Pain reduction following vertebroplasty and kyphoplasty

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Abstract

Purpose To evaluate the clinical efficacy, especially the pain reduction, of vertebroplasty and balloon kyphoplasty in the treatment of osteoporotic vertebral compression fractures (OVCFs).

Methods Eighty-six patients with OVCFs were treated with vertebroplasty or balloon kyphoplasty. All patients were followed up for seven–36 months. Visual analog scale (VAS), vertebral height, and local kyphotic angle were evaluated at pre-operation, postoperation, and final follow-up.

Results The VAS pain score decreased significantly after surgery in both kyphoplasty and vertebroplasty groups ($p<0.001$), and the improvement of VAS score had no significant difference between the two groups ($p=0.826$). There was a significant difference in the improvement of vertebral height ($p<0.001$) and local kyphotic angle ($p<0.001$) between the two groups. Improvement of VAS score had no correlation with improvement of vertebral height (vertebroplasty: $r=-0.029$, $p=0.869$; kyphoplasty: $r=0.175$, $p=0.219$) or local kyphotic angle (vertebroplasty: $r=0.159$, $p=0.361$; kyphoplasty: $r=0.144$, $p=0.312$) in either group.

Conclusion Vertebroplasty and kyphoplasty are effective procedures for the reduction of pain in OVCFs, and they have the same efficient effect on pain reduction. Correction of vertebral height and local kyphosis may have minimal effect on pain reduction.

Introduction

The ageing of the population all over the world has brought more attention to osteoporosis. Approximately 1.7 million

vertebral compression fractures occur in America and in Europe annually, and osteoporosis remains the most common cause of vertebral compression fractures [1]. Osteoporotic vertebral compression fractures (OVCFs) cause spinal misalignment, particularly kyphosis, and backache is a significant complaint for patients with OVCFs.

Vertebroplasty (VP), which was first reported in 1987, is a minimally invasive procedure to treat OVCFs [2]. Since then, VP has been performed to alleviate pain caused by various types of vertebral compression fracture, and dramatic effectiveness in this regard has led to frequent use [3]. VP is also useful for backache caused by OVCFs [4]. As another effective minimally invasive procedure, kyphoplasty (KP), which was developed from VP, uses an inflatable bone tamp to create a cavity in the fractured vertebral body and then bone cement is deposited into the cavity [5]. Like VP, KP can improve backache, and has a better effect on reducing kyphosis and restoring the height of the vertebral body [6].

Previous studies reported that kyphoplasty had better effects on reduction of vertebral compression fractures than vertebroplasty did, but was not superior to vertebroplasty in pain relief [7, 8]. We hypothesized that correction of vertebral height and local kyphosis may have minimal effect on pain reduction, but there are few studies that have appropriate data to evaluate the relationship between them.

Methods

Patients

The study included 86 patients (52 women and 34 men, aged 60–81 years, with a mean age of 70.1 years) with a total of 94 OVCFs that were analysed. Bone mineral density of the lumbar spine was 0.616 ± 0.15 g/cm². Of these patients, 35 (aged from 62 to 81 years, mean 70.5 years) with 37 OVCFs were subjected to VP; the treated levels included T9 ($n=1$), T11 ($n=6$), T12 ($n=11$), L1 ($n=11$), L2

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($n=5$), and L3 ($n=3$). KP was adopted to the other 51 patients (aged from 60 to 80 years, mean 69.8 years) with 57 OVCFs; the treated levels included T10 ($n=2$), T11 ($n=12$), T12 ($n=17$), L1 ($n=15$), L2 ($n=9$), and L3 ($n=2$). All fractures involved gradual collapse of the vertebral body. Potential subjects were excluded from participation if they had previous surgery of the spine, significant scoliosis, or a neurologic disorder.

Procedures

The purpose and procedures involved in the study were fully explained to the patients, and informed consent was obtained before data collection. Weight (kg) and height (cm) of each patient were measured. Arm span was measured with a tape measure, as the distance between the tips of the middle fingers as subjects stood against a wall with their arms extended laterally at shoulder level. This measurement has been found to be more representative of the true height in subjects with spinal deformity [6]. Before operation, a comprehensive assessment of the patients' general condition was performed.

