Experience with Telemedicine in a Tertiary Academic Otologic Clinic During the COVID-19 Pandemic

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**INTRODUCTION**

The COVID-19 pandemic accelerated adoption of telemedicine services in the health care sector to address the acute need for distanced care and increases in reimbursements for virtual visits (1,2). Previously, researchers had identified otolaryngology as a medical specialty particularly suitable for adopting telemedicine services due to frequent reliance on imaging findings and lack of access to tertiary otolaryngology care in rural communities (3–11). Another consideration for the use of telehealth is the high risk otolaryngologists face of exposure to aerosolization of COVID-19 viral loads concentrated in the upper airway (12). Specific to the subspecialty of neurotology, paradoxically, many patients with hearing loss have reported to prefer virtual visits over in-person consultation due to better integration of visual content (e.g., typing through integrated chat features). These patients have also tended to benefit in virtual visits during the COVID-19 pandemic from providers being able to safely remove their masks, sit closer to the camera to enhance visual cues, increase speaker volume, and potentially employ automated closed captioning (12–14).

In addition, many otologic and neurotologic disorders are suitable for telemedicine since diagnosis and treatment plans for common conditions are often determined by temporal bone and neuroimaging, audiogram results, and patient history, which are conducive to being evaluated during a virtual visit (15–18). The primary exception may be chronic ear disorders which may require otoscopic examination for

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diagnosis and in-office care. These purported benefits among others in the context of continued challenges posed by the COVID-19 pandemic call for further evaluation of the utility of video visits for otology and neurotology care.

The objectives of this study are to: i) examine whether the video visit platform is a beneficial modality to evaluate and make treatment recommendations for newly referred neurotology patients, and ii) identify which otologic and neurotologic indications are particularly suitable for telemedicine. We hypothesize that the use of a telemedicine platform alongside review of external medical records will enable neurotologists at tertiary care centers to successfully make clinical recommendations for a subset of patients without an in-person clinical consultation.

**METHODS**

**Patient Selection**

A retrospective review of patients presenting via video visits between January 2020 and January 2021 at a tertiary academic neurotology clinic was conducted. The study was deemed IRB exempt by the institutional review board (IRB 20-011853). A list of all patients who underwent video visits with a staff neurotologist was generated from the electronic medical record. Appointments were reviewed to identify patients seeking a second opinion, treatment for a new neurotologic concern, postoperative follow-up or general follow-up for a previously established neurotologic disorder (Fig. 1). Video visits were conducted via Zoom Version 5.6.6 under a Health Insurance Portability and Accountability Act compliant Zoom for Health Care license (Zoom Video Communications, Inc; San Jose, CA), mainly using application integrated real-time audio/video streaming and screenshare technologies with no supplemental technologies (e.g., video otoscopy) (19). Of note, not all patients between the study period had been offered video visits. For example, to schedule a video visit to establish care for a new neurotologic consultation, patients were required to have certain diagnostic testing/imaging available depending on their visit indication. Patients requesting a visit for vestibular schwannoma or meningioma management required prior contrast enhanced head magnetic resonance imaging (MRI) studies and a recent audiogram. For patients with middle ear (otosclerosis, cholesteatoma) conditions, a recent audiogram was required; however, imaging was recommended but not required for the visit. Within our triage algorithm, for superior semicircular canal dehiscence syndrome, a prior temporal bone computed tomography (CT) and audiogram were required; however, vestibular testing was recommended but not required. Patients requesting consultation to the author's institution for indications related to dizziness are triaged separately through an established vestibular triage system and, with the exception of people with a previously established diagnosis of superior canal dehiscence syndrome, are not seen through virtual consultation. Rather, based on a patient questionnaire, review of outside records, and usually in-house comprehensive vestibular testing, patients are subsequently referred to respective specialists based on test results. Regarding postoperative follow-up, patients preferring the video option often elected to have procedural components of the first follow-up (e.g., suture/staple removal) performed locally if applicable, with subsequent visits conducted by video with physicians at our institution.

