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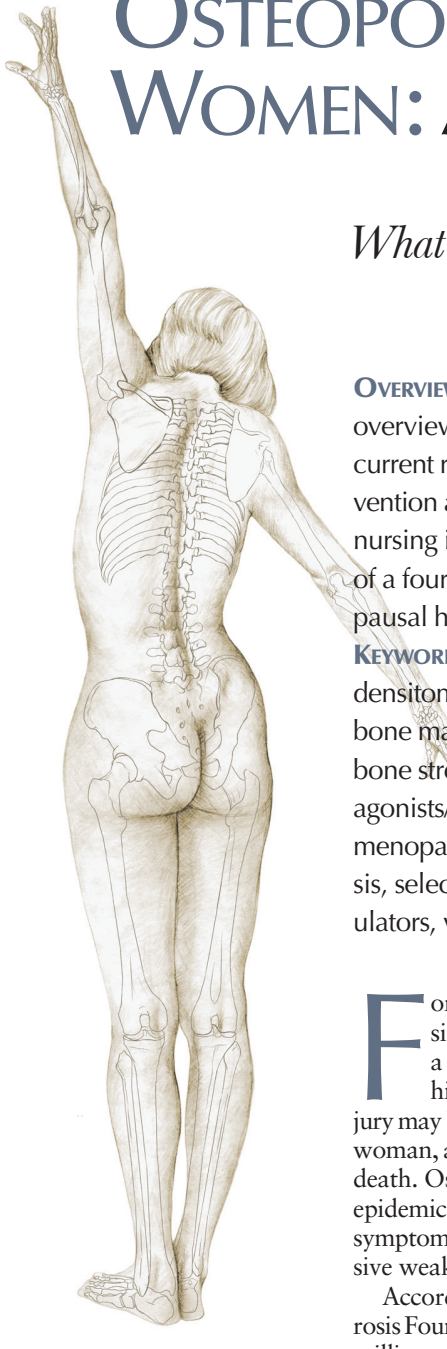
Prevention and Treatment of Osteoporosis in Postmenopausal Women: A Review

What nurses can do to help patients avoid the 'silent epidemic.'



Overview: This article provides an overview of osteoporosis, describes current recommendations for its prevention and treatment, and discusses nursing implications. This is part two of a four-part series on postmenopausal health.

Keywords: bisphosphonates, bone densitometry testing, bone health, bone mass, bone mineral density, bone strength, calcium, estrogen agonists/antagonists, hip fracture, menopause, osteopenia, osteoporosis, selective estrogen receptor modulators, vertebral fracture, vitamin D

For a woman with osteoporosis, simply lifting a box or slipping on a wet floor can result in a broken hip or spinal fracture. Such an injury may be all it takes to disable an active woman, and all too often it leads to early death. Osteoporosis is called the "silent epidemic" for good reason; there are no symptoms to alert women to the progressive weakening of their bones.

According to the National Osteoporosis Foundation (NOF), an estimated 10 million people in the United States have osteoporosis and 80% of them are women.[1] Osteoporotic fractures are a major cause of morbidity in older women and significantly decrease quality of life.[2] In the United States about 40% of white women over the age of 50 will fracture their hip, vertebrae, or wrist because of osteoporosis; fracture rates in other ethnic groups are much lower.[3] For many women, the injury will be the first indication that they have the disease. The annual cost of osteoporotic fractures in the United States is projected to be more than $20 billion by 2015.[4]

The World Health Organization (WHO) defines osteoporosis as "a systemic skeletal disease characterized by low bone density and microarchitectural deterioration of bone tissue," leading to increased bone fragility and fracture risk.[5] Modifiable risk factors include low calcium and vitamin D intake, sedentary lifestyle, and smoking; nonmodifiable risk factors include advanced age, genetics, thinness, and menopause status.[3]

Prevention of osteoporosis should start early in life, but it's never too late to improve bone health. There are measures women can take to prevent or attenuate bone loss, and accurate diagnostic tools and effective treatment are available. Nurses are essential to the multidisciplinary approach needed. This article provides nurses with a review of osteoporosis and current recommendations for prevention and treatment so they can assist women in maintaining optimal bone health.

