INTRODUCTION
Osteoporotic vertebral compression fractures (OVFs) can be the source of substantial pain and deformity, leading to disability and poor quality of life. In certain instances, percutaneous transpedicular vertebroplasty (PVP) is used in place of nonoperative therapy to treat OVFs. PVP typically consists of passing a 10- to 15-gauge cannula percutaneously through each pedicle and injecting polymethylmethacrylate (PMMA) cement into the cancellous bone of the vertebral body (VB) to provide strength and support. The technique reportedly results in good pain relief with a low complication rate, minimizing the effect of donor and vertebral level. The VBs were wrapped in saline-soaked gauze, sealed in a plastic bag, and floated in a bath (37°C) for at least 1 hour to simulate a plastic bag, and floated in a bath (37°C) for at least 1 hour to simulate the interior of each VB, resulting in an interior fill of 2, 4, 6, or 8 cc, respectively. We disarticulated the vertebrae, excised their discs, and removed the posterior elements to more readily facilitate mechanical testing. Using a Latin square design, the VBs were segregated into three regional groups of four levels each: thoracic (T6-T9), thoracolumbar (T10-L1), and lumbar (L2-L5). Within each region, the VBs were assigned to receive one of four cement volumes. In this manner, the number of VB specimens from each level and each spine were evenly distributed among the fill-volume groups, while minimizing the effect of donor and vertebral level. The VBs were wrapped in saline-soaked gauze, sealed in plastic bags, and stored at -20°C until the day before testing.

All specimens were thawed at room temperature (20°C) 24 hours before testing. An impression of the end plates of each vertebra was made using a common epoxy resin (Fastray, Bosworth, Skokie, IL). Each VB was floated in its sealed plastic bag in a water bath (37°C) for at least 1 hour before mechanical testing. Anterior, posterior, and right and left lateral VB heights were measured using digital calipers accurate to 0.01 mm. Each VB was seated between its respective impressions, placed between platens on an Instron materials testing machine, and compressed at a rate of 5 mm/min. Compression was applied to the superior platen along the central axis of the VB until failure occurred. Failure was defined as a precipitous decrease in load with increasing compression of the VB. Strength was defined as load at failure and stiffness was defined as the slope of the force versus deformation curve between 448 and 1112 N.

After the simulated compression fracture was created, an 11-gauge cannula was inserted through each pedicle. Orthocomp™ cement (Orthovita, Malvern, PA) was prepared per manufacturer’s recommendations at room temperature and a bolus was then injected through each cannula into the interior of each VB, resulting in an interior fill of 2, 4, 6, or 8 cc, respectively. Orthocomp™, a new bioactive cement composed of Bis-GMA/Bis-EMA resin reinforced with inert and bioactive fillers, was developed to overcome some of the deficiencies of current cements used in PVP. After injection, each VB was wrapped in saline-soaked gauze, sealed in a plastic bag, and floated in a bath (37°C) for at least 1 hour to simulate physiologic conditions and to allow the bone cement to cure. VB heights were measured as before and specimens were then recompressed according to the initial crush protocol. Stiffness was calculated as before. Posttreatment strength was defined as the load corresponding to the deformation at which the initial failure occurred. Using linear regression, we checked for significance (P < 0.05) in the relationship between the volume of cement and the pretreatment vs posttreatment difference in strength and stiffness.

RESULTS
The regression analysis suggested that to restore initial VB strength, 7.7, 5.0, and 2.9 cc should be injected in the lumbar, thoracolumbar, and thoracic regions, respectively (Fig. 1). Similarly, to restore VB stiffness, 8.8, 11.1, and 6.7 cc should be injected in the lumbar, thoracolumbar, and thoracic regions, respectively (Fig. 2).

Only for the thoracolumbar group was the relationship between cement volume and strength restoration significantly correlated, albeit weakly (r² = .23). For all other groups, we found no significant relationship between cement volume and restoration of stiffness or strength. This result is likely due to the sample size (n = 5) and the associated variance in the data.

DISCUSSION
The results of this study provide practitioners of PVP some guidance regarding the volume of cement required to restore VB strength and stiffness. Clinically, the pain relief experienced with PVP may be due to stabilization of the VB and prevention of micromotion at the fracture site; thus, restoring mechanical property may not be required. If this is the case, our analysis is an overestimate of the volume of cement required. Conversely, we used Orthocomp™, which is materially stronger and stiffer than PMMA. Thus, to obtain similar results using PMMA, greater volumes may need to be injected compared with the volumes of Orthocomp™

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