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Balloon kyphoplasty for osteoporotic spinal fractures with middle column compromise

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ABSTRACT

Background: Balloon kyphoplasty (BKP) is an effective method for osteoporotic vertebral compression fractures. However osteoporotic spinal fractures with middle column compromise are mentioned as a relative contraindication to BKP. Thus we investigated the safety and efficacy of BKP in the treatment of osteoporotic spinal fractures with middle column compromise but without neurological deficit.

Methods: In this retrospective study, 45 patients who suffered osteoporotic fractures with middle column compromise but without neurological deficits were treated by BKP from May 2007 to December 2010. The final follow-ups were finished during the time of July 2011–September 2011. The mean follow-up period was 20.2 months. The height of the compromised vertebral body, the kyphotic angle and spinal canal compromise were measured before surgery, one day after surgery, and at the final follow-up. A visual analogue scale (VAS) and the Oswestry disability index (ODI) were chosen to evaluate pain and functional activity.

Results: The mean VAS and ODI scores improved significantly from pre- to post-operation ($p < 0.05$), and this improvement was sustained at the final follow-up. The mean anterior vertebral body height ratio improved from 57.6% ± 11.8% preoperatively to 86.2% ± 12.2% postoperatively ($p < 0.05$), so did the mean middle vertebral body height ratio. The kyphotic angle improved from 16.3° ± 3.7° preoperatively to 9.3° ± 2.6° postoperatively ($p < 0.05$). At final follow-up, BKP stabilised vertebral height and prevented further kyphotic deformity. While there were no differences in spinal canal compromise between pre-operation and one day after surgery ($p > 0.05$), there was a significant difference from the measurement at the final follow-up ($p < 0.05$).

Conclusion: BKP is a safe and effective method for osteoporotic spinal fractures with middle column compromise but without neurological deficit. Spontaneous remodelling of the spinal canal also occurs after BKP.

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The conservative treatments for osteoporotic vertebral compression fractures include bed rest, narcotic analgesics, braces or physical therapy. Since Galibert et al. [1] initially treated vertebral angioma by PV in 1987, percutaneous vertebroplasty (PV) and balloon kyphoplasty (BKP) have gained wide acceptance as effective treatment options for osteoporotic vertebral compression fractures [2–4]. Compared with conservative treatment, PV and BKP were confirmed to have a quicker relief of pain and improvement of function [5–11]. Accordingly, the indications for the two procedures have been extended to vertebral compression fractures due to various causes, such as osteoporosis, metastases and multiple myeloma [2–4,12–14].

PV stabilises the fracture and avoids further height loss, but does not provide the opportunity for height restoration in the fractured vertebral body. BKP also stabilises the fracture and avoids further height loss, and it also has the potential for correcting vertebral deformity, thus reversing or preventing height loss, spinal deformity, and compromise of internal organs. A large number of studies have confirmed that BKP had better improvement at vertebral height, and kyphotic angle with lower occurrence of cement leakage [15–20]. Therefore, BKP was introduced as a safer and more effective treatment for vertebral compression fractures.

Osteoporotic spinal fractures with middle column compromise but without neurological deficits are an increasingly common problem. These fractures occurred through axial compression with failure of both the anterior and middle columns and resultant

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retropulsion of the posterior vertebral body wall into the spinal canal. This results in canal compromise, within the epidural space. The definition of osteoporotic spinal fractures with middle column compromise was either complete or incomplete burst fractures. In several articles and books referring to this subject, spinal cord compression or encroachment on the central spinal canal is mentioned as a relative contraindication for PV and BKP [21–23]. Some authors have reported good results with PV owing to its analgesic and stabilising effects in patients with osteoporotic spinal fractures with middle column compromise [22,24]. However, few studies to date have reported on the outcomes of BKP in the treatment of osteoporotic spinal fractures with middle column compromise. Furthermore, to our knowledge, no articles have shown whether there is spontaneous remodelling of the spinal canal after BKP. Here, we report on the safety and efficacy outcomes with BKP in a cohort of patients with osteoporotic spinal fractures with middle column compromise and without neurological deficits.

