Kyphoplasty versus vertebroplasty for treatment of osteoporotic vertebral compression fractures

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Background

The incidence of osteoporotic vertebral compression fractures increases with advancing age and is associated with significant healthcare expenditure. Patients who have sustained fractures from osteoporosis are at increased risk of additional fractures because of loss of bone strength caused by osteoporosis. Vertebroplasty is a minimally invasive vertebral augmentation procedure to relieve pain; it stabilizes the vertebral body. Kyphoplasty is a minimally invasive method for correction and augmentation of osteoporotic vertebral fractures.

Materials and methods

This study included two groups of patients suffering from painful osteoporotic vertebral compression fractures: the first group comprised 26 patients with 33 vertebral compression fractures treated by percutaneous vertebroplasty between April 2007 and October 2008. The results of this group were compared with those of another group of 18 patients (24 vertebrae) who were treated by kyphoplasty between November 2008 and July 2011. The visual analog scale (VAS) and the Oswestry Disability Index (ODI) were applied for the assessment of patients preoperatively and postoperatively.

Results

In the vertebroplasty group, the mean VAS score improved from 7.8 to 2.4 according to VAS and from 69 to 15 according to ODI. Cement leakage was noted in four patients (15.4%), without clinical consequence. Ten vertebrae (30.3%) revealed a mean improvement in vertebral height of 11% (8–14%). No patient showed progression of vertebral angles of the augmented vertebrae during the follow-up period. In the kyphoplasty group, the mean pain score improved from 8 to 2.1 according to VAS and from 71 to 17 according to ODI. Cement leakage was noted in two patients (11.11%), without clinical consequence. No thoracolumbar back pain was reported after kyphoplasty. Nineteen vertebrae (79.16%) revealed a mean improvement in vertebral height of 22% (range, 18–38%). No patient showed progression of vertebral angles of the augmented vertebrae during the follow-up period.

Conclusion

Both vertebroplasty and kyphoplasty resulted in significant improvement in VAS pain scores. Vertebroplasty, although less expensive than kyphoplasty, had a statistically greater risk for cement leakage and adjacent vertebral fracture.

Keywords:

kyphoplasty, osteoporotic vertebral compression fracture, vertebral height, vertebroplasty

Introduction

Osteoporotic vertebral compression fractures are a major healthcare problem. Symptomatic vertebral compression fractures (about 30% of all vertebral compression fractures occurring in the western world) can be associated with decreased quality of life and increased mortality in the elderly [1,2].

Irrespective of fracture pain, disability associated with vertebral compression fractures is apparently caused by changes in the alignment of the spine and is related to the severity of spinal deformity [3].

Different approaches for the treatment of painful osteoporotic vertebral compression fractures are currently available. Standard management includes bed rest, analgesia, bracing, or a combination of these. Prolonged bed rest leads to further loss of bone mass, whereas bracing cannot restore spinal alignment and is often poorly tolerated by older patients [4,5].

Percutaneous vertebroplasty and kyphoplasty are procedures used to treat pain associated with vertebral compression fractures. Controversies continue to exist on the indications, efficacy, and safety of the procedures and on the potential benefits, advantages,

and shortcomings of percutaneous vertebroplasty versus kyphoplasty.

The aim of this study was to compare the outcome of vertebroplasty with that of kyphoplasty for treatment of osteoporotic vertebral compression fractures.

Materials and methods

The vertebroplasty group included 26 patients with a total of 33 osteoporotic thoracolumbar vertebral compression fractures treated by vertebroplasty from April 2007 to October 2008. Nineteen patients (73.1%) were women and seven (26.9%) were men, with a mean age of 64 years (range, 52–71 years). The mean preoperative duration of symptoms was 8 weeks (6–12 weeks) (Figs 1 and 2; Tables 1 and 2).

In the kyphoplasty group, there were 18 patients with a total of 24 osteoporotic vertebral compression fractures treated by kyphoplasty from November 2008 to July 2011. Fourteen patients (77.77%) were women and four (22.22%) were men, with a mean age of 60 years (55–75 years). The mean preoperative duration of symptoms was 7.5 weeks (6–9 weeks).

