Clinical Focus

Stories From the Webcams: Cincinnati Children's Hospital Medical Center Audiology Telehealth and Pediatric Auditory Device Services

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Purpose: The purpose of this manuscript is to describe the regulatory, technological, and training considerations for audiologists investigating telehealth and to offer some examples of audiology services provided through telehealth. **Method:** The authors presented the regulatory components, the technology required for audiology staff and patients, and staff training for the audiology telehealth program at Cincinnati Children's Hospital Medical Center. Four case studies

highlighting the successful use of telehealth in providing auditory device services to patients were also presented. **Results and Conclusion:** The described regulatory, technological, and training hierarchy provides a framework for audiologists interested in starting a telehealth program. The cases presented illustrate that telehealth can be used to provide some auditory device services, such as troubleshooting, mapping, and parent consulting.

The use of a video conferencing platform to provide audiology services may be called telepractice, e-health, teleaudiology, telemedicine, or telehealth (Rushbrooke & Houston, 2016). When referencing the current program, the term telehealth will be used in this article. The terminology used by authors in cited articles will be used in order to accurately report their research.

Most parents of children with hearing loss understand that auditory devices such as hearing aids and cochlear implants need to function appropriately and be worn consistently in order for their children to achieve the best educational, social, and vocational outcomes. Auditory devices often do not function properly due to a variety of reasons—from minor issues, such as broken tubing, to major issues, such as physical damage. Parents are often the first people

to suspect that an auditory device may not be functioning properly and may need assistance in determining the status of an auditory device. Most parents are trained on how to troubleshoot auditory devices but may doubt their ability to troubleshoot them effectively (Muñoz et al., 2015) and are often unsure if the auditory devices are functioning appropriately.

Teachers face similar concerns in the classroom, particularly as they may not encounter children with hearing loss on a regular basis and as educational audiologists are often unavailable to help troubleshoot audiology equipment that may not be functioning appropriately (American Speech-Language-Hearing Association [ASHA], 2007). Although audiologists can train parents on the proper use and care of hearing aids or cochlear implants, it is often up to the parent to train the teacher to identify any problems that may arise with the devices during the school day.

If parents and/or teachers are unsure as to whether or not an auditory device is working properly, the next step is for the audiologist to assess the instrument. This can be a time-consuming process involving making an appointment with the audiologist, taking the device to the clinic, and waiting for the audiologist's assessment. If the device cannot be repaired in the clinic, there is an additional wait while the device is sent to the manufacturer for repair. For a child with hearing loss, this time without access to auditory information, particularly during a school

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day, can compromise their learning and development. The teacher's and parent's inexperience with troubleshooting auditory devices combined with barriers that increase wait time to ensure proper working equipment can be particularly frustrating and problematic.

The wait for pediatric audiology appointments can be as long as 2–3 months in some areas (Shaw, 2013). Families may have to travel for hours to access a pediatric audiologist (Madell, 2014), resulting in time away from work and school, in addition to travel-associated costs, such as gasoline and food. There may be adult audiology providers located near pediatric patients, but they may lack the skill set or equipment to work effectively with children, particularly if the problem is complex (Shaw, 2013). This can be challenging for patients and their parents, especially when the appointment is for troubleshooting, servicing, or updating programs of auditory devices. The provision of some pediatric audiology services, particularly for those that need immediate attention, through telehealth may help increase access and reduce time without amplification for children with auditory devices.

Telehealth has been used successfully in the delivery of some audiology services. Swanepoel and Hall (2010) performed a systematic review of peer-reviewed audiology telehealth publications and found that audiologic services from screening to intervention are being provided by telehealth with results comparable to in-person services. Similarly, a systematic review of hearing aid and cochlear implant telemedicine encounters by Bush, Thompson, Irungu, and Ayugi (2016) found similar outcomes and patient satisfaction between services delivered in person and those delivered through telemedicine. Some specific examples of successful telehealth encounters include remote hearing aid programming, verification and counseling (Campos & Ferrari, 2012), and hearing aid follow-up services (Angle, Schnittker, & Tharpe, 2017). In addition, both studies resulted in high patient satisfaction. Hughes et al. (2012) found no significant differences between remote and in-person management of patients with cochlear implants. In a follow-up study, Hughes, Goehring, Miller, and Robinson (2016) found that remote cochlear implant programming was effective with young children.