**Data Collection**

The primary outcome collected was the success of the telemedicine video visit and the resulting care plan. Patients were allocated to one of four groups based on certainty of diagnosis and certainty of plan after video visit evaluation: nondefinitive diagnosis and nondefinitive plan; definitive diagnosis and nondefinitive plan; nondefinitive diagnosis and definitive plan; or definitive diagnosis and definitive plan (Fig. 2). Video visits resulting in the latter two groupings were defined to be successful as the video visit
evaluation proved to be sufficient for the provider to designate a definitive treatment plan (e.g., surgery) using history, examination, and available work-up assessed during the video visit. Conversely, a video visit was considered unsuccessful if the provider explicitly documented the need for further in-person evaluation or workup (e.g., laboratories, tests, imaging, consults) to develop a definitive treatment plan that was surgical, medical, or observational in nature. For visits deemed successful, plans were characterized as medical, surgical, or observational in nature. Secondary outcome measures included characterization of visit diagnosis as well as information regarding diagnostic tests available to the provider at the time of the video visit to assess whether either factor influenced the success of formulating a clinical plan. Relevant diagnostic imaging (e.g., MRI, CT) and audiograms obtained within 1 year of the video visit and availability to the provider were reviewed and collected.

Statistical Analysis

Descriptive statistics including counts, mean, standard deviation, median, and interquartile ranges (IQR) were collected using JMP Version 16.0.0. (SAS Institute Inc.; Cary, NC) to characterize cohort demographics and visit features (Table 1). An unpaired two-tailed \( t \) test (\( \alpha = 0.05 \)) was used to compare the mean number of diagnostic tests available for patients who had successful versus unsuccessful video visits. Visit diagnoses were then categorized into the following seven groups based on underlying pathology for further analysis: 1) vestibular schwannoma; 2) sensorineural hearing loss; 3) acute and chronic otitis; 4) conductive hearing loss; 5) mixed hearing loss; 6) meningioma; and 7) other. Both univariate and multivariate logistic analyses were then performed to determine whether the visit diagnosis, number of diagnostic tests, patient age, and/or patient sex impacted the success of the virtual visit.

Heat Maps

Heat maps visually depicting patient catchment were generated using Tableau Version 2020.4.1 (Tableau Software, LLC; Seattle, WA). Maps comparing video visit spread in 2020 to in-person visit spread from 2019 used zip code data extracted from the electronic medical record. US population densities by zip code were acquired via publicly available open-source files from the United States Census Bureau (20).

RESULTS

Description of Video Visits and Patient Demographics

Between January 2020 and January 2021, 102 video visits were conducted by the Division of Otolaryngology and Neurotology at the authors’ institution. Most visits (\( n = 92, 90.2\% \)) took place for patients seeking second opinion or treatment for new, unaddressed otologic/neurotologic concerns. Postoperative follow-up and general follow-up accounted for the remaining visits, 2.9% and 6.9%, respectively. Notably, there were no instances of documented technical difficulties in completing video visits.

These 102 visits occurred for a cohort of 100 unique patients, 57.0% female with a median age of 53 years (IQR, 25.5–64.3 years). The median distance between patients’ home zip code and the authors’ institution was 452 miles (IQR, 649 miles; 203–852 miles) (Table 1). Per

![FIG. 2. Definition of successful virtual visits by certainty of diagnosis and certainty of plan.](image)

| TABLE 1. Baseline characteristics of patients |
|-----------------------------------------------|
| All Patients                                  |
| Total visits, n                               | 102 |
| Unique patients, n                            | 100 |
| Distance from institution to home zip (miles), n (%) |
| 0–50                                         | 3 (3%) |
| 50–250                                       | 28 (28%) |
| 250–500                                      | 21 (21%) |
| 500–1,000                                    | 32 (32%) |
| 1,000+                                       | 16 (16%) |
| Distance from institution to home zip code (in miles) |
| Mean (SD)                                     | 500 (387) |
| Median (IQR)                                  | 452 (649; 203–852) |
| International, number (%)                    | 6 (6%) |
| Sex, number (%)                              | |
| Male                                         | 43 (43%) |
| Female                                       | 57 (57%) |
| Age, mean (SD)                               | |
| Mean (SD)                                    | 50.2 (19.0) |
| Median (IQR)                                 | 53 (25.5; 37.8–64.3) |

IQR indicates interquartile range; SD, standard deviation.
Figure 3, there was an increased proportion of patients living outside the Midwest region evaluated by video visits as compared with in-person visits from the year prior. This was further reflected by patients with home addresses between 500 and 1,000 miles from our institution comprising the largest proportion of video visits (n = 32, 32%) (Table 1).

