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Abstract

Additively manufactured model of biceps brachii for electrophysiology visualization

A. Oltmann[1*], E. Aderhold[1], T. Friedrich[1] and P. Rostalski[1,2]

[1] Fraunhofer Research Institution for Individualized and Cell-Based Medical Engineering IMTE, Lübeck, Germany
[2] *Institute for Electrical Engineering in Medicine, Universität zu Lübeck, Lübeck, Germany*
[*] *Corresponding author, email: andra.oltmann@imte.fraunhofer.de*

Physiological processes in the human body, such as potential propagation due to electrical muscle activation, are complex mechanisms and difficult to resolve. One approach to improve the understanding of these processes is the visualization of modelling and simulation. In addition to the numerous applications of additive manufacturing in medicine, it also in general enables the transfer of digital models into haptic representations that can be used in training and education [1].

The electrical potentials on the skin surface caused by the electrical activity of the muscles during contraction can be recorded by surface electromyography (sEMG) [2]. As part of this work, a digital model of electrical signal propagation was developed to provide a better comprehension of sEMG recording at the biceps brachii for a specified electrode position. The final model is based on anatomical 3d representations from the BodyParts3D library [3] and includes both heads of the biceps brachii muscle, the arm bones (ulna, radius, and humerus), the skin of the upper torso, as well as a defined electrode position. Using a previously investigated simulation approach [4], a three-dimensional finite element simulation was used to calculate the electrical transfer behaviour between the electrode and the muscle. The absolute values of the resulting transfer coefficients on the muscle surface are integrated as a color-coded representation.

The anatomical reference and the representation of the simulation results were combined in the model and transferred to GrabCAD Print scaled down to 25 % of the real size and produced on a J850 PolyJet 3D printer using the materials VeroBlackPlus, VeroPureWhite, VeroMagneta-V, VeroYellow-V, VeroCyan-V, and VeroClear (Stratasys, Eden Prairie, USA). The simulated transfer coefficients are colormapped on the muscle surface. The model was post-processed after printing by polishing and lacquering the surface to improve the transparency of the manufactured skin surface.

The finished model not only visualizes the electrophysiological principle but also the technical principles of sEMG recordings. In particular, the well-known effect of the influence of electrode distance to signal source [2] becomes clearly visible by the color coding, as well as through the comprehensible size relations. The manufactured model is thus suitable for various applications in education, e.g. the correct placement of electrodes, as it unites both, anatomical structures and physiological information in one 3D visualization.

Author's statement

Authors state no conflict of interest.

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