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Telemedicine for corneal disease in rural Nepal

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Summary

We evaluated the diagnostic accuracy of slit-lamp photographs interpreted by telemedicine compared with a conventional clinical examination. A convenience sample of 21 patients with anterior segment disease was enrolled at the Lumbini Eye Institute (LEI) in Bhairahawa, Nepal. An ophthalmologist at the LEI examined each patient and assigned a diagnosis and follow-up interval; this represented the gold standard. An ophthalmic technician then obtained anterior segment photographs of each patient. Slit-lamp photographs and clinical histories were then uploaded to a server for access by three separate readers. These readers, one in Nepal and two in the US, provided a diagnosis and follow-up interval independently. The diagnostic agreement between the examiner and all readers was good ($\kappa=0.75$, $P<0.0001$). The agreement about the follow-up interval between the examiner and all readers was fair, with a kappa coefficient of 0.32 ($P<0.0001$). However, the agreement was high when comparing the examiner with the reviewer in Nepal ($\kappa=0.90$). The agreement was moderate when comparing the two US-based readers ($\kappa=0.45$). In general, the ophthalmologists in Nepal tended to recommend more rapid follow-up than their US-based counterparts. Our results suggest that the transmission of slit-lamp photographs from satellite clinics and eye health screening camps to the LEI and elsewhere for review and triage is an effective means of identifying anterior segment pathology.

Introduction

A core mission of eye-care practitioners is to identify the causes of vision loss and prevent further impairment through early intervention. A 2006 study in Nepal found that 4.6% of people surveyed ($n=5138$) had moderate to severe bilateral blindness (visual acuity $<20/200$).[1] This represents an improvement from a rate of 5.3% determined by a survey 11 years earlier, despite an increase in life expectancy from 54 to 63 years.[2] In 2006, the main causes of visual impairment were cataract (49%), refractive error (31%), corneal opacity (4%) and retinal disorders (4%).[1]

The Lumbini Eye Institute (LEI) is a tertiary referral centre in Bhairahawa, Nepal. The LEI provides most of the eye-care services in the Lumbini Zone in conjunction with numerous satellite clinics. The LEI provides access to eye health services through community outreach programmes and capacity building. The increased rate of vision-restoring cataract surgery in the region indicates the success of these programmes, rising from 44% to 62% for men and from 41% to 71% for women between 1995 and 2006.[1,2]

Other important causes of blindness from anterior segment disease remain difficult to identify and treat in a timely manner. For example, a large proportion of the Nepalese population rely on agriculture as their primary source of income, and ocular trauma with vegetable matter -- leading to infectious keratitis and corneal opacity -- is a significant cause of visual impairment. Anecdotal reports from LEI suggest that many patients with corneal trauma present weeks to months after their initial injury, at which time the visual prognosis is usually poor. A study of patients with infectious keratitis in Eastern Nepal found that 80% were engaged in agricultural work and 68% recalled associated ocular trauma.[3] In addition, 11% had corneal perforation and 9% had endophthalmitis at the time of presentation, suggesting significant delays between the injury and medical evaluation.[3] Poor utilization of eye health services in Nepal has been attributed to limited education (particularly about eye disease) and significant distances between home and health facilities. [4]

Earlier detection and treatment of anterior segment disease often results in less invasive or less complex therapy. For example, earlier detection of conjunctival malignancies typically permits smaller excisions without the need for extensive reconstruction, and prompt medical treatment of infectious keratitis often results in restoration of useful vision without the need for surgery using scarce and often poor quality graft tissue.

Telemedicine has been used in glaucoma, diabetic retinopathy and retinopathy of prematurity screening, as well as remote emergency room consultation.[5–8] The LEI recently established a telemedicine network linking its main centre in Bhairahawa and about a dozen satellite clinics in order to improve access to eye health services and allow more rapid triage of ocular pathology.

There have been few previous reports of the diagnostic accuracy of slit-lamp photographs interpreted by telemedicine.[9] The aim of the present study was to evaluate the diagnostic accuracy of slit-lamp photographs versus face-to-face clinical examinations for anterior segment disease.

Methods

A convenience sample of 21 patients with anterior segment disease presenting to the LEI over a three-week period in February 2013 was selected. Patients agreed to undergo both standard ophthalmic examination and slit-lamp photography. Verbal consent was obtained from all participants. The study was approved by the appropriate ethics committees.

The patients were examined at a slit-lamp by one of two LEI ophthalmologists with additional cornea training. The patient's age, gender, affected eye, visual acuity and clinical

history were obtained by an ophthalmic technician or assistant. The examiner was asked to provide a clinical diagnosis (the gold standard) and recommend the timing of follow-up: within one day (emergency), 1 week (urgent), 1 month (semi-urgent) or 3 months (routine).

Following examination, an ophthalmic technician working in the cornea clinic obtained anterior segment photographs of each patient (Figures 1 and 2). The technician had three years of clinical experience, which included slit lamp photography, prior to the study. Photographs were taken using a digital camera (Canon Powershot A540) with a slit-lamp adapter. If necessary, additional illumination was provided using a hand-held flashlight. The technician reviewed the photographs on the camera's built-in LCD display to ensure that at least three focused images capturing the lesion of interest were obtained for each patient. Video capture was not employed as it was felt that larger file sizes would exceed the data transfer capabilities of the available network.

Slit-lamp photographs in JPEG format and clinical histories recorded in a spreadsheet were then uploaded to a server for access by three separate readers: the LEI ophthalmologist who had not performed the clinical examination of the patient and two cornea specialists at the Kellogg Eye Center at the University of Michigan. The images were not modified from their original form prior to upload. Readers had the ability to magnify images as required and, as with the original examiner, were asked to provide a clinical diagnosis and follow-up recommendation. All diagnoses were subsequently grouped into one of four categories by an independent expert. The groups were: (1) infectious or inflammatory keratitis/ulcer, (2) corneal scar (not active), (3) corneal or conjunctival neoplasm, (4) trauma or surgical complication.

