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Audiology Telemedicine Evaluations: Potential Expanded Applications

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Abstract

There is underutilization of cochlear implants with delays in implantation linked to distance from implant centers. Telemedicine could connect cochlear implant specialists with patients in rural locations. We piloted telemedicine cochlear implant testing in a small study, largely comprised of normal hearing volunteers to trial this new application of teleaudiology technology. 13 subjects (8 with normal hearing and 5 with hearing loss ranging from mild to profound) underwent a traditional cochlear implant evaluation in-person and then via telemedicine technology. Routine audiometry, word recognition testing, AzBio and CNC testing was performed. Mean percent difference in AzBio between in-person and remote testing was 1.7% ($\pm 2.06\%$). PTA, SRT, and word recognition was similar between methods. CNC testing showed a difference of 6.8% ($\pm 10.2\%$) between methods. Testing conditions were acceptable to audiologists and subjects. Further study to validate this method in cochlear implant candidates and a larger population is warranted.

Keywords

Cochlear Implant; Telemedicine; Teleaudiology

Introduction

Approximately 1.2 million patients with severe hearing loss are likely candidates for Cochlear implantation within the US; however, the utilization rate of cochlear implants is only 5%.¹ Patients in rural areas face limited access to care. Kentucky is a largely rural state geographically and the extremely rural Appalachian region of the state is one of the most medically underserved and economically depressed regions of the country.^{2,3} There are very few Otolaryngology and audiology practices within the Appalachian region of Kentucky, and there are currently no cochlear implantation centers or cochlear implant audiologists.

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There is evidence of cochlear implantation delays for Appalachian patients with a linear correlation between distance from the CI center and the timing of implantation.⁴

The use of telemedicine in hearing healthcare, also known as teleaudiology, is relatively new and the applications include patient education, otoscopy, hearing aid fittings⁵, audiometric testing^{6,7}, and electrophysiological testing.⁸ This technology has also been used, primarily outside of the US, to program hearing aids and cochlear implants, thereby increasing the access to rehabilitation services.^{9–16} There is no published research on the use of telemedicine in the assessment for cochlear implantation candidacy. Telemedicine has the potential to connect CI specialists with patients with hearing loss in remote locations for the delivery of education regarding hearing loss treatments, diagnostic testing, and counseling regarding cochlear implantation. We designed a small pilot study to test the feasibility, of telemedicine cochlear implantation candidacy evaluations opposed to in-person evaluations for potential future use in the Appalachian region.

Materials and Methods

A prospective, randomized, single center, crossover, pilot study was conducted at the University of Kentucky Department of Otolaryngology and Head and Neck Surgery. This study was approved by the UK Institutional Review Board. Subjects were established patients in the clinic or were healthy normal hearing volunteers with normal hearing or hearing loss.

Subjects underwent two identical cochlear implant evaluations, in-person and telemedicine consecutively. Comprehensive audiological evaluation, including pure-tone air and bone conduction thresholds along with speech audiometry was performed. The CI evaluation included the use of two different speech testing batteries: Arizona Biological Test (AzBio) and Consonant-nucleus-consonant (CNC). The AzBio was used as the primary measure. AzBio and CNC was performed in the best-aided condition with +5 signal to noise ratio.

The telemedicine testing set-up involved face-to-face communication using a Polycom 500 series teleconference audio and live video set-up. The remote audiology testing utilized an OTOSphere comprehensive audiology set-up (Otovation, Philadelphia, PA) (Figure 1).

We hypothesized that mean difference in AzBio scores between methods would be within 5%, which we considered clinically insignificant test re-test variability.

Results

13 subjects participated in this study. This included 8 normal hearing individuals and 5 subjects with hearing loss. Of the subjects with hearing loss, 3 were mild-moderate hearing loss, 2 were moderately severe to profound. AzBio scores showed a mean difference of 1.7% ($\pm 2.06\%$) between in person and remote testing conditions (Table 1).

Other variables tested were the CNC, PTA, SRT, and word recognition scores for both the right and left ear. The mean difference in CNC test scores was 6.77% ($\pm 10.25\%$) (Table 2). There were 3 outliers, subject 9, 12 and 13 with difference in CNC testing greater than 20

percent. These 3 patients had hearing loss. PTA, SRT, and Word recognition scores were similar between groups.

Subjectively, the patients with worse hearing loss fatigued more quickly than normal hearing individuals and had difficulty finishing the complete twice in succession.

Discussion

Prior uses of telemedicine have used the technology to perform remote mapping and programming^{15–19}, post-implantation testing^{20,21}, remote intraoperative monitoring²², and remote clinical care of their cochlear implants²³. This study is the first of its kind attempting to administer cochlear implant evaluations using telemedicine technology.

In our pilot study, AzBio scores were similar between in-person and telemedicine testing methods. PTA, SRT and Word recognition testing was similar with a 5% or less difference between methods.

Interestingly, CNC testing varied much more than did the AzBio in our study, with a difference of 6.8% largely driven by 3 outlier patients. All 3 outliers had hearing loss and in all 3 subjects remote testing scores were lower than in-person testing. This may signify an issue with comparability of the CNC test when administered via telemedicine to subjects with hearing loss.

Our small pilot study has several limitations. The population was comprised largely of normal hearing individuals with values near the upper limit of normal decreasing potential variability. Also, none of these subjects would be considered cochlear implant candidates. We sought to trial this method with a population of normal/moderate hearing loss individuals prior to testing CI candidates. These results should ultimately be verified in this population however. We would recommend a protocol where in-person and telemedicine testing be performed on separate days to avoid testing fatigue.

Conclusion

This study is the first to examine cochlear implant candidacy testing via a telemedicine approach. It appears that this method is feasible to perform with the current technology. CNC testing may have a higher than acceptable variability between methods and should be examined more closely. This technology could be used to extend the reach of an implant center to more rural areas and improve the access to hearing healthcare. Further validation is warranted in larger populations, CI candidates and in true remote conditions.

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Figure 1.
Picture of Telemedicine Cart

Table 1

AzBio Scores In-person vs. Telemedicine

Subject	AzBio Telemed	AzBio In-person	% difference	Description of hearing loss
1	99	99	0	normal
2	100	99	1	normal
3	99	100	1	normal
4	96	100	4	normal
5	100	100	0	normal
6	100	100	0	normal
7	99	99	0	normal
8	100	99	1	normal
9	79	77	2	Severe/Profound
10	100	100	0	Moderate
11	86	92	6	Moderate
13	95	90	5	Severe
14	99	97	2	Mild
Average difference			1.69231	
SD			2.05688	

Table 2

CNC Scores In-person vs. Telemedicine

Subject	CNC Telemed	CNC In-person	% difference	Description of hearing loss
1	100	100	0	normal
2	96	100	4	normal
3	100	100	0	normal
4	100	100	0	normal
5	100	100	0	normal
6	98	98	0	normal
7	100	100	0	normal
8	100	100	0	normal
9	84	60	24	Severe/Profound
10	100	96	4	Moderate
11	88	80	8	Moderate
12	88	60	28	Severe
13	88	68	20	Mild
Average difference			6.769231	
SD			10.2482	