Bone Mineral Densities of the Vertebral Body and Intertransverse Fusion Mass after Instrumented Intertransverse Process Fusion

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Introduction

Study Design. We used dual-energy x-ray absorptiometry (DEXA) to examine the bone mineral densities (BMDs) of the vertebral bodies at the fused level (the fused vertebral BMDs), at the unfused level (the unfused vertebral BMDs) and the intertransverse fusion mass (the fusion mass BMD) after instrumented intertransverse process fusion.

Summary of Background Data. Device-related vertebral osteoporosis is a well-known phenomenon that occurs in an early adaptive phase following instrumented spinal fusion. However, any relationships among the unfused vertebral BMDs, the fused vertebral BMD and the fusion mass BMD in a later phase after obtaining successful spinal union are unknown.

Objectives. We wanted to determine whether there are any relationships among the unfused vertebral BMDs, the fused vertebral BMD and the fusion mass BMD after successful solid union.

Methods

This study included 17 female patients who had a solid union after instrumented intertransverse process fusion at the L4-5 level. The average patient age at the time of this study was 54 years (range: 46-69 years).

The vertebral BMDs at the fused level (L4), the vertebral BMDs at the unfused levels (L1 to L3) and the fusion mass BMD were measured at a mean follow-up period of 42 months (range: 24-131 months) after surgery.

The reciprocal correlations among the vertebral BMDs and the fusion mass BMD were analyzed.

