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Smartphone Capture of Flexible Laryngoscopy: Optics, Subsite Visualization, and Patient Satisfaction

Sarah E. Maurrasse, MD; Theresa W. Schwanke, MD; Abtin Tabaee, MD

Objective: To determine whether a smartphone adaptor can record laryngoscopic videos of adequate quality for clinical diagnosis and communication among otolaryngologists and assess the impact of recorded exams on patient satisfaction.

Methods: Twenty adult inpatients undergoing flexible laryngoscopy in a tertiary care medical center were prospectively enrolled. Each subject’s larynx was visualized with the standard laryngoscope eyepiece and with an attached mobile phone adaptor with video recording capabilities. A 5-point Likert scale was used by the resident performing the scope to grade the adaptor and eyepiece exams. The same scale was used by an offsite otolaryngology attending to grade the adaptor video. Patients were shown the video, and a satisfaction survey was administered.

Results: In all patients, the adaptor was easy to use and required minimal setup. Ninety percent of patients reported an increase in satisfaction after watching the video of their exam. The eyepiece was superior to the adaptor in resolution, focus, color fidelity, brightness, and optical fluidity (P < 0.05). The video recording was deemed sufficient for clinical assessment in 90% of cases. The offsite reviewer determined that there would be "little" (15%) or "no value" (65%) in repeating the scope exam in the majority of patients. The laryngeal subsites were equally visible with the eyepiece and the adaptor ("full view," 85%–100%).

Conclusion: Laryngoscopy videos recorded by a portable smartphone adaptor are sufficient for clinical evaluation in the majority of cases. This technology may improve patient satisfaction and communication among clinicians.

Key Words: Laryngoscopy, flexible laryngoscopy, smartphone, telehealth.

Level of Evidence: 4

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INTRODUCTION

Since its introduction in the 1970s,1 awake laryngoscopy with a flexible endoscope has become a critical tool for diagnosing upper aerodigestive tract pathology in otolaryngology. As the technology has improved in quality and declined in cost, it has become the diagnostic standard of care in both the office and hospital setting. Adjunctive technologies that are capable of recording and storing digital photos and videos of endoscopic examinations are now widely available in the operating room and office. In contrast, recording exams at the bedside in the inpatient and emergency room settings remains difficult due to practical limitations including cost and the bulkiness and transportability of standard recording equipment. To address this issue, several companies have developed adaptors—also known as coupling devices—that allow smartphones to attach to the eyepiece of the flexible laryngoscope, creating a portable and cost-effective method for recording endoscopic examinations. These adaptors are rising in popularity; however, very few studies have investigated the diagnostic value of the videos produced by these adaptors.2 Many questions remain relating to the quality, practical considerations, patient benefit, and clinical utility of videos recorded on these portable devices.

The purpose of this study was to 1) evaluate whether access to recorded exams improved patient satisfaction, 2) determine whether smartphone video recordings differed significantly in optical quality compared to an eyepiece exam alone, and 3) to assess whether these videos were sufficient for diagnosis and communication among providers.

MATERIALS AND METHODS

Study Design

Institutional review board approval was obtained for this study. The study is a case series of patients requiring inpatient consultation—including flexible laryngoscopy—by the otolaryngology service at the study authors’ institution from September 30, 2016, to December 31, 2016. Flexible laryngoscopy was performed on each patient, and two separate techniques were used to visualize the exam: 1) direct visualization through laryngoscope’s built-in eyepiece, and 2) visualization of the exam on a mobile phone screen via an adaptor (see Equipment section).

Patient Selection

Inclusion criteria included age 18 years or older, a request for inpatient or emergency department evaluation by otolaryngology,
Equipment

Dedicated, password-protected, departmental iPhone 5S (Apple Inc., Cupertino, CA) smartphones were used to capture and record all the laryngoscopy exams. The adaptor used in the study was manufactured by MobileOptx (Philadelphia, PA). The adaptor consists of an iPhone case, which snaps into place on the phone, and a channel in the case that allows a lens to click into place (Fig. 1). The lens and phone complex can be attached to the top of the laryngoscope (Fig. 2) in a similar fashion to a camera head, and the exam can be observed on the phone screen when in camera mode. The smartphone camera interface can be used to record video and take still photos.

