Continued focus on optometry and vision research

The year 2021 has ended with the global pandemic reaching new highs. In this issue of the *Scandinavian Journal of Optometry and Vision Science* (*SJOVS*) you will learn about the challenges of the COVID-19 pandemic from the optometrist's perspective in Nigeria (Musa et al., 2021). You will also get the opportunity to advance your knowledge about advanced imaging of the anterior eye, specifically tarsal plate imaging (Recchioni, 2021a) and about eye movements and fixation stability of children with and without dyslexia (Vikesdal et al., 2021). Meanwhile, both the Italian optometry association SOPTI and the USN National Centre for Optics, Vision and Eye Care organised hybrid optometry and vision science conferences. The scientific abstracts from the SOPTI annual meeting (Recchioni, 2021b). and the Kongsberg Vision Meeting (Baraas, 2021) are published in this issue.

There have been some further important developments to the scope of the journal. The editorial board and scientific advisory board members have been working on different aspects related to continued focus on optometry and vision research, discussing and selecting special topics. We will announce the special topics, one at a time. We encourage optometrists, researchers, and related professionals to submit their work to be considered for publication in a *SJOVS* standard issue over a two-year period, if accepted, manuscripts, will be included in the online collection of the given special topic. The first special topic is announced in this issue of *SJOVS*, this is going to be: *vision screening*. The special topic editorial on vision screening is authored by Scientific Advisory Board member and guest editor Prof. Niall Strang, guest editor Prof. Brendan Barrett and the *SJOVS* Editor-in-Chief (Strang et al., 2021).

We would also take this opportunity to thank all the reviewers for their valuable contribution in evaluating the manuscript submitted to *SJOVS*. The peer review process is an essential component in dissemination research and making it available to clinical and scientific community. Only with peer review is it possible to ensure that manuscripts published in *SJOVS* are have scientific value and the content can be trusted. We know that reviewers often use their own time to contribute to the journal with their expertise and we are grateful for their generous contributions.

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On behalf of SJOVS, we wish you all a safe and prosperous New Year.
Editor-in-Chief Rigmor C. Baraas
Associate Editor Antonio Filipe Teixeira Macedo

Vision Screening Programmes: Collaborative work for developing evidence-based vision screening protocols.

The ability to see clearly both at distance and at near is important in allowing children and adolescents to develop to their full potential in life. The WHO's first world report on vision published in October 2019 (WHO, 2019) showed that more than 1 billion people in the world have vision problems that are preventable, with the majority being related to uncorrected refractive errors. As stated in the UN resolution 75/310, the provision of eye care services for everyone is essential for achieving the Sustainable Development Goals 1, 2, 3, 4, 8, 10 and 11. While there is a general acceptance that children's vision screening is important, uncertainty remains about the best approach to take to develop and run a successful programme. This is evidenced by the different methods of vision screening employed across the world. This inconsistency is not unexpected when one considers that screening protocols are influenced by factors of resources/cost, the skills of the screener, time constraints and prevalence of eye and vision problems in the target population. There is a consensus that examining children at about 4–5 years of age is useful at detecting problems such as reduced visual acuity, amblyopia, strabismus, and some refractive errors. However, the ability to detect these problems accurately will be influenced by the approach taken. For example, measuring distance visual acuity in each eye is likely to pick up most children with amblyopia, myopia and higher levels of astigmatism but is much less likely to pick up strabismus and hyperopia. The addition of a distance and near cover test would allow strabismus to be picked up, but hyperopia may still prove elusive. Additional tests would be required to detect hyperopia, but there is a lack of knowledge to what combination of tests might be most useful. Potential options include near VA testing, cycloplegic refraction or measuring distance vision through positive (e.g. +2.00D) or negative spherical lens power (e.g. -4.00D). All these possibilities bring additional levels of complexity and resource that could impact on the viability of a screening programme. For example, the addition of a near test may help detect additional hyperopia but the availability of print sizes that are close to VA threshold continue to make this a difficult option.

Current knowledge would also suggest that it is not enough to just have one screening at about 4–5 years of age, as eyes and vision continue to develop throughout childhood, into adolescence, when myopia often first appears, and beyond. Furthermore, hyperopia may impose an increasing problem during later school years when the level of near work required to be able to do school- and homework puts an increasing demand on sustained comfortable vision. This suggests that there may not necessarily be one gold standard approach to vision screening that should be undertaken across all age groups. However, it would be useful if the decisions taken when developing future vision screening programmes could be evidence-based.

In this special topic of the Scandinavian Journal of Optometry and Vision Science we hope to address some of the issues outlined above and would welcome contributions that will help vision screeners during the development stage of screening protocols. One important question would be to assess the trade off in sensitivity and specificity that can occur when additional tests are included in a screening protocol. To this end we are hoping to develop a screening protocol paper that would be available to researchers and project students around the world to generate data. This protocol will help to address questions surrounding the most effective methods of picking up hyperopia in different age groups. Is cycloplegia essential or do techniques such as near vision assessment and plus blur have a role, at least in some age groups?

