IMAPACT OF RESTRICTED PIP JOINTS ON MCP JOINT MOTION IN THE HUMAN HAND

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INTRODUCTION

Loss of motion of the metacarpophalangeal (MCP) and proximal interphalangeal (PIP) joints caused by trauma or degenerative processes impairs hand function. Patients with arthritis often have involvement of multiple finger joints, which further decreases function. Surgical alternatives for severe PIP arthritis are arthrodesis and implant arthroplasty. Arthrodesis provides a pain-free and stable joint, but sacrifices motion, resulting in a need for compensatory increased motions at neighboring joints. Arthroplasty is an attractive option, but its risks should be weighed against the impairment caused by fusion. The impact of stiff finger joints on the performance of activities of daily living is unclear. In this study we aim to determine the affect of restricting PIP motion on the range of MCP motion while performing several manual tasks.

METHODS

After obtaining IRB approval, 15 subjects (5 male/9 female) without upper extremity compromise were recruited from the local community. Subsequently, informed consent was obtained from each subject. The goal was to evaluate the motions used by the MCP joints of the dominant hand for a series of thirteen activities of daily living (ADL) with the PIP joints free and splinted. Tasks included: tying a shoe, buttoning a shirt, turning a doorknob, drinking, opening a jar, answering a phone, pouring milk, stirring rice, picking up small objects, eating soup, typing, wringing out a washcloth and signing ones name.

Motion of each finger was monitored using an Optotrak (Northern Digital, Inc., Waterloo, Ontario) motion analysis system with two position sensors. Each task was evaluated under two conditions: 1) unrestricted PIP and MCP motion (i.e. without the use of splints), and 2) fully restricted PIP motion of each finger (excluding the thumb) with unrestricted MCP motion.

Figure 1. Splinted Finger Setup

For the first condition, four LEDs were affixed to each finger and the respective MCP joint was digitized with respect to a sensor placed on the back of the hand. Subjects were instructed to begin and end each task in the neutral position (i.e. with their fingers in line with the long axis of the third metacarpal). For the second condition, all four of the PIP joints were splinted at 40 degrees of flexion using small aluminum splints covered with self-adherent Coban (3M) and secured to the fingers with tape. The position sensor remained on the back of the hand and markers were applied directly to each splint (Figure 1). Each task was performed at a self-selected pace, while finger motions were recorded.

Data was processed using a Motion Monitor System (Innovative Sports Training, Chicago, IL) and then exported to a custom written Matlab program that used Euler angle transformation to compute the three-dimensional positions of the markers with respect to a local hand coordinate system. Differences in the maximum range of motion measurements were measured between the splinted and non-splinted trials for each task.

RESULTS AND DISCUSSION

A significant increase occurred in the amount of MCP flexion used to perform some of the tasks during the splinted trials. Tasks normally involving substantial PIP motion typically produced an increase in MCP flexion when the PIP joints were restricted. For example, buttoning a shirt showed a significant increase in MCP flexion ROM at all four fingers ($p<0.05$) when splinted (Figure 2). Although recorded, increases in the amount of MCP flexion for most tasks were small and did not display great changes statistically due to high standard deviations.

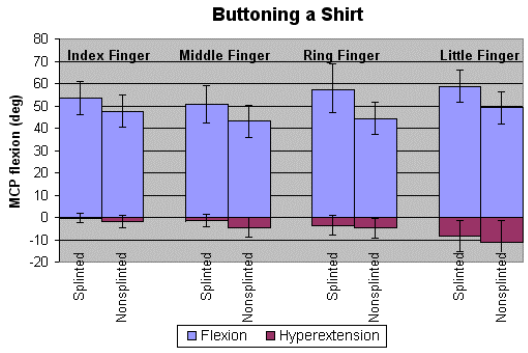

Figure 2. MCP flexion/hyperextension while buttoning

This investigation lends insight into the amount of compensatory motion used by the MCP joints when PIP joint motion is restricted at 40° of flexion. A wide range of required flexion was used by each subject indicating individuals accommodate well when PIP joints are splinted in this position. Since the finger DIP joints and thumb were neither monitored nor restricted, the affects of PIP restriction may have been underestimated in arthritic patients who often have multiple joint involvement. In fact, we observed that subjects altered thumb use to compensate for the restricted PIP joints in tasks such as tying a shoe and stirring rice.