The goal of assessing bones in the context of osteoporosis is to estimate the risk for a given bone to fracture in the near future. This type of assessment requires the estimation of bone strength. However, bone strength assessment, in its pure sense, requires mechanical testing, and such testing is not practical in vivo. Several image-based surrogates have been developed in the past to mimic the assessment of bone strength, and the most popular of these is bone density measured by dual-energy x-ray absorptiometry (DXA). Unfortunately, DXA parameters capture mostly bone density, but bone strength is dependent equally on the strength of the bone material, of which density is a major influencing parameter, and bone architecture. Currently, the best method to capture both bone density and bone architecture is computed tomography (CT), which can provide a 3-dimensional image of a given bone by measuring numerous adjacent cross-sections.

DXA actually combines geometry and density to some extent, as it expresses the amount of bone projected into a plane, resulting in the densitometric units of g/cm2. These units include the amount of bone along the x-ray beam path and, thus, are influenced by bone size, which ultimately reflects bone strength. Computed tomography, in contrast, creates 3-dimensional images, and these can be analyzed for volumetric density as well as geometry. They can also be used to create computer models of the bones, which can then be subjected to simulated forces. Such models, if constructed accurately, are probably the ultimate predictors of bone strength, short of mechanical testing. However, the accurate creation of such models depends both on extracting accurate bone boundaries from the 3-dimensional images as well as accurate density values. Based on experiments with human cadaver bones, we have demonstrated how such accurate models need to be constructed and how they can be used to predict bone strength.