosis are determined through pain relief. The overall expenditure of single-level vertebroplasty is approximately 200 Euros [19].

Kyphoplasty

The term kyphoplasty refers to all procedures that aim to adjust the vertebrae and restore vertebral body height. Kyphoplasty is meant to reduce pain, stabilize the fracture and restore the height of the vertebral body. In addition, kyphoplasty can correct and prevent the progression of the kyphotic deformity [20]. Kyphoplasty procedure is usually performed under general anesthesia, and it entails the introduction of two inflatable bone balls in the vertebrae which will create a cavity filled with bone cement [14]. The formation of this cavity would lessen the risk of cement loss. A mono- or bilateral trans- or para-pedicular approach is followed to introduce a working cannula into the posterior portion of the vertebral body. This technique is usually guided through a bi-planar fluoroscopy or computed tomography (CT) scan. Two functioning channels within the anterior aspect of the vertebral body are formed through reaming tools, then the compatible balloon is inserted. The balloon is inflated through visual volume and under pressure control to minimize the fractured vertebra and to produce a cavity. The rising in pressure must be slow and the inflation should be stopped when the pressure reaches over 250 psi. Inflation must also stopped when the balloon touches the cortical surface of the vertebral body, or if the balloon extended beyond

the boundaries of the vertebral body, or when the height of the vertebra is retrieved. Subsequently, the balloons are withdrawn and the PMMA is injected using a blunt cannula under constant fluoroscopic observation. The injection is achieved at low pressure by pushing from a cannula. Abrupt descent in pressure suggests rupture of the balloon or unprompted movement of the vertebral endplate [20]. The overall fund for single-level kyphoplasty is estimated to be 3,000 Euros (35) [19].

Discussion

The incidence of osteoporotic vertebral compression fractures is mounting public health concern. Patients usually complain from bone pain and kyphotic deformity, which affect their physical performance, psychosocial status, and overall quality of life [21,22]. Vertebroplasty and kyphoplasty are both well-tolerable and efficient procedures that are performed to reduce pain associated-fractures, but there is a lack of evidence regarding which of these procedures provide better clinical outcomes with fewer complications on the long-term follow-up. Thus, several recent trials have been comparing vertebroplasty and kyphoplasty for the management of vertebral compression fractures (Table 1). This literature review reveals the inferences from recently published trials, aiming to provide a scoping view of both techniques in the current practices.

Author/Year	Country	Fracture type (level)	Case (n) vs. Control (n)	Follow-up time	Age (case : control)
Dohm/2014	USA	Osteoporotic compression fracture (T5-L5)	KP (199) vs. VP (205)	24 months	KP: 75.6 VP: 75.6
Endres/2012	Germany	Osteoporotic (Middle, lower thoracic and lumbar)	VP (21) vs. KP (20) -SKP (18)	6 months	VP: 63.3 (53-77) KP: 71.3 (63-77) SKP: 67.1 (47-79)
Evans/2015	USA	Compression fractures (T4–L5)	KP (59) vs. VP (56)	12 months	KP: 75.1 ± 10 VP: 76.1 ± 10.1
Liu/2015	Taiwan	Osteoporotic vertebral compression fracture (T12–L1)	BKP (50) vs. VP (50)	5 years	BKP: 72.3 ± 7.6 VP: 74.3 ± 6.4

Table 1: *Basic characters of randomized studies comparing kyphoplasty and vertebroplasty.*

BKP: Balloon Kyphoplasty, VP: Vertebroplasty, KP: Kyphoplasty.