The level of agreement between the examiner and readers was evaluated by calculating kappa coefficients.

Results

Of the 21 study participants, 15 (71%) were male. The average age was 38 years (range 14–73). The average logMAR visual acuity was 0.81 (SD 0.77) and Snellen acuity ranged from 20/20 to finger counting at 30 cm (Table 1). There were 14 patients (67%) with infectious or inflammatory keratitis, 3 patients (14%) with corneal/conjunctival neoplasm, 3 patients (14%) with trauma or surgical complications and 1 patient (5%) with an inactive corneal scar. The recommended follow-up time based on clinical examination was 1 day for 14 patients (67%), 1 week for 5 patients (24%) and 1 month for 2 patients (10%).

The agreement about the diagnostic category between the examiner and all readers was good (kappa=0.75, $P<0.0001$), see Table 2. When comparing the results individually, there was greatest agreement between the examiner and the reviewer in Nepal (kappa=1.0) and the lowest agreement between the two US readers (kappa=0.53).

The agreement about the follow-up interval between the examiner and all readers was fair, with a kappa coefficient of 0.32 ($P<0.0001$). However, the agreement was high when comparing the examiner with the reviewer in Nepal (kappa=0.90). The agreement was moderate when comparing the two US-based readers (kappa=0.45). In general, the

ophthalmologists in Nepal tended to recommend more rapid follow-up than their US-based counterparts.

Discussion

The results of our pilot study suggest that anterior segment photography is a reliable means of diagnosing anterior segment pathology compared to conventional examination techniques. When comparing the impressions of the ophthalmologists working in Nepal, there was complete diagnostic agreement between the examiner and reader on all the patients in the sample. There was also good overall agreement when the US-based readers were included in the analysis ($\kappa=0.75$). This level of agreement is similar to a corneal telemedicine study in Australia, which found kappa values of 0.72–0.85 using anterior segment images to diagnose gross corneal abnormalities such as oedema and neovascularization.[9]

There was disagreement between the examiner and the US-based readers when attempting to differentiate between healing corneal ulcers and inactive scars. The diagnostic accuracy in these cases could probably be improved by supplying a more detailed clinical history to the readers. Future studies may include a standardized history form with targeted questions regarding ocular discomfort, tearing and discharge.

There was less overall agreement on follow-up interval, although this improved when comparing just the Nepal- or US-based ophthalmologists. This suggests a variability in practice patterns based on region of training. In every case, the ophthalmologists in Nepal recommended shorter follow-up intervals than the US-based readers. Limited access to eye health services in Nepal may explain this result, as many patients presenting to the LEI have travelled a great distance from home and stay in or near the hospital, remaining there until there is evidence of clinical improvement. The Nepal-based ophthalmologists, familiar with local barriers to care, expressed concerns that patients might be lost to follow-up if not monitored closely.

Our pilot study was designed to assess the accuracy and feasibility of a store and forward system of telemedicine, where images are captured on a remote device and transmitted to another location for review by the appropriate specialist. The limitations of the study include the small sample size and lack of control/normal images, preventing the calculation of diagnostic sensitivity and specificity. In addition, while monitors of similar quality were used for image viewing, it was difficult to standardize viewing conditions (e.g. lighting, glare) between the two sites.

The good diagnostic accuracy of the foreign readers means that ophthalmologists in other countries who wish to volunteer their time could also receive images from the LEI (or eye hospitals in other locations), allowing them to aid in the triage and care of patients abroad. Although larger studies are needed, our results suggest that the transmission of slit-lamp photographs from satellite clinics and eye health screening camps to the LEI and elsewhere for review and triage is an effective means of identifying anterior segment pathology and has the potential to prevent avoidable blindness.

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Figure 1.
Technician and assistant (left) obtaining slit lamp images

(A) Active corneal ulcer - infectious or inflammatory keratitis/ulcer category

(B) Inactive corneal scar - corneal scar (not active) category

(C) Pterygium - corneal or conjunctival neoplasm category

Figure 2.
Examples of slit lamp images.

Table 1

Characteristics of the patients

	Value
Gender	
Male (%)	15 (71)
Female (%)	6 (29)
Eye	
Left (%)	8 (38)
Right (%)	13 (62)
Mean age, years (SD)	38 (18)
LogMAR visual acuity * (SD)	0.81 (0.77)

* decimal acuity could not be calculated in two patients (LP or NLP)

Table 2

Agreement between the examiner and the readers

	Comparison	Kappa	P-value*
Diagnosis category	All	0.75	<0.0001
	Examiner vs. Reader, Nepal	1.0	<0.0001
	Examiner vs. Reader 1, US	0.67	<0.0001
	Examiner vs. Reader 2, US	0.83	<0.0001
	Reader, Nepal vs. Reader 1, US	0.67	<0.0001
	Reader, Nepal vs. Reader 2, US	0.83	<0.0001
	Reader 1, US vs. Reader 2, US	0.53	<0.0001
Follow-up interval	All	0.32	<0.0001
	Examiner vs. Reader, Nepal	0.90	<0.0001
	Examiner vs. Reader 1, US	0.35	0.0091
	Examiner vs. Reader 2, US	0.05	0.67
	Reader, Nepal vs. Reader 1, US	0.58	<0.0001
	Reader, Nepal vs. Reader 2, US	0.17	0.061
	Reader 1, US vs. Reader 2, US	0.45	<0.0001

* P-values from a test of the null hypothesis that the kappa value is equal to zero