Inclusion criteria: patients with osteoporotic vertebral compression fractures, refractory to conservative treatment for at least 6 weeks, were included in the study.

Exclusion criteria

(1) Vertebral compression fracture due to causes other than osteoporosis.
(2) Neurological symptoms or signs.
(3) Old injuries after more than 12 weeks.
(4) Stenosis of the vertebral canal of more than 30%.

Preoperative assessment for all patients included thorough history taking, clinical examination, anteroposterior and lateral radiographs, MRI, dual energy X-ray absorptiometry scans to assess the preoperative regional and local bone mass density, and measurement of kyphotic angles by Cobb's method.

Technique of vertebroplasty

Vertebroplasty was performed for all patients under local infiltration anesthesia deep down to the periosteum and in the prone position in addition to conscious sedation. A 2.0 mm Kirschner wire was advanced manually into the pedicle and through the posterior vertebral wall under the guidance of an image intensifier.

Thereafter, a vertebroplasty cannulated needle or an ordinary biopsy needle was introduced over the K-wire into the anteromedial part of the vertebral body. After removing the K-wire, low-viscosity polymethylmethacrylate was injected using a cement gun or a normal syringe under image control.
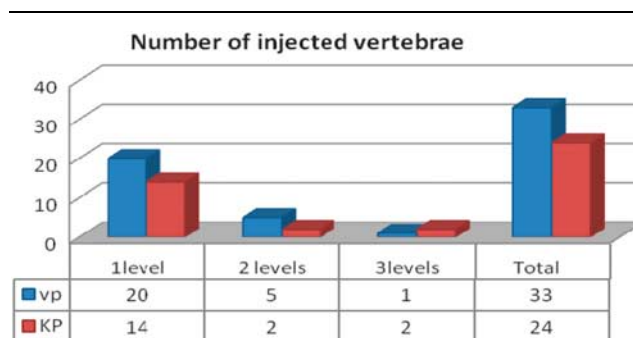
Vertebroplasty was performed at a single level in 20 patients (76.9%) for 20 affected vertebrae (60.1%), at two levels in five patients (19.2%) for 10 affected vertebrae

Figure 1
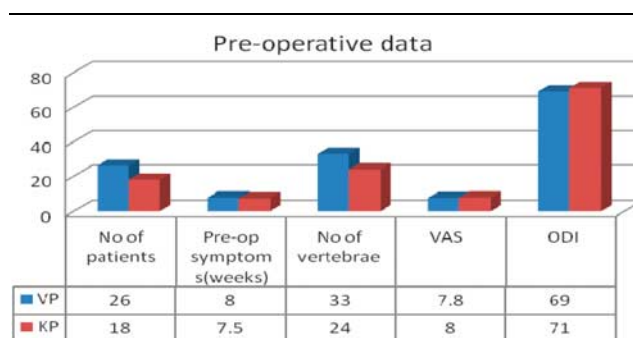
Demographic and preoperative data.

Figure 2

Number of vertebrae injected (levels).

Table 1 Demographic and preoperative data

	Vertebroplasty	Kyphoplasty
Mean age (years)	64 (52–71)	55–75
Male–female	19–7	14–4
Number of patients	26	18
Preoperative duration of symptoms (weeks)	8 (6–12)	7.5 (6–9)
Number of vertebrae injected	33	24
Mean preoperative VAS	7.8	8
Mean preoperative ODI	69	71

ODI, Oswestry Disability Index; VAS, Visual Analog Scale.

Table 2 Number of vertebrae injected (levels)

	Vertebroplasty [n (%)]	Kyphoplasty [n (%)]
One level	20 (60.6)	14 (58.33)
Two levels	5 (30.3)	2 (16.66)
Three levels	1 (9.1)	2 (25)
Total number of vertebrae injected	33 (100)	24 (100)

(30.3%), and at three levels in one patient (3.8%) for three affected vertebrae (9.1%). The injection time was 35–55 min for each level with a mean of 40 min.

