Telerehabilitation Tools for the Provision of Remote Speech-Language Treatment

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Telerehabilitation is the method of using communication technologies to provide rehabilitation at a distance. Advancements in videoconferencing and networking technologies present opportunities to deliver rehabilitation services to patients at home, at school, in the workplace, and in the community. Speech-language treatment is an area of rehabilitation well suited for telerehabilitation. This article will review the technology for performing remote speech-language diagnosis and treatment for patients after stroke. Development of a telerehabilitation system incorporating computerized therapy tasks with a touchscreen interface is described. Such a system enhances off-the-shelf videoconferencing equipment and extends the potential utility and effectiveness of telerehabilitation sessions. Key words: communication disorders, rehabilitation, speech-language pathology, stroke, telemedicine

Telerehabilitation (telerehab) provides new ways of delivering both traditional and innovative rehabilitation services to patients for whom they might otherwise be unavailable. Advances in technology have lowered the cost and increased the power and availability of the tools necessary for telerehab; for example, high-speed Internet connections and videoconferencing equipment continue to grow in use and acceptance. Considering the changes in medical reimbursement and shortened lengths of inpatient hospital stay, telerehab holds significant promise for extending the continuum of care and improving outcomes for persons with stroke.

Telerehabilitation Overview

Telerehab is the method of using communication technologies to provide rehabilitation services at a distance. The primary benefit of telerehab is that it improves access to care, not only for those living in rural settings but also for patients where distance and/or mobility are factors. Telerehab also enables the cost of care to be reduced by minimizing travel expenses and helping to avoid secondary complications. Both of these benefits have the potential to enhance the quality of care of rehabilitation services that are delivered to the patient after inpatient discharge. Although telerehab is still in its relative infancy (the term telerehabilitation did not appear in the literature until the fall of 1996), the field is expanding rapidly through the advancement of communication technologies, the growth of clinical telerehab programs, and funding opportunities from the government.

Telerehab sessions commonly are con-
ducted via interactive communication techniques such as videoconferencing, where live two-way audio and video signals are transmitted between locations. There are two different categories of videoconferencing systems: direct dial and Internet based. In a direct-dial videoconference, participants connect using stand-alone videophone equipment over standard analog POTS (plain old telephone system) phone lines or other higher bandwidth wiring (e.g., ISDN). Internet-based (or IP) videoconferencing, as the name implies, relies on the Internet as the connection network. The basic equipment needed for IP videoconferencing is a multimedia computer with videoconferencing software, an Internet connection, and a camera or other video-capture device.

The speed of the connection between participants in a videoconference, frequently referred to as bandwidth, is the primary factor in determining the quality of the signals. Higher bandwidth connections allow for data to travel faster between locations, resulting in improved quality as evidenced by faster, sharper, and larger video images. Videoconferencing equipment typically allows users to optimize the available bandwidth to favor video speed or image quality (e.g., to achieve faster a video speed, the quality of each video image will decrease).

With all videoconferencing equipment, there are a number of tradeoffs and considerations that need to be taken into account. The most significant considerations are cost and availability, not only of the physical equipment but also of the network across which they connect. POTS videophones connect at slower speeds, which results in a lower quality of audio and video signals, but they are relatively low cost (ranging from $300 to $500) and benefit from the high availability of analog phone lines, both domestically and internationally. Although higher bandwidth direct-dial systems can allow for near TV-quality signals, they are more costly to install, maintain, and operate. IP videoconferencing does not require specialized videophone equipment (beyond a standard multimedia-equipped computer) and can use any connection to the Internet, although quality will improve significantly with higher bandwidth (e.g., DSL, cable, Local Area Network [LAN]) connections. Additionally, the necessary software is low cost or free (as in the case of Microsoft NetMeeting™) and allows for added features such as file transfer, chat, whiteboarding, and application sharing.

Telerehab can also make use of other non-videoconferencing techniques. Store-and-forward is a method where information from one location is recorded live (typically as video or still images) and transmitted at a later time to the remote location. This technique is often used for medical consultations where the size of the transmitted information or the limitations of the available communication infrastructure make the consultations unsuitable for a live connection. Other techniques involve the use of sensors to capture physiologic or other health status and performance measures. Transmission of this information to the remote site provides another level of interaction between the clinician and patient.