Measuring Bone Strength

Bone strength is dependent on bone mineral density (BMD) (also called bone mass) and other aspects of bone microarchitecture such as mineral crystal size, collagen structure, and heterogeneity of mineralization.[6] However, only BMD can be measured with current

technology. (For an understanding of how the body balances levels of minerals in bone, see Figure 1; for a related discussion, see *Pathophysiology of Bone Loss*.[3,7-11])

BMD is a measurement of the grams of mineral per area volume.[3] The most commonly used test is dual-energy X-ray absorptiometry scanning of the spine and hips. The scan reports BMD as a Z score or a T score. Both scores are a measurement of the number of standard deviations (SDs) the recorded density is from the density of a reference population. The Z score is used in premenopausal women; it represents the difference between the test result and the average score for women of the same age and ethnicity. The T score is used in postmenopausal women and represents the difference between the result and the average score for a healthy 30-year-old woman. Ethnicity is not considered in the calculation of a T score, although this approach is not universally agreed upon.

The WHO has established the following four diagnostic categories based on BMD measured at the hip, femoral neck, or lumbar spine[12]:

- normal—BMD within 1 SD of the young adult reference mean
- osteopenia—BMD greater than 1 SD but less than 2.5 SDs below the young adult reference mean
- osteoporosis—BMD 2.5 SDs or more below the young adult reference mean
- severe osteoporosis—BMD 2.5 SDs or more below the young adult reference mean with one or more fragility fractures

A lower BMD is associated with an increased risk of fractures in women. For each SD decrease in BMD, the risk of nonspinal osteoporotic fracture increases by 37% in black women and 49% in white women[13] and the odds of having a vertebral fracture increase by 1.78.[14]

Bone densitometry testing is not indicated for all postmenopausal women. According to recommendations from the North American Menopause Society (NAMS) and the NOF, bone densitometry tests should be conducted in[3,15]

- all postmenopausal women who have had a fracture.
- all women who have a condition associated with bone loss (such as rheumatoid arthritis or hyperparathyroidism), regardless of age.
- all women who have taken medications associated with bone loss (such as chemotherapy or glucocorticoids taken daily for three or more months), regardless of age.
- women younger than age 65 who have one or more osteoporotic risk factors (addressed in the following section on osteoporosis-related fractures).
- all women age 65 or older, regardless of clinical risk factors.
- women being treated for osteoporosis.

The WHO has developed a Fracture Risk Assessment Tool (FRAX) to calculate the risk of a fracture in adults with osteopenia or osteoporosis. It uses a combination of BMD scores and risk factors to calculate a person's risk of a major osteoporotic fracture over the next 10 years. For more information on FRAX, see "Incorporating the WHO FRAX Assessment Tool into Nursing Practice" in this issue and visit www.shef.ac.uk/FRAX.

OSTEOPOROSIS-RELATED FRACTURES

The three most common sites of osteoporotic fractures are the vertebrae, wrist, and hip.[5] According to a study of the incidence and cost burden of osteoporosis-related fracture by Burge and colleagues, vertebral fractures are the most common (27%) in women, followed by fractures of the wrist (22%), and hip (15%).[4] Other sites combined account for the remaining 36% of fractures. Vertebral and hip fractures are of particular concern because they cause considerable morbidity and mortality in older women.

AN ESTIMATED 10 MILLION PEOPLE IN THE UNITED STATES HAVE OSTEOPOROSIS AND 80% OF THEM ARE WOMEN.

According to NAMS, the major risk factors for an osteoporotic fracture include low BMD scores, older age, lower body mass index, inactive lifestyle, smoking, high alcohol intake (more than two units a day; a unit is 12 fluid ounces of beer, four of wine, or one of liquor), parental history of a hip fracture, history of exposure to glucocorticoids, rheumatoid arthritis, history of a fall, back pain, prior history of an osteoporotic fracture, and early menopause.[3]

Vertebral fractures. Osteoporotic vertebral fractures are compression fractures of the vertebra, most commonly occurring in the midthoracic or thoracolumbar area.[16] The Study of Osteoporotic Fractures, a prospective study of more than 9,700 women ages 65 years or older, found a 20% prevalence rate of vertebral fractures among the 9,575 women who had baseline radiographs of the spine.[17] Most vertebral fractures occur in women in their mid-70s.[3] Many such fractures go undiagnosed, and it's estimated that up to

two-thirds are asymptomatic. In many cases there is no history of trauma; the fracture happens during normal activities such as lifting a moderately heavy object or sneezing. Even if a woman experiences pain, she will often attribute it to activity or aging, perhaps because there's no obvious physical deformity to be seen as there usually is with a wrist or hip fracture.

Adequate calcium and vitamin D intake are the most important modifiable factors in ensuring bone health.