Success of Video Visit Based on Diagnosis
The most common indications for seeking second opinion and potential treatment were vestibular schwannoma (n = 32, 31.5%), followed by sensorineural hearing loss (n = 20, 19.6%), acute or chronic otitis (n = 11, 10.8%), and mixed hearing loss (n = 7, 6.9%). Together, these diagnoses comprised nearly two-thirds of all visits (Table 2).

Characterization of Diagnostic Tests Available at the Time of Video Visit
Availability and utility of diagnostic tests varied based on indication and are shown in Table 2. Overall, the most common diagnostic tests were MRI scans, available for 65.7% (n = 67) of patients. Patients grouped together across did not exhibit an increased odds of having a successful visit based on the presence of any single type of diagnostic test (audiogram, CT, and MRI) (p > 0.05). Patients’ age and sex were also not statistically significant predictors of a successful video visit in either the univariate or adjusted multivariate logistic regression models (Table 3).

Recommendations Following Video Visit
Video evaluation resulted in a definitive plan for most patients (n = 93, 91.2%). Only 8.8% (n = 9) of patients required a subsequent in-person visit prior to treatment recommendations. The distribution of proposed plans following visits for each diagnostic group is shown in Table 2. Medical plans included intratympanic steroid injections, ear tubes, and hearing aids; surgical plans covered a broad array of procedures including microsurgical tumor resection and stereotactic radiosurgery. Of the 79 patients offered surgery as one potential treatment option, 54.4% (n = 43) had elected to undergo surgery at our institution at the time of review, with all surgeries being the procedure initially discussed during the video consult. Of those who did not elect to undergo surgery at our institution, most frequently patients opted for continued observation with serial imaging (n = 10). Patients not having a treatment plan made successfully via video visit (n = 9, 8.8%) were advised to schedule in-person follow-up to obtain additional imaging, vestibular evaluation, cochlear implant candidacy evaluation, or referral to another specialty before a definitive plan could be finalized.

Furthermore, in all selected instances of postoperative and general follow-up visits (Fig. 1), the video visit was sufficient. Postoperative follow-up visits (n = 3) included visits after osteointegrated implant placement, infant sedated auditory brainstem testing, and paraganglioma resection. Only postparaganglioma resection required local primary care involvement. Among patients with general follow-up visits, four of seven required MRI from local institution for serial imaging.

FIG. 3. Heat maps depicting regional spread of visits based on patient zip code data extracted from the medical record. Left: blue dots represent patients seen during in-person visits (2019). Right: red dots represent patients seen during virtual visits (2020).
## TABLE 2. Characterization of visit attributes

