Clinical Trial/Experimental Study

Medicine®

OPEN

CONSORT—Assistive technology-180° rotating eating spoon improves the ability of eating of self-care patients with upper extremity dyskinesia

Rotating eating spoon improves eating ability

Jin-Xia Sun, MD[a,*], Li-Fang Li, PhD[a,*], Yu-Long Zhao, MD[b], Gui-Wei Lu, MD[c]

Abstract

Objective: This study aims to develop an assistive technology-180° rotating feeding spoon that could improve the ability of eating of self-care patients with upper extremity dyskinesia.

Methods: The Brunnstrom 6-stage rating of hemiplegia was adopted. During the different recovery stages of the upper limbs, the patients orally ate using a feeding spoon with a non-rotatory head and a 180° rotating feeding spoon. The ability of these patients to eat by themselves was observed, and the basic activity of daily living (BADL) was assessed using the Barthel index (BI).

Results: The Brunnstrom assessment scale was used to analyze the results of the patient's upper limb function examination, and the results revealed that the 180° rotating feeding spoon could assist patients with different degrees of upper limb dysfunction when eating independently.

Conclusions: The 180° rotating feeding spoon can assist patients with upper limb dysfunction when eating independently. For patients with different degrees of upper limb dysfunction, the spoon can provide different degrees of aid.

Abbreviations: AT = assistive technology, BADL = basic activity of daily living, BI = Barthel index, ICC = intraclass correlation coefficient.

Keywords: 180° rotating feeding spoon, aid in eating independently, assistive technology, self-care ability in eating, upper limb dysfunction

1. Introduction

With the progress of society and the high demand for quality of life of the disabled, the development of assistive technology (AT) has been promoted. AT is a tool that can be used to help the disabled complete their daily tasks, such as eating, dressing, walking or controlling the environment, learning, working, or engaging in leisure activities.[1] In the public law PL100–407 issued by the United States in 1988, AT was defined as, any project, equipment, or product system can be used to increase or improve the ability of the disabled, no matter purchased from shopping malls, or remade, or customized.[2–3]

AT tends to be divided into 2 major categories: low-tech and high-tech. Low-tech appliances tend to be simple, non-electric appliances, and thousands of low-tech AT appliances are effective for the disabled.[4] A study revealed that the correct use of AT tools by patients with dysfunctions can effectively improve their self-care ability.[5] Some studies have also revealed that the AT tools and assistive techniques for old people can assist them to overcome the dysfunction of action, hearing, visual acuity, mental dysfunction, and dysphagia, and are important means to postpone senility and maintain the self-care ability, as well as to improve the quality of life of the elderly.[6–7] Therefore, the wide use of assistive equipment is very important for young people with dysfunction or the aged who have lower self-care abilities.

The 180° rotating feeding spoon is a low-tech assistive tool. When patients with upper extremity dyskinesia eat using this spoon, the angle of the spoon can be changed to achieve the purpose of self-care eating. Through a year of clinical applications, the 180° rotating feeding spoon has played a very good role in improving the self-care eating of patients with upper limb dysfunction. The details are reported as follows.

1.1. Introduction of the assistive appliance

1.1.1. Introduction of the structure and function. The first screw hole was set at 1 end of the head of the 180° rotating feeding spoon. Upper and lower connecting pieces were set at 1 end of the spoon handle. The second screw hole was set on the upper connecting piece, while the third screw hole and a bolt were set on the lower connecting piece. These arrangements allowed the spoon head to be rotated on the spoon handle. The head of the spoon was adjusted to a proper angle, allowing users with upper

Editor: Jianxun Ding.

The authors have no conflicts of interest to disclose.

[a] Department of Rehabilitation, [b] Department of Surgery, [c] Department of Medicine, Jiangsu Taizhou People's Hospital, Taizhou, China.

[*] Correspondence: Jin-Xia Sun, Department of Rehabilitation, Jiangsu Taizhou People's Hospital, No. 210 Yingchun Road, Hailing District, Taizhou 225300, China (e-mail: jinxiasun_dr@163.com); Li-Fang Li, Department of Rehabilitation, Jiangsu Taizhou People's Hospital, No. 210 Yingchun Road, Hailing District, Taizhou 225300, China (e-mail: lifangli_dr@hainan.net).

