

Merging novel imaging technologies to understand muscle dynamics in monkey mouths

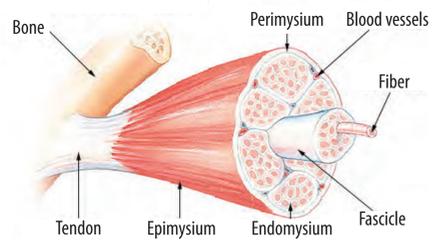
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Research question

How do whole muscles behave during feeding?

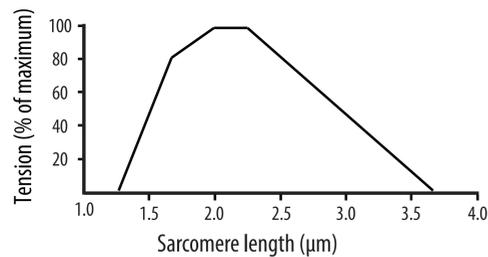
Muscle 101

Skeletal muscle anatomy



Muscle force is length-dependant

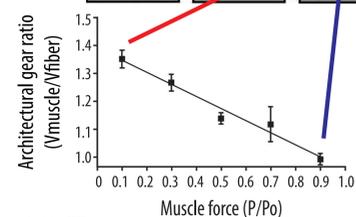
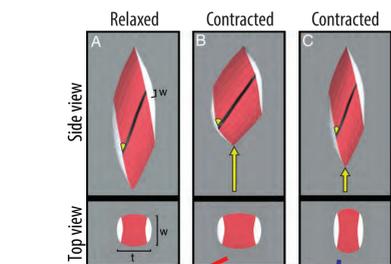
Force is maximal at an intermediate length and declines as a muscle's fibers are either stretched or shortened.



Modified from Gordon et al. 1966

Muscles change shape (bulge)

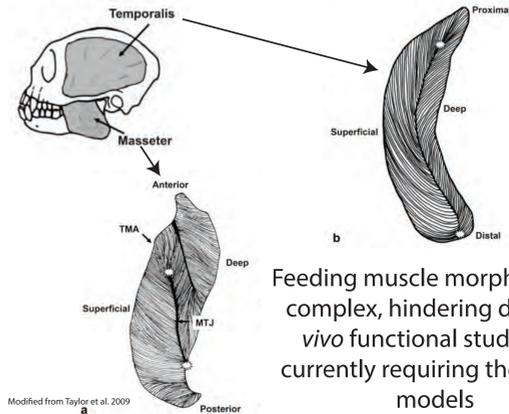
If muscle fibers rotate during contraction, the ratio of whole-muscle shortening to muscle fiber shortening is not constant



Modified from Azizi et al. 2008

Therefore, the pattern of bulging effects muscle force output

Feeding muscle architecture

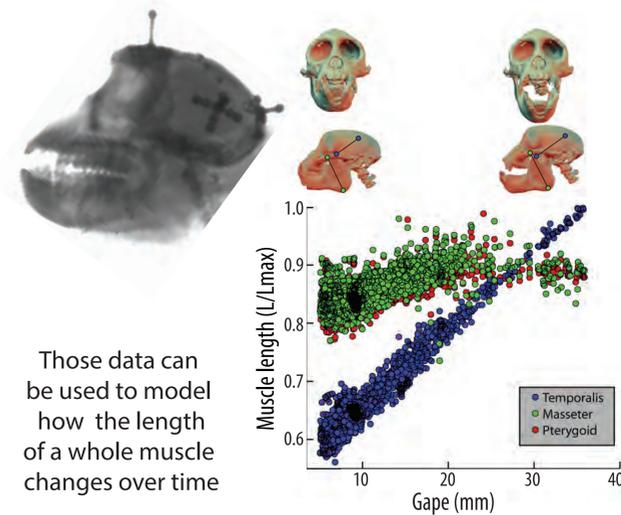


Feeding muscle morphology is complex, hindering direct *in vivo* functional study and currently requiring the use of models

Whole muscle length models

X-ray Reconstruction of Moving Morphology

A new technology at UC that merges CT scans and x-ray videos to precisely measure how bones move *in vivo*

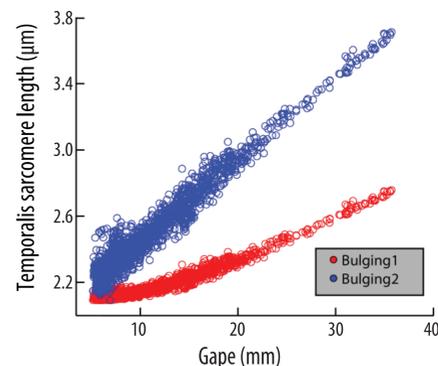


Those data can be used to model how the length of a whole muscle changes over time

