Taking Vertebroplasty to a New Level or Making a Mountain out of a Molehill?

Several recent publications, including the article by Dublin et al in this issue of the *AJNR,* have reported restoration of height of fractured vertebral bodies treated with vertebroplasty (1, 2) and kyphoplasty (3, 4). From my own experience with the procedures and perusal of the literature, restoration of vertebral body height with vertebroplasty and kyphoplasty is not very dramatic. The measurement and reporting of height restoration with these procedures has had an interesting evolution. In the 1990s, neuroradiologists noted occasional cases of modest vertebral body height restoration following vertebroplasty. Despite any obvious height restoration in most cases, most patients (90%) reported substantial pain relief (5). Patients have generally been quite happy about their pain relief, and, at least in my practice, have not expressed disappointment in a lack of height restoration. Because patients were generally happy with results, I suspect vertebroplasty practitioners did not see any compelling need to pull out microcalipers to measure and report a minimal height restoration.

Then along came kyphoplasty. Kyphoplasty was developed around the use of a balloon, which is intended to restore the vertebral body height while creating a cavity to be filled with bone cement (3). Vertebroplasty and kyphoplasty are quite similar procedures, except for the use of this balloon. Indeed, one might refer to kyphoplasty as balloon-assisted vertebroplasty. To promote kyphoplasty as a practical alternative to vertebroplasty, a study was necessary to substantiate claims of height restoration with kyphoplasty. The study used a method of measurement of height restoration that tends to yield height restoration numbers that, at first glace, are impressive. The mean preprocedure height loss due to the fracture was reported to be 8.7 mm, and the mean height restoration with treatment was reported to be 35% of that 8.7 mm. That amounts to a mean height restoration of 2.9 mm. For Americans who are accustomed to measuring their personal height in feet and inches, that translates into about an eighth of an inch.

A subsequent study of height restoration resulting from kyphoplasty was reported by McKiernan et al (4). They reported that height restoration occurred in 23 of 65 vertebral compression fractures treated. In the 23 cases with height restoration, the mean height restoration was 8.7 mm, but the mean height restoration for the entire group of patients treated was 3.1 mm.

It is also interesting to note that change in kyphosis angle was not reported with kyphoplasty, since the term kyphoplasty implies treatment of kyphosis and kyphosis is generally quantitatively measured as an angle. In a figure, Lieberman et al (3) show a single case where the kyphosis angle was measured. The kyphosis angle improved in this single case, but we are told nothing about the kyphosis angle results in the overall group. I suspect that the kyphosis angle before and after kyphoplasty would have been reported if the results had shown a consistent overall improvement in the angle after the procedure.

Regardless of how much height restoration actually occurs with kyphoplasty, the marketing of kyphoplasty results in pressure on vertebroplasty proponents to show that vertebroplasty offers a similar degree of height restoration. Teng et al (2) reported a height restoration of 27%, and Dublin et al reported an improvement of 49% with vertebroplasty, which compare favorable with the height restoration of 35% reported by Lieberman et al (3) with kyphoplasty. Hiwatashi et al (1) reported an increase in height of 2.7 mm with vertebroplasty, which is remarkably similar to the 2.9 mm in the series by Lieberman et al (3) and the 3.1 mm in the series reported by McKiernan et al (4) with kyphoplasty. Although these studies might suggest to some that vertebroplasty offers *just as much* height restoration as kyphoplasty, interpretation of these studies in the context of my own experience leads me to believe that vertebroplasty offers *just as little* height restoration as kyphoplasty. Nonetheless, this comparison of kyphoplasty results to vertebroplasty is useful, because if the height restoration achieved with kyphoplasty is no better than is achieved with vertebroplasty, there is likely no benefit to using the kyphoplasty balloon that would justify the substantial added expense.

It is certainly conceivable that pain from vertebral body collapse is at least in part due to malalignment of musculoskeletal structures that results from height loss. There might be a tendency toward more pain relief with patients who are treated with height restoration versus those whose treatment results in no height restoration; however, pain relief certainly can be achieved with vertebroplasty in the absence of significant height restoration (6). From the patient's perspective, there might be some intrinsic value to height restoration, but I suspect that nearly all patients in my practice are seeking pain relief and would consider cosmetic height restoration to be only a small bonus. Restoring a few millimeters of height to a single vertebra probably has no effect on the patient's apparent kyphosis or overall height loss. Certainly, there are patients with many vertebral body fractures who have lost inches of overall height, but performance of extensive multilevel kyphoplasty or vertebroplasty at all levels would be necessary to restore even a single inch to their overall height. Subjecting these fragile patients to multilevel procedures simply for height gain might do more harm than good.