General Information

The pediatric audiologists at Cincinnati Children's Hospital Medical Center (CCHMC) decided to develop a telehealth program with the primary goal of improving patient access to some audiology services. As audiology services provided through telehealth are not reimbursable by third-party payers, the focus for telehealth was on services that were not charged or were paid for privately. After consideration of the variety of audiology services provided at CCHMC, three audiology services were identified for development: (a) postfitting hearing aid checks, (b) auditory device troubleshooting due to problems at home or school, (c) and remote cochlear implant mapping.

After a hearing aid fitting, parents and school personnel often have questions or need reinstruction, especially if the child was fit with new technology. Parents may call the clinic with questions or to make an appointment with the audiologist. The audiologists at CCHMC anticipated that a telehealth service delivery model could be a way to connect with parents in their homes or school personnel in the educational setting to answer their questions or to provide additional instruction in the care and use of devices.

Similarly, troubleshooting auditory devices is a common issue that the CCHMC audiologists address, both from parents and school systems. Parents often call to make an appointment if they suspect the devices are not working properly. The CCHMC audiologists also receive multiple phone calls and e-mails per month from school personnel asking for help with a student's hearing aid or FM system. The CCHMC audiologists hypothesized that telehealth could be a way to assist both parents and school personnel to troubleshoot and solve problems with auditory devices without having to schedule a clinic appointment.

Remote cochlear implant mapping was also identified as an area where audiology could support children with hearing loss, particularly those who reside a significant distance from the medical center. For example, CCHMC has a long-standing relationship with a medical facility in the Dominican Republic. Children come to the Dominican Republic medical facility and can receive services through telehealth that may not be available from local providers. The CCHMC audiologists wanted to investigate if telehealth would work for the provision of remote cochlear implant mapping services.

CCHMC Center for Telehealth Program

The first step in audiology's telehealth program development was to contact the CCHMC Center for Telehealth. The Center for Telehealth was established to support the provision of hospital services through secure video conferencing. The reach of the Center for Telehealth is vast, providing over 5,000 local, national, and international encounters annually. There is an established process for departments to follow when applying for telehealth services, including an application for telehealth support and a proposal review by the CCHMC telehealth steering committee. The first proposal that audiology presented to telehealth was to provide diagnostic auditory brainstem responses from the main hospital (hub) to patients at CCHMC facilities in rural Indiana (spoke); however, this proposal was deemed to not be economically feasible. With this in mind, the audiologists later submitted an additional proposal for services that were not billed or were paid for by private contract, specifically postfitting hearing aid checks, device troubleshooting, and mapping with patients in the Dominican Republic. This proposal was accepted by the steering committee.

After approval, a telehealth program manager observed audiology practice at a location where staff saw many

patients for hearing device services and were interested in performing telehealth. The telehealth program manager and audiologists diagrammed the current process for patients receiving device troubleshooting in the office and examined it for potential ways that telehealth could be used to create efficiencies for patients and staff. They determined that the addition of a telehealth component, allowing staff to see the auditory device, would be beneficial to the troubleshooting process. The updated process was piloted at that specific location and later spread to other CCHMC locations.

Next steps included meetings with the Ohio Speech and Hearing Professionals Board to learn about state regulations for the provision of audiology services via a telehealth delivery model. They also reviewed telehealth best practice guidelines and information from professional organizations, including those promoted by ASHA (2014) and the American Academy of Audiology (2015). One audiologist joined ASHA's telehealth special interest group, SIG 18, to be an active participant of a speech and audiology-focused telehealth community. The American Telemedicine Association website provided audiology staff an overview of telehealth and a resource for practice guidelines (American Telemedicine Association, 2016).

An important discovery was that audiologists must be licensed in the state where the patient is physically located to provide services through telehealth. As CCHMC is in southwest Ohio at the junction of Ohio, Kentucky, and Indiana, patients could be physically located in any of these three states, and therefore, awareness of the licensing status of the attending audiologist must be considered. The audiology providers are required to ask the patient where they are physically located at the start of each session and document this information in the appointment chart note.

CCHMC uses the hub and spoke model, much like the hub and spokes of a bicycle wheel, where the provider is at the institution's main location or one of the satellite locations, called the hub, and the patient is at a remote location, such as a school or home, called the spoke. When the spoke site is at another institution such as a school, there may be another professional with the patient, but it is unlikely that another professional would be present if the spoke site is the patient's home.

There are many platforms that may be used to connect people over the Internet, with some being Health Insurance Portability and Accountability Act (HIPAA) compliant and therefore appropriate for health care delivery. The CCHMC Center for Telehealth investigated several platforms and selected a video conferencing system based on ease of use for the patient and HIPAA compliance. The video conferencing system is compatible with most commonly used web browsers and is available in a free app that can be downloaded on most smartphones. The CCHMC Center for Telehealth also created policies, procedures, and job aids for service provision to ensure secure, HIPAA-compliant services and documentation.

