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Mini Review

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Treatment of Osteoporotic Spine Fractures Using Cement Augmentation: A Mini Review

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INTRODUCTION

Vertebral body compression fractures due to osteoporosis is the most common fracture in patients with osteoporosis.[1] It affects significantly the quality of life (QoL) and is associated with pain interfering with activities of daily living. The management of osteoporotic vertebral body fracture could be surgical or non-surgical. Medical treatment is focused on better mineralization of bone to stop osteoporosis or to improve the quality of bone. Any underlying metabolic abnormalities and provision of supplemental calcium/vitamin D in conjunction with bisphosphonates or calcitonin, or both. Routine hormone replacement therapy has fallen out of favor because of concerns regarding adverse effects identified in long-term follow-up studies. In many cases, the vertebral body fracture is significant and requires surgical intervention. This can be achieved by sagittal alignment correction and vertebral body height restoration utilizing pedicle screw instrumentation or by using cement augmentation. This article will focus on cement augmentation options.

TYPES OF CEMENT AUGMENTATION PROCEDURES

Vertebral body augmentation utilizing poly(methyl methacrylate) (PMMA) cement injected into the involved vertebral body. This can be done by 2 main techniques: vertebroplasty (VP), or kyphoplasty (KP).

Vertebroplasty was first introduced and kyphoplasty was introduced later to overcome the complications with mainly cement extravasation and to better restore the vertebral body height. Although there are several studies supporting both procedures, there were few studies that were questioning the outcome. Two studies that created lots of discussion among the medical community are the papers by Kallmes et al[2] and Buchbinder et al[3] they found vertebroplasty and sham vertebroplasty to be equally effective in reducing pain and improving function.[2,3] But, this was criticized due to the relatively small number of cases and the numerous number of studies with the opposite conclusions. The general consensus is that cement augmentation is one of the acceptable treatment options in pathologic fractures including osteoporosis.

VERTEBROPLASTY

Historically, Deramon and Galibert performed the first vertebroplasty in France in 1984 for a case of hemangioma. Lapras et al[4] published the first article for the application of vertebroplasty in osteoporotic fractures in 1989. Since then, vertebroplasty procedures expanded as one of the treatment modalities to treat pathologic fractures including vertebral body osteoporotic fractures. The thermal effect and the vertebral body augmentation helped with the pain control of these cases. It's done utilizing image guided open or percutaneous techniques where PMMA is mixed with radio-opaque material and then injected into the vertebral body through pedicle portals. It can be done either by local or general anesthesia. The cement is forcibly injected through syringes attached to the portals. This is a high pressure system led in many cases to cement leak outside the vertebral body. The reported rate of cement extravasation was 11-

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76% when computerized tomography (CT) scans where used.[5] If leakage happened into the neural canal it could cause neurologic deficits. Other complications reported includes pulmonary embolism, infection, and incomplete stabilization.

Compared with medical treatments, pain relief after ventroposterior (VP) seems on the whole significantly superior. The follow-up point at which the difference becomes insignificant varies between studies at 3 months, 6 months, or 1 year.

KYPHOPLASTY

Kyphoplasty is a contemporary balloon-assisted vertebroplasty alternative for treatment of vertebral body compression fracture. It was first reported by Mark Reiley[6] in 1998. It modified the vertebroplasty technique by introducing an inflatable balloon before the cement was injected. The balloon served to elevate the end plates in an attempt to restore the vertebral body height and the sagittal alignment by correcting the kyphosis, hence it was called kyphoplasty. Another advantage was creating a void after balloon removal to inject the cement into a low pressure void system compared to the high pressure system in vertebroplasty. Although, this helped lower the complication rates especially in cement leak to a range of 4.8-39% in some reports.[5] Studies have shown that patients underwent kyphoplasty had immediate pain relief, height restoration with a mean of 4.7 mm mid vertebral body,[7,8] and an average kyphosis correction of 62.4%+/-16.7% (average 6.6°).[7,9] New fractures of adjacent vertebrae occurred for both procedures at rates that are higher than the general osteoporotic population but, approximately equivalent to the general osteoporotic population that had a previous vertebral fracture.[9]

Regarding kyphoplasty, 2 prospective controlled studies evaluated and compared the efficacy and safety of this technique *versus* medical management and found better long-term pain relief and superior functional outcome with kyphoplasty, up to 3 years.