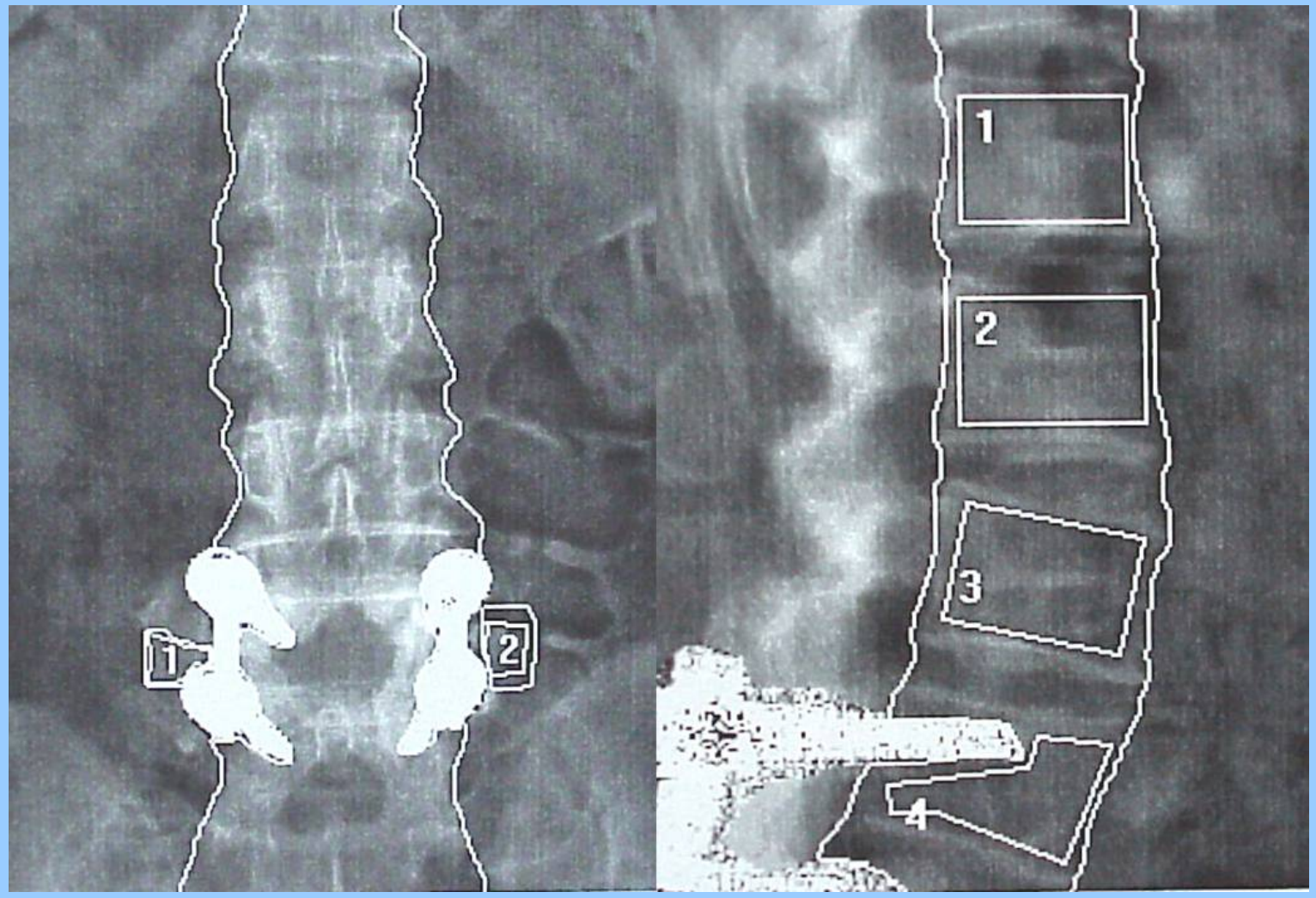


Figure 1. Dual-energy x-ray absorptiometry (DEXA) was used to examine the bone mineral densities of the vertebral bodies (the vertebral BMDs) and the intertransverse fusion masses (the fusion mass BMDs) after instrumented intertransverse process fusion. Special effort was made to avoid the pedicle screws and the superimposition of the ilium for the L4 body. The BMDs of the L1 and L2 bodies were measured without consideration of the overlap of rib. For the intertransverse fusion mass, the fusion mass BMDs of the right and left sides were measured independently and the final fusion mass BMD was calculated by averaging the two BMDs on both sides.

Results

Table 1. The Patients' Demographic Data and the BMDs of the Vertebral Bodies and Fusion Masses

				Bone Mineral Density (g/cm^2)				
Case No.	Sex/Age (yrs)	Diagnosis	Follow-up (mo)	L1	L2	L3	L4	Fusion Mass
1	F/46	DS	43	0.500	0.385	0.331	0.290	0.709
2	F/47	DS	24	0.882	0.740	0.682	0.755	0.553
3	F/47	DS	29	0.966	1.063	0.569	0.810	0.678
4	F/50	DS	35	1.140	0.805	0.726	0.679	0.696
5	F/50	DS	24	1.045	0.686	0.525	0.753	0.497
6	F/51	DS	131	1.013	0.764	0.513	0.697	0.521
7	F/51	IS	51	0.780	0.724	0.563	0.555	0.514
8	F/51	DS	29	1.105	0.958	0.847	0.962	0.398
9	F/52	DS	28	0.642	0.607	0.399	0.386	0.344
10	F/55	DS	51	0.628	0.481	0.381	0.264	0.611
11	F/55	DS	27	0.688	0.688	0.528	0.356	0.252
12	F/56	DS	24	0.803	0.732	0.482	0.566	0.791
13	F/56	IS	56	0.746	0.833	0.581	0.662	0.740
14	F/57	IS	63	1.522	1.264	0.940	0.741	0.701
15	F/63	DS	45	0.448	0.387	0.381	0.508	0.423
16	F/68	DS	28	0.599	0.521	0.297	0.266	0.461
17	F/69	DS	36	0.691	0.552	0.841	0.551	0.375

DS indicates degenerative spondylolisthesis; IS, isthmic spondylolisthesis.

