Identifying hidden secrets of shark teeth (Chondrichthyes, Elasmobranchii) using sophisticated approaches

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The taxonomy of sharks (Chondrichthyes, Elasmobranchii) remains difficult since this group has a cartilaginous skeleton instead of ossified bones, which makes complete body fossils rather rare. Contrary to the sporadic preservation of skeletons, cartilaginous fishes developed species specific teeth and a permanent tooth replacement pattern, which provides abundant material for classification on all taxonomic levels.

The most important character for classification is the superficial tooth morphology including ornamentation patterns. The crown morphology is an easily accessible character, which allows mostly a prompt although not always distinct identification. On the other hand, the crown morphology is quite plastic and changes easily in relation to feeding adaptations and hunting behaviours. Conversely, the root morphology is more conservative because its only function is to fix the tooth to the jaws. Consequently the root represents a more stable character for supra-species level taxonomy. The nutrient supply of the teeth is provided by nerves and blood vessels that enter through the root and form distinct vascularisations within the root and crown independent of superficial morphological changes. Four distinct, major types (anaulacorhize, hemiaulacorhize, holaulacorhize, polyaulacorhize) and various modifications of these types generally are recognized, which also reveal information about evolutionary traits.

Generally, thin sections of teeth are prepared to investigate their internal structures. The consequence is the loss of most of the tooth. An innovative solution is provided by computer tomography scanning with subsequent visualization using various software packages (e.g., Amira, VG Studio Max, 4d data visualization). Such software solutions are costly. Open-source scientific visualisation software packages, conversely, might represent cost-efficient solutions. Here, we demonstrate the benefit of the free available Drishti software solution, which is user-friendly to generate three-dimensional reconstructions of the internal tooth vascularization pattern including foraminal openings and occurrences and directions of canals. The possibility of non-invasive CT scans and 3D reconstructions of the external tooth morphology in combination with visualization of internal structures is important to provide a better understanding of the evolutionary development of tooth characters in cartilaginous fishes.