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ORIGINAL RESEARCH—PEDIATRIC OTOLARYNGOLOGY

Digital images for postsurgical follow-up of tympanostomy tubes in remote Alaska

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OBJECTIVE: To determine if video otoscope still images of the tympanic membrane taken in remote clinics are comparable to an in-person microscopic examination for follow-up care.

DESIGN: Comparative concordance, diagnostic reliability.

METHODS: Community health aide/practitioners in remote Alaska imaged 70 ears following tympanostomy tube placement. The patients were then examined in person by two otolaryngologists. Images were later reviewed at 8 and 14 weeks.

RESULTS: Intraprovider concordance for physical examination findings was: "Tube in," 94 percent –97 percent ($\kappa = 0.89-0.94$); "Tube patent," 94 percent –97 percent ($\kappa = 0.89-0.94$); "Drainage," 90 percent –96 percent ($\kappa = -0.04-0.38$); "Perforation," 90 percent –96 percent ($\kappa = 0.61-0.82$); "Granulation," 97 percent –100 percent ($\kappa = 0.49-1.0$); "Middle ear fluid," 88 percent –96 percent ($\kappa = 0.28-0.71$); "Retracted," 83 percent –91 percent ($\kappa = 0.26-0.58$). These agreement rates are similar to interprovider concordance when two otolaryngologists examine the same patient in person. Intraprovider concordance for diagnoses was 76 percent –80 percent ($\kappa = 0.64-0.71$) and 77 percent –88 percent ($\kappa = 0.66-0.81$) when poor images were excluded. Interprovider diagnostic concordance for the in-person exam was 89 percent ($\kappa = 0.83$).

CONCLUSION: Video-otoscopy images of the tympanic membrane are comparable to an in-person examination for assessment and treatment of patients following tympanostomy tubes. Store-and-forward telemedicine is an acceptable method of following patients post tympanostomy tube placement.

Otitis media with effusion (OME) is often treated with myringotomy and placement of tympanostomy tubes (TT). Candidates for surgery include children with OME lasting four months or longer with persistent hearing loss or other signs and symptoms, recurrent or persistent OME in children at risk regardless of hearing status, and OME and structural damage to the tympanic membrane (TM) or middle ear.[1] Due to the prevalence of OME, tube insertion is the leading procedure for children less than 15 years old, with 512,000 surgeries being performed in ambulatory and inpatient settings in 1996.[2] Postsurgical follow-up of these children typically involves examination of the TM at one month (or earlier) and then at intervals no longer than six months.[3] Otolaryngologists, however, have individual preferences; most follow up within one month (97%), and the second and subsequent visits occur at three months (29%), four months (25%), or six months (37%).[4]

American Indian and Alaska Native (AI/AN) children face a particularly difficult situation, as they often have higher rates of otitis media (OM) and thus greater rates of TT placement—but live in an environment that makes postsurgical follow-up challenging and expensive. This paper considers an alternative method of TT follow-up using image acquisition and telemedicine.

Historically, Alaska Native and Canadian First Nations populations have been burdened with a high prevalence of OM and associated morbidity.[5-9] A survey conducted in 1992 of four remote Alaskan villages found that chronic OME occurred in 8.9 percent of persons under 20 years of age and in 21 percent of children under 5 years of age.[10] The incidence of ambulatory care visits related to OM for AI/AN children is twice that for all US infants, and the placement rate for TT in AI/AN children less than age five was 20 times higher in Alaska compared to the continental United States.[11]

The Alaska Native Medical Center (ANMC) in Anchorage, Alaska provides otolaryngology specialty care for AI/AN throughout the state of Alaska and during a five-year period (2000–2004), 1450 TT were placed in children.[11] Most of these patients live in remote locations, making it challenging to achieve the recommended follow-up. When follow-up does occur, it frequently requires expensive air travel, sometimes in precarious weather conditions. A safer, more reliable, and cost-effective means to perform follow-up is needed as the "in-person" encounter with an otolaryngologist is no trivial matter.

