Ocular health screening among care-center residents with disabilities: a smartphone adaptive fundus camera cross-sectional study

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Abstract. – OBJECTIVE: **The aim of this study was to evaluate the ocular health of care-center residents with disabilities who have difficulty accessing health care using a novel smartphone-adapted fundus camera device, and to compare the results to age- and gender-matched health subjects.**

PATIENTS AND METHODS: **In this study, 47 care-center residents with disabilities were investigated between October 1, 2021, and December 31, 2021. A control group was made up of healthy volunteers. All participants underwent a comprehensive ocular exam, which included measuring visual acuity and assessing dry eye with Schirmer and tear break-up time tests. The posterior segment was examined using a smartphone-adapted fundus camera. The data gathered was compared with statistical significance between the two groups.**

RESULTS: **The mean ages of disabled and healthy participants were 59.7±15.2 and 56.6±15.0 years, respectively (*p*=0.305). While 11.1% of the 36 visually impaired participants were legally blind, the percentage among healthy subjects was only 3.7% (*p*=0.168). In comparison to healthy participants, disabled people had statistically significantly higher rates of dry eye (27.7%), senile macular degeneration (23.4%), and cataracts (29.8%) (*p*<0.05).**

CONCLUSIONS: **Screening for ocular health with a novel smartphone-adapted fundus camera revealed significantly higher rates of various ocular diseases in care center disabled residents. Given technological progress, remote control method-assisted ocular exams appear to be potentially feasible and clinically beneficial. This could allow trained allied health personnel to perform ocular health screenings without the need to transport a disabled person to the hospital. Thus, diagnosis and follow-up of various chronic ocular diseases may be properly organized.**

Key Words:
Care center, Disabled, Fundus camera, Ocular health, Screening, Smartphone, Medical device.

Introduction

Disabled people are those who are unable to meet their daily needs due to a physical or mental disability, either congenital or acquired. They need socialization, protection, care, and rehabilitation services[1]. According to reports[2], 12% of Americans are disabled. The World Report on Disability 2011 of the World Health Organization (WHO) estimated the global disabled population to be 15.6% of the population over the age of 18. This proportion is expected to rise to 11.8% in high-income countries and up to 18% in low-income countries[3].

Dry eye prevalence ranges between 3.9% and 33.7%; however, its incidence increases with age[4,5]. This disorder impairs visual function, interfering with daily activities such as computer work, reading books, and newspapers[6]. Similar to dry eye, diseases such as cataracts and age-related macular degeneration are expected to become more prevalent as people age. Cataract prevalence has been reported to be 6% in the population aged 45-49, but this rate rises to 77% in individuals aged 85-89 years, and it is predicted that 240.8 million people worldwide will have low vision problems due to cataracts by 2050[7]. Whilst also age-related macular degeneration caused significant vision loss in 26.6 million people in 2015, this figure is expected to rise to 55.1 million by 2050[8].

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The purpose of our study was to assess the ocular health of care-center residents with disabilities who have difficulty accessing health care using a novel smart phone-adapted fundus camera device and compare the results to age- and gender-matched health subjects.

Patients and Methods

Study Design and Participant Selection

The cross-sectional study was carried out between October 1, 2021, and December 31, 2021, with 49 disabled participants residing in a private disability care center. The study had no sample size calculation and attempted to reach out to all residents of the disabled care center. There were no exclusion criteria established for the study's participants; 47 (95.9%) of those who agreed to participate were included. A group of 54 healthy volunteers who did not smoke or drink alcohol and did not have any ocular or systemic diseases served as the control group.

The study protocol adhered to the Declaration of Helsinki's ethical principles and was fully approved by the Afyonkarahisar Health Sciences University Ethics Committee Institutional Review Board with the approval code and date: 2021/433. All participants were informed about the questionnaire, after which their consent was obtained.

Data Collection

Face-to-face interviews with the study's disabled participants were conducted using a questionnaire containing socio-demographic characteristics and Edmonton Frail Scale questions[9]. This scale assesses nine frailty domains: cognitive status, general health status, functional independence, social support, medication use, nutrition, mood, continence, and functional performance. "General health status" and "medication use" are assessed with two questions, while the others are assessed with a single question. The scale yields a minimum of 0 points and a maximum of 17 points. An increase in the total score of the scale indicates that the frailty severity is becoming more severe. The frailty level was classified as no frail (0-4 points), frailty (5-6 points), mild frailty (7-8 points), moderate frailty (9-10 points), and severe frailty (11-17 points)[10]. Participants were asked about their smoking status, which was defined as having smoked at least one cigarette per day for ≥6 months.