Medicine (2019) 98:9(e14597)

Received: 12 February 2018 / Received in final form: 24 December 2018 / Accepted: 24 January 2019

http://dx.doi.org/10.1097/MD.0000000000014597

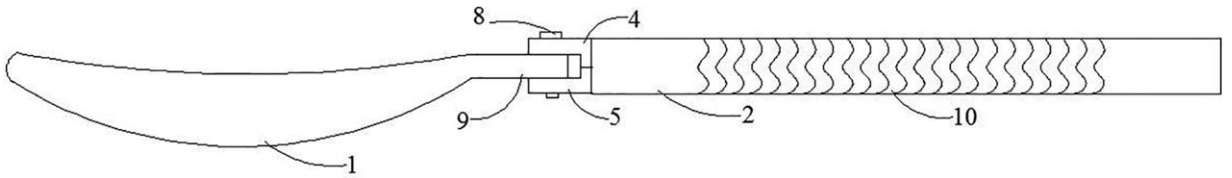

Figure 1. The structure of assistive appliance. 1. Spoon head 2. Spoon handle 4. On the connector 5. Under the connector 8. Bolt 9. Connected components 10. Non-slip texture.

extremity dyskinesia to expediently use it. The user can adjust the angle between the spoon head and spoon handle. Thus, the moving angle of the spoon handle and the user's mouth was reduced when the user holds the spoon handle, reducing the user's difficulty (Fig. 1).

1.1.2. Achievement introduction. The 180° rotating feeding spoon was applied for a patent of utility models to the State Intellectual Property Office of The People's Republic of China on July 18, 2016 (Patent number: ZL 201620754871.7).

1.1.3. How to use the spoon. The patient took a seat and held the spoon in the hand with a motor dysfunction. The person with difficulty in grasping the hand could fix the spoon handle in the palm of the hand with a fixing strap. According to the flexion range of the elbow and the stability of the shoulder joint, the angle between the spoon head and the spoon handle was adjusted, and the angle of the spoon head was used to facilitate the food entering into the mouth.

1.1.4. The advantages of spoon design

1.1.4.1. Spoon head volume was designed according to the safety of adults (<30 mL). According to the evaluation of clinical safe oral intake of patients with dysphagia, the volume of safe feeding spoon suitable for patients was selected.

1.1.4.2. Spoon head shape: the spoon head length is long, and the spoon head width is narrow. Food in this shape easily enters the mouth cavity and reaches the tongue root.

1.1.4.3. Rotating axis. According to the horizontal rotation design of the spoon, the rotating angle of the spoon in clockwise direction and counterclockwise direction is $0 \sim 90$. This design can satisfy the grip of the patient's left or right hand.

1.1.5. Spoon handle. According to the design for comfort of patient when gripping, the design of 12 cm to 15 cm in length can reduce the discomfort of the hemiplegic hand grip; the design of 1.0 cm to 1.5 cm in width, 0.6 cm to 1.0 cm in thickness and anti-skid lines on the spoon handle can increase the grip firmness of the patient.

2. Material and methods

2.1. Basic information

From January 2017 to July 2017, 58 stroke patients suffering from hemiparesis involving the upper limb, who was admitted to our department, were enrolled in this study. Among these patients, 38 patients were male and 20 patients were female. The average age of these patients was 67.36 years old. The course of the disease ranged within 0.5 to 31.5 months. In addition, 12 brain trauma patients with limb activity disorder were enrolled in this study. Among these patients, 8 patients were male and 4 patients were female. The average age of these patients was 56.54 years old. The course of disease ranged within 1.0 to 25.60 months. This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of our hospital. Written informed consent was obtained from all patients.

2.2. Selection criteria

Inclusion criteria:

(1) patients who met the "Diagnostic Key Points of Various Cerebrovascular Diseases" established at the Fourth Academic Conference of National Cerebral Vascular Disease in 1995, and confirmed with cerebral infarction or cerebral hemorrhage by computed tomography (CT) or magnetic resonance imaging (MRI);
(2) patients with dysfunction of the upper limbs induced by brain trauma;
(3) patients with stable conditions, and a sitting balance of ≥grade 2;
(4) patients who have a lucid mental state and could undergo daily language communication;
(5) patients with a basic activity of daily living (BADL) score (as assessed through the Barthel index [BI]) of <10 points, and >5 points.

Exclusion criteria:

(1) patients with severe organ diseases and complications;
(2) patients with mental disorder or poor mental ability, or cognitive dysfunction;
(3) patients who had unstable conditions, and could not sit or undergo oral feeding;
(4) patients whose upper limbs needed absolute immobilization.

2.3. Evaluation methods

The Brunnstrom technique referred to the method of using coordinated motion and other pathological motion patterns and reflection patterns as an accelerating method in the initial stage of damage of the central nervous system, and then gradually modifying these motion patterns into functional motions to restore motor control ability. Brunnstrom's 6-stage theory of hemiplegia in stroke recovery could reflect the degree of recovery of motor function.