Costs

The use of telehealth for service provision is a priority of CCHMC, so individual departments are not charged for telehealth supplies or support services. The setup costs to provide services via telehealth can be expensive and time-consuming, so the Center for Telehealth is very selective about the programs it supports. The most expensive cost is for a HIPAA-compliant video conferencing system, which can range from a hundred to thousands of dollars, depending on the system used. Each provider has a webcam and headphones that vary in price from \$75.00 to \$250.00 per set.

Each provider or group of providers needs a video conferencing software license. Individual video software licenses were given to providers who were interested in providing many services through telehealth. Groups of providers who were at the same location and not sure about the amount of services they wanted to provide were given generic, location-specific software licenses. Telehealth stations were created by utilizing existing computers that allow multiple users to engage in telehealth appointments. Video conferencing licenses are between \$200.00 and \$400.00 per license for the first year, with an annual fee thereafter of \$30.00 per year.

The Center for Telehealth estimated that clinical departments would need support from telehealth for approximately a year. The number of telehealth support visits can range from one or two a month to weekly support, depending on the provider's familiarity with telehealth; the complexity of the procedure, which is being performed through telehealth; and the patient's comfort level with the video conferencing technology.

Reimbursement

It should be noted that insurance payment for services provided through telehealth is limited. The states of Ohio and Kentucky do not currently have telehealth parity laws in effect. This means that there are no state laws requiring private insurers to pay for services delivered through telehealth. Medicaid and Medicare do not recognize audiologists as providers of telehealth and therefore do not reimburse for audiology services delivered via telehealth. Medicaid and Medicare will pay for some services provided by recognized telehealth providers including physicians, physician assistants, psychologists, and social workers, but there are often restrictions on where the patient can be located while receiving services. For example, services provided via telehealth to patients in their home or school will not be covered by Medicaid or Medicare. Also, there is often a geographical requirement for Medicare in which the patient must be in a designated rural area. In addition, Ohio Medicaid has a requirement that patient and provider must be more than 5 miles apart.

Economic Benefits

The financial benefits of delivering audiology services via telehealth have not been firmly established. There are

concerns that the cost of equipment and technology needed to deliver audiology services, in combination with the need for spoke site support personnel, will offset any economic gains. The CCHMC audiology approach focuses on the provision of services that are not typically reimbursed by third parties or are included in the warranty period after the fitting of auditory devices. Most services are also provided without the need for support staff with the patient at the spoke site.

Two important economic benefits were considered when developing the CCHMC audiology telehealth program. First, telehealth appointments could be scheduled to take advantage of times when patient care activities are otherwise slow. At CCHMC, audiologists provide coverage for walk-in otolaryngology clinics, some of which do not result in significant numbers of referrals. By scheduling follow-ups at the beginning or end of these clinics, audiologists take advantage of times when the audiology workload is traditionally less time demanding. The second benefit is that service delivery through telehealth can be more efficient for the patient as they do not have to take time off work and drive to an appointment.

Audiologist and Patient Technology

Since telehealth involves the use of technology for both providers and patients, assessing technology was a necessary step in program development. Provider access to desktop or laptop computers connected to CCHMC's computer network via Ethernet connections was needed. Laptops could also be connected wirelessly with Wi-Fi; however, connection via Ethernet is preferred as it often results in a more stable video connection. In addition to the computer, the video and audio systems also needed to be considered. Although webcams were already available as part of the desktop systems at CCHMC, a few audiologists opted for wide-angle cameras as they are easier to use when demonstrating hearing aid parts or function to parents, such as how to change the battery. For accessing sound, the audiologists could select a headset or listen and speak directly through the computer audio system. The video conferencing software was loaded onto the computers identified for telehealth. The telehealth appointments were scheduled in rooms that were HIPAA compliant so that confidential patient care could occur.

Patients, their parents, and school personnel have many options in terms of the technology they can use for telehealth. They are able to connect with CCHMC audiologists using a desktop computer, laptop, tablet, or smartphone, as long as these devices have a forward-facing camera. These devices can be personal or institutional and need to be connected to the Internet by either an Ethernet connection or Wi-Fi. Knowledge of how to access the internal camera, microphone, and speaker on their device or use of external components is required. For patients requesting cochlear implant mapping, additional equipment is required on both the hub and spoke sides, as a computer for the telehealth connection and an additional computer

with interfaces for mapping are used. CCHMC video conferencing software must be downloaded onto the patient's device in order for the telehealth appointment to occur. A link is sent by the audiologist via text message or e-mail and downloaded by the patient for the appointment. The software download is complete in a few minutes. The patient is advised to download the software prior to the appointment so that CCHMC Information Services can provide assistance if needed.

