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Relationship of Vertebral Size to Fracture in Osteoporotic Spines

Richmond W. Smith, Jr., M.D. and Peter M. Taft

This study is an extension of early observations that Negro women were free of vertebral fractures and had lower mean values for vertebral dimensions than white women. Skeletal dimensions should be considered in the further study of osteoporosis and its structural consequences, the authors state.

The severity of vertebral osteoporosis is often judged by the extent of resulting deformities such as biconcavitation, wedging or overall compression. While this correlation is undoubtedly high, severe atrophy may be seen in roentgenograms of spines without evident deformity, and but little density loss may be observed in spines with nonpathological compressions or wedging. These changes presumably result from excessive strains of trauma or undue loading. Accordingly, the degree of osteoporosis can be misjudged. Although much needed methods of densitometry are being developed for both compact and cancellous bone, only little attention has been given to vertebral size as a possible determinant of the structural consequences of osteoporosis. In this communication we present evidence that, in osteoporotic spines, size and fracture are significantly related and (incidentally noted), that the type of deformity is determined, at least in part, by the anatomic location of the involved vertebra.

Methods

Radiologic and clinical data were obtained from two sources. The first was a group of 68 Caucasian women with back symptoms which had led to a radiologic diagnosis of vertebral osteoporosis; 36 had biconcavities, wedgings and/or compressions. The age range was 55 to 69 years. The second source was an outpatient population of 2063 ambulatory women, ages 45 to 90, who had participated in an epidemiologic

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survey of osteoporosis. Two groups were selected from this large survey population whose clinical characteristics were reported previously. In the first group there were 79 Caucasian women, ages 55 to 69, who had significant vertebral osteoporosis; 37 had grossly evident biconcave, wedged or compressed vertebras. Data for the latter subjects were combined with those of the known osteoporotics with fractures; likewise combined were those of nonfracture survey subjects and known osteoporotics. Selected for the second group of survey subjects were 31 Negro women, ages 55 to 69, whose vertebral

Figure 1

Dimensions measured in lateral roentgenograms of lumbar vertebra; A for unrotated and B for rotated spines. AP=anteroposterior and V=posterior vertical measurement.
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atrophy, although comparable to that of the Caucasians, was uncomplicated by fractures. Of the 130 Negroes in the entire survey population, none had wedged or compressed vertebrae.

For both the symptomatic osteoporotics and the survey subjects, the degree of vertebral wasting or relative vertebral density (RVD) was that of grade 1 or grade 0 by criteria previously reported. Assessment of RVD and fractures and measurements of vertebral dimensions were made in standard lateral roentgenograms of the dorsolumbar spine. The second lumbar (L-2) vertebra, when intact, was selected for the measurements since it was centrally located in most films. When L-2 was deformed, unduly rotated or the site of hypertrophic changes, L-3 was measured. Measurements to the nearest 0.5 mm were made of the posterior height and of the anteroposterior diameter along the lower end plate, as shown in Figure 1A. From measurements made of a plastic model of a human lumbar vertebra, it was found that for roentgenograms of spines rotated less than 30° about the vertical axis, in which case the two convexities of the posterior vertebral surface would be seen, the mean of the two AP measurements equalled the projected AP diameter of the unrotated vertebra (Figure 1B). Record was made of all vertebrae below T-9 with marked biconcavitation, wedging or overall compression.

Results

From the two sources there were 73 Caucasian women with biconcave, wedged or overall compressed vertebrae. The distribution of these women according to the types of vertebral deformities is shown in Table 1, and the distribution of 176 deformed

<table>
<thead>
<tr>
<th>Types of Vertebral Deformity</th>
<th>No. of Patients</th>
<th>Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior Wedging</td>
<td>31</td>
<td>42.5</td>
</tr>
<tr>
<td>Compression</td>
<td>13</td>
<td>17.8</td>
</tr>
<tr>
<td>Anterior and Posterior Wedging</td>
<td>10</td>
<td>13.7</td>
</tr>
<tr>
<td>Anterior Wedging and Compression</td>
<td>4</td>
<td>5.5</td>
</tr>
<tr>
<td>Anterior Wedging and Biconcavity</td>
<td>4</td>
<td>5.5</td>
</tr>
<tr>
<td>Compression and Biconcavity</td>
<td>3</td>
<td>4.1</td>
</tr>
<tr>
<td>Biconcavity</td>
<td>2</td>
<td>2.7</td>
</tr>
<tr>
<td>Posterior Wedging</td>
<td>2</td>
<td>2.7</td>
</tr>
<tr>
<td>Anterior and Posterior Wedging and Compression</td>
<td>2</td>
<td>2.7</td>
</tr>
<tr>
<td>Posterior Wedging and Compression</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>Posterior Wedging and Biconcavity</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>Totals</td>
<td>73</td>
<td>100.0</td>
</tr>
</tbody>
</table>

