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MR Imaging and Osseous Spinal Intervention and Intervertebral Disk Intervention

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Back pain is one of the most common ailments in the United States, second only to headache in terms of the number of annual physician visits [1,2]. Back pain has multiple etiologies and can originate in various anatomic regions of the spine: the osseous portions, the joints, the muscles, the nerves, and the intervertebral disks. Until recently, treatment for persistent, severe back pain deemed refractory to conservative therapy often ultimately resulted in open surgery. Percutaneous spine intervention, a wide range of invasive spine procedures performed through a puncture hole or through a small incision not requiring soft tissue closure and with few or no skin sutures or staples, is rapidly emerging as an effective alternative to open surgery. Such interventions are expanding dramatically in terms of both the number and types of procedures performed.

Because of the large number of people with back pain requiring more advanced therapy and because of the potential advantages of minimally invasive therapy, this area has tremendous growth potential [3,4]. The modern diagnostic radiologist must acquire a general understanding of the procedures being performed, the postprocedural MR imaging appearance of the spine, and the complications that may arise.

In this article, the authors describe many of the minimally invasive osseous, intervertebral disk, and spinal nerve interventions currently being performed. Some of these procedures have been performed for longer periods and are more widely established. Others have been developed more recently and are less widely performed. A general introduction to these types of procedures is provided, along with the characteristic pre- and postprocedural MR imaging appearance related to these techniques. Reported and theoretical complications that may arise and their respective MR imaging appearances are also be discussed.

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MR imaging and osseous spinal intervention

Osseous spinal interventions for the treatment of pain related to vertebral compression fractures have increased dramatically since vertebroplasty was first introduced in the literature by Galibert and colleagues in 1987 [5]. These techniques include vertebroplasty and kyphoplasty, as well as newer techniques, such as spineoplasty and arcuplasty. The growing popularity of these types of procedures is understandable given that over 700,000 vertebral compression fractures occur in the United States each year [6,7], and that vertebroplasty and kyphoplasty have been demonstrated to be safe and effective interventions [8–12]. This section briefly presents the types of osseous spinal interventions currently being performed, the potential complications associated with them, and their postprocedural MR imaging appearance.

Vertebroplasty

Vertebroplasty is a percutaneous, image-guided procedure performed for the treatment of pain associated with compression fractures related to osteoporosis, malignancy, or hemangiomas [8–17]. It involves the percutaneous placement of bone cement into fractured vertebral bodies through a needle placed via a transpedicular or a parapedicular approach [8,18]. It is generally well tolerated and may be performed as an outpatient procedure. The procedure usually takes approximately 15 to 45 minutes per vertebral level, and the time necessary to perform the vertebroplasty mostly depends on the severity of the fracture.

Vertebral bodies treated with vertebroplasty have a distinctive appearance on MR imaging, although there is some variability depending on the type of bone cement used. Polymethylmethacrylate (PMMA), the chemical name for bone cement, is the most common material used, and it appears hyperdense on CT and dark on all standard MR imaging pulse sequences (Fig. 1).

No one has determined what amount of cement is best for pain relief and that issue remains controversial. Generally, a uniform filling of 50% to 75% of the vertebral body is desired, and care should be taken to prevent cement extravasation. Injecting higher cement volumes has not been demonstrated to provide increased pain relief, and injecting a large amount of cement may increase the stiffness of the fractured vertebral level more than that of its prefracture level. In an ex vivo study, Belkoff and colleagues [19] performed bilateral injections of bone cement into fractured osteoporotic vertebral bodies and found that as little as 2 mL of cement was enough to restore preinjury strength, but a total of 4 to 8 mL was necessary to restore preinjury stiffness, depending on the type of cement and the vertebral body level treated. Kosmopoulos and colleagues [20] found that restoration of stiffness with vertebroplasty is best attained with 3 to 5 mL of cement properly placed in the central portion of the vertebral body, but that complete replacement of the marrow volume resulted in an apparent stiffness above preinjury.

Also, the individual interpreting MR imaging of the spine should be aware of the importance of cement placement within the vertebral body. Dean and colleagues [21] evaluated the concept that cement placement is more important than injected volume or percentage of filled vertebral body. The investigators found an asymmetric flow pattern of cement when using a standard unilateral vertebroplasty technique to inject cadaveric vertebral bodies. The strength of the injected vertebral bodies was greater than that of the noninjected control group. However, the magnitude of strength increase did not correlate with the amount of cement

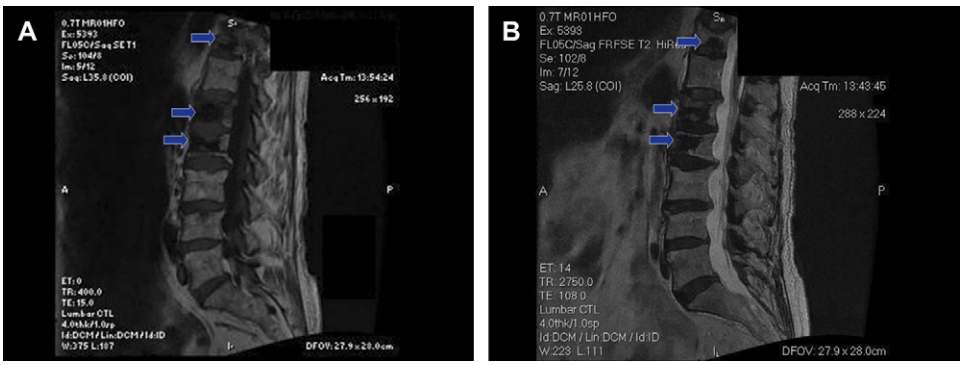

Fig. 1. (*A*, *B*) Sagittal T2-weighted MR imaging of lower thoracic and lumbar spine following treatment of T11, L1, and L2 vertebroplasty with PMMA. Bone cement appears dark on all sequences (*arrows*).