The Impact of Osteoporosis on Patients With Maxillofacial Trauma

John W. Werning, MD, DMD; Nathan M. Downey, DDS, MS; Ray A. Brinker, MD; Sadik A. Khuder, PhD; William J. Davis, DDS, MS; Allan M. Rubin, MD, PhD; Haitham M. Elsamaloty, MD

Background: Although maxillofacial injuries in the elderly population frequently result from falls and motor vehicle crashes, the association between osteoporosis and fractures of the maxillofacial region remains poorly defined.

Objective: To evaluate the relationship between osteoporosis and maxillofacial trauma in the elderly.

Design, Setting, and Main Outcome Measures: A retrospective review of 59 patients 60 years or older treated for maxillofacial fractures at a trauma center between 1989 and 2000 was performed. The severity of osteoporosis was graded by evaluating the radiographic appearance of the vertebral bodies of each trauma patient using the Saville index. The number of maxillofacial fractures and the severity of osteoporosis in each patient was assessed to determine whether an association between osteoporosis and maxillofacial trauma exists.

Results: Of the 59 patients evaluated, 51% were injured by falls and 46% were involved in motor vehicle crashes. Seventy-three percent of the patients had multiple facial fractures. As the severity of osteoporosis worsened, patients were more likely to sustain a greater number of maxillofacial fractures (P = .01). The mechanism of injury had no impact on the relationship between osteoporosis and the number of fractures.

Conclusions: Osteoporosis is an independent risk factor for the development of maxillofacial fractures. Since more than half of these patients are injured by falls, safety measures must be instituted to prevent fall-related maxillofacial injuries in the home and the community.


Although maxillofacial trauma involving the general population has been extensively studied, few publications that address maxillofacial trauma in the elderly population exist.1,2 As the elderly segment of the US population grows, the number of elderly patients treated for maxillofacial injuries is expected to proportionately increase. Consequently, our knowledge of the cause, socioeconomic impact, and ultimate outcome of elderly patients with injuries of the maxillofacial region must be augmented.

Osteoporotic fractures typically refer to fractures that involve weight-bearing portions of the skeleton such as the hip or vertebrae that result from relatively minor trauma such as a fall from standing height. Since osteoporosis is a systemic condition, however, osteoporosis may also affect the outcome of fractures sustained during more severe traumatic events. A few studies mention osteoporosis as a condition identified in the medical histories of elderly patients with maxillofacial trauma.1,2 To our knowledge, however, no publication has attempted to clarify the association between osteoporosis and fractures of the maxillofacial region. The present study was performed to evaluate the relationship between osteoporosis and maxillofacial fractures by using a semiquantitative radiographic tool to estimate the severity of osteopenia in each of these patients.

METHODS

We reviewed the medical charts of all patients who were evaluated at the Medical College of Ohio, Toledo, for maxillofacial injuries and were 60 years or older at the time of evaluation between January 1989 and December 2000. All patients diagnosed as having a maxillofacial fracture who also underwent plain film radiography of the vertebral spine within 1 year of maxillofacial injury were included in the analysis. Sixty-five patients met the inclusion criteria.

Each patient’s medical chart was reviewed to ascertain the type and number of maxillofacial fractures incurred as well as the mechanism of injury. Maxillofacial radio-
Of the 65 patients who met the inclusion criteria, 6 patients were excluded because their radiographs were not available for review. The remaining 59 patients ranged in ages from 60 to 95 years (median, 72 years) at the time of their maxillofacial injuries, and there were 42 women (71%) and 17 men (29%). Of the 59 patients evaluated, 30 (51%) were injured by falls, 27 (46%) were involved in motor vehicle crashes, and 2 (3%) were assaulted.

The frequency distribution of maxillofacial fractures in the patients studied is summarized in Table 1. There was a total of 160 maxillofacial fractures in the 59 patients evaluated. Forty-three patients (73%) had multiple facial fractures (median, 2). The distribution of fractures by anatomic site is reviewed in Table 2. Nasal fractures were sustained by 37 patients (63%), whereas frontal bone fractures (the least commonly fractured bone) occurred in only 4 patients (7%).

The mean Saville index score assigned by each radiologist was 1.76 (R.A.B.) and 1.88 (H.M.E.), and both radiologists assigned a median score of 2. There was fair interobserver agreement between the independently reported Saville index scores by the 2 radiology reviewers, which was statistically significant (weighted $\kappa = 0.30$; 95% confidence interval, 0.14-0.45). The severity of osteoporosis was positively associated with patient age ($r = 0.25$; $P = .05$), but there was no significant association between the sex of the patient and the degree of osteoporosis ($P = .47$).

There was a statistically significant positive association between the number of maxillofacial fractures and the severity of osteoporosis for each radiologist: R.A.B., $r = 0.30$ ($P = .02$); H.M.E., $r = 0.27$ ($P = .04$). When the Saville index scores of both radiologists were averaged together, this positive relationship remained statistically significant ($r = 0.32$; $P = .01$). Thus, as osteoporosis worsened, patients were more likely to sustain a greater number of maxillofacial fractures (Figure). In addition, the multiple linear regression model showed that after adjusting for the type of injury, the degree of osteoporosis significantly predicted the number of injuries sustained ($P = .05$). Therefore, low-impact injuries from falls were as likely to result in multiple facial fractures as motor vehicle crashes if the patient had severe osteoporosis.

