Bone Quality

Educational Tools for Patients, Physicians, and Educators

Junaid Shams BA, Allison B. Spitzer BA,
Ann M. Kennelly BA, Laura L. Tosi MD

Published online: 12 March 2011
© The Association of Bone and Joint Surgeons® 2011

Abstract

Background Defining bone quality remains elusive. From a patient perspective bone quality can best be defined as an individual's likelihood of sustaining a fracture. Fracture risk indicators and performance measures can help clinicians better understand individual fracture risk. Educational resources such as the Web can help clinicians and patients better understand fracture risk, communicate effectively, and make decisions concerning diagnosis and treatment.

Questions/purposes We examined four questions: What tools can be used to identify individuals at high risk for fracture? What clinical performance measures are available? What strategies can help ensure that patients at risk for fracture are identified? What are some authoritative Web sites for educating providers and patients about bone quality?

Methods Using Google, PUBMED, and trademark names, we reviewed the literature using the terms “bone quality” and “osteoporosis education.” Web site legitimacy was evaluated using specific criteria. Educational

Web sites were limited to English-language sites sponsored by nonprofit organizations

Results The Fracture Risk Assessment Tool® (FRAX®) and the Fracture Risk Calculator (FRC) are reliable means of assessing fracture risk. Performance measures relating to bone health were developed by the AMA convened Physician Consortium for Performance Improvement® and are included in the Physician Quality Reporting Initiative. In addition, quality measures have been developed by the Joint Commission. Strategies for identifying individuals at risk include designating responsibility for case finding and intervention, evaluating secondary causes of osteoporosis, educating patients and providers, performing cost-effectiveness evaluation, and using information technology. An abundance of authoritative educational Web sites exists for providers and patients.

Conclusions Effective clinical indicators, performance measures, and educational tools to better understand and identify fracture risk are now available. The next challenge is to encourage broader use of these resources so that individuals at high risk for fracture will not just be identified but will also adhere to therapy.

One of the authors (LLT) serves on the Own the Bone Steering Committee of the American Orthopaedic Association. This campaign is mentioned in the article.

This work was performed at Children's National Medical Center, Washington, DC, USA.

J. Shams, A. B. Spitzer, L. L. Tosi
George Washington University School of Medicine,
Washington, DC, USA

A. M. Kennelly, L. L. Tosi (✉)
Bone Health Program, Division of Orthopaedic Surgery
and Sports Medicine, Children's National Medical Center,
111 Michigan Avenue, NW, Washington, DC 20010, USA
e-mail: ltosi@cnmc.org

Introduction

The term bone quality began to compete with the better-known term osteoporosis in the bone health lexicon approximately 15 years ago [10, 57]. At that time, researchers began to note that bone density, a measure of mineral and bone size used by the World Health Organization to define osteoporosis, reliably predicted fracture risk for large populations but that it was not always accurate in predicting bone health in the individual [10]. Defining bone quality, however, remains elusive because

the many factors influencing bone strength such as bone structure (size or mass), geometry (distribution of mass or shape), and material composition cannot be measured clinically. From the patient's perspective, however, it can be argued that a strict biologic definition of bone quality is irrelevant. What matters to the patient is the likelihood of sustaining a fracture and what can be done to prevent it. In other words, patients are interested in their fracture risk, or better, fracture resistance.

The challenge for medical educators and clinicians, therefore, is not to define bone quality, but to be able to communicate to patients the link between reduced bone quality and fracture risk so that individual patients at high risk will be identified, evaluated, and treated. Although there have been tremendous advances in the diagnosis and treatment of low bone quality/osteoporosis in the past two decades, it remains underdiagnosed and undertreated.

The need for improved diagnosis and care is urgent. The number of persons aged 65 years or older (the population at highest risk) is increasing rapidly. Burge et al. [7] project that the number of fragility fractures will increase by almost 50% by 2025 with the major increase in persons aged 65 to 74 years. The increase in the numbers of fractures is projected to be greatest among blacks and Hispanics because gains in life expectancy have been greatest in these groups. Randomized trials have conclusively shown use of bisphosphonate therapy in men and postmenopausal women can reduce the risk of fragility fractures by 35% to 40%. However, the majority of individuals who would benefit from treatment, particularly those who have already fractured, do not receive appropriate treatment. Finally, most of the research and education to date focuses on diagnosis and treatment of osteoporosis in white women. There is limited information available to help improve the care of persons of nonwhite ancestry, to say nothing of aiding the care of individuals with less common disorders such as Paget's disease, hypophosphatasia, and osteogenesis imperfecta.

This article highlights some of the new educational and clinical tools that have been developed in an effort to improve communication about reduced bone quality and fracture risk. The article looks at four questions: (1) What are some of the newest tools (ie, fracture-risk calculators) that can be used to identify individuals at high risk for fracture? (2) What clinical performance measures are being used to move the fracture-prevention agenda forward? (3) What clinical and educational strategies are being used to ensure patients at high risk for fractures are identified? (4) What are some authoritative, easy-to-access Web sites for educating physicians and patients about bone quality not just in white women, but in children, men, persons of nonwhite ancestry, and those with less common bone disorders?

Methods

The Web sites suggested as educational resources for patients and providers presented in this article were found using the search engine Google using the terms "bone quality" and "osteoporosis education." All Web sites are currently active. Furthermore, the identified Web sites were last updated on or after September 2007. Web site legitimacy was evaluated using specific criteria, which included complete content review. We restricted our search to English language Web sites maintained by nonprofit organizations.

The Web sites discussing screening tools for fracture risk were found on the Google search engine using their registered trademark names. References cited in other portions of the article were based on a selective review of articles from PubMed.

Results

What Are Some of the Newest Tools, ie, Fracture-risk Calculators, That Can Identify Individuals at High Risk for Fracture?

In an effort to develop a clinical tool that can serve as a surrogate for bone-quality measures, integrate individual clinical risk factors for fracture and (when feasible) bone mineral density (BMD), John Kanis and Olaf Johnell and colleagues [34], in partnership with the WHO, developed the Fracture Risk Assessment Tool (FRAX®) [22] (Fig. 1). The tool built on the methodologic experience of communities such as breast cancer and coronary heart disease research in developing risk-assessment models that calculate the 10-year absolute risk of an event on the basis of multiple variables. The consensus is that access to information on absolute (rather than relative) risks allows patients to make better-informed decisions about therapy [47].