Vertebral fractures can significantly affect a woman's quality of life. In a study of 107 patients with acute vertebral fractures, four out of five continued to experience pain, disability, and decreased quality of life a year later.[18] Vertebral fracture is also predictive of future osteoporotic fractures. Women with vertebral fractures have a five-to-sevenfold increased risk of another vertebral fracture, and up to two and a half times the risk of other osteoporotic fractures.[3, 19]

There is strong evidence that vertebral fractures increase the risk of death. Studies have found that, compared with women who haven't had a vertebral fracture, those who have are from 1.23 to 3.7 times more likely to die during the next five to eight years.[17, 20] However, in one prospective study of more than 7,200 community-dwelling adults, researchers found no increased risk when they controlled for weight loss and frailty.[21]

Detection. Early identification of vertebral fractures is necessary to ensure appropriate treatment and prevent further disability. Height measurement is an important and easy screening method; studies consistently show that loss of height is predictive of vertebral fractures.[22-24] Siminoski and colleagues investigated the accuracy of historical height loss in detecting vertebral fractures.[23] They found that when historical height loss was 6 cm (2.4 inches) or more, its positive predictive value was relatively low and its negative predictive value was quite high—that is, historical height loss is a much better predictor of true negatives than of true positives. They recommended that women who have lost more than 6 cm have a radiographic examination to rule out vertebral fractures. A more recent study of men and women found that height loss of half an inch corresponded to a 19% increase in the odds of having had a vertebral fracture; with a height loss of three inches, the odds of fracture increased as much as 177%.[24] While 45% of participants had osteoporosis according to BMD or fracture criteria, 30% of participants would have been misdiagnosed—not considered to have osteoporosis—had BMD alone been assessed.

In older women, height loss, back pain (particularly in the thoracic region), and history of vertebral or low-trauma nonvertebral fracture warrant further investigation for the presence of vertebral fractures.[25] Radiographic imaging should be considered, especially when more than one risk factor is present.

Treatment is focused on pain relief and minimizing disability. Acute vertebral fractures may be treated with opioids and rest for a few days, but early mobilization is important. Chronic pain, which can result from postural changes and facet joint osteoarthritis as well as from the fracture, is treated with nonsteroidal anti-inflammatory medications, physiotherapy, and calcitonin. Although its mechanism of action is not fully understood, calcitonin, a hormone produced by the thyroid gland that slows down the release of calcium from bones, helps relieve the pain associated with vertebral fractures[26] and decreases the risk of new ones.[27] It's available as a nasal spray and as a subcutaneous injection (as calcitonin salmon, a form extracted from salmon). It is not effective in the treatment of nonvertebral fractures and is not recommended for that purpose.[3]

Surgery is rarely used to treat osteoporotic vertebral fractures. In cases of intractable pain, either a vertebroplasty or balloon kyphoplasty might be performed. Both entail a percutaneous injection of polymethyl methacrylate cement into the fractured vertebra, usually under local anesthesia.[28] Kyphoplasty has the added benefits of decreasing kyphosis and restoring height; a balloon is used to expand the vertebral body before injecting the cement into the resultant space.[29] Both procedures have been shown to reduce pain and improve functioning.[28]

Hip fractures result in disability, loss of independence, and early death more often than any other type of osteoporotic fracture.[3, 30] According to Johnell and Kanis, nearly 19 million disability-adjusted life-years are lost worldwide because of hip fractures.[31] A systematic literature review found that the risk of death for a patient during the first year after a hip fracture is at least double that for an age-matched control without such fracture, and continues to be higher for several years.[32]

In the United States, about 18% of women will suffer a hip fracture in their lifetime, with the highest incidence among women in their mid-70s.[3, 30] According to the WHO, blacks have about one-third and Asians and Hispanics about half the risk of suffering a hip fracture compared with whites.[5]

Most osteoporotic hip fractures are a result of a sideways fall that causes excessive stress on the proximal femur.[33] There is some evidence to support the use of hip protectors to prevent hip fractures in frail, institutionalized older adults, but the evidence doesn't support their use in community-dwelling older adults.

Treatment. Hip fractures are treated with surgical repair, ideally within 24 hours of the injury.[34] The type of surgery performed depends on anatomical site and type of fracture; the patient's age, health status, and

activity level; and the surgeon's preference.[34, 35] High-quality postoperative care and rehabilitation is essential as the risk of death is greatest in the first six months after a hip fracture. The Agency for Healthcare Research and Quality's guideline on the management of hip fracture in older adults provides information on evidence-based care and is available at www.guidelines.gov/content.aspx?id=15206.

