How Much Force Can an Intra-fascicularly Terminating Fiber Transmit Through the Endomysium?

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BACKGROUND: Shearing of endomysium is thought to be responsible for the transfer of force from an intra-fascicularly terminating fiber to myotendinous junction [1]. However, it is unclear how much force can be transferred and how much the force depends on the fiber length and endomysium shear modulus. We created finite element (FE) and analytical models to determine how much of its peak isometric force a terminating fiber can transfer to the myotendinous junction, if the fiber length (L) and endomysium shear modulus (G_{end}) are within a physiological range.

METHODS: We created an analytical model of a terminating fiber at initial length L and a diameter of 80 *μm*, surrounded in endomysium (Fig. 1A). On one end, the fiber and endomysium are fixed, and on the other end, the endomysium is fixed and the fiber is free from constraints (simulating a terminating fiber). We calculated the active force generated in the fiber as a function of L for several values of G_{end} (Fig. 1D). We created a FE model of the same simple geometry to validate the analytical model (Fig. 1B). We created a FE model of a fiber bundle from a histological cross-section to determine the validity of the simple geometry models. We compared the force generated in a terminating fiber in the bundle with that of the simple FE model for a given L (40 *μm*) as a function of G_{end} (Fig. 1E).

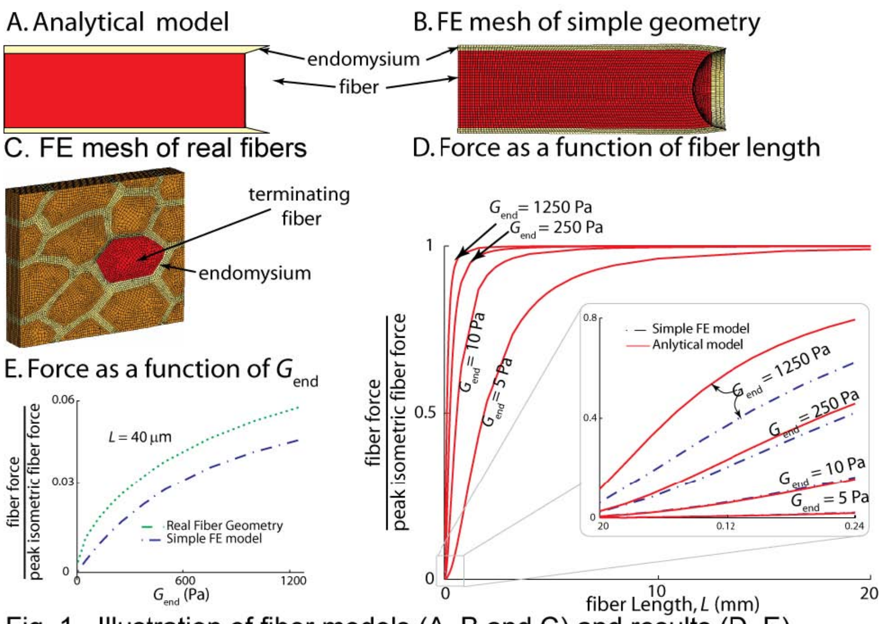

Fig. 1. Illustration of fiber models (A, B and C) and results (D, E)

RESULTS: The analytical model showed that force generated by a terminating fiber approaches peak isometric force as L and G_{end} increase (Fig. 1D). For a low G_{end} of 5 *Pa*, a fiber of average diameter that terminates with a length of a 2 *cm* can generate 99% of its peak isometric force (Fig 1. D). The simple FE model and the analytical model show good agreement for small G_{end} (Fig. 1 D, inset). For larger G_{end}, the FE model predicts lower forces than the analytical model. As in the analytical model, the FE forces rise faster for larger G_{end} compared to smaller G_{end}. The generated force for the real fiber geometry and the simple finite element model follow a similar trend (Fig. 1 E).

CONCLUSION: The amount of force that can be generated and transmitted laterally through shearing of the endomysium in a terminating fiber is dependent on both L and G_{end}. However, for values of L and G_{end} that are in a physiological range, a terminating fiber can transmit virtually all of its peak isometric force through the shearing of endomysium.

REFERENCE: [1] Purslow, P.P. and J.A. Trotter, J. Muscle Res. Cell Motil., 1993. **15**: p. 299-308.