

## Osteoporosis and Fracture

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### The Problem

Osteoporosis is a condition that is defined by a loss of bone substance that renders the entire bone weaker mechanically thus more likely to fracture. The majority of the more than 10 million Americans with osteoporosis are at risk of fracturing the hip, spine (vertebra) or wrist (distal radius). Nearly 1.5 million fractures are attributed in part to osteoporosis annually in the US, making osteoporosis a public health issue of a very large scale. The direct costs (in current dollars) attributed to care/treatment of osteoporosis-related fracture is in the range of \$20 billion per year in the US. With a population living longer and co-existing medical conditions (e.g. cancer survivors) and medication (e.g., corticosteroids) that predispose to osteoporosis, the number of osteoporosis related fractures is expected to increase for the next 60 years [National Osteoporosis Foundation website, accessed August 2, 2016].

### Background

The natural history of bone strength in the general population is the loss of bone content and strength starting around age 25. Women lose bone more quickly than men on average with acceleration of bone loss after menopause- thus the term 'post-menopausal osteoporosis'. Population studies have shown that those individuals who maximize their bone strength in their younger years will retain greater bone strength later in life. Those same population studies have shown that in the U.S. women, on average maximize their bone strength at a lower threshold than men, thus another problem causing greater numbers of fractures later in life after decades of bone strength loss. The incidence of hip, spine and wrist fracture in women over a lifetime is between 3 times and 5 times more common than in same-aged men. Caucasians men and women have less bone density, thus less bone strength, than African Americans and Asian-Americans. The lifetime risk of fracture is accordingly less for African-American and Asian-American people.

Bone mineral density is the term that is used to describe the amount of bone present when tested by an imaging technique such as DEXA or in vivo when demonstrated in bone biopsy tissue. Bone as a tissue is composed of a biological polymer protein called collagen plus the chemicals Calcium and Phosphate (Phosphorous and Oxygen combined). It is the Calcium Phosphate that makes bone stiff and hard, the collagen is very soft and flexible. When bone loses Calcium it becomes weaker mechanically and if bone loses the collagen it will also lose Calcium, thus becoming weaker. Bone the organ is organized to have a blood supply and nerves- e.g. your leg bone the tibia. When a bone cracks or breaks apart into pieces- the loss of continuity is called a fracture.

### Fracture

When osteoporosis exists in bones there is a greater chance of a fracture happening under relative normal conditions, meaning that a less serious trauma is needed to create a hip or wrist fracture. An adult who trips and fall forward will likely put out their hands to protect the fall and with normal bone strength it is unlikely that a wrist fracture will occur. That same adult in later years with weakened bone due to osteoporosis will likely fracture one or both wrists from a similar fall. Fracture may occur without a single event due to repetitive force to a bone that is significantly weakened by osteoporosis- this may be referred to as a stress or fatigue fracture. Fractures occur in bones with normal mechanical strength but there is greater external force (trauma) needed when compared with a bone weakened by osteoporosis.

The diagnosis of osteoporosis is made by non-invasive imaging using low intensity radiation either via a conventional computed tomogram or a dual energy photon analysis (DEXA). These imaging studies focus on a particular region of the skeleton that is representative of the general bone health and has proven predictive value for increased incidence of hip, spine or distal radius fracture. The gold standard previous to the advent of advanced imaging was a bone biopsy from the pelvis. The biopsy could distinguish between osteoporosis and other metabolic conditions such as osteomalacia (a lack of Calcium Phosphate in the protein fabric of bone)- which also leaves adults with weakened bone strength. Osteomalacia may be confused with osteoporosis and does weaken bone, though treatment of osteomalacia is different that treatment for osteoporosis.

The World Health Organization defines osteoporosis mathematically as greater than 2.5 standard deviations [World Health Organization website, accessed August 4, 2016] below the population mean bone density for a person of the same age and gender. That is not a very helpful definition for everyday use by non-specialists in bone health, however, the use of a defined standard does help with establishing a diagnosis, predicting the risk of future fractures and monitoring treatment. Having non-invasive screening tests that can accurately define bone density has aided in the recognition and treatment by replacing an invasive (possibly painful) bone biopsy with an easy, painless imaging study.