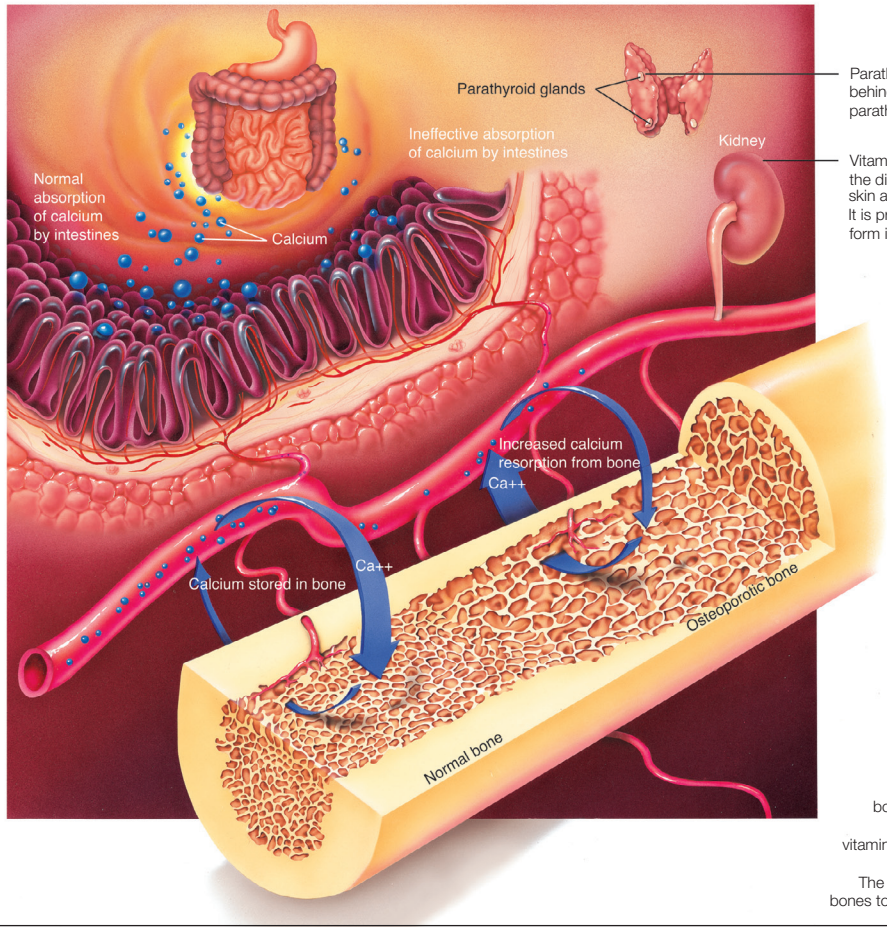
PREVENTION AND MANAGEMENT OF OSTEOPOROSIS

A consideration of lifestyle factors is fundamental to effective prevention and management.[3] Adequate calcium and vitamin D intake are the most important modifiable factors in ensuring bone health, followed by weight-bearing exercise. Avoiding smoking and excessive alcohol intake are also important, as is preventing falls. When osteoporosis progresses despite lifestyle changes, then hormone therapy or pharmacotherapy, including bisphosphonates and estrogen agonists/antagonists (also known as selective estrogen receptor modulators, or SERMs), may be prescribed. Calcium and vitamin D deficiencies must be corrected before initiating pharmacologic therapy.

Calcium and vitamin D. For women ages 50 years and older, the National Institutes of Health and the NOF recommend a daily intake of at least 1,200 mg of elemental calcium.[15,36] Ideally, calcium should come from dietary sources,[15] but the data indicate that among women older than 50, 10% or fewer get enough calcium from diet alone.[37] According to NAMS, the average postmenopausal woman's diet contains only about 700 mg of calcium daily; women who are lactose intolerant, vegetarian, or have poor nutrition consume even less.[3] A study using data from the 1999–2002 National Health and Nutrition Examination Survey found that, even with calcium supplementation, only 38% of American women meet recommended calcium intake levels.[38] Although there is no definitive test to diagnose calcium deficiency, according to NAMS "a 24-hour urine calcium level of less than 50 mg suggests either insufficient intake or poor absorption."[3]

