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Original Article

Treatment of osteoporotic vertebral burst fracture with kyphoplasty and decompressive laminectomy

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Abstract: Osteoporotic vertebral burst fracture (OVBF) is an unstable type of fracture that often leads to neurological deficits. Advanced age and the presence of fracture comorbidities may increase mortality and disability rates. To evaluate clinical results of kyphoplasty and decompressive laminectomy for OVBF, 32 patients (19 men, 13 women) underwent kyphoplasty and decompressive laminectomy were included to evaluate the efficacy of this procedure for OVBF. Their average age was 72 years old. The visual analog pain scale score, Oswestry disability index score, intraspinal bone occupation rate, Cobb angle, anterior vertebral compression rate, and complications were recorded and analyzed preoperatively, 1 week postoperatively, and 6 months postoperatively. All patients were followed up. The mean blood loss and surgery time were 55 ml and 87 min, respectively. Cerebrospinal fluid leakage occurred in one patient, and postoperative back pain occurred in two patients. No cement leakage occurred, and no significant spinal or neural complications were observed. The mean visual analog scale score, anterior vertebral compression rate, Oswestry disability index score, intraspinal bone occupation rate, and Cobb angle were significantly different between the preoperative and postoperative periods. In conclusion, kyphoplasty and decompressive laminectomy may be a relatively safe and effective treatment for OVBF, especially for patients who cannot tolerate traditional open reduction and internal fixation.

Keywords: Osteoporosis, vertebral burst fractures, vertebroplasty, vertebral decompression

Introduction

At present, improvements in medical treatments have resulted in a gradual increase in the size of the aging population. Osteoporosis is one of the most common chronic conditions among the elderly and affects the physical health of elderly men and postmenopausal women [1, 2]. In China, osteoporosis affects about 5.6% of the total population, resulting in a higher risk of osteoporosis-related fractures [2, 3]. The spine is the most common site of osteoporotic fracture. Osteoporotic vertebral burst fracture (OVBF) is an unstable type of fracture that often leads to the intrusion of bony fragments into the vertebral canal, resulting in neurological deficits. Pedicle screw fixation is necessary for this type of fracture. However, advanced age and the presence of fracture comorbidities may increase mortality and disability rates [4]. Thus, conservative treatment is fundamental for elderly patients with OVBFs. However, the incidence of late collapse, pseudarthrosis, and complications related to a bedridden status such as hypostatic pneumonia, bedsores, and urinary tract infection is significantly increased in such patients, leading to poor clinical outcomes for fracture patients.

Kyphoplasty can help relieve the pain associated with osteoporotic vertebral compression fractures [5-11], which is considered for the treatment of OVBF. Vertebral compression fractures are often treated with kyphoplasty, but they are not routinely used to treat burst fractures because of the increased risk of cement leakage and the inability to decompress the spinal canal [12-14]. To address these two issues, we herein present our experience with kyphoplasty and decompressive laminectomy in 32 patients who were hospitalized for OVBF between June 2016 and May 2019.

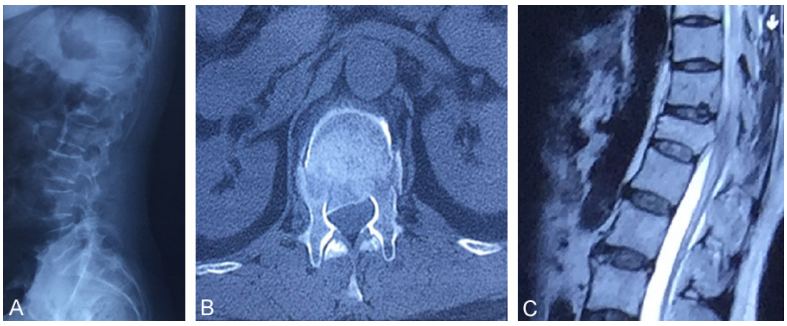

Figure 1. A. Preoperative X-ray. B. Computed tomography showed that the bone block invaded the spinal canal, compressing the dura. C. Magnetic resonance imaging showed the posterior wall of the T12 vertebral body in the spinal canal.

