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Significance of dynamic mobility in restoring vertebral body height in vertebroplasty

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Significance of dynamic mobility in restoring vertebral body height in vertebroplasty

Abstract

Background and Purpose: Many authors have reported the increase in vertebral body height after vertebroplasty. However, McKiernan demonstrated dynamic mobility in patients who underwent vertebroplasty, and concluded that any article that claims vertebral height restoration must control for the dynamic mobility of fractured vertebra. The purpose of this study was to compare pre-vertebroplasty (supine cross-table with a bolster beneath) with post-vertebroplasty vertebral body height to find out whether vertebroplasty itself really increases the vertebral height.

Materials and Methods: From July 2005 to July 2010, 102 consecutive patients with 132 VCFs underwent vertebroplasty at our institution. The indications for vertebroplasty were severe pain that was not responsive to medical treatment, and MRI confirmed edematous lesions. Pre-vertebroplasty (supine cross-table with bolster beneath) lateral radiographs were compared to post-vertebroplasty radiographs to evaluate the height change in vertebroplasty. Kyphotic angle and anterior vertebral body height were measured.

Results: The patients ranged in age from 62 to 90 years. There were 16 men and 86 women. The difference of kyphotic angle between supine cross-table with bolster and post-vertebroplasty was -0.49 ± 3.59º (range, -9 to 16º), which was not statistically significant (P=0.124).The difference of anterior vertebral body height between supine

cross-table with bolster and post-vertebroplasty was 0.84 ± 3.01 mm (range, -7.91 to 8.81 mm), which was statistically significant (*P=0.002*).

Conclusions: The restoration of vertebral body height in vertebroplasty seems to be mostly due to the dynamic mobility of fractured vertebrae; vertebroplasty itself does not contribute much to the restoration of vertebral height.

Key words: dynamic mobility, height increase, osteoporosis, vertebral compression fractures, sitting and supine radiographs, vertebroplasty.

Abbreviation Key: VCF = vertebral compression fracture; MRI = magnetic resonance imaging; STIR = short-tau inversion recovery; AP = anteroposterior; VAS = visual analog scale; PACS = picture archiving and communication system; SD = standard deviation

Introduction

Hiwatashi and colleagues found increases in vertebral body height after vertebroplasty and published their results in 2003.[1] Since then, several articles related to height increase after vertebroplasty or kyphoplasty have been reported.[2-5] These articles all concluded that vertebroplasty or kyphoplasty can increase the height of fractured vertebrae. They proposed that the mechanism of increase in vertebral body height is probably related to padding beneath the upper chest and pelvic region, injection of the high viscosity bone cement under pressure, or balloon tamps. However, McKiernan et al demonstrated dynamic mobility in 44% of 41 patients (35% of treated vertebrae) who underwent vertebroplasty.[6] They concluded that any article that claims vertebral height restoration must control for the dynamic mobility of fractured vertebrae. A recent study, which used sitting and supine cross-table (with a bolster beneath) lateral radiographs, demonstrated that dynamic mobility occurred in 87.5% of the treated vertebrae.[7] They found that 87.5% of 144 MRI-proven edematous vertebral compression fractures (VCFs) were demonstrated to be mobile. The average vertebral body height increase from sitting position to supine with bolster was 8.48 ± 5.36 mm. Since high percentages of fractured vertebrae are mobile, the following question needs to be answered: what is the real reason for vertebral body height increase in vertebroplasty?

The objective of this study was to compare pre-vertebroplasty (supine cross-table with a bolster beneath) with post-vertebroplasty vertebral body height to evaluate factors that may correlate with these changes in height (including the occurrence and degree of mobility of the fractured vertebral endplates).

Materials and Methods

From July 2005 to July 2010, 102 consecutive patients with 132 osteoporotic VCFs underwent vertebroplasty at our institution. The Institutional Review Board approved this radiographic analysis. The indications for vertebroplasty were severe pain that was not responsive to medical treatment and magnetic resonance imaging (MRI)-confirmed edematous lesions (hyperintensity signal on short-tau inversion recovery [STIR] sequence and/or contrast enhancement on fat-suppressed gadolinium-enhanced T1-weighted imaging). Pre- and post-vertebroplasty anteroposterior (AP) and lateral radiographs were obtained. In addition, a pre-procedural sitting lateral radiograph centered on the fractured vertebra and a supine cross-table lateral radiograph centered on the index vertebra with a bolster (10 cm in height) placed beneath were obtained for each patient.