The Brunnstrom 6-stage rating of hemiplegia was applied to patients who were included in the present study, in order to determine their recovery stage of the upper limbs. Then, these patients orally ate using a feeding spoon with a non-rotatory head and a 180° rotating feeding spoon, their ability to eat by themselves was observed, and the BADL score was assessed using the BI.

2.3.1. Brunnstrom rating method (examination of the upper limbs).

The patient was placed in a sitting position. Then, the passive motion and speed of the upper limb were examined (Table 1).

2.4. Data acquisition

The participants were evaluated by 2 rehabilitation physicians and 2 rehabilitation nurses who had been uniformly trained. At the same time point, the assessment of the same patient was performed by a rehabilitation physician and a rehabilitation nurse. Then, within that day, the patient was assessed by another rehabilitation physician and rehabilitation nurse. The methods and contents of the assessment were consistent with the previous one. At different periods of time, the assessment of the same patient was performed by the rehabilitation physician and rehabilitation nurse who performed the first assessment.

2.5. Statistical analysis

Data were analyzed using statistical software SPSS 19.0. The reliability tests included the following:

(1) the inter-rater reliability of different groups (1 group consisted of a rehabilitation physician and a rehabilitation nurse) of evaluators for the same patient at the same time point;

Table 1

Examination of the upper limbs.

Stage	Performance
I	Involuntary movement (soft palsy stage)
II	The appearance of synkinesis or its composition (spasms appear) (1) Synkinesis of musculus flexor; (2) Synkinesis of musculus extensor
III	Optional synkinesis or its composition: Synkinesis of musculus flexor: Shoulder girdle-lifting, retraction; Shoulder joint-retraction, abduction, external rotation; Elbow joint-flexion; Forearm-supination Synkinesis of musculus extensor: Shoulder joint-pectoralis major (anterior flexion, adduction, and internal rotation); Elbow joint-extension; Forearm-pronation
IV	A movement out of the basic synkinesis (a little reduction in spasm): Hand in the back of the waist; Horizontal forward flexion of the upper limb (elbow extension, and forward flexion of the shoulder by 90°); Forearm pronation (elbow flexion at 90°) and supination (elbow flexion at 90°)
V	From the basic common movement to the independent movement (spasm reduction): Horizontal abduction of the upper limb (elbow extension, and abduction of the shoulder by 90°); Upper limb lifting over the head (elbow extension, and forward flexion of the shoulder by 180°)
VI	Generally normal in coordination movement (mild spasm): How many times can you do it in 5 seconds? Horizontal abduction of the arms; Arms upward over the head; Elbow extension pronation; Elbow extension supination

(2) the inter-rater reliability of the same group of evaluators for the same patient at the same time point;
(3) the re-test reliability (presented as intraclass correlation coefficient [ICC]) of the same evaluator for the same patient at different time-points;
(4) the inter-test reliability of the same evaluator for the same parameter in the same patient at the same time-point.

The results on whether these patients could independently eat while using a spoon without a rotatory head and while using a 180° rotating feeding spoon at different Brunnstrom stages were evaluated using *t* test (measurement data) or X^2-test (count data), and the criterion validity was tested. The Brunnstrom staging results were analyzed using logistic regression (Wald X^2) analysis on the results about whether the patient could independently eat while using a 180° rotating feeding spoon, and its predictive validity was determined.

3. Results

3.1. Analysis of inter-rater reliability

The reliability of evaluators in different groups for the same patient in the same time-point was 0.90 ($P<.01$). The reliability of the same patient in the same time-point between evaluators in the same group was 0.89 ($P<.01$). These results were highly homogenous.

3.2. Analysis of retest reliability

The situation that the same patient orally ate using a feeding spoon with a non-rotatory head and a 180° rotating feeding spoon was assessed twice by the same evaluator using the Brunnstrom assessment scale, and the results were analyzed. The results revealed that the 2 assessments were highly correlated: the ICC was 0.93 ($P<.01$) in patients who ate using a feeding spoon with a non-rotatory head, while the ICC was 0.91 ($P<.01$) in patients who ate using a 180° rotating feeding spoon.

3.3. Analysis of the criterion validity test

The patient's upper limb function was examined using the Brunnstrom assessment scale. The results revealed that for patients with grades I and II of upper limb function, the difference in the ability of patients to eat by themselves using a feeding spoon with a non-rotatory head and using a 180° rotating feeding spoon was not statistically significant ($P>.05$). In patients with grade III of upper limb dysfunction, the difference in the ability of patients to eat by themselves using a feeding spoon with a non-rotatory head and using a 180° rotating feeding spoon was statistically significant ($P<.01$). In patients with grade IV of upper limb dysfunction, the difference in the ability of patients to eat by themselves using a feeding spoon with a non-rotatory head and using a 180° rotating feeding spoon was statistically significant ($P<.05$). In patients with grade V or VI of upper limb function, the difference in the ability of patients to eat by themselves using a feeding spoon with a nonrotatory head and using a 180° rotating feeding spoon was not statistically significant ($P>.05$).