| Characterization of visit attributes | Acoustic Neuroma (Vestibular Schwannoma) | Sensorineural Hearing Loss | Acute or Chronic Otitis | Mixed Hearing Loss | Conductive Hearing Loss | Meningioma | Other (e.g., Hemifacial Spasm, Trigeminal Neuralgia) |
|--------------------------------------|------------------------------------------|----------------------------|-------------------------|-------------------|------------------------|-----------|--------------------------------------------------|
| **All Patients**                     | All Patients                             |                            |                         |                   |                        |           |                                                  |
| Total visits, n                      | 102                                      | 32 (31.4%)                 | 20 (19.6%)              | 11 (10.8%)        | 7 (6.9%)               | 6 (5.9%)  | 7 (6.9%)                                        | 19 (18.6%) |
| Reason for visit, n (%)              | 92 (90.2%)                               | 29 (90.6%)                 | 17 (85%)                | 10 (90.9%)        | 7 (100%)               | 6 (100%)  | 7 (100%)                                        | 16 (84.2%) |
| Seeking advice/treatment             | 92 (90.2%)                               | 29 (90.6%)                 | 17 (85%)                | 10 (90.9%)        | 7 (100%)               | 6 (100%)  | 7 (100%)                                        | 16 (84.2%) |
| Postoperative follow-up              | 2 (2.0%)                                 | 0 (0%)                     | 2 (10%)                 | 0 (0%)            | 0 (0%)                 | 0 (0%)    | 0 (0%)                                          | 0 (0%)     |
| General office follow-up             | 8 (7.8%)                                 | 3 (9.4%)                   | 1 (5%)                  | 1 (9.1%)          | 0 (0%)                 | 0 (0%)    | 0 (0%)                                          | 3 (15.8%)  |
| Visits with technical difficulties, n (%) | 0 (0%)                                  | 0 (0%)                     | 0 (0%)                  | 0 (0%)            | 0 (0%)                 | 0 (0%)    | 0 (0%)                                          | 0 (0%)     |
| Certainty of diagnosis               |                                          |                            |                         |                   |                        |           |                                                  |
| Definitive, n (%)                    | 91 (89.2%)                               | 31 (96.9%)                 | 18 (90%)                | 11 (100%)         | 4 (57.1%)              | 6 (100%)  | 6 (85.7%)                                       | 17 (89.5%) |
| Nondefinitive, n (%)                 | 11 (10.8%)                               | 1 (3.1%)                   | 2 (10%)                 | 0 (0%)            | 3 (42.9%)              | 2 (100%)  | 1 (13.4%)                                       | 2 (10.5%)  |
| Certainty of plan                    |                                          |                            |                         |                   |                        |           |                                                  |
| Definitive (i.e., successful video visit), n (%) | 93 (91.2%)                               | 31 (96.9%)                 | 19 (95%)                | 10 (90.9%)        | 5 (71.4%)              | 5 (83.3%) | 7 (100%)                                        | 16 (84.2%) |
| Medical                              | 9 (9.7%)                                 | 0 (0%)                     | 5 (26.3%)               | 1 (10%)           | 0 (0%)                 | 2 (40%)   | 0 (0%)                                          | 1 (6.3%)   |
| Surgical                             | 35 (37.6%)                               | 9 (29.0%)                  | 6 (31.6%)               | 4 (40%)           | 2 (40%)                | 2 (40%)   | 5 (71.4%)                                       | 7 (43.8%)  |
| Multiple options offered (independent of further workup) | 44 (47.3%)                               | 22 (71.0%)                 | 4 (21.1%)               | 5 (50%)           | 3 (60%)                | 1 (20%)   | 2 (28.6%)                                       | 7 (43.8%)  |
| Observation only                     | 5 (5.4%)                                 | 0 (0%)                     | 4 (21.1%)               | 0 (0%)            | 0 (0%)                 | 0 (0%)    | 0 (0%)                                          | 1 (6.3%)   |
| Nondefinitive (i.e., unsuccessful video visit), n (%) | 9 (8.8%)                                 | 1 (3.1%)                   | 1 (5%)                  | 1 (10%)           | 2 (28.6%)              | 1 (20%)   | 0 (0%)                                          | 3 (15.8%)  |
| Diagnostic tests                     |                                          |                            |                         |                   |                        |           |                                                  |
| Number of overall visits having >= 1 diagnostic test available | 91 (89.2%)                               | 32 (100%)                  | 18 (90%)                | 7 (63.6%)         | 6 (85.7%)              | 5 (83.3%) | 7 (100%)                                        | 16 (84.2%) |
| Number of tests available at time of visit for successful video visit | 1.5 (0.8)                                | 1.7 (0.5)                  | 1.6 (0.7)               | 0.7 (0.9)         | 1.8 (0.8)              | 1.2 (1.0) | 1.9 (0.7)                                       | 1.5 (0.8)  |
| Mean (SD)                            | 2 (1; 1–2)                               | 2 (1; 1–2)                 | 2 (1; 1–2)              | 1 (1; 0–1)        | 2 (1; 1–2)             | 1 (1; 1–2) | 2 (0.5; 1–5.2)                                | 2 (1; 1–2) |
| Median (IQR)                         |                                          |                            |                         |                   |                        |           |                                                  |
| Number of tests available at time of visit for unsuccessful video visit | 1.6 (0.8)                                | 2 (0)                     | 2 (0)                  | 2 (0)             | 0.5 (1)                | 3 (0)     | N/A                                             | 1.3 (1.3)  |
| Mean (SD)                            | 2 (1; 1–2)                               | 2 (0; 2–2)                 | 2 (0; 2–2)              | 0.5 (0.5; 1–3)    | 3 (0; 3–3)             | N/A       | 1.5 (1.5; 0.5–2)                              | 1.1 (1.5; 0.5–2) |
| Median (IQR)                         |                                          |                            |                         |                   |                        |           |                                                  |
| Type of diagnostic tests, n (%)      |                                          |                            |                         |                   |                        |           |                                                  |
| MRI                                  | 67 (65.7%)                               | 31 (96.9%)                 | 11 (55%)                | 2 (28.6%)         | 1 (16.7%)              | 7 (100%)  | 14 (73.7%)                                      | 10 (52.6%) |
| CT                                   | 29 (28.4%)                               | 1 (3.1%)                   | 5 (25%)                 | 3 (27.3%)         | 2 (28.6%)              | 4 (66.7%) | 4 (57.1%)                                       | 10 (52.6%) |
| Audiogram                            | 61 (59.8%)                               | 23 (71.9%)                 | 17 (85%)                | 5 (45.5%)         | 6 (85.7%)              | 4 (66.7%) | 2 (28.6%)                                       | 4 (21.1%)  |

