

## PERCUTANEOUS VERTEBROPLASTY

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**Abstract:** *The potential of interventional radiology in providing simple and effective minimally invasive solutions for debilitating disorders; is best demonstrated by percutaneous vertebroplasty. Since its introduction in the late 1980's, it has gained popularity as an alternative to spinal surgery in the treatment of selected cases of vertebral compression fractures. It has proved to be effective in stabilizing the collapsed vertebra, as well as providing pain relief. This review describes the procedure and its role in vertebral compression fractures of various etiologies.*

**Key Words:** Vertebral compression fractures ; Percutaneous vertebroplasty

### INTRODUCTION

Percutaneous vertebroplasty (PVP) is an interventional radiological procedure that involves the injection of acrylic polymer into a partially collapsed vertebral body under imaging guidance. The procedure attempts to provide stability to the collapsed vertebra and relief of pain. Though initially, this procedure was used in management of vertebral hemangiomas, it has proved to be an effective technique in the management of vertebral compression fractures (VCFs) due to a wide range of etiologies such as osteoporosis, osteolytic metastases, multiple myeloma, lymphoma and other benign vertebral lesions<sup>1</sup>.

### VERTEBRAL COMPRESSION FRACTURES

Vertebral fractures are common in elderly individuals who have osteoporosis. It is estimated that up to half of women and up to one quarter of men will have vertebral fractures at some point in their lives. Multiple vertebral fractures are seen in half of these cases<sup>2</sup>. These fractures are usually located in the thoraco-lumbar region, which represents a transition between the relatively stiff thoracic vertebrae and the more mobile lumbar segments. In the bones weakened by osteoporosis or tumors, even a simple fall or even daily activities such as picking up a bag of groceries may result in a VCF.

Advanced age is also associated with an increase in risk of pathological VCF due to malignancy. Involvement of the vertebral body is a common mode of presentation in osteolytic metastases, multiple myeloma and lymphoma. Primary modes of treatment in these patients include radiotherapy, chemotherapy or surgical resection and internal fixation. Though radiotherapy and chemotherapy may reduce the tumor burden, pain relief is usually delayed by weeks or months.

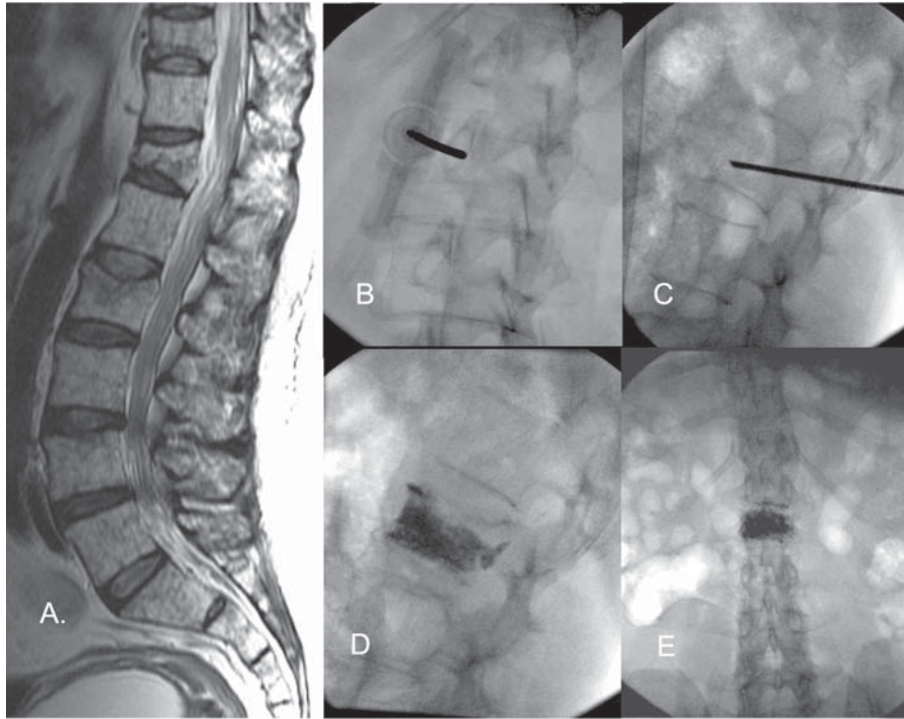
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Clinical examination of patients with vertebral compression fractures usually reveals deep tenderness over the affected vertebra. Associated neural compression may result in myelopathy or radiculopathy. In addition, the kyphotic deformity that results, may compromise the gastrointestinal and pulmonary function. Patients with VCFs have lower levels of functional performance and need more assistance, as compared to age matched controls.

