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ORIGINAL RESEARCH–OTOLOGY AND NEUROTOLOGY

Preoperative planning for ear surgery using store-and-forward telemedicine

John Kokesh, MD, A. Stewart Ferguson, PhD, and **Chris Patricoski, MD,** Anchorage, AK

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ABSTRACT

OBJECTIVE: To determine if store-and-forward telemedicine can be used to accurately plan ear surgery.

STUDY DESIGN: Case series with chart review.

SETTING: Tertiary care hospital.

SUBJECTS AND METHODS: Charts were reviewed for elective major ear surgeries resulting from telemedicine referrals during a 13-month period. The store-and-forward telemedicine referrals (electronic consultations) included clinical history, digital images, and audiology data. Consultants reviewed each telemedicine case and documented the recommended surgery and estimated operative time. These charts were matched with patients seen in person during a standard evaluation and had identical surgeries recommended. For the telemedicine evaluation and in-person evaluation groups, the recommended surgeries were compared with actual surgeries performed and the estimated time was compared with the actual operative time.

RESULTS: Forty-five ear surgeries were recommended by the telemedicine evaluation and were matched with 45 surgeries from the standard evaluation and included tympanoplasty with or without canalplasty, mastoidectomy, stapes surgery, and myringoplasty. Telemedicine and in-person evaluation accurately predicted the surgery 89 percent and 84 percent of the time, respectively. The average difference of "actual time" and "estimated time" for the actual surgical procedures performed was not statistically different between the two groups: 32 minutes for the telemedicine evaluation group and 35 minutes for the in-person evaluation group.

CONCLUSION: Store-and-forward telemedicine is as effective as in-person evaluation for planning elective major ear surgery.

Video-otoscopy has been shown to be useful for diagnosing and treating diseases of the middle ear and tympanic membrane (TM).[1-3] Physician review of video-otoscope images correlates closely with binocular microscopic examination of the TM for certain pathologic states.[4] In Alaska, significant experience has been gained in the use of transmitted TM images for managing remotely located patients with ear disease. Store-and-forward telemedicine consisting of digitized images, clinical histories, and audiograms is now used extensively for evaluation and follow-up of patients with otitis media, TM perforations, tympanostomy tubes, hearing loss and hearing aid medical clearance.[5,6]

The otolaryngologists at Alaska Native Medical Center (ANMC) in Anchorage, Alaska, have gained confidence using store-and-forward telemedicine to diagnose and plan therapy for a wide range of otologic conditions, including those for which major reconstructive ear surgery is required. It has become common practice to schedule a patient for major ear surgery based solely on the information contained in the store-and-forward telemedicine case, with the initial in-person encounter occurring on the day prior to surgery during the preoperative visit. The advantage of this process is that the patient no longer travels to see the specialist for an initial consultation that precedes the date of elective surgery. This stands in contrast to the traditional practice of using the in-person consultation with the surgeon to determine whether surgery is indicated, to be followed by a second visit with its attendant travel to actually have the procedure. While some patients are able to drive to Anchorage for specialty care, most need to fly, at a cost of $200 to $1200 per person. Telemedicine has the potential to reduce the time, risk, and cost associated with expensive travel. It is important to know if store-and-forward telemedicine leads to accurate surgical planning.

The purpose of this study is to determine if store-and-forward telemedicine is useful for preoperative planning of major ear surgery. The study evaluates if telemedicine can accurately predict the surgical procedure indicated and estimates the operative time needed for the procedure, compared to the standard face-to-face evaluation.

Methods

Using the computerized surgery scheduling system, patients were identified who had major elective ear surgery over a 13-month period resulting from telemedicine referrals. Major ear surgery was considered to be tympanoplasty, tympanoplasty with canalplasty, mastoidectomy, stapedectomy, or sta-

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pedotomy and myringoplasty. Tympanostomy tube placement was not considered to be major ear surgery, and those cases were not included in this analysis. For the "telemedicine" evaluation group (TM-EVAL), charts were identified of patients who had been referred for major ear surgery based on a store-and-forward telemedicine review. These charts were matched with an "in-person" evaluation group (IP-EVAL), i.e., charts of patients who were referred for identical surgeries based on a typical in-person ENT evaluation. The "in-person" charts were selected solely on the basis of same intended surgery; other criteria such as age or gender were not considered, although the patients tended to be age matched based on the specific surgical procedure.