Hands-On Training for Audiologists

A hierarchy of audiology training was developed by the Center for Telehealth based on successful training in other divisions. A telehealth specialist was assigned to Audiology for Telehealth training. Although the technical aspects of using the video conferencing software were covered, the training also included a role play between the audiologist and the telehealth program manager. The program manager played the audiologist, and the audiologist played the parent. This allowed the audiologist to experience the steps the parents would need to go through downloading and using the software. The audiologists also practiced with each other inside the medical center and then outside the medical center.

The next step of training was practicing with actual patients who pretended to have hearing device problems. Four patients agreed to participate in this training exercise. The audiologists e-mailed or texted each patient a video conferencing software link before the appointment. All patients were able to successfully download the video conferencing software and connect to the audiologist using the link. The first trial was a parent in a parking lot who connected through her cell phone asking a question about her son's earmold. The audiologist was able to see the patient's hearing aid clearly and coach the parent on how to correctly insert her son's earmold. Another trial was conducted with a teacher who successfully connected to the audiologist through a school computer. A third trial was with a teenage girl who connected with the audiologist from her cell phone at her home without any difficulty. These trials were successful in that the audiologist could effectively communicate, view the "problems," and then provide appropriate "solutions."

The final trial identified challenges that might occur when attempting a telehealth appointment. A patient's mother was connecting with the audiologist from her cell phone at work. She could see and hear the audiologist, but the audiologist could not see or hear her. The patient's mother called the audiologist on the telephone and reported the problem. According to the CCHMC's telehealth program manager, this type of connection issue is typically the result of the parent not understanding how to set up the phone to access the camera and microphone and/or reduced bandwidth at the spoke location. This type of lesson was valuable to understanding the potential limitations of telehealth appointments as well as identifying solutions.

Application of Telehealth for Pediatric Hearing Aid Fitting Follow-Up

Following the fitting of hearing aids, CCHMC audiologists make follow-up appointments to answer questions, check earmold placement, and start the hearing aid self-management process. These appointments are generally scheduled at 1–2 weeks postfitting and often include both the audiologist and the audiology clinical program assistant (CPA). As these appointments rarely result in additional testing or changes to the device programming, particularly for infants, a telehealth appointment can be offered as an alternative to an in-person appointment.

Case Study 1. “Jane”: Pediatric Hearing Aid Fitting Follow-Up

Jane is a 12-year-old girl with Down syndrome and a moderate, low-frequency, nonfluctuating conductive hearing loss rising to normal hearing at 4000 Hz and above. Following the hearing aid fitting, Jane’s mother, Mrs. Smith, selected telehealth for the follow-up appointment as Jane becomes anxious while receiving care at the medical center. At the time the appointment was scheduled, Mrs. Smith received a link through e-mail for the appointment and instructions for how to download the link.

The telehealth appointment occurred while Jane and her mother were at their home and Jane’s audiologist was at a CCHMC outpatient location. Mrs. Smith reported difficulty in downloading the software but called the phone number listed on the appointment instructions for technical support and received assistance prior to the appointment. With assistance, the software was successfully downloaded. At the scheduled appointment time, Mrs. Smith connected with the audiologist through the video conferencing software. There were no issues connecting. Jane, Mrs. Smith, and the audiology staff were able to see and hear each other well. The audiologist was able to see Jane’s hearing aids and verified that the earmolds were inserted correctly and the hearing aids were sitting appropriately on the ears.

Mrs. Smith reported that Jane was adjusting well to the hearing aids and that she had no questions or concerns regarding their use and care. When asked how often Jane wore her hearing aids, Mrs. Smith responded that Jane wore the aids for a few waking hours, specifically 3–4 hr per day. Mrs. Smith also reported that she observed some improvement in Jane’s hearing ability with the use of her hearing aids. The audiologist asked Mrs. Smith questions from the CCHMC hearing aid self-management assessment form to obtain an indication of Mrs. Smith’s confidence in addressing hearing aid issues. Mrs. Smith indicated, on a scale of 1–10 (with 10 being certain), her comfort level with managing Jane’s hearing loss and hearing aids. She rated her comfort level as a 10. At the hearing aid fitting, she rated her comfort as an 8, so the current rating was an improvement. She also reported

that Jane used her hearing aids in all environments except for school.