VERTEBROPLASTY VERSUS KYPHOPLASTY COMPARISON AND LONG-TERM FOLLOW-UP

"Vertebroplasty *versus* kyphoplasty" sounds like a battle of competitive procedures fighting for supremacy. The time to further assess and develop these procedures is of immense importance.

There are very few studies available to compare these 2 procedures head to head. In one study, pain relief in kyphoplasty was found to be similar to that observed with vertebroplasty, and the peri-operative complication rate was 10%, though no complications related to the procedure were claimed by the authors.[10]

Considerable differences exist in the cost of vertebroplasty and kyphoplasty. The kyphoplasty kit (without bone cement) is approximately $3,400, whereas a vertebroplasty kit (with bone cement) is less than $400. Although not a prerequisite of the procedure, kyphoplasty is often performed in the operating room with general anesthesia. The patients may be kept overnight in the hospital for observation. Vertebroplasty is usually performed with intravenous sedation only and a brief period of observation followed by discharge home after the procedure. All of these differences combine to make kyphoplasty cost 10-20 times more than vertebroplasty. This cost difference is acceptable only if there are demonstrated substantial positive benefits for the more expensive procedure.[11]

Kyphoplasty is even sometimes referred to as "balloon-assisted vertebroplasty".[12] Biomechanical data comparing the mechanical stabilization by vertebroplasty and kyphoplasty show similar results.[13] Advocates of kyphoplasty, routinely point out the reduced likelihood for cement leaks with this procedure compared with vertebroplasty.[14] This is apparently due to the "high pressure" injection of cement in vertebroplasty whereas kyphoplasty fills a void created by the bone tamp and is therefore "low pressure."

Lieberman et al[10] reported a cement leak rate during kyphoplasty of 8.6%. Fortunately, as with vertebroplasty, most cement leaks were asymptomatic. Kyphoplasty reports have noted a very high cement leak incidence with vertebroplasty, but they have failed to distinguish between symptomatic and asymptomatic leaks. When this is done, there is little difference between the 2 procedures. Symptomatic cement leaks have occurred with both procedures.[15]

Biomechanical evaluations by Belkoff and Mathis[16] reported "significant" height restoration with KP compared with percutaneous vertebroplasty (PV). Their investigation, however, looked only at vertebra that had a maximum height loss of 25%. Vertebroplasty was noted to experience height recovery, but less than KP. The actual height gain difference achieved by kyphoplasty was on the order of 3 mm.

Lieberman et al's[10] data, which show an average height restoration of approximately 3 mm per vertebra treated, suggest that kyphoplasty may have a limited effect at height restoration in many patients. Vertebral compression fractures that are treated closer to their date of incidence tend to experience more height restoration.[10]

Vertebral height restoration reported in some kyphoplasty studies has been linked to correction of associated kyphotic deformity of the spine.[7] Theodorou et al[7] reported an average kyphosis correction of 62.4±16.7%, however, patients who are pain free following vertebroplasty or kyphoplasty usually experience less muscle spasm and tend to stand straighter with the elimination of spine pain. Mathis[15] demonstrated this effect in a PV case with 50% kyphosis reduction after PV alone. Teng et al[17] reported kyphosis improvement following PV in 45 of 53 patients, with 49% having a kyphotic angle reduction of 5° or more.

