An assessment of the neurovascular structures of the trigeminal nerve and their relationship to tooth morphology in *Rattus sp.*, *Pithecia pithecia*, *Saimiri sciureus*, and *Chiropotes sp.*

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Introduction

Primates use nervous tissues in the skin, eyes, mouth, teeth (among others) to determine if a food is safe for processing and consumption based on color, palatability, size, and texture [1,2]. The primary nerves that supply the internal mechanisms of the oral cavity are branches of the trigeminal complex (cranial nerve V) that pass through the maxillary (V2) and mandibular (V3) alveolar bone [3-5]. Few studies have examined the relationship between the trigeminal nervous tissues and the bony canals of the mandible through which these tissues pass, cross-sectional areas of these nerves, or their overall volumes in relation to tooth morphology [2,6,7]. It has been established that the diet of a primate is related to tooth form and mastication patterns, suggesting that the morphological properties of teeth and their accompanying nerves are selected for simultaneously in relation to how the oral structures are sensing food material properties [8,9]. Teeth with larger surface areas are predicted to need more nervous tissue to detect any changes (i.e. stiffness, toughness, etc) in these material properties [10-13]. **To further understand the broader implications of tooth morphologiy and facial nervous tissues between primate species, this pilot study compared structural variation of the third branch of the trigeminal nerve (V3) of the white-faced saki (*Pithecia pithecia*) the common squirrel monkey (*Saimiri sciureus*), and the bearded saki (*Chiropotes sp.*) to a mammalian outgroup (*Rattus sp.*).**

Materials and Methods

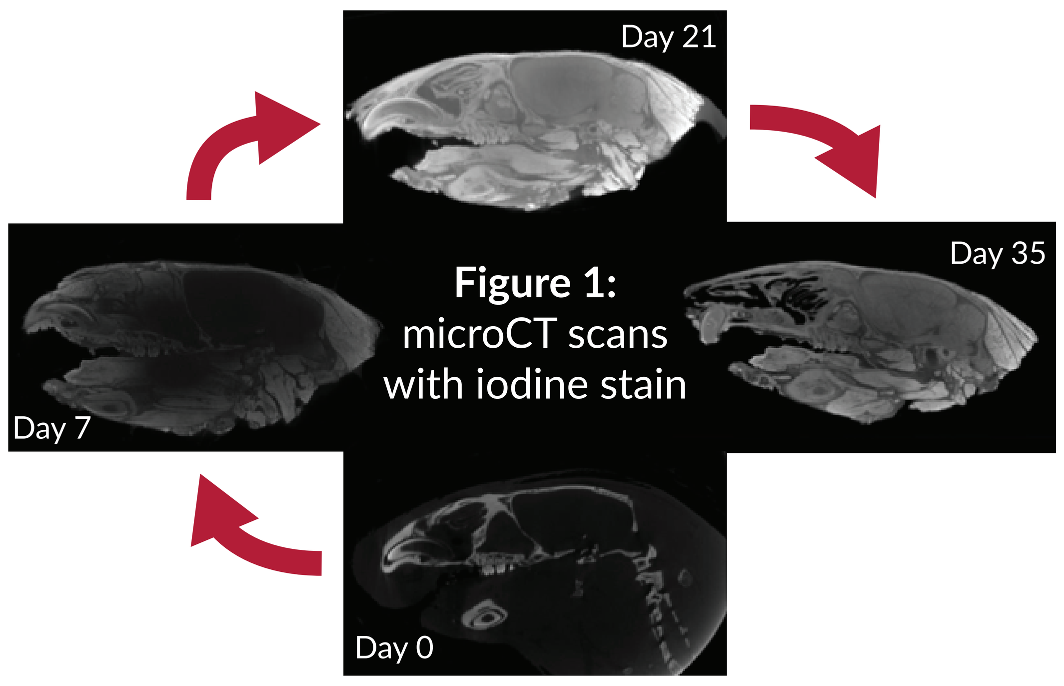
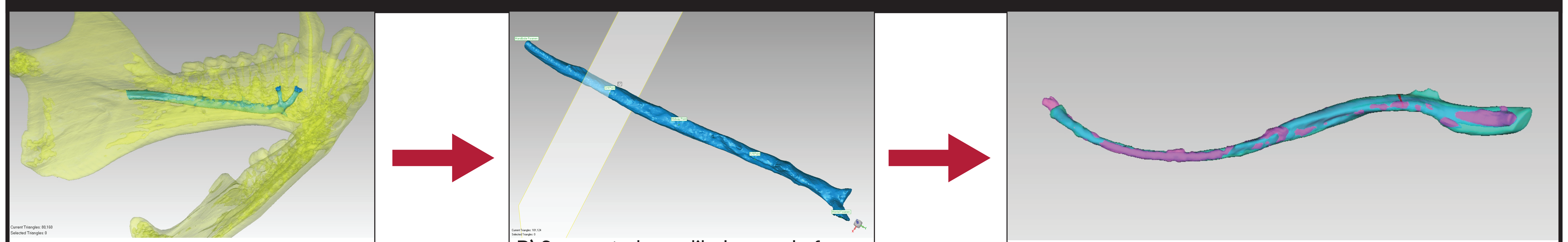