Ocular Assessment

A portable handheld slit lamp (Reichert Inc, Depew, NY, USA) and a portable visual chart with letters were used in a large room with adequate lighting. An ophthalmologist (I. Ethem Ay) examined the disabled and used Volk 90D (Volk Optical Inc, Mentor, OH, USA) to perform fundus imaging. Initially, visual acuity testing was performed separately for both eyes from a distance of 6 m. Participants who could not undergo visual acuity testing due to dementia or mental disability were documented. Those who had a visual acuity of <3/60 in their best eye were legally blind, according to the WHO definition[11]. In all participants, a hand-held slit-lamp was used to assess the presence of cataract, as well as dry eye using the Schirmer (Biotech, Ahmedabad, India) and tear break-up time tests. Those with vision <20/20 had their pupils dilated, and a fundus examination was performed using a fundus camera [VolkinView, Volk Optical Inc, (Mentor, OH, USA)], which can be adapted to a smartphone with the Volk 90D (Figures 1 and 2). Senile macular degeneration was diagnosed in participants who had >5 drusen or age-related macular scar.

Statistical Analysis

Statistical analysis was performed using a statistical package for the social sciences, version 23.0 (SPSS Inc., IBM Corp., Armonk, NY, USA). Continuous variables were defined using the mean and standard deviation, while categorical variables were defined using numbers and percentages. The *t*-test was used to compare groups for continuous variables and the Chi-square test for categorical variables. The statistical significance limit was determined as $p<0.05$.

Results

Socio-demographic Characteristics and Frailty Scores

The mean ages of disabled and healthy participants were 59.7±15.2 and 56.6±15.0 years, respectively ($p=0.305$). Males outnumbered females in both groups, with 56.6% of disabled participants and 59.3% of health subjects being males ($p=0.974$). The majority of participants were primary school graduates, with 44.7% being disabled and 48.1% being healthy subjects. 57.4% of disabled and 79.6% of health participants had never smoked. 85.1% of disabled participants reported having a chronic disease or disability, and 51.1% took regular medication. Furthermore, 83.0% of disabled participants used a walker or wheelchair to get to the restroom, 12.8% had fallen in the previous year, and 33.3% had to apply to the hospital after falling. The mean frailty

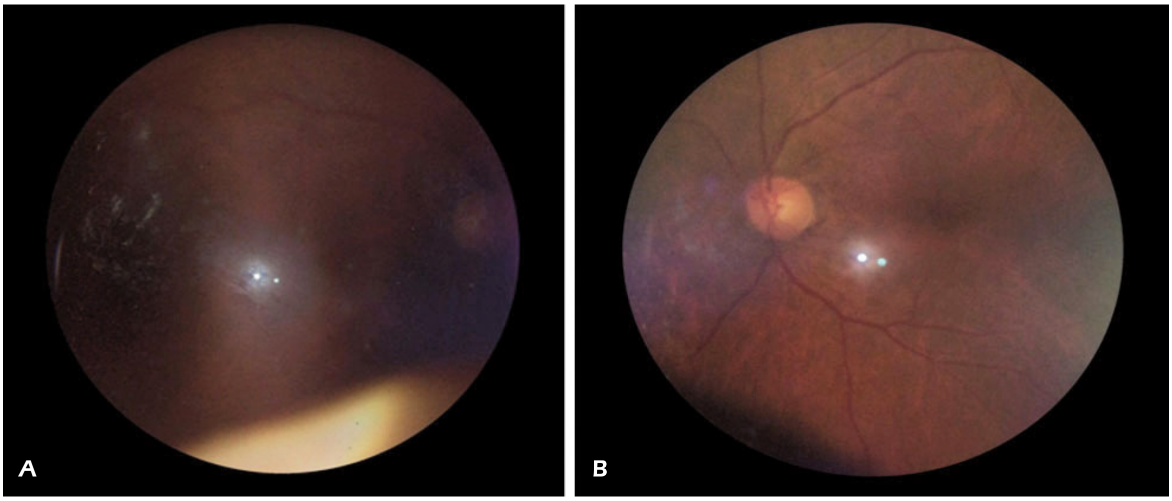

Figure 1. **A**, Fundus photograph taken with a smartphone, blurred image due to cataract. **B**, Retina details are clear.

