HOW IS SARCOMERE LENGTH AFFECTED BY THE PROCEDURES FOR INTRAOPERATIVE MEASUREMENTS USING LASER DIFFRACTION?

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INTRODUCTION

Measurement of sarcomere lengths in human muscles during reconstructive surgery provide valuable information for the evaluation and optimization of surgical outcome (2). Intraoperative measurement of sarcomere lengths via laser diffraction involves dissecting a small bundle of muscle fibers on the surface of the muscle belly so that a laser myometer can be inserted underneath the fibers (Fig. 1). A 5 mW He-Ne laser beam is projected through a prism, which reflects the beam through the fiber bundle, resulting in a diffraction pattern that characterizes sarcomere spacing (1). If placement of the myometer elevates the fiber bundle relative to the muscle surface, sarcomere lengths in the bundle can be artificially increased. Previous work indicates that the intraoperative technique implemented by experienced users of the laser myometer introduces errors in sarcomere lengths of less than 0.2 µm (1).

Figure 1. Intraoperative measurement of muscle sarcomere lengths via laser diffraction.

The goal of this study is to quantify how different elevations of the fiber bundle relative to the muscle surface influence sarcomere length in the elevated bundle. Our ultimate aim is to provide guidelines to instruct novice users of the laser myometer and to identify surgical approaches that will minimize the potential for error during intraoperative data collection.

METHODS AND PROCEDURES

In the deeply anesthetized cat, the soleus muscle was dissected free from surrounding tissues while its origin and insertion were left intact. At maximal dorsiflexion of the ankle (~30°), two fiber bundle segments of 20 mm length were exposed. Each fiber bundle was elevated and either 1 or 2 rubber pieces (1.5 mm thick, 5 mm wide) were inserted underneath them. The muscle (still attached to the skeleton at maximum dorsiflexion) was fixed in 10% formalin for 48 hours. Connective tissue was mildly digested in 30% nitric acid for 24 hours. The elevated fiber bundles were excised and 4 smaller samples from each bundle were mounted on a microscope slide. The average sarcomere length of each sample was measured using light microscopy (×630). The average sarcomere lengths from two control fiber bundles were also measured from the same muscle, again using 4 samples per bundle. The control bundles were neither dissected nor elevated before fixation.
RESULTS

The average sarcomere length of each of the elevated fiber bundles was significantly (p < 0.05) longer than average sarcomere length of the two control bundles (Fig. 2). We observed sarcomere length increases that ranged from ~0.2 µm to ~0.4 µm. The average sarcomere length of the fiber bundle that was elevated by 1.5 mm was 6.9% longer than the average sarcomere length of the two control bundles. The average sarcomere length of the fiber bundle that was elevated by 3.0 mm was 11.3% longer than the control bundle.

![Figure 2](image)

**Figure 2.** Mean (±SD) sarcomere length for the elevated and control bundle segments. Asterisk denotes a significant difference (p < 0.05).

Simple geometric calculations suggest that the length of the dissected fiber bundle may influence the increase in sarcomere length that is imposed by a given elevation of the fiber bundle (Fig. 3). For example, our calculations suggest that dissecting a fiber bundle of 40 mm length (rather than 20 mm length) would substantially reduce the increase in sarcomere length that is associated with 3 mm of fiber bundle elevation. We calculate the length of the entire fiber bundle would increase by only 1.5% (from 40 mm to 40.6 mm) with a 40 mm bundle. This is four times less than our calculation of the length increase (6%, from 20 mm to 21.2 mm) associated with a 3 mm elevation of a 20 mm fiber bundle.

![Figure 3](image)

**Figure 3.** Increasing the fiber bundle dissection length has the potential to minimize the increase in sarcomere length caused by fiber elevation.

DISCUSSION AND SUMMARY

Our work indicates that elevation of fiber bundles by 1.5 mm to 3.0 mm can result in significant increases in sarcomere length. However, the sarcomere length increase associated with fiber bundle elevation could be highly sensitive to the length of the fiber bundle that is dissected. Ongoing work in our laboratory is now aimed at evaluating the potential for minimizing the error imposed by fiber elevation by dissecting longer fiber bundles. This work will ultimately provide information that will help us to instruct novice users of the laser myometer device how to collect the most accurate data possible. In addition, it will help us to evaluate the potential error associated with intraoperative measurements of sarcomere lengths.

REFERENCES


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