Another important consideration in any screening programme is the issue of cost, and vision screening programmes that give full details of cost are limited. This is unsurprising when one considers the drivers of costs such as the availability of drugs, equipment, screening personnel and time are all likely to vary between countries. To this extent, knowledge from other research fields may become important. The use of technology is likely to continue to drive some screening approaches. For example, deep learning has shown reasonably good performance at predicting refractive error from fundus images (Varadarajan et al, 2018) and a novel vision screener instrument has reported good success at detecting strabismus and amblyopia in a school age population (Bosque et al., 2021). The ubiquitous mobile phone may also play an important role in measuring visual performance as technology develops. Equally simple solutions may be the most effective. Modifying visual acuity chart design to allow easier scoring (WHO, 2018) may be a quick and cost-effective solution and the role of questionnaires in vision screening has yet to be fully examined.

The above discussion highlights the scope of the topic that needs to be examined further in the field of children's vision screening. We hope that by making vision screening a special topic in *SJOVS* we can encourage collaboration between groups of researchers, clinicians, and students and help in the development of evidence-based solutions to the current problems facing vision screening across the world. Of course, identifying eye and vision problems represents only the first stage in a screening process. It is important to mention that any screening programme requires several follow up steps to be successful. Good access to further examination for screening is required and affordable spectacles need to be provided. A mechanism of follow up is also important as, once dispensed, the spectacles need to be worn appropriately. Failure to address any of these issues will limit the benefits of a screening programme and innovative methods of addressing these issues are encouraged.

Niall Strang
Scientific Advisory Board Member, Guest Editor

Brendan Barrett
Guest Editor

Rigmor C. Baraas
Editor-in-chief

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Managing in early COVID-19: The Nigerian optometry experience

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Abstract

This study was designed to assess the knowledge, attitude, and practices of Nigerian optometrists and optometry students with regard to the COVID-19 pandemic, while also assessing its impact of their daily personal and professional routines.

The Google Forms suite was used to design an online structured survey/questionnaire. This was sent to Nigerian optometrists and optometry students along with a message soliciting their voluntary participation. This survey took place between 10th April and 15th May 2020. The responses received were electronically transmitted to the authors and populated via Google suite software. Descriptive statistics and inferences were then derived from these data.

A total of 399 valid responses were logged during this study. Of these, 183 (45.4%) respondents were optometry students from the eight optometry education departments in Nigeria. Optometric doctors made up 216 of the respondents. 86% of optometrists reported having cases of COVID-19 in their state. No optometrists reported suffering from the COVID-19 disease while one (0.5%) student had been infected with COVID-19. Twelve percent of student respondents felt educational facilities were adequate to cater for post COVID- 19 resumption, while 21.5% of students felt that the ongoing academic session should be restarted.

The COVID-19 Pandemic has impacted greatly on service delivery among Nigerian optometrists and optometry education. Educational institutions must also adjust to current realities in order to be able to provide safe and adequate training when the academic section resumes or restarts.

Keywords: COVID-19, pandemic, optometrists, optometry

Introduction

The Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2 or COVID-19) was first reported worldwide in December 2019 (Chen et al., 2020). The index case of an infected individual in Nigeria was an Italian expatriate, as reported on the 27th of February 2020 (Ebenso & Otu, 2020).

In Africa, Nigeria ranked ninth in number of confirmed cases with 165,419 cases, and tenth in the number of deaths from the pandemic (2065 mortalities) at the time of this survey (World Health Organisation, 2020). These numbers pale when compared to the numbers from the western world (Sim, 2020).

The COVID-19 pandemic continues to affect daily life as much as any other single factor in recent times. It has resulted in more than 158.5 million cases and 3.3 million deaths across the world (John Hopkins University, 2021).

The health care industry has taken a major hit from the crisis with estimates ranging from 50–70% of economic losses. Optometric patient care in Nigeria is predominantly provided by private clinics, similar to radio-diagnostic care. These clinics were very vulnerable to economic loss during the lockdown (Cavallo & Forman, 2020).

It is vital that healthcare workers remain in good health of mind and body to be able to render much needed skills in the management of COVID-19 patients, and in fact regular patients who still need health care.

With increasing cases confirmed daily, healthcare workers across the professional spectrum are increasingly exposed to physical and mental health risk. Data already exists that shows the psychological burden healthcare workers are exposed to in such dire times (Wu et al., 2009). Such health risks include direct infection, physical stress, and exposure to injury; and these in turn put families of healthcare workers at risk (World Council Of Optometry, 2020).

Optometrists are primary care providers that serve as the first point of contact for patients in the eye care system. In addition, Nigerian optometrists are responsible for patient consultation, investigation, detection, and management of ocular conditions that pose a risk to the eye. This is often in addition to assessing biometric parameters that directly or indirectly impact the integrity of the visual system like blood pressure, blood sugar, blood, and hormonal panels etc.

The COVID-19 pandemic presented professional and economic consequences for optometrists while also disrupting the academic calendars of optometry students. The use of personal protective equipment (PPE), environmental controls (such as regular disinfection of high contact surfaces) and administrative controls such as screening protocols for patients and staff have been suggested (Seah et al., 2020). It is recommended that PPE use become compulsory for optometrists to safely perform their duties (Centres for Disease Control and Prevention, 2020).

This critical role optometrists play has necessitated the World Health Organization (WHO) to recommend a ratio of one optometrist to 50,000 people by this year 2020 (Raman, 2009). Studies have suggested that optometrists perform as many as 17.2 million eye care visits per year in the United States (Wilson et al., 2015).

