



Research Paper

Diagnostic utility of flexible fiberoptic nasopharyngolaryngoscopy recorded onto a smartphone: A pilot study

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Abstract *Objectives:* To evaluate the diagnostic accuracy of flexible fiberoptic examinations of the larynx recorded onto smartphones.

Methods: Prospective, blinded study of inpatients requiring laryngoscopy. A live exam was performed, then a smartphone was attached to the endoscope using a novel coupling device and the same examination was recorded. The live and recorded exams were evaluated by two laryngologists, each blinded to the findings of the other.

Results: Eighteen subjects were evaluated. Evaluation of airway patency was identical (Kappa = 1.0 [1, 1]). Evaluation of vocal cord motion was identical for 14 subjects: 9 normal, 3 parietic, 2 paralytic (Kappa = 0.69 [0.38, 1]).

Conclusion: There is high correlation between laryngeal diagnoses using live flexible fiberoptic laryngoscopy and recordings using a coupling device to transfer the recordings on to smartphones. Critical findings such as airway patency and vocal fold motion showed the highest correlation.

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Introduction

The use of smartphones, especially those with cameras, is widespread in medicine. A recent survey found over 85% of physicians at ACGME accredited programs use smartphones.¹ These devices contain cameras that can take photographs and video in high-definition, store a large amount of data, and transmit wirelessly.

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Studies evaluating the use of photos taken and transmitted by cellular telephones have been performed in several clinical settings including outpatient evaluation of nasal fractures, emergency room triage of hand trauma, monitoring of the status of free flap reconstructions, and emergency evaluation of airway radiology.^{2–5} These have shown improvements in triage and immediate patient care through the use of this technology versus the standard consultation methods. Other studies have evaluated the use of more traditional methods of transmitting photographs and videos in otolaryngology, showing the advantages of remote consultation with specialists.⁶ Similar methods would be useful for the documentation and rapid sharing of laryngeal examinations given its complex anatomy and possible need for acute intervention. There has been recent interest in the use of smartphone technology for video recordings, and a recent study demonstrated that there was no significant difference in the video quality ratings between mobile and tower video recordings.⁷

The current method for recording Flexible Fiberoptic Nasopharyngolaryngoscopy (FF-NPL) examinations requires a camera to be attached to the optical eyepiece of the endoscope, which is then wired to a video tower. Alternatively, distal-chip endoscopes can provide excellent images, however are limited by cost and the physical size of the infrastructure needed to utilize their capabilities. It would be of benefit to physicians and patients to have a method that allows high quality recording of FF-NPL examinations which is portable, reliable, and secure. As utilization of a new method requires assurance that diagnostic accuracy is not degraded by use of the new technology, the goal of this study is to evaluate the diagnostic accuracy of flexible fiberoptic examinations of the larynx recorded onto smartphones as compared to the live examination.

Methods

IRB

This study was approved by the Institutional Review Board at the Hospital of the University of Pennsylvania under protocol number 814831.

Patient recruitment/endoscopy

Consecutive inpatients at the Hospital of the University of Pennsylvania whose primary medical team requested an Otorhinolaryngology consult were considered for participation. The primary consulting otorhinolaryngologist would evaluate the patient, and if a bedside FF-NPL examination was required the patient would be asked to participate in the study. If they agreed the senior author (NM) would perform the endoscopy at the bedside through the optical eyepiece using a flexible laryngoscope (Karl Storz Tuttlingen, Germany). Once her exam was complete, but before the endoscope was withdrawn, she would attach the smartphone adapter and record approximately 30 s of video on an iPhone 4 (Apple Corporation, Cupertino, California, USA). Videos were extracted from the smartphone and transmitted electronically to a second laryngologist (KL) who was blinded to the history and pathologic findings of

the original exam. A diagnostic survey was created for this study, which was completed by both physicians immediately following their respective examinations (Fig. 1).

Smartphone adapter

A custom-designed adapter which included a plastic casing surrounding a lens designed for telephoto pictures on an iPhone 4 (Apple Inc., Cupertino, CA) with an approximately 8× optical zoom (Apixel Technology Co., Shenzhen, China) was used (Figs. 2 and 3). The same adapter and phone were used for all examinations.

Statistical analysis

Statistical analysis was performed using R version 3.1.1 (<http://cran.us.r-project.org>) via RStudio 0.98.953 (<http://www.rstudio.com>). Un-weighted Cohen's Kappa correlation coefficients were calculated with their 95% confidence intervals, and categorical interpretation was based on Landis and Koch.⁸

Results

Eighteen patients were evaluated between July 2013 and January 2014. There were a significant number of blank responses on the following survey sections: Nasal Cavity, Nasopharynx, Oropharynx, and Base of Tongue, which were excluded from the statistical evaluation. Data is displayed in Table 1.

Evaluation of airway patency was identical by the 2 methods, with 17 determined adequate, and 1 inadequate using both live and recorded examination (Kappa 1.0, 95% CI [1, 1]).

Evaluation of vocal fold motion was similarly identical between evaluators for 14 of the 18 subjects (78%). Nine were interpreted as normal, 3 as paretic, and 2 as paralytic (Kappa 0.69 [0.38, 1]). There was no disagreement on the sidedness of the vocal fold involved (3 left, 1 right, 1 bilateral). There was one 'Paretic'-'Paralytic' and two 'Normal'-'Paretic' discrepancies. There were no 'Normal'-'Paralytic' discrepancies. One response was left blank.

Evaluation of each sub-site showed overall moderate reliability (Kappa 0.51, [0.34, 0.69]). Evaluation of the arytenoids had fair agreement with a Kappa of 0.28 [0.022, 0.53]. Five were scored as 'Normal' for both, and five as 'Edema' for both. The most common discrepancy was 'Normal' on live exam and 'Edema' on recorded exam ($n = 7$). One 'Lesion' on live and 'Edema' on recorded exam was noted.

Evaluation of the epiglottis showed a Kappa of 0.68 [0.29, 1]. Eleven were 'Normal' and three showed 'Edema' on both evaluations. One subject was rated as 'Malacia' on live exam and 'Normal' on recorded exam, and one as 'Normal' on live exam and 'Edema' on recorded exam. Two subjects were not scored by both methods and were not included.

The aryepiglottic folds showed substantial agreement with a Kappa of 0.85 [0.57, 1]. Thirteen subjects were scored as 'Normal', and 4 as 'Edema' on both. One patient

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