REVIEW ARTICLE

Osteoporosis and the orthopaedic surgeon: basic concepts for successful co-management of patients' bone health

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Abstract Osteoporosis has been recognised as a public health concern for at least three decades but it has been relatively recent that the push has been for orthopaedic surgeons to take a more active role in the diagnosis and treatment of patients with decreased bone mineral density (BMD). Most often these patients are encountered after they have suffered a fracture making secondary prevention the area where orthopaedists may exert the greatest influence on patient care. The purpose of this article is to provide a succinct framework for the diagnosis and treatment of patients with decreased BMD. Patients are deemed to have decreased BMD if they have suffered a fragility fracture, a fracture caused by a lowenergy traumatic event. These patients are often encountered in the emergency department and admitted for further treatment of their fractures or recommended for follow-up in the clinic. Regardless of treatment course these are opportunities for the orthopaedic surgeon to intervene in the osteoporotic disease process and positively affect a patient's bone health. This article compiles the available literature on osteoporosis and presents it succinctly with the incorporation of both a diagnosis algorithm and treatment profile table. With the use of these two tools, orthopaedic surgeons everywhere should be able to take a more active role in their patients' bone health.

Keywords Osteoporosis · Orthopaedic surgeon · Early management · Screening · Fragility fracture

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Introduction

Osteoporosis, defined as the breakdown in the microarchitectural structure of bone due to decreased bone mineral density (BMD), has become a significant public health issue that is approaching epidemic proportions in both developed and developing countries [1]. The US Surgeon General recognised this area of increasing morbidity as being particularly important within the USA due to the increasing population of senescent individuals. In 2004 the US Surgeon General issued a report to bring awareness to this situation. Part of the report detailed a lack of cooperation and communication between primary care physicians (PCP) and orthopaedic surgeons who were often the first health care provider to have objective evidence of a specific patient's bone health following a low-energy fracture, termed a fragility fracture [2]. The American Orthopaedic Association (AOA) took up this charge in 2005 with the "Own the Bone" project. The goals of the project were to assess current practices within the orthopaedic community in preventing further low-energy fractures, to implement quality improvement measures and to assess what barriers might exist for the expansion of the project [3].

Many studies have highlighted that a previous fracture is highly correlated with an increased risk for a future fracture [4, 5]. As such it becomes important for orthopaedic surgeons to recognise that a patient with a low-energy fracture has poor bone stock and also to be proactive in the prevention of future fractures in the treatment of that patient [6]. To that end the purpose of this paper is to provide a basic framework for the work up of a patient with a primary fragility fracture and also to provide a treatment algorithm for easy reference (Fig. 1).



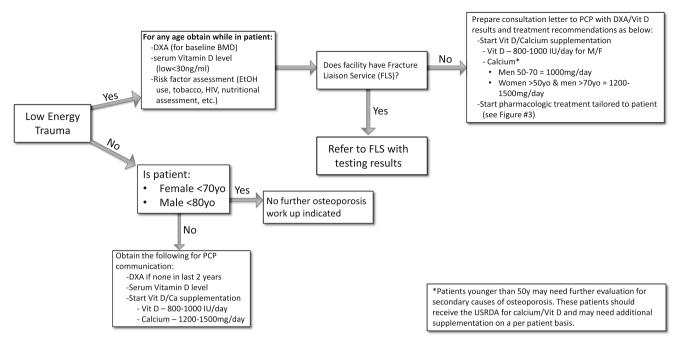


Fig. 1 Work up of a patient with a primary fragility fracture and treatment algorithm

Background

Osteoporosis is characterised by the breakdown in the microarchitectural structure of bone leading to decreased bone mass and subsequently to increased bone fragility and fracture risk [7, 8]. The decreased BMD results in bones that are more brittle and are consequently more easily broken when subjected to deforming forces that would not injure a person with normal BMD. Fractures that are attributable to osteoporotic bone stock are termed fragility fractures and are associated with increased morbidity and mortality [9, 10]. There tends to be some debate surrounding exactly which fractures are to be included in the fragility fracture definition, with some suggesting that all fractures resulting from low-energy mechanisms should be included, while others feel that only certain fractures should be included in the definition [8, 11]. For the purposes of this review all fractures that result from a lowenergy traumatic event will be included regardless of age, gender and race. Though this may lead to diagnostic testing of individuals who do not have decreased BMD, it should ensure that patients who do have decreased BMD are not missed.

