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Abstract

Complete Kinematic and Kinetic Hand Function: A Method, Mapping and Model

By

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Osteoarthritis (OA) is the leading cause of hand dysfunction in America, affecting over 60% of Americans over the age of 55. However, the current methods to quantify changes to hand function—such as questionnaires, goniometers, and dynamometry—are limited. In order to move towards personalized medicine and to design better devices for individuals with reduced hand function, it is critical to have an objective understanding of how hand function changes. Therefore the goals of this work were to 1) develop a method to quantify and interpret function of the four fingers in terms of kinematics (where the digits can reach) and kinetics (how the digits can apply force); 2) experimentally quantify the function of healthy fingers and develop a generalized linear mixed model (GLMM) to represent the finger function; and 3) track how hand function changes due to osteoarthritis and due to surgery.

A functional testing protocol was developed to obtain the kinematic space (everywhere the digits can reach) and the forces that can be applied over that kinematic space. These kinematic and kinetic functional abilities were mapped together to understand how function differs between individuals, within populations, and between populations. Next, the functional testing protocol was used to quantify finger function of forty-one healthy individuals and develop a generalized linear mixed model to estimate healthy finger strength across the ranges of motion for all four fingers. The healthy participants’ index finger function was then compared to a group of participants with hand OA. Finally, five patients were tested to determine the effects of thumb suspensionplasty (removal of the trapezium followed by insertion of a suture wire between the first and second metacarpals).

The ability to quantify motion and force data for each digit and map them together provides an improved understanding of the effects of treatments and rehabilitation which will assist clinicians in identifying functional loss due to injury or disease and improve device design. The models presented in this work can be used to compare an individual’s function to normative function so clinicians can determine how much function was lost and develop a treatment plan. Going forward, this process can be used to compare other populations, such as stroke patients or juvenile arthritis, to determine how function has changed as well as to compare other surgeries to understand how different procedures lead to different outcomes for patients with severe OA.