Telerehabilitation for Speech-Language Treatment

In recent years, telerehab has seen substantial growth in the field of speech-language pathology (SLP). Speech-language treatment relies heavily on the quality of the auditory and visual input provided by the clinician and patient. These are well served by the technologies described above, video signals and audio signals being two of the most important. Speech-language pathology and telecommunication technology are well suited to SLP sessions, whether face to face or with computer and mail.

Telerehabilitation is not only applicable, effective, and convenient, but also cost effective, providing a cost-effective alternative to traditional treatment delivery. Speech-language pathologists are currently involved in the care of patients with both physical and neurological disorders, as well as communicative disorders such as aphasia. In treatment involving speech-language disorders, the clinician and patient are often separated by great distances, whether due to the patient's disabling conditions, their family circumstances, or other factors. These factors are further complicated by the dearth of services in many areas.

More generally, the growth in the use of auditory and visual computer technologies is driven by increased battery life and increased computing power, making these tools more practical for use in daily life. The use of these technologies in speech-language pathology is also driven by the need to provide services to individuals in remote locations, and the desire to improve the quality of care for patients with speech-language disorders.
auditory and visual interaction between clinician and patient. Videoconferencing tools are well suited for conducting SLP sessions remotely, as they transmit both audio and video signals.\(^1\) However, because the quality of the communication signals is so important during SLP sessions, the technology and procedures used during a telehealth SLP session should not distort or interfere with communication in either direction.

Telehealth has been shown to be a feasible, effective, and appropriate method for providing remote SLP services.\(^2\) The earliest efforts consisted of using basic telephony to deliver SLP services to veterans with communicative disorders such as alaryngeal speech, articulation defects, stuttering, aphasia, dysarthria, and auditory and voice disorders.\(^3\) The services that were delivered ranged from direct patient-clinician telephone communication for progress reviews to telephone counseling of patients and their families. The outcomes of this work were promising, and it was seen as a viable method for improving access and frequency of service to patients living in remote areas.

More recent work expanded upon this auditory-only technique by using video and computer methods to remotely diagnose neurogenic communication disorders.\(^4\) A battery of diagnostic speech-language measures was administered to each participant in three different conditions: traditional face-to-face, closed-circuit television, and computer-controlled video laserdisc. For each participant, performance on standardized measures, as well as the diagnosis given by clinicians, was compared across each of the three conditions. In nearly all cases, the diagnoses and performance of individual participants showed no significant difference across conditions. The investigators concluded from their findings that closed-circuit television and computer-controlled video laserdisc were valid methods for appraisal and diagnosis and could be considered "essentially the same" as the traditional face-to-face approach.

A recent and comprehensive study built upon the potential identified in the prior research by investigating a two-way satellite-based audio and video system as a tool for remote diagnostic evaluations of communicative disorders.\(^5\) The evaluations (totaling more than 150) consisted of oral motor, motor speech, and language examinations. They were conducted using real-time auditory and visual methods: remote visual inspection of size, symmetry, and range of motion of the jaw, tongue, and palate of participants, and traditional assessment tasks, such as reading aloud, vowel prolongation, and picture identification. In addition, store-and-forward video clips were also used to explore the possibility of off-line evaluations. Similar to earlier researchers, these investigators concluded that remote evaluations were "reliably accurate" and an "appropriate medium" for SLP consultation.

