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Abstract:

The strength of bone is related to its mass and geometry, but also to the physical properties of the tissue itself. Bone tissue is composed primarily of collagen and mineral, each of which changes with age, and each of which can be affected by pharmaceutical treatments designed to prevent or reverse the loss of bone. With age, there is a decrease in collagen content, which is associated with an increased mean tissue mineralization, but there is no difference in cross-link levels compared to younger adult bone. In osteoporosis, however, there is a decrease in the reducible collagen cross-links without an alteration in collagen concentration; this would tend to increase bone fragility. In older people, the mean tissue age (MTA) increases, causing the tissue to become more highly mineralized. The increased bone turnover following menopause may reduce global MTA, and would reduce overall tissue mineralization. Bone strength and toughness are positively correlated to bone mineral content, but when bone tissue becomes too highly mineralized, it tends to become brittle. This reduces its toughness, and makes it more prone to fracture from repeated loads and accumulated microcracking. Most approved pharmaceutical treatments for osteoporosis suppress bone turnover, increasing MTA and

mineralization of the tissue. This might have either or both of two effects. It could increase bone volume from refilling of the remodeling space, reducing the risk for fracture. Alternatively, the increased MTA could increase the propensity to develop microcracks, and reduce the toughness of bone, making it more likely to fracture. There may also be changes in the morphology of the mineral crystals that could affect the homogeneity of the tissue and impact mechanical properties. These changes might have large positive or negative effects on fracture incidence, and could contribute to the paradox that both large and small increases in density have about the same effect on fracture risk. Bone mineral density measured by DXA does not discriminate between density differences caused by volume changes, and those caused by changes in mineralization. As such, it does not entirely reflect material property changes in aging or osteoporotic bone that contribute to bone's risk for fracture.

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