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Evaluation of Mobile Electronic Devices in Detecting Optic Disc and Visual Field Parameters in Patients with Glaucoma at a Tertiary Hospital in Northeastern Tanzania

Francisco Alcides Mulobuana[1*], Tolbert Sonda[2], Martin M. Rwabilimbo[3], William Makupa[4]

[1]Kilimanjaro Christian Medical University College, Moshi, Tanzania
[2]Kilimanjaro Clinical Research Institute, Moshi, Tanzania
[3]Department of Epidemiology and Applied Biostatistics, Kilimanjaro Christian Medical College University, Moshi, Tanzania
[4]Kilimanjaro Christian Medical Centre, Moshi, Tanzania
Email: *franciscofranciscoalcides@gmail.com, makupauw@yahoo.com, t.sonda@kcri.ac.tz, martinmujun@gmail.com

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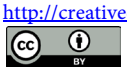

Abstract

Background: Glaucoma is a serious public health problem since it causes visual impairment impacting social, mental and physical health of an individual. Diagnosis and management of glaucoma continue to be a challenge due to few qualified personnel and high cost of the equipment. The use of portable Eye Examination Kit such as Smartphone and tablets can be used in glaucoma screening for taking high-resolution fundus photos for optic disc and visual field parameters, respectively. This study was conducted to evaluate the applicability of mobile electronic device to detect optic disc and visual field parameters for glaucoma in a resource limited setting. **Objective:** To evaluate the applicability of mobile electronic devices to detect optic disc and visual field parameters for glaucoma. **Methodology:** Across-sectional study was conducted at KCMC Eye department from October 2018 to June 2019. Study included 140 participants attending eye clinic of which 67 had glaucoma and 73 without glaucoma. Clinical and socio-demographic data were collected using a structured questionnaire and analysed using Stata 15. Glaucoma examination was made on the right eye and photo comparison made between those with and without glaucoma. PEEK Smartphone fundus photo examination was compared with the gold standard machine (Slit Lamp Biomicroscopy), Amsler grid chart installed on a tablet (Microsoft surface, internal storage 256 GB, 2013) and contrast sensitivity compared with Humphrey field analyser (i series, model 740117434, Carl Zeiss Meditec). **Results:** The kappa (k) agreement between Slit lump biomicroscopy fundus view image and PEEK Smartphone concerning the optic disc measurement was 0.92 with sensitivity and specificity

of 90.32% (95% CI: 80.12 - 96.37) and 93.59% (95% CI: 85.67 - 97.89) with a $p < 0.001$ respectively. An agreement between Amsler grid and Humphrey Field Analyser was 0.67 with sensitivity of 33.33% (95% CI: 20.76 - 47.92) and specificity of 86.52% (95% CI: 77.63 - 92.83) with a $p < 0.005$. An agreement for contrast sensitivity and Humphrey Field Analyser was 0.51 with sensitivity of 48.91% (95% CI: 38.3 - 59.56) and specificity of 54.17% (95% CI: 39.17 - 68.63) and p value of 0.729. **Conclusion:** PEEK Smartphone fundus image specificity was almost in perfect agreement compared with Amsler grid and Contrast sensitivity. The PEEK Smartphone fundus view optic disc parameter for vertical cup to disc ratio has a potential to enhance detection of glaucoma and thus improve its management in resource-limited settings.

Keywords

Glaucoma, PEEK Smartphone, Contrast Sensitivity, Amsler Grid, Kilimanjaro

1. Introduction

Glaucoma is a serious public health problem causing visual impairment, which subsequently impacts social, mental and physical health of an individual. The number of people visually impaired around the world is estimated to be over 200 million; of whom more than 30 million are blind; amongst these, more than 80% are people at middle age and more [1]. Glaucoma is one of the leading causes of blindness and the prevalence in Africa is about 15% with some countries such as Western Cameroon with 8.2%, and those aged 40 years and more were 5.0% in Nigeria and 8.5% in Ghana and in Kenya, according to the same report the prevalence was 4.3% for those aged 50 years and more [2]. In Tanzania having prevalence of all types of glaucoma is 4.16% and the primary open angle glaucoma as the main type [3].