IQR indicates interquartile range; SD, standard deviation; CT, computed tomography; MRI, magnetic resonance imaging.
monitoring (two vestibular schwannomas, one facial neuroma, one endolymphatic sac tumor); other general follow-up visits consisted of surgical planning and management based on existing imaging or testing.

### DISCUSSION

#### Overview

The rapid implementation of telemedicine services during the COVID-19 pandemic was required to maintain essential health services. Changes in insurance reimbursement for virtual visits alongside relaxation of state licensure limitations implemented during the early COVID-19 pandemic catalyzed development and implementation of telemedicine. It is important to critically assess the efficacy and value of these changes. Our retrospective review of telemedicine data provides granular information on specific otologic and neurotologic indications for which video visits may be an effective resource as well as specific indications for which video visits may be less effective.

Geographically, patients were seen by video visits across the United States with a higher percentage of patients being seen outside of the Midwest region when compared to patients seen by in-patient visits (Fig. 3). The increased percentage of out-of-region patients may reflect a combination of increased accessibility and preference for the convenience and cost-savings of telehealth over being seen in-person. In viewing the 2020 video visits map, it is evident that patients in both urban and rural areas used telemedicine services, demonstrating a key opportunity to address the problem of low access to otolaryngology specialty care in rural areas. One study in rural Alaska reported that waiting times of more than 5 months or longer to be seen by an otolaryngologist dropped from 47% to 3% after 3 years of implementing telemedicine visits (21). In addition to access for rural populations, telemedicine enables patients more discretion in choosing which centers to establish their care with, an important development for efforts to centralize some otology procedures, like vestibular schwannoma surgery, to higher volume centers for better patient outcomes (22,23). The geographic trends observed here support that virtual appointments can provide benefits to patients across the country and can be offered as the entry care-point to a tertiary care center. Telemedicine presents an opportunity to improve access and quality of neurotology care, but it requires health care teams to adapt to different processes. For example, the workflow to prepare and execute visits can be more intensive including gathering records, confirming telemedicine appointments, and helping patients navigate technology (12).