The kyphotic angles of the VCFs were measured from the superior and inferior endplate of the fractured vertebra. Measurement of the anterior vertebral body height

of the fractured vertebra was based on the techniques used by McKiernan et al.[8] In order to eliminate the inter-radiographic magnification error, we matched each index VCF to the referent vertebra on the sitting lateral radiograph. Each index-referent vertebral pair remained constant throughout the analysis. For supine cross-table with bolster and post-vertebroplasty lateral radiographs, dimensions of the index vertebra were expressed as percentage of the analogous dimension of the referent vertebra, and then scaled to the absolute dimensions of the original sitting lateral radiograph. This cancelled out any residual inter-radiographic magnification error and allowed for direct radiographic comparisons. For outcome measurement, a visual analog scale (VAS) with 10 divisions was used.

Digital files of the patients' radiographs were retrieved for analysis from the picture archiving and communication system (PACS). Two of the authors (D-F L and Y-J C) performed the measurements. Intra-observer and inter-observer reproducibility of these measurements was evaluated by using intra-class correlation coefficients.

Statistical analysis

The results are expressed as the mean ± the standard deviation (SD). The statistical significance of changes in vertebral body height and the kyphotic angle was evaluated with the paired *t* test. A P value < 0.05 was considered to indicate a statistically significant difference. All statistical analyses were carried out using the statistical

package SPSS 12.0 (SPSS Inc., Chicago, IL, USA), Windows version.

Results

One hundred two patients underwent vertebroplasty to treat 132 MRI-proven edematous VCFs. The patients ranged in age from 62 to 90 years (mean, 76.97 years). There were 16 men and 86 women. Seventy-four patients (72.5 %) had 1-level fracture, 26 patients had 2-level fractures, and 2 patients had 3-level fractures. L1 was the most common level affected (n = 32), followed in order by T12 (n = 31), and L2 (n =17).

Pain assessed by the VAS was significantly decreased (P <0.001) from a mean of 8.91 ± 0.74 (range, 7 to 10) before the procedure to 1.90 ± 1.48 (range, 0 to 9) after 1-month follow-up. Ninety-one patients (89%) were satisfied with the results. Only one patient described having no improvement in pain after vertebroplasty.

Intra-observer (Y-J C) reproducibility was 0.93 for height of the vertebral body and 0.96 for kyphotic angle. Inter-observer reproducibility was 0.94 for height and 0.93 for the kyphotic angle. The average kyphotic angle on sitting lateral radiographs was 17.96 ± 8.45º (mean ± SD) (range, 0 to 40º). It changed to 7.22 ± 7.24º (range, -15 to 26º) on supine cross-table with bolster radiographs, and 7.71 ± 6.83º (range, -9 to 29º) on post-vertebroplasty radiographs. The average anterior vertebral height on

sitting lateral radiographs was 13.83 ± 7.01 mm (range, 1.12 to 29.87 mm). It changed to 22.01 ± 6.28 mm (range, 6.09 to 38.53 mm) on supine cross-table with bolster lateral radiographs, and 21.24 ± 5.59 mm (range, 6.11 to 37.51 mm) on post-vertebroplasty radiographs (Table 1). The pre-vertebroplasty (supine with bolster) anterior vertebral body height was higher than the post-vertebroplasty anterior vertebral body height in 87 vertebrae (65.9%). The difference in the kyphotic angle between supine cross-table with bolster radiographs and post-vertebroplasty radiographs was -0.49 ± 3.59º (range, -9 to 16º), which was not statistically significant (*P*=0.124). The difference in anterior vertebral body height between supine cross-table with bolster radiographs and post-vertebroplasty radiographs was 0.84 ± 3.01 mm (range, -7.91 to 8.81 mm), which was statistically significant (*P=0.002*).

Eighty-one percent (107/132) vertebrae had height increase >3 mm (10.3 ± 5.1 mm) from sitting to supine cross-table with bolster radiographs; 19% (25/132) vertebrae had height increase ≦3mm. Seventy-nine percent (104/132) vertebrae had improvement in the degree of kyphosis >5º (-12.9 ± 5.7º) from sitting to supine cross-table with bolster radiographs. Of those 25 vertebrae with fixed height (height increase≦3mm) from sitting to supine cross-table with bolster radiographs, only 4 (16%) had height increase >3 mm (mean 4.7mm, range 3.1-6.9mm) after vertebroplasty.