In a recent trial for patients with vertebral body compression fractures, 59 (51.3%) were blindly allocated to kyphoplasty and 56 (48.7%) were assigned to vertebroplasty [23]. The authors deduced that both procedures were equally effective since the change in the mean pain score as well as Roland-Morris Disability Questionnaire (RMDQ) for disability assessment did not significantly vary between kyphoplasty and vertebroplasty [23]. Similarly, in a prospective quasi-randomized study including 66 patients suffering from osteoporotic thoracolumbar fractures, and divided study population into three major groups; balloon Kyphoplasty, vertebroplasty, and shield kyphoplasty, the backache was evaluated through visual analog scale (VAS) and improvement in quality of life was assessed using the Oswestry Disability Index (ODI). Interestingly, the authors concluded that the three augmentation procedures provided significant improvement in VAS pain assessment and ODI; however, no significant difference was noted between augmentation systems [24]. The trial performed among 100 participants by Liu., *et al*. had consistent findings, where the VAS pain scores were not significantly changed among kyphoplasty and vertebroplasty group [25]. In addition, Garnier., *et al.* in a multicenter review of 127 patients reported that both procedures can alleviate pain, with no significant difference, but the operative time is shorter with vertebroplasty (P = 0.0002) [26]. More recently, another large randomized trial of 191 who underwent kyphoplasty and 190 had vertebroplasty reported similar findings [27]. Vertebroplasty had a shorter procedure and hospitalization duration, and both procedures resulted in marked improvement in back pain, quality of life score, and ODI from baseline. However, there was no statistically significant difference between treatment groups [27].

Other major roles of augmentation procedures are the maintenance of vertebral body height and deformity correction. In the Dohm., *et al*. trial, the kyphotic correction following the surgery was statistically significant for both kyphoplasty and vertebroplasty [27]. After 24 months follow-up, assessment of kyphosis correction was better in the kyphoplasty group, the mean difference was statistically significant (P .036) [27]. This is consistent with the findings reported by Garnier., *et al*. where kyphoplasty technique significantly improved the kyphotic wedge angle better than vertebroplasty (P = 0.002) [26]. By way of contrast, the study by Liu., *et al.* revealed that the vertebral body heights and kyphotic wedge angles were not obviously modified in either treatment groups at the end of follow-up [25]. Similar findings were observed in the Endres at al. trial where vertebroplasty, balloon kyphoplasty, and shield kyphoplasty did not alter the vertebral body height [24].

Generally speaking, vertebroplasty and kyphoplasty are not complication-free procedures. In the trial carried out by Dohm., *et al*. procedural pain was one of the most common complications; affected cases were 12 (6.2%) patients from kyphoplasty versus 9 (4.7%) in the vertebroplasty group [27]. In addition, back pain was reported in 14 (7.3%) cases of the kyphoplasty group compared to 28 (14.7%) subjects of those who underwent vertebroplasty. The incidence of subsequent radiographic fractures was higher among vertebroplasty patients, but the difference was not significant (p = 0.23). Fortunately, no device- or procedure-related deaths were noted. Furthermore, cement extravasation and intravascular extravasation were low in kyphoplasty group compared to vertebroplasty with (P .047) and (0.028), respectively [27]. This is inconsistent with the findings by Endres., *et al*. where no adjacent fractures occurred among both groups. There were also no further clinical complications except for eight cases of (lateral and disk) leakage among vertebroplasty group and five (lateral, disk, and anterior) leakage among kyphoplasty group, but the differences between groups were not significant (P > 0.05) [24]. In 2015, the authors of a randomized trial declared no clinical adverse events among all enrolled participants. However, eight patients had adjacent fractures after kyphoplasty compared to seven patients after vertebroplasty. In addition, nonadjacent fracture was reported among four subjects from the kyphoplasty group compared to three cases in the vertebroplasty group [25]. In contrast, the retrospective review by Granier., *et al*. revealed no incidence of new fractures of the treated or adjacent vertebrae. Additionally, there were no neurological complications or systemic complications because of the cement [26].

Conclusion

Vertebroplasty and kyphoplasty are utilized for the management of drug-resistant osteoporotic vertebral compression fractures. Both techniques are equally effective in alleviating pain and disability associated with vertebral fractures, as well as improving the patients' quality of life. Nonetheless, there is inconsistent evidence regarding the role of both procedures in maintenance of vertebral body height and kyphotic angle correction. Although there is no report of death-related procedure, several complications such as cement leakage, back pain, and adjacent fractures have been reported with both procedures. Future large-scale randomized trials with longer follow-up are recommended to further investigate vertebroplasty in comparison to kyphoplasty for the management of osteoporotic vertebral compression fractures.

Conflict of Interest

The authors declare no conflict of interest.

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