Table 2. Results of the Bone Mineral Densities

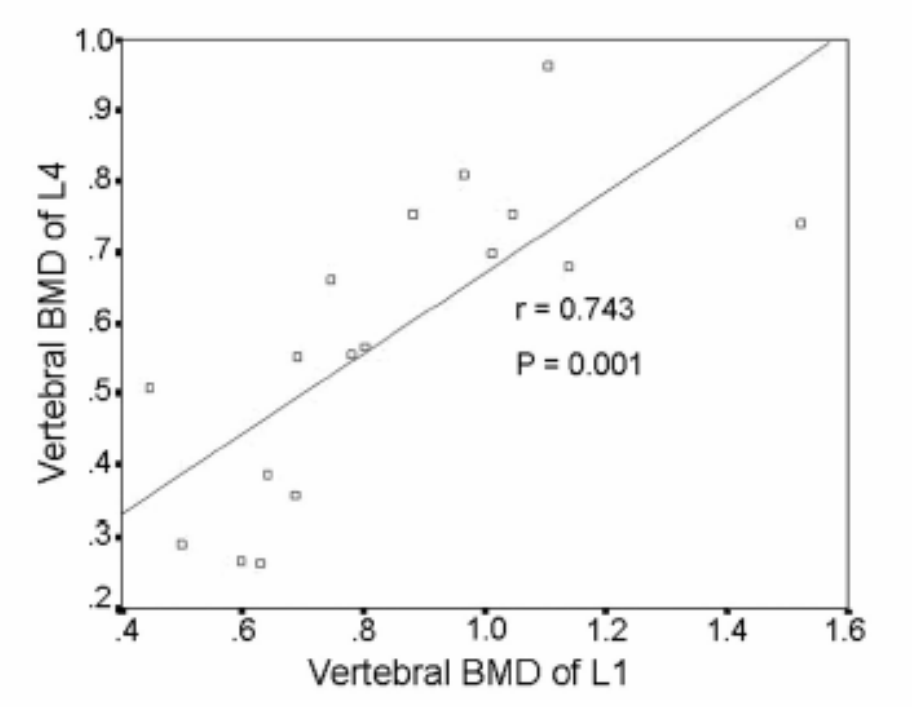
	L1	L2	L3	L4	Fusion Mass
BMD (g/cm^2)	0.84 ± 0.27	0.72 ± 0.23	0.56 ± 0.19	0.58 ± 0.21	0.54 ± 0.16

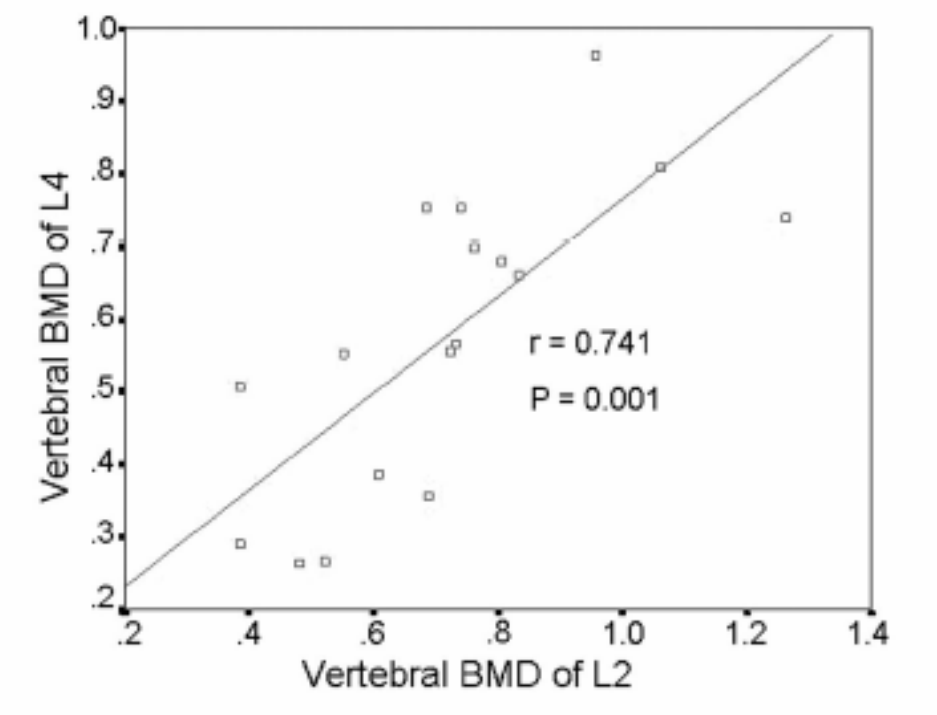
All values are means ± SDs.

Table 3. Reciprocal Correlations Among the BMDs

	L1	L2	L3	L4	Fusion Mass
L1		$r = 0.882$ $P < 0.001$	$r = 0.756$ $P < 0.001$	$r = 0.743$ $P = 0.001$	$r = 0.289$ $P = 0.261$
L2	$r = 0.882$ $P < 0.001$		$r = 0.714$ $P = 0.001$	$r = 0.741$ $P = 0.001$	$r = 0.311$ $P = 0.224$
L3	$r = 0.756$ $P < 0.001$	$r = 0.714$ $P = 0.001$		$r = 0.717$ $P = 0.001$	$r = 0.043$ $P = 0.869$
L4	$r = 0.743$ $P = 0.001$	$r = 0.741$ $P = 0.001$	$r = 0.717$ $P = 0.001$		$r = 0.179$ $P = 0.493$
Fusion mass	$r = 0.289$ $P = 0.261$	$r = 0.311$ $P = 0.224$	$r = 0.043$ $P = 0.869$	$r = 0.179$ $P = 0.493$	