With a population of approximately 200 million (Amoo et al., 2020), Nigeria is one of the fastest growing countries in Africa (Gramlich, 2019). However, with about 4000 optometrists, and just eight optometric education departments producing a minimum of 150 optometrists yearly (Oduntan et al., 2014), Nigeria meets both the LV Prasad Eye Institute recommendation of one optometrist to 250,000 people (Holden & Resnokoff, 2002) and the WHO (one Optometrist to 50,000 people) models (Raman, 2009). Yet compared to Asia and Europe, Nigeria lags behind.

Ocular manifestations of COVID-19 include hyperaemia, epiphora, photophobia, episcleritis and increased secretions (Bostanci Ceran & Ozates, 2020). Researchers were able to confirm the presence of COVID-19 in the tears of individuals infected with this virus (Willcox et al., 2020). Transmission of COVID-19 through human tear secretions has recently been confirmed (Wu et al., 2020).

The restrictions of movement and lockdowns of interstate travel has had a direct impact on the number of patients visiting eye clinics. A survey of ophthalmologists in India found that 72.5% of them had stopped services completely during the Indian government-imposed lockdown (Nair et al., 2020).

Beginning on the 19th of March 2020, the Nigerian government ordered a shutdown of federal schools to safeguard the health of the public, including students (Nlebem, 2020). State-run and private schools also closed at various times within a few days of this announcement.

The COVID-19 virus was first reported in December 2019

(Chen et al., 2020). Nigeria experienced its index case on the 27th of February 2019 (Nigeria Centre for Disease Control, 2020). This presented unique challenges for a country with a struggling health care system (Omoleke & Taleat, 2018). However, the occurrence of an outbreak of Ebola virus disease some years earlier (Ebenso & Otu, 2020) meant that the country had some experience already in dealing with similar outbreaks.

The supervisory body tasked with providing health care workers and the general public with information about the pandemic and preventive measures in Nigeria, is the Nigerian Centre for disease control (NCDC). Recommendations given by the NCDC include social distancing, self-isolation, quarantine of suspected/confirmed cases in addition handwashing with soap and use of sanitisers. The COVID-19 pandemic, however, has presented new challenges for healthcare workers, including optometrists.

Optometry education in Nigeria is both academic and clinical. This means there must be in-person instruction, and patient management that involves working in close contact with colleagues and members of the public.

In the past, optometry departments have been partially shielded from the effects of interruptions such as industrial actions and even some holidays due to the flexible curriculums run by professional courses compared with the rigid two-semester yearly sessions in other university programs. This portends a unique situation for clinical programs integrated in the Doctor of Optometry (O.D.) curriculum, as clinical sessions involve patient management. Wide ranging changes will be needed if students are to safely return to such clinical training and external rotation.

Little literature currently exists on the effect of the COVID-19 pandemic on optometrists and optometry education in Nigeria.

This study was a pilot and sought to assess the knowledge of COVID-19 amongst optometrists and optometry students, including preventive measures and regulatory guidelines about the disease. In addition, availability and access to this information was assessed. The impact of the pandemic on personal lives of respondents, optometric services, and remuneration was also assessed. Finally, this study also assessed the effect of COVID-19 on the delivery of optometric education and its subsequent impact on optometry students.

Materials and methods

This was a prospective cross-sectional study.

Nigeria is home to 4500 registered optometrists and about 3500 optometry students (ODORBN, 2020). The sample size was calculated using the Cochran (1977) formula:

$$n = Z^2 pq/d^2$$

where n is the sample size, Z is the standard normal deviate (1.96), p is the proportion of target population expected to have a particular characteristic, $q = 1 - p$, and d is the degree of accuracy required. Since this was a novel study in Nigeria and West Africa, the authors assumed the proportion of the population with the desired characteristic to be 50%. The desired confidence interval was 95% while the precision was set at 5%. Using these parameters, the sample size was set at 384 respondents which is expected to provide representative data of the whole population.

A questionnaire was designed using Google Forms (see Supplementary file). This structured electronic questionnaire was sent out to optometrists through the individual state chairmen of the 36 states in Nigeria including the Federal Capital Territory (FCT). Follow-up questionnaires were also sent by email to optometrists and posted in social media spaces in an effort to attract a broad response. A similar arrangement was made with the executives of the Nigerian Optometric Student Association (NOSA-National) requesting them to help ensure that the questionnaire got to every optometry student from second year and upwards. This distinction was made because classes in the first year of training are handled by the general faculties and not the Department of Optometry/School of Optometry. All students who participated in this survey were pursuing the Doctor of Optometry (O.D.) degree.

The authors had no way of knowing who would respond and as such it was a randomised observation.

Respondents to the questionnaire were either optometry students or optometrists. The survey began with an introduction of the lead researcher and then requested that respondents go through an informed consent section followed by five questions on general demographics and knowledge of COVID-19. The fifth question in this series automatically redirected the respondent to one of five subsequent categories. These categories were:

- Optometry students
- Optometrists – Interns in pre-registration training
- Optometrists – Public service employed
- Optometrists – Practice owners
- Non-optometrists or students

On completion of any of these sections, the survey ended, ensuring that each respondent answered only the questions related to their status. One of these five sections was designed to prevent non-optometrists or students from taking the questionnaire. As soon as a respondent selected that option ("Am not an optometrist but would like to participate"), the survey ended immediately.