#### Telehealth for Neurotologic Care

In this retrospective cohort, virtual visits most frequently occurred for patients seeking initial evaluation or treatment (90.2%) as opposed to early postoperative or established general follow-up (2.9%, 6.9%, respectively). This may reflect patients who seek follow-up visits being accustomed to in-person care and less willing to follow-up virtually or perhaps surgeons’ preferences to examine early postoperative patients in-person. The latter point acknowledges a possible selection bias in part by the clinician in deciding which patients to offer general or postoperative follow-up. These findings may also reflect fewer follow-up appointments in this period as elective surgeries themselves were delayed because of the pandemic. Notably, however, all instances of postoperative and general follow-up were categorized as successful, suggesting these visit types may be amenable to being conducted via the video modality when appropriately selected. For example, serial monitoring that does not necessarily require in-house testing (i.e., testing and imaging that can occur at local facilities such as MRI or laboratory testing) or follow-up care that is not dependent on new testing, appear to be amenable. Although outside the scope of the current study, the senior author has noticed an uptick in virtual follow-up patients within the last year, particularly for patients with vestibular schwannomas. We would be interested in observing whether patients who have established their care through telemedicine are more apt to continue to use the modality for follow-up appointments. The increased access to care via telemedicine may allow otolaryngologists more discretion in observing conditions without intervention, an important option for small vestibular schwannomas monitored by serial MRI, for example (12,16,17,24).

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**Table 3. Crude univariate and multivariate odds ratios for successful treatment plan made via video visit.**

| Variables                  | Crude OR (95% CI) | p (Univariate) | Adjusted OR (95% CI) | p (Multivariate) |
|----------------------------|-------------------|----------------|----------------------|------------------|
| Sex                        |                   |                |                      |                  |
| Female                     | 1.7 (0.4–6.9)     | 0.4            | 1.1 (0.2–5.7)        | 0.9              |
| Age (per unit)             | 1.0 (0.9–1.0)     | 0.3            | 1.0 (0.9–1.0)        | 0.1              |
| Diagnosis                  |                   |                |                      |                  |
| Vestibular schwannoma      | Reference         |                | Reference            |                  |
| Hearing loss—sensorineural | 0.6 (0.04–10.4)   | 0.7            | 0.8 (0.04–16.6)      | 0.9              |
| Acute or chronic otitis    | 0.3 (0.02–5.6)    | 0.4            | 0.3 (0.01–6.6)       | 0.4              |
| Hearing loss—conductive    | 0.2 (0.009–3.0)   | 0.2            | 0.09 (0.003–3.0)     | 0.1              |
| Hearing loss—mixed         | 0.08 (0.006–1.1)  | 0.1            | 0.2 (0.007–5.9)      | 0.2              |
| Meningioma                 |                   |                |                      |                  |
| Other                      | 0.2 (0.02–1.8)    | 0.2            | 0.2 (0.02–2.9)       | 0.3              |

Sample size limited calculations involving diagnosis categories of meningioma. Category p values included where applicable.
Visit Indications Amenable to Virtual Televideo Visits

Our data suggest evaluation by virtual visit may be particularly useful for a range of neurotologic conditions, including vestibular schwannomas, meningiomas, and sensorineural hearing loss (Table 2). Vestibular schwannomas and meningiomas may be more conducive to virtual platforms since evaluation and surgical consideration relies mainly on patient report of symptoms, audiometric data, and neuroimaging, and less often on in-person physical examination (15,17,18,25). Though MRI and audiometric testing cannot be obtained without a visit to a center performing specialized testing, these tests are frequently ordered by local physicians and the results are forwarded to tertiary care centers for review. This allows otolaryngologists at these institutions to review imaging beforehand and effectively use virtual visits to discuss treatment plans with patients. Among patients with vestibular schwannomas in this cohort, 71% exhibited tumors that were small and amenable to either observation, radiosurgery, or microsurgery. In most cases, patients in this group elected for initial observation based on provider recommendations. Primarily based on larger tumor size, 29% of patients in this subset were advised to undergo microsurgical resection alone (Table 2). For patients presenting with meningioma, the recommended treatment plan was surgery-skewed, with 71% of patients being recommended surgery and 29% given multiple treatment options. One possible challenge with evaluating these conditions would be if imaging or audiometric data were not available before the visit. This in conjunction with not being able to perform a thorough physical examination and evaluation of cranial nerve involvement may be a further limitation. Notably, facial nerve function may be readily assessed via video visits; however, trigeminal hypoaesthesia or dizziness for example, may be more challenging. [30] The authors wish to point out that patients requesting consultation for symptoms of dizziness are not generally first seen through a virtual consultation at the author’s center. Rather, as outlined in the methods section, this population is generally first evaluated through an established triage system, including a visit patient questionnaire, review of outside records, and usually in-house comprehensive vestibular testing. We realize patients presenting with symptoms of dizziness are often included in the common neurotologic referral pool and therefore, for the purposes of a more generalizable model, we have included this population within the “intermediate suitability” group within Figure 4.

