

ORIGINAL ARTICLE

# Effect of a home telecare program on oral health among adults with tetraplegia: a pilot study

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**Study design:** one group pre- and post-test design.

**Objectives:** The primary aim was to examine both the short- and long-term effects of an oral home telecare program on improving gingival health among adults with tetraplegia.

**Methods:** Eight adults with tetraplegia participated. The oral home telecare program consisted of individualized oral hygiene training in the use of assistive devices (powered toothbrush and adapted flosser and/or oral irrigator) using personal computer-based videoconferencing between each participant and an occupational therapist. Training was conducted on an average of five 15–30 min sessions across 3 months. During these training sessions, supervised practice of oral hygiene, and provision of immediate corrective feedback and positive reinforcement in the use of adaptive oral hygiene devices was emphasized. Gingival health assessment using the Löe-Silness gingival index (LSGI) was conducted at baseline, 6 and 12 months.

**Results:** From baseline to 6 months, participants showed statistically significant differences (that is, improvement with less gingival inflammation) in their LSGI scores ( $z=2.18$ ,  $P=.03$ ). From baseline to 12 months, participants also showed a statistically significant difference (that is, improvement,  $z=2.03$ ;  $P=0.04$ ) in their LSGI scores.

**Conclusion:** This study indicates that preventive oral home telecare with repeated oral hygiene training in the use of adaptive devices improved gingival health at 6 and 12 months among adults with tetraplegia.

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**Keywords:** oral hygiene; adaptive devices; teledentistry; dental health education; tetraplegia; telemedicine

## INTRODUCTION

People with tetraplegia tend to have more dental plaque and gingival inflammation due to impaired manual dexterity, which interferes with performing oral hygiene.<sup>1,2</sup> They are less likely to floss their teeth and brush twice daily, when compared with able-bodied controls.<sup>2</sup> Many have difficulty handling a regular toothbrush and are unable to manipulate regular dental floss to clean their teeth.<sup>3</sup> The combination of poor oral hygiene performance, dry mouth from xerostomia-causing medications (commonly used to reduce muscle spasms and to regulate neurogenic bladder) and limited wheelchair accessibility to dental offices for routine preventive care increases the likelihood of dental caries and periodontal disease.<sup>3–5</sup> Preserving the teeth is critical for members of this population as they often use their teeth to assist in various daily activities.<sup>6</sup>

Adaptive oral hygiene devices may assist people with tetraplegia to improve their oral health.<sup>7</sup> However, teaching people with tetraplegia to be proficient in using oral hygiene devices and motivating them to establish regular oral hygiene routine requires repeated, supervised practice accompanied by provision of corrective feedback and positive reinforcement.<sup>8–12</sup> Such intense coaching also requires face-to-face interaction between the patient and the health care provider. Nevertheless, one-time, individual, in-person oral hygiene instruction by dental professionals, conducted at the dental office, has been shown to be insufficient for long-term maintenance of behavior change regarding oral home care.<sup>13,14</sup> Thus, an innovative

way to improve and maintain proper oral home care on a long-term basis among this population is critical.

The expansion of technological delivery of health care (including oral health) to patients in their homes is increasingly feasible, because of reduced costs in technology and the expanding use of high-speed Internet, which enables training and monitoring of self-care activities, such as oral hygiene, to be conducted in patients' homes via videoconferencing (that is, teledentistry).<sup>15</sup> The face-to-face interaction without limitation of travel distance and available professional personnel as in-home visits is a unique feature of telecare.<sup>16</sup> A feasibility study using a personal computer-based videoconferencing as a mode of delivering oral hygiene training in the use of assistive devices was successfully tested on two community-dwelling women with tetraplegia.<sup>17</sup> Extending this feasibility study, the aim of the present trial was to evaluate the efficacy of using videoconferencing to deliver oral hygiene training in the use of assistive devices to improve gingival health among people with tetraplegia, and to explore their oral home telecare experience.

## MATERIALS AND METHODS

### Participants

For adults to be eligible for participation in the study, the following inclusion criteria had to be met: (1) Experienced a traumatic spinal cord injury resulting in quadriplegia that occurred at least 1 year before the date of enrollment; (2) Aged  $\geq 19$  years; (3) Living in the community; (4) Some arm and shoulder

movement; able to hold a manual toothbrush with aid of a universal cuff to brush teeth; (5) Had difficulty in manipulating a manual toothbrush to perform oral hygiene; (6) Had high-speed Internet (such as cable or digital subscriber line) available at home or in the resident's neighborhood area; (7) Oriented to time, place, person and situation; and (8) Able to provide informed consent.