Procedures

Following informed consent for study participation, each patient underwent flexible laryngoscopy by a member of the otolaryngology house staff. All exams began with the mobile phone adaptor connected to the laryngoscope eyepiece. The time for device setup was recorded for each patient, rounded to 30-second intervals. Laryngoscopy was then performed. After a complete exam had been performed and recorded, the mobile phone adaptor was removed—leaving the scope in position in the airway—and the larynx was visualized and carefully examined again with the eyepiece alone. The scope operator made note of any adaptor adjustments that were required or any technological problems that were encountered during the mobile phone portion of the exam.

RESULTS

Analysis Methods

Descriptive statistics were used for patient demographics and nominal data. Ordinal data including the patient questionnaire, video quality, and laryngeal subsite visualization was analyzed using the two-tailed Mann–Whitney U-test.

Outcomes

The exam findings and diagnostic implications were explained to the patient verbally. Subsequently, the patient was shown the video of their exam on the mobile phone screen, and the findings were again discussed. The patient then completed a survey, which included the following questions: 1) “How well do you feel you understood the findings of the examination after having them explained to you verbally by your doctor?” 2) “How well do you feel you understood the findings of the examination after reviewing the video footage with your doctor?” and 3) “How did the ability to view the video change your satisfaction with the exam?” A 5-point Likert-scale was used to grade patient understanding (1 = “very poorly,” 2 = “poorly,” 3 = “adequately,” 4 = “well,” 5 = “very well”) and change in satisfaction (1 = “decreased greatly,” 2 = “decreased slightly,” 3 = “stayed the same,” 4 = “increased slightly,” 5 = “increased greatly”).

Immediately after completing the patient encounter, the laryngoscopy operator filled out questionnaires assessing the optical quality of the adaptor and eyepiece exams. The optical parameters included optical resolution, focus, color fidelity, brightness, fluidity, and an overall quality. Each characteristic was scored on a 5-point Likert-like scale: 1 = “very poor,” 2 = “poor,” 3 = “fair,” 4 = “good,” 5 = “excellent.” The operator also graded the ability to visualize specific anatomical subsites with each method. The anatomical subsites graded in each exam were the vallecula, epiglottis, aryepiglottic folds, arytenoids, false vocal folds, true vocal folds, and pyriform sinuses. The view of each site was scored as either a “full view,” “partial view,” or “no view.” The operator also provided an opinion on whether the adaptor recording was a sufficient fiberoptic laryngoscopy (1 = “strongly disagree,” 2 = “disagree,” 3 = “neutral,” 4 = “agree,” 5 = “strongly agree”).

De-identified videos of the adaptor exams were then e-mailed to a single offsite otolaryngology attending (A.T.) for review using the secure hospital server. The offsite reviewer was blinded to the results of the operator questionnaires. The offsite reviewer watched the videos on a computer monitor and graded the optical quality and the ability to visualize anatomical subsites using the same scales as the operator. The offsite reviewer also determined the adequacy of the exam by grading the value of a repeat in-person exam (1 = “not valuable,” 2 = “little value,” 3 = “some value,” 4 = “valuable,” 5 = “very valuable”). No clinical information was available for the offsite reviewer.
with either the eyepiece or video adapter. The complete exam, including adaptor and eyepiece components, was well tolerated without any complications by the remaining 20 patients. There were 10 male and 10 female patients. The mean age of the study population was 51.5 years of age (range 22–75, standard deviation [SD] 15.7 years). Table I describes the indications for laryngoscopy in the study population.

In all 20 cases, the smartphone adaptor was easily set up in less than 30 seconds. All examinations were carried out without the need to adjust the adaptor. The mean understanding score of subjects after a verbal discussion of their results was 4.5 (median 5, SD 0.61); this score corresponded to a descriptive answer of an understanding between “well” and “very well.” The mean understanding score of subjects after review of the video was 4.7 (median 5, SD 0.47), which also corresponded to a score between “well” and “very well.” There was no significant difference between these scores ($P = 0.379$). Overall, 90% of subjects reported an increase in satisfaction with their exam after viewing the video of their laryngoscopy (Fig. 3).

