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# Beyond Jaws: The Mineralized Cartilage of Shark Vertebral Centra

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When most people think of mineralized tissue in sharks, they think of the teeth and jaws. The vertebral bodies (centra) of sharks are also mineralized in many species and are made up of nanocrystals of carbonated apatite (cAp) embedded within a matrix of cartilage (type 2 collagen). Shark centra possess remarkable resistance to millions of cycles of large in vivo strains exceeding 4%, and a hierarchy of structures spanning dimensions from centimeters to nanometers evolved to produce the remarkable performance. This talk presents recent tomography and x-ray diffraction results probing different size scales of shark centra of orders Carcharhiniformes and Lamniformes. At the 20  $\mu\text{m}$  and larger scales, laboratory microCT on entire centra provides a 3D quantitative picture of the macrostructure and of microstructure. Energy dispersive diffraction tomography of entire centra reveals anatomically-related, 3D variation of crystallographic texture of the biomineral phase. At the 1  $\mu\text{m}$  level, blocks cut from centra and imaged with synchrotron microCT demonstrates that the centra tissue consists of closely spaced, mineralized trabeculae; these 3D characteristics (trabecular thickness and spacing) have been quantified. At the 0.1 nm – 100 nm scales, wide angle x-ray scattering (WAXS) and small angle x-ray scattering (SAXS) reveal that the centra's mineral phase is slightly different from the cAp in bone and that the centra's cAp nanocrystal arrangement has somewhat stronger preferred orientations. Speculation on how these different components contribute to in vivo mechanical performance concludes the talk.

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