DUE TO EPIMUSCULAR MYOFASCIAL FORCE TRANSMISSION, SURGICAL APONEUROTOMY CAUSES A FORCE REDUCTION NOT ONLY FOR THE AGONIST BUT ALSO FOR ITS NON-TARGETED SYNERGISTS

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INTRODUCTION

Aponeurotomy is a surgical technique performed to correct movement disorders due to spastic contractures: the target muscles' aponeurosis is reached and cut transversely. In clinical surgery, major stated goals are to reduce force of the target muscle or lengthen the muscle. Such acute effects of aponeurotomy have been shown in fully dissected muscle [1]. However, for muscle with intact extramuscular connections, recent model work showed less pronounced effects including a diminished force reduction due to myofascial force transmission [2]. The goal of the present study was to assess the effects of aponeurotomy on force of not only the target muscle, but also of its synergistic muscles in conditions characterized by epimuscular myofascial force transmission i.e., muscle with intact connections to its neighboring muscular as well as nonmuscular structures.

METHODS

The left anterior crural compartment of the rat, enveloping extensor digitorum longus (EDL), tibialis anterior (TA), and extensor hallucis longus (EHL) muscles, was exposed. TA+EHL muscle complex was restrained at reference position (knee and ankle angles equaling 120º and 100º respectively). Distal forces of EDL and TA+EHL as well as proximal force of EDL were measured simultaneously (n=6) after distal lengthening of EDL isometrically, in two conditions: (1) *intact* (epimuscular connective tissues at muscle bellies were left intact) and (2) after *surgical aponeurotomy*. The latter represents a compound intervention: a) partial fasciotomy (cutting half of the fascia covering anterior crural compartment) and limited blunt dissection performed to reach the proximal EDL aponeurosis, b) aponeurotomy (transecting the aponeurosis). Possible history effects in the intact condition due to previous activity at high length [3] were eliminated: First, control forces were measured at high (EDL optimum length) and low (length at reference position) muscle length subsequent to collection of length force data. Then, control forces were compared to those measured at identical lengths after aponeurotomy. Force differences were considered significant at $p<0.05$ for ANOVA testing for repeated measurements.

Effects of *aponeurotomy per se* (i.e. excluding tearing of intramuscular connective tissues) on the restrained synergistic muscles were studied using finite element modeling (for a detailed description of the model see [2]).

RESULTS AND DISCUSSION

Experiments At low lengths, no significant effects of aponeurotomy were shown on EDL forces. In contrast, the intervention caused significant and substantial effects at high length: i) EDL distal force decreased by 26.87% and ii) EDL proximal force decreased even more (by 35.86%). A novel result is that aponeurotomy acutely caused a significant and sizable force reduction also for the non-targeted synergistic muscles. Moreover, such effect occurred at both low and high EDL lengths: TA+EHL force decreased by 7.93% and 11.88% at low and high lengths respectively.

Finite Element Model For restrained synergists after distal lengthening of the aponeurotomized neighboring muscle, distal force reductions similar to those of experiments (ΔF= 4.41% and 10.59% at low and high lengths, respectively). Such force reduction is explained by altered sarcomere length distributions within the restrained muscle: sarcomeres located at the distal ends of muscle fibers showed enhanced shortening. In the more distal segments of fascicles (III and IV in Fig. 1), this causes decreased fiber direction stress, a key determinant of active muscle force.

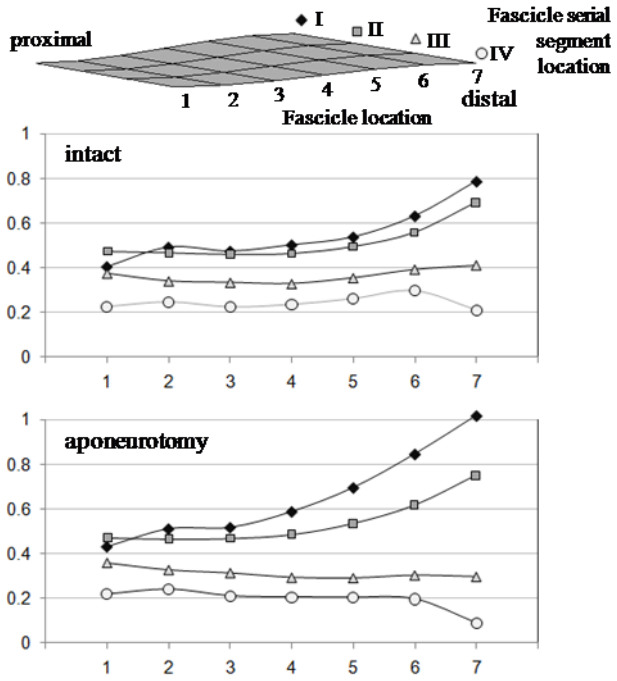

Fig. 1. Modeled fiber stresses of restrained synergistic muscle as a function of fascicles location (1-7, top panel) and fascicle serial segment location (I to IV, top panel).

CONCLUSIONS

Surgical aponeurotomy causes a substantial force reduction in the target muscle only at higher muscle lengths. However, due to epimuscular myofascial force transmission, aponeurotomy also yields other remarkable effects: (1) For the target muscle, the force reduction is different at its proximal and distal tendons and (2) a sizable force reduction occurs also for the non-targeted neighboring synergistic muscles. These results are important to consider for the design and application of the surgery.

REFERENCES

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