Chapter 38

Novel Rehabilitation Devices for Hand Movement Disorders

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ABSTRACT

Numerous therapeutic rehabilitation devices have been studied. This chapter describes novel rehabilitation devices designed to treat hand movement disorders. Recently, robot-aided rehabilitation using instruments, such as a hand motion robot and a robotic glove, have attracted interest because they help recover motor function in stroke patients. The lack of proper care for at-home patients is a major problem. The authors of this chapter developed a novel portable device, consisting of two grips, that allows the patient to perform exercises at home. While a patient grasps both grips with one hand, the driving grip reciprocates at several speed adjustments. The relative distance between the movable and fixed grip enables the hand to open. In addition, a master-slave system that measures the surface EMG on the healthy arm is proposed for self-controlled rehabilitation therapy. This portable device is not complex and can be used without assistance. Future development will improve the quality of the system, and the recovery effect will be evaluated in clinical trials.

INTRODUCTION

The number of patients with a disability resulting from stroke or bone fracture has increased in proportion with the aging Japanese population. In particular, motor disorders of the hand affect daily activities such as eating, writing, or manipulating objects. Physical rehabilitation is typically performed in hospitals by therapists. However, therapists are in a relative shortage, and it is not always possible for patients to rehabilitate sufficient motor functions from ADL (Activities of Daily Living). There are numerous patients with chronic movement disorders of the hand (Abe,
A rehabilitation device that allows the patient to self-perform exercises would be beneficial.

Mechanical devices that are used for rehabilitation are grouped into two categories. One type is a continuous-passive–motion (CPM) device. During the early stages of hand rehabilitation, a therapist typically performs exercises that repetitively extend and flex finger joints to prevent contracture in a range-of-motion (ROM) exercise. A CPM device performs the ROM exercise in place of the therapist.

Rehabilitation is also performed using robotic devices. Robotic devices accurately and systematically control the applied force and progressively adapt to the ability of the patient. Robot-aided rehabilitation is used to enhance, quantify, and document neurological rehabilitation. Neurological rehabilitation is a complex medical process that aims to aid recovery from a nervous system injury and minimizes and/or compensates for any functional alterations. Whereas classical rehabilitation is limited by the subjective observations of therapists and patients, robotic devices precisely quantify the progress achieved by stroke patients. Robotic arm rehabilitation therapies have been clinically tested (Lum, Burgar, Shor, Majmunda, & Van der Loos, 2002), (Fasoli, Krebs, Stein, Frontera, & Hogan, 2003).

Conversely, hand rehabilitation is somewhat difficult because the hand possesses many degrees of freedom of motion, and the mechanical device would have to be small. There are three joints in each finger, the metacarpophalangeal (MP), proximal interphalangeal (PIP), and distal interphalangeal (DIP) joints. We have previously introduced some rehabilitation devices to be used for hand movement disorders. This chapter describes the development of a novel device that promotes hand rehabilitation at home. A control method is also presented for self-performed exercises.

**HAND REHABILITATION DEVICES**

**CPM Device**

Figure 1 shows the CPM device for the hand and wrist (SAKAI Medical Co., Ltd.). Accessories correspond to ROM training of the hand and forearm during the early stages of rehabilitation. Repetitive passive movements are believed to improve joint, muscle and tendon mobility (Hesse, Schulte-Tigges, Konrad, Bardeleben, & Werner, 2003).

**Robotic Device**

A robotic interface to train opening/closing of the hand and knob manipulation was developed (Dovat, Lambercy, Ruffieux, Chapuis, Gassert, Bleuler, Teo, & Burdet, 2006), (Lambercy, Dovat, Gassert, Burdet, Teo, & Milner, 2007). This DOF device can be used to rehabilitate a complete opening movement, i.e., the movement from a contracted and closed hand to an opened position.

To enhance the quality of life of patients with hand impairments, the Hand Motion Assist Robot was developed (Kawasaki, Ito, Ishigure, Nishimoto, Aoki, Mouri, Sakaeda, & Abe, 2007; Ueki, Nishimoto, Abe, Kawasaki, Ito, Ishigure, 2007; Ueki, Nishimoto, Abe, Kawasaki, Ito, Ishigure, 2007).