The store-and-forward telemedicine cases were originated by midlevel providers, physicians, and audiologists in rural and remote Alaska. Using established protocols, the store-and-forward telemedicine cases included images of both TMs, a focused clinical history (including general health status and ear and hearing problems), audiogram, tympanogram, and any additional information that the referring provider thought relevant. The platform for the cases was the AFHCAN tConsult software (Fig 1). TM images were obtained using an AMD/Welch Allyn 300S Imaging and Illumination Platform (AMD Global Telemedicine, Inc., North Chelmsford, MA). Images were saved and subsequently transmitted as 24-bit color JPEG visually lossless images with 640 × 480-pixel resolution and typically compressed at a 13:1 ratio. Clinical histories were keyboarded as free text directly into the telemedicine software, and audiograms and other documents were scanned in and added as attachments.

All telemedicine cases were reviewed by one of seven staff otolaryngologists, who requested additional images or information from the referring provider as needed. The reviewing otolaryngologist documented the operation to be performed ("planned surgical procedure") as well as the "planned surgical time" and the need for ancillary studies (computed tomography [CT] scan, magnetic resonance imaging [MRI], repeat audiogram, consultation with other specialties). As per standard hospital protocol, operative times were estimated in increments of 30 minutes. Recommendations for surgery were communicated to the patient, and a date for elective surgery was established, taking into account patient preference and schedule availability.

All patients were seen in person on the business day prior to scheduled surgery for a standard "preoperative" evaluation. The patient's history was reviewed and examination repeated, including examination of the ears using a binocular operating microscope. Audiogram and tympanograms were reviewed, as were any ancillary studies such as CT or MRI scans. Informed consent was obtained. Surgery was performed on the following business day.

The "actual surgery performed" and the "actual surgical time" were recorded at the time of the procedure. Surgical time was defined as beginning when the patient entered the operating suite and ending when the patient was transported from the operating suite. The surgeon who reviewed the telemedicine case performed the preoperative assessment and the subsequent surgery. This study was approved by the Alaska Native Medical Center Human Research and Review Committee.

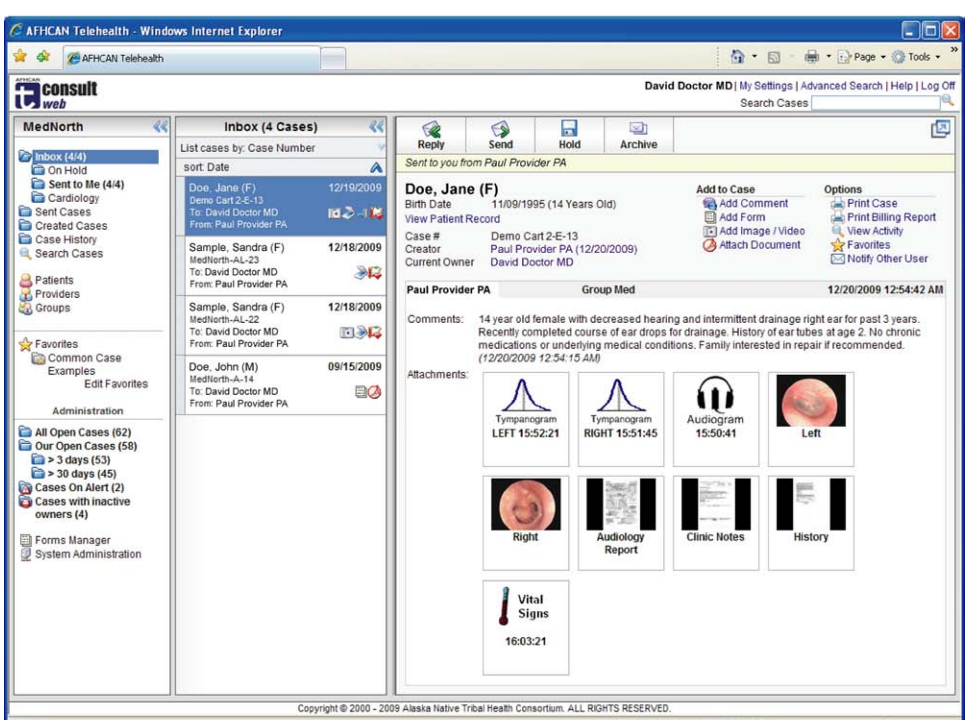

Figure 1 An example of the software screen used by ENT specialists to review a telemedicine case. (Sample page with fictitious names and data.)

