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Clinical Study

Basivertebral foramen could be connected with intravertebral cleft: a potential risk factor of cement leakage in percutaneous kyphoplasty

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Abstract

BACKGROUND CONTEXT: Among different types of cement leakage in percutaneous kyphoplasty (PKP) for osteoporotic vertebral body compression fractures, leaks into the spinal canal are considered to be the most common complication. One potential structure causing this type of cement leakage is the potential connection between the basivertebral foramen and the intravertebral cleft, which is revealed clearly on magnetic resonance (MR) images, but is often ignored in the literature.

PURPOSE: The purpose of this study is to assess the incidence rate of different types of cement leakage in PKP with or without intravertebral clefts and to determine whether the basivertebral foramen could be connected to the intravertebral cleft.

STUDY DESIGN: This study is a retrospective assessment of the presence of an intravertebral cleft in osteoporotic vertebral bodies and the different types of cement leakage after PKP on radiographs, computed tomographic (CT) scans, and MR images.

PATIENT SAMPLE: A total of 164 consecutive patients underwent PKP to treat 204 osteoporotic vertebral compression fractures.

OUTCOME MEASURES: Outcome measures include the occurrence of different types of cement leakage in the groups with an intravertebral cleft and without intravertebral clefts.

METHODS: A total of 204 vertebrae in 164 consecutive patients who underwent PKP to treat osteoporotic vertebral compression fractures were classified into two patterns based on preoperative radiographs, CT scans, and/or MR images of the treated levels: cleft pattern (with an intravertebral cleft in the vertebral body) and trabecular pattern (without intravertebral clefts). When an intravertebral cleft was identified, the investigators examined the basivertebral foramen and looked for a communication between the two structures on three-dimensional CT scans and MR images. On direct postoperative images, the patterns of cement leakage were classified as five types: type A, through a cortical defect into the paraspinal soft tissues; type B, through the basivertebral foramen; type C, via the needle channel; type D, through a cortical defect into the disc space; and type E, via the paravertebral vein. The association of the distribution of the cement leakage and the presence of an intravertebral cleft was analyzed retrospectively. Moreover, the association of type B leakage with the communication between the basivertebral foramen and the intravertebral cleft was also assessed.

RESULTS: The average interobserver kappa values for determining the type of cement leakage and the presence of intravertebral cleft were 0.916 (range, 0.792–1) and 0.935, respectively. In 41 of 204 vertebrae (19.9%), an intravertebral cleft was confirmed on preoperative images. A communication between the intravertebral cleft and the basivertebral foramen was seen in 10 vertebrae (24.4%). Cement leakage was 36.2% in the group with a trabecular pattern and 41.5% in the group with a cleft

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pattern (p>.05). Leaks through the basivertebral foramen (type B; N=30, 14.7%) and through cortical defects into the disc space (type D; N=14, 6.9%) were more common than other types. Twenty of 163 vertebrae with the trabecular pattern (12.3%) and 10 of 41 vertebrae with the cleft pattern (24.4%) were identified as type B leaks, which reached statistical significance (p<.05). There was no statistical difference between the trabecular pattern and the cleft pattern on other types of leaks. **CONCLUSIONS:** Type B leaks are more common in vertebrae with an intravertebral cleft, which supports the presence of a connection between an intravertebral cleft and the basivertebral foramen. Thus, care must be taken when PKP is performed in these patients to avoid direct cement leakage into the spinal canal through the basivertebral foramen.

Keywords: Intravertebral cleft; Basivertebral foramen; Percutaneous kyphoplasty; Cement leakage; Osteoporotic vertebral compressive fracture

Introduction

Cement leakage after percutaneous kyphoplasty (PKP) for osteoporotic vertebral body compression fractures (OVCFs) has been reported to be as high as 25% [1]. Complications arising from cement leakage, such as neurologic deficit, fractures in adjacent vertebral bodies, and pulmonary embolism, have also been reported in the literature [2–5]. Most of the complications are asymptomatic, but some require operative management. Among different types of cement leakage, leaks into the spinal canal were the most common [6], suggesting there may be a specific structural cause.

The basivertebral foramen, which is revealed on magnetic resonance (MR) images and computed tomographic (CT) scans, but is rarely described in the literature, lies adjacent to the posterior wall of the vertebral body, and may play a role in OVCFs and in burst fractures. It is involved in nearly half of all sagittally oriented burst fractures [7]. In addition, during the treatment of OVCFs by PKP, the basivertebral foramen can be involved in epidural leakage and can lead to severe complications [8].

Another potential structure involved in cement leakage is the intravertebral cleft, defined as a low-resistance confluent reservoir for polymethylmethacrylate [9] in PKP. Maldague et al. [10] first reported an ''intravertebral cleft'' (or ''intravertebral vacuum phenomenon'') to be common in patients with OVCFs, and it is also associated with multiple myeloma [10–14]. The cleft is usually ascribed to ischemic necrosis of the vertebral body, previously known as Kümmel disease or pseudoarthrosis [9,10,15–17]. Sarli et al. demonstrated that the intravertebral clefts do not contain a vacuum, but 95% nitrogen gas [18]. The appearance of intravertebral clefts changes with body position and with time [9,19,20].

Percutaneous vertebroplasty for OVCFs in the presence of an intravertebral cleft may increase the risk of certain types of cement leakage [21–23]. However, scant attention has been paid to intravertebral cleft-related rates of cement leaks in PKP, or to a possible communication between the basivertebral foramen and the intravertebral cleft. In our experience with PKP, we noticed that cement could enter the region of the basivertebral foramen and extrude into the spinal canal if an intravertebral cleft was present.

In the current study, we assessed the incidence of cement leakage in PKP in vertebrae with and without an intravertebral cleft. Magnetic resonance images, CT scans, and conventional radiographs were analyzed from 164 patients who underwent PKP for painful osteoporotic fractures.

Clinical data and methods

Patients

Between January 2009 and January 2012, 183 patients underwent PKP to treat OVCFs. All patients reported refractory low back pain and tenderness, and failed to respond to conservative treatment for at least 2 months. Exclusion criteria were more than five affected vertebrae, severe trauma, known malignancies, neoplastic fractures, blood disease, and spinal infections. We selected 204 vertebrae in 164 patients (129 women and 35 men) with a mean age of 71 years (range, 56–91 years). The average body mass index was 22.3 (range, 15.1–30.6) and the average duration of symptoms was 9.1 months (range, 2–72 months). The locations and numbers of the treated vertebrae in our study group are shown in (Fig. 1).

Operative technique

Standard PKP was undertaken using local anesthesia with fluoroscopic guidance. A bilateral transpedicular approach to the fractured vertebral body was performed sequentially with trocars, guidewires, and cannulas, and the tip of the cannulas was situated in the posterior portion of the vertebral body. Balloon tamps were inserted through the cannulas and then inflated slowly to create a cavity for the injection of cement and to reduce the fracture deformity. Inflation was stopped when the pressure gauge read 220 psi or if the balloon contacted the cortical surface of the vertebral body. The balloon was then deflated and removed. Bone-filling devices were filled with cement and then placed through the cannulas into the anterior aspect of the void created by the balloon, and the cement was injected into the void. The bone-filling device was then pulled back carefully but kept in place until the cement hardened. The mean amount of polymethylmethacrylate injected was