The Foundation for Osteoporosis Research and Education used the same input variables as FRAX® (ie, base fracture rates and relative risks) to build a somewhat different tool, the Fracture Risk Calculator (FRC) [20, 21] (Fig. 2). FRC also calculates 10-year absolute fracture risk, but displays it graphically, superimposed on the average risk for an individual of the same gender and ethnicity. The FRC categorizes fracture risk into three categories: low (< 10%), medium (10%–20%), and high (> 20%). Not all patients understand risk and treatment options in the same way; providing information by category gives physicians another tool to promote patient understanding of their individual risk.

Fig. 1 An image of the Fracture Risk Assessment Tool is shown, displaying the wide variety of questions used to assess fracture risk. (Image used with permission of the WHO Collaborating Centre for Metabolic Bone Diseases, University of Sheffield. FRAX® is registered to Professor JA Kanis, University of Sheffield.)

FRAX™ WHO Fracture Risk Assessment Tool

HOME CALCULATION TOOL PAPER CHARTS FAQ REFERENCES

Calculation Tool

Please answer the questions below to calculate the ten year probability of fracture with BMD.

Country : US(Caucasian) Name / ID : About the risk factors ⓘ

Questionnaire:

1. Age (between 40-90 years) or Date of birth
Age: 65 Y: M: D:

2. Sex ☐ Male ☒ Female

3. Weight (kg) 63.5

4. Height (cm) 165.1

5. Previous fracture ☐ No ☒ Yes

6. Parent fractured hip ☒ No ☐ Yes

7. Current smoking ☒ No ☐ Yes

8. Glucocorticoids ☒ No ☐ Yes

9. Rheumatoid arthritis ☒ No ☐ Yes

10. Secondary osteoporosis ☒ No ☐ Yes

11. Alcohol 3 more units per day ☒ No ☐ Yes

12. Femoral neck BMD
T-score -1.8

BMI 23.2
The ten year probability of fracture (%)

with BMD

Major osteoporotic	23
Hip fracture	2.1

Fig. 2 An image of the Fracture Risk Calculator (FRC) output data that allows patients to visualize their own risk of fracture in comparison to those of high, moderate, and low risk is shown. (Reprinted with permission from the Foundation for Osteoporosis Research and Education dba American Bone Health.)

In the United States, both FRAX® and FRC can be applied to men as well as women and to individuals of four different ethnicities (white, Hispanic, Asian, and black). Both tools calculate the 10-year risk of hip fracture as well as of fractures to three other anatomic sites (ie, forearm, shoulder, and clinically apparent spine fractures). Both tools allow the user to print both the input variables and the user's 10-year absolute risk of hip and major osteoporotic (hip, spine, forearm, or shoulder)

fracture; FRAX®, however, performs more adjustments for interactions among variables. Users of both FRAX® and FRC get very similar, but not identical, estimates of fracture risk. FRAX® has recently been updated to reflect falling mortality rates as well as more extensive fracture data [13, 33].

FRC and FRAX® are available free at <http://riskcalculator.fore.org/> and <http://www.shef.ac.uk/FRAX/>, respectively.

What Clinical Performance Measures Are Being Used to Move the Fracture-prevention Agenda Forward?

Data from the National Committee on Quality Assurance (NCQA) have consistently demonstrated that among the most vulnerable population of all, namely, women older than 67 years who have had a fracture, only one in five are receiving appropriate postfracture evaluation or treatment [43]. In response, two national organizations have pushed performance improvement measures for bone health. The Centers for Medicare & Medicaid Services has developed the Physician Quality Reporting Initiative (PQRI), which uses a financial incentive to encourage compliance with bone health quality measures [8]. These measures are evolving. The 2010 PQRI measures include two measures related to primary osteoporosis care, two related to post-fracture care, and two related to fall prevention (Table 1). These measures were developed by the AMA convened Physician Consortium for Performance Improvement.® The Joint Commission has also taken up the cause of bone health and has developed 10 quality measures (Table 2).

The challenge is to get these measures accepted and used. In response to this challenge, the American Orthopaedic Association (AOA) has developed a Web-based quality improvement initiative, Own the Bone™ (OTB) [53]. The program, which the AOA is promoting nationally, focuses on improving care after a low-energy or fragility fracture. The AOA chose to focus on the prevention of secondary fractures because a low-energy fracture

in an adult is a sentinel event that signals the presence of a frail skeleton and a high risk for future fracture and subsequent disability. There is extensive documentation that patients with low-energy fractures are not receiving appropriate care [19, 23, 25, 26, 29, 43, 48]. A fracture offers physicians a teachable moment and an opportunity to affect the behavior of patients as well as of primary care physicians.

OTB uses a Web-based registry to document patient risk factors and then verify compliance with measures distilled from National Osteoporosis Foundation (NOF), Joint Commission, and PQRI measures appropriate for patients who have already sustained a fracture (Table 3). OTB partnered with the NOF and refers physicians to their Clinician's Guide to Prevention and Treatment of Osteoporosis (Available at: http://www.nof.org/professionals/NOF_Clinicians_Guide.pdf; accessed August 18, 2010) and their teaching materials as well as to those of the National Institutes of Health (NIH) Osteoporosis and Related Bone Diseases National Resource Center (NRC). Because it is Web-based, OTB can continuously update its evidence-based educational materials as well as benchmark the success (or failure) of participating institutions. The registry can be used in hospitals, clinics, or private offices. The goal of OTB is to identify and support champions throughout the medical community who are dedicated to improve efforts to prevent subsequent fractures. There is a great need for champions; numerous studies report that simply alerting primary care physicians about a fracture

Table 1. AMA convened Physician Consortium for Performance Improvement® performance measures are included in the Physician Quality Reporting Initiative and seek to promote and improve identification and therapy of patients with poor bone health

