Trabecular mapping: Leveraging sliding landmarks for analyses of bone microstructure

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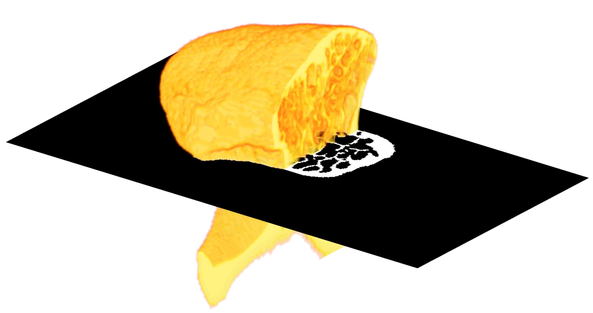
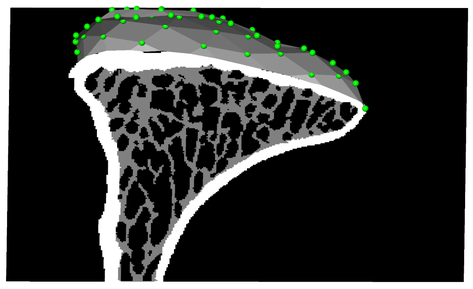
Introduction: Grounded in Wolff's Law, studies of trabecular bone have sought to find links between behavior and bone microstructure. A limitation of previous studies has been the use of a single volume of interest (VOI), which only samples a small portion of the trabecular structure, or treating structures such as the mandibular condyle as a single VOI. Here we present a method that utilizes geometric morphometric techniques to position multiple VOIs deep to the cortical shell to quantify variation in trabecular bone parameters across joint surfaces. We demonstrate this method for the mandibular condyle, and we ask two questions: 1) are microstructural variables homogeneous across the condyle? and 2) if microstructure is not homogeneous, are higher values of microstructural variables concentrated on the lateral pole, as predicted by biomechanical models of TMJ function?

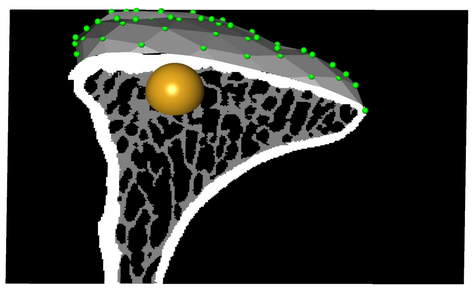
Materials and Methods:



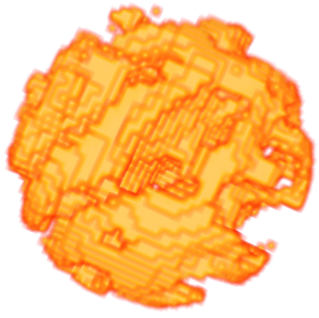
- 11 pathology-free captive *Cercocebus atys* (Sooty mangabey) mandibular condyles
- CT scanned at ~ 68-81µm voxel size (isotropic)
- Surface models generated in Avizo



- 83 sliding semi-landmarks (green spheres) distributed across the articular surface using standard geometric morphometric techniques
- Cortical and trabecular bone separated using a custom algorithm

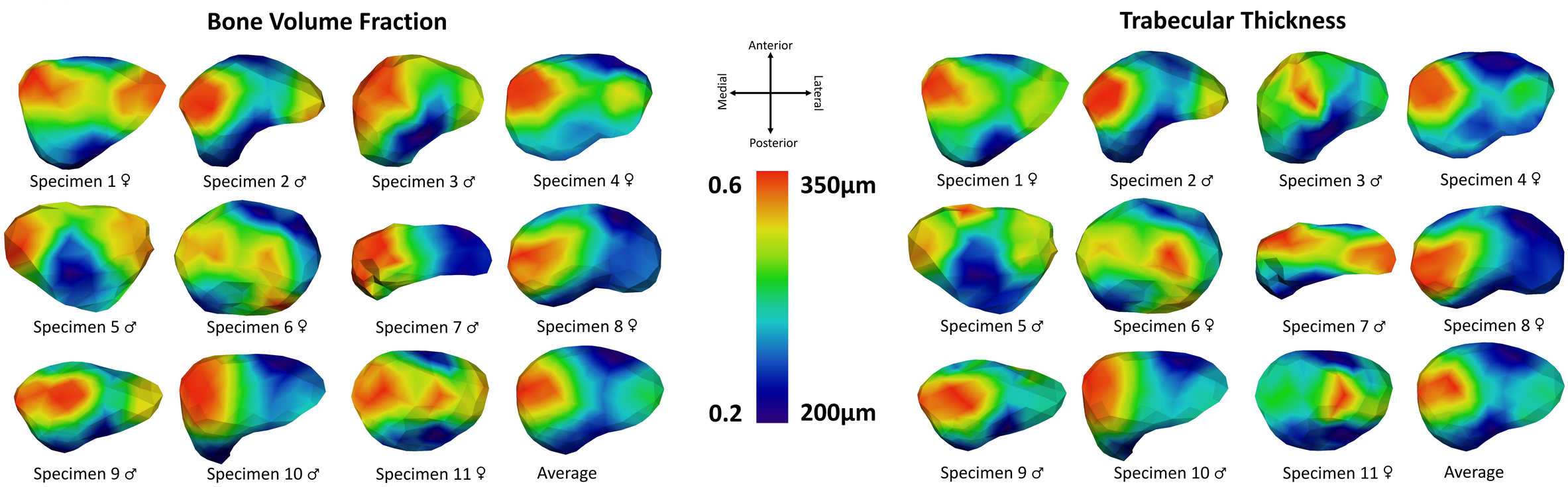


- Each sliding semi-landmark and associated vector (surface normal) were used to position a VOI (~3mm diameter) deep to the cortical shell (one VOI pictured as gold sphere)
- 83 VOIs extracted per specimen



- Bone volume fraction and trabecular thickness were measured for each VOI using BoneJ[1]
- Values were mapped onto the surface of each specimen and average values onto the average mandibular condyle

Results:



Discussion: Results suggest that bone microstructure is not homogeneous across the mandibular condyle. Bone volume fraction and trabecular thickness are highest along the center of the condyle and are particularly concentrated at the medial pole. These results are counter to our original prediction that microstructural variables would be highest at the lateral pole, as indicated by biomechanical models which suggest that the lateral aspect of the temporomandibular joint experiences increased compressive forces[2-4]. These results indicate that further investigations are warranted regarding variation in microstructural properties across the condylar surface, and that similar investigations of other articular surfaces may reveal more nuanced variation in trabecular architecture.

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References: 1. Doube M et al. (2010) BoneJ: free and extensible bone image analysis in ImageJ. *Bone* 47:1076-9. 2. Bouvier M. (1986a) Biomechanical scaling of mandibular dimensions in new world monkeys. Int J Primatol 7:551-567. 3. Bouvier M. (1986b) A biomechanical analysis of mandibular scaling in old world monkeys. Am J Phys Anthropol 69:473-482. 4. Hylander W. (2006) Functional anatomy and biomechanics of the masticatory apparatus. In: Temporomandibular Disorders: An Evidenced Approach to Diagnosis and Treatment (eds. Laskin JL et al.), pp. 3-34. NY: Quintessence.