The only concern that Mrs. Smith reported was that Jane’s teacher did not want Jane to wear the aids at school until after the winter school break, which was in a month. This was upsetting to Mrs. Smith as she wanted Jane to wear the aids at school so that any problems could be discovered and then addressed during winter break. Mrs. Smith and the audiologist discussed the situation and decided the best course of action was for Mrs. Smith to talk with Jane’s teacher and explain the importance of daily hearing aid use, that Jane was adjusting well to the aids and that audiology staff, as well as Mrs. Smith, request that the aids be worn at school as soon as possible. If Jane’s teacher continued to resist, the audiologist would communicate directly with her to learn more about her concerns regarding Jane’s hearing aid use.

The audiologist recommended that Jane wear her hearing aids during all possible waking hours and return in 1 month for an in-person appointment. Audiology staff, Jane, and Mrs. Smith all agreed that the appointment was successful as everyone was able to see and hear each other well. Also, Mrs. Smith and Jane’s audiologist were able to discuss Mrs. Smith’s concerns regarding Jane not being allowed to wear her hearing aids at school until after the winter break. Everyone felt confident that the situation could be corrected and that Jane could start wearing hearing aids at school after Mrs. Smith talked with the teacher about the importance of daily hearing aid use. Mrs. Smith was empowered by her conversation with the audiologist. Most importantly, Jane received a hearing aid service while in her home and not in the anxiety-provoking hospital environment. Jane was so happy that she danced in front of the camera for the audiology staff to see.

Application of Telehealth for Troubleshooting Devices

The process map of troubleshooting a potential problem with an auditory device is described in Figure 1, panels A and B. This is the standard CCHMC auditory device troubleshooting process with the addition of the telehealth component. The process typically begins with a phone call from the patient, his or her parent, or the teacher with a request for assistance with a hearing aid concern. The CPA who answers the phone is the initial contact to resolve the concern. If the CPA thinks that the issue could be resolved more easily through a telehealth consultation and the patient has an e-mail account and/or phone to receive a text message, the CPA sends the patient a video conferencing link and a time for an appointment. Typically, the appointment can occur immediately. The CPA attempts to identify the seriousness or complexity of the problem and, if possible, resolve it immediately. In addition to the immediate resolution of the problem, the patient benefits from not having to schedule an appointment or deal with travel and time issues. If the CPA is unable to resolve

Figure 1. Auditory device trouble-shooting process.

the issue, she will connect the patient to an audiologist. The audiologist uses the same video conferencing software to assess and attempt to resolve the problem. If the issue still cannot be resolved, the patient is asked to schedule an in-person appointment. Two cases illustrate this process. The first case study focuses on a student requiring urgent assistance with his hearing aids prior to standardized testing at school. The second case study is a telehealth appointment for a cochlear implant magnet issue.

Case Study 2. “Gabe”: Troubleshooting: Urgent Hearing Aid Problem at School

A teacher from a neighborhood school called the clinic regarding Gabe, a 13-year-old student with a nonfunctioning FM system. Gabe is an experienced hearing aid user with a moderate sloping to moderate-severe sensorineural hearing loss in each ear. He recently transitioned from behind-the-ear hearing aids to receiver-in-the-ear hearing aids. Gabe and his teacher examined the hearing aids and FM system but were unable to determine the reason why the FM was not working. Gabe was anxious because he was scheduled

for state education testing later that afternoon and was afraid he would not score as well without his FM system.

A telehealth appointment with a CCHMC outpatient medical center facility as the hub site and Gabe’s school as the spoke site was recommended due to the time constraints of the situation. A telehealth consent was received from Gabe’s parent and a video conferencing link was sent to his teacher. The link was successfully downloaded on the school computer. The connection was excellent for the majority of the session, allowing Gabe and his teacher to show the equipment they were using and explain the problem to the audiologist. Some intermittent pixilation of the visual signal occurred, but it did not interfere with the appointment.

The audiologist at the hub site was able to see Gabe’s equipment, which included his hearing aids, two FM receivers, and an FM transmitter. Listening and visual checks performed by Gabe and his teacher indicated that the hearing aids were working and that the transmitter and the receiver were synchronized. The problem was that sound was not being transferred from the transmitter to the receivers. The audiologist visually confirmed that the equipment was set up appropriately. He also reviewed Gabe’s audiology

Figure 1. (Continued).

B

chart at the hub site and verified that the hearing aids had an FM program.

The audiologist noticed that the hearing aids were equipped with program buttons that had to be pressed to activate the FM program. He asked Gabe to verify that the program buttons were pressed. Gabe reported that the program buttons had not been pressed. He pressed the buttons, activated the FM program, and was able to hear through the FM system.

