The Eggshell Technique for Prevention of Cement Leakage During Kyphoplasty

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Abstract: Cement extravasation during kyphoplasty occurs between 4% and 9%, a much lower incidence than with vertebroplasty. However, because of the potential complications of cement in and around the spinal canal, any egress of cement outside the vertebral body is extremely concerning. Aborting the procedure will cease the extraosseous leakage and minimize potential immediate complications. However, the cavity will remain unfilled and the fracture unstable. Rather than aborting, we have devised a technique, called the eggshell technique, to manage the patient's fracture once extravasation is noted so that the procedure can be safely completed.

Key Words: kyphoplasty, vertebral compression fracture, osteoporosis, spine, surgical technique

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Since the mid-1980s, vertebroplasty has been used as a technique for stabilization of vertebral compression fractures due to either osteoporosis or tumor.[1–5] The procedure, which involves high-pressure cement injection into the fracture, has been shown to be beneficial at alleviating the pain associated with these fractures; however, no attempt is made to restore lost vertebral height or to correct the resultant kyphosis.[2,3,6] As a consequence, there is potential for the patient's center of gravity to be shifted anteriorly, thereby producing a longer flexion moment arm acting on the apex of the kyphotic deformity. Because of this resultant force, there is the potential for aggravating the existing deformity or creating additional fractures.

Complications associated with vertebroplasty have mainly been due to the high-pressure injection of low-viscosity cement. Extravertebral leakage of cement has been reported in 30% to 67% of patients.[3,4,6,7] This cement can leak into the disk space, para-vertebral soft tissues, spinal canal, neural foramen, or vascular system. Complications reported secondary to this occurrence include symptomatic and lethal pulmonary embolism, radiculopathy, soft tissue femoral neuropathy, and spinal cord compression with either claudication or paraplegia requiring open surgical decompression.[7–10]

In the early 1990s, a modification was made to the vertebroplasty procedure in an effort to allow restoration of lost vertebral height and correction of kyphotic deformity. This procedure, known as kyphoplasty, uses insertion of a balloon into the fractured vertebral body.[6] The details of the procedure have been reported elegantly by Garfin et al.[6] The balloon is inflated in an effort to compact the cancellous bone and reexpand the vertebral body, thereby reducing the fracture. Once this is accomplished, typically via 2 balloons in a bi-pedicular fashion, the resultant cavity is injected with cement under low pressure. The low-pressure injection of cement along with creation of the cavity in the vertebral body represents attempts to inhibit potential egress of cement.

An in vivo comparison of extravertebral cement leak after vertebroplasty and kyphoplasty using injection of contrast showed significantly lower extravertebral leakage with kyphoplasty ($P = 0.0001$).[7] However, the contrast leakage with kyphoplasty was not zero. The clinical incidence of cement extravasation is much lower with kyphoplasty, reported at 4% to 9%.[2,7,11] Complications reported for kyphoplasty have included cement embolus to lungs, neurologic compromise secondary to spinal canal cement injection, anterior cord syndrome, and an epidural hematoma related to a postoperative heparin bolus.[6]

Cement extravasation during kyphoplasty occurs through either endplate fractures or instrumentation malpositioning. When a route for egress of cement exists, this will typically be noticed during balloon inflation or cement injection portion of the procedure on the fluoroscopy monitor. Aborting the procedure at this point will cease extravasation and minimize potential immediate complications. However, the cavity will remain unfilled and the fracture unstable. Rather than aborting, we have devised a technique, called the eggshell technique, to manage the patient's fracture once extravasation is noted so that the procedure can be safely completed.