In the wake of the pandemic, several regulatory bodies including the Nigeria Centre for Disease Control (Nigeria Centre for Disease Control, 2020)), State and Federal Ministries of Health, and the World Health Organization (WHO) issued measures to help combat the pandemic. At the time of this survey, the now widespread use of face masks had not been issued as a regulatory measure. This survey sought to test optometric doctors' knowledge of regulatory guidelines.

Optometrists responding to the survey were asked a range of questions to gather data on their demographics, knowledge of coronaviruses/COVID-19, the impact of COVID-19 on optometrists, and attitudes of optometrists to conferences and scientific sessions during this early pandemic period. Students were asked to indicate their health status at the time of filling in the questionnaire. Students were also asked to indicate how they were coping academically during the imposed lockdown of universities nationwide.

Student respondents also indicated what measures they felt would make their stay at home academically productive amongst DVDs of study material, online video classes, social media groups to interact with lecturers, textbooks, or if they needed none of the listed suggestions.

Responses were updated in real time to the Google servers and were available to authors for as long as the survey was kept open to respondents. This survey was open from 10th April to 15th May 2020. The results obtained are presented using tables, bar charts, line charts and graphs.

The study adhered to the principles of the 1967 Helsinki Declaration. Participants consented to voluntarily participate in this study.

Results

Demographics of respondents to survey

Data from 404 respondents (202 males and 202 females) were logged into the database. Five respondents were neither optometrists nor optometry students and as such their responses

were automatically deleted and a total of 399 valid responses were logged in this study. Optometrists who responded are classified according to occupation status in Table 1.

Table 1: *Distribution of respondents by occupation and age.*

Occupation	*n*	%
Student	183	45.3
Intern/optometrist under employment of another optometrist	90	22.3
Public service optometrist employed by the government	62	15.4
Optometric practice owner/self employed	64	15.9
Non-optometrist/student*	5	1.2
Age		
18–24 years	180	45.1
25–34 years	112	28.1
35–44 years	77	19.3
45–54 years	22	5.5
55–65 years	8	2.0

Note: *records were deleted.
The average age of participants in this study was 27.91 years SD = 15.14 years.
Total number of participants = 399.

Most respondents were in the 18–24-year age group (see Table 1). This age group is expected to include most of the students and some young optometrists. The 55 years and above group had the fewest respondents.

In total 216 optometrists (97 females (45%), 119 (55%) males) responded to the survey. Of these 22 (10.2%) were unemployed at the time of filling in the questionnaire, 69 (32%) worked in government run hospitals, 120 (55.6%) were privately employed optometrists while five (2.3%) worked in jobs outside optometry.

A total of 183 optometry students (102 (56%) females and 81 (44%) males) responded to this survey.

Responses were received from all eight training institutions with University of Benin providing the most respondents (117), University of Ilorin 41, Ado Bayero University 10, Abia State University six, Imo State University and Federal University Owerri three each, Madonna University two, and Afe Babalola University Ado-Ekiti providing one respondent. This research was based in the University of Benin and that may account for the difference in numbers of respondents.

Knowledge of coronaviruses/COVID-19

An understanding of coronaviruses in general, and not just the novel COVID-19, is important to enable students and optometrists to help educate the public about this relatively new outbreak. Among responding fully qualified optometrists, 215 (100%) reported that COVID-19 is caused by a virus, while one respondent reported that it was a government-fuelled hoax.

Most respondents ((52.9% (211)) believed that coronaviruses were first discovered in 2019, 0.5% (2) reported that they were discovered in 2018, 3.8% (15) said they first appeared in 2020, while 42.9% (171) of respondents selected "a long time ago".

Of the fully qualified optometrists 97 (44.9%) correctly responded that coronaviruses have existed for a long time, 111 (51.4%) reported that coronaviruses were discovered in 2019 while 8 (3.7%) optometrists reported that coronaviruses were first discovered in 2020. Two (1.1%) students responded that COVID-19 started in 2018, 100 (54.6%) students selected 2019, 7 (3.8%) selected 2020 and a further 74 (40.8%) simply selected the option stating: "a long time ago".

Optometrists were asked to identify symptoms associated with COVID-19 and regulatory measures to mitigate the spread of infection. This is especially critical for optometrists who were still working during the outbreak when screening at-risk patients and staying safe themselves. The symptoms most frequently suggested were "Cough" and "High fever" while "Dry mouth" and "Red eyes" were least commonly suggested (see Figure 1). Social distancing (99.5%), self-isolation (93.5%) and hand washing for at least 20 seconds (82%) were the regulatory measures most frequently selected by optometrists (see Table 2).