Discussion

A large part of the success of vertebroplasty depends on correct patient selection, and MRI plays a vital role in this process.[9] Many authors[9-11] recommended using MRI as pre-procedural examination. Brown et al[12] stated that 100% of patients with bone marrow edema had clinical benefit. We followed this rule, and vertebroplasty was performed in vertebrae with bone marrow edema in MRI. If the patient is contraindicated for MRI, we will use dynamic radiographs (sitting and supine with bolster) to find out which vertebrae is symptomatic (dynamic mobility) after we rule out the possibility of infection. If a patient suffered from severe back pain without edematous lesion in MRI, we will also use dynamic radiographs to check the mobility. Usually, if the pain is severe, there always has some dynamic mobility at the fractured vertebra.

Hiwatashi et al measured the height of 85 vertebral bodies in 37 patients before and after vertebroplasty.[1] The average increase in vertebral body height was 2.5 mm; 13 of 85 treated vertebrae remained unchanged. They concluded that vertebral body height often increases during vertebroplasty. Teng et al reviewed digital radiographs of 73 vertebral bodies in 53 patients before and after vertebroplasty and found that the restoration percentage for the height of the vertebral body was 29% for the anterior border.[2] They therefore also concluded that vertebroplasty increases the height of a

fractured vertebra. Many other authors have also reported increased vertebral body height from vertebroplasty (with or without any reduction maneuver) or kyphoplasty.[3-5,13-15]

However, McKiernan et al demonstrated dynamic fracture mobility in 44% of their patients (35% of treated vertebrae) who underwent vertebroplasty.[6] They concluded that in any article for which vertebral height restoration is claimed, the occurrence of dynamic mobility of the fractured vertebra must be controlled for. In a study of Chen et al, 87.5% of 144 MRI-proven edematous VCFs were demonstrated to be mobile.[7] The average vertebral body height increase from sitting to supine with bolster lateral radiograph was 8.48 ± 5.36 mm (range, -1.17 to 24.04 mm), which was statistically significant ($P < 0.001$). Based on these findings, we proposed that dynamic mobility of a fractured vertebra may contribute to height restoration in vertebroplasty.

As McKiernan et al mentioned, since any article that claims vertebral height restoration must control for the occurrence of dynamic mobility of the fractured vertebra, we compared the vertebral body height between supine with bolster lateral radiographs and post-vertebroplasty radiographs to decide whether the height increase comes from the dynamic mobility of fractured vertebra or from vertebroplasty itself. In this study, the difference in the kyphotic angle between supine cross-table with

bolster radiographs and post-vertebroplasty radiographs was -0.49 ± 3.59º (range, -9 to 16º), which was not statistically significant (*P*=0.124).That means there was no significant difference between the kyphotic angle on supine with bolster and post-vertebroplasty radiographs; the correction of the kyphotic angle was due to the dynamic mobility of fractured vertebrae, not due to vertebroplasty itself. Vertebroplasty itself did not contribute to the correction of the kyphotic angle.

The difference in anterior vertebral body height between supine cross-table with bolster and post-vertebroplasty radiographs was 0.84 ± 3.01 mm, which was significant (*P=0.002*). That means the anterior vertebral body height restoration on supine with bolster radiographs was more than that on post-vertebroplasty radiographs, and was statistically significant. However, the difference was so small it may not have any clinical significance. Why is the vertebral height on supine with bolster radiographs higher than the height on post-vertebroplasty radiographs? It is because of the bolster that causes the fractured vertebrae to be in a hyperextended position (Fig 1B); the degree of hyperextension is less during vertebroplasty (Fig 1C). But the difference is not much, only 0.84 ± 3.01 mm.

Theoretically, if the vertebra is fixed, there should have no any height increase after vertebroplasty. Why some fixed vertebrae (height increase ≦3mm) had the height increase after vertebroplasty in our study? The reasons may be due to poor

positioning of the bolster so the fractures didn't open well; pain-induced muscle spasm during the examination, and some measurement error due to poor quality of radiographs. This situation only happened in fractures with mild mobility.