Alaska villages have health clinics staffed by community health aide/practitioners (CHA/Ps), who are trained through

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the CHA/P Program to provide a broad spectrum of care. The CHA/P Program forms the primary care backbone of the Alaska Tribal Health System, allowing patients to access care within their village.[12] A previous study demonstrated that images of the TM taken under ideal circumstances in post-TT patient are comparable to an in-person examination.[13] In that study, however, images were not taken at the village clinic and were not taken by CHA/Ps.

In this study, we examined the level of concordance between an in-person encounter and images taken in the "real-world" clinical setting—where images of the TM were taken by CHA/Ps in remote village clinics from patients following TT placement. The purpose was to determine if the telehealth encounter and images obtained under these conditions (and sent to an otolaryngologist) are comparable to an in-person examination by an otolaryngologist.

METHODS

This study was conducted in partnership between the Alaska Native Tribal Health Consortium (ANTHC) in Anchorage and Maniilaq Association in Kotzebue, Alaska. The study was approved by the Indian Health Service Alaska Area and National Indian Health Service institutional review boards. Patients who had TT placement during the prior two years were identified from ANMC operating room logs. Thirty-five patients from nine Maniilaq villages consented to participate.

CHA/Ps at the nine village clinics received video-otoscopy and telehealth software training two to six weeks prior to seeing the patients. On the day of the visit, CHA/Ps obtained a history from the parent, examined the patients' ears, and obtained TM images using a video otoscope and AFHCAN telehealth software. Regardless of obstructing cerumen or difficult patient exam, images were obtained for all 70 ears. The video otoscope consisted of AMD/Welch Allyn 300S imaging and illumination platform with Solarc lamp, fiber optic bundle, camera cable, camera head, c-mount 45-mm optical coupler (AMD 2450), and otoscope ENT probe (AMD 2015) (AMD Telemedicine, North Chelmsford, MA). The NTSC S-video output from the video otoscope was connected to an Integral Technologies FlashBus MV Pro video capture board (Pelco, Clovis, CA), from which still images were captured of individual video frames. Images were saved as 24-bit color JPEG visually lossless images with 640 × 480-pixel resolution, and compressed at 13:1 ratio.

One to seven days following the CHA/P visit, participants were flown to Maniilaq Health Center in Kotzebue for a one-day otolaryngology clinic, hereafter referred to as $Exam_0$. Two board-certified otolaryngologists used a Zeiss otology microscope (Carl Zeiss Meditec, Dublin, CA) to examine each participant independently in separate rooms. During this in-person examination, each otolaryngologist documented physical exam, assessment, and plan using a follow-up form. The physical exam portion of the form listed: "Tube in the TM," "Tube patent," "Drainage," "Perforation," "Granulation tissue," "Fluid in middle ear," "Retracted TM," and "Other," and otolaryngologists selected all that applied to each ear. The assessment portion of the form listed: "Intact and functional tube," "Nonfunctional tube," "Tube extruded/normal TM," "Perforation and dry," "Perforation and draining," "Otitis media," and "Retracted TM," and otolaryngologists selected one assessment for each ear.

Otolaryngologists reviewed images for all 70 ears at 8 weeks ($Review_1$) and 14 weeks ($Review_2$) after the in-person examination. A delay was introduced between the in-person exam and the subsequent image review to reduce possible bias caused by recollection of the in-person exam. AFHCAN telehealth software was used to display images on Viewsonic VP150m LCD monitors. Basic historical information, including dates of TT placement and significant postsurgical events, was available to the otolaryngologists at the time of image review. Otolaryngologists used the same follow-up form to document the physical exam and assessment based on their interpretations of digital images. They also rated image quality from "excellent" to "very poor" using a Likert scale.