Although telehealth may be a viable method for providing diagnostic SLP services, work to date has not concentrated on the potential of telehealth to affect aspects of communication itself and improve outcomes. Issues such as technophobia, the user's prior experience with and attitude toward technology, and the quality of the audio and video signals have the potential to affect communication during telehealth sessions. Understanding how communication is influenced by these variables is important in advancing the use of telehealth for speech-language treatment.
An investigation is currently underway to assess the influence of telerehab on aspects of the communication process. Two groups of stroke patients, right-CVA (RCVA) and left-CVA (LCVA), currently receiving inpatient/outpatient SLP treatment at the National Rehabilitation Hospital (NRH) are asked to retell stories in both face-to-face (FF) and telerehab (T) conditions. In both conditions, participants are asked to retell an equivalent set of three picture-supported, digitally recorded stories from the story retelling procedure (SRP). The FF setting is structured to represent a standard SLP treatment session, with the clinician and participant seated at a table in the same room. The clinician manually places pictures in front of the participant and controls the playback of the story sound files and recording of the participant’s SRP responses using a computer placed out of view. In the T setting, the clinician and participant are located in separate rooms in the hospital, with interaction occurring via computer-based videoconferencing over a high bandwidth LAN connection. The participant is seated in front of a flat panel computer monitor on which a window (approximately 2 in. x 2 in. in size) shows live video of the clinician. Similarly, the clinician’s computer shows live video of the participant. Speakers and microphones allow the participant and clinician to speak to and hear each other. The clinician remotely controls the computer at the participant’s location to present the stories and pictures as well as to record the participant’s responses. Stories are scored after the experimental sessions using the percent information unit scoring metric that allows quantification of comprehension and production of spoken narrative discourse.

In addition to measuring the quantity of information retold, surveys are used to collect additional relevant information concerning each participant and session. A pretest questionnaire collects descriptive variables related to the participant’s background with computers and other types of technology. The results from this survey are used to arrive at a technology score for each participant that takes into account her/his level of computer use as well as the types of computer applications with which he or she is most familiar. Posttest surveys ask the clinician and participant to rate the participant’s attention to the task, ability to express herself or himself, comprehension, and comfort level in each setting.

Preliminary results have been collected (n = 18) for more than half of the planned 30-participant sample. Results do not suggest a difference across conditions for either group regarding the amount of information retold. Even though participants overall report a high level of acceptance of videoconferencing, some interesting trends are appearing. Four of the 10 LCVA participants stated it was easier to express themselves in the FF condition compared with the T condition, whereas only 1 of the 8 RCVA participants indicated this response. LCVA participants are more likely than RCVA participants to experience language problems, and it may be that LCVA participants rely heavily on nonverbal components of language, such as facial expressions and gestures, both receptively and expressively. One LCVA participant, when asked about telerehab setting, stated, “It is a nice way to do it differently, but I felt like I did better when you were right next to me.”

Preliminary results from the clinician’s exit survey indicate that across all participants, the clinician frequently (15 of 18 par-
participants) perceived the participant’s comfort level to be the same in both conditions. However, only 6 of the 10 LCVA participants and 4 of the 8 RCVA participants indicated their comfort level was the same in each setting. At the same time, there were two LCVA and two RCVA participants who stated their comfort level was better in the T setting. One stated, "I was less self-conscious when you were out of the room." Another said, "I wasn’t intimidated by the computer; it could be convenient for someone who is not able to get to the therapist." Yet another stated, "I was more comfortable in the telerehab setting because I was less distracted, because the computer made it interesting."

The variety of feedback received from the participants highlights the importance of soliciting the patient’s impressions concerning telerehab interaction. Some patients may find it a stimulating and useful approach to receiving therapy, whereas others may prefer the traditional face-to-face interaction. Given the question, "Would you use videoconferencing again to talk to a clinician?", all of the participants responded "yes." This differs significantly from responses received from a group of traumatic brain injury (TBI) participants tested using the same procedure (to be described in future publications). Given the same question, four participants in the TBI group responded "yes," two responded "no," and one responded "maybe."

Enhancing SLP Telerehabilitation

Advances in videoconferencing and networking technologies present numerous opportunities to deliver both traditional and innovative rehabilitation services to patients at home, at school, in the workplace, and in the community. As has been described previously, high bandwidth videoconferencing can provide audio and video transmission with sufficient quality to allow for natural conversation.

Further work within the Rehabilitation Engineering Research Center on Telerehabilitation at the NRH has been aimed at incorporating a touchscreen with videoconferencing technology to provide a third mode of interaction during audio and video SLP telerehab sessions. The touchscreen is used as an interface to computerized language and cognitive SLP treatment. The goal of this work is to develop an innovative system that is based on current SLP treatment methods and is designed with strict adherence to user interface guidelines to maximize ease of use and clinical relevance and acceptance.