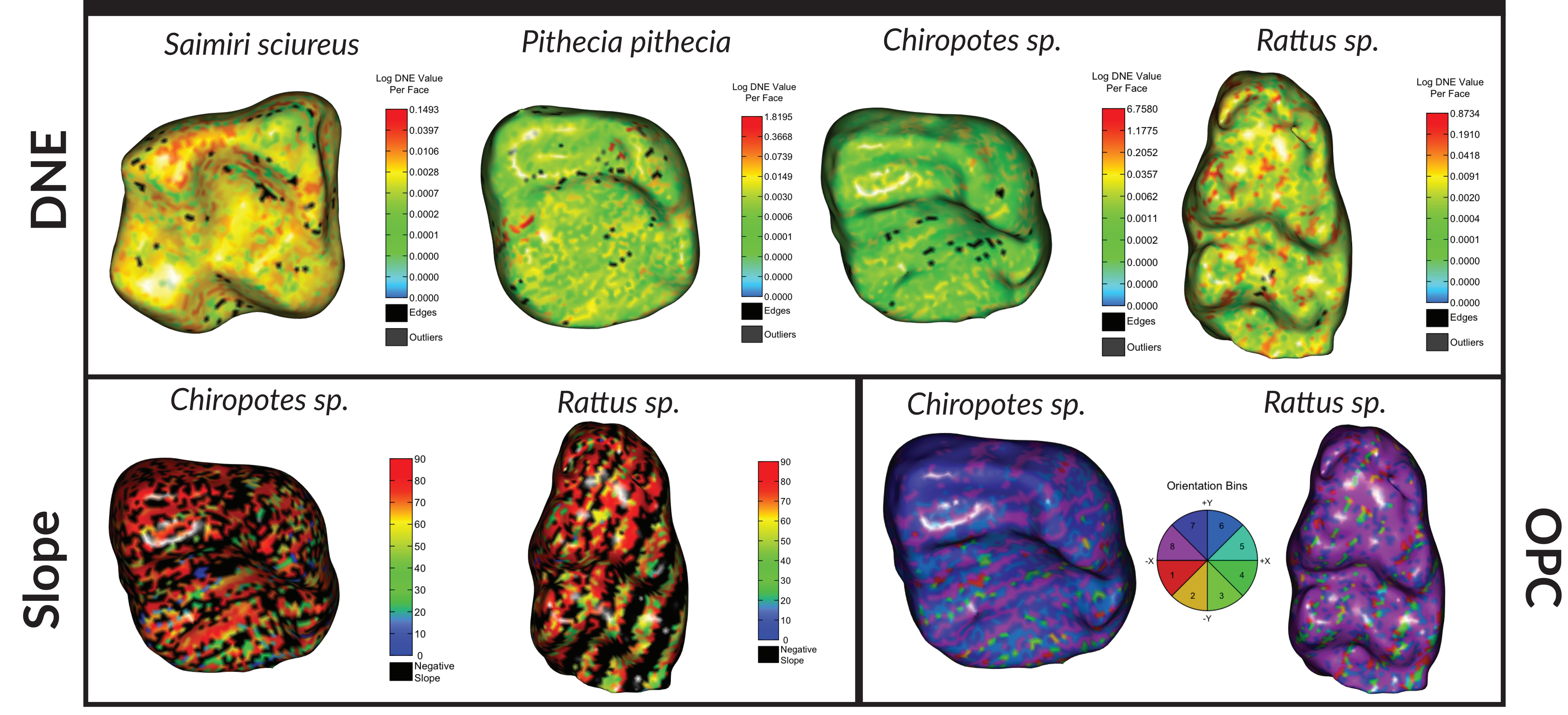
Figure 1: microCT scans with iodine stain