Technique of kyphoplasty

A small incision is made in the back through which a narrow tube is inserted. Using fluoroscopy to guide it to the correct position, the tube creates a path through the

back into the fractured area through the pedicle of the involved vertebrae. Using radiographic images, a special balloon is inserted through the tube and into the vertebrae and then gently and carefully inflated. As the balloon inflates, it elevates the fracture, returning the pieces to a more normal position. It also compacts the soft inner bone to create a cavity inside the vertebrae. The balloon is removed and polymethylmethacrylate is injected. Kyphoplasty is performed under local anesthesia and sedation. The injection time was 35–55 min for each level with a mean duration of 48 min/level.

Percutaneous kyphoplasty was performed at a single level in 14 patients (77.77%) for 14 affected vertebrae (58.33%), at two levels in two patients (11.11%) for four affected vertebrae (16.66%), and at three levels in two patients (11.11%) for six affected vertebrae (25%). In either vertebroplasty or kyphoplasty, the procedure was performed by unipedicular injection in most of the cases, and bipedicular cement injection was applied in some cases when the distribution of cement was not satisfactory. Bone biopsy was obtained intraoperatively to exclude malignancy or osteomalacia in all cases.

The postoperative program was the same for both groups. The supine position was maintained for 2 h; sitting and standing under nursing supervision was allowed only after 2 h. NSAIDs may be needed for 3 days. Before discharge, each patient was evaluated for the development of back pain, chest pain, and neurological defects. A postoperative plain radiograph (anteroposterior and lateral views) was obtained to assess the distribution of the cement, filling of the vertebral body, and cement leakage and to measure the postoperative kyphotic angle. Patients may spend 1 day in the hospital after the kyphoplasty procedure. A short course of bracing was advised for high-risk patients. The patients were advised to restrict their activities until they were evaluated at the first follow-up visit after 2 weeks.

Medical treatment for osteoporosis (bisphosphonate or strontium ranelate in addition to calcium and vitamin D) was started immediately postoperatively for all patients. Two weeks postoperatively, all patients were advised to undergo a physical therapy program of at least 12 sessions for strengthening their paravertebral muscles.

For each patient, preoperative and postoperative pain were evaluated using VAS, and the functional outcome was evaluated using the ODI. These were performed preoperatively, on the second day postoperatively, and at 6 weeks, 3 months, 6 months, and 1 year postoperatively.

In the vertebroplasty group, the mean duration of follow-up was 12 months (6–21 months). In the kyphoplasty group, the mean duration of follow-up was 12 months (6–32 months).

Statistical analysis
For statistical analysis, preoperative and follow-up VAS scores, ODI scores, and radiographic vertebral height values were compared by Student's paired t-test using the SPSS program (SPPS Inc., Chicago, Illinois, USA).

Differences between groups were evaluated by Fisher's exact test. Correlations were investigated through Pearson's analysis. For all comparisons, a P-value of less than 0.05 was considered significant.

Results
In the vertebroplasty group
The mean pain score (VAS) improved significantly from 7.8 preoperatively to 2.4 postoperatively. The ODI improved from 69 preoperatively to 15 postoperatively. The mean injected volume of cement per vertebral body was 4.1 ml (1.2–6.9 ml). Four cases (15.4%) had extra-vertebral leakage of cement but without clinical consequence in any patient. As regards restoration of the vertebral height of the augmented vertebrae in relation to the adjacent sound level, 10 vertebrae (30.3%) revealed a mean improvement of 11% (8–14%) in vertebral height. Five cases (19.2%) had an adjacent fracture at the end of follow-up. No patient showed progression of kyphotic angles of the augmented vertebrae during the follow-up period. None of the patients reported aggravation of symptoms after the procedure (Fig. 3 and Table 3).