Dairy products are the major dietary sources of cal-

FIGURE 1. Controlling Bone Mineral Balance



Calcium from the digestive system is normally absorbed by the blood and deposited into the bones. In osteoporosis, blood levels of calcium are slightly low due to dietary calcium deficiency, the inability of intestines to absorb calcium, or the lack of estrogen in the body as in postmenopause. To maintain calcium in the blood, resorption from the bones increases and causes osteoporosis. In addition to enhanced bone resorption, low blood calcium increases the effects of two other factors: PTH and vitamin D. Both stimulate calcium absorption from the intestine and increase resorption from bone. The result is an increased sacrifice of calcium in the bones to maintain normal levels of calcium in the blood.

cium, with low-fat yogurt, cheddar cheese, and nonfat milk having the most milligrams per serving. Nondairy sources include canned sardines with bones; dark, leafy vegetables; canned salmon with bones; firm tofu made with calcium sulfate; and calcium-fortified orange juice and cereals.[36] However, vegetable sources are not especially high in calcium (spinach provides 120 mg per serving; most others, less than 100 mg); also, phytic and oxalic acids found in some vegetables (including spinach and collard greens) can interfere with calcium absorption.

Studies consistently show a significant decrease in falls among women who participate in regular exercise programs.

Calcium is poorly absorbed without adequate levels of vitamin D, which also plays an important role in muscle strength and balance, important factors in decreasing the risk of falling. Mounting evidence that recommended intake levels of vitamin D were too low to maintain optimal bone health led the NOF to recommend an intake of 800 to 1,000 IU of vitamin D daily for postmenopausal women.[15]

The primary source of vitamin D is sunlight. But unprotected exposure to the sun increases the risk of skin cancer, and the use of sunscreen with a sun protection factor of 8 cuts vitamin D production by 98%.[39] And even prolonged, unprotected sun exposure will not produce enough of the vitamin for people living in temperate or extreme northern or southern latitudes.[3, 40] It's difficult to meet vitamin D requirements through dietary sources. Very few foods, aside from oily fish such as salmon and mackerel, naturally contain vitamin D. Most dietary intake comes from fortified products, particularly milk, milk products, orange juice, and breakfast cereals.[37] Fewer than 10% of adults get enough vitamin D from diet alone; even with supplementation, fewer than 30% of women ages 50 or older meet the current recommendations.[41]

There is a definitive test for evaluating whether a person is getting enough vitamin D: serum 25-hydroxyvitamin D [25(OH)D]. According to NAMS, for peak calcium absorption efficiency, serum 25(OH)D should be 29 to 32 ng/mL (some sources recommend slightly higher levels).[3] Levels should be rechecked three months after starting supplementation to allow time for a steady-state level to be reached.

Most postmenopausal women require both calcium and vitamin D supplementation, which has been shown to improve BMD and decrease the risk of fractures in people over age 50. In one large study of postmenopausal women already enrolled in a Women's Health Initiative (WHI) trial, researchers evaluated the efficacy of calcium plus vitamin D supplementation in preventing hip and other fractures.[42] They found that women who took calcium plus vitamin D supplements had a small but significant improvement in hip bone density; those who were at least 80% adherent to the regimen had a 29% decreased risk of hip fractures. A meta-analysis of 17 trials in which fracture was an outcome found that calcium alone or in combination with vitamin D was associated with a 12% reduced risk of fractures overall; that risk was reduced to 24% when adherence to treatment was high.[43] A recent pooled analysis of 68,500 patients found that calcium plus vitamin D reduced the overall risk of fractures by 8% and the risk of hip fractures by 16%.[44] Improved bone density with the use of calcium or calcium-plus-vitamin-D supplementation was also reported.[43, 44]

Exercise. Weight-bearing exercise and resistance training may enhance bone health in both premenopausal and postmenopausal women. Bones adapt their structure as a response to stress at the loaded site, increasing cortical thickness and bone strength.[45] A Cochrane review concluded that weight-bearing exercise "appears to be effective in increasing bone density at the lumbar spine and hip in women with postmenopausal osteoporosis."[46] While the positive effects of exercise on bone have been supported by a number of more recent studies,[45, 47, 48] it appears that strict compliance to a regular high dose of exercise is necessary to increase bone strength and reduce fracture risk.[49-51] There is evidence that some or all of the positive effects on bone may be lost once a woman stops exercising.[52, 53]

Exercise is also important in preventing falls that can lead to osteoporotic fractures. Studies consistently show a significant decrease in falls among women who participate in regular exercise programs, especially programs that address balance and those that have a higher overall dose of exercise.[54-56]

