

Smart Phone Based Retinal Imaging- A Practical Tool for Neurosurgeons

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Abstract: ***Introduction:** Effectiveness of papilledema in predicting raised intracranial pressure has been well documented over years .As medical fraternity's interest and reliance on direct ophthalmoscopy has waned over time,fundus photography has emerged as an alternative method of fundus examination. **Aims & Objectives:** In this study ,our aim is to compare the efficacy of smart phone based retinal imaging with direct ophthalmoscopic examination in detecting papilledema in neurosurgical setting. **Materials & Methods:**We examined the fundus of 112 neurosurgery inpatients,with various neurosurgical conditions using smart phone based retinal imaging system and documented papilledema.We also obtained direct ophthalmoscopic evaluation by ophthalmologists for these patients and results were compared with intraclass co-efficient agreement analysis. **Results:** Of these 112 cases, using smart phone based retinal imaging system ,papilledema was documented in 29 patients and primary optic atrophy in 5 patients .On direct ophthalmoscopic examination ,papilledema was noted in 27 cases and primary optic atrophy in 5 cases .On comparison ,results strongly agree ,proving the efficacy of this system. **Conclusion:** Smart phone based retinal imaging system is similar in efficacy to direct ophthalmoscopy for detection of papilledema.Constant improvement in technology and the potential for telemedicine will likely contribute to a widespread use of this technology in numerous specialities.*

Keywords: Retinal imaging, ophthalmoscope, papilledema

1. Introduction

Effectiveness of papilledema in predicting raised intracranial pressure has been well documented over years .As medical fraternity's interest and reliance on direct ophthalmoscopy has waned over time, fundus photography has emerged as an alternative method of ocular fundus examination.

2. Background

Fundus examination is an important aspect of neuro-ophthalmology for which the use of smart phones appears promising. Direct or indirect ophthalmoscope is traditionally employed to view the retina .Von Helmholtz invented direct ophthalmoscope in 1851^[1,2]. Since then, it has undergone various developments including incorporation of concave and convex lenses, attachment of a camera all in a bit to improve clarity of the image seen by correcting errors of refraction in the patient and/or the observer, and for documentation purposes^[1]. The limitation is in its field of view and cost of the camera attachment.

The indirect ophthalmoscope, first developed by Giraud-Teulon which has a wider field of view and stereopsis, has also passed through series of developments, from the attachment of teaching mirror useful for training to the inclusion of video camera attachment in the digital version which can be used for archiving, teleconsultation, and education^[3].The digital indirect ophthalmoscope is relatively bulky, has a steep learning curve, and is largely unaffordable for neuro-ophthalmology practice in developing countries.

The use of smartphones for various purposes is said to be on the rise among health workers; rising from 30% in 2001 to 64% in 2009 and 86% in 2013.They have been put to different uses in patient care in various specialties of medicine by virtue of the availability of various applications on the phones. In the field of neurosurgery and ophthalmology over 300 applications are in use today.Some applications enhance the education of health professionals and patients. Other medical applications are useful in clinical evaluation and patient management.

Smartphone based retinal imaging is useful in outpatient clinics to assess both adults and children especially in young children who may be too young to use the traditional fundus camera^[4]. Smartphone retinal imaging is also a boon in evaluating drowsy or unconscious patients in neurosurgical ICU setting. They are also applicable for mass screening as in eye camps for identifying sight-threatening .They are also needed in the accident and emergency room where fundus camera and indirect ophthalmoscope may not be readily available due to cost and portability^[5].Sometimes when these equipment are even available, using them may also not be feasible due to poor supply of electricity in an underdeveloped rural areas.

Table top non mydriatic fundus cameras also require a co-operative patient who is able to sit upright which is not required with smart phone based fundus imaging systems. The fundus camera costs about 25 times more than a smartphone with retinal imaging system. Since phones are readily available, relatively less expensive, easy to use,

portable and always accessible, their advanced technology of capturing fundus images seems a good alternative^[6].