There were significant reciprocal correlations between the vertebral BMDs. However, the fusion mass BMD had no significant correlation with any of the vertebral BMDs (Table 3)





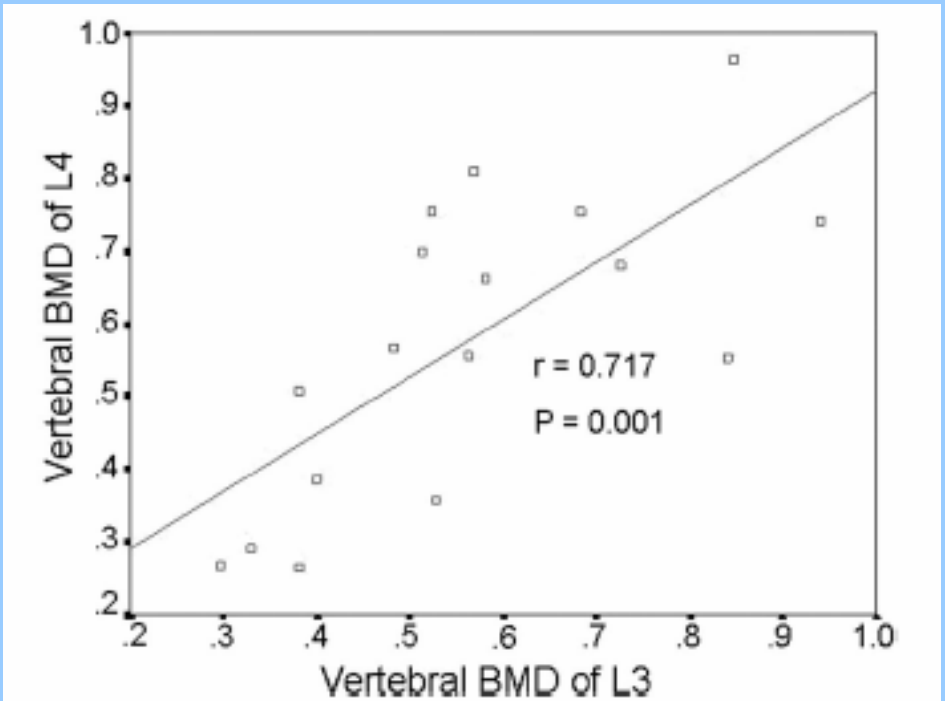


Figure 2. Correlation among the BMDs.
The graphs show that there are reciprocal correlations between the vertebral BMDs at the fused (L4) and unfused levels (L1-L3).

Discussion

Our results showed that there were statistically significant reciprocal correlations among the vertebral BMD at the fused level (L4) and those at the unfused level (L1–L3); that is, a patient who has higher vertebral BMDs at the unfused level also has a higher vertebral BMD at the fused level and vice versa. Because BMD is the end result of bone remodeling, these correlations indirectly indicate that the vertebral bodies at the fused level, whether or not the initial effect of device-related osteopenia is permanent or unrecoverable, undergo osteoporosis in a pattern similar to what naturally occurs in the vertebral bodies at the unfused level.

The prevalence of vertebral fractures in women in Beijing (northern China) increased steeply with age, from 3.9% at age 50–59 years to 31.2% for the women aged 80 years and older. Similarly, in Hong Kong (southern China) the prevalence of vertebral fracture is 29% for women aged 70–79 years. These figures were not much lower than those observed for Caucasian Americans, which were 22% for women aged 70–79 and 34% for women aged 80 and above. Similar percentages of the women who undergo instrumented intertransverse process fusion are expected to suffer from osteoporotic vertebral fractures in their later lives (Fig. 3).