Examples of health care delivery models using telemedicine in otology exist within the cochlear implant literature. Specifically, cochlear implant care models leveraging telemedicine, local resources (for imaging and audiologic testing), and remote programming have demonstrated feasibility prior to the onset of the COVID-19 pandemic (26,27). More recently, the Complete Cochlear Implant Care model, has combined the above technology and resources to develop a highly coordinated care model that minimizes travel and increases access to a high-volume cochlear implant center for patients (28). Efforts to incorporate telehealth into routine care for patients, when appropriate, offers opportunities to expand health care access and minimize patient inconvenience while maintaining excellent patient care.

Visit Indications less Amenable to Virtual Televideo Visits

Conditions such as acute and chronic otitis and conductive or mixed hearing loss may present diagnostic and treatment challenges in the virtual setting. A major limitation for otitis is the diagnostic role of otoscopes for external and middle ear pathology, and the potential need to clean or debride the ear canal under microscopy (15,29). Though these conditions are generally less suitable for virtual visits

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**FIG. 4.** Suitability of varying neurotological concerns for virtual visit. Most recommendations presented in this figure are based on study data presented herein. However, some indications (e.g., dizziness, tinnitus, otalgia) were not represented in this study, but were added to this figure to more comprehensively cover the breadth of the specialty, with these recommendations based on clinical insight. CHL indicates conductive hearing loss; CI, cochlear implant; CSF, cerebrospinal fluid; IT, intratympanic; MHL, mixed hearing loss; SNHL, sensorineural hearing loss; Tplasty, tympanoplasty.

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based on need for otoscopy, the relative success of visits in these categories still exceeded 70% in the current study. This can be primarily explained by the fact that many of these cases had been previously evaluated by an outside otolaryngology clinic and subsequently referred after examination. Notwithstanding, several innovations have been studied to address this issue, including the use of store-and-forward otoscopes for referring physicians to send otoscope images to specialist or hybrid virtual visits with telehealth facilitators, including primary care providers and audiologists, using otoscopes live with a virtual otolaryngologist (3–5,8,9,30–33). In cases of cerumen impaction, it may be feasible in some cases to have the patient present to a local facility for cerumen removal to facilitate visualization of the tympanic membrane if deemed important for care (12). Recognizing certain potential limitations, current home digital video otoscope systems and home self-administered audiograms may be potential future options in select cases (34). Figure 4 summarizes the spectrum of cases a neurotologist may encounter as well as the suitability of a specific indication to be evaluated by virtual visit.

Limitations and Future Directions

This study is not without limitations. Our review originates from a single tertiary academic center experience and was retrospective in nature. We acknowledge the risk of generalizability bias that can occur from data originating from tertiary care centers (35). Telemedicine was particularly effective at our center as the study population primarily consisted of patients who have likely already seen a physician, received a preliminary diagnosis, and/or had imaging and laboratory tests available to review beforehand (89.2% with past imaging available). This reflects upfront time and resources critical to the success of telemedicine observed at our institution variable for local providers initially evaluating patients. It is also notable that there was undoubtedly some level of selection bias regarding the type of visit seen. For example, when triaging appointments, surgeons may be less enthusiastic to commit to an initial virtual visit for concerns related to chronic ear disease given the importance of otomicroscopy and potential need for debridement and topical medical therapy. Further exploration into what work-up would maximize the utility of video visits for visits of varying indications would be of interest. Lastly, tele-otoscopy, either administrated by the patient or a local provider, may be an important refinement to facilitate effective otologic televideo consults and deserves further investigation, particularly for indications of conductive hearing loss or mixed hearing loss.

CONCLUSION

With appropriate case selection and previsit preparation, virtual televideo visits represent a valuable and effective adjunct to specialized neurotologic care. We found that telemedicine is conducive to formulating definitive treatment plans, as well as providing patients second opinions regarding many common neurotologic conditions.

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