Detecting patients with low BMD is vitally important due to the increased risk of a secondary fracture. Patients who have suffered a fragility fracture are almost twice as likely to suffer another fragility fracture as their age-matched peers who have not had a fragility fracture [4, 12]. Though all fractures have some degree of morbidity and mortality, the overarching concern with a second fracture in an osteoporotic patient is that the patient will suffer a hip fracture. Hip fractures are

the most devastating consequence of osteoporosis, with 25 % of patients having to spend time in a nursing home following the fracture and 50 % of patients never reaching their pre-fracture activity levels. The mortality rate following a hip fracture is 25 % in the first year with men almost twice as likely to die as women [2]. It has been shown that close to 50 % of patients who have suffered a hip fracture had a previous fragility fracture suggesting that there is an opportunity for early diagnosis and treatment [13].

In addition to the mortality associated with a fragility fracture, the financial costs of treatment and rehabilitation continue to increase. Multiple estimates have suggested that the annual cost hovers around 18-20 billion dollars annually in the USA alone and is only going to increase [12]. Despite its increasing financial costs and dramatic consequences, the recognition, diagnosis and treatment of osteoporosis continues to be an area needing further improvement and education within the health care community [3, 14-17]. It is unacceptable for close to 80 % of patients with a hip fracture to never have received medication to treat their pre-fracture osteoporosis, particularly given that osteoporosis treatment decreases the rate of fragility fractures and mortality by up to 30 % [18–21]. The presence of fragility fractures should lead to the consideration of treatment or at least exploration of bone metabolism. The orthopaedic surgeon is routinely involved in cases of fragility fractures, and many studies have shown that early osteoporosis screening by the orthopaedic surgeon, as part of the treatment plan, leads to better disease management [3, 22–25].



Who are the osteoporotic patients and what can I do for them?

Orthopaedic surgeons are typically only involved in the osteoporotic patient's care as a consequence of a fracture and with the single biggest risk factor for a future fracture being a previous fragility fracture, it therefore follows that the area of focus for the orthopaedist should be on the secondary prevention of future fractures [4, 26, 27]. Though there has been a historical reluctance to get involved in the osteoporosis treatment of patients seen with fragility fractures that reticence has changed [28]. With the instigation of the Own the Bone program by the AOA, the idea of the orthopaedist being a key component in the care of a patient's bone health, beyond the acute fracture care, has gained a great deal of traction [16]. Due to this interest there has been a great deal of research undertaken regarding which patients can most benefit from the interventions of the orthopaedic surgeon in the acute phase of fracture care and how the surgeon can effect a positive change in BMD.

As previously stated there should be a high degree of suspicion for low BMD in any patient that suffers a fracture from a low-energy mechanism. Though there is debate about which fractures should be considered fragility type fractures, we advocate for assuming all fractures should be considered fragility fractures, except for fractures of the facial bones, skull, feet, hands, digits and patella [8]. Areas of fracture outside of the above exceptions have been correlated with decreased BMD and therefore are deemed fragility fractures [29]. These patients should all be considered osteoporotic until proven otherwise by diagnostic testing.

Interestingly enough, one of the fractures that are the most common in the osteoporotic individual is also the most often missed: vertebral body fractures. They are most often missed due to a lack of inclusion in the differential diagnosis of patients with back pain and are thus overlooked [30]. A vertebral body fracture should be suspected in any patient at risk for osteoporosis with back pain or kyphosis. Due to their potentially asymptomatic presentation, the National Osteoporosis Foundation recommends screening by vertebral imaging of the following patients:

- Women >70 years old and men >80 years old
- BMD measurements compatible with osteopenia in women aged 65–69 and men aged 75–79
- In postmenopausal women aged 50–64 and men aged 50–69 with a low-energy traumatic vertebral body fracture, actual height loss (prospective 0.8 inches or historical of 1.5 inches) or corticosteroid use [31]

Though the full work up of patients with presumed decreased BMD should include tests designed to tease

out if their decreased BMD is due to a primary or secondary pathology, this work up is best left for a patient's PCP, geriatrician or endocrinologist. Areas where orthopaedic surgeons can be most effective are in the initial consultation with the patient where a conversation takes place regarding the patient's modifiable and non-modifiable risk factors (Fig. 2), the initiation of pharmacological treatment if appropriate (Fig. 3) and obtaining or recommending a bone mineral densitometric analysis using dual-energy X-ray absorptiometry (DXA) [14, 23]. In addition to diagnostic tests, the FRAX tool can also be used to assess a patient's ten year risk of fracture based on lab values and DXA scores if available [32]. Studies have demonstrated that with well-developed communication systems between the orthopaedic surgeon and the PCP of patients where the results of the aboveoutlined tests can be communicated there is increased BMD assessment using DXA scans, increased pharmacological treatment and decreased secondary fractures [12, 20, 33].