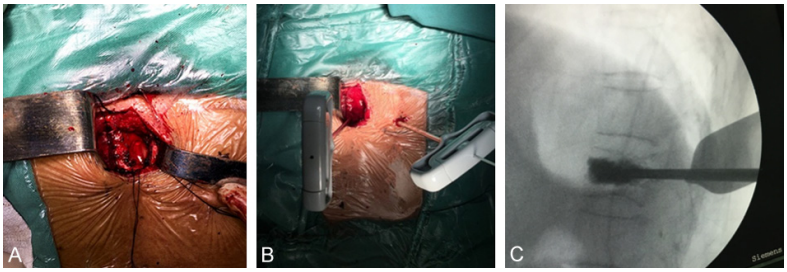

Figure 2. A. Decompressive laminectomy. B. One side of the puncture needle was placed through the incision, and the other side of the puncture needle was positioned depending on the C arm. C. Bone cement diffusion was observed by C-arm fluoroscopy.

Patients and methods

Patients

Data for patients treated from June 2016 to May 2019 were obtained. The enrollment criteria were as follows: (1) osteoporosis in men older than 65 years and women older than 60 years, (2) the presence of associated neurological deficits, (3) thoracolumbar OVBFs with bone fragments in >30% of the spinal canal volume, and (4) ability to tolerate surgery and anesthesia.

Thirty-two patients were included in this prospective study (19 men, 13 women; median age 72 years; range 60-85 years). All patients had thoracolumbar OVBFs with neurological deficits. Recent fractures were confirmed by magnetic resonance imaging findings of marrow signal changes, and computed tomography (CT) scans showed bone fragments in >30% of the spinal canal volume (**Figure 1**). Among the 32 patients, 6 had T12 fractures, 7 had L1 fractures, 1 had an L2 fracture, 10 had L3 fractures, 7 had L4 fractures, and 1 had an L5 fracture. Ten patients had urination and defecation function disturbances, and 16 patients had gastrointestinal symptoms such as abdominal distension and regurgitation. The average duration of hospitalization was 8.5 days (range 2-15 days).

Preoperative examination

Patients taking aspirin discontinued this medication one week before the surgery. All chronic diseases were assessed and treated before the surgery. All patients underwent lateral radiography, CT, and MRI.

Methods

The surgery was performed with the patient in the prone position and complete anesthesia. Spinal lordosis was achieved by placing the surgical bolsters under the thorax and iliac crests, which is beneficial for fracture reduction.

A complete decompressive laminectomy was performed in a standard fashion with removal of the hemi-lamina and ligamentum flavum and performance of a neural foraminotomy. Bone fragments that invaded the spinal canal were restored to the vertebral body by a special osteotomy under the dural sac (**Figure 2**). If an obstruction is found on the bone fragment, a bone hammer is used to strike the bone tail.

The second surgical stage involved percutaneous kyphoplasty with two balloons after cannulation of the pedicles through the incision on one side and by percutaneous implantation on the other side. The balloons were inserted into the anterior part of the vertebral body by the cannulations, and iodinated alcohol was injected to reduce the fracture. Bone cement (polymethylmethacrylate) was then injected into the anterior part of the vertebral body to consoli-

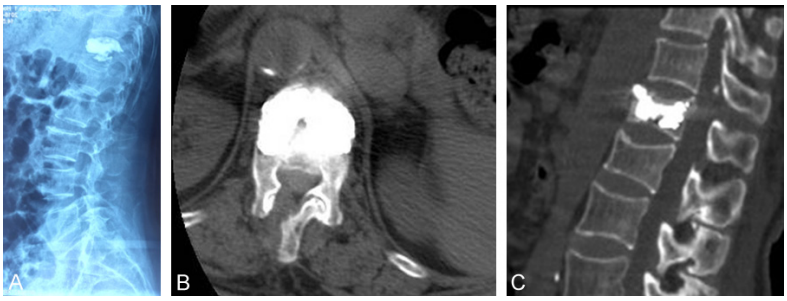

Figure 3. (A) Postoperative X-ray showed vertebral height recovery. The (B) cross section and (C) vertical plane of the computed tomography scan showed satisfactory filling of bone cement and relief of the reduction of the bone mass in the vertebral canal.

date the reduction. During injection, the reduction of the fragment was closely monitored, and re-protrusion of the pieces into the spinal canal was avoided.

