

Cartilage or Bone? Collagens in “Cartilaginous” Fish Skeletons Answer an Old Question

Michael Blumer², Ronald Seidel¹, Elisabeth–Judith Pechriggl², Kady Lyons³ and Mason Dean¹

 Author Affiliations

¹Biomaterials Max Planck Institute Germany

²Clinical–Functional Anat Medical Univ. Innsbruck Austria

³Biology CSU Long Beach United States

Abstract

The skeletons of cartilaginous fishes (sharks and rays) comprise an inner core of uncalcified cartilage, an outer fibrous perichondrium, and a layer of mineralized tiles (tesserae) between them. As mammalian perichondrium and cartilage are patterned on different collagens (Coll1 and Coll2, respectively), it has been debated whether tesserae are more like bone (Coll1–based) or mineralized cartilage. Using an array of histology techniques we show that stingray tesserae are bipartite, having an upper, mineralized perichondrium “cap zone” (Coll1) that merges into a lower, mineralized cartilage “body zone” (Coll2), with the two collagens interspersed at the zones’ interface. Waves of varying mineral density observed in tesserae, believed to be records of growth processes, are mirrored in periodic density variation of the collagen matrix. Collagen fiber bundles extend uninterrupted between unmineralized and mineralized areas (e.g. from perichondrium into the cap zone or through joint spaces between tesserae). The upper (perichondral) portions of joints contain both Coll1 and Coll2, yet lower (chondral) portions contain finer, unidentified fibers that stain neither for Coll1, Coll2, nor elastin. Unlike mammalian growth plate cartilage, mineralization fronts (tesseral edges) were not associated with hypertrophic cells or Coll10 expression, although Coll10 staining was observed in a thin layer of cartilage matrix (Coll2) sometimes seen between tesserae and perichondrium. Our results show that tesserae exhibit an amalgam of features of bone and mineralized cartilage, and indicate that cartilage mineralization can occur without Coll10 expression, cell hypertrophy or cell death.