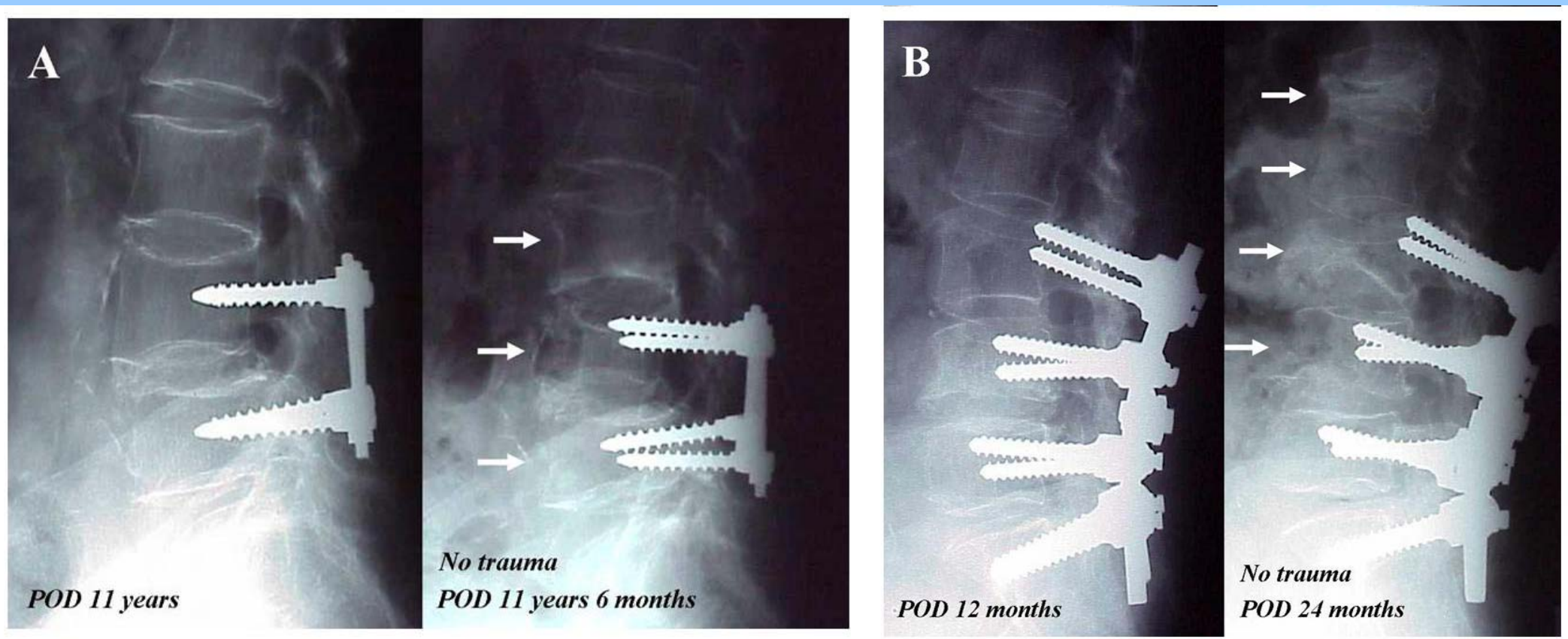


Figure 3. A, An 83-year-old female patient. Osteoporotic compression fractures at the unfused (L3) and fused levels (L4-L5) developed at postoperative 11 years 6 months without any history of trauma. Cutting out of the screws happened due to osteoporotic compression fractures. B, A 76-year-old female patient. Compared with the 12 months postoperative X-ray, osteoporotic compression fractures at T12-L3 developed at 24 months of follow-up after surgery without any history of trauma. The fused vertebral bodies (L2-L3), as well as the unfused vertebral bodies (T12-L1), were compressed, and cutting out of screws was noted.

In a particular situation when the osteoporotic fractures occur at the fused level, it is very difficult to manage these fractures in these elderly patients because they probably have serious co-morbidities that make further invasive treatments difficult. Thus, it is very important for both the patients who underwent or will undergo instrumented intertransverse fusion and their attending physicians to understand that the vertebral BMDs at the fused level also decrease with age, and that osteoporotic vertebral fractures can occur at this fused level.

The present study showed no significant correlations among the vertebral (L1–L4) and fusion mass BMDs; that is, a patient who had higher vertebral BMDs did not necessarily have a higher fusion mass BMD and vice versa. In addition, predicting the fusion mass BMD based on the vertebral BMDs is unreliable.

Conclusions

The vertebral bodies at the fused level may undergo osteoporosis in a pattern similar to what naturally occurs in the vertebral bodies at the unfused level.

However, the fusion mass BMD appears to be influenced by bone remodeling mechanisms that are different from those that influence the vertebral bodies.

None of the authors has any potential conflict of interest