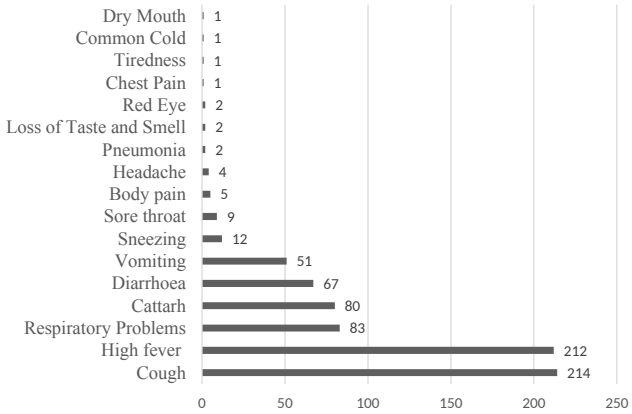

Figure 1: *COVID-19 symptoms identified by responding optometrists.*

When knowledge of PPE was tested by presenting optometrists with a multiple-choice question on what represented an example of PPE, 181 (83.8%) respondents correctly selected gloves, while 21 (9.7%) and 14 (6.5%) wrongly selected hand sanitisers and social distancing respectively.

Table 2: *COVID-19 regulatory measures as selected by optometrists.*

Measure	*n*	%
Social distancing	215	99.5
Self-isolation	202	93.5
Use of water and soap to wash hands for at least 20 seconds	177	82.0
Taking warm water and lime	28	13.0
Warm baths	23	10.7
Taking food with alkaline pH	20	9.3
Total number of respondents	216	

Impact of COVID-19 on optometrists

Optometrists also indicated their recent health status with respect to the raging pandemic. Table 3 shows that most optometrists were either isolating or had no changes to routine. No optometrist reported to be suffering from the COVID-19.

The survey sought to find out if responding optometrists lived in a state that had experienced a case of the novel COVID-19 disease. Their responses showed that 86% lived in states that had at least one COVID-19 case.

Hand sanitisers were the most commonly provided infection control measure by the optometric clinics respondents worked in, while COVID-19 test kits were the least reported (see Table 4). Hazmat suits were not included amongst the options. A combination of items available in functioning optometry clinics were also itemised by respondents in Table 4.

Table 3: *Health status of optometrists and presence of COVID-19 in residing states among optometrists during the period of study.*

Health status	*n*	%
Fine – no changes to routine	100	46.3
Fine – quarantined	14	6.5
Fine – but self-isolating	98	45.4
Ill – other causes	4	1.9
Ill – COVID-19	0	0
Presence of COVID-19 in states where optometrists live		
Yes	186	86.1
No	26	12.0
Don't know	1	0.5
Total number of respondents	216	

Table 4: *Combination of infection control measures made available to optometrists in their clinics.*

Item(s)	*n*	%
Gloves, hand sanitisers, face masks, washstands	136	63.0
Gloves, hand sanitisers, face masks	28	13.0
Hand sanitisers, washstands	13	6.0
Gloves, hand sanitisers, washstands	10	4.6
Hand sanitisers, face masks	5	2.3
Gloves, hand sanitisers, face masks, washstands, COVID-19 test kits	3	1.4
Hand sanitisers only	3	1.4
Washstands only	3	1.4
Face masks, washstands	2	0.9
Gloves, hand sanitisers	2	0.9
Gloves, face masks, washstands	1	0.5
Gloves, washstands	1	0.5
Total number of respondents	216	

Optometrists were then asked to indicate which procedures they had to stop or adjust due to the outbreak of COVID-19. Only nine (4.17%) optometrists reported that there was no change to their routine (see Table 5) with the most frequent alterations to clinical practice being stopping of ophthalmoscopy (52.8%) and contact tonometry (43.5%). These two procedures form the bedrock for glaucoma screening and monitoring for Nigerian optometrists, and it can be implied that there was a reduction in the quality of glaucoma services as a direct result of the pandemic.

Table 5: *Adjustment made by optometrists to clinical practice.*

Adjustment	*n*	%
None, but I adjusted my technique	90	41.7
Contact tonometry stopped	94	43.5
Blood pressure/Blood sugar measurement stopped	29	13.4
External exam stopped	28	13.0
Ophthalmoscopy stopped	114	52.8
All techniques carried out in the same way as before	9	4.2
Total number of respondents	216	

The economic effect of the pandemic was felt by optometrists due to travel restrictions for some patients and a general apathy to healthcare amongst others. During the survey period 109 (49.3%) optometrists were working while 107 (48.4%) responded that they were not working.

Optometrists were asked to describe their patient load during the reviewed period as either normal, less than normal or more than normal. The number of patients visiting their optometrist during this period as compared to pre – COVID-19 pandemic numbers was reduced for 203 (94%) respondents, 11 (5%) optometrists reported no change in patient numbers while two (1%) reported an increase in patient numbers.

Health care businesses (both privately owned and public run) were exempted from locking down during this period by the Nigerian Government. The survey showed that 43.5% (98) of respondents felt that optometric clinics should not remain open during the pandemic, 40.7% (88) felt that optometric clinics should be functional, while 15.7% (34) were indifferent.

Of 216 optometrists responding to the survey, 108 (50%) indicated that their clinics were not closed during the survey period, another 93 (43.1%) reported that their clinics were closed, while 15 (7%) reported that although their clinics were currently functional, they intended to close in the future as the pandemic went on. The majority (60.2%) of these closures took place between 26th of March and 1st of April 2020 (see Figure 2).