Figure 2: Segmentation of mandibular canal and nerve, example of cross-sectional area measurements



A) Mandible and segmented canal (blue) of *Hapalemur griseus*.
B) Segmented mandibular canal of *Saquinus oedipus* with a cross-sectional area measurement taeken in geomagic
C) Segmented mandibular nerve (purple) within a partially segmented mandibular canal (blue) of *Rattus sp.*

Figure 3: Tooth morphological variables: OPC, DNE, and Slope.



- *Rattus sp.* (n=8)
  - >All males
- *Saimiri sciureus* (n=3)
  - >2 males, 1 female
- *Pithecia pithecia* (n=3)
  - >All female
- *Chiropotes sp.* (n=2)
  - >All male

- microCT scans from MICRO at the University of Arkansas

- Canal and nervous tissues were segmented using Avizo with all measurements taken in Geomagic

- Cross-sectional area measurements taken at the mental foramen, mandibular foramen, and when possible, the mandibular canal below M1 and the corresponding nervous tissue (i.e. mandibular nerve and periodontal ligament)

- Measurements were then compared to the tooth morphological variables established via molaR in R [14] of Dirichlet's normal energy (DNE), occlusal patch count (OPC), and average slope using linear regressions (Figure 3)

Results

Table 1: Regression results for *Rattus sp.* (highlighted values showing significance)

	Slope			OPC			DNE		
	R^2	F-statistic	p-value	R^2	F-statistic	p-value	R^2	F-statistic	p-value
Mental nerve CS	0.70	11.64	0.02	0.01	0.04	0.85	0.69	11.37	0.02
Mandibular nerve CS	0.70	11.64	0.02	0.01	0.04	0.85	0.69	11.37	0.02
Mental foramen CS	0.04	0.23	0.65	0.72	12.79	0.02	0.09	0.492	0.51
Mandibular foramen CS	0.08	0.45	0.53	0.48	4.59	0.09	0.001	0.01	0.94

Table 2: Regression results for all primate species (highlighted values showing significance)

	Slope			OPC			DNE		
	R^2	F-statistic	p-value	R^2	F-statistic	p-value	R^2	F-statistic	p-value
Mental nerve CS	0.03	0.18	0.69	0.06	0.38	0.56	0.004	0.02	0.88
Mandibular nerve CS	0.03	0.18	0.69	0.06	0.38	0.55	0.004	0.02	0.88
Mental foramen CS	0.27	2.24	0.18	0.77	19.96	0.004	0.56	7.66	0.03
Mandibular foramen CS	0.21	1.64	0.25	0.38	3.72	0.10	0.65	11.02	0.02

Figure 4: Boxplot showing the average mandibular nerve cross-sectional area divded by the mandibular foramen cross-sectional area