score among 37 disabled participants was 7.95±4.07, with 24.3% reporting severe frailty. Table I summarizes the participants' socio-demographic characteristics as well as their frailty scores. All disabled participants had been vaccinated against COVID-19 disease as of the date of the study.

Chronic Diseases and Medications

Hypertension was the most common chronic disease seen in disabled people (31.9%), followed by diabetes mellitus (23.4%) (Table II).

Ocular Findings

When compared to healthy participants, disabled participants had a statistically significantly higher proportion of dry eyes (27.7%), senile macular degeneration (23.4%), and cataracts (29.8%) ($p<0.05$). Visual acuity could not be assessed in 23.4% of disabled participants with mental retardation or disability, such as Alzheimer's disease. While 11.1% of the remaining 36 visually disabled participants were legally blind, the percentage among healthy subjects was only 3.7% ($p=0.168$) (Table III).

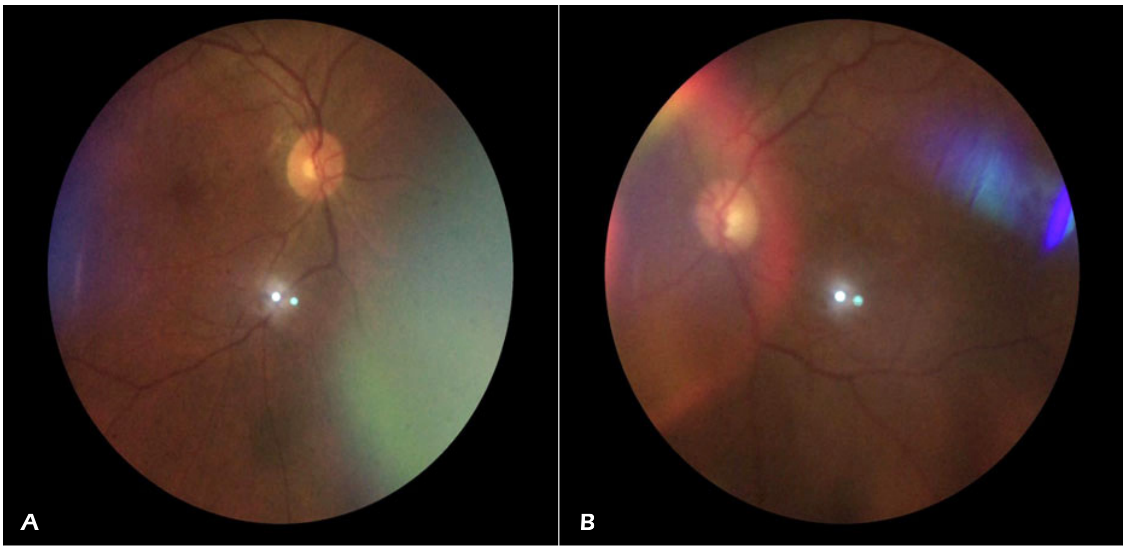

Figure 2. **A-B**, Fundus photographs show retina clearly, and senile macula degeneration seen in left eye.

Table I. Participants' socio-demographic characteristics and their frailty scores.