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Kyphoplasty and vertebroplasty achieved similar improvement of clinical outcomes and patient satisfaction at 2 years after surgery, albeit kyphoplasty had more ability to markedly reduce vertebral deformity and resulted in less cement leaks compared with vertebroplasty.[18]

Zhou Jian-Iin et al[19] concluded percutaneous kyphoplasty (PK) and PV have the similar therapeutic efficacy in treatment of vertebral compression fracture with minimal invasion, less operation time and blood loss. However, PK is superior in the recovery of vertebral height and decreasing leakage rate.

Brinjikji et al[20] in their study, found no significant long-term or short-term differences between the 2-whether it was pain relief that was being evaluated or disability.

A randomized trial compared effects of vertebroplasty *versus* kyphoplasty in 100 patients[21] and found no difference in symptoms between the groups after 6 months. There was a greater post-operative increase in the vertebral body height in the kyphoplasty group. Two patients in the kyphoplasty group had adjacent vertebral fractures.

A non-randomized prospective study comparing these 2 procedures enrolled 60 patients, and again no difference in pain was seen between vertebroplasty and kyphoplasty.[22] Only one adjacent vertebral fracture was seen, and that was in a patient who had the kyphoplasty.

Avery J Evans et al[23] presented the results of a randomized controlled trial (RCT) evaluating the efficacy of vertebroplasty *versus* kyphoplasty in treating vertebral body compression fractures. Outcomes were assessed at 3 days, 1 month, 6 months, and 1 year following the procedure. One-hundred and fifteen subjects were enrolled in the trial with 59 (51.3%) randomly assigned to kyphoplasty and 56 (48.7%) assigned to vertebroplasty. Their study indicated that vertebroplasty and kyphoplasty appear to be equally effective in substantially reducing pain and disability in patients with vertebral body compression fractures.

Al-Qazaz et al[24] concluded PK and PV have similar therapeutic efficacy in the treatment of vertebral compression fracture with minimal invasion, less operation time and blood loss. However, kyphoplasty is superior in the recovery of vertebral height.

Li, Xigong et al[25] concluded that kyphoplasty and vertebroplasty demonstrated similar good clinical outcomes during the 12-month follow-up. Kyphoplasty offers a higher degree of spinal deformity correction and results in less cement leakage than vertebroplasty.

FUTURE DEVELOPMENTS

A variety of recent modifications of these techniques with variable success have been introduced. Vesselplasty was described as an alternative technique. It uses polyethylene terephthalate balloon container that will expand the vertebral body and at the same time contain the cement.

Another technology under assessment is the absorbable kyphoplasty balloon.[26] It utilizes a balloon with physiologic matrix that is inserted in similar fashion like kyphoplasty, but the balloon is not retrieved. It is maintained *in situ* and later filled with PMMA, the balloon is sealed with a special valve that prevents any cement extravasation, and thus eliminate complications related to cement leak. The balloon dissolves at a later stage after the PMMA material is solid. This technique delivered a system can control cement leak. Since material extravasation is not an issue in this innovation, then other materials can be used like artificial bone graft instead of PMMA.

A modified procedure employs reusable hinged tip curette to manually create a cavity in fractured vertebral bodies under fluoroscopy guidance, allowing low resistance injection of more viscous cement.

Another issue is the combination of percutaneous cementoplasty using PMMA with other techniques, such as radiofrequency thermal ablation (RFTA). The combined use of RF ablation and cementoplasty appears to be useful in order to achieve tumor necrosis and stabilize the fractured vertebrae. The coagulation necrosis produced by RFTA may promote the homogenous distribution of the bone cement within the ablated lesion.

Radiofrequency assistance and heating the needle tip constantly can also be used to increase cement viscosity, lowering the extravasation.

CONCLUSION

Kyphoplasty remains an option for the treatment of osteoporotic fractures. Although risks are relatively low, it requires special training and expertise. The future developments are promising to overcome cement leak complications.

Meta-analysis of published papers show fair to good evidence that in patients with osteoporotic vertebral compression fractures (VCF) outcomes on physical disability, general health and pain relief are better with VP and KP than with medical management within the first 3 to 6 months after intervention.

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