EGGSHELL TECHNIQUE

Either during the balloon inflation or during the cement injection portions of kyphoplasty, cortical bone defect(s) may be noted. To prevent resultant cement extravasation through the defect(s), the following

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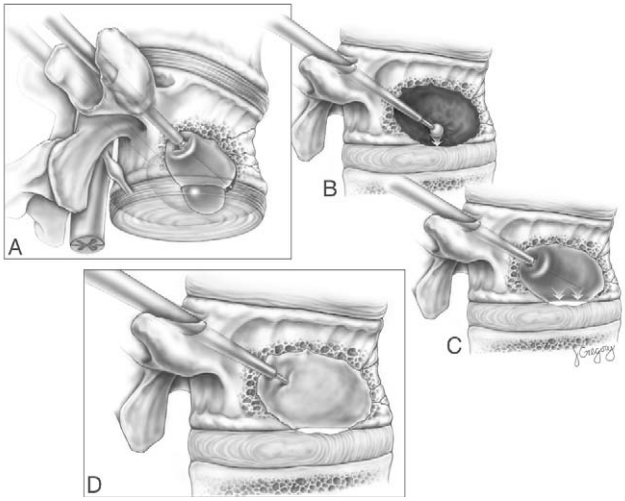

FIGURE 1. Kyphoplasty eggshell technique. A, Endplate violation occurs during balloon inflation. B, Balloon removed, then small amount of doughy cement injected to provide coverage of endplate defect. C, Kyphoplasty balloon then reinserted and slowly reinflated to press cement against defect. D, Once cement over defect hardens, cement then inserted in the usual fashion with careful fluoroscopic monitoring.

technique should be used. If during balloon inflation violation of cortical bone occurs, antero-posterior and lateral fluoroscopy images should be used to locate the exact location of the defect(s) (Fig. 1A). Once this is accomplished, the balloons should be deflated and removed, keeping them sterile for reinsertion later. The cannula for cement injection should be localized so that insertion of a small amount of cement will allow for coverage of the defect(s), bilaterally if necessary depending on the size of the defect(s) (Fig. 1B).

Cement should then be mixed, and once it has reached the doughy consistency phase (no longer liquid), injection of a small amount through the cannula is performed to provide coverage of the defect(s). If the defect(s) spans a significant portion of the vertebral body, it may be necessary to use bilateral cannulas for coverage. Once this small amount of cement is inserted, the kyphoplasty balloons are then reinserted and slowly reinflated to press the cement against the defect. Fluoroscopy should be carefully monitored to ensure that the cement is not extravasated during the balloon reinflation. The balloons can be left in place as long as desired, even until the cement hardens, as they will not stick to the cement (Fig. 1C).

As the patient's body temperature is significantly warmer than ambient air, cement inside the body will harden quicker than outside. As a result, it may not be necessary to mix a new batch of cement while waiting for the defect coverage cement to harden. However, as cement hardening varies depending on temperature, humidity, and rapidity of mixing, it is a good idea to always have an extra batch on hand just in case. Once the cement outside the body reaches the end of the doughy phase, it can be assumed that the cement previously injected has now successfully hardened over the defect(s). The balloons can be deflated, removed, and low-pressure cement insertion can be accomplished in the usual fashion (Fig. 1D). Once again, fluoroscopy should be carefully monitored to ensure that egress of cement does not occur.

Using the eggshell technique, we have been able to successfully accomplish kyphoplasty procedures that would otherwise need to be abandoned or potentially lead to complications secondary to cement extravasation.

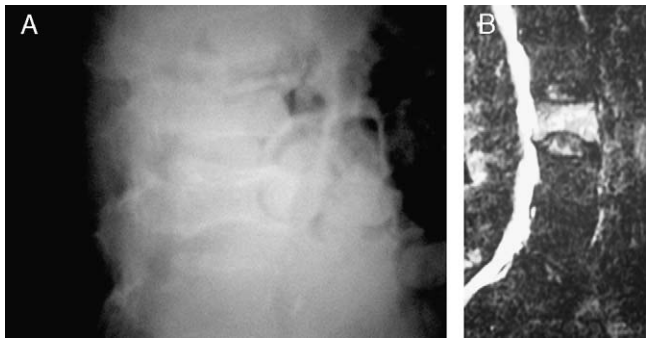

FIGURE 2. Preoperative imaging studies. A, Preoperative plain film. B, Preoperative magnetic resonance imaging.