Table 1
Analysis of the surgical procedures that did not match the planned surgical procedure

Planned surgical procedure	Actual surgery performed	IP-EVAL	TM-EVAL	Grand total
Tympanoplasty	Tympanoplasty, adenoidectomy	1	1	2
	Tympanoplasty, canalplasty	2	2	4
	Tympanoplasty, excise facial nevus	1	1	2
Tympanoplasty, canalplasty	Tympanoplasty	1		1
Tympanoplasty, mastoidectomy	Tympanoplasty	1	1	2
Tympanoplasty, myringoplasty	Tympanoplasty	1		1
Total		7	5	12

IP-EVAL,"in-person" evaluation group; *TM-EVAL*, "telemedicine" evaluation group.

Results

Forty-five patients were indentified who had TM-EVAL. These were matched against 45 patients with IP-EVAL, based on identical planned surgical procedures. Together, the total number of 90 planned surgical procedures included: tympanoplasty, 62 (69%); tympanoplasty and canalplasty, 10 (11%); tympanoplasty and mastoidectomy, six (7%); stapedectomy, four (4%); fat myringoplasty, four (4%); revision mastoidectomy, two (2%); and tympanoplasty and myringoplasty, two (2%). The distribution of patient ages was similar for both groups, with a predominance of young adults. The TM-EVAL group had a median age of 13 and mean age of 20, and patients ranged in age from five to 62 years old. The IP-EVAL group had a median age of 12 and mean age of 20, and patients ranged in age from six to 66 years old.

The actual surgical procedure matched the planned surgical procedure for 40 of the 45 patients (89%) referred through telemedicine, compared to 38 of the 45 patients (84%) referred through in-person visits. The mismatches between planned and actual surgical procedures are shown in Table 1 for both TM-EVAL and IP-EVAL groups. The most common disparity between the surgery scheduled and that eventually done was due to the addition of a canalplasty or, alternatively, to the failure to perform a canalplasty when one was originally scheduled.

The distribution of planned surgical times for each type of surgery are shown in Figure 2. In general, the planned time for surgical procedures correlated well with the type of procedure, with little difference between the TM-EVAL and IP-EVAL group. Surgeries in which only a tympanoplasty was planned had the greatest range in planned surgical time, ranging from 1.5 hours to four hours. Tympanoplasty and canalplasty had a smaller range of times, from 2.5 to 3.5 hours.

Despite the variations in planned surgical time, the actual times for surgery closely matched the planned time for most patients (Fig 3). Values in the right half of the plot represent cases that took longer than planned (42% of telemedicine cases and 47% of in-person cases); values in the left half represent cases that took less time than planned (58% of telemedicine cases and 53% of in-person cases). The majority of all surgeries were performed within 30 minutes of

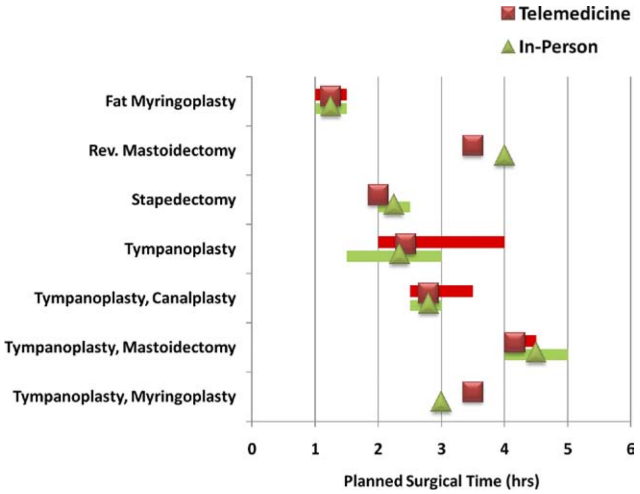

Figure 2 Average planned time for surgical procedures based on telemedicine referrals (*squares*) and in-person referrals (*triangles*); *range bars* indicate minimum to maximum time planned for each.

