Bone mineral density testing after fragility fracture

Informative test results likely

Joshua Posen PhD  Dorcas E. Beaton PhD  Joanna Sale PhD  Earl R. Bogoch MD FRCSC MSc

Abstract

**Objective** To determine the proportion of patients with fragility fractures who can be expected to have low bone mineral density (BMD) at the time of fracture and to assist FPs in deciding whether to refer patients for BMD testing.

**Data sources** MEDLINE, EMBASE, and CINAHL were searched from the earliest available dates through September 2009.

**Study selection** English-language articles reporting BMD test results of patients with fragility fractures who were managed in an orthopedic environment (eg, fracture clinic, emergency management by orthopedic surgeons, inpatients) were eligible for review. While the orthopedic environment has been identified as an ideal point for case finding, FPs are often responsible for investigation and treatment. Factors that potentially influenced BMD test results (eg, selection of fracture types, exclusion criteria) were identified. Studies with 2 or more selection factors of potential influence were flagged, and rates of low BMD were calculated including and excluding these studies.

**Synthesis** The distribution of the proportion of persons with low BMD was summarized across studies using descriptive statistics. We calculated lower boundaries on this distribution, using standard statistical thresholds, to determine a lower threshold of the expected rate of low BMD.

**Conclusion** Family physicians evaluating patients with fragility fractures can expect that at least two-thirds of patients with fragility fractures who are older than 50 years of age will have low BMD (T score ≤ -1.0). With this a priori expectation, FPs might more readily conduct a fracture risk assessment and pursue warranted fracture risk reduction strategies following fragility fracture.
Ostéodensitométrie après une fracture pathologique

Probabilité de résultats de tests informatifs

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Résumé

Objectif Déterminer la proportion des patients présentant une fracture de fragilité qui risquent d’avoir déjà une densitométrie osseuse (DMO) basse au moment de la fracture et aider le MF à décider quand les diriger vers une ostéodensitométrie.

Source des données On a consulté MEDLINE, EMBASE et CINAHL à partir des plus anciennes dates disponibles jusqu’à novembre 2009.

Choix des études Les articles de langue anglaise rapportant les résultats des tests de DMO chez des patients traités en milieu orthopédique pour des fractures de fragilité (p. ex. clinique de fracture, traitement d’urgence par un chirurgien orthopédiste, patients hospitalisés) ont été retenus et révisés. Même si le milieu orthopédique est un endroit idéal pour repérer ce type de cas, les MF sont souvent responsables de l’investigation et du traitement. On a identifié des facteurs qui peuvent influer sur les résultats des tests de DMO (p. ex. le choix des types de fracture, les critères d’exclusion). Pour les études qui avaient au moins 2 facteurs de sélection susceptibles d’avoir une influence, on a calculé les taux de basse DMO en incluant et en excluant ces études.

Synthèse On a utilisé des statistiques descriptives pour établir, pour l’ensemble des études, la distribution de la proportion des sujets ayant une DMO basse. Les limites inférieures de cette distribution ont été calculées à l’aide de seuils statistiques standards afin de déterminer un seuil inférieur pour le taux de DMO bas attendu.

Conclusion Le médecin de famille qui évalue des patients de plus de 50 ans qui ont une fracture de fragilité peut s’attendre à ce qu’au moins les deux tiers d’entre eux aient une DMO basse (score de T≤-1,0). Compte tenu d’une telle perspective, le MF devrait pouvoir mieux évaluer le risque de nouvelles fractures et instaurer des stratégies reconnues pour en réduire l’incidence.
A person sustaining a low-trauma or fragility fracture, resulting from a fall from standing height or less, has a 1.5- to 9.5-fold increased risk of further fracture, including a life-threatening hip fracture. Bone-sparing medications reduce the risk of subsequent fracture by 30% to 50%; however, uptake of testing or treatment initiation for low bone mass after a fragility fracture is as low as 20%. This persistent gap between knowledge and action has spurred numerous efforts to improve rates of investigation, fracture risk assessment, and care to reduce the risk of subsequent fracture, particularly hip fracture.