Data analysis included examination of interprovider and intraprovider concordance. Interprovider concordance is a comparison of results between the two different otolaryngologists. This was calculated comparing the otolaryngologists' results for the in-person examination ($Exam_0$) and also for their interpretation of images ($Review_1$ and $Review_2$). The interprovider concordance during $Exam_0$ is a critical measurement, and is often used throughout this paper as a benchmark or gold standard to compare with other agreement rates obtained. Intraprovider concordance is a comparison of a single physician's results from two different points in time. For example, intraprovider concordance was calculated for $Exam_0$ vs $Review_1$, $Exam_0$ vs $Review_2$, and $Review_1$ vs $Review_2$. In some instances, data from the two image review sessions ($Review_1$ and $Review_2$) were aggregated and reported as $Review_{1,2}$.

Concordance is a measure of how often results match and indicates percentage of agreement. Kappa statistic (κ) was used to quantify "strength of agreement" based upon the range in which kappa statistic matches: "poor agreement" ($\kappa = 0.00$), "slight agreement" ($\kappa = 0.01–0.20$), "fair agreement" ($\kappa = 0.21–0.40$), "moderate agreement" ($\kappa = 0.41–0.60$), "substantial agreement" ($\kappa = 0.61–0.80$), "almost-perfect agreement" ($\kappa = 0.81–1.00$).[14]

RESULTS

Participation and image quality

Participants included 35 Alaska Natives age 1 to 16 years (Table 1). Otolaryngologists each examined both ears on 35 patients at $Exam_0$, resulting in 70 in-person evaluations per otolaryngologist. At both $Review_1$ and $Review_2$, 70 sets of images (one set per ear) were evaluated by each

Table 1
Patient age distribution and overall image quality

Patient age	Number of patients	Image sets rated "poor" or "very poor"	Image sets rated "adequate" or better
1 y	6 (17%)	9 (19%)	39 (81%)
2 y	9 (26%)	30 (42%)	42 (58%)
3 y	5 (14%)	7 (17.5%)	33 (82.5%)
4-5 y	5 (14%)	0 (0%)	40 (100%)
6-8 y	4 (11%)	5 (16%)	27 (84%)
9-12 y	5 (14%)	9 (22.5%)	31 (77.5%)
13-16 y	1 (3%)	0 (0%)	8 (100%)
Total	35 (100%)	60 (21%)	220 (79%)

otolaryngologist, for a total of 140 sets of images per review. Most image sets contained two images (54%) or three images (31%), although up to six images were captured for one ear.

Image quality ratings during $Review_1$ and $Review_2$ revealed 79 percent image sets rated "adequate" or better when results of all 280 image reviews were combined ($Review_{1,2}$). Provider "AA" rated 44 (31%) image sets as "poor" or "very poor" during $Review_1$ and $Review_2$ compared to 16 (11%) image sets for provider "BB." The age of the patient had an impact on the ability to obtain quality images, as shown in Table 1. Forty-two percent of all image sets taken for two-year-olds were rated "poor" or "very poor." And while two-year-olds accounted for 26 percent of the participants, they represented 50 percent of all "poor" or "very poor" image sets (30 out of 60).

Physical examination findings

The otolaryngologists independently recorded physical findings during the in-person patient encounter ($Exam_0$). The combined distribution for these findings (indicated by a "Yes" on the physical examination form) for both otolaryngologists examining 70 ears (hence, 140 exams) were as follows: Tube in, 72 (51%); Tube patent, 70 (50%); Drainage, 3 (2%); Perforation, 20 (14%); Granulation, 2 (1%); Middle ear fluid, 7 (5%); Retracted, 17 (12%).