Thus, any therapeutic benefit of height restoration remains entirely speculative.

The current status of our knowledge of height restoration with vertebroplasty and kyphoplasty can be summarized as follows: (1) vertebroplasty restores vertebral body height, but only a little and not in all cases; (2) kyphoplasty restores vertebral body height, but only a little and not in all cases; (3) height restoration with kyphoplasty and vertebroplasty has not yet been shown to correspond to degree of pain relief, or any other benefit. Height restoration will only be a relevant outcome variable if it correlates with pain relief or some other measurable improvement in the patients quality of life.

A convincing benefit to kyphoplasty relative to vertebroplasty can only be proved by comparing outcomes from both procedures in a prospective, randomized study. The balloons add considerable expense to the procedure, and there is no proven benefit to treating osteoporotic compression fracture with a balloon versus without a balloon. Certainly, future developments in vertebral body compression fracture therapy may provide substantial height restoration, but claims of substantial height restoration with current techniques for vertebroplasty and kyphoplasty seem to be making a mountain out of a molehill.

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Show Me the Gadolinium!

Numerous investigations have demonstrated various imaging techniques aimed at optimizing contrast-enhanced MR imaging since the introduction of gadolinium contrast agents in the mid-1980s. In particular, the use of enhanced MR imaging for diagnosing meningeal diseases of the brain represented a significant advance over CT, which is very insensitive to this category of abnormalities. The study by Galassi et al in this issue of *AJNR* is the latest proposal to improve our ability to detect intracranial meningeal diseases. They suggest that for meningeal diseases, contrast-enhanced T1-weighted imaging with fat suppression is superior to enhanced fluid-attenuated inversion recovery (FLAIR) imaging, which has been advocated by several other authors for these diseases.

Enhanced fat-suppressed T1-weighted imaging represents one of many tools that radiologists can use to optimize detection of enhancing abnormalities and that include increased dosage of gadolinium, delayed imaging, magnetization transfer (MT) saturation, and FLAIR sequences. Galassi et al attribute the success of enhanced T1-weighted imaging with fat suppression to the increased dynamic range of gray-scale contrast achieved by suppressing the high signal intensity from scalp and marrow fat. They neglect to mention the MT effects of chemical shift fat-saturation sequences. For example, the standard fat-saturated T1-weighted sequence used in my practice results in approximately 15% background suppression from off-resonance MT effects compared with 30% background suppression from our standard T1-weighted sequence with MT saturation. The weaker MT saturation achieved with their sequence along with the saturation of high signal intensity from fat may actually produce a more visually appealing MT sequence to some radiologists. One of the complaints about MT imaging is that the images are flat and lack anatomic detail (specifically, gray-white differentiation) and that too much enhancement is seen. Intense vascular enhancement, in particular, is a complaint made by many radiologists when viewing standard MT imaging. Less-intense vascular enhancement and slightly better gray-white differentiation should be produced with fat-suppressed T1-weighted imaging compared with sequences with greater MT saturation, and this may be a beneficial compromise that will appeal to many radiologists.

The fact that vascular enhancement is still emphasized on these images may improve the sensitivity for meningeal diseases as mentioned by Galassi et al, but it also may reduce the specificity of this sequence for these abnormalities. (Sensitivity and specificity could not be determined in the study by Galassi et al because only patients with meningeal disease were evaluated.) The fact that FLAIR imaging does not have vascular enhancement may decrease its sensitivity in some series but potentially could increase its specificity. In a given patient, one cannot predict which sequence will best detect contrast enhancement. Even in Galassi et al's study, enhanced FLAIR imaging was superior to fat-suppressed T1-weighted imaging in

approximately 25% of the studies. Enhanced FLAIR imaging may, therefore, have a complementary role in detecting meningeal diseases.

Whether spin-echo T1-weighted imaging, T1-weighted imaging with MT, or, based on Galassi et al's study, fat-suppressed T1-weighted imaging is used as the primary sequence after contrast injection will be a choice based on personal preferences and compromises between members of a clinical practice. Whatever the choice, we must keep in mind that there are a number of techniques we can use to improve our detection of enhancing abnormalities, including meningeal disease, and that we should be prepared to offer these techniques to our patients and referring clinicians when needed.

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