Surgical procedures

KP was performed with the patient in a prone, lordotic position, with a bolster placed under the sternum and pelvis to facilitate the reduction of the fractured vertebral body. Using C-arm fluoroscopy visualization, transpedicular puncture was performed. If the vertebral body was compressed into a V-shape, puncture was performed from the "10 o'clock" and "2 o'clock" positions on the anteroposterior projection of the pedicles. If the vertebral body was compressed

horizontally, puncture was performed from the "9 o'clock" and "3 o'clock" positions. The bone needle was inserted on both sides. After reaching the posterior margin of the vertebral body, the bone needle was exchanged for a working cannula, and a sample of the fractured bone was removed for histologic analysis. Bilateral balloon placement under the fractured endplate was performed. Balloons were inflated with radio-opaque media and deflated after elevating the superior endplate and achieving height restoration and kyphosis correction. The pre-formed cavity was filled with polymethylmethacrylate (PMMA) cement after the balloon was withdrawn; C-arm fluoroscopy was used to monitor cement distribution, to avoid leakage. Fluoroscopic examination was performed after crystallization.

The procedure of VP was much the same as KP, but without insertion and inflation of the balloon. After the bone needle was exchanged for a working cannula, cement filling was done using C-arm fluoroscopic visualization.

Assessment indices

Pain was evaluated using a visual analogue scale (VAS: 0=no pain at all, 10=worst pain imaginable). Radiographs were taken to measure the anterior and posterior vertebral height and local kyphotic angle (LKA, Cobb's method) of the fractured vertebral body before surgery, after surgery (two days after operation) and at the last follow-up. Points (a) and (c) were placed at the most anterosuperior and posterosuperior end-plate margins, respectively, and points (b) and (d) at the most anteroinferior and posteroinferior margins. Vertebral height was the distance between identical points on the superior and inferior end-plates at the anterior (anterior vertebral height, line ab) and posterior location (posterior vertebral height, line cd) and

Fig. 1 Radiograph showing the measurement of the vertebral height (anterior vertebral height, line ab, posterior vertebral height, line cd)

Fig. 2 Radiograph showing the measurement of the local kyphotic angle (LKA)

(posterior vertebral height, line cd) [9] (Fig. 1). LKA was measured by making a straight line from the superior end plate of the vertebra one level above the treated vertebra and a straight line from the inferior end plate of the vertebral body one level below the treated vertebra. The two lines were then drawn to perpendicularly intersect each of these lines. The angle that was formed by the intersection of the two perpendicular lines was then measured [6] (Fig. 2). All radiographic measurements were performed in a double-blinded fashion by two physicians.

Statistical analysis

All data were expressed as mean $\pm$ standard deviation (SD). Measurement data including VAS score, anterior and posterior height of the fractured vertebral body, and LKA before and after VP or KP were compared using a paired student's t-test. The comparisons between the two groups were made by student's t-test. Pearson correlation coefficients were calculated to assess the relationship between the decreased values of pain scores (VAS) and the improvement of anterior vertebral height and LKA. $p < 0.05$ indicated statistical significance.

Results

Characteristics of patients

Mean values of age, height, arm span, and weight of patients are presented in Table 1. The mean measured height of subjects in the VP group was 156.7 cm and the mean arm span was 158.7 cm, representing, on average, a 2.0 cm reduction of height in patients. In the KP group, the mean height, arm span, and reduction of height was 156.6 cm, 158.7 cm, and 2.1 cm respectively.

Clinical outcomes

All 86 patients tolerated the operation well. Patients had follow-up from seven to 36 months (mean: 21.3 months). The VAS pain score decreased significantly in both groups: from a preoperative value of 8.29 ± 0.94 , to a postoperative value of 3.01 ± 1.13 ($p < 0.001$) in the KP group, and from 8.21 ± 1.02 to 2.96 ± 0.84 ($p < 0.001$) in the VP group. The score decreased further to 2.64 ± 0.87 and 2.65 ± 0.81 at final follow-up after KP and VP respectively, but was not significantly different from the postoperative value ($p = 0.07$ in KP

Table 1 Physical characteristics of patients

Variable	VP group (N=35)			KP group (N=51)		
	Mean	SD	Range	Mean	SD	Range
Age (y)	70.5	5.7	62–81	69.8	6.4	60–80
Height (cm)	156.7	4.9	146.4–168.2	156.6	5.0	146.4–169.8
Arm span (cm)	158.7	5.2	149.2–170.9	158.7	4.8	150.8–172.0
Weight (kg)	58.8	6.5	45.0–71.2	59.7	6.7	46.1–77.1