The weaknesses of this study are: (1) as a retrospective study from a single center, there was potential for several biases (referral bias, patient characteristics, etc); (2) The number of patients enrolled was small; (3) Patients were screened using MRI and not other modalities, and had to show signs of edema – this group may not be representative of all patients, or all fractures, undergoing vertebroplasty; (4) Although we tried our best to measure the radiographs correctly, there may be still some measurement error.

Conclusion

The restoration of vertebral body height in vertebroplasty seems to be mostly due to the dynamic mobility of fractured vertebrae; vertebroplasty itself does not contribute much to the restoration of vertebral height.

If height restoration is mainly due to dynamic mobility, and can be restored by posture reduction, we should try to get a better height restoration by using towel rolls under the shoulders and hips to hyper-extend the back and open the fracture cleft.

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Table 1. The average kyphotic angle and vertebral body height in pre-procedural and post-procedural lateral radiographs.

	Pre-procedure		Post-procedure	*p*-value[+]
	Sitting	Supine with bolster		
Kyphotic angle	17.96 ± 8.45º	7.22 ± 7.24º	7.71 ± 6.83º	0.124
Vertebral height (mm)	13.83 ± 7.01	22.01 ± 6.28	21.24 ± 5.59	0.002*

The results are expressed as the mean ± the standard deviation.

[+] P values is the statistical significance of changes in pre-procedure (supine with bolster) and post-procedure.

* Significant at *p*-value < 0.05

Figure Legends

FIGURE 1. A 62 year-old woman suffered from severe back pain due to T12 compression fracture. The anterior vertebral body height in sitting (A) lateral radiograph is 7.23 mm, changed to 21.22 mm in supine with bolster (B) lateral radiograph, and 15.41 mm in post-vertebroplasty radiograph.

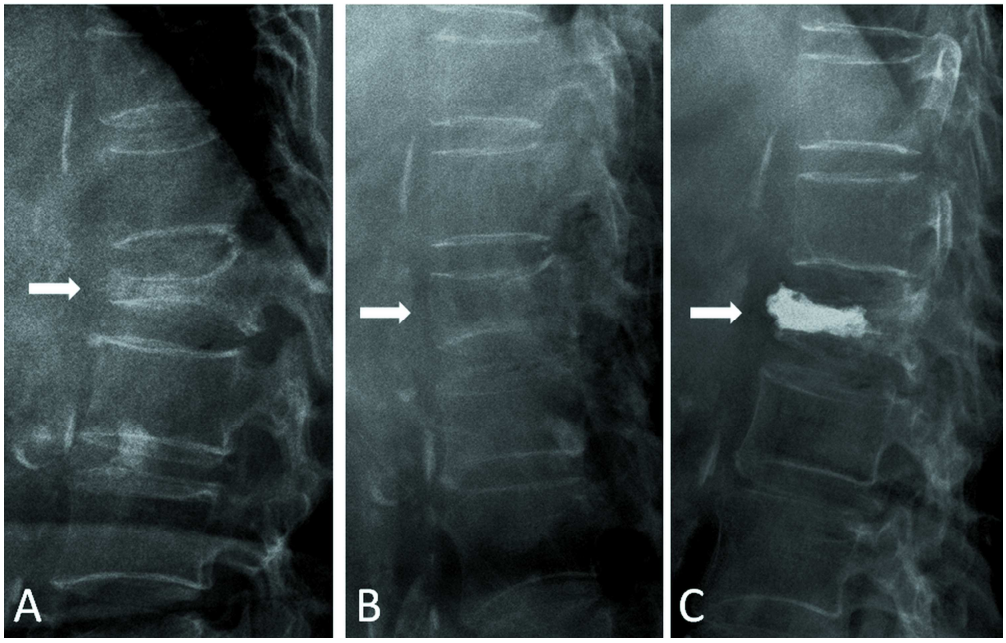

FIGURE 1. A 62 year-old woman suffered from severe back pain due to T12 compression fracture. The anterior vertebral body height in sitting (A) lateral radiograph is 7.23 mm, changed to 21.22 mm in supine with bolster (B) lateral radiograph, and 15.41 mm in post-vertebroplasty radiograph. 190x120mm (400 x 400 DPI)