Quality measure	Performance
Osteoporosis: communication with the physician managing ongoing care postfracture of hip, spine, or distal radius for men and women aged 50 years and older	Percentage of patients aged 50 years and older treated for a hip, spine, or distal radial fracture with documentation of communication with the physician managing the patient's ongoing care that a fracture occurred and that the patient was or should be tested or treated for osteoporosis
Screening or therapy for osteoporosis for women aged 65 years and older	Percentage of female patients aged 65 years and older who have a central dual-energy xray absorptiometry (DXA) measurement ordered or performed at least once since age 60 or pharmacologic therapy prescribed within 12 months
Osteoporosis: management after fracture of hip, spine, or distal radius for men and women aged 50 years and older	Percentage of patients aged 50 years and older with fracture of the hip, spine, or distal radius who had a central DXA measurement ordered or performed or pharmacologic therapy prescribed
Osteoporosis: pharmacologic therapy for men and women aged 50 years and older	Percentage of patients aged 50 years and older with a diagnosis of osteoporosis who were prescribed pharmacologic therapy within 12 months
Falls: risk assessment	Percentage of patients aged 65 years and older with a history of falls who had a risk assessment for falls completed within 12 months
Falls: plan of care	Percentage of patients aged 65 years and older with a history of falls who had a plan of care for falls documented within 12 months

Measures in this table derive from two measure sets and are copyright 2006–2009 by the American Medical Association. All rights reserved. For the complete performance measurement sets, see www.physicianconsortium.org.

Table 2. Joint Commission performance measures aiming to promote and improve bone health especially in regard to screening and identifying patients

Quality measure	Performance
Screening for females at risk	Patients aged 60–64 with one or more risk factors or patients older than age 65 who have had at least one DXA performed
Secondary causes	Laboratory investigation for secondary causes of osteoporosis
Bone mineral density testing, glucocorticoid patients	Bone mineral density testing for those at high risk of fracture resulting from glucocorticoid administration
Dietary education, osteoporosis	Dietary education regarding calcium and vitamin D intake for patients with osteoporosis
Activity education, osteoporosis	Activity education appropriate to age and condition or a referral for activity counseling for patients with osteoporosis
Pharmacotherapy	Pharmacotherapy for patients with osteoporosis aged 50 and older
Risk assessment/treatment after fracture, acute	Patients older than age 49 who have had a fracture in acute care settings
Risk assessment/treatment after fracture, nonacute care	Patients older than age 49 who have had a fracture in nonacute care settings
Smoking and alcohol education for patients with osteoporosis and fracture	Education for osteoporosis and fracture patients, aged 50 and older, regarding cigarette smoking cessation and excess alcohol consumption
Fall risk and personal safety education	Patients (or their caregivers) aged 50 and older with new osteoporosis or fracture diagnosis who have received documented fall risk and personal safety education to minimize risk of future falls

DXA = dual-energy xray absorptiometry.

Table 3. Web sites of special interest displaying services and educational resources for clinicians and patients

American Society for Bone and Mineral Research (ASBMR)	http://app2.capitalreach.com/esp1204/servlet/tc?cn=asbmr&c=10169&s=20292&e=4521&e	Lectures and slides from a 2005 conference on Bone Quality: What Is It and Can We Measure It? The ASBMR specifically addresses the many aspects of bone quality
International Bone and Mineral Society (IBMS)	www.fractures.com/index.html	Bone Key (free online service for original scientific knowledge in the fields of bone, cartilage, and mineral metabolism)
International Osteoporosis Foundation (IOF)	www.iofbonehealth.org/download/osteofound/filemanager/publications/pdf/FRAX-report-09.pdf	The IOF also offers a free pamphlet entitled “FRAX®—Identifying People at High Risk of Fracture”
International Society for Fracture Repair (ISFR)	www.fractures.com/index.html	Tool kits for physicians providing strategies for the management of patients with prior and new fragility fractures
National Dairy Council	www.nationaldairycouncil.org/Pages/Home.aspx	Archives to recent publications and research summaries on dairy nutrition topics
National Osteoporosis Foundation	www.nof.org/	Offers access to patient support groups

does little [40] or nothing [3, 32, 50] to improve post-fracture diagnosis or treatment.

What Strategies Are Being Used to Ensure That Patients at High Risk for Fractures Are Identified?

Whether their goal is to manage primary screening for osteoporosis or to prevent subsequent fracture, clinicians face a number of critical process issues. Foremost among these are assigning responsibility for case finding and intervention, screening for poor bone quality, evaluating secondary causes of osteoporosis, determining optimal

education methods, performing cost-effective patient identification, and defining the role of information technology.

One explanation for the reluctance to screen is the absence of randomized controlled trials that demonstrating that screening works. However, a recent article by Barr on screening initiated in the early 1990s demonstrates that screening for osteoporosis substantially increases treatment and reduces fracture incidence [2]. Although most authors agree that primary care physicians and obstetricians/gynecologists should take the lead in ordering osteoporosis screening, responsibility for the care of the patient who has sustained a fracture remains in flux. Orthopaedic surgeons, the physicians who treat most low-energy fractures, are in a

unique position to facilitate and improve low-energy fracture care. However, virtually all authors underscore the importance of a dedicated coordinator of care [4, 31] or fracture liaison [41] to aid in this endeavor. Both in inpatient and outpatient settings, coordinator-facilitated programs have proven effective for the identification, education, assessment, referral, and treatment of patients with fractures.

Several authors have reported the success of outpatient followup clinics within fracture clinics or free-standing osteoporosis clinics. Patients in these clinics are typically between 50 and 80 years old and have a history of a nonhip fracture [4, 30, 35]. Few protocols have explored inpatient evaluation, probably because in-hospital initiatives generally require organizational paradigm shifts. Several authors [27, 51, 52] underscore that initiation of a postfracture care path or referral must not be left to chance; an admission protocol that prompts initiation of an osteoporosis evaluation and discharge plan is essential.

The most commonly used bone measurement tests used to screen for osteoporosis in the United States are dual-energy xray absorptiometry (DXA) of the hip and lumbar spine and quantitative ultrasound of the calcaneus. (Although quantitative ultrasound is less expensive and more portable than DXA and does not expose patients to ionizing radiation, current diagnostic and treatment criteria for osteoporosis rely on DXA measurements only.) Unfortunately, there is no consensus on what those criteria should be, particularly for women younger than 65 years and men younger than 70 years. The proceedings of the 2008 Summit for a National Action Plan for Bone Health noted that osteoporosis guidelines are “complex, inconsistent, and not widely used” [1]. However, the recent US Public Service Task Force on screening for osteoporosis offers a most thoughtful compromise. They suggest anyone whose risk for fracture is the same or worse than that of a woman aged 65 years with no risk factors, using the FRAX questionnaire, should have DXA screening to improve their decision making regarding therapy [55]. They support use of the FRAX questionnaire because (1) the tool relies on easily obtainable clinical information (eg, age, body mass index, parental fracture history, tobacco and alcohol use); (2) its development was supported by a broad international collaboration and extensively validated in two large US cohorts; and (3) it is freely accessible by clinicians and the public.