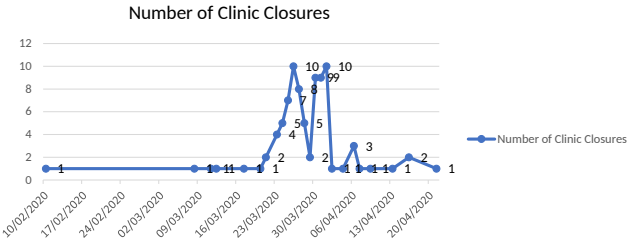

Figure 2: *Respondents' self-reported daily closures of optometric clinics.*

Respondents were asked if optometrists' salaries should be fully paid, prorated or if a fixed cut should be applied during the pandemic. Seventy-six (35.2%) optometrists felt that salaries should be prorated based on clinic income, 100 (46.3%) felt that salaries should be fully paid and 40 (18.5%) felt that staff should take a fixed pay cut.

Impact of COVID-19 on students

Students responding to the questionnaire were required to answer seven questions ranging from their institution of training, their health status during the period surveyed and the effect of the COVID-19 pandemic on their studies, to questions on how they rated their schools' preparedness for continuing training upon resumption.

Fifty-eight (31.7%) students indicated that they were fine and had no changes to daily routine, 62 (33.9%) indicated they were fine but in isolation while one individual was ill with COVID-19 (see Table 6).

Table 6: *Health status of optometry students when filling survey.*

Health status	*n*	%
Fine – but in isolation	62	33.9
Fine – but in quarantine	52	28.4
Fine – no changes to daily routine	58	31.7
Ill – COVID-19	1	0.6
Ill – other causes	5	2.7
(blank)	5	2.7
Total number of respondents	183	

On the question of how they were coping with their studies, 38% (69) of the students reported that their departments had organised online lectures, 39% (71) were engaged in personal study while at home, and 23% (42) were taking a break from studying. Online video classes (21.9%) and social media groups to allow interaction with lecturers (24.6%) were the most frequently suggested measures to help students while at home

during the pandemic (see Table 7).

Table 7: *Proffered measures suggested by students to help academic activities while at home.*

Measures	*n*	%
None	13	7.1
Textbooks only	25	13.7
DVDs of study material only	9	4.9
Online video classes only	40	21.9
Social media groups to interact with lecturers only	45	24.6
DVDs of study material and textbooks	1	0.6
Online video classes and textbooks	1	0.6
Social media groups to interact with lecturers and textbooks	6	3.3
DVDs of study material and social media groups to interact with lecturers	3	1.6
Online video classes and social media groups to interact with lecturers	7	3.8
DVDs of study material, online video classes, and textbooks	1	0.6
Online video classes, social media groups to interact with lecturers, and textbooks	9	4.9
DVDs of study material, social media groups to interact with lecturers, and textbooks	2	1.1
DVDs of study material, online video classes, and social media groups to interact with lecturers	8	4.4
DVDs of study material, online video classes, social media groups to interact with lecturers, and textbooks	13	7.1
Total number of respondents	183	

Importantly, the student respondents were asked to rate the preparedness of their respective universities for social distancing preparedness in terms of lecture halls and clinic spaces on a scale of 1 to 3, where 3 represented very adequate and 1 represented very inadequate. Their opinions are displayed in Figure 3. The average was 2.44 ± 0.6 showing that students on average felt that school facilities were adequate.

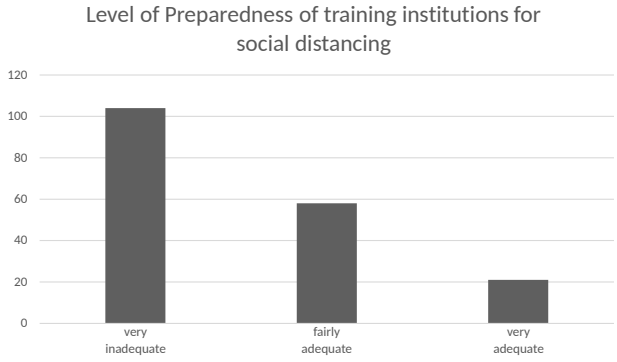

Figure 3: *Level of preparedness of training institutions for social distancing.*

Students were also asked their opinion on what school authorities should do with the current academic session when the restrictions were lifted. Most (47.5%) felt the session should pick up from where it was interrupted by COVID-19, 27.3% were indifferent as they were already on holiday when the COVID-19 disease hit the country, while 25.1% felt the entire academic year should be restarted.

Attitude towards Annual Conference/Outdoor Scientific Sessions

The 2020 Annual National Conference of Nigerian Optometrists was billed to take place during the first week of July 2020 and was planned to proceed in person. Only 4% (16) of respondents wanted the conference to go ahead as scheduled without any changes, 56.89% (227) wanted it to be held at a later date, 45 (11.3%) wanted it to be moved to a different venue, and 26.8% of respondents wanted the conference cancelled completely. Two respondents abstained from answering the question.

Given the restrictions on interstate travel and mass gatherings, students were asked if the National Conference organised by the student body (NOSA) should go ahead. The majority (74.3%), represented by 136 students felt the conference should go ahead but at a much later date, 11 (6%) students felt it should be held as scheduled despite the ongoing pandemic while 36 (19.7%) felt that the 2020 students' conference should be cancelled in its entirety.