*grade 3 highest, grade 0 lowest rating of visually assessed relative vertebral density (RVD). Grades 2 and 1 are intermediate.
vertebras according to type and location is shown in Table II. Seventy percent of anter-
ior wedging involved the lower two thoracic and first lumbar vertebrae, whereas 63
per cent of posterior wedging involved the fifth lumbar vertebra. Although for Cauca-
sians with or without fractures, the ranges and means of age, height and weight were
similar, the Negroes were approximately three years younger, 2.5 cm. taller and at
least 11 kg. heavier (Table 3). Values for posterior vertebral height differed minimally
between the Caucasian groups but those of the Negroes average 0.9mm less (p<0.05)
than that of the Caucasians without fractures. In respect to AP diameters, subjects with
fractures had a greater range and a mean value which was significantly greater than
those of Caucasians without fractures (p <0.001) and Negroes (p <0.005). Between
the latter two groups the difference was not significant. Frequency distributions of
the AP diameters for all subjects are shown in Figure 2.

Table III
Inter-group Comparisons of Data for Age, Heights, Weights and Vertebral Dimensions

<table>
<thead>
<tr>
<th>Clinical Groups</th>
<th>No. Subjects</th>
<th>Mean Age</th>
<th>Mean Hgt(cm)</th>
<th>Mean Wgt(kg)</th>
<th>AP Diameter (mm) Range</th>
<th>Posterior Height (mm) Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caucasians</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Fractures</td>
<td>74</td>
<td>63.4</td>
<td>155.8</td>
<td>62.9</td>
<td>33.0-45.0</td>
<td>30.5-42.0</td>
</tr>
<tr>
<td>Fractures</td>
<td>73</td>
<td>63.8</td>
<td>155.3</td>
<td>64.7</td>
<td>35.0-51.0</td>
<td>30.0-41.0</td>
</tr>
<tr>
<td>Negroes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Fractures</td>
<td>31</td>
<td>60.6</td>
<td>158.5</td>
<td>75.9</td>
<td>33.0-44.5</td>
<td>30.0-40.0</td>
</tr>
</tbody>
</table>

* ± 1 Standard deviation
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Figure 2

Frequency distributions of vertebral diameters for fracture and nonfracture subjects.

Discussion

Heretofore, vertebral density and the magnitude of compression stress have been cited as the two determinants of nonpathological vertebral fractures, assuming functional integrity of the inter-vertebral discs as stress distributors. Mechanical principles and clinical experience have led to a general recognition that heavy compressional loads on a spine are more likely to result in vertebral fracture if the spine is flexed. In this latter respect, Nachemson in recent studies of intradiscal pressures found that the total load on the third lumbar disc was 50 percent greater in the spine flexed 20 degrees than in the erect spine. These observations are germane to our findings in that for a given degree of flexion, other factors being equal, the spine with vertebrae of larger diameters probably will have greater compression stress on the anterior portion of the vertebral bodies. Whether or not a compression fracture results probably relates to the compressional load and to the amount and distribution of the vertebral spongiosa. Osteoporotic vertebrae are characterized by the reduction in size and/or the absence of the horizontal trabeculas which serve to dissipate strains throughout the vertebral body. Thus, it is reasoned that biconcavitation would occur during vertical compressions and that anterior wedging, perhaps with ultimate overall collapse, would occur during flexural compressions. Of some interest is our observation that the frequency of anterior wedging increases abruptly at the level of the 11th thoracic vertebra where the absence of the splinting action of ribs would permit a greater degree of spinal
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flexion. On the other hand, the fifth lumbar vertebra was the predominant site of posterior wedging, presumably due to the normal lordosis at this level and the rigid sacrum below.

The senior author recently reported that, of osteoporotic subjects in a radiologic survey, not only were the Negro women free of the common vertebral fractures but they also had lower mean values for vertebral dimensions than did the white women. The present study is an extension of these earlier observations. Our results for the intra-Caucasian comparison of vertebral dimensions lead us to conclude that size is a determinant of fracture in osteoporotic spines and that the generally recognized lower incidence of vertebral fracture in Negro women may be due in part to their smaller diameter vertebral bodies. When viewed with our other findings, previously reported, that the midshaft diameters of adult femurs expand with age as cortical thickness declines, it becomes evident that skeletal dimensions should be considered in the further study of osteoporosis and its structural consequences.

REFERENCES