Several authors have underscored the fact that many patients with fractures, particularly those with a hip fracture, have one or more secondary causes of osteoporosis/poor bone quality [18, 37]. Osteoporosis in men is likely to be a marker of a systemic disease; 65% to 70% of men have secondary causes that contribute to osteoporosis, whereas this is only true for 20% to 40% of women with

osteoporosis [17, 46]. Most commonly these secondary causes are the result of insufficient or deficient vitamin D, chronic kidney disease, monoclonal gammopathy, or low calcium absorption. Although there is not yet a consensus as to the appropriate workup for secondary osteoporosis, recommended tests include assessment of vitamin D status, evaluation for disorders in calcium absorption and excretion, protein electrophoresis, and renal function studies [18, 27]. Other endocrine, gastrointestinal, and connective tissue disorders have been identified as secondary causes of osteoporosis/poor bone quality and should therefore not be overlooked. These include hyper-/hypoparathyroidism, hypogonadism, anorexia nervosa, diabetes mellitus, lactose intolerance, rheumatoid arthritis, giant cell arteritis, alcohol abuse, and exogenous hyperthyroidism [16]. The majority of secondary causes are correctable and it is believed that by identifying and correcting these associated disorders, treatment aimed at reducing fracture risk will be more effective.

The challenges of educating patients about poor bone quality are substantial. This is particularly true for patients with hip fracture, who, according to Switzer et al. [52], are frequently older than age 80 years, minimally ambulatory, and have multiple medical comorbidities and cognitive impairment. Independent of age, numerous studies have underscored the importance of direct (personal) over information-based (pamphlet) communication. For example, Gardner et al. [25] compared rates of treatment between control subjects who received a pamphlet on fall prevention and treatment group patients, who had a 15-minute discussion about osteoporosis evaluation with a research nurse and were provided with a list of questions for their primary medical physician about osteoporosis evaluation and treatment followed with a telephone reminder 6 weeks after hospitalization about the need to address osteoporosis. Six months later, 42% of those in the treatment group had received attention for osteoporosis compared with 19% in the control group. Success was attributed to the impact of the research nurse's activities.

At present, only integrated health systems have been able to demonstrate cost savings from case finding. Data from two integrated health systems underscore the financial savings that can be achieved when fracture incidence is reduced. The Geisinger Health System in Pennsylvania established an Osteoporosis Disease Management Program, which combined clinical practice guidelines, physician and allied healthcare provider education, community education, and a bone density testing program to target rural women older than 55 years of age [45]. They estimated that the resultant reduction in hip fracture rates saved the health plan \$7.8 million over 5 years. Kaiser Permanente's “Healthy Bones Program” demonstrated an over 37% reduction in hip fracture rates over historical projections in

2006, saving Kaiser over \$30 million in 1 year. Kaiser recruits orthopaedic surgeons to serve as the leaders of a multidisciplinary effort that includes outreach programs to target for diagnostic screening those individuals at high risk for fracture, particularly individuals older than age 75 years and, when appropriate, therapy [15]. A weakness of both of these studies, however, is they do not include all costs, especially the substantial personnel costs that were likely required to achieve these savings. In addition, as underscored in a recent commentary in the *Journal of the American Medical Association* by David Mechanic, as of 2006, only 9% of US physicians were in practice groups of 11 or more [42]. Thus, it may not be possible to achieve the extraordinary communication and coordination achievement seen in integrated health systems over the short term.

The ability to apply information technology to identify and manage patients with low bone quality is still in its infancy; however, it should be underscored that a major element of the success of Kaiser's "Healthy Bones" program came from Kaiser's ability to take advantage of the electronic medical record to provide health update reminders at all patient visits. Harrington et al. improved osteoporosis care by developing an information systems enhancement (ie, fracture billing data review) that automatically referred fracture patients to an osteoporosis care service [29]. OTB hopes to be at the forefront of documenting and benchmarking compliance with bone health performance measures using its Web-based performance improvement tool.

What Are Some Authoritative, Easy-to-access Web Sites for Educating Physicians and the Public About Bone Quality?

Lectures and slides from Bone Quality: What Is It and Can We Measure It?, a 2005 conference sponsored by the American Society for Bone and Mineral Research

(ASBMR), are available at <http://app2.capitalreach.com/esp1204/servlet/tc?cn=asbmr&c=10169&s=20292&e=4521&&> (Table 3). Although numerous academic articles on "bone quality" can be identified by searching PubMed, the free database for accessing the MEDLINE database of citations, abstracts, and some full-text articles on life sciences and biomedical topics managed by the National Library of Medicine, only the ASBMR site specifically addresses the many aspects of bone quality.

The Web site for the International Osteoporosis Foundation (<http://www.iofbonehealth.org/>) lists Web sites for English-language nonprofit organizations whose primary purpose is to educate clinicians and patients about bone health. Virtually all these sites focus on osteoporosis, not bone quality, because the former has been the focus of educational efforts for many decades. Most government-sponsored Web sites provide their information at no charge; materials from private organizations may carry a fee.

A useful government-sponsored Web site is that of the NIH Osteoporosis and Related Bone Diseases National Resource Center, whose mission is to increase the awareness, knowledge, and understanding of physicians and other health professionals, patients, underserved and at-risk populations (such as Hispanic and Asian women, adolescents, and men), and the general public about the prevention, early detection, and treatment of osteoporosis and related bone diseases. They have recently updated their bone health Web site and their reports can be accessed at www.bone.nih.gov. In addition, their brochure "Once Is Enough: A Guide to Preventing Future Fractures" (available at www.niams.nih.gov/Health_Info/Bone/Osteoporosis/Fracture/preventing_fracture.pdf) provides a reader-friendly discussion about how to prevent subsequent fractures.

Some Web sites offer free slide sets to supplement presentations on bone health (Table 4) and some are specifically designed to enhance education of trainees and physicians about bone health.