Even though Gabe was instructed on the use of the program buttons at his hearing aid fitting, he did not remember they were there and therefore did not use them. His teacher also reported being unaware that program buttons had to be used to connect with the FM system. This was a simple but profound lesson on the use of telehealth to provide immediate assistance resulting in important outcomes. In addition, it reminded the CCHMC audiologists of the need to overemphasize device features when patients are changing styles or manufacturers and to make sure that parents, family, and teachers are aware of the changes.

In this case, the solution was simple, resolved quickly, and provided education to Gabe and his teacher that could be used for later reference. The ability to resolve this situation remotely enabled Gabe to stay in school rather than go to an audiology appointment, reduced Gabe's anxiety promptly, and allowed him to take state testing at the scheduled time.

Case Study 3. "Mara": Troubleshooting: Cochlear Implant Magnet Problem

Mara is a 21-year-old woman with a profound bilateral sensorineural hearing loss and a significant developmental delay. She received her cochlear implant when she was 17 years old. Mara enjoys hearing through her implant and becomes confused, frustrated, and often combative when she is without it. She currently lives in her own apartment with substantial assistance from a local support agency. The agency provides services including scheduling appointments, transportation, and regular visits to make sure their clients have what they need. Mara provided permission for CCHMC audiology to communicate with the support agency for situations involving her hearing or cochlear implant.

Mara's audiologist received a phone call from a nurse with the support facility reporting that Mara's sound processor magnet would not stay in place. The nurse was concerned that something was wrong with the internal magnet as the processor appeared to be in good condition. The audiologist could not understand the full extent of the problem based on the verbal description and recommended a telehealth appointment. The appointment was scheduled for the next business day. Consent and a video conferencing link were sent to Mara's nurse.

CCHMC was the hub site, and Mara's apartment was the spoke site. The video conferencing software was downloaded without incident, and the spoke site was able to connect with the hub site without difficulty. Mara, her

nurse, and the audiologist were able to see and hear each other well. Mara reported through simple signs that her processor constantly fell off, as if the magnet had lost its strength. The audiologist was able to see the processor and threaded magnet clearly enough to determine that the magnet was unscrewed from the headpiece. This reduced the attraction force between the internal and external devices, causing the headpiece to easily fall off. With simple instruction, the nurse was able to tighten the magnet, enabling it to remain in place.

Four benefits to this troubleshooting approach are apparent. First was the obvious reduction in necessary resources for Mara and the support agency. Mara did not have to travel, which, for her, means the utilization of support facility vehicle and driver. The second was the unpredicted need for sign language. Typically, Mara uses spoken language to communicate but knows some sign language. Through the benefit of the visual aspect to this telehealth appointment, the audiologist was able to use simple sign with Mara, which allowed her basic communication and helped reduce her anxiety. Third, the support staff at the spoke facility included individuals unfamiliar with cochlear implants who also had not accompanied Mara for prior in-person appointments. The telehealth connection provided the opportunity to answer several questions about device function, such as expected battery life, so that they might support Mara better in the future. Finally, her concerns were addressed in a timely manner, reducing her time without sound and the behavioral issues that often accompany these episodes.

Application of Telehealth for Cochlear Implant Follow-Up and Mapping

International patients requiring remote cochlear implant services go through a slightly different process (see Figure 2). Patients are referred directly to audiology from a physician outside the United States, or the patient contacts our institution's international patient appointment facilitation center. They forward patient requests for audiology service to the Audiology department. The audiologist and physician consult regarding the patient's needs and determine if he or she would be best served by in-person appointments, telehealth appointments, or some combination of the two. If in-person appointments are required, options for travel to CCHMC are discussed. If telehealth would be appropriate for the patient, equipment requirements are discussed.

Equipment needs consist of two computers at the hub site and two computers at the spoke site, with an appropriate Internet connection. One set of computers is used for the cochlear implant services, and the other set is used for the visual and audio connection. The computers for the cochlear implant services need to be loaded with the correct software. The accessories needed to connect with and service the cochlear implants must also be available. In addition to the equipment, it may be necessary

Figure 2. Telehealth audiology cochlear implant (CI) process. CCHMC = Cincinnati Children's Hospital Medical Center.

Telehealth Audiology CI Process

to have an interpreter on site with the patient at the spoke site. There are many factors to consider when scheduling these appointments. The patient, the spoke physician, the hub audiologist, and telehealth consultation rooms for programming at both the hub and spoke locations all need to be available.