MATERIALS/METHODS

We have used the eggshell technique on 7 patients (ages 64 to 82), 5 women and 2 men. The fractures were located between T12 and L4, and all patients underwent preoperative magnetic resonance imaging scans showing high signal in the affected levels indicating either acute or subacute injury. During kyphoplasty cement extravasation was noted through either the superior endplate or the lateral body wall.

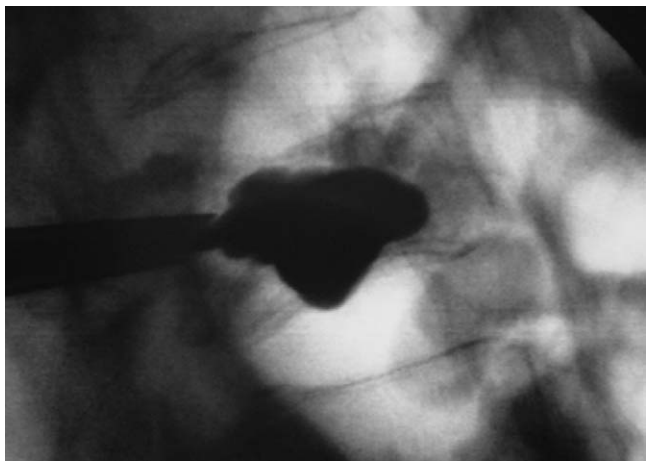

FIGURE 3. Intraoperative fluoroscopy image of balloon inflation showing inferior endplate defect.

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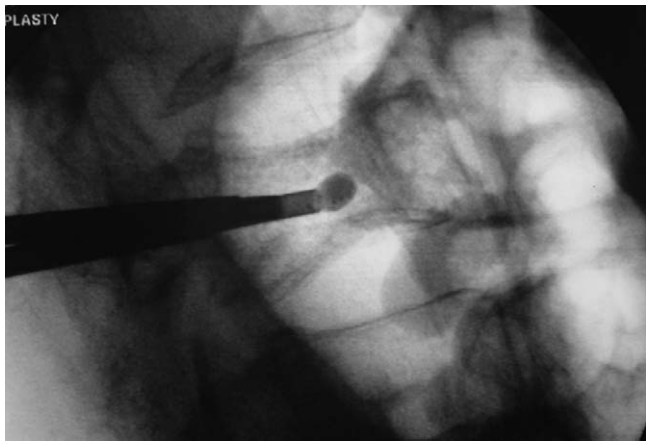

FIGURE 4. Initial cement injection for beginning of eggshell technique.

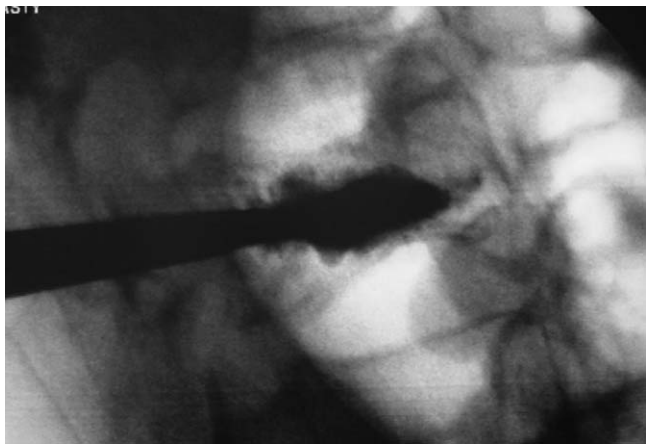

FIGURE 6. Balloons removed, cement injection restarted. Notice lack of extravasation.

CASE EXAMPLE

Patient is a 74-year-old man who presented from an assisted-living home with recalcitrant pain and decreased ambulation secondary to an L3 compression fracture sustained 8 weeks prior. Plain films and magnetic resonance imaging were obtained which showed the fracture with associated edema and increased signal intensity (Fig. 2). The decision was made to perform kyphoplasty for pain control and potential vertebral body height restoration. Bilateral transpedicular entry was made in the usual fashion under fluoroscopy. However, as the balloon inflation began for creation of the osseous cavity, endplate violation was noted in the inferior aspect of the vertebral body (Fig. 3).