Otolaryngologists exhibited a high level of interprovider agreement on physical exam findings during $Exam_0$, ranging from 90 percent to 99 percent depending on the specific finding (Table 2). The corresponding kappa statistic indicates that the agreement was "moderate" or better ($\kappa > 0.4$). The kappa statistic indicated "almost-perfect agreement" ($\kappa > 0.8$) for the three most common findings ("Tube in," "Tube patent," and "Perforation"), with correspondingly lower values on findings with lower frequency. Note that high concordance can be associated with small kappa values (see "Drainage" in Table 2) when a given finding occurs as a small percentage.

Otolaryngologists also exhibited a high level of interprovider agreement on physical exam findings during image reviews at 8 and 14 weeks ($Review_1$ and $Review_2$) (Table 2). Generally, the otolaryngologists agreed with each other in these findings 87 percent to 100 percent of the time when viewing image sets. For most exam findings, the kappa statistic indicated that the strength of the agreement was similar to that found during the in-person examination ($Exam_0$).

For each otolaryngologist, the physical findings at $Exam_0$ were compared to those at $Review_1$, $Review_2$, and the combined $Review_{1,2}$ (Table 2). This intraprovider comparison measures how much one otolaryngologist's in-person exam agrees with his image review. Otolaryngologists exhibited a

Table 2
Kappa values (κ) and percent concordance for physical examination findings*

	Tube in	Tube patent	Drainage	Perforation	Granulation	Middle ear fluid	Retracted
Interprovider AA vs BB							
$Exam_0$	0.97 (99%)	0.97 (99%)	0.49 (97%)	0.83 (96%)	0.66 (99%)	0.47 (94%)	0.58 (90%)
$Review_1$	0.94 (97%)	0.91 (96%)	−0.02 (94%)	0.75 (94%)	1.00 (100%)	0.45 (87%)	0.67 (93%)
$Review_2$	0.89 (94%)	0.86 (93%)	0.21 (91%)	0.82 (96%)	0.66 (99%)	0.72 (94%)	0.63 (93%)
$Review_{1,2}$	0.91 (96%)	0.89 (94%)	0.13 (93%)	0.78 (95%)	0.80 (99%)	0.58 (91%)	0.65 (93%)
Intraprovider for provider AA							
$Exam_0$ vs $Review_1$	0.94 (97%)	0.94 (97%)	−0.04 (93%)	0.75 (94%)	1.00 (100%)	0.28 (89%)	0.58 (91%)
$Exam_0$ vs $Review_2$	0.91 (96%)	0.89 (94%)	−0.04 (90%)	0.82 (96%)	1.00 (100%)	0.71 (96%)	0.58 (91%)
$Review_1$ vs $Review_2$	0.91 (96%)	0.89 (94%)	0.74 (97%)	0.93 (99%)	1.00 (100%)	0.48 (90%)	0.87 (97%)
Intraprovider for provider BB							
$Exam_0$ vs $Review_1$	0.92 (96%)	0.94 (97%)	−0.01 (96%)	0.61 (90%)	0.66 (99%)	0.28 (86%)	0.32 (83%)
$Exam_0$ vs $Review_2$	0.89 (94%)	0.94 (97%)	0.38 (96%)	0.61 (90%)	0.49 (97%)	0.34 (89%)	0.26 (83%)
$Review_1$ vs $Review_2$	0.97 (99%)	1.00 (100%)	−0.02 (94%)	0.88 (97%)	0.66 (99%)	0.65 (91%)	0.53 (91%)

*Kappa values are shown (with percent concordance in parenthesis) for all physical examination findings associated with inter-provider and intraprovider comparisons.