The exclusion criteria were: (1) Dual diagnosis of brain injury with documented moderate to severe cognitive impairment; (2) Severe visual, hearing or expressive or receptive communication impairments that impeded interaction with the therapist during videoconferencing; (3) No impairment in hands and finger movement; (4) Dependent on caregiver or attendant to perform oral hygiene; (5) Use of a rechargeable, oscillating-rotating-pulsating powered toothbrush; (6) Had fewer than 15 natural teeth; (7) Generalized severe periodontal disease (more than 30% of the sites had pocket depth >7 mm) or non-restorable caries lesions in more than 30% of the teeth; (8) Had fixed orthodontic or removable prosthodontic appliances; (9) Required prophylactic antibiotic premedication before dental treatment; (10) Received active periodontal therapy or preventive oral prophylaxis within the previous 3 months; (11) History of uncontrolled or poorly controlled diabetes mellitus; and (12) Used corticosteroid/steroids within the previous month.

### Recruitment

Mailing addresses and phone numbers of adults with tetraplegia in Alabama, whose residential addresses were estimated to be within 1.5 h driving distance from the University of Alabama at Birmingham where the dental assessment was conducted, were obtained from the database of the University of Alabama at Birmingham spinal cord injury model system. Three hundred and sixty invitation letters were sent to these adults with tetraplegia (that is, American Spinal Injuries Association Impairment Scale of A, B, C or D; Frankel grade of A, B, C or D; or complete, incomplete or minimal deficit between C3-T1 levels). Details of recruitment process are included in Figure 1. The protocol was approved by the Institutional Review Board of the University of Alabama at Birmingham.

### Procedures

One to two days before the study appointment at the university research dental clinic, potential participants were informed not to perform any oral self-care procedures, nor to use chewing gum the evening and morning before the appointment. Baseline evaluation included a dental assessment, completion of a questionnaire regarding socio-demographic background, brief medical history and oral health behaviors, and participants' demonstration of their normal toothbrushing routine done at home. All potential participants who met the study criteria and chose to participate received a dental scaling and prophylaxis following the baseline dental assessment, which was conducted by a dental hygienist. The dental hygienist/examiner had been trained and calibrated to conduct periodontal examinations.

After dental cleaning, participants received a rechargeable, powered Oral-B oscillating-rotating-pulsating toothbrush (with brushing time display, <http://www.oralb.com/products/professional-care-smart-series-4000/>), a Reach Access Flosser (<http://www.reachbrand.com/our-floss>) and a Waterpik Cordless Water Flosser (<http://www.waterpik-store.com/detail/WAT+WP-450>), as well as a universal holder ([http://www.pattersonmedical.com/app.aspx?cmd=getProductDetail&key=070\\_921020224](http://www.pattersonmedical.com/app.aspx?cmd=getProductDetail&key=070_921020224)), if necessary, so that the oral hygiene device could be fastened onto their hand. In addition, each participant received two tubes of fluoride toothpaste. The dental hygienist explained the various features of each device, instructed the participants on the proper way to operate the devices, and provided a brief oral hygiene instruction. Participants were required to demonstrate the use of the devices, and instructed to brush their teeth (timing for 2 min) twice daily, and to clean the interdental space at least once daily. In addition, a web camera was provided to those participants whose computer did not have a camera attached to the monitor. Participants were informed that they would receive another dental scaling and prophylaxis at the completion of the study, to reduce the likelihood that they would have their teeth professionally cleaned immediately before the 12 month dental assessment.