Discussion

The age demographics in this survey indicate that respondents within the ages of 18–24 formed the largest group (45.1%). This is expected as a majority of students are included in this group. There are also more younger optometrists in Nigeria within this age range as compared to other age groups due to new training institutions that have recently started graduating optometrists (Oduntan et al., 2014).

Optometrists displayed varying levels of knowledge with regards to the pandemic. About 42.9% of respondents correctly responded that coronaviruses were discovered a long time ago while others gave varying incorrect responses. Fully qualified optometrists (44.9%) were more likely to correctly answer that coronaviruses started a long time ago compared to optometry students where 40.8% selected "a long time ago".

Approximately 50% of optometrists were not working during the period surveyed. This was despite an exemption from lockdown directives coming from regulatory authorities. Possible reasons for this may include optometrists preferring to stay at home (to avoid infection) or temporary clinic closures due to reduced patient load. This number is lower than the 72.5% reported for eye care practitioners (ECPs) in another study (Nair et al., 2020). Yet, as early as March 2020, over 200,000 patients had been seen exclusively by optometric clinics in the USA (American Optometric Association, 2020). In many ways this prevented at-risk populations from going to general hospitals and potentially picking up the virus. It would be safe to assume that optometrists working during this period also attended to a significant number of patients.

The majority (66.3%) of the respondents worked in private clinics. This means that the burden of the provision of safety items and personal protective equipment was borne by the optometrists and not by the government. Private optometric practices probably did not budget for the large amounts of PPE required during the pandemic.

Only 4.17% of responding optometrists reported carrying out all clinical procedures they were doing before the COVID pandemic. Social distancing measures which prevent coming in close contact may explain this shift in practice procedures. This demonstrates the enormous impact the pandemic has on conventional optometric practice. Research suggests that optometrists should hasten the development of electronic support to delivery of services by ECPs (Nagra et al., 2020).

Gloves, face masks, hand sanitisers and wash hand basins represented the most likely (63%) combination of infection control measures available optometric clinics. These closely tally with projections by ECPs of measures to be taken in the clinical setting when attending to patients. It has been shown that optometrists who plan on using face masks and hand washing/sanitisation are more likely to require their patients to do the same (Pult, 2020).

Online video classes (21.86%) and social media groups to interact with lecturers (24.59%) ranked highest in the suggestions made by students in this survey to help with academic activities while at home. Interestingly, studies in India report that 93.5% of sampled optometric educators have switched to e-learning

alternatives due to academic disruption caused by the COVID-19 pandemic (Rajhans et al., 2020). It remains to be seen how Nigerian optometric educators will adapt to this novel way of teaching.

One limitation of this study was that it was not designed to grade the knowledge of respondents. This would have enabled the authors to assess differences in the knowledge about COVID-19 among fully qualified optometrists compared to optometry students. Also, responding students were largely from the authors' home institution. More respondents from sister institutions would have ensured a better sample spread.

Even though the majority (57.4%) of the respondents recommended that the annual general meeting and scientific conference be shifted to a later date, at the time of preparation of this report, the association had decided to cancel the event in its entirety, siding with 26.7% of the respondents.

The COVID-19 pandemic continues to greatly impact on optometric practice and training in Nigeria. This is causing significant loss of income through closure of practices and reduction in patient numbers. Presently, there is no government support/incentive for healthcare workers in the Nigerian private sector. Optometrists who manage to keep their clinics and practices open have to provide PPE and disinfecting materials for themselves in spite of the financial challenges of these pandemic times. The Federal Government has a role to play in providing all health care workers with required supplies for protection of clinician and patient. This will reduce the burden on the public hospitals to care for patients and reduce exposure of patients to nosocomial viral infection.

Educators are encouraged to explore e-learning as a viable alternative to in-person lectures. It can be social distancing compliant and available at convenient times for all. Moreover, it expands the scope of learning as educators are at liberty to invite other experts to join online classes to share experience and demonstrate clinical instrumentation and skills that may not be readily available locally. To some the COVID-19 has showed that the world is indeed a small village; encouraging e-learning means education can now surpass geographical limitations. Again, the regulatory agencies have a role to play in ensuring that educators are trained in e-learning skills and required materials are provided.

The rapid increase in literature (Adhikari et al., 2020) on the COVID-19 pandemic is expected to give more understanding and help the world prepare better for a repeat occurrence of such a pandemic.

Conflicts of Interest

The authors declare no conflict of interest.

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Håndtering av tidlig COVID-19: Erfaringer fra nigeriansk optometri

Sammendrag

Denne studien ble designet for å kartlegge kunnskap, holdninger og praksis hos nigerianske optometrister og optometristudenter med hensyn til COVID-19 pandemien, og undersøke hvordan pandemien har påvirket deres personlige og profesjonelle daglige rutiner.

Google Forms ble brukt til å lage et webbasert strukturert spørreskjema. Dette ble sendt ut til nigerianske optometrister og optometristudenter. Spørreundersøkelsen ble foretatt mellom 10. april og 15. mai 2020. Svarene ble sendt elektronisk til artikkelforfatterne og ble registrert via Google programvare. Deskriptiv statistikk og inferens ble utledet fra innsamlet data.