Parameters	Care-center residents with disabilities		Healthy subjects	
	Number of participants	Percentage	Number of participants	Percentage
Gender				
Female	19	40.4	22	40.7
Male	28	59.6	32	59.3
Educational Status				
Illiterate	11	23.4	1	1.9
Literate	11	23.4	25	46.3
Primary education	21	44.7	26	48.1
High school and above	4	8.5	2	3.7
Smoking behavior				
Never smoke	27	57.4	43	79.6
Smokes at least one cigarette per day	7	14.9	7	13.0
Quit smoking	13	27.7	4	7.4
Chronic diseases				
Present	40	85.1	14	25.9
Absent	7	25.9	40	74.1
Medication				
Present	24	51.1	16	29.6
Absent	23	48.9	38	70.4
Assistive vehicle use				
Walker/Wheelchair	39	83.0	4	7.4
Glasses	0	0.0	10	18.5
Hearing device	1	2.1	0	0.0
Nothing	7	14.9	40	74.1
History of falling in the last 1 year				
Yes	6	12.8	7	13.0
No	41	87.2	47	87.0
Hospitalization following a fall among those with a fall history				
Yes	2	33.3	5	71.4
No	4	66.7	2	28.6
Frailty groups				
No frail	7	18.9	-	-
Insecure	7	18.9	-	-
Mild frailty	7	18.9	-	-
Moderate frailty	7	18.9	-	-
Severe frailty	9	24.3	-	-

Discussion

The use of smartphones among medical professionals has been growing, as well as their application in ophthalmology[12-16]. These devices have also been widely used by medical professionals for the patient and medical education, patient participation in treatment, as well as sharing high-quality images and videos in the medical field[17]. Many things are now possible thanks to advancements in phone hardware and software, and the use of smartphones has an important place in the medical field when resources are limited. Chen et al[18] proposed that cataract patients could be diagnosed using a smartphone, a potentially cost-effective method[19]. Several studies[20-22] also claim that smartphones can be used to diagnose and monitor retinal diseases such as diabetic retinopathy. In our study, which we believe is the first of its kind, we used a novel smartphone-adapted fundus camera device to assess the ocular health of care-center residents with disabilities who have difficulty accessing health care.

Table II. Chronic disease and medication status of the participants.

Parameters	Care-center residents with disabilities: Number of participants	Care-center residents with disabilities: Percentage	Healthy subjects: Number of participants	Healthy subjects: Percentage
Chronic diseases**				
Hypertension	15	31.9	8	14.8
Paralytic***	13	27.7	-	-
Diabetes mellitus	11	23.4	10	18.5
Alzheimer's disease and mental retardation	11	23.4	-	-
Hyperlipidemia	5	10.6	2	3.7
Asthma or chronic obstructive pulmonary disease	3	6.4	2	3.7
Cancer	3	6.4	-	-
Medication**				
Anti-hypertensives	15	31.9	8	14.8
Anti-diabetics	10	21.3	10	18.5
Anti-lipidemics	5	10.6	2	3.7
Bronchodilators	3	6.4	2	3.7
Anti-cancers	1	2.1	-	-

*Column percentage was used. **Multiple options were marked. ***Paralyzed individuals included those with spinal cord paralysis, those with a history of cerebrovascular accident and cerebral palsy, and those who could not walk due to progressive musculoskeletal disease.

Undoubtedly, dry eye is one of the most common ocular health issues in the ophthalmology world, with a negative impact on quality of life. It is believed to affect nearly one-third of the world's population[23,24]. The ocular surface is inflamed, which causes increased osmolarity in the tear film, as well as frequent ocular complaints like discomfort, burning, and stinging[25]. There are two types of dry eye: those caused by aqueous insufficiency and those caused by evaporation.

Table III. Chronic disease and medication status of the participants.

Parameters	Care-center residents with disabilities: Number of participants	Care-center residents with disabilities: Percentage	Healthy subjects: Number of participants	Healthy subjects: Percentage
Dry eye				0.034
Present	13	27.7	6	11.1
Absent	34	72.3	48	88.9
Senile macular degeneration				0.024
Present	11	23.4	4	7.4
Absent	36	76.6	50	92.6
Cataract				0.000
Present	14	29.8	2	3.7
Absent	33	70.2	52	96.3
Visual acuity	-			
Assessed	36	76.6	54	100.0
Not assessed	11	23.4	0	0.0
Legal Blindness in the visual acuity assessed group				**0.168**
Present	4	11.1	2	3.7
Absent	32	88.9	52	96.3

The former is characterized by a decrease in tear production caused by lacrimal gland pathology. The latter, on the other hand, has a high rate of evaporation due to a decrease in the blink reflex caused by prolonged exposure to a screen or being in air-conditioned environments, resulting in the dry eye picture[26].