Muscle fiber length models

Extremes of bulging are not physically possible

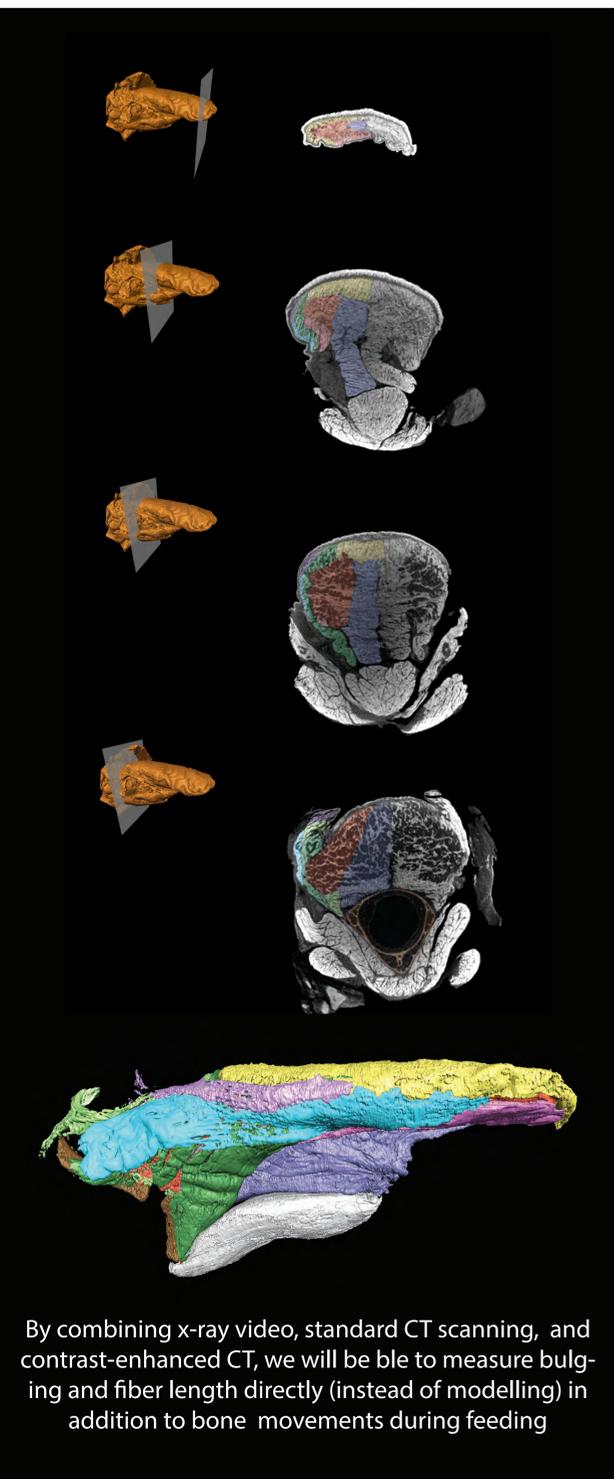
Stretching from 2.1 microns to 3.8 damages muscle



Direct measurement through a novel combination

Diffusible iodine-based contrast-enhanced CT

Permits high-resolution study of muscle architecture, even in structures as complex as the tongue. Compute nodes on Midway have been invaluable for analysis of these morphological datasets



By combining x-ray video, standard CT scanning, and contrast-enhanced CT, we will be able to measure bulging and fiber length directly (instead of modelling) in addition to bone movements during feeding

How does RCC help with our data?

Problems

Hours of high-resolution video from two high-speed x-ray cameras from each individual translate into terabytes of video data per individual, with several individuals on each of several studies.

Solutions

Volume

The RCC has organized direct downloading of our video data from the computers that collect them automatically and securely stores data while maximizing accessibility

Management

Several calibration files, muscle activity data, brain wave data and other datastreams are recorded in synchrony with the videos

The RCC is creating a custom-made client that will keep each trial's data organized and expedite entry of metadata for each trial

Logistics

Different facilities used for data acquisition and analysis, and data shared with collaborators at several institutions

Midway server allows access to data both on and off campus

Analysis

Historically, analytical tools require human input at almost every step, from extracting marker coordinates to calculating bone movements to registering marker locations within CT scans. Each step is hugely time-consuming

Our collaborating institutions have automated some analytical tools, but upload to their servers has been completely manual. The RCC is working with their programmers to automate and streamline our use of their tools.

Acknowledgements

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References

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Gordon, A. M., A.F. Huxley, and F.J. Julian. "The variation in isometric tension with sarcomere length in vertebrate muscle fibres." *J. physiol* 184, no. 1 (1966): 170-192.
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