INTRODUCTION

Until recently, the upper limb prosthetist has been limited by prehension patterns provided by standard externally powered terminal devices. Of the six types of commonly known hand prehension patterns, only opposition (palmar) grip, that approximated tip and cylindrical grip patterns, were available with hand-type terminal devices, while hook-type devices offered lateral and passive hook prehension. The latest innovations in brushless motor drives and battery technology have permitted a number of new designs that offer independent finger articulation, not only at the MCP (Metacarpal-Phalangeal) joints, but at the PIP (Proximal-Interphalangeal) joints as well as the CMC (Carpal-Metacarpal) positioning of the thumb. These features come with inherent technical limitations to Glove Durability, Grip Strength, Closing Speed, Positional Feedback, and Cosmetic Presentation. Clinical issues have become evident in the early introduction of these devices, which further delineate the functionality and usage of these hands with respect to Control Complexity, Active Thumb Positioning, Lateral/Oppositional Gripping, and Effect of Wrist Adaptation and Rotation.

METHODS

A literature review regarding physiologic hand biomechanics and frequency of predominant grip patterns with respect to thumb and finger positions was performed. Current literature regarding grip patterns was examined that suggested that lateral prehension and multi-finger prehension was utilized more than previously described. A technical overview of the various multiarticulating designs was created that examined the various design specifications regarding hand speed, current draw, grip strength, control options, and wrist function. Qualitative clinical case studies were gathered from 12 patients nationally who had comparative experience with two or more multi-articulating hands. A survey of clinical specialists was also created to examine thoughts and opinions fitting these hands.

RESULTS

The literature review provided a variety of information concerning frequency of grip, hand biomechanics, loading distribution, and control theory. However frequency showed some disparity. Earlier references indicated that palmar prehension was used 50%, lateral 33%, and tip 17% of the time during picking up an object and however later research indicates a more uniform prehension frequency with tip at 20%, lateral 10%, palmar 10%, and five-finger pinch. The neuroscience of physiologic hand prehension describes the patterns that utilize touch, loading distribution, visual, and proprioceptive feedback. Multiarticulating prosthetic designs still rely on visual feedback which limits the control loop of the devices and may increase the mental loading of the devices when controlling more than two functions. The number of drive motors conversely affected closing speed, grip strength, current draw, and overall noise. Two designs employ passive manipulation of the thumb position and mode switching with four and eight different grip patterns available. One design provides active positioning of the thumb as well as finger adduction, and adaptive positioning of the wrist. The qualitative case studies revealed additional considerations of mental loading of the various prehension patterns. Early results from an ongoing survey of prosthetists who fit multi-articulating hands, indicate that patients may only utilize two gripping patterns although more may be available. The prosthetists rate palmar and key grip as the most relevant and indicate that grip strength and durability should be improved for future function.

DISCUSSION

The technical differences between the designs seem to correspond to the number of drive motors employed by the design as well as the presence of active thumb positioning. While increased drive motors allowed a greater number of grasping configurations, speed of movement and grip strength may be compromised. Active thumb positioning increased use of the main grips of lateral and opposition. Patients were often challenged when asked to use more than two types of prehension patterns. More research is needed to understand grip pattern priorities in prosthetic hands and what combinations are the most desirable, and if they match physiologic function. It is noted that aging increases the number of physiologic prehension patterns used as grip strength decreases. This may indicate the prosthetic grip strategies may be inherently different than physiologic grasping and challenges this comparison.

REFERENCES


DISCLOSURE

Authors are employed by Ottobock Healthcare in Minneapolis, Minnesota.