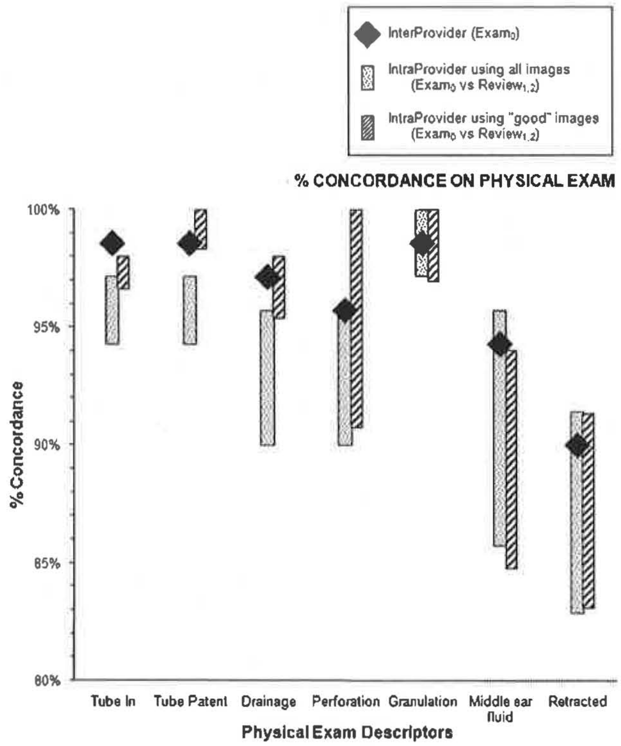

Figure 1 Physical exam agreement. Ranges on the concordance levels for physical exam findings for both interprovider and intraprovider comparisons. The *black diamonds* indicate the percent concordance between providers during the in-person exam ($Exam_0$). The *speckled bar* indicates the range of concordance for individual otolaryngologists (intraprovider) between their descriptors at $Exam_0$ and their descriptors during the image review ($Review_1$ and $Review_2$). The *range* of these *bars* represents the minimum and maximum of four values (two otolaryngologists each with $Exam_0$ vs $Review_1$ and $Exam_0$ vs $Review_2$) provided in Table 2. The *diagonally-striped bars* represent a similar min/max range for intraprovider concordance once ears were removed from consideration, for which the image sets were rated as having "poor" or "very poor" image quality.

high level of concordance between the in-person physical exam findings and corresponding image reviews. This was true for both $Review_1$ and $Review_2$, suggesting that the six-week interval between the two image reviews had little impact on the results.

The ranges of intraprovider concordance approximated the "gold standard" of the interprovider concordance at $Exam_0$. This is shown graphically in Figure 1. The interprovider concordance at $Exam_0$, represented by the diamond symbols, is shown in comparison to the range of intraprovider concordance, represented by the bars. Concordance increased when "poor"- and "very poor"-quality images were removed, as shown by the striped range bars. This approximates the clinical setting where a provider would reject poor-quality images as being of insufficient quality to make a patient care decision.

Assessment findings

The otolaryngologists independently recorded a single assessment for each ear during the in-person patient encounter ($Exam_0$). The combined distribution for these findings for both otolaryngologists examining 70 ears (hence, 140 exams) was as follows: Intact & functional tube, 70 (50%); Nonfunctional tube, 2 (1%); Tube extruded/normal TM, 32 (23%); Perforation, dry, 17 (12%); Perforation, draining, 3 (2%); Otitis media, 6 (4%); Retracted TM, 10 (7%).

At $Exam_0$ there was an 89 percent interprovider concordance on the assessment using the in-person exam, with an associated kappa value (0.83) indicating "almost-perfect agreement" (see Table 3). Interprovider concordance for image reviews was 79 percent to 80 percent and improved to 85 percent to 92 percent when the analysis was restricted to "adequate" or better image sets. Similarly, intraprovider concordance was 76 percent to 89 percent and improved to 77 percent to 91 percent with the higher-quality images.