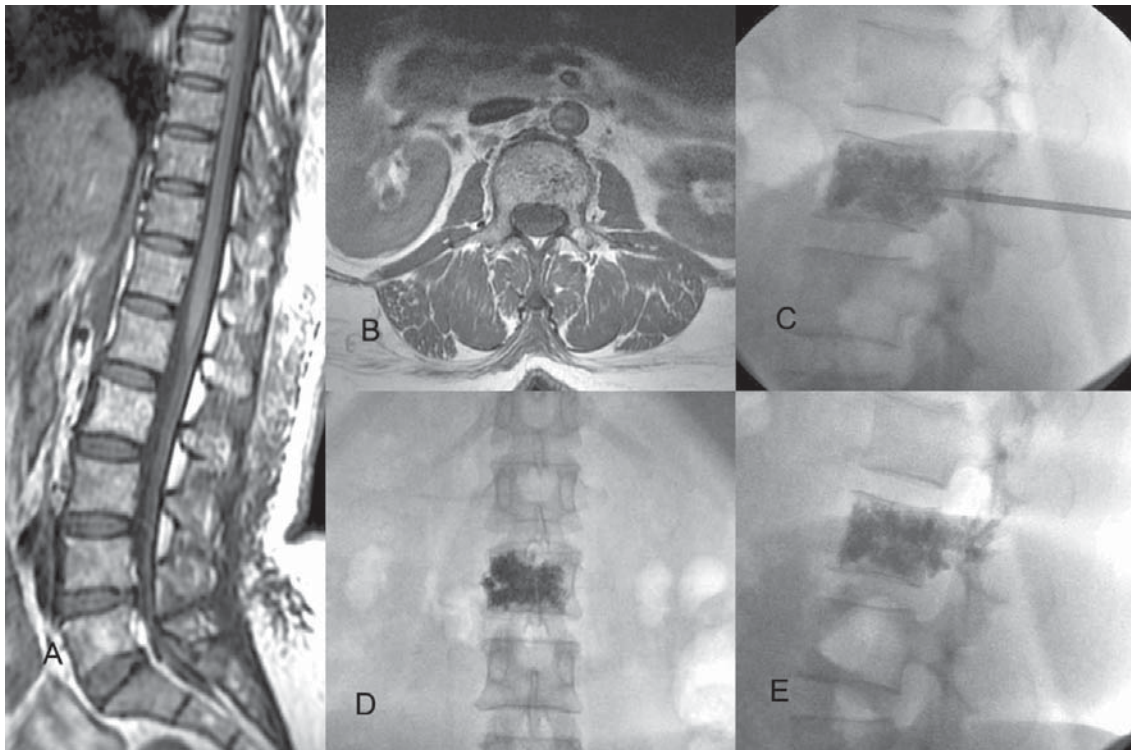
Vertebral hemangiomas are the most common tumors of the spine, with a reported incidence of 12% based on autopsy series. Most lesions are asymptomatic and are often seen on MR imaging studies of the spine. These lesions require treatment when they present with neural compromise and pain. Though surgery is the treatment of choice for aggressive lesions, there is a potential for large blood losses during surgery. Over the years, PVP has proved to be an effective therapeutic modality in the management of all the above conditions (figure 1 & 2). The indications and contraindications of PVP in each of these pathological conditions are summarized in Table 1.<sup>3</sup>

