Small angle x-ray scattering and x-ray diffraction of shark mineralized tissue

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Bone and mineralized shark cartilage are tissues based on collagen fibers and reinforced with bioapatite nanoparticles. The nanostructure of mineralized shark cartilage has received relatively little attention compared to bone, and it is important to establish the extent to which the shark tissues' bioapatite lattice parameters, crystallite size, crystallographic texture and nanoparticle spatial distribution are similar to or different from those of bone. First, these quantities affect the materials' tissue-level properties, and, if they are similar, then the considerable bone literature on quantities such as Young's modulus variation as a function of texture can be incorporated into numerical models of in situ loading of shark tissue. Second, these quantities reflect physiological processes and their variation over time, and inferences obtained on the shark bioapatite might suggest novel directions for human bone and cartilage research.

This talk presents high-energy wide angle x-ray scattering (WAXS, i.e., x-ray diffraction) and small angle x-ray scattering (SAXS) results on shark tissue and contrasts these results with those on bone. WAXS shows the shark tissues' lattice parameters differ slightly from those typical of bone and crystallite sizes are slightly larger than those of bone. The observation of D-period peaks in SAXS shows the nanoparticle spacing is similar to that in bone. The azimuthal width of the D-period arcs of the shark tissue are narrower than those of bone (SAXS), and this indicates that crystallographic texture is sharper for the shark tissue than for typical bone. In the centrum of the shark vertebra, crystallographic texture varies with position, and this is related to the centrum's millimeter-level architecture. Conclusions based on the WAXS and SAXS data are discussed in the context of the functionality of the shark vertebrae, in particular, their ability to withstand millions of cycles of straining to 4-8%. Future directions of research are also suggested.