The clinical significance of assessment concordance requires an analysis of the specific areas of agreement and disagreement (Tables 4 through 6). During $Exam_0$, the otolaryngologists had complete agreement on the assessment for 62 of the 70 ears, shown by the numbers on the diagonal of the matrix (Table 4). There were eight ears lacking agreement (off diagonal cells); seven of these discordant outliers had one of the otolaryngologists selecting "Retracted TM" or "Tube extruded and normal TM." The interprovider image $Review_{1,2}$ showed high concordance along the main diagonal (Table 5), but 81 percent discordant outliers was accounted through one of the otolaryngologists selecting "Retracted TM" or "Tube extruded and normal TM." When the image analysis was restricted to "adequate" or better images, there were fewer outliers, but 9 of the 11 were still "Retracted TM" or "Tube extruded and normal TM" (Table 6).

Table 3
Kappa values (κ) and percent concordance for assessment

Interprovider	All images	"Adequate" or better images
Interprovider		
$Exam_0$	0.83* (89%)	
$Review_1$	0.69 (79%)	0.78 (85%)
$Review_2$	0.71 (80%)	0.78 (92%)
$Review_{1,2}$	0.70 (79%)	0.83 (89%)
Intraprovider for provider AA		
$Exam_0$ vs $Review_1$	0.66 (77%)	0.75 (83%)
$Exam_0$ vs $Review_2$	0.71 (80%)	0.81 (88%)
$Review_1$ vs $Review_2$	0.75 (83%)	0.87 (91%)
Intraprovider for provider BB		
$Exam_0$ vs $Review_1$	0.66 (77%)	0.70 (80%)
$Exam_0$ vs $Review_2$	0.64 (76%)	0.66 (77%)
$Review_1$ vs $Review_2$	0.83 (89%)	0.85 (90%)

*Images were not involved in the interprovider comparison at $Exam_0$, so the results are shown as a single column.

Table 4
Agreement and outliers for assessment: results for in-person exam ($Exam_0$)*

$Exam_0$ — Agreement: 89% — Kappa: 0.83

		AA assessment							
		Intact & functional tube	Nonfunctional tube	Otitis media	Perforation, draining	Perforation, dry	Retracted TM	Tube extruded/normal TM	
BB assessment	Intact & functional tube	**35**	0	0	0	0	0	0	35
	Nonfunctional tube	0	**1**	0	0	0	0	0	1
	Otitis media	0	0	**1**	0	0	2	0	3
	Perforation, draining	0	0	0	**1**	0	0	0	1
	Perforation, dry	0	0	0	1	**7**	0	1	9
	Retracted TM	0	0	1	0	0	**3**	1	5
	Tube extruded/normal TM	0	0	1	0	1	0	**14**	16
		35	1	3	2	8	5	16	70

*Table demonstrates the distribution of interprovider concordance. Values on the diagonal (in bold) indicate the number of ears with full concordance between the two otolaryngologists.

Table 5
Agreement and outliers for assessment: results for all image reviews ($Review_{1,2}$)*

$Review_{1,2}$ — Agreement: 79% — Kappa: 0.70

		AA Assessment							
		Intact & functional tube	Nonfunctional tube	Otitis media	Perforation, draining	Perforation, dry	Retracted TM	Tube extruded/normal TM	
BB assessment	Intact & functional tube	**66**	1	2	1	0	0	2	72
	Nonfunctional tube	2	**2**	0	0	0	0	1	5
	Otitis media	0	0	**7**	0	1	7	1	16
	Perforation, draining	0	0	0	**0**	1	0	1	2
	Perforation, dry	0	0	2	0	**12**	0	2	16
	Retracted TM	0	0	0	0	0	**2**	1	3
	Tube extruded/normal TM	0	0	0	1	0	3	**22**	26
		68	3	11	2	14	12	30	140

*Table demonstrates the distribution of interprovider concordance. Values on the diagonal (in bold) indicate the number of ears with full concordance between the two otolaryngologists.