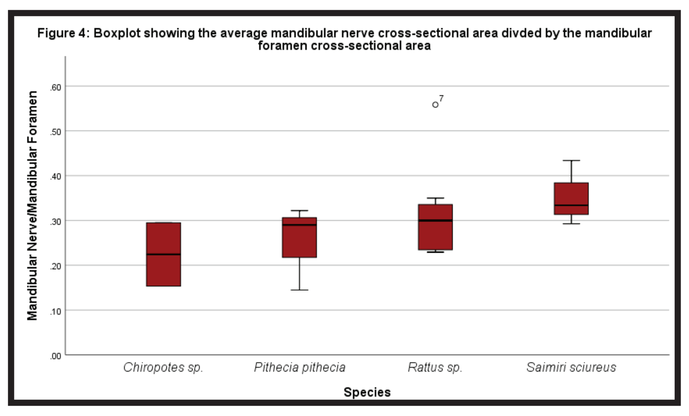


Figure 5: Boxplot showing the average mental nerve cross-sectional area divded by the mental foramen cross-sectional area

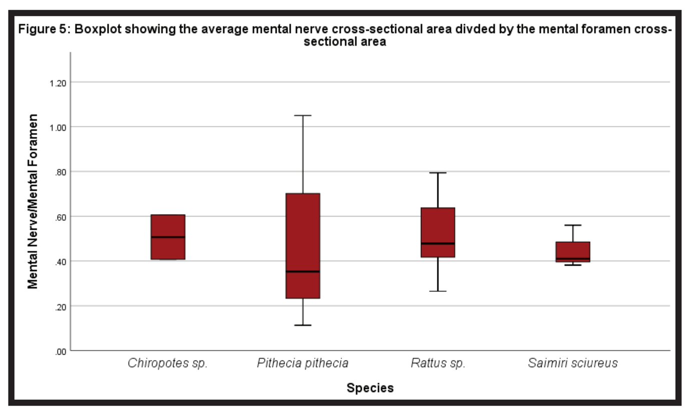
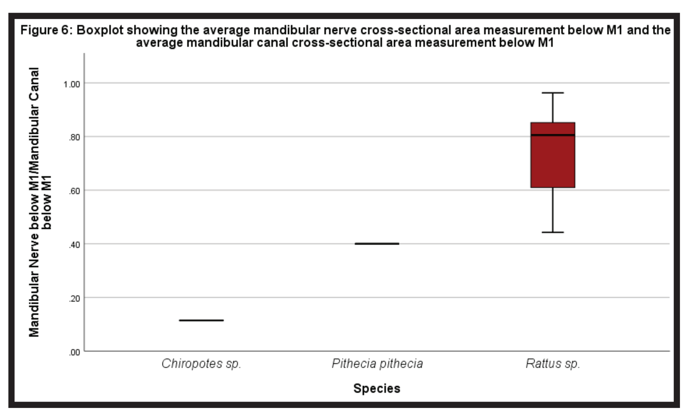


Figure 6: Boxplot showing the average mandibular nerve cross-sectional area measurement below M1 and the average mandibular canal cross-sectional area measurement below M1



Discussion

These preliminary results indicate:

- Bony structures cannot be used as a proxy for the size of the nerve that passes through
  - >11-100% of the mental foramen (Fig. 4)
  - >14-55% of the mandibular foramen (Fig. 5)
  - >11-96% of the cross-section beneath the first molar (Fig. 6)
- OPC (Table 1, 2)
  - **>Predicts mental foramen cross-sectional area for both rats and primates**
- DNE (Table 1, 2)
  - >Predicts nervous tissue cross-sectional area in rats
  - **>Predicts mental foramen and mandibular foramen cross-sectional area in primates**
- Occlusal Surface Slope (Table 1, 2)
  - >Predicts nervous tissue cross-sectional area in rats

These preliminary results indicate that while the nervous tissues have a strong relationship to tooth morphology in rats, the bony morphology may not. Conversely, **the nervous tissues of primates do not correlate significantly with tooth morphology, while the bony morphology of the mandible does correlate with tooth morphology**. This could be due to the specialized chewing adaptations of rats and their loss of both the canine and pre-molar tooth forms. Rat molars are highly specialized to perform all chewing while the incisors are only involved in gnawing, indicating the molar teeth are directly responsible for the breakdown of food. While primates use their molars to grind food into a bolus, they also use their anterior teeth for processing and pre-molar teeth to grind and process foods. Future research will focus on larger primate sample sizes to determine if these results are applicable across all of primates.

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