Table 4. Web sites offering free slide sets from nonprofit organizations that can be used in a variety of educational modalities to enhance healthcare providers and others on different aspects of bone quality

Organization	Web site
American Society for Bone and Mineral Research (ASBMR)	www.asbmr.org/Publications/Primer/PrimerSlideSets.aspx
Bone Research Society, UK	www.brsoc.org.uk/gallery/index.htm#slides
International Osteoporosis Foundation (IOF)	www.iofbonehealth.org/health-professionals/educational-tools-and-slide-kits.html
International Society of Bone Densitometry	www.iscd.org/visitors/resources/
National Osteoporosis Foundation (NOF)	www.nof.org/professionals/powerpointpresentation/index.htm
North American Menopause Society	www.menopause.org/aboutmeno/consensus.aspx
US Bone and Joint Decade	www.usbjd.org/healthcare_pro/index.cfm?pg=patient_materials.cfm#presentations

Table 5. Web sites that promote outreach to educate and engage children and adolescents about the importance of bone health

Web site	Description
http://www.nutritionexplorations.org/educators/lessons/littled/littled-main.asp?tab=1	Little D's Nutrition Expedition and Arianna's Nutrition Expedition features hands-on learning about eating healthy
www.nutritionexplorations.org/kids/main.asp	Nutrition Explorations, created by the National Dairy Council offers fun education for kids
www.nichd.nih.gov/milk/kids/kidsteens.cfm	Milk Matters, a campaign from the NICHD promotes calcium consumption in children aged 11–15 through fun games
www.bestbonesforever.gov	The US Department of Health and Human Services "Best Bones Forever" campaign for girls aged 9–14
www.mypyramid.gov/kids/index.html	MyPyramid for Kids is a child-friendly version of the USDA MyPyramid.gov web site
www.3daysuperfans.org/	The 3-A-Day of Dairy Superfans web site designed to resemble a "playbook," contains 3-A-Day and NFL activities for kids
http://exhibits.pacsci.org/nutrition/nutrition_cafe.html	The Nutrition Café website is a joint endeavor of the Pacific Science Center and the Washington State Dairy Council that provides fun games for older adolescent children such as Nutrition Sleuth, Have-A-Bite Café, and Grab a Grape
Tools for educators	
www.beabonebuilder.com/welcome.html	Bone Builders is an osteoporosis awareness program for girls and young women presented by the southern California chapter of the Arthritis Foundation
www.bones4life.org/121.aspx	Bones4Life has resources to educate children about Bone Health and fun activities for elementary school children as well
http://science.education.nih.gov/customer.nsf/MSBone.htm	NIH Curriculum Supplement for Middle School Children (Grades 7–8)
http://courses.washington.edu/bonephys/index.html	Osteoporosis and Bone Physiology

A key challenge in improved bone quality is maximizing peak bone mass in young adults. There are a number of sites that focus on this topic (Table 5). The sites are both instructional and entertaining. One of the newest campaigns, developed by the US Department of Health and Human Services, is Best Bones Forever (a play on the popular phrase "best friends forever," or "BFF") targets girls between the ages of 9 and 14. The Web site provides girls with information about bone health, calcium intake, and the importance of eating right and being active in a fun, accessible, and interactive format. The program provides a range of free materials within the United States, including diaries for tracking calcium and food intake as well as exercises, book covers, tattoos, and pamphlets for parents.

Some Web sites are designed specifically for individuals with rare bone disorders (Table 6). According to the National Organization of Rare Diseases (www.rare-diseases.org/), a rare disease is one that affects fewer than 200,000 people. The NIH's National Resource Center provides easy-to-understand information on an extensive list of rare bone diseases. The Rare Bone Disease Patient Network is a partnership of patient advocacy groups that have banded together to increase awareness and research about these disorders. Osteogenesis imperfecta, osteopetrosis, fibrous dysplasia, and Paget's disease have distinct foundations or associations that conduct research and provide education in their respective areas.

Discussion

The purpose of this article was to highlight some of the new educational and clinical tools that have been developed in an effort to better inform both physicians and the public about bone quality and fracture risk. Specifically, we explored (1) new tools (ie, fracture-risk calculators) that can identify individuals at high risk for fracture; (2) clinical performance measures being used to move the fracture-prevention agenda forward; (3) strategies that are being used to ensure that patients at high risk for fractures are identified; and (4) authoritative, easy-to-access Web sites for learning about bone quality. Tremendous strides have been made, yet each effort has its unique limitations.

The authors acknowledge limitations to this review. First, the paper focuses on only two tools, FRAX® and FRC, as measures for identifying fracture risk. Although each of these tools offers an extraordinary step forward in making it possible to estimate individual fracture risk, they do have shortcomings. Most important, neither tool includes input for the tendency to fall (although this limitation is partially compensated for by adjusting fracture risk for age). Additionally, FRAX®/FRC do not allow for inclusion of spinal BMD. Third, they do not include all known fracture risk factors because many of these factors were not included in the databases on which the tools are based. FRAX®/FRC can only be used in untreated

Table 6. Web sites of organizations on a variety of rare bone disorders

Resources	Web site
Genetics Home Reference	http://ghr.nlm.nih.gov/
Rare Bone Disease Patient Network	http://www.usbjd.org/projects/RBDPN_op.cfm?dirID=252
The National Institutes of Health, National Resource Center supported by the National Institute of Arthritis and Musculoskeletal and Skin Diseases	http://www.niams.nih.gov/health_Info/Bone/
Fibrous dysplasia	
Fibrous Dysplasia Foundation	http://www.fibrousdysplasia.org/
Children's Craniofacial Association (A Guide to Understanding Fibrous Dysplasia)	http://www.ccakids.com/Syndrome/FibrousDysplasia.pdf
Hypophosphatasia	
National Organization of Rare Disorders	http://www.rarediseases.org/search/rdbdetail_abstract.html?disname=Hypophosphatasia
Osteogenesis imperfecta	
Osteogenesis Imperfecta Foundation	http://www.oif.org/site/PageServer
Osteopetrosis	
International Osteopetrosis Association (IOA)	http://www.internationalosteopetrosisassociation.org/
Paget's disease	
The Paget Foundation	http://www.paget.org/

patients. FRAX®/FRC can be used only by physicians who have access to the Internet. Finally, fracture risk varies significantly by country, and only a limited number of country models are available.