The osteoporotic patient in my clinic...who should I call?

Osteoporosis diagnosis and treatment requires a multidisciplinary approach. The management of this condition highlights the patient-centred medical home concept. Part of the Own the Bone concept was to impassion orthopaedic surgeons to make systematic changes in their practices to facilitate a more open flow of communication with a patient's primary care provider [16]. Studies in many different countries have demonstrated that with increased communication between the orthopaedist, patient and patient's PCP there is increased usage of pharmacotherapeutics, calcium and vitamin D supplementation, and BMD assessment with DXA scan [34]. There is also good evidence that the use of calcium, vitamin D and pharmaceutical interventions results in a decreased risk of fragility fractures [31, 35].

A concept that has been implemented in a few health care systems in the USA and has shown good results in increasing communication between the orthopaedist and a patient's PCP is the Fracture Liaison Service (FLS) [36, 37]. The FLS functions by identifying patients who have suffered fragility fractures in the emergency department, orthopaedics ward and outpatient clinics. The service can then ensure patients are appropriately diagnosed as being osteoporotic or at risk of osteoporosis. The diagnosis can then facilitate further assessment of bone density and ensure proper treatment has been initiated. The FLS can also coordinate the communication between the orthopaedist and the PCP and make sure that all information is passed on to the PCP [38].



Fig. 2 Modifiable and non-modifiable risk factors

Modifiable Risk Factors	Non-Modifiable Risk Factors	
Smoking history	Age	
Alcohol intake (3 or more drinks/day)	Gender	
Overall nutrition	Family history	
	Rheumatoid Arthritis	
	Glucocorticoid usage	
	Secondary osteoporosis	

Early interventions that can be driven by the orthopaedist

Besides pharmacological treatments, there are also certain general interventions listed below that can be recommended to most patients to reduce fracture risk.

- Ensure adequate calcium and vitamin D intake
- Decrease alcohol, caffeine and tobacco consumption
- Encourage regular physical activity [39]
- Fall prevention, with a home safety evaluation, if indicated [31, 40]

Recommending the use of calcium and vitamin D supplementation is an easy and relatively inexpensive intervention that can be applied to the vast majority of people encountered after a fragility fracture. There are good meta-analyses on the fracture risk reduction of calcium and vitamin D supplementation, with the corollary that the benefit might be seen more in institutionalised individuals more so than in communitydwelling individuals [41-43]. Although there is some controversy regarding calcium and vitamin D supplementation [44], there are many clinical representative bodies that support the use of calcium and vitamin D for fracture prevention including the National Osteoporosis Foundation, the Institute of Medicine and the American Association of Clinical Endocrinologists [31, 45, 46]. Figure 4 outlines the current dietary recommendations for both calcium and vitamin D taken from the above references.

Excessive alcohol or tobacco consumption also needs to be addressed, and if needed a referral to a substance abuse specialist should be made [31]. It has long been thought that alcohol in any amount has a negative effect on bone health, but researchers are now concluding that alcohol consumption in excess of three average drinks per day does indeed have a deleterious effect on BMD but low to moderate alcohol consumption, one to three drinks per week, in fact seems to be beneficial for bone health [47]. Smoking on the other hand should be avoided altogether [48].

Weight-bearing exercise should also be encouraged. Two meta-analyses have shown improvements in the BMD at the lumbar spine and femoral neck in postmenopausal women involved in weight-bearing exercises [49,

50]. The American College of Sports Medicine recommends weight-bearing exercise three to five times a week and resistance exercise two to three times a week for 30-60 minutes to improve bone health [51]. These guidelines may seem to be unrealistic, particularly for a busy populace, but any type of physical activity needs to be encouraged [52]. At a minimum, a daily 30- to 40 minutes walk as suggested by the American Association of Clinical Endocrinologists should certainly be encouraged [45]. In addition to its positive effects on BMD, physical activity may also show a benefit in fall prevention. A recent Cochrane Review looked at exercise as part of a fall prevention strategy and the authors' conclusions were that exercises that incorporated multiple different types of exercises were successful at reducing the fall risk in both individuals who were classified as "high-risk" and "low-risk" for falls [53]. And with the best predictor of future falls being previous falls [27, 54], it is of paramount importance to halt the fall cycle as early as possible with referrals to physical therapy and occupational therapy for general physical exercise recommendations and also for home safety evaluations. With the close relationship between orthopaedic surgeons and the physical and occupational therapists, it should be relatively effortless to provide this referral while seeing patients with fragility fractures either in the clinical setting or in the emergency department.