One of the leading public health concerns of osteoporosis is the occurrence of a 'fragility fracture'. A fracture of the proximal femur (hip area), distal radius (wrist) or vertebra (spine). When these fractures occur from a fall, modern best practice should include an evaluation of bone quality via one of the imaging studies to establish a diagnosis of osteoporosis. At present the number of patients admitted to hospital with fragility fractures, mostly hip fractures since distal radius and vertebral fractures are orthopaedically treated out-patient, who receive an appropriate evaluation for osteoporosis is unknown. There are screening criteria for adults at risk for osteoporosis without

having a fragility fracture. These people are for the most part asymptomatic for bone problems yet may have a list of factors such as lactose intolerance, family history, lack of exposure to sunshine, low circulating level of vitamin D3, use of systemic corticosteroids, chronic renal failure, and many other medical conditions and medications.

The population living longer with chronic conditions that over time weaken bones, the prevalence of osteoporosis in theory should be increasing. Increasing public awareness and willingness of primary care physicians to initiate treatment to reduce or reverse bone loss will blunt the theoretical rise of age related osteoporosis in the population most at risk. Simple measure to slow the progression of bone loss during middle years may provide protection in later years against fracture.

The healing of fractures in osteoporotic bones is nearly the same as healing in bones unaffected by osteoporosis. A confounding issue is the number of co-morbidities and medications taken by elderly with osteoporosis. Someone with a hip fracture and osteoporosis may have insufficient vitamin D and calcium intake, mild renal failure and using medication that inhibits calcium absorption from the gut. This theoretical patient may have delayed healing of the fracture and require further surgery to replace the hip, while suffering from inactivity a decline in overall health is likely that affects cardio-pulmonary function and endurance. The osteoporotic person with overall poor health will likely have greater difficulty recovering from the surgical treatment of a hip fracture. Poor standing balance, weak lower extremity muscles, painful lower extremity joints, poor cardiac function all combine to lessen the independence of a person recovering from hip fracture surgery and likely leads to a shortening of lifespan.

### Surgery for Osteoporotic Fracture

The objective of surgery for fractures is to reduce the pain and loss of function that comes from a bone that no longer is performing its structural task, to restore more normal alignment, to ensure bone healing. Fracture of the hip (proximal femur or acetabulum) makes it nearly impossible to stand, walk and change position. Surgery restores mechanical integrity and allows movement and weight-bearing while the bone is healing. In earlier times, a hip fracture in an elderly person led to death from immobility. Progress that began in the mid-20th century in designing more efficient surgical procedures allows for earlier mobility and thus earlier rehabilitation with return of overall function and health has improved the prognosis from fracture of the hip. A vertebral fracture in the thoracic or lumbar spine is initially inhibitory of standing, walking, changing position and possibly inhibits chest wall expansion (breathing) - and later may develop spinal deformity that affects posture and balance. By reducing the pain of vertebral fracture which in some cases is by surgical stabilization, mobility is restored much sooner and overall function is preserved.

Recent public health measures to improve awareness of osteoporosis and enhance bone health in adults may very well counter the natural

tendency of weakening bones with age. Programs that encourage walking and exercise to strengthen muscles in the lower extremities have the benefit of helping maintain bone strength. Dietary sources of vitamin D, calcium and protein similarly provide some protection against bone atrophy or weakening due to decreased walking activity. When osteoporosis is diagnosed and over time there is measurable bone loss despite increased physical activity, vitamin D3 and calcium, there are several medications now available for use to reduce bone loss and even help improve bone density. Prescription drugs include bisphosphonates, teriparatide, hormone (estrogen) replacement, denosumab, raloxifene and calcitonin. Of particular value is initiating osteoporosis treatment with one of these drugs following major fractures [1].

### Summary

As the public awareness and the treatment awareness of physicians improves concerning osteoporosis, the consequences of unrecognized and untreated osteoporosis are likely to be lessened. There already is evidence that the number of hip fractures in the United States is considerably lower than projected 20 years ago based on the then prevalence of elderly people with hip fracture [2]. And the incidence of spontaneous vertebral fracture associated with osteoporosis has leveled-out and not increased in the past 5 years. These are indirect measures of success but encouraging signs that individuals and society are making gains over the threats of osteoporosis and other forms of metabolic conditions that weaken bone.

In addition to a public health approach to osteoporosis there are numerous advances in medical management, nutritional support, exercise therapy, fall prevention and post-surgery rehabilitation. The attention of the medical community to the consequences of osteoporosis have helped support the many stakeholders in society who are trying to lessen the harm that comes from not treating or simply neglecting osteoporosis. Today there are many more resources to help people with osteoporosis find information and treatment. Physicians, physical therapists, nurse practitioners, dieticians as well as surgeons are learning to recognize osteoporosis in the populations at risk and matching patients to treatment earlier in the course of this disorder. Eventually there may be a treatment/prevention strategy that will nearly eliminate the threat of osteoporosis to the lives of ageing citizens and others with this disorder.

### References

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