Postoperative management

The negative-pressure drainage was discontinued 1 to 2 days postoperatively. Patients performed sit-up and walking exercises with lumbar support one week after surgery. The visual analog scale (VAS) score, intraspinal bone occupation rate, Cobb angle, Oswestry disability index (ODI) score, anterior vertebral compression rate, and complications were recorded and analyzed preoperatively, 1 week postoperatively, and 6 months postoperatively.

Statistical analysis

All data were expressed as mean ± standard deviation, and all statistical analyses were performed using the statistical software SPSS version 16.0 (SPSS, Inc., Chicago, IL, USA). Statistical differences were evaluated using the t-test. A *P* value of < 0.05 was considered statistically significant.

Results

We prospectively analyzed 32 patients who underwent kyphoplasty and decompressive laminectomy. The mean blood loss was 55 mL (range 30-80 mL), and the mean operation time was 87 min (range 67-100 min). The mean amount of cement injected was 4 ± 1 mL. Cerebrospinal fluid leakage occurred in one patient and was resolved in 72 h by a shift to the trendelenburg position. Postoperative back pain occurred in two patients and was relieved by nonsteroidal analgesics in 1 month in one patient and immediately after surgery in the other. Cement leakage did not occur in any patient. The posteroanterior and lateral radiographs showed that the bone cement was well distributed, and CT showed that the bone mass that had intruded into the vertebral canal forcefully returned to the vertebral body without nerve compression (**Figure 3**).

All 32 patients were followed up for six months postoperatively (**Table 1**). Pain as evaluated by the VAS improved from the preoperative period to 1 week postoperatively (from 7.78 ± 1.75 to 3.12 ± 1.26) and further improved to 2.64 ± 0.98 at the 6-month follow-up examination. The anterior vertebral height loss was 32.50% ± 2.46% preoperatively, 16.14% ± 1.34% at the 1-week follow-up, and 15.78% ± 1.26% at the 6-month follow-up. The limitation of daily activities as evaluated by the ODI was 80.26% ± 6.18% preoperatively, 32.23% ± 3.16% at the 1-week follow-up, and 29.28% ± 1.63% at the 6-month follow-up. The ratio of canal compromise was 36.25% ± 3.04% preoperatively, 10.34% ± 2.06% at the 1-week follow-up, and 11.03% ± 2.83% at the 6-month follow-up. The Cobb angle was 20.98° ± 3.60° preoperatively, 11.49° ± 2.48° at the 1-week follow-up, and 12.96° ± 2.30° at the 6-month follow-up. The difference between preoperative and postoperative times was statistically significant ($P < 0.05$).

Discussion

Summary of OVBF

Osteoporosis is a metabolic disease associated with decreased bone strength, characterized by a decrease in bone mass, an increase in bone fragility, and a deterioration in bone structure [15]. Osteoporosis is common in the elderly population. The incidence of osteoporotic fractures has increased with the aging of the community. Fractures caused by osteoporosis

Table 1. Observation indices before and after the operation (n = 32)

Time	VAS	ODI	Anterior vertebral height loss (%)	The ratio of canal compromise (%)	Cobb angle (°)
preoperative ①	7.78 ± 1.75	80.26 ± 6.18	32.50 ± 2.46	36.25 ± 3.04	20.98 ± 3.60
one week after operation ②	3.12 ± 1.26	32.23 ± 3.16	16.14 ± 1.34	10.34 ± 2.06	11.49 ± 2.48
one month after operation ③	2.64 ± 0.98	29.28 ± 1.63	15.78 ± 1.26	11.03 ± 2.83	12.96 ± 2.30
P_{1-2}	0.000	0.000	0.000	0.000	0.000
P_{1-3}	0.000	0.000	0.000	0.000	0.000
P_{2-3}	0.119	0.002*	0.366	0.251	0.023*

Data are presented as mean ± standard deviation. *P < 0.05, indicating a significant difference between groups. VAS, visual analog scale; ODI, Oswestry disability index.

are the most common fractures in the elderly. Fracture sites include the spine, proximal humerus, distal forearm, and proximal femur [16]. Osteoporosis causes fractures in more than 18 million people in China every year. In the elderly population, thoracolumbar burst fractures occur after axial pressure is applied to the thoracolumbar spine. The fracture results in a burst of the vertebral body, rupture of the vertebral endplate on one or both sides, and a backward protrusion of the posterior wall of the vertebral body into the spinal canal [17].