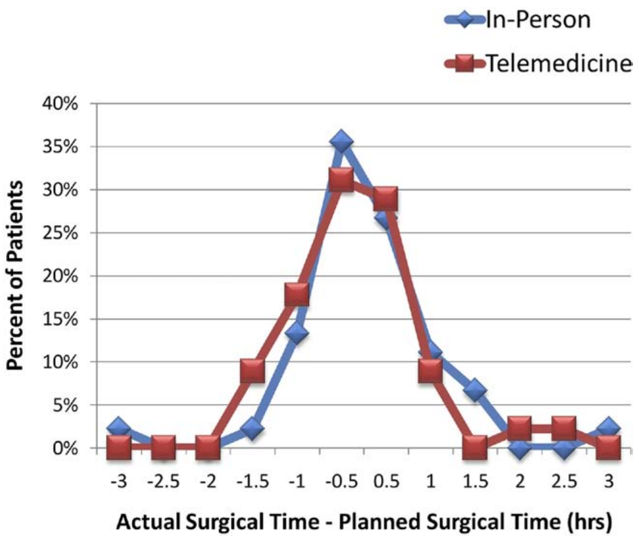

Figure 3 Difference of actual surgical time minus planned surgical time for telemedicine and in-person cases. The majority of surgeries were performed within 30 minutes of planned time.

the planned time (60% for TM-EVAL, 62% for IP-EVAL). The average deviation from the planned surgical time was 32 minutes for TM-EVAL and 35 minutes for IP-EVAL. The median deviation was 25 minutes for both groups. An F test revealed no significant differences between the variances of the difference in surgical times ($F = 0.39$). A two-tailed unpaired t test assuming equal variances revealed no significant differences between the means of the differences in surgical times ($t = 0.64$).

It is possible that variations in the surgical time or complexity of the surgical procedure could be explained through delays between the date when the patient is evaluated and the date when surgery is performed. However, the average time between evaluation and surgery for the TM-EVAL group (137 days) was not statistically different from the IP-EVAL group (124 days), as measured using a two-tailed unpaired t test assuming unequal variances ($t = 0.58$). Similarly, the median time between evaluation and surgery was similar for the two groups: 98 days for the TM-EVAL group compared to 79 days for the IP-EVAL group.

Discussion

This study reviewed our experience in using store-and-forward telemedicine (electronic consultation) as a means to evaluate patients in need of otologic surgery. The results confirm the consensus within our practice that for selected cases, an appropriately created store-and-forward telemedicine case can be used to accurately determine the indicated otologic procedure and required surgical time; and that the accuracy is comparable to when similar decisions are made during a standard in-person encounter. This supports the practice of physicians using telemedicine to preoperatively assess patients and prevent the cost and time associated with traveling to see the physician. The results show that for the cases presented, the combination of digital images, clinical history, and audiometric data led to accurate surgical scheduling and time estimates. Others have documented the utility of store-and-forward telemedicine in diagnosing and creating treatment plans for patients with otologic disorders.[7] Eikelboom noted that with regard to otologic disease, "images, together with audiometric and tympanometric data and clinical history, are usually sufficient for the clinician to make a diagnosis and decide a treatment plan."[8] To our knowledge, this is the first study to look at telemedicine use for otologic surgical planning accuracy. This is especially important because the surgical suite is one of the most costly functional areas of the hospital, and as a cost center it must be scheduled and run efficiently for the financial viability of the organization.

It was not surprising that tympanoplasty was the most common major ear surgery scheduled and performed in the both the TM-EVAL and IP-EVAL groups. Due to the high prevalence of acute otitis media and chronic suppurative otitis media seen in Alaska Native populations,[9] chronic TM perforation is the most common indication for major ear surgery seen in our practice. It was also in keeping with our experience that the addition of a canalplasty was the most common reason for the performed surgery to vary from that scheduled. The decision to perform a canalplasty, the widening of the ear canal to improve the surgical exposure of the TM, is frequently made intraoperatively. As a canalplasty generally adds about 20 minutes to a procedure, the inability to predict in all cases when it will be needed is not of great significance from a scheduling or utilization standpoint.

One factor that could affect scheduled versus actual operative times is the time interval between the patient assessment, whether by telemedicine or face-to-face encounter, and surgery itself. Like any other disease process, ear disease changes with time; and the longer the time interval between the patient assessment and decision for surgery and the actual surgery date, the more likely the situation with the ear will have changed and an adjustment in the surgical plan may be required. For example, the simple, dry TM perforation treatable with a tympanoplasty may evolve into an intractably draining ear requiring tympanoplasty and mastoidectomy. The data suggest that the time delay between evaluation and surgical intervention does not depend on the type of evaluation (telemedicine vs in-person) and does not correlate to differences in the surgical procedure or surgical time.