Early diagnosis for effective detection in high risk populations is crucial to prevent loss of vision related with glaucoma [4]. The gold standard for diagnosing glaucoma is perimetry such as Humphrey field device, but by the time the patients come at the health facilities and these defects detected, the visual loss is already installed and permanent [5]. New technological development of portable devices for glaucoma screening such as Smartphone or tablets is worth exploring. The advantages of these tools are related with their accessibility around the world; convenience, low cost compared with gold standard devices, decreased travel time of the patients to the medical clinics away from their communities for follow up, increased access to specialized care for glaucoma, and decreased patient costs [4]. Smartphones or tablets are handy and can be used for taking high-resolution fundus photos image and help in diagnosing and implement early treatment in patients with glaucoma and thus avoiding blindness in remote or under-serviced communities such as rural or remote areas where there are limited ocular specialists [4].

This study was conducted to evaluate the applicability of mobile electronic devices to detect optic disc and visual field parameters for glaucoma.

2. Materials and Methods

2.1. Study Design and Area

This was an analytical cross-sectional study for detection of glaucoma; conducted at KCMC Eye Clinic during October 2018 to June 2019. KCMC is a tertiary referral hospital for over 15 million people, which is located in the foothills of Mount Kilimanjaro in Northern Tanzania. The eye department attends more than two thousand patients a year, with an admission service which contains 62 beds and many types of surgery is done in this setting such as glaucoma surgery (e.g. trabeculectomies, goniotomies), ocular plastic surgery, corneal transplant surgery, retinal surgery and many others.

2.2. Ethical Considerations

Ethical approval for this study has been obtained from the KCMU Co Ethical Committee prior to the commencement of this study with certificate number 2321. Permission to conduct this study has been sought from the Director of the hospital and Head of Eye Department. A written informed consent was obtained from each participant or from parents or relatives before enrolment into the study. Confidentiality and privacy of study subjects was maintained by the use of unique identifiers and only the research team had access to data.

2.3. Ophthalmological Procedure

Patients attending Eye clinic at KCMC hospital were conveniently sampled and enrolled into this study and a sample size of adequate sensitivity and a power of 95% confidence interval with the precision of estimate which does not exceed from 7% were used for calculation [6].

The inclusion criteria was patients above 18 years who consent to participate in the research study, patients with and without glaucoma, patients with refractive error less than +4.75 dioptres and less than −6.0 dioptres and the exclusion criteria was patients with blindness BE and other ocular cormobilities.

All enrolled patients underwent a medical history, visual acuity by Snellen chart recorded in logMAR, portable Eye examination Kit (PEEK) visual acuity (in logMAR) and contrast sensitivity by Smartphone (SonyExperia, m1, d2403, 2015), Auto refractor and Amsler grid tested on the tablet (Microsoft surface, internal storage 256 GB, 2013) and visual field by Humphrey field (Humphrey field analyzer i series, model 740117434, Carl Zeiss Meditec) was done by a trained personnel who was blinded for glaucoma. After all examination, those participants with and without glaucoma were selected if the vertical cup to disc ratio (VCDR) as less than 0.7 and equal or more than 0.7, visual field within normal limits and outside normal limits, respectively. Also patients with refractive error less than +4.75 diopters and less than −6.0 diopters for spherical and

cylindrical were included. For contrast sensitivity, those with equal or less than 2.5% were considered normal and those with more than 2.5% were considered abnormal and the comparison was made with visual field from Humphrey Field Analyser. Amsler grid measured the areas of scotoma, those with no areas of scotoma were considered normal and those with areas of scotoma were considered abnormal and comparison with visual field results 10 - 2 from Humphrey field was made and recorded [7] [8].

2.4. Statistical Analysis

All analyses were performed using Stata 15. Descriptive statistics were determined for all demographic and ocular characteristics and presented as proportions. Data for the right eye was chosen for analyses. To compare Smartphone performance with the gold standard tools kappa coefficient of agreement was calculated. We also calculated sensitivity, specificity, positive and negative predictive value of Smartphone in detecting glaucoma.