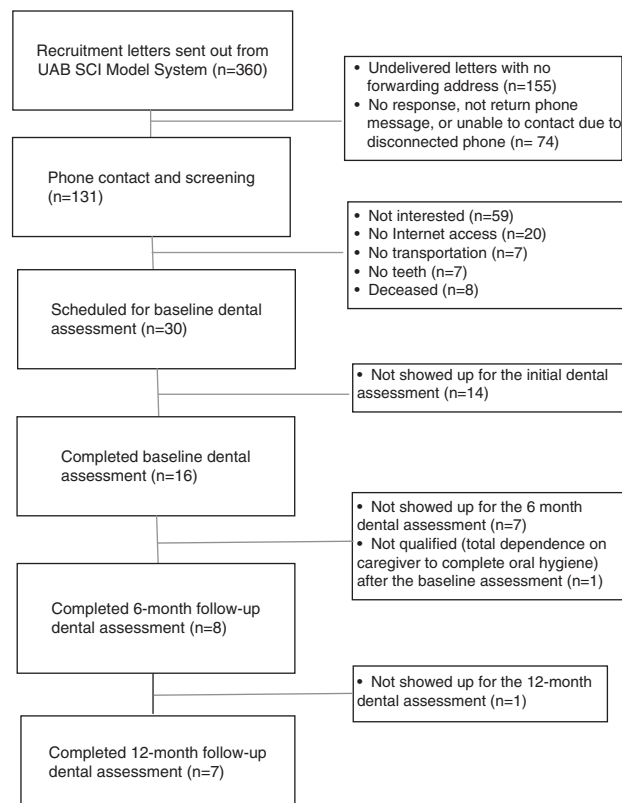


Figure 1 Recruitment flow chart.

### Oral hygiene training in the use of adaptive device via videoconferencing

Videoconferencing was conducted using SCOPIA Desktop, which is centrally managed by the University of Alabama at Birmingham. SCOPIA is designed for conducting videoconferencing with a standard personal computer and high-speed internet connection. The research coordinator e-mailed participants a web link to the SCOPIA site. After installation of the program onto their personal computer, participants simply clicked on the web link and entered a password to join the meeting. With the picture-in-picture configuration feature of SCOPIA, the participant can see the meeting party on the primary screen, and himself/herself on the secondary nested screen, which serves as a mirror to complete oral hygiene while videoconferencing with the therapist. The research coordinator tested the quality of the connection by making a videoconferencing call to the participants' home, and provided a brief orientation of the essential icons and buttons for testing the following devices: speaker, microphone and camera.

The time and day of the week for videoconferencing between the participant and the occupational therapist was determined by the participant. The therapist has been working in an in-patient spinal cord injury rehabilitation unit for 4 years. Her role in the unit included conducting assessment and intervention related to activities of daily living including oral hygiene. In addition, the therapist received 2 h training to familiarize her with the content of the videoconferencing session protocol. Videoconferencing was conducted mainly in the evening or on the weekend, as half the participants and the occupational therapist worked full-time. The therapist conducted the videoconferencing from her home office.

Typically, five sessions were conducted across 12 weeks or 3 months: the first two sessions were conducted weekly, the next two sessions conducted every third week (at weeks 5 and 8), and a final session at week 12. Depending on the progress of individual participants, flexibility in the number and spacing of sessions was allowed. The first two sessions lasted about 30 min, and each subsequent session lasted about 15 min. Following a protocol guide, the

occupational therapist reviewed and enforced the oral hygiene instruction given by the research dental hygienist during the first two sessions. The therapist used various teaching principles in an effort to enhance participants' adherence to the oral hygiene routine, which included demonstration, return demonstration, repeated corrective feedback and positive reinforcement on the proper use of different adaptive devices to perform oral hygiene. Through the involvement in problem-solving with the therapist, the participant came up with strategies to address difficulties encountered in using the devices. Because of considerable variability in upper extremity movement control and secondary conditions among participants, which included manual dexterity impairment, pain and fatigue, specific strategies were individualized to meet participants' needs. Modification of the oral hygiene activity set up at home, and sometimes acquisition of an alternative interdental cleaning device were continued throughout the first two to three sessions to ensure optimum independence in device use to complete the oral hygiene routine. During the next two to three sessions, the therapist suggested various motivational strategies such as self-talk,<sup>18</sup> and assisted the participants in developing goals for the development of new oral hygiene habits and plans to sustain them.

### Outcome measures

The Löe-Silness gingival index (LSGI) was used as the primary outcome measure to estimate different degrees of inflammation in marginal gingiva.<sup>19</sup> The gingival tissues surrounding each natural tooth were divided into four areas for scoring: mesial, distal, buccal and lingual. Each area was scored for gingivitis on a 0–3 ordinal scale according to the following criteria: 0 = normal gingiva, 1 = mild inflammation, 2 = moderate inflammation and 3 = severe inflammation. The LSGI scores were collected from a maximum of 28 teeth in each participant (third molars excluded). A mean LSGI score for the whole mouth was calculated by taking the average of scores on the four areas of each natural tooth by the number of the teeth that the participant had, excluding third molars. Secondary outcome measures included the frequency of daily oral hygiene behaviors and toothbrushing time.

