The Effect of a Memory Training Application for a Patient with Traumatic Brain Injury

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Abstract. [Purpose] Memory impairment is a common sequela in patients with traumatic brain injury (TBI). Little is known about applications for memory training for patients with TBI. We investigated the effect of a memory training application in a patient with TBI. [Subjects and Methods] A 37 year-old male patient presented with memory impairment since onset of TBI resulting from a traffic accident. We developed a memory training application for use with a tablet PC. It consists of six stages. Each stage is composed of visual and auditory memory training parts. Two training sessions were conducted per day, five days per week, for a period of three months from nine months after onset to 11 months after onset. [Results] The patient’s scores on the Memory Assessment Scale showed improvement after participating in the memory training program for a period of three months: global memory, 56.6%; short-term memory, 13.2%; visual memory, 75.0%; and verbal memory, 37.9%. [Conclusions] We observed significant improvement of memory function of this patient after memory training using this application. As a result of these findings, we believe that this application could be useful for improving memory impairment of patients with TBI.

Key words: Telerehabilitation, Applications, Brain injury

INTRODUCTION

Memory impairment is a common sequela in patients with traumatic brain injury (TBI)1). Often, it becomes a serious limitation in performance of activities of daily living, return to work, social activities. Many studies have attempted to develop strategies for improvement of memory impairment in patients with TBI2). These strategies include computer-based memory training programs, therapist-assisted memory training, cholinergic drugs, and memory aids including a notebook, appointment diary, or to-do-list3–4). Telerehabilitation is defined as a set of instruments and protocols aimed at providing rehabilitation at a distance5). With the rapid development of modern technology and the use of computers in communications, many applications and telerehabilitation programs have been developed for rehabilitation various functions, including cognition6–19). However, little is known about applications for memory training based on telerehabilitation for patients with TBI.

In the current study, we investigated the effect of a memory training application as a telerehabilitation program for a patient with TBI.

CASE REPORT

A 37 year-old male patient who had suffered a traffic accident underwent decompressive craniectomy for treatment of traumatic subdural hematoma at the department of neurosurgery in our university hospital. He lost consciousness for seven days from the time of injury onset. Brain MRI performed at three months from injury onset showed focal encephalomalacia at the left pons and right cerebral centrum semiovale. The patient presented with memory impairment, which occurred as a result of the injury received in the traffic accident. The patient received rehabilitation management beginning two months after onset of TBI at the rehabilitation department of our university hospital. The patient understood the purpose of the study and provided written, informed consent prior to participation. The study protocol was approved by the Institutional Research Board of our university hospital.

Evaluation of memory function

The Memory Assessment Scale (MAS) was used for evaluation of memory function. The MAS assesses verbal, visual, short-term and global memory (standard score for sum of verbal and visual memory). The reliability and
validity of MAS are well-established\(^\text{20}\)). Prior to starting the memory program, the patient was assessed two times with an interval of one month (nine and 10 months after onset of TBI), and the assessments were performed every month for a period of three months after starting the training program.

**Applications**

A Galaxy Tab (tablet PC: Samsung Electro Co, Republic of Korea) was used for the development and optimization of the application. The application consists of six stages. Each stage is composed of visual and auditory memory training parts. For visual memory training, a certain figure, for example, a triangle or quadrangle was presented on the tablet PC screen for a period of five seconds. Subsequently, a figure was displayed at random on the tablet PC screen (Fig. 1). If the latter figure was the same, or, if it differed from the former figure, the patient was instructed to touch either the “O” or “X” button, according to memory. For auditory memory training, the sound (auditory task) of a word was played through the tablet PC speaker for a period of five seconds; then a word was displayed on the tablet PC screen. If the sound was same as the displayed word, the patient was instructed to touch the “O” button. If they were not the same, the patient was instructed to press the “X” button. Each stage consisted of a different number of questions and sessions (stage 1: one question and two sessions; stage 2: two questions and three sessions; stage 3: three questions and four sessions; stage 4: four questions and four sessions; stage 5: five questions and four sessions; and stage 6: six questions and four sessions) for visual and auditory memory training. When the patient gave correct answers to all the questions in a session of a stage, the patient was allowed to proceed to the next session of the stage.

**Memory training protocol**

Two training sessions were conducted per day, five days (Monday to Friday) per week for a period of three months from nine months after onset to 11 months after onset. During the evaluation and training period, the patient did not change medication or rehabilitative managements.

**Connection of the tablet PC to the hospital server**

Results of memory training were transferred to the server at our hospital, and the physiatrist and occupational therapist were able to evaluate the patient’s information (name, ID number), training date, training duration, and sessions/day, final level per training session, correct answer rate, and reaction time for each question. Based on the results, the physiatrist and occupational therapist were able to provide feedback to the patient.

**RESULTS**

During the three-month training period, the patient underwent memory training for a total of 59 days without adverse reaction (first month: 21 days, second month: 19 days, and third month: 19 days). On the first day, the patient started from the second session of the first stage. He was able to reach the third session of the fifth stage at the end of one month of memory training. He progressed to first session of the sixth stage at the end of two months of memory training, and the third session of the sixth stage at the end of three months of memory training.

Before starting memory training, MAS scores were similar over a period of one month. However, after starting memory training, MAS scores, in terms of total, short-term, visual, and verbal memory, began to show improvement. As a result, all MAS scores evaluated showed improvement (just before memory training > three months of memory training: global memory, 53 > 83; short-term memory, 68 > 77; visual memory, 56 > 98; and verbal memory, 58 > 80) (Fig. 2).

**DISCUSSION**

In the current study, we attempted to investigate the effect of an application for memory training as an approach
to telerehabilitation for a patient with TBI. Memory function according to the MAS scores of this patient showed improvement after three months of memory training: global memory, 56.6%; short-term memory, 13.2%; visual memory, 75.0%; and verbal memory, 37.9%. We found that visual memory showed greater improvement than verbal memory by as much as almost two times. Although there were training programs for verbal memory, the fact that this memory training program was based mainly on visual function appears to be related to the result. Specifically this application was displayed on a tablet PC screen, therefore, the patient was required to interact with the tablet PC screen. In addition, for verbal training, the patient was required to provide answers using the tablet PC screen.

Since the 1990s, many telerehabilitation programs have been developed for patients with brain injury5, 9, 14, 17, 18, 21). Most of these programs have focused on rehabilitation of physical disability or speech impairment5, 9, 13, 14, 17, 18). In contrast, only a few studies have reported on telerehabilitation for cognition7, 8, 10). These studies have been performed using internet-based virtual reality or computer software programs. With the rapid spread of tablet PCs and smartphones, many applications have been developed for rehabilitation11, 13, 15, 16, 19, 20). Some studies have demonstrated the usefulness of smartphones for improvement of memory impairment22–24). However, to the best of our knowledge, no application for memory training has been developed.

In conclusion, memory training using this application resulted in significant improvement of memory function in a patient with TBI. Accordingly, we believe that this application could be useful for improving the memory function of patients with memory impairment following brain injury. One of the limitations of this study was that we did not recruit an isolated control group; instead, we adopted a single subject pretest-posttest comparative design. In addition, because it is a case report, the result of this study cannot be generalized; therefore, additional complementary studies including a larger number of patients are warranted.

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