

# Tele-ophthalmic Approach for Detection of Corneal Diseases: Accuracy & Reliability



**KELLOGG EYE CENTER**  
MICHIGAN MEDICINE

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## BACKGROUND

- Remote eye care is a promising solution for millions of Americans with inadequate access to eye care services.<sup>1-5</sup>
- One-third to one-half of Americans are at high risk for visual loss and do not or rarely see an eye care provider.<sup>1-4</sup>
- Corneal and anterior segment diseases cause the majority of urgent visits to non-eye care professionals.
- A method to diagnose and guide management of corneal diseases remotely could help vision outcomes, especially for patients in low resource settings.

## PURPOSE

We evaluated the diagnostic accuracy and reliability of detecting corneal diseases using diffuse light photographs from two portable cameras for telemedicine purposes.

## METHODS

- Adult patients were recruited from the University of Michigan Kellogg Eye Center cornea and comprehensive clinics from May 1, 2014 to June 1, 2016.
- Subjects were eligible for study if they were ≥18 years old and had at least one eye with a diagnosis of corneal abrasion or corneal opacity, which included corneal ulcers, corneal scars, and pterygia.
- At enrollment, an ophthalmic photographer took a series of 7 diffuse light photographs of each cornea, including fluorescein cobalt-blue photos, with two cameras - the iTouch 5G (Apple, Cupertino, CA) and the Nidek VersaCam (Nidek, Fremont, CA).



The iTouch 5G (Apple, Cupertino, CA) has a camera with 5.0 megapixel resolution and weighs 3.10 ounces. The Nidek VersaCam (Nidek, Fremont, CA) has a camera with 5.0 megapixel resolution and weighs 8.96 ounces

- Three cornea specialists (graders) assessed each photo series for the presence or absence of corneal disease – the gold standard.
- Accuracy to detect disease was compared to the gold standard diagnosis, stratified by camera and grader. Reliability was evaluated with kappa statistics.

## RESULTS

- 198 eyes of 110 participants were included in the study.
- Subjects were on average 54.3±18.9 years old, 62% female, and 85% Caucasian
- By gold standard diagnosis, 59 eyes (30%) had corneal scars, 34 eyes (17%) had corneal ulcers, 13 eyes (7%) had corneal abrasions, 10 eyes (5%) had pterygia, and 82 eyes (41%) had no corneal disease.

**Table 1. Sensitivity and specificity to detect corneal pathology from iTouch and Nidek photo series compared to gold standard diagnosis**

Diagnosis by Grader	Gold Standard Dx Normal	Gold Standard Dx Pathology	Sensitivity (CI) (%)	Specificity (CI) (%)	Sensitivity p-value*
Grader 1, iTouch					1
Normal	67	34	70.7 (62.8, 79.4)	81.7 (70.9, 88.3)	
Pathology	15	82			
Grader 1, Nidek					0.007
Normal	77	35	69.8 (62.7, 79.5)	93.9 (86.0, 97.4)	
Pathology	5	81			
Grader 2, iTouch					0.04
Normal	79	53	54.3 (45.5, 63.9)	96.3 (89.0, 98.8)	
Pathology	3	63			
Grader 2, Nidek					0.007
Normal	80	40	65.5 (56.6, 73.8)	97.6 (90.8, 99.4) <sup>a</sup>	
Pathology	2	76			
Grader 3, iTouch					0.04
Normal	76	39	66.4 (57.7, 75.0)	92.7 (85.1, 97.2)	
Pathology	6	77			
Grader 3, Nidek					0.04
Normal	75	29	75.0 (68.2, 83.9)	91.5 (82.4, 95.5)	
Pathology	7	87			

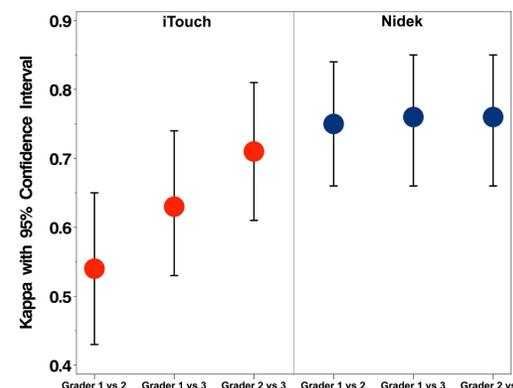
Note: 95% confidence intervals are adjusted for the correlation between eyes of a subject with use of a logistic regression model with generalized estimating equations; <sup>a</sup>Wald confidence interval reported due to convergence issues with the model

**Table 2: Sensitivity to detect corneal pathology from images, stratified by diagnosis, grader, and camera**

Grader/Camera	Corneal Abrasion (n=13) Sensitivity (CI) <sup>a</sup>	Corneal Scar (n=59) Sensitivity (CI) <sup>b</sup>	Corneal Ulcer (n=34) Sensitivity (CI) <sup>b</sup>	Pterygium (n=10) Sensitivity (CI) <sup>b</sup>
Grader 1				
iTouch	77 (50, 91.8)	54.2 (41.7, 67.4)	91.2 (77.0, 97.0)	90.0 (59.6, 98.2)
Nidek	92.3 (66.7, 98.6)	50.9 (38.7, 65.0)	88.2 (73.4, 95.3)	90.0 (59.6, 98.2)
Grader 2				
iTouch	69.2 (42.4, 87.3)	28.8 (19.0, 39.7)	82.4 (66.5, 91.7)	90.0 (59.6, 98.2)
Nidek	69.2 (42.4, 87.3)	42.4 (30.6, 55.1)	94.1 (80.9, 98.4)	100.0 (72.3, 100.0)
Grader 3				
iTouch	76.9 (49.7, 91.8)	44.1 (31.6, 57.1)	91.2 (77.0, 97.0)	100.0 (72.3, 100.0)
Nidek	84.6 (57.8, 95.7)	57.6 (45.0, 71.0)	94.1 (80.9, 98.4)	100.0 (72.3, 100.0)

CI: 95% confidence interval, includes <sup>a</sup>Wilson CIs when diagnosis category contains no subjects contributing both eyes or only 1 subject contributing both eyes, and <sup>b</sup>CIs calculated from a logistic regression with generalized estimating equations adjustment to account for the correlation between eyes of a subject

**Table 3. Inter-rater reliability for diagnosis of corneal pathology**



## RESULTS cont.

- Sensitivity to detect any corneal pathology ranged from 54-71% for iTouch and 66-75% for Nidek, across graders; specificity ranged from 82-96% for iTouch and 91-98% for Nidek.
- Sensitivity to detect specific corneal pathology was variable, with lower specificity to detect corneal scars (range 29-54% by iTouch, 42-58% by Nidek) and higher specificity to detect pterygia (range 90-100% for both iTouch and Nidek).
- Inter-grader reliability for diagnosis was moderate to strong (kappa ranges: 0.54-0.71 for iTouch; 0.75-0.76 for Nidek).

## CONCLUSIONS

- Accuracy of remote diagnosis of corneal pathology for this study did not achieve telemedicine standards (>80% sensitivity).
- Sensitivity and specificity of image interpretation from portable cameras to detect corneal ulcers and pterygia achieved the standards for ophthalmology telemedicine, albeit with wide confidence intervals, suggesting there may be a role for using portable cameras to monitor corneal ulcers or pterygia with portable imaging.
- The goal of screening modalities should remain to serve patients with limited access to eye care with equal accuracy to current screening methods and at an affordable cost.

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