Tobacco and alcohol use. The evidence is conclusive regarding cigarette smoking and osteoporosis: smoking greatly increases bone loss and the risk of fracture in women as they get older.[48, 57] The relationship of alcohol consumption to osteoporosis is less clear. Moderate drinking (0.5 to 2 drinks per day, according to one meta-analysis, although individual study definitions of "drink" varied[58]) has been shown to decrease the risk of hip fractures compared with abstaining or heavy drinking, and there appears to be a favorable linear effect of alcohol on bone density.[58, 59] NAMS recommends that women who drink consume no more than seven units of alcohol a week and no more than two in any six-hour period.[3]

Falls prevention is another important component in health care for women with osteoporosis. Fractures are the most concerning outcome of osteoporosis, and one of the strongest risk factors for a fracture is history of a fall.[60] Along with exercise, fall prevention strategies should include careful monitoring and adjusting

of medications. Sleep, psychotropic, and cardiac medications are of particular concern and gradually withdrawing them when reasonable can reduce the risk of falls.[61] Modifying the environment for safety hasn't been shown to significantly decrease the risk of falls except in those at high risk for falls at home, such as the visually impaired.[61]

Hormone therapy is very effective at maintaining bone density and preventing fractures. In WHI studies of estrogen and estrogen-plus-progestin use in postmenopausal women, increases in BMD were greater and fracture rates were lower in women using hormone therapy compared with the control groups.[62-64] Both hip and vertebral fracture rates were more than 30% lower in women taking estrogen plus progestin[63] and almost 40% lower in women taking estrogen alone.[62] However, once hormone therapy is discontinued, benefits related to fracture risk disappear, in some cases within a year.[64] The risks of hormone therapy are well known; treatment should be considered only in women with diagnosed osteoporosis for whom other options are not appropriate or not tolerated.[3] (For more information, see "Menopausal Hormone Therapy: What We Know Now," June.)

Bisphosphonates used in the United States for the treatment of osteoporosis are alendronate (Fosamax), ibandronate (Boniva), risedronate (Actonel), and zoledronic acid (Reclast). Ibandronate and zoledronic acid are available for IV administration in women who are not able to tolerate oral administration.

The most common adverse effect of oral bisphosphonates is gastrointestinal distress, particularly abdominal pain, nausea, vomiting, and esophageal and gastric irritation.[66] Many women discontinue treatment because of these symptoms. Gastrointestinal distress is often attributed to nonadherence to administration instructions, and it's especially important to maintain an upright posture for 30 to 60 minutes after dosing. Oral bisphosphonates are therefore contraindicated in those who can't remain upright for 30 to 60 minutes after administration.[3] Use of monthly dosing or IV formulations should be considered in women unable to tolerate gastrointestinal adverse effects. Some women using IV bisphosphonates, particularly zoledronic acid, experience an acute-phase reaction causing transient flu-like symptoms for a few days after administration; it usually happens only with the first dose, is self-limited, and has no lasting effects.[3]

MOST EXPERTS AGREE THAT THE RISKS ASSOCIATED WITH OSTEOPOROSIS OUTWEIGH THE KNOWN RISKS OF BISPHOSPHONATE USE.

Pharmacotherapy is appropriate if lifestyle changes don't adequately control bone loss. According to NAMS, pharmacotherapy is appropriate in[3]

- all postmenopausal women with BMD T scores less than or equal to –2.5 at the lumbar spine, femoral neck, or total hip region.
- postmenopausal women with BMD T scores from –1 to –2.5 and a 10-year risk of a hip fracture of at least 3% or of another major osteoporotic fracture of at least 20% (based on the FRAX calculator).
- all postmenopausal women with a history of a vertebral or hip fracture.

Pharmacologic options include bisphosphonates, raloxifene (an estrogen agonist/antagonist), and calcitonin. (Because calcitonin is used only for vertebral fractures, it's discussed earlier in that section.)

Bisphosphonates are a class of drugs that bind strongly to bone minerals at sites of active remodeling and slow down bone resorption by inhibiting the activity of osteoclasts.[65] Oral bisphosphonates are poorly absorbed: less than 3% of the drug is bioavailable from the gastrointestinal tract. They must be taken with water on an empty stomach, 30 to 60 minutes before eating breakfast.

Bisphosphonates can cause renal toxicity. All women should have serum creatinine checked before starting therapy and those receiving IV formulations should have it checked before each dose.[3] Ocular disturbances have also been reported, primarily related to inflammation, but resolve with discontinuation of therapy.