We revealed a significantly higher rate of ocular diseases such as dry eye, senile macular degeneration, and cataracts in disabled participants. Higher dry eye proportion in disabled participants compared to in age- and gender-matched health participants could be attributed to the fact that these participants spend the majority of their time in a closed and air-conditioned environment, often with screen exposure such as tablets, phones, and televisions. It has previously been reported that the frequency of dry eyes increases in an air-conditioned environment and when spending extended periods with electronic devices such as tablets and phones[27,28]. We could not find any academic study showing that dry eye is more common in disabled individuals. However, we observed that those staying in the disabled care center had low self-care. We think there may be a link between this and dry eye. New studies are needed in this area.

Age-related macular degeneration and cataract have both been associated with poor nutritional status and stress[29,30]. In our study, higher rates of cataracts and senile macular degeneration in disabled participants may be related to malnutrition and stress exposure throughout life. Despite the absence of a statistically significant difference, legal blindness was discovered in 11.1% of the 36 visually disabled participants but only 3.7% of the healthy participants (p=0.168). This could be attributed to the study's small sample size; however, our study found nearly the same percentage as a previous study[31], which found that 9.5% of 231 elderly care center residents were legally blind. Moreover, we found that the rate of legal blindness in disabled participants was higher than the global rate (2.4%), which was close to the rate determined in healthy participants (3.7%)[32]. We think that the reason why legal blindness is frequently seen in the disabled group is the limited access to health services for the disabled. Although there was no statistically significant difference with the control group, diseases that cause preventable blindness such as cataract and senile macular degeneration may be associated with a higher incidence of legal blindness in disabled people.

In our study, 83.0% of disabled participants used a walker or wheelchair to get to the restroom, 12.8% had a fall history in the previous year, and 33.3% of those with a fall history were hospitalized after falling. Another noteworthy finding in our study was that legally blind disabled participants lost their sight due to cataract and senile macular degeneration, both of which are preventable causes of blindness. In the absence of regular visual examinations, the number of legally blind disabled people will increase over time as a result of diseases such as cataracts and senile macular degeneration, and orthopedic problems caused by falls may become more common. Maintaining visual acuity is also critical for disabled people. Increased access to health care services can help to solve the problem in a cost-effectively manner. Future smartphone eye scans could benefit people with disabilities, particularly those with limited access to healthcare.

Limitations

There are limitations to our study. The relatively small number of participants in our study, which enrolled disabled people from only one care center, could be the most important determinant of our study findings. The presence of chronic disease and the medications used were obtained directly from the participants and the care center's medical records, which could be incomplete. Furthermore, our study's findings cannot be applied to all disabled people. The reason might be that people living in care centers face more difficult circumstances than the general population. They are housed in a care facility as no one is available to provide them with regular care.

Conclusions

Given the increasing popularity of smartphones in society, it is reasonable to anticipate that smartphone-adapted fundus cameras will become more common for use in ophthalmology daily. If medical assistants are trained to use such devices, information about the patient can be electronically transferred to the ophthalmologist, allowing for a low-cost diagnosis, follow-up, or treatment. In the future, such an examination and ocular health screening may be available to a broader population, beginning with the disabled, those in quarantine due to the epidemic, and patients isolated following bone marrow transplantation. Given the relationship between frailty and visual acuity, using smartphones to evaluate people with high frailty, particularly disabled people and those who are thought to have difficulty accessing health services, will pave the way for early diagnosis and treatment of many diseases that impair vision. As a result, people with disabilities may have lower frailty ratings.

Acknowledgments

None.

Funding

The authors declare that they have received no public or private financial support or involvement in the products, methods, or materials mentioned in this manuscript.

Conflict of Interest

The authors declare that they have no conflict of interests.

Ethics Approval

This study followed the Helsinki Declaration and was approved by the Afyonkarahisar Health Sciences University Clinical Research Ethics Committee under approval number: 2021/433.

Informed Consent

Each participant signed a written informed consent form before participating in the study.

Author Contributions

Ibrahim Ethem Ay: Conceptualization, methodology, formal analysis, investigation, writing-original draft, writing-review and editing, visualization, project administrator. Fırat Kose: Conceptualization, methodology, formal analysis, writing-review and editing, project administrator.

Data and Material Availability

The datasets used and/or analyzed during the current study are available upon reasonable request from the corresponding author.

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