While patients with fragility fractures are often first seen in an orthopedic environment, responsibility for assessment of future fracture risk, referral for investigation, initiation of treatment, and management of underlying chronic disease often falls to FPs. To determine a patient’s risk of future fracture, and future hip fracture, a fracture risk assessment should be conducted using a tool such as FRAX or the CAROC system. According to the CAROC system, all patients with fragility fractures who are older than 50 years of age have a moderate risk of future fracture. Those who also have low femoral neck bone mineral density (BMD), particularly women, will likely be considered at high risk. A BMD test result is required to complete a fracture risk assessment calculation. In turn, the FP’s decision to order the BMD test required for fracture risk assessment will, in part, be driven by the anticipated yield on the results.

The purpose of this study is to estimate the proportion of patients with fragility fractures who can be expected to have low BMD and to assist FPs in deciding whether to refer patients for BMD testing and conduct a fracture risk assessment. The pivotal role of FPs in directing bone health management could be enhanced by a clear expectation of likely BMD test results in their patients with fragility fractures.

Research | Bone mineral density testing after fragility fracture

A literature search of interventions to manage patients with fragility fractures was performed using MEDLINE, EMBASE, and CINAHL to identify English-language publications for a systematic review. The search period covered the earliest search dates available through September 2009; all articles found were published after 2000. The current review includes a subset of studies that reported BMD test results, as measured by dual-energy x-ray absorptiometry, in patients with fragility fractures who were managed in an orthopedic environment. Fragility fracture was defined as a low-trauma fracture from standing height or less in all studies. Full details on the search strategy and key words are available upon request.

Descriptive data (ie, study design, sample size, patient characteristics) were extracted by 2 independent reviewers (J.P. and J.S.). One reviewer (J.P.) extracted BMD test results.

The primary outcome was BMD test results. In all studies, the lowest recorded T score was used to categorize patients according to T score thresholds defined by the World Health Organization: T score greater than -1.0 for normal BMD results; T score of -1.0 or less and greater than -2.5 for mild bone loss; and T score of 2.5 or less for severe bone loss. Since mild or severe bone loss lead to consideration of treatment according to guidelines, we dichotomized BMD results into “normal” (> -1.0) or “low” (≤ -1.0) BMD results. The distribution of the proportion of persons with low BMD was summarized across studies using descriptive statistics (mean proportion with low BMD, mode, median, standard deviation [SD]). Lower boundaries were calculated using standard statistical thresholds to determine the lower threshold of the expected rate of low BMD. A boundary of 2 SDs below the mean described the lower boundary of the distribution at a 95% CI. The fifth percentile provided a nonparametric lower boundary above which 95% of the observations were found in a distribution.

Patient selection and potential bias

The generalizability of this review’s results might be challenged by the degree to which samples in each study were representative of a typical population of patients with fragility fractures. Specific patient groups (eg, elderly patients with fragility fractures) are often selected to answer research questions, which might lead the reported BMD test results to be worse or better than one might find in the same physician’s typical practice. We used 2 approaches to estimate if selection factors influenced the rates of low BMD summarized from these studies.

First, we contacted the authors who reported the highest 3 and lowest 3 rates of low BMD to verify reported BMD rates and ascertain whether the reported study sample was representative of their general practice, and in turn of typical patients with fragility fractures who might be seen by FPs. We chose 3 studies at each end of the range because of an observed break in the proportion of patients with low BMD at the higher end of the range (> 90% low BMD), which was mirrored at the low end of the range. These studies were designated as numbers 1, 2, 3, 18, 19, and 20.

Second, we determined if selection factors might have biased the reported rates of low BMD findings. We looked for factors that were likely to result in the lowest rate of low BMD results: wrist fractures only; younger age; study sample not restricted to fragility fractures (ie, might have included moderate-trauma fractures but no high-trauma fractures); and BMD testing received.

DATA SOURCES

A literature search of interventions to manage patients with fragility fractures was performed using MEDLINE, EMBASE, and CINAHL to identify English-language publications for a systematic review. The search period covered the earliest search dates available through September 2009; all articles found were published after 2000. The current review includes a subset of studies that reported BMD test results, as measured by dual-energy x-ray absorptiometry, in patients with fragility fractures who were managed in an orthopedic environment. Fragility fracture was defined as a low-trauma fracture from standing height or less in all studies. Full details on the search strategy and key words are available upon request.
as part of an integrated program (ie, more people with normal BMD might have been tested).16,27–29 We identified which of these factors were present in the selection of subjects, alone or in combination, for each of the studies reviewed. We then reviewed BMD rates including and excluding the studies with 2 or more factors, to determine if the factors affected the observed rate of low BMD.