Figure 4 demonstrates the mean quality scores for the eyepiece, adaptor, and offsite reviewer. The quality rating of the operator’s adaptor exam was found to be significantly lower quality ($P < 0.05$) than the eyepiece exam for all parameters measured. Despite lower ratings for the adaptor compared to the eyepiece, adaptor quality was still scored between “good” and “excellent” (4–5) in

### Table I.
The Primary Indication for Laryngoscopy in This Study.

<table>
<thead>
<tr>
<th>Indication</th>
<th>N (%)</th>
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<tbody>
<tr>
<td>Dysphonia</td>
<td>7 (35%)</td>
</tr>
<tr>
<td>Airway evaluation</td>
<td>3 (15%)</td>
</tr>
<tr>
<td>Neoplasm</td>
<td>3 (15%)</td>
</tr>
<tr>
<td>Oral cavity lesions</td>
<td>4 (20%)</td>
</tr>
<tr>
<td>Dysphagia</td>
<td>1 (5%)</td>
</tr>
<tr>
<td>Nasal symptoms</td>
<td>2 (10%)</td>
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</tbody>
</table>

Fig. 3. Patient satisfaction after review of video laryngoscopy examinations.

Fig. 4. Comparison of image quality characteristics. Asterisks over adaptor bars indicate a statistically significant difference compared to eyepiece. Asterisks over offsite bars indicate a statistically significant difference compared to adaptor.
the areas of “focus” and “fluidity,” and the mean score for all the remaining categories was at least 3.9 or greater. The scope operator reported that the adaptor exam was a sufficient laryngoscopy exam in 90% of cases (3 cases “agree,” 15 cases “strongly agree”). In one case (5%) the operator was neutral, and in one case (5%) the operator found the adaptor exam to be insufficient.

The offsite examiner quality ratings were significantly higher ($P < 0.05$) than the operator’s adaptor quality ratings for “color fidelity,” “brightness,” “fluidity,” and “overall quality” of the exam. There was no significant difference between the operator’s and the offsite reviewer’s quality ratings for “focus” or “resolution.” The offsite reviewer rated resolution and focus significantly lower ($P < 0.05$) than the eyepiece exam in the areas of “resolution” and “focus,” but there was no significant difference between the exams for the other quality parameters or overall quality of exam.

Figure 5 shows the subsite view ratings for the eyepiece, adaptor, and offsite reviewer. In all subjects, all subsites were at least partially visualized by the eyepiece, adaptor, and offsite reviewer. There was no significant difference between the eyepiece and adaptor or offsite reviewer in the frequency of a partial view versus full view for any of the subsites. The subsite with the highest frequency of partial view (15% on eyepiece, 15% on adaptor, and 10% by offsite reviewer) was the pyriform sinuses; however, this did not reach statistical significance.

The offsite reviewer reported that a repeat exam would be “valuable” in one case (5%) and “of some value” in three cases (15%). The reason for the repeat exam in these cases was a subjective limitation in the visualization and optical qualities of the recorded examination findings. The offsite reviewer stated that a repeat exam would be of “little value” in three cases (15%) or “no value” in 13 cases (65%).


discussion

Flexible laryngoscopy is an essential component of clinical evaluation and diagnosis for many otolaryngologic conditions in both the outpatient and inpatient setting. The ability to electronically record, store, and transmit digital photos and videos of these examinations is widely available in the office and operating room, but remains less accessible in the inpatient setting. The use of a small, portable, smartphone adapter to digitally record laryngoscopy examinations provides an efficient and cost-effective solution for data capture and storage in the inpatient consult setting. However, prior to widespread adoption, the video quality and clinical utility of this technology must prove to be as reliable as on-site examination.

A limited number of studies have investigated the value of recording endoscopic exams with smartphone adaptors in terms of diagnostic accuracy and resident education.2–5 However, only one previous study has looked at optical parameters.3 Liu et al. found no significant difference in video quality ratings between endoscopy video tower recordings and smartphone adapter recordings.3 However, in contrast to our study, they did not investigate the optical quality of an in-person eyepiece exam, evaluate subsite specific data, or examine the impact of video recording on patient satisfaction and education.

Mobile phone adaptors also have potential benefits for the timely sharing of information among providers. In the inpatient setting, the majority of initial laryngoscopic evaluations are done by providers other than the attending, including residents, physician assistants, and nurse
practitioners. Current models of care require the attending physician to either repeat the endoscopy in person, which may result in a delay in care, or to rely on a verbal report, which may not provide enough detail. The ability to view a video of the endoscopy in near real time provides an opportunity for a comprehensive telehealth consultation.