At the end of all videoconferencing sessions with the occupational therapist (that is, at 3 months), participants completed a 21-item questionnaire, the oral home telecare questionnaire (OHTQ),<sup>17</sup> which was adapted from the telemedicine satisfaction and usefulness questionnaire and the telemedicine perception questionnaire.<sup>20,21</sup> The internal consistency reliability of the OHTQ in the present study estimated by Cronbach's alpha was 0.87, which is considered to be very good.<sup>22</sup> The OHTQ assessed participants' satisfaction with the quality of oral care and interaction with the therapist via videoconferencing and perceptions about the mode of service delivery (for example, acceptance of the technology, effective use of the oral care devices). Each item was rated on a five-point, Likert-type scale ranging from 1 = strongly disagree, to 5 = strongly agree, with a higher score indicating greater satisfaction and a more positive perception of the oral home telecare experience. Three questions were worded negatively.

In addition, participants were interviewed to explore their interpretation of lived experience using videoconference communication with the therapist in regard to oral hygiene training. The interview was designed to elicit feedback from participants regarding their perceptions of the oral home telecare service and recommendations for improving it. The purpose of the interview was to capture outcomes that could not be measured by standardized quantitative outcome measures, and that could not be anticipated at the beginning of the study.

### Six and 12 months evaluations

The research coordinator called participants 1–2 days before each follow-up evaluation to request that they refrained from oral hygiene practices as they did before the baseline evaluation. At each follow-up evaluation, the dental assessment and participants' toothbrushing demonstration were exactly the same as that in baseline evaluation, which was conducted by the same dental hygienist. Participants' current oral hygiene routine at each follow-up visit was recorded. At the 6 months evaluation, the dental hygiene products and device parts were replenished.

### Data analysis

Due to the small sample size and because the LSGI scores did not meet the assumptions of normality, a non-parametric Wilcoxon signed-ranks test (two-sided at  $\alpha = 0.05$ ) was performed to test the following hypotheses: Compared with baseline data, participants will show differences in their LSGI scores at the 6 and 12 months follow-up dental assessments. All analyses were performed using IBM SPSS Statistics for Windows, version 20 (www.spss.com).

### RESULTS

Of the 30 potential participants scheduled for baseline dental assessment, 14 did not show up for the appointment and 16 completed the baseline assessment. Of the 16 participants who completed the baseline evaluation, one was not qualified owing to total dependence on his caregiver to complete oral hygiene and not willing to be more independent in performing oral hygiene, and 8 (7 males and 1 female) returned for the 6 months dental assessment. In addition, the female participant did not return for her 12 months appointment; as a result, 7 completed the 12 months dental assessment. Reasons for participants not completing the follow-up dental assessments included admission to a rehabilitation center, presence of decubitus ulcers, recuperating from surgery, moved out of state, repeatedly missed rescheduled appointments, no transportation to accommodate an electric wheelchair, no reply after multiple attempts to contact, and the spouse who provided transportation was no longer interested in participation.

The mean, s.d. and median age of the eight participants were as follows:  $49 \pm 11$  years, 50 years, respectively, ranging 32–60 years. The mean, s.d., median years since spinal cord injury of the eight participants were as follows:  $17 \pm 12$  and 16, respectively, ranging 3–36. Five sustained their injury at the level of C5 and two at C4 and one at C6. In terms of neurologic completeness, five were classified as American Spinal Injuries Association Impairment Scale A, and three were American Spinal Injuries Association Impairment Scale D. Six were white and two were black. The majority of them ( $n = 7$ ) had received education beyond high school, and ( $n = 5$ ) had an annual household income of less than US\$45 000; half of the participants ( $n = 4$ ) worked full-time. Only the female participant had private dental insurance.

In terms of oral health, four participants had at least one decayed tooth (up to 4). The means  $\pm$  s.d. and medians of the LSGI scores at baseline, 6 and 12 months were as follows:  $1.25 \pm 0.47$ , 1.11 ( $n = 8$ ),  $1.03 \pm 0.52$ , 1.05 ( $n = 8$ ),  $1.2 \pm 0.47$ , 1.07 ( $n = 7$ ). From baseline to 6 months, a statistically significant difference was observed (that is, improvement with less gingival inflammation) in LSGI scores ( $z = 2.18$ ,  $P = 0.03$ ). For the whole study period (baseline to 12 months), a statistically significant difference was also observed ( $z = 2.03$ ;  $P = 0.04$ ) on LSGI scores. The mean  $\pm$  s.d and median improvement (reduction) in LSGI score from baseline at 6 months was  $0.22 \pm 0.28$  and median = 0.13; whereas, at 12 months (based on data of  $n = 7$ ), it was  $0.12 \pm 0.13$ , and median = 0.09.