A second overall limitation of the present study is that it is restricted to quality measures developed in the United States and focuses on a quality improvement effort developed by a single orthopaedic organization. Fractures are a worldwide concern, and a more exhaustive review would include quality initiatives from across the globe. Third, our review of efforts to identify individuals at risk for fracture was limited because almost all published studies focus on women; little data are available on identifying men at risk. There are likewise little data available on fracture risk in African Americans, Hispanics, and American Indians. Finally, our list of educational websites is far from comprehensive. Faced with an abundance of sites and limited space, we purposefully limited our list to sites in the English language and those maintained by nonprofit sources.

Cost-effectiveness analyses and treatment guidelines based on US fracture rates and costs have recently been published [13, 14, 54]. These analyses suggest pharmacotherapy should be initiated when the 10-year risk of hip fracture is 3% or more or the 10-year risk for any of four fractures (hip, wrist, humerus, and lypine) is greater than 20%. However, although FRAX®/FRC identify patients at high risk for fracture, they do not predict whether treatment will safely reduce the fracture rate. Reducing fracture rates depends on other factors such as underlying disease states, allergies, and drug-drug interactions. Moreover, FRAX®

is based on fracture rates in untreated individuals and does not account for the effects of osteoporosis treatment. For this reason, it cannot be used in patients who have already received osteoporosis therapy.

Perhaps the greatest challenge will be to get healthcare professionals to incorporate FRAX® and/or FRC into their practices. Cranney et al. have demonstrated physicians currently rely heavily on bone density reports to guide therapeutic decision-making and do not factor in other risk elements [11].

A growing body of evidence suggests performance measures can help educate physicians and motivate them to follow guidelines. Perhaps the most famous program is Get With the Guidelines [36], an effort initiated by the American Heart Association to increase the use of beta blockers after a heart attack. This program has been so successful that, as described by Lee in "Eulogy for a Quality Measure," "prescription of a beta-blocker following myocardial infarction" has been retired. Compliance is so high that the measure can no longer be used to distinguish programs [38]. The challenge for proponents of bone quality performance improvement efforts such as Own the Bone is to match this extraordinary success story.

Although there is still ample room for improvement, rates of screening for low bone quality are rising slowly [9, 12, 58]. There is, moreover, indirect evidence that screening and treatment efforts are making a difference. In the United States [6] and Canada [39], hip fracture rates and subsequent mortality among persons 65 years and older are declining, especially among women older than 85 years, despite the fact that comorbidities among patients

with fractures have increased. Although the decrease in incidence corresponds temporally with the market release of several bisphosphonates, this pharmacotherapy alone does not fully explain the decline in the fracture rate. Brauer et al. [6] suggest the decline in fracture rate may also be attributable to a greater focus on healthy lifestyles.

Although recent research has reflected a new willingness on the part of the orthopaedic community to assume the challenge of improving efforts to prevent subsequent fractures [49], the data suggest this is not really the case. Haaland et al. have noted that in patients with hip fractures, the greatest predictor of diagnosis and treatment for osteoporosis in a previously undiagnosed individual was transfer to a rehabilitation or geriatrics unit [28]. As noted earlier, data from NCQA continue to document low levels of compliance with their quality measures in managed care environments. Patients at risk for subsequent fractures are the population OTB hopes most to impact.

A frequent explanation for low rates of screening in the general population, particularly by primary care physicians, is that there are so many other life-threatening problems needing attention (eg, hypertension, diabetes) that osteoporosis screening is a low priority [5]. Unfortunately, a recent article by Nayak et al. demonstrated those patients with the most risk factors for fracture are also the most likely not to receive diagnostic tests and treatment. In addition, men with osteoporosis appear to be identified and treated even less often than women [44].

As clearly demonstrated by the Web sites delineated in the Results section and tables, numerous foundations, organizations, and advocacy groups have launched major efforts to enhance the knowledge of physicians and the public about bone quality via Web sites. Unfortunately, research data clearly show that adherence to osteoporosis therapy, once the decision to treat is made, is very poor. Explanations for this behavior are wide-ranging. The decision to start an osteoporosis treatment in the first place appears to be correlated with the patient's confidence in the effectiveness of the osteoporosis therapies and their general mistrust of medications altogether [59]. The decision whether to continue taking an osteoporosis medication includes fear of possible side effects and dosing requirements [56]. Unfortunately, there are no proven strategies for improving adherence. However, there is a growing consensus that simply referring patients to Web sites or downloading relevant handouts will not do the job. As noted earlier in the discussion of work by Gardner et al., nurse-patient (and physician-patient) interaction and discussion are a critical component of the education effort [24].

These are exciting times in medicine. Personalized medicine and point-of-care technologies hold hope that each individual's evaluation and treatment will be evidence-based and specific to his or her needs. In the field of bone

health, with the advent of tools such as FRAX® and FRC, we now have effective tools with which to gauge an individual's risk of fracture. Equally promising, we now have extensive Web-based tools for educating both patients and clinicians. Realizing the full benefits of these advances, however, will not be easy. It will require surmounting extraordinary hurdles that go far beyond the scope of this article. For example, will insurers support osteoporosis screening, care coordination, and therapy? How can we overcome the considerable level of denial among the baby boomers, now rapidly becoming our senior population, who do not want to admit that they might be susceptible to a "little old lady disease"? How, too, do we increase their sense of personal responsibility to maximize and maintain their bone health with simple strategies such as exercise as well as adequate calcium and vitamin D? How do we ensure that those patients who do fracture, and thus demonstrate that they at substantial risk for future fracture, receive optimum evaluation and care? Will Own the Bone or other performance-improvement efforts succeed in achieving the bone quality and reduction in fracture rates patients deserve? The Web sites and strategies discussed in this article are an important first step, but much work remains to be done.