In the kyphoplasty group
The mean pain score improved from 8 preoperatively to 2.1 postoperatively according to VAS and from 71 preoperatively to 17 postoperatively according to ODI. The mean injected volume of cement per vertebral body was 5.1 ml (3.2–6.4). Cement leakage was reported in two patients (9.09%) with extravertebral leakage of cement but without clinical consequence in any patient. Two patients (11.1%) had an adjacent fracture at the end of follow-up. With regard to restoration of the vertebral height of the augmented vertebrae in relation to the adjacent sound level, 19 vertebrae (79.16%) revealed a mean improvement of 22% (17–38%) in vertebral height. No patient showed progression of kyphotic angles of the augmented vertebrae during the follow-up period. None of the patients reported aggravation of symptoms after the procedure.

Discussion
Vertebral compression fractures occur more frequently than hip and ankle fractures combined. These fragility fractures frequently result in both acute and chronic pain, but more importantly, they are a cause for increased morbidity and possibly mortality. For those patients with severe pain or progressive collapse due to osteoporotic or osteolytic vertebral compression fractures, early vertebral augmentation affords excellent early pain relief, early return to function, and restoration and maintenance of sagittal alignment. Both vertebroplasty and kyphoplasty allow for the introduction of bone cement into the fracture site, with clinical results indicating substantial pain relief in ∼90% of patients [6,7].

Vertebroplasty involves percutaneous injection of bone cement into the fractured vertebra/e in order to stabilize
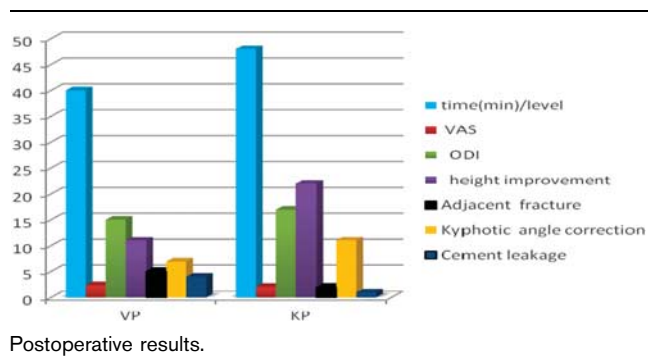
Figure 3

Postoperative results.

Table 3 Postoperative results

	Vertebroplasty	Kyphoplasty
Mean cement volume used (ml)	4.1	4.7
Mean operative time/level (min)	40	48
Cement leakage [n (%)]	4 (15.4)	2 (11.11)
Mean postoperative VAS	2.4	2.1
Mean postoperative ODI	15	17
Mean vertebral height improvement (%)	11	22
Adjacent level fracture [n (%)]	5 (19.23)	2 (11.11)
Mean kyphotic wedge angle correction (%)	11	22

ODI, Oswestry Disability Index; VAS, Visual Analog Scale.

the fracture. Kyphoplasty involves an initial step of expansion of a balloon into the vertebral body, which creates a cavity to be filled with bone cement and allows for reduction of the fracture. Vertebroplasty and kyphoplasty have so far been proposed as alternative techniques because of the presumed possibility of reduction of the vertebral body deformity by kyphoplasty [5,8,9]. Vertebroplasty has also been reported to be involved in fracture reduction [10].

To date, a few prospective studies have reported comparative results of kyphoplasty and vertebroplasty in patients affected by osteoporotic vertebral compression fractures [11].

Both vertebroplasty and kyphoplasty result in significant improvement of VAS pain scores. Vertebroplasty leads to a significantly greater improvement in the pain score but has a statistically greater risk for cement leakage and new fracture [12].

Costa et al. [13] treated 34 patients suffering from 42 thoracolumbar fractures. The mean preoperative VAS score was 8.32 (range 5–10). Vertebroplasty was performed in 25 patients (73.5%) and kyphoplasty in nine (27.5%); 27 patients showed a single-level fracture and seven showed multilevel fractures. Pain relief and disability, analyzed by VAS and ODI, showed good results at late follow-up.