There are several limitations of this study related to its design. This study was retrospective, and the construction of the comparison group was based only on one characteristic (the surgery scheduled). Operative times were estimated in increments of 30 minutes; actual operative times were measured to the minute. While this created a situation where it was quite difficult for the estimated surgical time to exactly match the actual surgical time, it did serve the purpose of determining whether there were gross inaccuracies in estimated surgical times of the type that cause problems in a busy operating room. Finally, this study did not consider the clinical outcomes of the surgeries performed, although there were no obvious discrepancies in outcome.

In practice, store-and-forward telemedicine is an effective triage tool for the otologic surgeon. It allows the surgeon to determine which patients may be directly scheduled for surgery or, alternatively, which patients would benefit from an office appointment before any decisions regarding surgery are made. It is in the latter group that a more detailed history, additional ancillary testing, and a hands-on examination, including an ear examination with a binocular microscope, is critical in developing a treatment plan. The great strength of store-and-forward telemedicine as used in our circumstance is that it allows the surgeon to choose the most appropriate route for the patient: a direct route to surgery for those with straightforward surgical problems, or a more deliberate route for those requiring the more detailed evaluation that can only be obtained from a face-to-face encounter. However, store-and-forward telemedicine is highly dependent on the diligence of the referring provider to create a quality case. It requires that data be thoughtfully considered and organized before it is "packaged" for presentation to the specialist, thereby maximizing the efficiency of the specialist.[10] Some programs believe that a well-defined clinical protocol for assembling the electronic consultation is needed.[11] In our program, collegial relationships with referring providers and simple protocols have resulted in telemedicine cases with adequate images, data, and free-text information to allow for proper ENT consultation.

It is readily apparent to the consulting surgeon when the store-and-forward case contains information of insufficient quantity or quality to make the clinical decision. In those situations, the consulting surgeon may request additional information or choose to arrange a face-to-face encounter to complete the evaluation. Whether the use of live videoteleconferencing can be used to replace face-to-face encounters in these more difficult clinical situations remains to be seen. The utility of videoconferencing for preoperative planning and screening in a variety of clinical situations has been previously reported.[12-15]

Telemedicine offers many advantages for providing specialty care. By helping overcome barriers created by distance and lack of specialist local availability, access to specialists improves. Early identification of serious disorders and enhanced information exchange between providers can lead to improved outcomes, higher care quality, and more satisfying relationships between providers and patients.[16,17] Patients at ANMC have been very satisfied with video-otoscopy as a teaching tool and the overall telemedicine experience.[5] Store-and-forward telemedicine has several characteristics that are highly attractive to the busy consultant. It is asynchronous, so that the referring and consulting providers do not need to be available simultaneously. It does not require the scheduling and bandwidth associated with videoconferencing. Store-and-forward cases can be reviewed during the unavoidable "downtimes" in a physician's schedule, enhancing physician productivity. Store-and-forward telemedicine is well suited to otology, where the combination of digital images and clinical data can lead to appropriate diagnoses and treatment, as shown by this review of patients needing major ear surgery.

Conclusion

Store-and-forward telemedicine is useful in planning common ear surgery such as tympanoplasty, canalplasty, mastoidectomy, stapes surgery, and myringoplasty. Otologic surgeons were able to determine the needed surgery and required operative time as accurately as when patients were seen during a traditional in-person encounter.

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Author Information

From Alaska Native Medical Center, Otolaryngology (Dr. Kokesh), Anchorage, AK; and Alaska Native Tribal Health Consortium: AFHCAN (Drs. Ferguson and Patricoski), Anchorage, AK.

Corresponding author: John Kokesh, MD, ANMC 4315 Diplomacy Drive, Anchorage, AK 99508-5926.

E-mail address: jkokesh@anmc.org.

Author Contributions

John Kokesh, conception, design, acquisition and/or analysis of data, writing, intellectual content, and final approval; **A. Stewart Ferguson,** conception, design, acquisition and/or analysis of data, writing, intellectual content, and final approval; **Chris Patricoski,** conception, design, acquisition and/or analysis of data, writing, intellectual content, and final approval.

Disclosures

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