References

1. American Society for Bone and Mineral Research. National Action Plan for Bone Health. Available at: <http://www.asbmr.org/Advocacy/NAP.aspx>. Accessed March 7, 2011.
2. Barr RJ, Stewart A, Torgerson DJ, Reid DM. Population screening for osteoporosis risk: a randomised control trial of medication use and fracture risk. *Osteoporos Int*. 2010;21:561–568.
3. Bliuc D, Eisman JA, Center JR. A randomized study of two different information based interventions on the management of osteoporosis in minimal and moderate trauma fractures. *Osteoporos Int*. 2006;17:1309–1317.
4. Bogoch ER, Elliot-Gibson V, Beaton DE, Jamal SA, Josse RG, Murray TM. Effective initiation of osteoporosis diagnosis and treatment for patients with a fragility fracture in an orthopaedic environment. *J Bone Joint Surg Am*. 2006;88:25–34.
5. Boyd CM, Darer J, Boult C, Fried LP, Boult L, Wu AW. Clinical practice guidelines and quality of care for older patients with multiple comorbid diseases: implications for pay for performance. *JAMA*. 2005;294:716–724.
6. Brauer CA, Coca-Perraillon M, Cutler DM, Rosen AB. Incidence and mortality of hip fractures in the United States. *JAMA*. 2009;302:1573–1579.
7. Burge R, Dawson-Hughes B, Solomon DH, Wong JB, King A, Tosteson A. Incidence and economic burden of osteoporosis-related fractures in the United States, 2005–2025. *J Bone Miner Res*. 2007;22:465–475.
8. Centers for Medicaid and Medicare Services. Physician Quality Reporting Initiative. Available at: www.cms.hhs.gov/pqri/. Accessed March 7, 2011.
9. Cohen K, Maier D. Osteoporosis: evaluation of screening patterns in a primary-care group practice. *J Clin Densitom*. 2008;11:498–502.

10. Cooper C. The epidemiology of fragility fractures: is there a role for bone quality? *Calcif Tissue Int.* 1993;53(Suppl 1):S23–S26.
11. Cranney A, Lam M, Ruhland L, Brison R, Godwin M, Harrison MM, Harrison MB, Anastassiades T, Grimshaw JM, Graham ID. A multifaceted intervention to improve treatment of osteoporosis in postmenopausal women with wrist fractures: a cluster randomized trial. *Osteoporos Int.* 2008;19:1733–1740.
12. Curtis JR, Carbone L, Cheng H, Hayes B, Laster A, Matthews R, Saag KG, Sepanski R, Tanner SB, Delzell E. Longitudinal trends in use of bone mass measurement among older Americans, 1999–2005. *J Bone Miner Res.* 2008;23:1061–1067.
13. Dawson-Hughes B, Looker AC, Tosteson AN, Johansson H, Kanis JA, Melton LJ 3rd. The potential impact of new National Osteoporosis Foundation guidance on treatment patterns. *Osteoporos Int.* 2010;21:41–52.
14. Dawson-Hughes B, Tosteson ANA, Melton LJ 3rd, Baim S, Favus ML, Khosla S, Lindsay RL. Implications of absolute fracture risk assessment for osteoporosis practice guidelines in the USA. *Osteoporos Int.* 2008;19:449–458.
15. Dell R, Greene D, Schelkun SR, Williams K. Osteoporosis disease management: the role of the orthopaedic surgeon. *J Bone Joint Surg Am.* 2008;90(Suppl 4):188–194.
16. Dumitrescu B, van Helden S, ten Broeke R, Nieuwenhuijzen-Kruseman A, Wyers C, Udea G, van der Linden S, Geusens P. Evaluation of patients with a recent clinical fracture and osteoporosis, a multidisciplinary approach. *BMC Musculoskelet Disord.* 2008;9:109.
17. Ebeling PR. Clinical practice. Osteoporosis in men. *N Engl J Med.* 2008;358:1474–1482.
18. Edwards BJ, Langman CB, Bunta AD, Vicuna M, Favus M. Secondary contributors to bone loss in osteoporosis related hip fractures. *Osteoporos Int.* 2008;19:991–999.
19. Elliot-Gibson V, Bogoch ER, Jamal SA, Beaton DE. Practice patterns in the diagnosis and treatment of osteoporosis after a fragility fracture: a systematic review. *Osteoporos Int.* 2004;15:767–778.
20. Ettinger B. A personal perspective on fracture risk assessment tools. *Menopause.* 2008;15:1023–1026.
21. FORE Foundation for Osteoporosis Research and Education. 10-year Fracture Risk Calculator. Available at: <http://riskcalculator.fore.org/>. Accessed March 7, 2011.
22. FRAX®. WHO Fracture Risk Assessment Tool. Available at: <http://www.shef.ac.uk/FRAX/tool.jsp>. Accessed March 8, 2011.
23. Freedman KB, Kaplan FS, Bilker WB, Strom BL, Lowe RA. Treatment of osteoporosis: are physicians missing an opportunity? *J Bone Joint Surg Am.* 2000;82:1063–1070.
24. Gardner MJ, Brophy RH, Demetrakopoulos D, Koob J, Hong R, Rana A, Lin JT, Lane JM. Interventions to improve osteoporosis treatment following hip fracture. A prospective, randomized trial. *J Bone Joint Surg Am.* 2005;87:3–7.
25. Gardner MJ, Flik KR, Moar P, Lane JM. Improvement in the undertreatment of osteoporosis following hip fracture. *J Bone Joint Surg Am.* 2002;84:1342–1348.
26. Giangregorio L, Papaioannou A, Cranney A, Zytaruk N, Adachi JD. Fragility fractures and the osteoporosis care gap: an international phenomenon. *Semin Arthritis Rheum.* 2006;35:293–305.
27. Glowacki J, Harris MB, Simon J, Wright J, Kolatkar NS, Thornhill TS, Leboff MS. Brigham fracture intervention team initiatives for hospital patients with hip fractures: a paradigm shift. *Int J Endocrinol.* 2010;2010:590751.
28. Haaland DA, Cohen DR, Kennedy CC, Khalidi NA, Adachi JD, Papaioannou A. Closing the osteoporosis care gap: increased osteoporosis awareness among geriatrics and rehabilitation teams. *BMC Geriatr.* 2009;9:28.
29. Harrington JT, Broy SB, Derosa AM, Licata AA, Shewmon DA. Hip fracture patients are not treated for osteoporosis: a call to action. *Arthritis Rheum.* 2002;47:651–654.
30. Harrington JT, Deal CL. Successes and failures in improving osteoporosis care after fragility fracture: results of a multiple-site clinical improvement project. *Arthritis Rheum.* 2006;55:724–728.
31. Hawker G, Ridout R, Ricupero M, Jaglal S, Bogoch E. The impact of a simple fracture clinic intervention in improving the diagnosis and treatment of osteoporosis in fragility fracture patients. *Osteoporos Int.* 2003;14:171–178.
32. Jaglal SB, Hawker G, Bansod V, Salbach NM, Zwarenstein M, Carroll J, Brooks D, Cameron C, Bogoch E, Jaakkimainen L, Kreder H. A demonstration project of a multi-component educational intervention to improve integrated post-fracture osteoporosis care in five rural communities in Ontario, Canada. *Osteoporos Int.* 2009;20:265–274.
33. Kanis JA, Johansson H, Oden A, Dawson-Hughes B, Melton LJ 3rd, McCloskey EV. The effects of a FRAX revision for the USA. *Osteoporos Int.* 2010;21:35–40.
34. Kanis JA, Johnell O, Oden A, Johansson H, McCloskey E. FRAX and the assessment of fracture probability in men and women from the UK. *Osteoporos Int.* 2008;19:385–397.
35. Kuo I, Ong C, Simmons L, Bliuc D, Eisman J, Center J. Successful direct intervention for osteoporosis in patients with minimal trauma fractures. *Osteoporosis Int.* 2007;18:1633–1639.
36. LaBresh KA, Ellrodt AG, Gliklich R, Liljestrand J, Peto R. Get With the Guidelines for cardiovascular secondary prevention: pilot results. *Arch Intern Med.* 2004;164:203–209.
37. LeBoff MS, Kohlmeier L, Hurwitz S, Franklin J, Wright J, Glowacki J. Occult vitamin D deficiency in postmenopausal US women with acute hip fracture. *JAMA.* 1999;281:1505–1511.
38. Lee TH. Eulogy for a quality measure. *N Engl J Med.* 2007;357:1175–1177.
39. Leslie WD, O'Donnell S, Jean S, Lagacé C, Walsh P, Bancej C, Morin S, Hanley DA, Papaioannou A. Trends in hip fracture rates in Canada. *JAMA.* 2009;302:883–889.
40. Majumdar SR, Johnson JA, McAlister FA, Bellero D, Russell AS, Hanley DA, Morrish DW, Maksymowych WP, Rowe BH. Multifaceted intervention to improve diagnosis and treatment of osteoporosis in patients with recent wrist fracture: a randomized controlled trial. *CMAJ.* 2008;178:569–575.
41. McLellan AR, Gallacher SJ, Fraser M, McQuillan C. The fracture liaison service: success of a program for the evaluation and management of patients with osteoporotic fracture. *Osteoporos Int.* 2003;14:1028–1034.
42. Mechanic D. Replicating high-quality medical care organizations. *JAMA.* 2010;303:555–556.
43. National Committee for Quality Assurance. The state of health care quality: 2009. Available at: www.ncqa.org/tabid/836/Default.aspx. Accessed March 7, 2011.
44. Nayak S, Roberts MS, Greenspan SL. Factors associated with diagnosis and treatment of osteoporosis in older adults. *Osteoporos Int.* 2009;20:1963–1967.
45. Newman ED, Ayoub WT, Starkey RH, Diehl JM, Wood GC. Osteoporosis disease management in a rural health care population: hip fracture reduction and reduced costs in postmenopausal women after 5 years. *Osteoporos Int.* 2003;14:146–151.
46. Nguyen TV, Eisman JA, Kelly PJ, Sambrook PN. Risk factors for osteoporotic fractures in elderly men. *Am J Epidemiol.* 1996;144:255–263.
47. Peters E, Hibbard J, Slovic P, Dieckmann N. Numeracy skill and the communication, comprehension, and use of risk-benefit information. *Health Aff (Millwood).* 2007;26:741–748.
48. Siris ES, Bilezikian JP, Rubin MR, Black DM, Bockman RS, Bone HG, Hochberg MC, McClung MR, Schnitzer TJ. Pains and plaster aren't enough: a call for the evaluation and treatment of