Case Study 4. “Ramone”: Cochlear Implant Mapping Appointment

Ramone is a 23-year-old man from the Dominican Republic who presented to the CCHMC cochlear implant team with a long-standing severe-to-profound sensorineural hearing loss. Despite the degree of hearing loss, he is a relatively successful oral communicator due to a history of extensive auditory and speech therapy. Ramone utilized traditional amplification but admitted that there were times where the subjective sound quality was too poor to make wearing the hearing aids worthwhile.

Ramone had been evaluated for a cochlear implant by clinicians outside CCHMC but was not considered to be a good cochlear implant candidate because of inner ear anatomy irregularities. During the CCHMC work-up to determine cochlear implant candidacy, radiographics confirmed that the hearing loss etiology was likely secondary to bilateral cochlear nerve deficiency. The CCHMC cochlear implant team has extensive experience with patients benefiting from cochlear implantation despite abnormal cochlear anatomy. Ramone was subsequently implanted with a Nucleus Cochlear Implant (Cochlear CI512 with a Nucleus 6 Processor) in the right ear. The outcome of the initial activation and follow-up appointments suggested that he would do well with his cochlear implant. He progressed quickly to a cochlear implant map that provided good access to sound (20–30 dB) from 250 Hz to 8 kHz. Because of the brevity of appointments at the hub location, speech perception testing was not able to be completed.

Because Ramone’s home is in the Dominican Republic, the CCHMC cochlear implant team had several conversations about long-term follow-up management of his cochlear implant. The initial plan for Ramone included initial activation at CCHMC, followed by two more local appointments over the course of 2 weeks, and then using telehealth for the remaining long-term appointments. During those first three appointments, in addition to the typical cochlear implant programming, skills that would be needed to make the telehealth appointments as successful as possible were also addressed. Psychophysical measurements can be easy to obtain with a compliant patient in the same room as a clinician because posturing, sign language, and other forms of communication such as writing are immediate. However, through telehealth, these responses may not be immediate due to audio and video quality, lag time, and possible intermittency. Therefore, demonstrations and exercises to show Ramone what would be expected of him on the spoke end of the appointment were discussed and demonstrated.

Prior to Ramone’s telehealth encounter, the hub site audiologist and spoke site physician who would be working

with Ramone in the Dominican Republic met over a video platform connection to assess the software on the spoke site mapping computer. The audiologist at the hub site determined that updated software needed to be installed on the spoke site computer and that a programming interface was required. Ramone was given a programming interface to take to the Dominican Republic for use during his telehealth appointment. The audiologist sent a link to the necessary software to the spoke site physician via e-mail. The spoke site physician downloaded the software onto the spoke site mapping computer. After the software download, the hub site audiologist and spoke site physician met again over a video platform connection to make sure the software loaded correctly. Ramone brought the programming interface to his appointment at the spoke site. Ramone’s first follow-up appointment via telehealth occurred about 3 weeks after the last in-person appointment.

At the hub site, two sets of computers were used at the same time: one was for mapping and one for visual and auditory communication with Ramone and others at the spoke site. The computer setup at the spoke site was similar in that there was a computer for programming the cochlear implant and another computer for visual and auditory communication with the audiologist at the hub site. Personnel at the spoke location included Ramone, Ramone’s father, the spoke site physician, and a technical support person. The effort required of individuals at the spoke was limited to establishing the remote connection by accepting a present meeting invitation, thus limiting the time burden to no more than 5 min prior to the actual appointment. The physician remained present for the duration of the appointment to provide interpretation and to facilitate the appointment on the spoke end.

Ramone’s cochlear implant processor was connected to a proprietary programming interface in the mapping computer at the spoke site. The audiologist noticed a slight lag of about 0.5–1 s between a command, such as increase in stimulation on a given channel, and visualization of the action on the hub end was perceptible. Once the delay was known to be relatively consistent, it became easier to anticipate the expected timing of the patient’s response for psychophysical measures. The audiologist at the hub site was able to successfully update Ramone’s map.

The overall outcome of this initial appointment and subsequent follow-up appointments was positive. Certainly, the work of preteaching with Ramone in person was a benefit that may not be available to every clinician or patient followed via telehealth. Furthermore, Ramone was able to provide very consistent feedback throughout the appointment. Finally, the authors recognize that the success of this telehealth connection was due in large part to the support of professionals on both the hub and spoke ends of the appointment.