SYNTHESIS

The literature search identified 2259 articles. A review of titles and abstracts resulted in 422 articles that met our screening criteria. The full articles were reviewed, and 57 articles describing an intervention to improve osteoporosis care in an orthopedic setting were selected for inclusion in the systematic review.15 Twenty of these studies reported BMD test results for at least a subgroup of study participants and were included in the present analysis.

Description of the studies

Descriptive data for the 20 studies are found in Table 1.26–45 Study enrolment ranged from 59 to 5897 participants, with BMD test results available for 4543 patients across all studies (range 29 to 2077). Ten studies were conducted in Europe, 8 in North America, and 2 in Australia or New Zealand. Studies were ordered by increasing proportion of patients with normal BMD: study number 130 had the lowest proportion of patients with normal BMD while study number 2045 had the highest. Studies conducted in Europe had, on average, a slightly higher proportion of patients with low BMD than studies conducted in North America or Australasia (86% vs 81% and 79%, respectively) did.

Patient age ranged from 46 to 102 years. Three studies had a higher mean age of participants33,34,42; 3 studies had a lower mean age of participants33,42,43. The proportion of women ranged from 53% to 100%. Two studies included only women.34,42 All fracture types were represented across the studies; 6 studies included only wrist fractures,28,34,36,43–45 and 1 study included only hip fractures.40

Low BMD rates

The proportion of patients with low BMD ranged from 69%45 to 100%30 across studies (Table 1).26–45 Figure 1. The average proportion (low BMD rate) was 83% (SD 7.7%); the median was 83.5%. Most studies reported a low BMD rate between 70% and 89% (Figure 2).

Using the lower boundaries of the distribution to estimate the lower end of what one might expect to see for low BMD findings, the boundary of mean minus 2 SDs was 67.6%, and the nonparametric lower boundary of the fifth percentile of the distribution was 69%.

Selection factors of potential influence

Contact with the authors of the 6 studies at the margins confirmed our interpretation of reported low BMD rates in 5 studies.29,31,44,45 An Australian study providing education, BMD assessment, reporting of results, and treatment recommendations directly to patients with fragility fractures confirmed a slightly higher proportion of people with low BMD owing to the study design.42 Demographic and enrolment information confirmed the representativeness of the samples to a typical general orthopedic practice.

Six studies included only wrist fractures28,34,36,43–45; 3 studies had a lower mean age of participants (<65 years)33,42,43; 1 study included some patients with moderate-trauma fractures27; and 17 studies reported that BMD testing was conducted as part of a designed program.26–29,31–42,44 These selection factors would have biased BMD test results toward a smaller proportion of the sample presenting with “low BMD.” Six studies27,28,33,42–44 had 2 or more selection factors (Table 1).26–45

Exclusion of these studies led to a lower boundary (mean minus 2 SDs) of 69%, and of 70% at the fifth percentile, indicating a consistent estimation of low BMD findings. The new mean was 85% (range 69% to 100%; SD 7.5%), compared with 83% (SD 7.7%) when the 6 studies were included. The 6 studies with 2 or more selection factors are compared with the remaining 14 studies in Figure 3.

Notwithstanding, the summary rate of all 20 studies clearly demonstrated that low (ie, below normal) BMD can be expected in at least two-thirds of patients with fragility fractures. This will lead to a classification of moderate or high risk of future fracture. The rate of very low BMD (ie, osteoporosis) ranged from 20% to 79% and exceeded 41% in more than half the studies (Table 1).26–45

DISCUSSION

Clinical fracture risk assessment requires a BMD test result, which is often unavailable when patients older than 50 years of age are first seen by their FPs following fragility fracture. Our review suggests that FPs can expect that this test will yield informative results, with at least two-thirds of these patients having low BMD. This expected high yield might aid the decision making about whether to conduct a BMD test for completion of a fracture risk assessment—a pivotal first step in reducing the risk of future fracture.