What happens to patients that I refer for evaluation?

Though orthopaedic surgeons are willing and interested in being an integral part of the diagnosis and initial treatment of patients with decreased BMD, previous studies have demonstrated that the gap in the treatment of osteoporotic individuals occurs between the orthopaedist and the patient's primary care provider [33, 55, 56]. In an effort to rectify this situation, the FLS has been proposed to function as the clearing house and manager for a patient's BMD work up and treatment [34, 57]. This concept has been in place for many years in various countries throughout the world and with continued analysis has become more efficacious with time and experience. When the FLS is designed such that there is an independent



Drug	Indication	Dosage Regimen
BISPHOSPHONATES		
(contraindicated in pts w/ GFR<30-35ml/min;		
Zoledronic acid in pts w/ CrCl <35ml/min)		
Alendronate	- Tx of men and postmenopausal women w/ osteoporosis	PO preparations only
	- Reduces incidence of spine and hip fractures by 50% over 3y in patients	A. 10mg/day;
	with previous vertebral body fracture and reduces incidence of vertebral	B. 70mg/wk;
	fractures by 48% over 3y in patients without prior vertebral fracture	C. 70mg + 2800-5600 IU Vit D3
Ibandronate	- Tx of postmenopausal osteoporosis; not approved for men	A. 150mg/mo PO
	- Reduces incidence of vertebral fractures by 50% over 3y; no data on non-	B. 3mg/3 mo IV
	vertebral fractures	B. SHIR/S HIG IV
	- Tx of men and postmenopausal women w/ osteoporosis and for patients	A. 5mg/d
	using glucocorticoids.	B. 35mg/wk
Risedronate	- Reduces incidence of vertebral fractures by 41-49% and non-vertebral	C. 75mg on 2 consecutive
	fractures by 36% over 3 years w/ significant risk reduction in 1st year, in	days/mo
	patients with a prior vertebral fracture	D. 150mg/month
	- Tx of men and postmenopausal women with osteoporosis; approved for	
Zoledronic acid	secondary fracture prevention after hip fracture	5mg IV/yr may require pre-
	- Reduces incidence of vertebral body fractures 70%; hip fractures 41%; and	infusion treatment w/ APAP due to possible infusion reaction
	non-vertebral fractures 25% over 3y	
	- Tx of osteoporosis in women at least 5y post-menopause	
Calcitonin	- Reduces incidence of vertebral fractures by 30% in those with prior	A. 200 IU intranasal
Calcitoriiii	vertebral body fracture, no risk reduction of non-vertebral fractures	B. 50-100 IU subcutaneously Qday or QOD
	vertebrar body mactare, no risk reduction of non-vertebrar mactares	or god
	- Prevention of osteoporosis and other symptoms of menopause	
Estrogen/Hormone Therapy	- 5y of hormone therapy reduced risk of clinical vertebral and hip fractures	Many different regimens available
	by 34% and other fractures by 23% (Women's Health Initiative)	
	T.	
ESTROGEN AGONIST/ANTAGONIST (SERMs)		
	- Prevention of osteoporosis in postmenopausal women	
Raloxifene	- Reduces risk of vertebral fractures by 30% in patients with prior vertebral	60mg/d PO
	fracture and 55% in patients without prior fracture; no data on risk	001116/ 0110
	reduction of non-vertebral fractures	
	- Tx of men and postmenopausal women w/ osteoporosis and high fracture	
Parathyroid Hormone: Teriparatide	risk	20ug/d subcutaneous
,	- Reduces risk of vertebral fractures by 65% and non-vertebral fractures by	
	53% after an average of 18 months of treatment	
RANK-L inhibitor		
IVANIA-E IIIIIDILOI	- Ty of mon and northernopaural woman w/ esteenorasis and high fire stress	
	- Tx of men and postmenopausal women w/ osteoporosis and high fracture	
Denosumab	risk	60mg/6 months subcutaneous
	- Reduces incidence of vertebral fractures by 68%, hip fractures by 40%,	
	and non-vertebral fractures by 20% over 3y	

Fig. 3 Pharmacological treatment

practitioner or team of practitioners that function to identify, assist with assessment and coordinate information and treatment with a patient's PCP it has shown excellent success at reducing the rates of a second fracture in patients [58–60].