### THERAPEUTIC BENEFITS OF PERCUTANEOUS VERTEBROPLASTY

PVP aims at stabilizing the vertebral body by filling the inter-trabecular spaces with an acrylic polymer (Polymethyl methacrylate (PMMA); bone cement). The injected bone cement slowly diffuses into the inter-trabecular marrow spaces and forms a firm internal cast that anchors the fracture fragments. Injection of cement volumes as low as 2ml have shown to restore the strength of the vertebra in thoracic and lumbar regions. It is this restoration of stiffness that prevents micro-motion at the fracture site, promotes repair and thus relieves the pain. Similarly, the flexion-extension and lateral compliance parameters are restored, similar to the biomechanics of the normal spine.<sup>4</sup> Polymerization of bone cement is an exothermic reaction. The destruction of nerve endings within the vertebra by the thermal effects of polymerization, as well as the cyto-toxic, mechanical and



**Figure 1:** Multiple vertebral compression fractures in a patient with multiple myeloma. Sagittal T2 weighted MR scan (A) reveals collapse of D10, D12 and L2 vertebral bodies. Note the buckling of posterior cortex and absence of epidural soft tissue component. Introduction of the needle through the pedicle into the vertebral body (B & C) are demonstrated. Post vertebroplasty radiographs revealing an internal cement cast.



**Figure 2:** Vertebral hemangioma. Sagittal and Axial T1 weighted images (A&B) reveal a large hemangioma involving the L2 vertebral body. Injection of bone cement was performed through pedicular access (C). Post vertebroplasty radiographs reveal good cement cast within the lesion (D&E)

vascular effects of PMMA are thought to play a role in the pain relief provided by PVP.<sup>5</sup>

## PROCEDURE

If PVP is considered as a therapeutic option in a patient with VCF, plain radiographs of the affected region are performed to localize the collapsed vertebrae. These radiographs also play the role of baseline studies for comparison of follow up radiographs. Further, cross sectional imaging (CT scan or MRI) is performed to assess the integrity of the posterior cortex of the vertebral body, to evaluate for epidural soft tissue components and to exclude other causes of back pain. Most patients with osteoporosis and other destructive lesions of the vertebral bodies have multiple chronic fractures, most of which would be asymptomatic. The most severely compressed vertebra may not be the source of the patient's symptoms. Thus, it is essential to confirm a strong correlation between the clinical signs and symptoms and imaging studies, to ensure best procedural results.

The procedure requires guidance of high-quality fluoroscopy, and is usually performed in an interventional radiology suite. Some operators prefer to perform the procedure under CT scan guidance. Most patients tolerate the procedure well with a combination of neuroleptic analgesia and generous infiltration of local anesthetic agent along the path of the

needle, down to the periosteum. Patients who are in severe pain may require administration of general anesthesia to ensure proper positioning and absolute immobility that are required during the procedure.

For PVP of dorsal and lumbar vertebra, the patient is positioned prone and the vertebral body is most commonly accessed from the posterolateral aspect, through a transpedicular access. Under fluoroscopic guidance, the pedicle is projected end-on over the target vertebral body and an 11-gauge or 13-gauge needle is advanced through the skin and muscular planes so as to enter the vertebra through the pedicle. The tip of the needle is advanced to lie in the anterior third of the collapsed vertebral body. A slight medial angulation of the needle during entry enables positioning of the needle tip near the midline, so that more uniform filling of the vertebra can be achieved from unilateral pedicular access.

Once the needle is in optimal position, the acrylic bone cement is prepared to achieve a "tooth-paste" like consistency. The bone cement is injected slowly using 1cc syringes, under careful fluoroscopic monitoring to track its progress. If early progression of the cement into the posterior part of the body or into the peri-vertebral veins is noted, the injection is halted for a few seconds and then resumed to

