

## SIGNIFICANCE OF SURGICAL ATTACHMENT LENGTH FOR HAND FUNCTION FOLLOWING BRACHIORADIALIS TENDON TRANSFER

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### INTRODUCTION

Intraoperative sarcomere length measurements have provided evidence that transferred muscles are often attached longer than optimal length during tendon transfer surgery [1]. It is possible that surgical outcomes could be compromised if post-operative muscle fibers are too long to generate active force. However, the relationship between surgical attachment length and functional outcome remains unclear.

Brachioradialis (Br), an elbow flexor, is the most commonly utilized donor muscle to restore hand function following tetraplegia. The aims of this study are (i) to quantify the sarcomere length of the brachioradialis chosen by surgeons at the time of tendon transfer and (ii) to evaluate theoretically muscle operating ranges given the current surgical approach.

### METHODS

Sarcomere length was measured *in vivo* using laser diffraction in 13 individuals (14 limbs) with tetraplegia undergoing tendon transfer of brachioradialis to FPL (n = 12), ECRB (n = 1), or FDP (n = 1). All patients provided informed consent. Sarcomere length was measured both *in situ* and following transfer in 11 limbs, and following transfer only in 3 limbs. Measurements were taken with the elbow positioned in extension (approximately 0°-20° elbow flexion), the forearm in neutral rotation, the wrist in neutral, and the thumb in a lateral pinch posture.

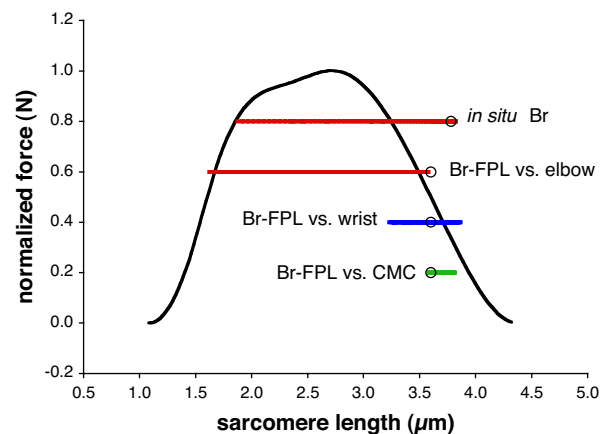
A model of the Br-to-FPL tendon transfer was developed using a computer-graphics-based model of the upper extremity [2]. We assumed the line of action of the transfer was identical to the path of brachioradialis at the elbow joint and to the path of FPL at the wrist and thumb joints. Sarcomere length of the transferred brachioradialis in the model was set at the surgical attachment length measured intraoperatively, assuming the same limb posture and zero muscle activation. We then estimated the length of the transferred Br under full activation as a function of elbow, wrist, and CMC positions.

### RESULTS AND DISCUSSION

The average sarcomere length of the brachioradialis following tendon transfer was  $3.59 \pm 0.27 \mu\text{m}$ . Transferred sarcomere lengths ranged from  $3.10 \mu\text{m}$  to  $3.90 \mu\text{m}$  across subjects. For the eleven limbs in which sarcomere length was measured both *in situ* and after tendon transfer, transferred length was significantly correlated to *in situ* length ( $r = 0.76$ ,  $p < 0.01$ ). The paired *in situ* and transferred lengths indicate that chosen surgical attachment lengths were slightly shorter ( $p < 0.01$ ) than *in situ* lengths (mean =  $3.78 \pm 0.27 \mu\text{m}$ ). *In situ* lengths ranged from  $3.39 \mu\text{m}$  to  $4.15 \mu\text{m}$ .

After transfer to the FPL, the Br changes length as a function of elbow, wrist, and thumb position. Based on the intraoperative data, we estimate that, with the wrist in neutral and

the thumb in a lateral pinch posture, Br lengths span the plateau of the isometric force-length curve, and are comparable to lengths of the *in situ* Br (Fig. 1, compare red bars). Individuals with tetraplegia and Br-FPL transfers tend to extend their wrists when using their hands to augment the tenodesis effect; CMC extension is needed to grasp larger objects. Wrist extension and CMC extension both increase the transferred Br's length. With the elbow fully extended, the wrist at 70° extension, and the CMC joint at 45° extension, we estimate the sarcomere length of the transferred Br is approximately 13% longer than the measured surgical attachment length and 8% longer than the *in situ* length.



**Figure 1.** Br operating ranges as function of elbow position (red bars, 0°-130° elbow flexion), wrist position (blue bar, 70° extension to 70° flexion) and CMC position (green bar, 45° extension to 0° flexion). Open circles indicate sarcomere length measured *in situ* and following transfer at 10° elbow flexion, neutral forearm and wrist, and the thumb in a lateral pinch posture (0° CMC flexion).

### CONCLUSIONS

This analysis suggests that the surgical attachment lengths documented intraoperatively could result in muscle lengths that are sub-optimal for force development in extended joint postures, which are functionally important. We expect that the sarcomere lengths observed here could either compromise clinical outcome in extended postures or promote structural adaptations in the transferred muscle [3].

### REFERENCES

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