Furthermore, this technology allows archiving of exams, which is especially useful for conditions that require serial exams, including airway edema.5 This is important in the hospital setting where the practitioner performing the examination may differ day to day. Decreased continuity of care has been found to be associated with an increased incidence of repetitive procedures on patients.6 Smartphone technology could decrease this by allowing otolaryngologists to accurately share examination findings with each other during care transitions.

In addition, our study showed that allowing patients to review the video of their exam improved satisfaction in 90% of patients. Although we used a Likert scale, which is not a measure validated specifically for patient satisfaction, the results are still compelling. We postulate that the observed increase in satisfaction is a result of the patients feeling more involved in their care and being allowed to spend additional time with their physician. Saunders et al. showed that spending sufficient time with a clinician and receiving a copy of medical information were strong predictors of patient satisfaction.8

Widespread adoption of any new technology is predicated on systematic assessment of benefit, limitation, and risk. Brant et al. found a high correlation between findings on live and video recorded laryngoscopy exams, including mucosal evaluation, vocal fold mobility, and airway patency.9 Our findings indicate that the smartphone video adaptor produces a high-quality image with an excellent view of anatomic subsites and that the exam rarely needs to be repeated in person. However, examinations that require attention to fine detail or identification of subtle mucosal alterations may benefit from an eyepiece exam rather than relying solely on an adaptor recorded version.

Interestingly, the offsite reviewer tended to rate the quality of the video exams higher than the scope operator, likely because the offsite reviewer did not have the eyepiece exam as a reference point for comparison. Additionally, the offsite examiner watched the videos using a computer monitor rather than a smartphone screen, which may have provided a higher quality image.

Prior studies have demonstrated strong inter-rater agreement between resident and attending diagnoses on flexible laryngoscopy.5 However, in our study, the scope operator and the offsite reviewer did not always agree on the ability to visualize anatomical subsites, which is a more specific characteristic than diagnosis alone. This may be due to the difference in training levels because it has been found that laryngoscopy skills improve with increased experience.10,11 This further demonstrates the value of a recorded exam—instead of a verbal exchange of information alone—for communication between residents and attendings.

Despite the utility of this new technology, it also presents potential challenges regarding patient privacy and compliance with the Health Insurance Portability and Accountability Act (HIPAA). Our study used a secure hospital e-mail server for transfer of videos to protect patient privacy. Additional strategies include uploading videos onto a HIPAA-approved secure cloud-based platform, or complete de-identification of the exam. Unfortunately, de-identification of exams increased the potential for confusion of exams between patients. Whereas safety measures, such as the use of dedicated hospital devices instead of personal phones, password protection of devices, and transferring data on secure hospital wireless networks are important measures, they do not provide complete privacy. McKnight and Franko demonstrated that HIPAA compliance on mobile devices already tends to be poor among both house staff and attendings12; thus, additional effort in this area is warranted.

Several limitations are identified in our study. Although our sample size was adequate to identify statistically significant differences in several of the study measures, a larger sample size could be useful in confirming the absence of subsite visualization variation and to investigate whether certain quality parameters were more consistently problematic. It would also be useful to validate our results with a larger group of scope operators and offsite reviewers. Whereas the Likert scale utilized in this study is not specifically validated for display quality, several studies have used similar optical characteristics and scaled grading to analyze optical data.10,11 As with any technology, subsequent adaptor models and devices made by competing manufacturers may differ in their clinical utility and features. Our study design did not assess the use of this technology for specific diagnoses, such as laryngeal masses, airway edema, or vocal cord mobility abnormalities. It is possible that study outcomes would differ based on pathology. It would also be helpful to investigate the impact of this device on patient care, cost, and workflow measures.

CONCLUSION

The use of smartphone adaptors to record laryngoscopy exams results in a high-quality video with adequate visualization for clinical assessment in the majority of patients. Although the quality of these videos is good, small but significant differences in optical characteristics exist and the eyepiece exam may remain superior for identifying subtle pathological findings. This technology could meaningfully improve communication among members of the team, facilitate continuity of care, reduce the need for repeat exams, and provide subspecialty care in resource poor settings. Practitioners should be aware of the potential privacy issues raised by using smartphones to capture patient exams and should ensure HIPAA compliance prior to clinical use.

BIBLIOGRAPHY