Recent reports have raised concerns that bisphosphonates may be associated with more serious adverse effects, including osteonecrosis of the jaw, unusual femur fractures, and esophageal cancer.[67-69] Osteonecrosis of the jaw (defined as healing delayed for more than eight weeks after a dental procedure) is most often seen in patients with cancer who are taking high-dose IV formulations.[70] It is rarely reported in women taking oral bisphosphonates.

In March 2010, the Food and Drug Administration (FDA) issued a statement about the occurrence of atypical femur fractures in patients receiving bisphosphonates for the treatment of osteoporosis.[69] These subtrochanteric fractures are rare, less than 1% of all hip fractures, and most occur in people who have used bisphosphonates long term (five years or more). However, there is still no clear evidence that these fractures are a direct result of the medication and not secondary

to the osteoporosis itself. In October 2010, the FDA added a warning to the labels of bisphosphonates about the risk. They did not recommend discontinuation of the drugs but did advise health care providers to re-evaluate their use in patients who'd been taking them for more than five years.[71]

The most common adverse effects are mild-to-moderate hot flashes and leg cramps, neither of which has significantly increased discontinuation rates.[73] But there is the potential for more serious adverse effects: the MORE trial found a nearly twofold increased risk of thromboembolic events in women taking raloxifene.[74] However, a secondary analysis of the MORE data found no increased risk of cardiovascular or cerebrovascular events.[77]

NURSES SHOULD MEASURE A WOMAN'S HEIGHT AT EACH OFFICE VISIT, BECAUSE ACCURATE SERIAL HEIGHT MEASUREMENTS CAN IDENTIFY WOMEN AT RISK FOR VERTEBRAL FRACTURES.

There is mixed evidence about the association between bisphosphonates and esophageal cancer. Two recent large cohort studies published within weeks of each other and using the same database, the United Kingdom General Practice Research Database, came up with inconsistent results. The first study found no difference in risk of esophageal cancer between patients who used bisphosphonates and those who did not,[67] while the second, which also examined the risk of bisphosphonate use relative to the length of exposure to the medication, found that the relative risk of esophageal cancer in bisphosphonate users was 1.30 compared with nonusers and increased to 2.24 with use longer than three years.[68] The second study followed patients three years longer than the first, 7.5 years versus 4.5 years, which may explain the difference in findings. Bisphosphonates should be avoided in women with a history of esophageal abnormalities.[3]

Most experts agree that the risks associated with osteoporosis outweigh the known risks of bisphosphonate use.[3,15] Overall, the level of risk appears quite small for the first five years of treatment, after which continued use should be reevaluated for each woman.

Estrogen agonists/antagonists increase BMD through decreased bone turnover; their action is similar to that of estrogen.[72] Currently the only estrogen agonist/antagonist approved for the treatment of osteoporosis in the United States is raloxifene (Evista). Studies consistently show that raloxifene increases BMD in the spine and femoral neck[73] and lowers the risk of vertebral fractures.[74,75] However, there is no evidence that it decreases the risk of nonvertebral fractures, including hip fractures.[74]

Raloxifene has the added benefit of decreasing the risk of invasive breast cancer. The Multiple Outcomes of Raloxifene Evaluation (MORE) trial, a large multicenter randomized, double-blind trial that enrolled more than 7,700 postmenopausal women, found that the risk of breast cancer decreased by 76% in women taking raloxifene.[76]

NURSING IMPLICATIONS

Assessment and monitoring. Assessment of postmenopausal women with osteoporosis should include postural blood pressure; balance, gait, and muscle strength; medication review; identification of comorbidities that could increase the risk of falls; evaluation of the safety of the home environment; and identification of high-risk activities.[78] Based on the findings and identified risk factors, an individualized multidisciplinary management plan can be created and interventions can be implemented.

Few nurses working in nonpediatric settings pay much attention to height measurement. Instead of asking a woman how tall she is, the nurse should measure the woman's height at each office visit. Accurate serial height measurements can identify women at risk for vertebral fractures.[22]

Hyperthyroidism can lead to excess calcium excretion. NAMS recommends that women have their thyroid-stimulating hormone levels tested periodically.[3] For women with low bone mass, NAMS recommends routine tests that include a complete blood count and measure serum calcium, phosphate, creatinine, alkaline phosphatase, and albumin levels.

Education and health promotion. Although most women know that calcium and vitamin D are vital to bone health, they might not know how to ensure adequate intake and maintain optimum levels. Advise women that even though it may seem easier to just take a pill and not worry about it, ideally calcium should come from food sources, and provide information on the best dietary sources. Explain also that the recommended daily amount of calcium refers to elemental calcium; women taking supplements should check the label for the amount of elemental calcium contained. Because calcium absorption actually lessens with higher

dosages, it's important to take no more than 500 mg of calcium at a time, and multiple daily doses might be necessary.[36] Calcium carbonate is better absorbed when taken with food; calcium citrate can be taken either with food or on an empty stomach.

