Authors:

N.A. Abd Razak, MEngSc

N.A. Abu Osman, PhD

M. Kamyab, PhD

W.A.B. Wan Abas, PhD

H. Gholizadeh, MEngSc

Affiliations:

From the Department of Biomedical Engineering, Faculty of Engineering, University of Malaya, Kuala Lumpur, Malaysia (NAAR, NAAO, WABWA, HG); and Department of Orthotics and Prosthetics, Faculty of Rehabilitation Sciences, Tehran University of Medical Sciences, Tehran, Iran (MK).

Correspondence:

All correspondence and requests for reprints should be addressed to: N.A. Abd Razak, MEngSc, Department of Biomedical Engineering, Faculty of Engineering, University of Malaya, 50603, Kuala Lumpur, Malaysia.

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Satisfaction and ProblemsExperienced with Wrist Movements

Comparison Between a Common Body-Powered Prosthesis and a New Biomechatronics Prosthesis

Functional prosthetic hands can be classified into two types: body-powered prostheses and externally powered prostheses.[1,2] There are several engineering systems available for the purposes of generating wrist movements that focus on flexion, extension, supination, and pronation movements within upper limb prostheses. These include neuroprosthesis,[3Y11] the brain computer interface system,[12,13] the hybrid system,[14Y16] the PneuGlove,[17] the Utah Arm,[18] and thermofluid systems.[19Y23] It is the role of the prosthetist to determine the suitability of a system in accordance with the level of amputation, the residual limb condition, and the user's average activity levels.[24]

An ideal prosthetic hand has a low cost, increases functionality, interacts naturally with the environment, provides increased grasping speeds and forces, is quiet, and is cosmetically attractive.[1] One of the most significant contributors to most of these elements is the actuator that is used within the system. There are several different types of actuators available, such as linear actuators including motors,[17,25Y27] linkages and gears,[28,29] pneumatic and hydraulics,[19Y23] and cables.[30Y35] The actuator is the most important element of a prosthetic device in terms of the contribution it makes toward creating a device that can mimic natural hand movement (either mechanically or electrically).[36Y38] It is crucial that an appropriate actuator is selected for each device; ultimately, the movements produced by the actuators are the ones that control and limit the movements or the degree of freedom of the upper limb movements.[1]

A new suspension system for wrist movements, called the biomechatronics wrist prosthesis, has been introduced and tested in a previous study.[14,24,39] The system involves rehabilitation medicine,

computer audit design (CAD) design, and biomechatronics engineering. It has been designed to allow servo motors that are placed in the transradial part to generate the wrist movement of the prosthetics. These enhanced qualities should be demonstrated not only objectively but also based on feedback of prosthetic users.

Several questionnaires have been developed to evaluate patients' satisfaction with prostheses and orthoses. These include the individual questions pertaining to satisfaction, pain, ambulation, prosthetic care, and self-efficacy. The survey scales are not dependent on each other, and therefore, it is reasonable to use only those scales that are of interest to a given study.

In the authors' previous work,[14,24,39] individuals with transradial amputation were found to be mostly satisfied with biomechatronics wrist prosthesis, except for difficulty in the abilities to pick and place objects and hold a cup. Because transradial amputation levels differ in terms of residual limb size, shape, appearance, and function, it was assumed that the effect of prosthesis systems on satisfaction would be different. This qualitative study aimed to compare satisfaction of users of transradial prosthesis with that of the biomechatronics wrist prosthetic system and the common body-powered prosthesis and to identify problems perceived with these systems. The authors hypothesized that people with transradial amputation would be more satisfied and would experience fewer problems regarding the wrist movements with a biomechatronics wrist prosthesis compared with the common body-powered prosthesis.

METHODS

Participants

Twenty persons with transradial amputation from the Department of Rehabilitation, Tehran University of Medical Sciences, Tehran, Iran, and the Department of Biomedical Engineering, University of Malaya, Malaysia, who met the inclusion criteria were invited to participate in this study. The inclusion criteria required that individuals with transradial amputation had used both suspension systems for at least a period of 2 yrs before commencement of this project. In addition, they were required to be using the biomechatronics wrist prosthesis at the time of entry to this study. This was a retrospective study because the prostheses had already been fabricated and the subjects were asked to recall their experiences. All participants first experienced using the common body-powered prosthesis and then elected to transition to the biomechatronics wrist system.[14,24,39] The ethics committees of Tehran University of Medical Science and the University of Malaya granted ethical approval for this study. After written consent, the subjects were asked to complete a questionnaire, which measured their level of satisfaction with both prosthetic systems. All the participants filled in one questionnaire for each prosthetic system. The questionnaires were either mailed to the participants or distributed to them on visiting either center.

Questionnaire

The first section incorporated demographic questions, such as age, height, weight, amputation side, time since amputation, hours of daily prosthetic use, and activity level. Section 2 of the questionnaire consisted of questions related to satisfaction, including supination and pronation; flexion and extension; perception of prosthetic appearance; and the abilities to open a door, hold and a cup, and pick up and place objects. In the third section, the participants

were also asked whether they experienced any of the following problems when using each suspension system: sweating, skin irritation, wounds, swelling (edema) of the residual limb, socket, unpleasant smell of the prosthesis or the residual limb, unwanted sound, and pain in the residual limb and problems regarding the durability of the suspension systems. The questionnaire items were scored on a range between 0 and 100, where 0 indicated unsatisfied or extremely bothered and 100 represented completely satisfied or not bothered at all.[40Y42] Moreover, to determine the overall satisfaction and problems, mean scores for the questions were calculated.

Analysis Procedures

Because the sample size of this study was small (N = 15), nonparametric tests were used to analyze the data. Therefore Wilcoxon's signed-rank test was used to compare within-subject wrist movement measurements and the satisfaction with the two prostheses. Statistical analyses were carried out using version 20 of the Statistical Package for the Social Sciences, statistical software (Statistical Package for the Social Sciences, Chicago, IL). The participants' demographic information is shown in Table 1.