It's All in the Wrist - An Agar Phantom Experiment to Inform Study of Geometric Wrist Moments Arms

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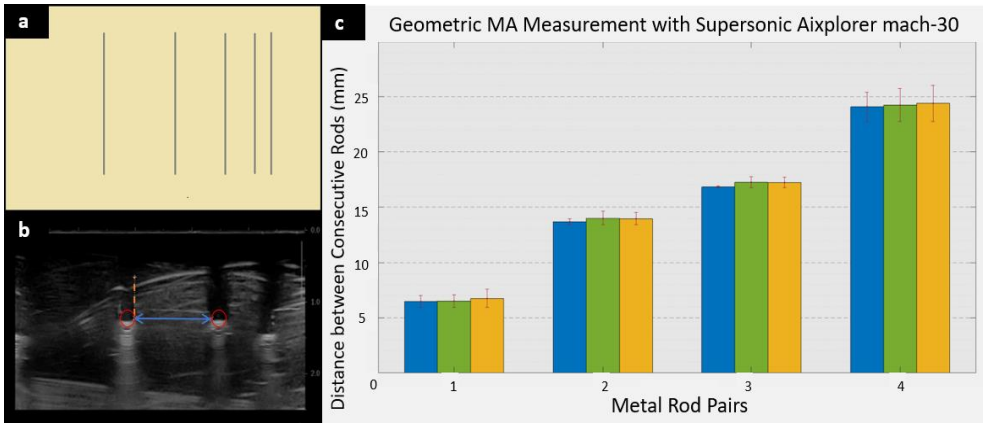
Introduction: Geometric moment arms (MAs), or the physical distance between the joint center of rotation and muscle line of action transform muscle forces into joint motion to enable movement. Ultrasound imaging has been used to measure geometric Mas in the ankle [1,2]. In contrast, at the wrist, MAs have been primarily studied using magnetic resonance imaging and cadaveric experiments [3,4]. To our knowledge, wrist MAs have not been measured using ultrasound. Here, as a critical first step toward measuring wrist muscle moment arms with ultrasound, we first evaluate whether distances with magnitudes similar to those of the wrist muscle moment arms can be accurately and reliably measured using standard B-mode ultrasound imaging.

Materials and Methods: To test the validity of our measurement capabilities, we employed the use of an agar-gel phantom [5]. Five, 100mm, metal rods were suspended in parallel within the phantom(Fig.1A**)**. Electronic calipers were used to measure the distance between the rods. This resulted in four baseline measurements between each rods: 5.948mm, 13.434mm, 16.744mm, 22.754mm. The same distances were then measured from transverse ultrasound images(Fig.1B) using a linear transducer (L18-5, SuperSonic Imagine). Five images of each distance were recorded on three separate days to evaluate measurement error within and across experimental sessions. Distances were measured from each recorded image using the ultrasound machine's linear measurement software tool. Percent error between the baseline and ultrasound measurements were calculated.

Results and Discussion: Across the typical magnitude of wrist muscle moment arms (10mm – 20mm), the measurement error between the ultrasound images and baseline measurements did not exceed 5%(Fig.1C). This indicates that the measurement errors were no larger than 0.5mm – 1mm. It should be noted the measurement error did tend to increase from the first day of the recording to the last. However, this may be due to the degradation of the phantom over time; for example, the time spent handling the phantom may have affected the material properties of the agar-gel and/or caused the metal rods to drift in the gel, displacing them from the initial position.



(**A)** Top-down illustration of the agar-phantom used, with metal rods shown in grey. **(B)** Transverse image of a rod pair (outlined in red) along with distance recorded between the rods (blue). **(C)** The data from the measurement software over the course of a week (Monday is blue, Wednesday is green, Friday is yellow).

Conclusions: The results indicate that ultrasound imaging is a valid method for measuring distances that fall within the magnitude of wrist muscle moment arms. Future will work will consist of identifying the joint center of the wrist and developing novel imaging techniques in order measure moment arms in human subjects.

References:

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