KP kyphoplasty; VP Vertebroplasty

Table 2 Comparison of VAS score, vertebral height, and LKA

Variable	Preoperative		Postoperative		Final follow-up	
	VP (N=35)	KP (N=51)	VP (N=35)	KP (N=51)	VP (N=35)	KP (N=51)
VAS score	8.21±1.02	8.29±0.94	2.96±0.84*	3.01±1.13*	2.65±0.81*	2.64±0.87*
Anterior vertebral height (mm)	13.72±2.36	13.76±2.43	15.65±2.34*	19.20±2.13*	15.62±2.34*	18.89±2.26*
Posterior vertebral height (mm)	21.83±1.97	21.90±2.03	22.30±1.96*	23.26±1.75*	22.28±1.96*	23.14±1.66*
LKA (°)	23.28±6.99	23.25±6.82	20.97±6.80*	14.93±5.32*	21.20±6.85*	15.64±5.31*

KP kyphoplasty; VP Vertebroplasty; LKA local kyphotic angle; VAS visual analogue scale (VAS: 0=no pain at all, 10=worst pain imaginable)

*Significant difference at $p<0.01$ compared with before surgery

group, $p=0.11$ in VP group) (Table 2). Mean improvement in LKA was 2.31° and 8.32° after VP and KP respectively. The mean restoration of anterior and posterior height of the fractured vertebral body was 1.93 mm and 0.47 mm, respectively after VP; and 5.44 mm and 1.36 mm, respectively after KP. The differences of improvement of LKA and vertebral body height between VP and KP were statistically significant ($p<0.001$). There was no significant loss in the height or the kyphotic angle of the treated vertebra at final follow-up, in all the patients. The improvement of VAS score had no significant correlation with the improvement of vertebral height ($r=-0.029$, $p=0.869$ in VP group, $r=0.175$, $p=0.219$ in KP group) or LKA ($r=0.159$, $p=0.361$ in VP group, $r=0.144$, $p=0.312$ in KP group) (Table 3).

Discussion

In our study, VP and KP were performed to relieve the patients' backache, to improve kyphosis, and to restore the height of the vertebral body. Though VP had less efficient effect on the improvement of vertebral body height and kyphosis, it had the same efficient effect on pain reduction with KP. There was no statistical correlation between pain reduction and correction of vertebral height or local kyphosis in either group. These results were comparable with previous studies [10, 11].

Table 3 Correlation coefficient (r) between the decreased values of VAS and improvement of the anterior vertebral height and LKA

	VP group (N=35)		KP group (N=51)	
	r	p	r	p
Δ Anterior vertebral height	-0.029	0.869	0.175	0.219
Δ LKA	0.159	0.361	0.144	0.312

KP kyphoplasty; VP Vertebroplasty; LKA local kyphotic angle

The causes of pain in OVCFs are multifactorial, due mainly to micro-movement of the vertebral fracture [12]. Effective pain reduction and satisfactory clinical outcomes can be obtained after elimination of the microfractures and vertebral stabilization [13].

For OVCFs patients with neurological symptoms, decompression, improvement of kyphosis, and spinal stabilization are the primary indications for surgery [14, 15]. For most patients without neurological symptoms, vertebroplasty or kyphoplasty is an ideal choice. Minimally invasive injection of bone cement can stabilize the fracture, stop the abnormal motion, restore vertebral height, and correct the kyphosis. Consistent with previous studies [16], we found significant pain reduction following both VP and KP. Pain relief after VP and KP is generally believed to result from the stabilization of the fractured vertebrae and elimination of microscopic and/or macroscopic motion at the fracture site [16–19]. Other postulated mechanisms of pain relief include a chemical neurolytic effect of PMMA and a thermal neurolytic effect of the PMMA exotherm [17, 18]. Factors separate from instillation of PMMA may also account for pain relief. Such factors may include the impact of local anesthesia, as well as nonspecific effects such as expectations of pain relief ("placebo effect"), natural history, and regression toward the mean [20, 21].

Some studies have shown a relationship between back pain and the severity of the hyperkyphosis in osteoporotic vertebra [22, 23], although other studies did not support this finding [5, 24]. Our study did not find an association. KP had better effects on reduction of vertebral compression fractures than VP did, but was not superior to VP in pain relief. The improvement of VAS score had no significant correlation with the improvement of anterior vertebral height or LKA. These suggest that the severity of back pain might be unrelated to the severity of the kyphosis or the vertebral height loss, and correction of vertebral height and local kyphosis may not affect the efficacy of pain reduction for OVCFs after VP and KP.

Conclusion

VP and KP are effective procedures for the reduction of pain in OVCFs, and they have the same efficient effect on pain reduction. Correction of vertebral height and local kyphosis may have minimal effect on pain reduction.

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