3. Results

3.1. Socio-Demographic and Clinical Characteristics of Study Participants

A total 140 patients who met the inclusion criteria were included in the analysis (Table 1). Out of 140 participants 74 (52.9%) aged 18 - 50 with 74 (52.9%) being female. It was observed that those with normal visual acuity measured by Snellen VA were more predominant 128(91.4%) with the similar results for PEEK visual acuity 129 (92.1%). Refractive error for spherical and cylindrical were evaluated and those scored < +2.00 diopters and those with <−1.5 diopters were 63 (45%) and 96 (68.6%), respectively.

Intraocular pressure was measured in all participants and found that most of the participants scored normal values in between 9 to 21 mmHg, 1 (0.7%) participants with less than 9 mmHg and 4 (2.9%) with more than 21 mmHg. For contrast sensitivity 92 (65.71%) of the participants scored more than 2.5% and those with no scotoma for Amsler grid were 89 (63.6%). For Amsler grid and Humphrey field severity was 89 (63.6%) and 11 (79.3%) for those with no scotoma, respectively. Participants with less than 0.7 vertical cup to disc ratio were 79 (56.4%) as measured by Smartphone which was similar with the slit lamp measurement of vertical cup to disc ratio in 78 (55.7%) participants.

According to Humphrey field, participants with within normal limits were 73 (52.14%) compared with those with outside normal limits that were 67 (47.86%). For mean deviation for those with ≤2 dB was 91 (65%).

3.2. Comparison between PEEK Smartphone Contrast Sensitivity and Humphrey Visual Field Analyser

The agreement (k) between PEEK Smartphone contrast sensitivity and Humphrey visual field analyser was 0.51 with $p > 0.05$ and sensitivity of 48.9% (95%

Table 1. Socio-Demographic and clinical characteristics of study participants (N = 140).

	Characteristics	N	%
Age	18 - 50	74	52.86
	Above 50	66	47.14
Sex	Female	74	52.86
	Male	66	47.14
Snellen VA	≤0.48 LogMAR	128	91.43
	>0.48 LogMAR	12	8.57
PEEK VA Smartphone	≤0.48 LogMAR	129	92.14
	>0.48 LogMAR	11	7.86
Refractive error spherical	<+2.00 diopters	63	45
	+2 to +4.75 diopters	4	2.9
	≤ 1.5 diopters	40	28.6
	−1.5 to −6.0	3	2.1
	Error	30	21.4
Refractive error cylindrical	<+2.00 diopters	9	6.4
	+2 to +4.75 diopters	1	0.7
	≤ 1.5 diopters	96	68.6
	−1.5 to −6.0	8	5.7
	Error	26	18.6
IOP	<9 mmhg	1	0.71
	9 - 21 mmhg	135	96.43
	>21 mmhg	4	2.86
PEEK Smartphone Contrast sensitivity	≤2.5%	48	34.28
	>2.5%	92	65.71
PEEK Smartphone Amsler grid	no scotoma	89	63.57
	1 or more scotoma	51	36.43
PEEK Smartphone Amsler grid severity	Mild - no scotoma	89	63.6
	Moderate - one scotona in one quadrant	12	8.6
	Severe - scotoma in more than one quadrant	39	27.9
PEEK retina smartphone	≥0.7 VCDR	61	43.6
	<0.7 VCDR	79	56.4
Slit lamp biomicroscopy	≥0.7 VCDR	62	44.29
	<0.7 VCDR	78	55.71
Humphrey visual fieldanalyzer	Outside normal limits is abnormal	67	47.86
	Within normal limits is normal	73	52.14
Humphrey visual field analyzer 10 - 2 severity	Mild - no scotoma	111	79.3
	Moderate - one scotona in one quadrant	1	0.7
	Severe - scotoma in more than one quadrant	28	20
mean deviation	≤2 dB abnormal	91	65.00
	≥2 dB normal	49	35.00

CI: 38.34 - 59.56), specificity of 54.2% (95% CI: 39.17% - 68.63%), positive of 67.2% (95% CI: 54.60 - 78.15) and negative predictive value of 35.6% (95% CI: 24.75 - 47.69) between contrast sensitivity Humphrey visual field analyser (Table 2).