Effective therapies supported by clinical practice guidelines17 are available to mitigate fracture risk. However, previous work has identified the gap between existing rates of investigation and treatment of bone loss in patients with fragility fractures and the rates recommended by clinical guidelines.8–10,46 This gap has spurred the introduction of care programs to improve
Table 1. Proportion of patients from each study with normal test results, osteopenia, and osteoporosis, as well as descriptive data extracted from the studies: N = 20.

<table>
<thead>
<tr>
<th>STUDY NO.</th>
<th>AUTHOR, YEAR</th>
<th>COUNTRY</th>
<th>SETTING</th>
<th>NO. OF BMD TEST RESULTS</th>
<th>BMD TEST RESULTS</th>
<th>2 OR MORE SELECTION FACTORS OF POTENTIAL INFLUENCE*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Schmid et al, 2004</td>
<td>Switzerland</td>
<td>Outpatient fracture clinic</td>
<td>29</td>
<td>0</td>
<td>28</td>
</tr>
<tr>
<td>2</td>
<td>Sidwell et al, 2004</td>
<td>New Zealand</td>
<td>Orthogeriatric rehabilitation ward</td>
<td>158</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>Becker et al, 2006</td>
<td>United States</td>
<td>Orthopedic and rehabilitation inpatient wards</td>
<td>61</td>
<td>7</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>Hegeman et al, 2005</td>
<td>The Netherlands</td>
<td>Outpatient fracture clinic</td>
<td>100</td>
<td>13</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>Astrand et al, 2006</td>
<td>Sweden</td>
<td>Emergency department and orthopedic inpatient ward</td>
<td>239</td>
<td>13</td>
<td>45</td>
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<tr>
<td>6</td>
<td>Mulherin et al, 2003</td>
<td>United Kingdom</td>
<td>Emergency department</td>
<td>91</td>
<td>14</td>
<td>34</td>
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<tr>
<td>7</td>
<td>Chevalley et al, 2002</td>
<td>Switzerland</td>
<td>Orthopedic inpatient ward and outpatient clinic</td>
<td>242</td>
<td>14</td>
<td>45</td>
</tr>
<tr>
<td>8</td>
<td>Hegeman et al, 2004</td>
<td>The Netherlands</td>
<td>Departments of surgery and traumatology</td>
<td>94</td>
<td>15</td>
<td>34</td>
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<tr>
<td>9</td>
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<td>France</td>
<td>Orthopedic inpatient ward</td>
<td>32</td>
<td>16</td>
<td>50</td>
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<td>10</td>
<td>Rozental et al, 2008</td>
<td>United States</td>
<td>Orthopedic outpatient clinic</td>
<td>32</td>
<td>16</td>
<td>50</td>
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<tr>
<td>11</td>
<td>Gallacher, 2005</td>
<td>United Kingdom</td>
<td>Orthopedic and trauma departments</td>
<td>NR</td>
<td>17</td>
<td>46</td>
</tr>
<tr>
<td>12</td>
<td>Harrington et al, 2005</td>
<td>United States</td>
<td>Orthopedic inpatient ward and outpatient clinic</td>
<td>154</td>
<td>18</td>
<td>50</td>
</tr>
<tr>
<td>13</td>
<td>McLellan et al, 2003</td>
<td>United Kingdom</td>
<td>Emergency department, orthopedic inpatient ward, and fracture clinic</td>
<td>2077</td>
<td>18</td>
<td>42</td>
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<tr>
<td>14</td>
<td>van Helden et al, 2008</td>
<td>The Netherlands</td>
<td>Emergency department and orthopedic inpatient ward</td>
<td>568</td>
<td>21</td>
<td>44</td>
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<td>15</td>
<td>Majumdar et al, 2007</td>
<td>Canada</td>
<td>Orthopedic surgery department</td>
<td>120</td>
<td>21</td>
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<td>16</td>
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<td>United States</td>
<td>Orthopedic inpatient ward and outpatient clinic</td>
<td>232</td>
<td>2</td>
<td>57</td>
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<tr>
<td>17</td>
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<td>Australia</td>
<td>Outpatient fracture clinic</td>
<td>135</td>
<td>24</td>
<td>46</td>
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<tr>
<td>18</td>
<td>Majumdar et al, 2008</td>
<td>Canada</td>
<td>Emergency and fracture clinics</td>
<td>95</td>
<td>28</td>
<td>52</td>
</tr>
<tr>
<td>19</td>
<td>Cuddihy et al, 2004</td>
<td>United States</td>
<td>Orthopedic inpatient ward and outpatient clinic</td>
<td>42</td>
<td>29</td>
<td>50</td>
</tr>
<tr>
<td>20</td>
<td>Majumdar et al, 2004</td>
<td>Canada</td>
<td>Emergency department</td>
<td>42</td>
<td>31</td>
<td>17</td>
</tr>
</tbody>
</table>