3.4. Predictive validity

Prediction for independent eating: the Brunnstrom staging results were analyzed using logistic regression (Wald X^2) analysis on the

results about whether the patient could independently eat while using a 180° rotating feeding spoon. The Wald X^2-value was 8.782, and the accuracy rate was 83.4%. This suggests that the scale has a certain predictive value for the independent feeding results of patients while using the 180° rotating feeding spoon.

4. Discussion

AT is a rapidly growing field. Knowledge in the field of AT continues to grow and become up to date, which sometimes goes based on a day.[8–9] The wide application of assistive appliances can protect the safety of nursing staff, improve the efficiency of nursing, maintain their dignity, and maintain the dignity and safety of the patients, and postpone the inability process.[10] New technologies, new researches and the increasing popularity of assistive appliances and services have improved the ability of the disabled to live and work, making a great contribution.

A clinical study was performed on 70 patients with upper limb dyskinesia caused by brain damage. The ability of patients to eat by themselves using a feeding spoon with a non-rotatory head and using a 180° rotating feeding spoon in different recovery periods of the upper limb function was compared. The results revealed that 20 patients (28.57%) had grades I and II of upper limb function (as assessed by the Brunnstrom assessment scale). In these patients, the difference in the ability to eat by themselves using a feeding spoon with a non-rotatory head and using a 180° rotating feeding spoon was not statistically significant ($P > .05$). This revealed that when the function of the upper limb has not reached the grades of separation movement or that the elbow joint cannot flex, the patients could not move independently, while when assisted by the 180° rotating feeding spoon, there was no difference from eating results, compared to using a feeding spoon with a nonrotatory head,

Among these 70 patients, 21 patients (30%) had grade III of upper limb function. When these patients with grade III of upper limb function ate using a 180° rotating feeding spoon, 16 patients (76.19%) were able to eat independently, and 5 patients (23.81%) were not able to be completely independent. The poor stability of the shoulder joint and small elbow flexion range were the main causes. Furthermore, the independent eating process could not be completed even if the angle between the spoon body and the head of the spoon was 90°. When patients with grade III of upper limb function ate using a feeding spoon with a non-rotatory head, 3 patients (14.28%) were able to eat independently, while 18 patients (85.71%) were not able to eat independently. The poor stability of the shoulder joint and the elbow flexion range of <90° were the main causes. Furthermore, the independent eating process could not be completed even if the torso and head of the patients leaned forward. It was also revealed by the data that the 180° rotating feeding spoon has clinical significance in improving the BADL of patients ($P < .01$).

Among these 70 patients, 19 patients (27.14%) had grade IV of upper limb function. When patients with grade IV of upper limb function ate using the 180° rotating feeding spoon, 19 patients (100%) were able to eat independently. When these patients ate using a feeding spoon with a non-rotatory head, 13 patients (68.42%) were able to eat independently. Among these 13 patients, 8 patients completed eating with the aid of the flexion of the upper part of the body and anteversion of the head. In addition, the time of eating (average: 25.6 min) was longer than that (15.8 min) using the 180° rotating feeding spoon.

Among these 70 patients, 10 patients (14.28%) had grade V or VI of upper limb function. When these 10 patients orally ate using the 180° rotating feeding spoon, 10 patients (100%) were able to eat independently. When these patients ate using a feeding spoon with a nonrotatory head, 10 patients (100%) were able to eat independently. These results revealed that in patients with grade V or VI of upper limb function, the function of the upper limbs has reached a level that allows them to independently eat. The difference in the ability to eat using a 180° rotating feeding spoon and using a feeding spoon with a non-rotatory head was not statistically significant ($P > .05$).

A large number of clinical data have verified many times that assistive appliances can effectively improve the life self-care ability for patients with dysfunction, allowing such a special population to have a better chance to return society. With the development of electronic information, more and more high-intelligent rehabilitation assistive appliances have also been constantly developed. For example, in the field of computer-aided technology, a large number of multimedia software products have been widely used in hospitals and families in the 1990s, computer-aided training and treatment have been carried out, and ideal effects were achieved.[11–14] On the basis of rehabilitation medicine, a rehabilitation robot applies advanced robotic technology to provide better service for the rehabilitation requirements of the disabled and the elderly. This has become a research hotspot in the field of international robotics.

