Project Description

Project title: Tooth shape across ontogeny in crocodylian species with varying degrees of heterodonty

PI: David Kay; Assistant Professor, Department of Biomedical Science, Bitonte College of Dentistry

Research location: NEOMED (Rootstown campus)

Abstract

In some vertebrates with socketed dentitions, alveoli (sockets) and tooth cusps are unusually related. For example, tooth cusp offset in some muroid rodents is the result of tooth bud-jaw interactions: parallel or offset cusps can be induced to vary developmentally based on experimentally manipulated lateral alveolar thickness in mice and voles. This research emphasized the jaw and teeth as a directly integrated developmental unit. Previously, I have also shown that tooth crown shape and alveolar shape are significantly related in adult *Alligator mississippiensis,* suggesting that a similar mechanically constraining mechanism found in rodents may extend to crocodylians as well. Further, crocodylians are uniquely polyphyodont with tooth sockets formed iteratively during ontogeny, implicating this integration as a means of generating heterodont or homodont dentition over the course of their lifespan. Preliminary investigations into alveolar mechanical constraint driving heterodonty in crocodylians suggests that iteratively growing alveolar septa generate a mesiodistal constraint to each developing crown and alveolar walls generate a buccolingual constraint. While this implies the alveoli mechanically shape teeth to produce heterodonty in crocodylians, the study did not take into account a quantification of tooth shape itself. This current project aims to investigate this by measuring tooth shape across ontogeny in crocodylian species with relatively more heterodont (differently shaped teeth) or homodont (similar shaped teeth) dentitions, by testing *Alligator mississipiensis* and *Crocodylus acutus*, respectively using a 3D digital anatomical approach.

Significance

My research program strives to deepen the understanding of socket-crown relationships, with the eventual goal of understanding its role in the evolution of complex dentitions. This then would provide a possible proof-of-concept for the use of extant crocodylians as a possible model system for tooth replacement in humans.

Research objectives/goals

Overall, the goal of my research is to investigate the relationship between alveoli and tooth shape in thecodont dentitions, comparing crocodylians and mammals to eventually understand the influence of tooth sockets on the evolution of complex dentitions. This project's goals are to 1) quantify alligator and crocodile tooth shape across ontogeny to better understand the amount of shape change from hatching to adulthood, and 2) compare the shapes between the

two species to quantify the degree of heterodonty between them and how that shifts across ontogeny. This understanding will be placed within the context of alveolar growth patterns to investigate a possible alveolar-tooth relationship driving heterodonty in extant crocodylians.

Research methods

The methods for this project rely heavily on using computational tools to measure 3D digital datasets in the form of micro-computed tomography scans of crocodilian heads and skulls.

Data analysis method

Tooth shape data from specimens will be analyzed using a specific set of methods from geometric morphometrics (statistical study of shape) called outline analysis using the program R. This methodology avoids the need for homologous landmarks but requires manual alignment of images to properly remove orientation, location and scale. Once quantified, shape data will then be ordinated, and specific statistical hypotheses will be tested and tied back to the overall objectives. I have developed the basic statistical workflow for this project, so R expertise is not necessary, but is a great learning experience for how to curate, analyze, and discuss complex data.

Fellowship research role

The research fellowship recipient will be tasked with processing, procurement, and analysis of tooth shape data. These insights on tooth shape differences between species and across ontogeny will play a critical role in my larger research program investigating the possible relationship between tooth sockets and tooth shape. The shape data provide the specific empirical evidence of how teeth change shape across tooth generations and vary between crocodylians. Currently my research only compares generalized whole-dentition levels of heterodonty, and lacks the specific information needed to synthesize this portion of my research program.

Student Fellow Training/Mentoring Plan

Training of the research fellowship recipient will take the form of scheduled meetings to discuss literature and progress, hands-on training modules, and informal meetings as data are gathered and analyzed. The first week or two (student schedule dependent) will be focused solely on introducing relevant primary background literature and completing an Avizo training module. The literature will largely surround the concepts of dental anatomy, alveolar-tooth interactions, and digital anatomical approaches. The Avizo training module will address the specific methods for processing a 3D dataset for measurement, segmentation, and rendering. Once these are completed, the student will be tasked with procuring the data needed for outline analysis. During this time, we will continue to discuss primary literature that is related to data analysis (e.g., geometric morphometrics) as well as further dental research. Depending on other students' interest, the literature discussions could take the form of a journal group that meets weekly.

The resources that will be involved in this research mostly revolve around the processing, measurement, and analysis of digital anatomical data. Processing and measurement of digital anatomical datasets will be carried out using the software suites Avizo and Fiji. Processed tooth outlines will be analyzed using a pre-developed analytical framework in R. Depending on specimen availability, there could be usage of NEOMED's in-house micro-computed tomography scanner to gather additional scan data. This would then include a more hands-on training regarding machine usage and safety. The current plan of this research will be centered on NEOMED's Rootstown campus. As the computing equipment is largely shared, scheduling for time on machines will require cooperation with other labs.