Discussion

Telehealth is a service delivery modality that can be applied to a range of audiology services from screening to

intervention (Swanepoel & Hall, 2010). Most applications require the availability of audiologic equipment on the remote site as well as the presence of a professional to work with the patient. In this article, most of the descriptions of telehealth services have focused on services that do not need audiologic equipment at the remote site. This increases the scope of services available through the CCHMC telehealth program.

All the patients and caregivers outlined in the case studies had the necessary technology, such as a computer with a camera and speaker or a smartphone, to access audiology services through telehealth. All patients and caregivers were able to successfully download the video conferencing software. One parent reported difficulty in downloading the software but called the CCHMC technology support phone number listed on the appointment instructions and received assistance prior to the appointment. Clear audio and visual connections were maintained for three out of the four appointments, with some intermittent pixilation of the visual connection during an appointment at the school. This was probably due to reduced bandwidth at the school.

It is important to note that adequate bandwidth must be maintained at both the hub and spoke sites to maintain a clear visual image. Even though CCHMC had adequate infrastructure to transmit the signal, it appears that the school may not have been able to receive it. Spoke sites are advised to turn off devices that utilize bandwidth so that adequate bandwidth is available for the appointment. This may not be possible in all situations, such as at a school. Fortunately, the visual image was clear for most of the appointment.

The CCHMC audiologists and patients receiving services through telehealth benefit from having an established Center for Telehealth at CCHMC with experience in working through problems and concerns. Their experience helps to avoid problems as well as quickly resolve problems that occur with the delivery of medical services via telehealth.

The audiologists were able to address all the patient and caregiver concerns during the telehealth appointments. In addition to the benefits for the children with hearing loss, the benefits for parents and caregivers cannot be overstated. Parents were not required to travel to the hub site for an in-person visit with the provider, saving them travel costs, such as gasoline, food, lodging, and time away from work. This is especially true for international patients where the costs and time required for travel can be prohibitive, particularly for multiple visits.

The CCHMC model for telehealth results in the ability to provide additional reimbursable services and thus improve financial productivity without the expenses of additional equipment or offsite personnel. Though not measured, parents and patients realize substantial time savings that can also be economically beneficial for them. By being able to provide services via telehealth, the patient benefits from not having to schedule and drive to an appointment, take time off work or school, and arrange child care or a

host of other factors that contribute to the economic impact of accessing audiologic services. It can also serve to reduce anxiety for some patients and to improve the outcomes by the audiologist being able to observe the child in their home environment.

Some of the case examples also illustrate unexpected benefits as the caregivers who were present during the telehealth appointment would probably not be present during in-person visits. Gabe's teacher and some members of Mara's facility support staff were present during their telehealth appointments, which allowed the audiologists to collaborate with their support staff on troubleshooting their auditory devices. This teamwork resulted in enhanced knowledge of the impact of nonfunctioning auditory devices, the ease of telehealth, and some increased ability to troubleshoot auditory devices. In addition, Gabe's teacher and Mara's facility support staff now have experience working with audiologists and a better understanding of the appropriate questions to ask to help determine auditory device issues. They may use this information with other individuals they work with who are having auditory device problems.

Perhaps most importantly, it should also be noted that appointments for troubleshooting devices occurred more quickly than in-person appointments could be scheduled. Gabe's appointment occurred within an hour after the phone call from the teacher, and Mara's appointment occurred on the next business day. Telehealth was used to provide urgent service to patients with nonfunctioning auditory devices.

Ramone's case study illustrates how implants can be successfully mapped through telehealth. This can be a valuable service for patients who do not live close to an audiologist with mapping experience or for patients looking for qualifications in addition to mapping, such as the ability to work with bimodal hearing or patients with complex needs. This lack of availability and choice in mapping providers creates a potential gap in patient care that could be filled by telehealth services.

Gabe's and Jane's case studies highlight the importance of contacting families after their children are fit with new hearing aids. Gabe clearly did not understand how to access the FM program with his new hearing aids, and Jane's mother had questions about how to work with Jane's teacher. The telehealth appointment gave Jane's mother access to an audiologist and an opportunity to ask questions and information to develop a strategy for how to best communicate with Jane's teacher.

Conclusion

The case studies presented illustrate how telehealth can be used to provide some audiology services that result in improved access without increased costs of equipment and staff. Audiology telehealth enables patients to receive some services more quickly than would be possible by scheduling a traditional in-person appointment. Telehealth

appointments can also save families travel-associated costs. Telehealth can be accessed in the home, at schools, or at outside institutions.

Third-party reimbursement of audiology services provided by telehealth would make the provision of services through telehealth more economically feasible. Similarly, the development of an interstate compact, resulting in audiology licensure portability, would make it easier for audiologists to provide services across state lines.

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