With an obvious channel for cement egress noted, the decision was then made to use the eggshell technique. The balloons were deflated, removed, and a small amount of viscous cement was injected through the cannulas bilaterally (Fig. 4). The balloons were then reinserted and inflated (Fig. 5). After approximately 7 minutes, the balloons were deflated, removed, and cement was injected bilaterally in the usual fashion, taking special care to

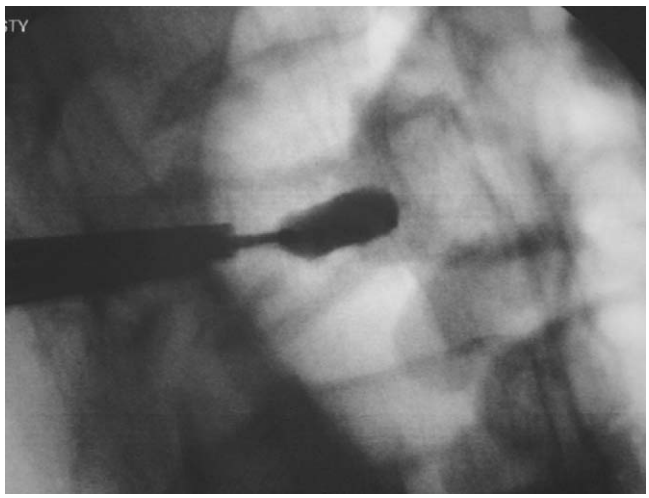

FIGURE 5. Reinsertion of balloons for eggshell technique.

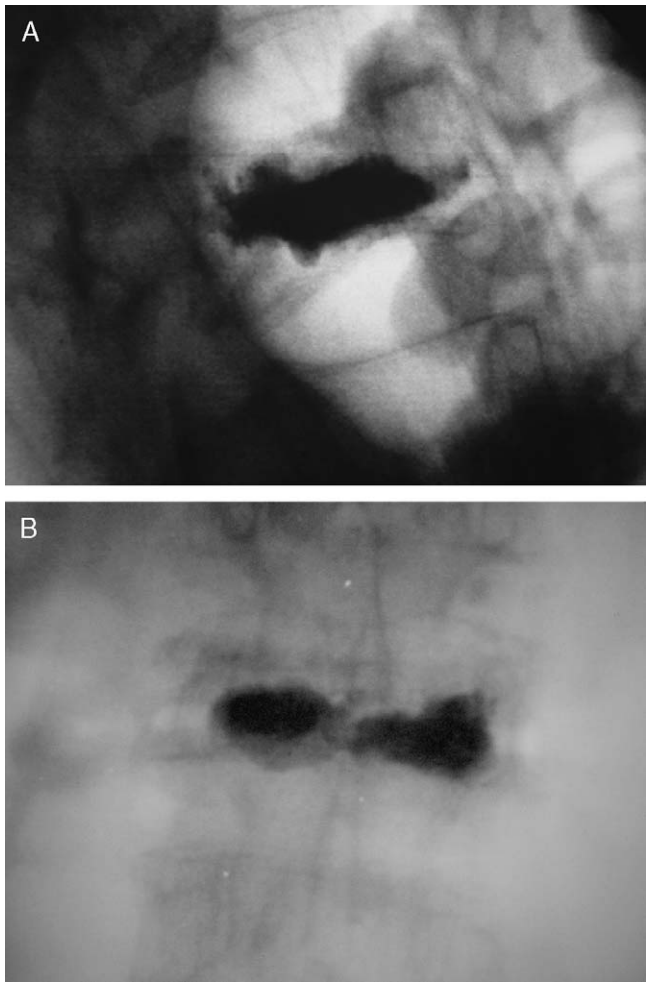

FIGURE 7. Final fluoroscopy images. A, Lateral. B, AP.

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monitor via fluoroscopy that no cement was being extravasated (Fig. 6). Final images displayed fracture stabilization with cement containment in the vertebral body (Fig. 7). The patient sustained no complications and postoperatively his pain decreased dramatically.

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