3.3. Comparison between PEEK Smartphone Amsler Grid and Humphrey Visual Field Analyser

The agreement (k) between PEEK Smartphone Amsler grid and Humphrey Visual Field Analyser was 0.67with sensitivity and specificity were 33.3% (95% CI: 20.76 - 47.92) and 86.5% (95% CI: 77.63 - 92.83), respectively. Positive and negative predictive values were 58.6% (95% CI: 38.94 - 76.48) and 69.4% (95% CI: 59.91 - 77.77), respectively and $p < 0.005$ (Table 3).

3.4. Comparison between PEEK Retina Smartphone and Slit Lamp Biomicroscopy

The agreement (k) between Smartphone and Slit lamp biomicroscopy was 0.92 with sensitivity and specificity of 90.3% (95% CI: 80.12 - 96.37) and 93.6% (95% CI: 85.67 - 97.89), respectively with $p < 0.0001$. Positive and negative predictive values were 91.8% (95%CI: 81.90 - 97.28) (Table 4).

Table 2. PEEK Smartphone Contrast sensitivity and Humphrey visual field analyser (N = 140).

Test	Measures	Estimate %	95%CI	Chi-square P value
Contrast sensitivity	Sensitivity	48.91	38.3 - 59.56	0.1199 > 0.05
	Specificity	54.17	39.17 - 68.63	
	PPV	67.16	54.60 - 78.15	
	NPV	35.62	24.75 - 47.69	

Table 3. PEEK Smartphone Amsler grid vs. Humphrey visual field analyzer.

Test	Measures	Estimate %	95%CI	Chi-square P value
Amsler grid	Sensitivity	33.33	20.76 - 47.92	7.7785 < 0.005
	Specificity	86.52	77.63 - 92.83	
	PPV	58.62	38.94 - 76.48	
	NPV	69.37	59.91 - 77.77	

Table 4. PEEK retina Smartphone f vs. Slit lamp Biomicroscopy.

Test	Measures	Estimate %	95%CI	Chi-square P value
PEEK Smartphone	Sensitivity	90.32	80.12 - 96.37	98.9256 < 0.0001
	Specificity	93.59	85.67 - 97.89	
	PPV	91.80	81.90 - 97.28	
	NPV	92.41	84.20 - 97.16	

4. Discussion

In the present study PEEK Smartphone for vertical cup to disc ratio measurement showed a promising potential to be used for glaucoma screening in LMICs. Smartphone had a strong agreement (92%) with Slit lamp biomicroscopy, which is considered a standard screening tool for glaucoma when optic disc parameters were evaluated. Similar to the current studies, several studies, which implemented Smartphone's for glaucoma screening, found strong agreement with standard screening tool [9].

In this study it was also noted that Smartphone agreement (92%) with Slit lamp biomicroscopy was almost the same with that recorded [10].

The almost same observed agreement between PEEK retinal Smartphone with Slit lamp biomicroscopy in the current study may be due to the quality of image and the almost same sample size.

This means that Smartphone fundus view can be used for glaucoma as sensitivity and specificity and due to its portability and easy to perform the test.

A moderate agreement of 0.51 was found in this study for PEEK Smartphone contrast sensitivity compared with the study done in United States of America, Spain and Turkey, respectively [11] [12] [13]. Those studies presented with the similar results due to refractive error and cataract. These results showed that contrast sensitivity may not be used alone to detect glaucoma because even those patients whereby they do not had glaucoma the contrast sensitivity scored more than 2.5%.

According to the comparison between PEEK Smartphone Amsler grid and Humphrey visual field analyzer (10 - 2), when related with areas of scotoma it was found an agreement of 0.67 which was similar with the study done in United States of America [14]. It was also found that PEEK Smartphone Amsler grid test had lower sensitivity compared with the study done in Switzerland, due to the sample size, severity of the disease and the fact that in the study were associated with wet-related macular generation was studied [15].

It may not be used to screen for glaucoma on the fact that it can miss to diagnose patients at the early stage of the disease.

5. Limitations

Some of the pictures from PEEK retina were difficult to evaluate because was not so clear compared with Slit lamp and subjectively were given the results. The auto refractor was giving error for 30 patients.

6. Conclusion

PEEK Smartphone fundus view image might be a good tool for screening of optic disc parameters of glaucoma. Its sensitivity and specificity in detecting optic disc damage and its low cost, portability and easy to use make it very more useful in LMICs.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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