**Table 1: Indications and Contraindications of Percutaneous Vertebroplasty**

<b>Percutaneous Vertebroplasty</b>
<p><b>Indications:</b></p> <ul style="list-style-type: none"> <li>• Painful vertebral compression fractures in a weakened bone (osteoporosis / benign or malignant neoplastic lesions / osteonecrosis) refractory to medical therapy or causing limitation of daily living activities</li> <li>• Unstable compression fracture with movement at the site of wedge deformity</li> <li>• Old traumatic fractures in a normal vertebra with non union of fracture fragments</li> <li>• Impending fracture in a vertebra destroyed by benign or malignant tumors</li> <li>• Impending fracture in patients with multiple osteoporotic compression fractures, where further collapse would compromise pulmonary or gastrointestinal function or increase risk of falls</li> </ul> <p><b>Absolute Contraindications:</b></p> <ul style="list-style-type: none"> <li>• Stable fracture with good response to medical therapy</li> <li>• Uncorrectable bleeding diathesis</li> <li>• Active infection</li> <li>• Acute traumatic fracture in a nonosteoporotic vertebra</li> <li>• Allergy to any component used in the procedure.</li> </ul> <p><b>Relative Contraindications:</b></p> <ul style="list-style-type: none"> <li>• Radicular pain caused by compressive syndrome unrelated to vertebral collapse</li> <li>• Retropulsion of fracture fragments with neural compromise</li> <li>• Epidural extension of tumor with significant canal compromise</li> <li>• Vertebra plana</li> <li>• Stable fracture of more than 2 years duration</li> </ul>

achieve optimal vertebral filling. Cement injection is terminated when the bone cement reaches the posterior cortex of the vertebral body or if significant leakage of the cement into the peri-vertebral venous plexus and foraminal veins occurs.

It is usually not necessary to achieve complete radiographic filling of the vertebral body. Injection of even small quantities of bone cement (~14% of the vertebral volume) results in restoration of bone strength to pre-collapse values. However, uniform distribution of the cement within the body permits more effective transmission of compressive loads.[6] Depending on the distribution of the cement within the vertebral body, a decision may be made whether injection through the contralateral pedicle would be required.

Following the procedure, the patient is encouraged to lie in a supine position for at least one hour to allow the cement to harden. The patient can be discharged after a few hours of observation after performing a neurological assessment and providing optimum analgesia. Pain relief is usually immediate and the patient can rapidly assume normal activities of daily living.

## RESULTS

There have been no randomized controlled studies comparing PVP with conservative therapy. However, several large series have demonstrated the benefit of this procedure. The reported rates of positive outcome after PVP range from 73 to over 90%, based on the predominant indication<sup>7,8,9,10</sup>. Experience reported from various centers in India has shown similar benefit with this procedure<sup>11,12</sup>.

Alleviating the pain and improving functional performance status, goes a long way in improving the quality of life in this group of individuals<sup>13</sup>. Careful selection of patients for therapy with attention to ensure concordance of clinical symptoms and radiological findings and exclusion of other causes of back pain are essential to ensure optimal procedural results.

Complications are commoner during management of tumor associated VCFs (5 - 10%) as compared to osteoporotic VCFs (1%). The most common complications are related to the leakage of bone cement into the spinal epidural space or into the foraminal veins. Clinically significant complications that require surgical decompression to remove the extruded cement or repair of a fractured pedicle occur in less than 1% of the procedures<sup>14</sup>. Careful preoperative evaluation of integrity of the posterior cortex of the vertebra and extreme care while injecting the bone cement, ensure that symptomatic leakage of cement into the epidural space does not occur. Other reported complications such as local hemorrhage, fracture of posterior elements, rib fractures, transient increase in pain and nerve root irritation are self limiting. Other potentially serious complications such as

pulmonary embolism due to PMMA, allergic reactions and hypotension due to the monomer component and infection are fortunately rare.

## FUTURE DIRECTIONS

Though most experience with PVP worldwide has come from the use of PMMA as the bone cement, it is not an ideal cementing agent. Newer bone cements that have more radiopacity and more favorable setting times are under development. The ideal bone cement would stabilize the vertebra in the immediate post-procedure period, would permit the growth of new bone and would be ultimately replaced by the new bone. Better delivery systems that permit more controlled injection of the bone cement into the vertebral body are currently being evaluated. PVP is effective in stabilizing the vertebra and preventing further collapse. However, it does little to restore the height or shape of the collapsed vertebra. Kyphoplasty is a modification of the PVP procedure, where the height of the collapsed vertebra is restored by inflating a high pressure balloon introduced into the vertebral body through trans-pedicular access. The resulting cavity is subsequently filled bone cement to ensure stability. Restoring the height of the collapsed vertebra may improve gastrointestinal and pulmonary functions and may prevent subsequent vertebral compression fractures.

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