Of particular advantage is the ability of Smartphones to acquire and store the images, and with data connectivity, enables sharing of images for consultation. Thus, neuro surgical telemedical consultation is made more convenient^[7]. With this, location and time no longer constitute constraints to neurosurgical care.

Follow up of post operative cases can also be done from remote areas based on clinical, radiological and fundus imaging data. This study will explore the use of smartphone based retinal imaging in a resource-limited economy for detection of papilledema.

3. Materials and Methods

This study was conducted in Department of Neurosurgery, Coimbatore medical College. We examined the fundus of 112 neurosurgery in patients with clinical suspicion of raised ICT, aged from 4 months to 72 years, with various neurosurgical conditions using smart phone based retinal imaging system and direct ophthalmoscopy. Direct Ophthalmic evaluation could not be done in drowsy/unconscious patients and very young children on whom smart phone based retinal imaging was possible and such cases were excluded from the study.

On using smart phone based retinal imaging, procedure was explained to the patients, pupils dilated with 2.5% Phenylephrine and 1% Tropicamide ophthalmic drops(one to two drops each eye) and examined 15-20 minutes later.D-eye retinal imaging system attached to smart phone camera and application turned on. Patient details were recorded and camera was held 1-3cm from the eye. Both fundus images and cine recordings of retina were done. Images and videos were stored for future reference and electronic transmission. Using smart phone, papilledema (according to modified Frisen scale Fig 1)was documented in 29 patients and primary optic atrophy in 5 patients .We also obtained direct ophthalmoscopic evaluation by ophthalmologists for these patients and documented papilledema (according to modified Frisen scale)in 27 patients and primary optic atrophy in 5 patients. Results were compared and agreement analysis done.

Stage 0 Normal Optic Disc	Prominence of the retinal nerve fibre layer at the nasal,superior and inferior poles in inverse proportion to disc diameter. Radial nerve fibre layer striations without tortuosity
Stage 1 Minimal	C-shaped halo that is subtle and grayish with a temporal gap

Table 1: Ophthalmoscopic findings in the neurosurgical inpatients

	No papilledema	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Primary optic atrophy
Smart Phone	78	10	3	4	7	5	5
Direct ophthalmoscope	80	8	2	5	8	4	5

For the collected data, agreement analysis was done with SPSS –Intraclass co-efficient measure and report generated. Intraclass co-efficient is 0.067 of lesser significance but with

	Disruption of normal radial retinal NFL arrangement striations Temporal Disc margin Normal
Stage 2 Low Degree	Circumferential halo Elevation of nasal border No major vessel obscuration
Stage 3 Moderate	Obscuration of 1 or more segments of major blood vessels leaving disc Circumferential halo; Elevation of all borders Halo-irregular outer fringe with finger-like extensions
Stage 4 Marked	Total Obscuration of a segment of a major blood vessel on the disc Elevation of whole nerve head, including the cup Border Obscuration complete; Halo complete
Stage 5 Severe	Partial Obscuration of all vessels on disc and Total obscuration of atleast one vessel on disc

Figure 1: Modified Frisen scale



Figure 2(A): Normal Disc

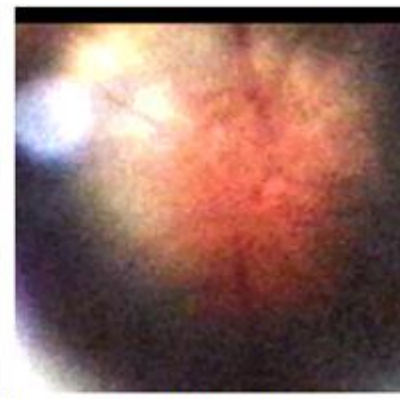


Figure 2(B): Disc with papilledema grade 5

4. Results

Out of 112 cases, using smart phone based retinal imaging, no papilledema was noted in 78 cases. Grade 1 papilledema was noted in 10 cases, Grade 2 papilledema in 3 cases, Grade 3 papilledema in 4 cases, Grade 4 papilledema in 7 cases and Grade 5 papilledema in 5 cases and primary optic atrophy in 5 cases.