Materials and methods

Patient selection

A total of 45 patients who suffered from osteoporotic fractures with middle column compromise but without neurological deficits underwent BKP from May 2007 to December 2010. Our series included stable burst fractures. According to Genant's classification [25], 25 were Grade I and 20 were Grade II. In our study, 40 patients suffered from primary osteoporosis, and the other 5 patients suffered from secondary osteoporosis. The mean age of the patients was 69.9 years old (range, 62–81). These patients suffered from severe back pain refractory to non-operative methods and the mean duration of symptoms was 3.3 months (0.8–10.9 months). The exclusion criteria included radicular symptoms, unstable fractures involving the posterior column, or cord compression. Symptomatic levels were identified by correlating the clinical data with magnetic resonance imaging findings of marrow signal changes consistent with osteoporotic fractures with middle column compromise. Furthermore, all of the patients had single symptomatic fractures, and all of the patients had osteoporosis that had been identified before BKP by dual-energy X-ray absorptiometry. Anteroposterior lumbar spine bone mineral density (BMD) was measured over L1–L4 by dual-energy X-ray absorptiometry, and the mean BMD of all of the patients was 0.588 g/cm^2. The mean T score was −4.56 (−6.68 to −2.70) [T score = (BMD − reference BMD)/SD] [26]. Levels treated by BKP were located in the thoracic spine and lumbar spine (Fig. 1).

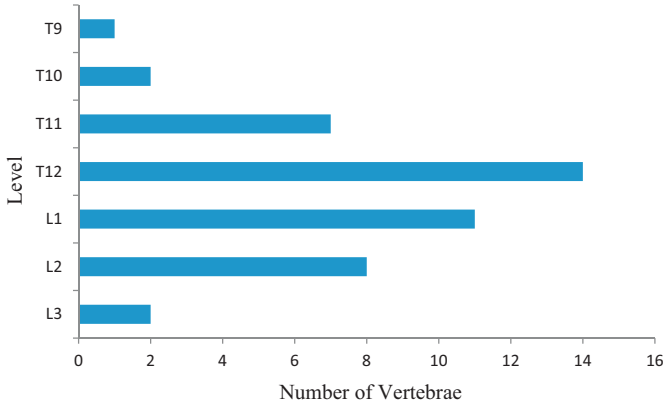

Fig. 1. Distribution of vertebral bodies treated by BKP among 45 patients with osteoporotic spinal fractures with middle column compromise and without neurological deficit.

Surgical technique

The operations were undertaken under general anaesthesia with fluoroscopic guidance. Guide wires were initially inserted to obtain bilateral transpedicular access to the fractured vertebral body. The opening was gradually enlarged using successively larger cannulae. Kyphon balloon tamps (Kyphon Inc., Sunnyvale, CA, USA) were inserted through the cannulae and placed in the anterior three-quarters of the vertebral body on the lateral view, covering both sides to the midline on anteroposterior view. The balloons were then inflated slowly to reduce the fracture and to create a cavity for the injection of cement. The inflation was stopped when the pressure reached between 150 psi and 300 psi or when the balloon made contact with the endplate. At this point, the volume of the balloon was noted. It was then deflated and removed. Polymethylmethacrylate cement was injected incrementally to fill the cavity. The bone cement introducer was then pulled back slightly but was kept in until the cement hardened. The patients were mobilised 12–24 h after the procedure.

Post-operative therapy

All of the patients in our study received the same post-op rehab programme advocated by Elizabeth A. Huntoon et al. [27]. Furthermore, the Rehabilitation of Osteoporosis Programme-Exercise instructions incorporate isometric back-extensor muscle strengthening and proprioceptive postural retraining. In addition, all of the patients were referred for treatment with calcium and vitamin D supplements and antiresorptive or anabolic agents.

Clinical assessment

Back pain was assessed using a visual analogue scale (VAS) with values ranging from 0 to 10 (a score of 0 represented no pain, and a score of 10 indicated severe pain) prior to BKP, one day after surgery, and at the final follow-up. Furthermore, Oswestry Disability Index (ODI) score used to assess functional capacity, was also documented.

Radiographic assessment

Plain digital radiographs and computed tomography (CT) with 3D reconstruction were performed prior to BKP, at one day postoperatively and at the final follow-up. The vertical heights (anterior and middle) of compromised vertebrae were measured preoperatively, postoperatively and at the final follow-up time points using lateral radiographs of the spine. The radiographs were taken according to published standardised protocol [28]. Vertebral body height measurements (anterior, midline) were obtained from standing lateral radiographs for compromised and adjacent un-compromised control vertebrae. For each patient and each radiograph, the normal height of the compromised vertebra was estimated from the mean of the measurements from the closest un-compromised vertebral cephalad and caudad to the treated level. The vertebral body height ratio was calculated as follows: height ratio (%) = (compromised vertebral height/mean adjacent control vertebral height) × 100. The kyphotic angle was calculated from the standing lateral radiographs using Cobb's methods. The measurement was taken from the superior endplate of the vertebra 1 level above the treated vertebra to the inferior endplate of the vertebra 1 level below the treated vertebrae. In our study, the cross-sectional areas of the spinal canal were measured on CT scans using the Picture Archiving and Communication System and by tracing the spinal canal at three levels of interest: above, at, and below the level of injury preoperatively, postoperatively, and at the final follow-up. The percentage of canal compromise was

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