Once patients have been referred to the FLS or other similar service, the FLS can then focus on this area of patient treatment. This can be particularly useful for patients who are encountered in the emergency department or in the clinic



Fig. 4 Current dietary recommendations for calcium and vitamin D

Daily Calcium Intakes	
Men aged 50-70 years old	1000 mg
Men aged >71 years old	1200 mg
Women aged ≥ 50 years old	1200 mg

Vitamin D	
Normal serum level	30 – 80 ng/ml
Recommended Daily intakes	800 to 1000 IU
Supplementation if serum level < 30 ng/ml	50,000 IU/week for 8 to 12 weeks

who will need specific follow-up and who might not have the opportunity acutely to obtain a DXA scan and the other recommended blood work.

Another area to consider with regards to the FLS is the push towards quality outcomes measurement in the USA. The Centers for Medicare & Medicaid Services (CMS) uses the Physician Quality Reporting System (PQRS) to measure and track the diagnosis and treatment of osteoporosis in patients. The PQRS currently assesses the appropriate treatment of osteoporotic individuals, among other measures, and passes that information on to CMS to use as a determination of health care reimbursement rates [61]. It has also been suggested that soon the Joint Commission will be using similar quality measures during its assessment of hospitals for accreditation [23].

ABC's of pharmacological treatment

In addition to a diagnostic work up of patients with fragility fractures, studies have also demonstrated decreased rates of secondary fractures when osteoporosis treatment is initiated at the time of the initial fracture [31, 62]. There also appears to be better long-term compliance with medication administration when the orthopaedic surgeon or FLS prescribe the medication. As part of the treatment of osteoporosis, communication with the patient's PCP should be carried out to not only inform the provider of the new medication but also how to assess the efficacy of the medication and what the follow-up should be [38].

Currently it is recommended by most clinical organisations dealing with osteoporosis that patients be treated subsequent to their fracture [31, 45]. There are many different drugs for the treatment of osteoporosis and often it can be confusing when and for whom a specific drug should be used. A brief description of the different categories is presented below with more in-depth treatment parameters presented in Fig. 3 [31].

Bisphosphonates

Calcitonin

Oestrogen agonist/ antagonists

Teriparatide

Receptor activator of nuclear factor kappa-B (RANK) ligand inhibitor Bind to calcium and are then resorbed by osteoclasts during bone remodelling and cause osteoclast cell death which results in decreased resorption of bone. Causes decreased resorption of bone by osteoclasts.

The only US Food and Drug Administration (FDA) approved drug in this class is raloxifene, which is an oestrogen receptor agonist in bone which causes decreased bone resorption by osteoclasts.

This is recombinant human parathyroid hormone and is an anabolic agent that causes an increase in BMD through greater absorption of calcium and stimulating osteoblastic activity. This drug is a monoclonal antibody with activity against RANK ligand. RANK ligand causes increased osteoclast activity; by binding the ligand with an antibody, osteoclastic activity is decreased.

Conclusion

With the 2004 position paper from the US Surgeon General regarding fragility fractures, there has been a great deal of interest generated in osteoporotic fractures, also termed fragility fractures. In general, patients who suffered a fracture from a low-energy mechanism that would not cause a fracture in a normal person should be considered osteoporotic until proven otherwise. With the suspicion of osteoporosis in a patient, it



now behoves the orthopaedic surgeon to initiate a diagnostic work up and initiate a referral to either the FLS or analogous position if available or generate a letter to the patient's primary care provider that provides the results of the diagnostic testing performed while the patient was under the care of the orthopaedic service. This testing is spelled out in the algorithm presented in Fig. 1. Once testing has been accomplished, immediate treatment for the patient should be initiated with calcium, vitamin D and depending on the patient often a bisphosphonate or other anti-resorptive pharmaceutical treatment. The treatment options currently available are listed in Fig. 3 including individual drug indications. With these tools readily at hand, diagnosis and treatment of osteoporotic patients should be more straightforward and efficacious.

Conflict of interest The authors declare that they have no conflict of interest.

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