Counseling women on tobacco cessation and moderate alcohol consumption is also important. Nurses should make sure that their patients understand how smoking affects bone health; offer information about cessation programs, the use of nicotine patches, and available medication; and provide ongoing counseling and support.

Counsel women with osteoporosis to be careful when starting an exercise program; activities that increase the risk of falling or place increased stress on the spine should be avoided. Walking and strength training with progressive resistance are beneficial and safe options.[3] Nursing support can help promote adherence to an exercise regimen. One study on the effects of nurse counseling in older adults in a walking program (almost all subjects in the study were men) found that those who received counseling walked significantly more often than those who did not.[79]

Medication management. A thorough assessment of the patient's medication regimen—including over-the-counter drugs, especially antihistamines and sleeping aids—is essential. Any drugs that could cause dizziness or decrease alertness should be identified, as these can

Pathophysiology of Bone Loss

Bone anatomy and physiology and the role of estrogen.

Bones are a dense conglomeration of collagen, minerals, and a gel-like material called ground substance. Collagen is the most prevalent organic compound in bones, making up 90% to 95% of bone tissue and giving it its tensile strength. Embedded in the collagen fibers are mineral crystals, primarily calcium and phosphorous. All of it is held together by ground substance, which is made up of proteins, primarily glycosaminoglycans, which interweave throughout the extracellular matrix.

There are two types of bone tissue: trabecular (also called cancellous), the spongy, porous inner portion at the bulky ends of long bones; and cortical (compact), the hard, compact outer portion. The cellular component of bones consists of osteoprogenitor cells, osteoblasts, osteocytes, and osteoclasts. Osteoblasts form from osteoprogenitor cells and build both trabecular and cortical tissue. Osteocytes are mature osteoblasts within the osseous matrix. They control the level of calcium and phosphorous embedded in the collagen fibers. Osteoclasts are macrophages that break down bone tissue, releasing calcium and phosphate into the blood.

Healthy bone mass results when there is a balance between osteoblastic bone formation and osteoclastic bone resorption. This balance is controlled primarily by three factors: serum calcium levels, estrogen, and mechanical stress.[7] When serum calcium levels drop below normal, osteoclasts increase bone resorption to release calcium and restore serum calcium to its normal level. Mechanical stress stimulates local bone formation through mechanosensors in osteocytes that regulate osteoclast formation and by enhancing osteoblast differentiation and survival, thereby tipping the balance back in favor of osteoblastic bone formation.[8-10]

Bone remodeling is continual, allowing the skeleton to replace weaker old bone tissue with stronger new tissue and adjust the shape and thickness of bones in response to stress. In most people, however, peak bone mass is reached at about age 30. After that the rate of bone resorption becomes greater than that of bone formation and bones begin to lose density and steadily weaken over time.[3] This loss increases dramatically for women after menopause.

The role of estrogen. Bone cells contain both types of estrogen receptors, ERα and ERβ. These receptors bind estrogen to trabecular and cortical bone with ERα being the most active.[9] What happens once the estrogen binds to bone cells still isn't fully understood. Multiple mechanisms are involved, including interactions with immune factors as well as coactivator proteins and transcription factors (proteins involved in genetic processes in cells). A recent study found that estrogen inhibits cellular apoptosis, increasing the lifespan of bone-forming osteoblasts.[11] This explains why the lifespan of osteoblasts is shortened by the loss of estrogen after menopause, a factor known to be important in menopausal osteoporosis. Researchers are also looking at estrogen's role in regulating oxidative stress and adaptive immune responses, which both affect bone mass.[9] However, because of the difficulty of studying these processes in humans, recent data that advance our understanding of the complex interplay between estrogen, the immune system, and the skeleton come primarily from animal models; so further research is needed.[9]

increase the risk of falls, and possible alternatives considered.

Nurses can also help women understand and manage the possible adverse effects of medications and hormone therapy. Make sure that patients taking bisphosphonates understand why it's important to take these drugs first thing in the morning and to remain upright for 30 to 60 minutes afterward. Provide women taking raloxifene with strategies for managing hot flashes and leg cramps. Make sure that all women, especially those on hormone therapy, are getting recommended breast cancer screening. ▼

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