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Ultrastructural, material and crystallographic description of endophytic masses – a possible damage response in shark and ray tessellated calcified cartilage

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ABSTRACT

The cartilaginous endoskeletons of Elasmobranchs (sharks and rays) are reinforced superficially by minute, mineralized tiles, called tesserae. Unlike the bony skeletons of other vertebrates, elasmobranch skeletons have limited healing capability and their tissues' mechanisms for avoiding damage or managing it when it does occur are largely unknown. Here we describe an aberrant type of mineralized elasmobranch skeletal tissue called endophytic masses (EPMs), which grow into the uncalcified cartilage of the skeleton, but exhibit a strikingly different morphology compared to tesserae and other elasmobranch calcified tissues. We use biological and materials characterization techniques, including computed tomography, electron and light microscopy, x-ray and Raman spectroscopy and histology to characterize the morphology, ultrastructure and chemical composition of tesserae-associated EPMs in different elasmobranch species. EPMs appear to develop between and in intimate association with tesserae, but lack the lines of periodic growth and varying mineral density characteristic of tesserae. EPMs are mineral-dominated (high mineral and low organic content), comprised of birefringent bundles of large monetite or brushite crystals aligned end to end in long strings. Both tesserae and EPMs appear to develop in a type-2 collagen-based matrix, but in contrast