Direct comparison between vertebroplasty and kyphoplasty is not possible because of the lack of prospective randomized data comparing the two procedures. Both appear to improve patient functional status in most studies. Overall complication rates for both procedures

are low. Systematic reviews have found significantly higher rates of cement leakage after vertebroplasty (40%) compared with kyphoplasty (8%), with 3% of vertebroplasty leaks being symptomatic [14]. In our study, cement leakage occurred in four patients of the vertebroplasty group (15.4%) and two patients of the kyphoplasty group (11.11%).

Liu et al. [15] treated 100 patients with vertebral compression fractures at the thoracolumbar junction who were randomly assigned to two groups: vertebroplasty and kyphoplasty (50 patients each). More polymethylmethacrylate was used in the kyphoplasty group than in the vertebroplasty group $(5.56 \pm 0.62$ vs. 4.91 ± 0.65 ml). The vertebral body height and kyphotic wedge angle of the T-L spine were also improved. Two patients in the kyphoplasty group had a fracture in the adjacent segment. In terms of clinical outcome, there was little difference between the treatment groups.

Significant differences were noted in multiple comparisons between vertebroplasty and kyphoplasty, including length of hospital stay and discharge to long-term facilities. However, these findings may simply reflect differences in practice patterns rather than real differences in efficacy between the procedures [16].

Han et al. [17] carried out a systematic review and meta-analysis of randomized and nonrandomized controlled trials comparing vertebroplasty with kyphoplasty. The outcome showed that vertebroplasty is more effective for short-term pain relief. Kyphoplasty had superior capability for intermediate-term functional improvement. As for long-term pain relief and functional improvement, there is no significant difference between these two interventions. Consistently, both interventions have a similar risk for subsequent fracture and cement leakage. Considering the higher cost of the kyphoplasty procedure, they recommend vertebroplasty over kyphoplasty for the treatment of osteoporotic vertebral compression fractures.

Kim et al. [18] treated 103 patients for osteoporotic vertebral compression fractures by either vertebroplasty $(n = 58)$ or kyphoplasty $(n = 45)$. Kyphoplasty was more effective than vertebroplasty, especially for middle column height restoration and bone cement leakage prevention. However, posterior column vertebral height was not restored in either the kyphoplasty group or the vertebroplasty group. The clinical outcomes did not differ between the two groups.

Both unipedicular kyphoplasty and bipedicular kyphoplasty can achieve satisfactory clinical and radiographic outcomes in the treatment of chronic painful osteoporotic vertebral compression fractures; the operation time is shorter in unipedicular kyphoplasty. However, bipedicular kyphoplasty is more efficacious for height restoration [19].

In our study, the procedure was performed by unipedicular injection in most cases, and bipedicular cement injection was applied in some cases when the distribution of cement was not satisfactory, as seen by intraoperative

radiology (two cases of vertebroplasty and only one case of kyphoplasty).

In our study, vertebral height restoration and kyphotic angle reduction were achieved in both groups, but the correction of spinal deformity was more significant in the kyphoplasty group. From a biomechanical perspective, height restoration and angular deformity correction may result in a reduced rate of subsequent fracture by reducing anterior stress. In our study, adjacent fractures were found in five patients of the vertebroplasty group and two patients of the kyphoplasty group.

Conclusion

Percutaneous vertebroplasty and kyphoplasty are two safe and effective techniques for the treatment of osteoporotic thoracolumbar fractures, and they allow good pain control and subsequent normal working activity and social life.

In terms of clinical outcome, there was little difference between the two techniques. Both techniques resulted in significant improvements in VAS and ODI scores. However, the kyphotic balloon procedure entailed higher cost and more exposure to an image intensifier, whereas vertebroplasty showed a statistically greater risk for cement leakage and adjacent vertebral fracture.

Kyphoplasty has a significant advantage over vertebroplasty in terms of kyphosis correction, vertebral height restoration, and cement leakage prevention. The benefits of these relative merits need to be ascertained in future long-term studies.

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