The system that has evolved is called RITA, for remote interactive touchscreen assessment (Fig. 1). The use of RITA during a telerehab session extends the basic auditory and visual interaction of videoconferencing by providing the clinician with instant access to a library of therapy tasks he or she can administer to the remote patient. The clinician controls which tasks are presented on the patient’s computer. Once a task has been presented, the patient’s responses are transmitted in real-time to the clinician’s screen. The patient interacts with the touchscreen using a finger, in much the same way he or she would use a finger or pencil with a workbook page. This interaction is highly intuitive and allows for fast and efficient control of a computer, even for users with minimal computer experience or certain cognitive-communicative impairments.13-15

RITA is unique among existing computer-
ized treatment programs in that it combines videoconferencing features with a collection of therapy tasks across a broad range of skill areas (e.g., reading comprehension, sentence completion, picture identification, sequencing, problem solving, deductive reasoning, functional math). The ability to communicate both verbally and visually with a patient makes RITA an ideal platform for providing additional remote SLP services such as coaching and counseling. Future versions of RITA will include an expanding library of therapy tasks as well as the capability to customize tasks based on the needs of specific patients. In addition, a database will allow for the storage of patient results and clinical notes and will provide the ability to generate reports and integrate with electronic medical records systems.

Implications for Stroke Rehabilitation

The American Speech-Language-Hearing Association (ASHA) has recognized the potential for the significant impact of telepractice in the field of SLP by stating that patients who cannot be seen face-to-face due to access problems, including rural/remote or housebound individuals, could in the future be “seen” for SLP services using telemedicine tools. Additionally, telepractice is a component of ASHA’s Focused Initiative on Technology for 2001–2003. Potential components of the initiative include devel-
velopment of a strategic plan and guidelines for telepractice; exploration of ethical, legal, and reimbursement issues unique to telepractice; and development of a coordinated information plan to educate ASHA members about telepractice.\textsuperscript{16}

The strong applicability of telepractice to the rehabilitation of individuals after stroke is exciting. Telerehab has the potential to provide for or enhance the diagnosis and treatment of common stroke-related communication problems, such as cognitive-communicative disorder, aphasia, and apraxia. In addition, telerehab could also be used to address other SLP-related disorders common to persons with stroke, such as dysphagia.

Frequently, one outcome of stroke is reduced mobility; telerehab could serve to make SLP services more accessible to this population. By eliminating the need to travel to access an SLP, telerehab could increase both the frequency and ease of receiving SLP services. Furthermore, telerehab may be a way to extend the length of time SLPs are able to provide service to individuals after stroke. The inadequacy of insurance coverage for poststroke SLP treatment is an increasing problem. It is possible that telerehab will provide an avenue that is cost effective for both the clinician and patient, so that SLP treatment can be extended economically when insurance coverage ends.

The potential use of telerehab tools with individuals after stroke is promising, but a number of people may not be candidates. Stroke-related symptoms such as poor vision, poor attention, severely impaired comprehension, or bilateral motor impairment may adversely affect a person’s ability to interact with telerehab equipment. Even though certain stroke survivors may be unable to benefit from telerehab, their caregivers/families may benefit to a very high degree from telerehab education/counseling. It is clear that candidacy for telerehab needs to be determined on a case-by-case basis.

**Conclusion**

Telerehab for speech-language treatment holds broad potential. Many of the services SLPs currently provide are well suited for telerehab and can be conducted remotely using existing technology. New developments can and will continue to allow for innovative treatment methods. Despite this, there are some areas where progress still needs to be made before telerehab achieves widespread acceptance. The vast majority of third party payers are not currently reimbursing for telerehab services, and professional organizations, such as ASHA, are still in the process of developing their policies regarding licensure for clinicians practicing telerehab. To maximize the potential that telerehab could have on the stroke population, more research and development is needed. Outcome models will help to show the relative effectiveness of telerehab interventions, consisting of both traditional treatment methods (such as those used in RITA) and innovative methods that may evolve around technologies such as “smart-home” sensors, virtual reality, and robotics.

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REFERENCES