Posterior surgery with pedicle screws is widely used to treat thoracolumbar burst fractures in young patients and can ensure three-dimensional fixation through the front, middle, and back of the three columns. For elderly patients with osteoporosis, however, this surgery has some disadvantages, such as a weak pullout capacity of the pedicle screws, inability to tolerate longer operative time, more intraoperative blood loss, and more severe injury [18]. Kyphoplasty, anterior grafts and instrumentation, and enhancement of pedicle screw fixation with bone cement have been reported [19, 20]. Kyphoplasty is applied to patients with minimal occupation of the spinal canal by bone fragments, no nerve compression symptoms, and a relatively complete posterior wall. The operative injuries induced by anterior instrumentation and bone cement-enhanced pedicle screw fixation are too large for elderly patients. Therefore, these methods are not clinically applicable to this population.

The operation in the present study resulted in less surgical trauma, less muscle peeling, a shorter operative time, more rapid recuperation, and fewer complications compared with other methods, indicating that it is a relatively safe and effective treatment for OVBF.

Analysis of the results

In the present study, treatment with kyphoplasty and decompressive laminectomy significantly reduced the severity of back pain compared with that before surgery. No pain was observed at the last follow-up examination, and the effect was long-lasting. The anterior height of the vertebra was satisfactorily restored, and there was no significant loss at six months; this was considered to be related to the strengthening of the vertebral body by the bone cement. The ODI score showed a high neurologic improvement rate, and limb function gradually improved with time, consistent with the changes in the spinal canal occupation rate and Cobb angle. These results indicate that our method can relieve nerve compression and improve nerve function by reducing spinal cord compression and correcting the kyphosis deformity. Bone cement acts as an adhesive for the free bone mass, maintaining the height of the vertebral body and the local analgesic effect. The small differences in the Cobb angle at 1 week and 6 months postoperatively were associated with the patients' degree of osteoporosis. The persistent loss of bone mass resulted in a slight collapse of the vertebral body, and the Cobb angle was the overall performance. We suggest treatment with anti-osteoporosis agents, both preoperatively and postoperatively.

Indications and contraindications

This operation is characterized by minimal trauma, short operation time, minimal bleeding, and other advantages. It can be applied to patients with osteoporosis, elderly patients

who cannot tolerate conventional surgery, patients with vertebral burst fractures involving protrusion of bone fragments into the spinal canal, and patients with obvious neurological symptoms. Elderly patients with multisystem diseases are contraindications to surgery due to their higher risk of surgery. For patients with severe vertebral compression that cannot be treated with bone cement injection and involves paralysis due to nerve injury, surgical outcomes are expected to be poor because the vertebral height cannot be restored and neurological symptoms cannot be improved.

Intraoperative complications

Elderly patients are generally in poor physical condition, increasing the risk associated with general anesthesia and surgery. Such patients should adequately be informed and prepared before the surgery, the operation time should be shortened, and vital signs must be closely monitored intraoperatively. Because of the fragile bones of elderly patients, aggressive handling of the bone block can readily break the intact bone fragment in the spinal canal into small pieces. This is considered to be the cause of cerebrospinal fluid leakage in the present study. A wide basal bone pistol and uniform force should be used during surgery. Fragments that cannot be reset should be removed to reduce the intraspinal occupation rate. The bone cement injection process can be observed under direct vision to determine whether bone cement leakage or backward bone displacement occurs. When cement leakage occurs, the injection should be stopped immediately. Repeated X-ray by C-arm fluoroscopy is still necessary, which cannot be replaced by direct vision. Excessive vertebral height restoration and bone cement injection readily lead to bone cement leakage and re-protrusion of the bone block into the spinal canal. When the bone block is pushed back to the spinal canal, it must be restored over a period of time consistent with the time required for cement solidification.

Kyphoplasty and decompressive laminectomy has been proven to be effective and reliable. It provides a new treatment choice for elderly patients with OVBF and spinal canal occupation. However, the process still depends on the surgeon's clinical experience and skills. The indications for surgery and the regulation of bone cement require further study.

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Disclosure of conflict of interest

None.

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