BMD—bone mineral density, NR—not reported.

*Selection factors of potential bias included study of wrist fractures only, younger age, study sample not restricted to fragility fractures (ie, might have included moderate-trauma fractures but no high-trauma fractures), and BMD testing received as part of an integrated program (ie, more people with normal BMD might have been tested).
Bone mineral density testing after fragility fracture

Testing and treatment uptake,24,26,43,47 and many programs include BMD testing as part of the bone loss screening program.26,48 Rozental et al28 found that BMD tests, combined with accurate reporting of results, improved the likelihood of guideline-based care. We believe that having an accurate expectation for the outcome of testing and the likelihood of low BMD can also set accurate expectations about the importance of care to reduce risk of future fracture and potentially influence the uptake of clinical practice guidelines.

Strengths and limitations

Our study has several strengths. We began with a robust review of the literature on interventions to improve fragility fracture management in orthopedic settings, where patients are often referred back to FPs for bone health management. We had strict screening and selection factors with multiple reviewers, and thus we are

![Figure 1. Proportion of participants with normal BMD, mild bone loss, and severe bone loss in each of 20 studies: Horizontal bar represents cumulative percent to 100% of BMD test results reported in that study. Black line represents the most conservative cutoff delineating low bone density (69%) from normal bone density (31%).](image)

**Figure 1.** Proportion of participants with normal BMD, mild bone loss, and severe bone loss in each of 20 studies: Horizontal bar represents cumulative percent to 100% of BMD test results reported in that study. Black line represents the most conservative cutoff delineating low bone density (69%) from normal bone density (31%).

![Figure 2. Frequency distribution of studies by proportion of patients with low BMD: N=20.](image)

**Figure 2.** Frequency distribution of studies by proportion of patients with low BMD: N=20.

![Figure 3. Proportion of patients from each study (N=20) with "low BMD" (T score of ≤ -1.0): Studies with 2 or more selection factors of potential influence* are separated at the right. Y-axis minimum is 60%.](image)

**Figure 3.** Proportion of patients from each study (N=20) with "low BMD" (T score of ≤ -1.0): Studies with 2 or more selection factors of potential influence* are separated at the right. Y-axis minimum is 60%.

*BMD—bone mineral density.

Selection factors of potential bias included study of wrist fractures only, younger age, study sample not restricted to fragility fractures (ie, might have included moderate-trauma fractures but no high-trauma fractures), and BMD testing received as part of an integrated program (ie, more people with normal BMD might have been tested).
We found that 69% to 100% of patients with fragility fracture who underwent BMD testing across 20 intervention studies had low BMD. Family physicians working with patients older than 50 years of age with fragility fractures can have an a priori expectation that more than two-thirds of such patients will have low BMD. Using current algorithms for calculation of 10-year fracture risk, the co-occurrence of a prevalent fragility fracture, age older than 50 years, and a BMD test showing low bone mass will result in these patients being at moderate or high risk of subsequent fracture, with many in the high-risk category.16-18 Most patients will have an indication for pharmacotherapy, shown to reduce risk of future fracture; the remainder will require surveillance for optimization of calcium and vitamin D intake, modification of lifestyle risks of fracture, and fall prevention. With this information in mind, we hope FPs will feel confident to proceed with BMD testing, congruent with evidence-based guidelines for investigation and treatment.13,17,49,50

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Contributors
All authors contributed to the concept and design of the study, literature review, analysis and interpretation of the studies, and preparing the manuscript for submission.

Competing interests
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