The morbidity, mortality, and economic cost associated with fractures in patients with osteoporosis is astounding. Osteoporotic fractures resulted in approximately 547 000 hospitalizations in 1995, and nearly $14 billion in medical expenditures are directed toward the medical management of osteoporotic fractures in the United States annually. Convalescence following hip fracture requires nearly 140 000 nursing home admissions each year in the United States, and osteoporotic fractures of the hip and vertebrae are associated with increased mortality. The internationally agreed definition of osteoporosis is “a disease characterized by low bone mass, microarchitectural deterioration of bone tissue leading to enhanced bone fragility, and a consequent increase in fracture risk.” In other words, excessive bone resorption in the absence of adequate bone formation results in osteopenia that can progress to osteoporosis. Object-

### Table 1. Frequency Distribution of Maxillofacial Fractures

<table>
<thead>
<tr>
<th>No. of Fractures</th>
<th>No. (%) of Patients (N = 59)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>16 (27)</td>
</tr>
<tr>
<td>2</td>
<td>18 (30)</td>
</tr>
<tr>
<td>3</td>
<td>11 (19)</td>
</tr>
<tr>
<td>4</td>
<td>7 (12)</td>
</tr>
<tr>
<td>5</td>
<td>3 (5)</td>
</tr>
<tr>
<td>6</td>
<td>1 (2)</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>1 (2)</td>
</tr>
<tr>
<td>9</td>
<td>2 (3)</td>
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The 2 radiologists independently evaluated the vertebral radiographs in a blinded fashion, and the resulting scores were communicated to an independent observer.

The relationship between the severity of osteoporosis and patient age and sex was evaluated using nonparametric analysis (Spearman rank correlation coefficient and Mann-Whitney test, respectively). The reliability of measuring the severity of osteoporosis by using the Saville index was statistically assessed with the weighted $\kappa$ coefficient to quantify the level of interobserver agreement between the 2 radiologists. The Spearman rank correlation coefficient was used to evaluate the association between the number of fractures and the severity of osteoporosis. This relationship was separately determined for each radiologist, and the Saville index scores assigned by both radiologists were averaged together to determine the overall association between osteoporosis severity and the number of fractures. Multiple linear regression was performed to determine the impact of the method of injury (ie, falls, motor vehicle crashes, or assaults) on the relationship between osteoporosis severity and the number of maxillofacial fractures. All analyses were carried out using SAS statistical software (SAS Institute Inc, Cary, NC).

**RESULTS**

The morbidity, mortality, and economic cost associated with fractures in patients with osteoporosis is astounding. Osteoporotic fractures resulted in approximately 547 000 hospitalizations in 1995, and nearly $14 billion in medical expenditures are directed toward the medical management of osteoporotic fractures in the United States annually. Convalescence following hip fracture requires nearly 140 000 nursing home admissions each year in the United States, and osteoporotic fractures of the hip and vertebrae are associated with increased mortality.

The internationally agreed definition of osteoporosis is “a disease characterized by low bone mass, microarchitectural deterioration of bone tissue leading to enhanced bone fragility, and a consequent increase in fracture risk.” In other words, excessive bone resorption in the absence of adequate bone formation results in osteopenia that can progress to osteoporosis. Object-
vertebral fractures, the classic hallmark of osteoporosis, are the most common osteoporotic fractures encountered. However, the greatest degree of morbidity is associated with hip fractures. Fewer than 70% of patients return to their prefracture levels of walking, \(^1\) and fewer than 50% regain prefracture competence in activities of daily living.\(^2\)\(^3\)

Low BMD is a strong predictor of osteoporotic fractures in postmenopausal women in the community setting\(^2\)\(^4\) and in nursing homes.\(^5\) Because of the inaccuracies of using uncalibrated radiographs to measure bone density, bone densitometers were developed. The development of single-energy densitometry provided a modality for measuring BMD more precisely in peripheral bones such as the wrist and the heel but was unable to directly measure BMD of the spine or hip. Single-energy densitometry has been largely supplanted by dual-energy densitometry, also known as dual x-ray absorptiometry, because of its ability to assess BMD in the spine and hip. Compact, portable dual x-ray absorptiometry systems have also become available to measure the peripheral skeleton, largely replacing single x-ray densitometers.\(^6\)