- patients with osteoporotic fractures. *J Clin Endocrinol Metab.* 2003;88:3482–3486.
49. Skedros JG, Holyoak JD, Pitts TC. Knowledge and opinions of orthopaedic surgeons concerning medical evaluation and treatment of patients with osteoporotic fracture. *J Bone Joint Surg Am.* 2006;88:18–24.
 50. Solomon DH, Finkelstein JS, Polinski JM, Arnold M, Licari A, Cabral D, Canning C, Avorn J, Katz JN. A randomized controlled trial of mailed osteoporosis education to older adults. *Osteoporos Int.* 2006;17:760–767.
 51. Streeten EA, Mohamed A, Gandhi A, Orwig D, Sack P, Sterling R, Pellegrini VD Jr. The inpatient consultation approach to osteoporosis treatment in patients with a fracture. Is automatic consultation needed? *J Bone Joint Surg Am.* 2006;88:1968–1974.
 52. Switzer JA, Jaglal S, Bogoch ER. Overcoming barriers to osteoporosis care in vulnerable elderly patients with hip fractures. *J Orthop Trauma.* 2009;23:454–459.
 53. Tosi LL, Gliklich R, Kannan K, Koval KJ. The American Orthopaedic Association's 'Own the Bone' initiative to prevent secondary fractures. *J Bone Joint Surg Am.* 2008;90:163–173.
 54. Tosteson ANA, Melton LJ 2nd, Dawson-Hughes B, Baim S, Favus MJ, Khosla S, Lindsay RL. Cost-effective osteoporosis treatment thresholds: the United States perspective. *Osteoporos Int.* 2008;19:437–447.
 55. US Preventive Services Task Force, Agency for Healthcare Research and Quality. Screening for Osteoporosis in Postmenopausal Women. Available at: <http://www.uspreventiveservices.org/uspstf/uspsooste.htm>. Accessed March 8, 2011.
 56. Warriner AH, Curtis JR. Adherence to osteoporosis treatments: room for improvement. *Curr Opin Rheumatol.* 2009;21:356–362.
 57. Watts BN. Bone quality: getting closer to a definition. *J Bone Miner Res.* 2002;17:1139–1147.
 58. Weiss TW, Siris ES, Barrett-Connor E, Miller PD, McHorney CA. Osteoporosis practice patterns in 2006 among primary care physicians participating in the NORA study. *Osteoporos Int.* 2007;18:1473–1480.
 59. Yood RA, Mazor KM, Andrade SE, Emani S, Chan W, Kahler KH. Patient decision to initiate therapy for osteoporosis: the influence of knowledge and beliefs. *J Gen Intern Med.* 2008;23:1815–1821.