Table 6
Agreement and outliers for assessment: results for reviews ($Review_{1,2}$) restricted to image sets rated "adequate" or better*

$Review_{1,2}$ (With adequate or better images only)	AA assessment: Intact & functional tube	Nonfunctional tube	Otitis media	Perforation, draining	Perforation, dry	Retracted TM	Tube extruded/normal TM		Agreement: 89%; Kappa: 0.83
BB assessment: Intact & functional tube	**50**	0	0	0	0	0	0	50	
Nonfunctional tube	0	**2**	0	0	0	0	0	2	
Otitis media	0	0	**7**	0	1	5	1	14	
Perforation, draining	0	0	0	**0**	1	0	0	1	
Perforation, dry	0	0	0	0	**9**	0	0	9	
Retracted TM	0	0	0	0	0	**2**	1	3	
Tube extruded/normal TM	0	0	0	0	0	2	**15**	17	
	50	2	7	0	11	9	17	96	

*Table demonstrates the distribution of interprovider concordance. Values on the diagonal (in bold) indicate the number of ears with full concordance between the two otolaryngologists.

DISCUSSION

This study evaluated an actual practice environment using store-and-forward telemedicine with lay health workers taking images of the tympanic membrane, without the benefit of an operating microscope to clean the ear canal prior to imaging. Surprisingly, 79 percent of images were considered to be "adequate" or better, demonstrating that CHA/Ps can be trained in video-otoscopy to capture quality images. In addition, cerumen and debris did not cause a large number of images to be discarded. This confirms our personal experience that the 2.7-mm tip of the Welch Allyn video-otoscope can usually be steered past obstacles in the external auditory canal until a full view of the TM is obtained.

There was a high level of concordance between the image reviews and the in-person encounters for physical exam findings and assessment, reassuring the practice of remote image acquisition and otolaryngology review. Concordance improved when the image review was limited to "adequate" or better images. Simply put, with a quality image, an otolaryngologist can accurately examine and assess the tympanic membrane. Poor-quality images are easily identifiable, and it is important to notify the sender that they are inadequate for making clinical decisions. In our experience, a specialist using images for TT follow-up can readily determine those cases where the store-and-forward modality is not appropriate for diagnosis and when an in-person evaluation must be performed. Two-year-olds were most difficult to obtain a quality image, an area that needs improvement.

Occasionally, the assessment of the in-person examination differed from the image review. Providers agreed on the in-person assessments on 62 of the 70 cases (Table 4), and the image review matched the in-person assessment in 42 of these cases. This left 20 cases in which the assessments from one or more of the four image review sessions did not match the in-person assessments. Images from these 20 cases were reexamined to understand any clinical implications.

Four cases (20%) had agreement between providers on image assessment that was different from assessments at $Exam_0$. Three cases can be explained by changes to the TM that may have occurred during the one- to seven-day interval between the acquisition of the images by the CHA/Ps and in-person exam by the otolaryngologists: a retracted TM had normalized, and in two instances a normal TM had become retracted or developed OM. The physical status of the ear can change substantially over a one-week period—especially when air travel occurs in a nonpressurized small plane. In the fourth case, a tube judged at $Exam_0$ to be extruded with a normal TM was thought on image review to be still within the TM yet blocked and nonfunctional. The lack of depth perception sometimes apparent with image review as compared with binocular microscope examination may account for lack of agreement in this case.

For the remaining 16 cases, assessments during the four image reviews were not unanimous, and at least one was different from the assessments during in-person examination. Poor focus leading to poor image quality made accurate assessment of images difficult or impossible in 11 cases. Cerumen or debris obstructing the view of critical areas affected the ability to provide an accurate assessment in four cases. Subtle differences in position of the TM and question of retraction led to differences in the image assessment in one case. Overall, the differences in assessment for these cases can be attributed to poor image quality and would normally have been retaken upon request from the consulting otolaryngologist.

Providers disagreed on some cases as to whether a TM was normal or retracted—during both in-person examinations and image reviews. It can be difficult to make this judgment when the degree of retraction is subtle, even when using a binocular microscope. Subtle findings such as mild retraction or rotation of the malleus may be apparent only when the image quality is of highest order. Tympanometry was not employed as part of this study and may have been helpful for difficult cases such as retracted TMs, small perforations, and TT patency.