In terms of oral hygiene behaviors, Table 1 shows an increase in frequency of daily toothbrushing, dental flossing and the use of an oral irrigator 6 months from baseline, and the same frequency of oral hygiene was maintained at 12 months. At 6 months, only one participant did not brush his teeth twice daily because no caregiver was available to set it up for him in the morning. Also, only one participant did not floss daily because he preferred to use the oral irrigator twice daily instead. Participants not only brushed their teeth more often but longer during their oral hygiene routine; one even brushed 4–5 min. Five participants who brushed their teeth for about 1 min (mean = 62 s) at baseline brushed longer than the 2 min

**Table 1 Comparison of oral hygiene habits among baseline, 6 and 12 months follow-up**

Frequency	Baseline (n = 8)	6 months (n = 8)	12 months (n = 7)
<i>Brushing</i>			
2 times daily	4	7	6
1 time daily	3	1	1
Occasionally (<1 time daily)	1	0	0
<i>Flossing</i>			
2 times daily	0	1	1
1 time daily	1	6	5
Occasionally (<1 time daily)	3	0	0
Do not floss	4	1	1
<i>Oral irrigator</i>			
2 times daily	0	1	1
1 time daily	0	2	1
Occasionally (<1 time daily)	0	3	3
Do not use	8	2	2

recommended brushing time (means = 147 s and 230 s) at the 6 and 12 months follow-up, respectively, during the toothbrushing demonstration at the dental clinic.

After recoding three negatively worded items, the mean  $\pm$  s.d of each item in the OHTQ ranged from  $3.6 \pm 1.3$ – $4.8 \pm .5$  (see Table 2). In general, items associated with the technical problems of videoconferencing connection (that is, no.5, no.9, no.20) received the lowest satisfaction scores, and items associated with improvement in participants' oral health care using the oral home telecare (that is, no.6, no.8, no.18) received the highest satisfaction scores. Two themes emerged from the interviews — participants felt more aware of their oral health and participants made a more conscientious effort to perform their oral hygiene since starting the study.

## DISCUSSION

On the basis of the findings from this study, it appears that an average of five sessions of videoconferencing across three months of oral hygiene training in the use of adaptive oral hygiene devices increases participants' oral hygiene frequency, and leads to the establishment of long-term oral hygiene habits. Furthermore, the oral home telecare program, increase in oral hygiene frequency, and the use of adaptive device resulted in a significant reduction of gingival inflammation. Findings of this study are consistent with improvements in oral home care skills and oral hygiene indicators (that is, plaque score) of four community-dwelling elderly men with brain damage in a pilot oral home telecare study, conducted in Japan, which incorporated oral care education with general health care via videophone for an average of 11 weeks of weekly 30 min' videoconferencing intervention.<sup>23</sup>

The improvement in LSGI scores at 6 months was 17.6%, which is within the recommended 15–20% from the American Dental Association to be clinically significant.<sup>24</sup> The overall improvement in LSGI scores at 12 months was about 9%. This study indicates that preventive oral home telecare (including the use of powered toothbrush and adapted flosser and/or oral irrigator) and repeated oral hygiene training in the use of adaptive devices improves gingival

**Table 2 Results of the oral home telecare questionnaire**

Item no.	Item	Mean $\pm$ s.d.
9	I can always trust the videoconferencing equipment to work.	3.6 $\pm$ 1.3
5	Video visits are a convenient form of dental health care for me.	3.8 $\pm$ 1.0
20	There were technical problems that made it difficult for me to hear or see the therapist.	3.8 $\pm$ 1.0 <sup>a</sup>
1	The therapist can get a good understanding of my oral hygiene condition over the videoconferencing.	3.9 $\pm$ .6
7	The home telecare helps me to better manage my oral health needs.	4.0 $\pm$ .8
14	Using videoconferencing the therapist will be able to monitor my oral health condition well.	4.0 $\pm$ .5
11	The use of the videoconferencing equipment seems difficult to me.	4.1 $\pm$ .4 <sup>a</sup>
16	I would recommend oral home telecare to a friend.	4.1 $\pm$ .6
17	I got enough information via oral home telecare to perform oral hygiene.	4.1 $\pm$ .4
21	I felt comfortable with the videoconferencing equipment used relative to in-person.	4.1 $\pm$ .4
2	I can explain my mouth and tooth care problems well enough during a video visit.	4.3 $\pm$ .5
12	I can be as satisfied talking to the therapist over videoconferencing as talking in-person.	4.3 $\pm$ .5
3	The lack of physical contact during a video visit is not a problem.	4.4 $\pm$ 1.1
13	Oral home telecare can save my time for visiting the therapist.	4.4 $\pm$ .9
4	Video visits make it easier for me to contact the therapist.	4.5 $\pm$ .5
15	I would be willing to use oral home telecare again.	4.5 $\pm$ .5
19	I feel more control over my oral health care since using oral home telecare.	4.5 $\pm$ .8
6	I am more involved in my oral health care since using home telecare.	4.6 $\pm$ .7
18	I have become more active in my oral health care since using oral home telecare.	4.6 $\pm$ .5
8	My oral health is better than it was before I joined the home telecare.	4.8 $\pm$ .5
10	Oral home telecare violates my privacy.	4.8 $\pm$ .5 <sup>a</sup>