Using direct ophthalmoscopic examination, no papilledema was noted in 80 cases. Grade 1 papilledema was noted in 8 cases, Grade 2 papilledema in 2 cases, Grade 3 papilledema in 5 cases, Grade 4 papilledema in 8 cases and Grade 5 papilledema in 4 cases and primary optic atrophy in 5 cases.(Table 1)

Two cases with obscuration of nasal margin of the disc had dissimilar report with smart phone based retinal imaging grading it as Grade 1 and direct ophthalmoscope reporting it as normal fundus.

smaller intervals indicates better extrapolation of the test in the population. The measure of agreement by kappa is 0.927 suggesting that smart phone based retinal imaging stongly

agrees with direct ophthalmoscopic measures in detecting papilledema

5. Discussion

Fundus examination is a fundamental component of the neurological examination often neglected^[8,9]. Direct Ophthalmoscopy is technically difficult and allows only a partial view of fundus. Digital fundus imaging promises to be a better alternative for screening of neurologic patients for papilledema in emergency settings.

Papilledema is optic disc swelling secondary to high intracranial pressure. Possible conditions causing high intracranial pressure and papilledema include intra cranial mass lesions, intra cranial hemorrhages, head trauma, meningitis, hydrocephalus, cortical venous thrombosis, craniosynostosis and idiopathic intracranial hypertension (IIH). Regardless of the cause, visual loss is the feared morbidity of papilledema, and the main mechanism of optic nerve damage is intra neural ischemia secondary to axoplasmic flow stasis. Treatment is directed at correcting the underlying cause.

Early recognition of papilledema in an emergency room and neurosurgery ICU is life saving^[10]. Neurosurgeons are frequently among the first physicians asked to evaluate patients with papilledema in ER, and the patient is often referred with the implication that they may require shunting. The effective use of smart phone based fundus imaging in such settings will reap mutifold benefits-rapid, easy to use, reproducible, electronically documented, clear fundus images can be obtained. The quality of fundus images taken by smart phone could be comparable to that of fundus cameras.

There has been no previous study comparing the efficacy of smart phone based retinal imaging in detecting papilledema with that of a direct ophthalmoscope though its been done in diabetic and hypertensive retinopathies^[11].

Smartphone fundus photography may appear a challenging technique in the beginning. However, like any other examination technique, mastering the technique needs practice and the process of smartphone imaging of the retina becomes routine with time. A particular challenge is related to the location of smartphone cameras and their screen. Most smartphone cameras are located at the corner of the phone while the screen to view and focus the image is at the center. A beginner should focus on mastering coordination between filming and lens hands and proper alignment of the phone, handheld lens, and the pupil axis.

Smartphone fundus photography is a safe technique. Kim *et al.* showed that iPhone 4 camera flashlight is 10 times less luminous than a conventional indirect ophthalmoscope light^[12]. While this may offer more comfort for patients during imaging, it limits image clarity in the presence of moderate to significant media opacity. In the same study, the light levels of the smartphone light source were 150 times below the limit set by the International Organization for Standardization (ISO 15004-2.2) for ocular thermal hazard and 240 times below those limits for the photochemical hazard^[12]. Although light intensity and energy have not been

measured for other smartphone models, it is suggested that they can be well below hazard limits.

6. Conclusion

Smartphone fundus photography is a safe and reliable technique for detection of papilledema in neurosurgical settings. It is as effective as direct ophthalmoscope in detection of papilledema. The effective use of smart phone based fundus imaging will also reap mutifold benefits in terms of rapid assessment and procurement of easily reproducible and electronically transferrable clear fundus images. Smart phone based fundus imaging is a boon for neurosurgery practice in rural setting.

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