Since the results of bone densitometry were not available for most of the patients included in our retrospective analysis, the osteopenia score for vertebral develop by Saville was used to semiquantitatively assess the BMD and predisposition toward fractures.\(^7\) Radiographically, osteopenia of the vertebrae includes increased radiolucency, vertical striation of the vertebra due to reinforcement of vertical trabeculae in the osteopenic vertebra, framed appearance of the vertebra (picture framing or empty box) due to an accentuation of the cortical outline, and increased biconcavity of the vertebral end plates. The biconcavity of the vertebrae results from protrusion of the intervertebral disk into the weakened vertebra body.\(^8\) The Saville index has never gained widespread acceptance because the radiographs are uncalibrated, and interpretation is affected by interobserver variability. However, the radiographic findings of osteoporosis mentioned above have been found to be significantly related to measured bone density, and bone densitometry measurements may not be completely accurate if radiographs display the characteristic changes of osteopenia.\(^9\)\(^10\) For example, spinal dual x-ray absorptiometry may not detect osteopenia in patients with degenerative changes of the lumbar spine (eg, facet hypertrophy and disk space narrowing) that artifically raise bone density or when overlying aortic calcification is present.\(^11\)\(^12\)

Table 2. Maxillofacial Fracture Sites

<table>
<thead>
<tr>
<th>Fracture Sites</th>
<th>No. (%) of Fractures (N = 160)</th>
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<tbody>
<tr>
<td>Nasal</td>
<td>37 (23.1)</td>
</tr>
<tr>
<td>Maxillary</td>
<td>29 (18.1)</td>
</tr>
<tr>
<td>Orbital</td>
<td>21 (13.1)</td>
</tr>
<tr>
<td>Zygoma</td>
<td>18 (11.3)</td>
</tr>
<tr>
<td>Mandible</td>
<td>15 (9.4)</td>
</tr>
<tr>
<td>Ethmoid</td>
<td>15 (9.4)</td>
</tr>
<tr>
<td>Sphenoid</td>
<td>13 (8.1)</td>
</tr>
<tr>
<td>Temporal</td>
<td>8 (5.0)</td>
</tr>
<tr>
<td>Frontal</td>
<td>4 (2.5)</td>
</tr>
</tbody>
</table>

The level of interobserver agreement between the 2 radiologists who rated osteoporosis severity using the Saville index was fair, according to the weighted \(\kappa\) coefficient value of 0.30.\(^2\) This low \(\kappa\) value may be attributed to the subjectivity of using the semiquantitative 5-point Saville index scale. The rate of interobserver disagreement, however, did not affect the direct relationship between the severity of osteoporosis that was determined by using the Saville index and the number of maxillofacial fractures. The statistically significant association was preserved when the radiologists’ Saville scores were evaluated together and separately. Thus, worsening osteoporosis is significantly associated with higher numbers of maxillofacial fractures.

Osteoporotic fractures typically allude to fractures associated with minimal trauma, such as hip fractures that result from falls during ambulation or vertebral fractures sustained while lifting a bag of groceries. However, Sanders et al\(^13\) have emphasized that fractures associated with more severe traumatic forces are generally excluded from estimates of the prevalence of osteoporotic fractures. Their research showed that women with high trauma fractures were 3 times more likely to have BMD in the osteoporotic range, and the exclusion of high trauma fractures in women older than 50 years may underestimate the contribution of osteoporosis to fractures in the community. Although nearly 50% of the pa-
tients in our study were involved in motor vehicle crashes, the number of maxillofacial fractures in these patients was not significantly different from those patients who were injured from falls. Osteoporosis, therefore, appears to predispose elderly patients to maxillofacial fractures in low-impact situations as well as high-impact situations.

The frequency of fall-related maxillofacial fractures in the present study mirrors the findings of other investigators. The probability of falling dramatically increases each year from about 20% of women aged 45 to 49 years to nearly 50% of women 85 years and older. Most falls occur when older persons are performing their usual daily activities such as rising from a chair or ambulating. In our study, fractures of the nose, maxilla, and orbit were the 3 most common fracture sites, and the relative distribution of fractures was similar to the findings of other investigators. Fewer than 10% of the fractures occurred in the mandible, whereas other studies documented rates of mandible fracture in the elderly as high as 27.5%. The findings in our investigation are surprising because alveolar ridge resorption following dental extractions would be expected to further weaken the osteopenic mandible, which should intuitively lead to more mandibular fractures in osteoporotic individuals.

This retrospective investigation only included elderly patients who had incurred maxillofacial fractures, representing a significant source of selection bias. The conclusions of this study regarding the impact of osteoporosis are therefore limited by the exclusion of elderly trauma patients who did not incur any maxillofacial fractures.

Our research demonstrates that osteoporosis is an independent risk factor for the development of maxillofacial fractures. Furthermore, elderly patients with osteoporosis are more likely to develop maxillofacial fractures following low-impact trauma. A prospective study that correlates bone densitometry with detailed information on the mechanism of injury and that evaluates the potentially confounding role of comorbid illnesses in elderly patients with maxillofacial fractures may further clarify this relationship. Additional research that quantifies the resultant morbidity, mortality, number of nursing home admissions, and overall economic cost attributable to maxillofacial trauma in patients with osteoporosis should be pursued, and programs that encourage the prevention of injuries from falls and motor vehicle crashes must be enacted.

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REFERENCES