Note: Each item was rated on a 5-point Likert-type scale, where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree.

<sup>a</sup>Items are worded negatively and had been recoded.

health at 6 and 12 months among adults with tetraplegia. Because of the upper extremity motor control impairments among adults with tetraplegia, even adherence to the recommended personal oral hygiene routine may not be sufficient to maintain gingival health in the long run without annual professional dental cleaning.

As indicated in the literature, a single oral hygiene instruction is not sufficient for long-term maintenance of behavior change regarding oral home care.<sup>13,14,25</sup> Without the intense training from the occupational therapist provided over the videoconferencing, participants were unlikely to make a conscientious effort to complete the oral hygiene routine using the devices provided (with appropriate adaptation) and adhere to the recommended daily oral hygiene frequency and duration on such a long-term. Participants appreciated the opportunity to participate in the study, and indicated that, through this study, their oral hygiene awareness was not only

heightened, but they were also assisted in the establishment of a new long-term oral hygiene routine. Three participants plan to purchase dental insurance at the next open enrollment period in their work place, which makes it more likely that they will have their teeth professionally cleaned on an annual basis (as public health insurance such as Medicaid does not cover dental visits).

Participants generally accepted the videoconferencing technology (for example, item no.15), were satisfied with the quality of oral care (for example, items no.7 and no.17), and the 'face-to-face' coaching and interaction with the occupational therapist via videoconferencing (for example, items no.12 and no.21) with few concerns about the loss of privacy as indicated by the very positive score of item no.10 of the OHTQ. Most participants indicated videoconferencing is more personal than teleconferencing, because they are able to see the therapist to whom they were talking. All participants were highly satisfied with their oral hygiene progress (for example, item no.8). Although participants rated the audio-visual aspect of the videoconferencing as adequate (for example, item no.20), inspection of the post-videoconferencing interview data with the participants and notes from the therapist taken during each session, indicated that most participants experienced one or more technical problems and/or interruption related to audio-visual connection either before or during the videoconferencing sessions. Several expressed frustration with the intermittent loss of connectivity and technical problems related to the videoconferencing during sessions, which included picture freeze-up, hearing, but not seeing the therapist or significant latency delay between video and audio input.

In the present study, 20 adults with tetraplegia who we contacted could not participate mainly due to the lack of high-speed internet service available in their home or neighborhood. Until a full penetration of high-speed internet service to more rural and remote areas, the use of in-home videoconferencing to deliver oral hygiene service (that is, teledentistry) is limited to only those with high-speed internet. Other problems related to oral home telecare using videoconferencing, which were identified in this study included lack of computer literacy in a number of participants, and the incompatibility of participants' computers with the videoconferencing program in relation to the audio-visual devices and set up.

### Limitations and recommendations

In addition to the inherent weakness of the one group pre- and post-test nature of the research design, the present study was limited by its small sample size. In particular, the findings may not generalize to younger adults with tetraplegia. Because of the nature of the research design, another limitation of this study was the inability to tease out the extent of the contribution from the adaptive oral device from the oral home telecare service. However, given the positive outcomes of this oral home telecare study, future studies should aim at confirming the findings of the present study through a large, multisite randomized-controlled trial. Another future direction is to integrate oral home care via videoconferencing as a broad, interdisciplinary comprehensive telerehabilitation service delivery program, with the goals of enhancing both oral and general health care outcomes for people with tetraplegia.

### DATA ARCHIVING

There were no data to deposit.

### CONFLICT OF INTEREST

The author declares no conflict of interest.

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