The goal of any AT assessment is to determine whether the person who accepts the service has the potential and desire, and can benefit from assistive appliances and services in the family, school, work, or entertainment. In particular, the application of assistive appliance adaptation assessment is an important link to guarantee the quality of service of an assistive device and is the basis of work of assistive appliance services. The service of assistive appliances is a systematic work, which requires interdisciplinary and multi-disciplinary team cooperation.[15–16] However, it is a challenge to evaluate the effects of assistive appliances on patients with dysfunction. The field itself is a multidisciplinary study field, which includes medicine, rehabilitation, psychology, education, engineering, and biotechnology, and involves in physical, cognitive, social-mental, sensory and physiological effects. Therefore, it also reflects some limitations of the present study. How to improve the comfort and self-care ability of patients with upper extremity dyskinesia to use an assistive device from the perspective of multiple disciplines, and how to measure its effect and where the effect would be recorded, these need to be further explored in clinical practice. Whether the 180° rotating feeding spoon can be widely used in the clinic, it also needs to be verified by a larger sample size. Hence, this work needs to be continued, in order to endeavor and perfect our rehabilitation care.

Author contributions

Conceptualization: Jin-Xia Sun.
Data curation: Yu-Long Zhao.
Formal analysis: Li-Fang Li.
Methodology: Li-Fang Li.
Project administration: Jin-Xia Sun.
Resources: Gui-Wei Lu.
Writing - original draft: Jin-Xia Sun.
Writing - review & editing: Jin-Xia Sun.

References

[1] Frontera WR, Jette A, Carter GT, et al. DeLisa physical Medicine & Rehabilitation principles and practice. 5th edition. Beijing, China: People's Medical Publishing House; 2013. 1537–1538.

[2] Congress of the U.S, Washington, DC. House Committee on Education and Labor. Technology-Related Assistance for Individuals with Disabilities Act of 1988. Report. House of Representatives, 100th Congress, 2nd Session. Washington, USA, 1988.
[3] Stover SL, DeVivo MJ, Go Bk. History, implementation, and current status of the National Spinal Cord Injury Database. Arch Phys Med Rehabil 1999;80:1365–71.
[4] Organization WH. International perspectives on spinal cord injury. Weed Res 2013;11:314–6.
[5] Manack A, Motsko SP, Haag-Molkenteller C, et al. Epidemiology and healthcare utilization of neurogenic bladder patients in a US claims database. Neurourol Urodyn 2011;30:395–401.
[6] Leuty V, Boger J, Young L, et al. Engaging older adults with dementia in creative occupations using artificially intelligent assistive technology. Assist Technol 2013;25:72–9.
[7] Kricos PB. Hearing assistive technology considerations for older individuals with dual sensory loss. Trends Amplif 2007;11: 273–9.
[8] Scherer MJ. Living in the State of Stuck: How Technology Impacts the Lives of Persons with Disabilities. 3rd edition. Cambridge, MA: Brookline Books; 2000.
[9] Phillips B, Zhao H. Predictors of assistive technology abandonment. Assist Technol 1993;5:36–45.
[10] Mortenson WB, Demers L, Fuhrer MJ, et al. Effects of an assistive technology intervention on older adults with disabilities and their informal caregivers: an exploratory randomized controlled trial. Am J Phys Med Rehabil 2013;92:297–306.
[11] Lima-Silva TB, Ordonez TN, Dos Santos GD, et al. Effects of cognitive training based on metamemory and mental images. Dement Neuropsychol 2010;4:114–9.
[12] Dichgans M, Markus HS, Salloway S, et al. Donepezil in patients with subcortical vascular cognitive impairment: a randomized double-blind trial in CADASIL. Lancet Neurol 2008;7:310–8.
[13] Berg A, Sadowski K, Beyrodt M, et al. Snoezelen, structured reminiscence therapy and 10-minutes activation in long term care residents with dementia (WISDE): study protocol of a cluster randomized controlled trial. BMC Geriatr 2010;10:5–11.
[14] Mitchell AJ. A meta-analysis of the accuracy of the mini-mental state examination in the detection of dementia and mild cognitive impairment. J Psychiatr Res 2009;43:411–31.
[15] Gramstad A, Storli SL, Hamran T. Older individuals' experiences during the assistive technology device service delivery process. Scand J Occup Ther 2014;21:305–12.
[16] Gramstad A, Storli SL, Hamran T. Exploring the meaning of a new assistive technology device for older individuals. Disabil Rehabil Assist Technol 2014;9:493–8.