CONCLUSION

Quality digital images of the TM after TT placement obtained by a trained health aide in a rural setting are comparable to an in-person microscopic exam. Store-and-forward video-otoscopy can be used for TT follow-up in those settings where the patient is remotely located from the specialist. There are several challenges in delivering specialty care to rural Alaskans. These patients are geographically separated from medical centers, and travel is expensive and, at times, dangerous. For these reasons, we are interested in developing models for improving the delivery of specialty care; utilizing telemedicine technologies is one way to accomplish this goal. Store-and-forward telemedicine using video otoscope images has several attractive features. The image documents the pathology, and transmission requires little bandwidth and is asynchronous, maximizing efficiency of the consultant. Video-otoscopy is a technical skill that can be taught to providers with various backgrounds and training. Finally, the nature of TM and middle ear pathology lends itself to diagnosis, triage, and treatment based on interpretation of images by an experienced otolaryngologist.

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REFERENCES

1. Rosenfeld RM, Culpepper L, Doyle KJ, et al. Clinical practice guideline: otitis media with effusion. Otolaryngol Head Neck Surg 2004; 130:S95–118.
2. Owings MF, Kozak LJ. Ambulatory and inpatient procedures in the United States, 1996. National Center for Health Statistics. Vital Health Stat 13 1998;139:1–119.
3. Cunningham MJ, Darrow DH, Goldstein MN. Follow-up management of children with tympanostomy tubes. Pediatrics 2002;109(2):328–9.
4. Derkay CS, Carron JD, Wiatrak BJ, et al. Postsurgical follow-up of children with tympanostomy tubes: results of the American Academy of Otolaryngology–Head and Neck Surgery Pediatric Otolaryngology Committee National Survey. Otolaryngol Head Neck Surg 2000;122:313–8.
5. Hamman C, Keeler F. Eye, ear, nose and throat infections in Natives of Alaska. Northwest Med 1957;56:423.
6. The McGroth Report: A documentation on the study and prevention of upper respiratory disease. Washington DC: State of Alaska, U.S. Government Printing Office; 1962.
7. Baxter JD. Otitis media in Inuit children in the Eastern Canadian Arctic—an overview—1968 to date. Int J Pediatr Otorhinolaryngol 1999;49(Suppl 1): S165–8.
8. Bruneau S, Ayukawa H, Proulx JF, et al. Longitudinal observations (1987-1997) on the prevalence of middle ear disease and associated risk factors among Inuit children of Inukjuak, Nunavik, Quebec, Canada. Int J Circumpolar Health 2001 Nov;60(4):632–9.
9. Hodgins S. Health and well-being challenges in Nunavik: health conditions, determinants, and lines of action. Kuujjuaq (QC): Department of Public Health, Nunavik Regional Board of Health and Social Services; 1996.
10. Middaugh J, Ryan C, Metzler C, et al. Otitis media and hearing impairment among selected racial groups in Alaska. Anchorage: Epidemiology Office, Division of Public Health, State of Alaska; 1983.
11. Singleton RJ, Holman RC, Plant RL, et al. Otitis media outpatient visits and tympanostomy tube placement rates in young American Indian and Alaska Native children: what are the trends? Abstract in: 2nd International Meeting on Indigenous Child Health. April 20-22, 2007, Montreal, Canada.
12. Community Health Aide/Practitioner Manual, 2006 Edition. Community Health Aide Program, Anchorage: Alaska Native Area Native Health Corporation.
13. Patricoski C, Kokesh J, Ferguson S, et al. A comparison of in-person examination and video otoscope imaging for tympanostomy tube follow-up. Telemed J E Health 2003;9(4):331–44.
14. Landis JR, Koch GG. The measure of observer agreement for categorical data. Biometrics 1977;33(1):159–74.