Totalt 399 gyldige svar ble registrert. Av disse kom 183 (45.4%) fra optometristudenter ved de åtte optometriutdanningene i Nigeria, og de resterende var fra optometrister. Blant optometristene rapporterte 86% at det hadde forekommet tilfeller av COVID-19 i deres delstat. Ingen optometrister hadde selv hatt COVID-19, mens en (0.5%) student hadde blitt smittet med COVID-19. 12% av studentene som svarte syntes at undervisningen hadde vært tilfredsstillende nok til at den kunne fortsette der den slapp etter COVID-19 oppholdet, mens 21.5% av studentene synes hele studieåret burde starte på nytt fra starten.

COVID-19 pandemien har hatt stor påvirkning på optometriske tjenester og optometriutdanning i Nigeria. Utdanningsinstitusjoner må også endre metoder for å kunne sikre trygge og tilfredsstillende utdanningsforhold når undervisningen gjenopptas.

Nøkkelord: COVID-19, pandemi, optiker, optometri

Gestione all'inizio del COVID-19: l'esperienza dell'optometria nigeriana

Riassunto

Questo studio è stato disegnato per comprendere la conoscenza, attitudine e condotte degli optometristi nigeriani e studenti di optometria con rispetto alla pandemia COVID-19, al tempo stesso valutando l'impatto a livello giornaliero delle loro abitudini personali e professionali. Il pacchetto di Google Forms è stato utilizzato per disegnare un'inchiesta/questionario online. Tale questionario è stato inviato ad optometristi nigeriani e studenti di optometria assieme ad un messaggio per la richiesta della loro partecipazioni volontaria. Questa inchiesta è stat fatta tra il 10 Aprile e il 15 Maggio 2020. Le risposte ricevute sono state trasmesse elettronicamente agli autori e compilate con il pacchetto programmi di Google. Statistica descrittiva ed inferenziale sono state considerate per questi dati.

Un totale di 399 rispost valide sono state registrate durante lo studio. 183 (45.4%) delle risposte sono di studenti di optometria provenienti dagli otto dipartimenti di educazione in optometria della Nigeria. Un totale di 216 dottori in optometria hanno fatto parte delle risposte date. 86% degli optometristi che ha risposto ha riportato casi di COVID-19 nel loro stato. Nessun optometrista ha contratto la malattia del COVID-19 mentre uno solo (0.5%) degli studenti è stato infettato dal COVID-19. Il 12% degli studenti ha risposto di sentirsi che gli ambienti educativi erano adeguati per far fronte al ritorno post COVID-19, mentre il 21.5% degli studenti ha risposto che le lezioni dell'università dovevano essere riprese. La pandemia del COVID-19 ha avuto un enorme impatto sull'erogazione dei servizi tra gli optometristi nigeriani e l'educazione optometrica. Istituzioni educative devono anche adattarsi alle correnti realtà per essere in grado di fornire una formazione sicura ed adeguata quando le lezioni dell'università riprenderanno o rinizieranno.

Parole chiave: COVID-19, pandemia, optometristi, optometria

Normal saccades but decreased fixation stability in a population of children with dyslexia

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Abstract

Developmental dyslexia affects around 5–15% of the population and has a heterogeneous aetiology. Optometric disorders are more prevalent in dyslexic populations but the relationship between eye movement control and dyslexia is not well established. In this study, we investigated whether children with dyslexia show saccadic or fixation deficits and whether these deficits are related to deficits in visual acuity and/or accommodation.

Thirty-four children with and without dyslexia were recruited for the project. All participants had an optometric examination and performed a saccade and fixation experiment. We used two eye movement paradigms: the step and the gap task. Eye movements were recorded by an infrared eye-tracker and saccade and fixation parameters were analysed separately.

Saccadic latencies, premature saccades, and directional errors were similar between children with dyslexia and typically developing children. In contrast, fixations were significantly less stable in the dyslexic group. Neither saccades nor fixations were associated with deficits in accommodation or visual acuity.

Children with dyslexia showed no difficulties in saccadic performance, but their fixation stability was reduced compared to the control group. The reduced fixation stability can be explained by general deficits in the cognitive processes that underpin eye movement control, that have also been found in other neuro-developmental disorders.

Keywords: Eye movements, dyslexia, fixation, saccades

Introduction

Developmental dyslexia is a prevalent condition affecting about 5-15% of the population (Heim et al., 2008; Helland et al., 2011; Schulte-Korne, 2010; Shaywitz et al., 2006). A child with developmental dyslexia (hereafter dyslexia) struggles with word recognition, spelling and word decoding, and therefore finds reading demanding (Bishop & Snowling, 2004). It is important that children with dyslexia are identified quickly and provided with effective interventions to prevent disruption to academic development (Bishop & Snowling, 2004). In Norway, dyslexia is commonly diagnosed around the age of 10–11 years, which is when the importance of learning through text increases (Morken & Helland, 2013). While efforts have been made to identify children at an earlier age, there is currently no program for early detection or intervention for at-risk children (Helland et al., 2011). There is no consensus on how to assess dyslexia and there is a lack of valid screening tools as well as a "gold standard" for diagnosis (Nergård-Nilssen & Eklund, 2018).

The phonological deficit theory is a well-known and often referenced explanation for dyslexia (Melby-Lervåg et al., 2012). In spite of its importance, a phonological deficit does not explain all facets of dyslexia, and a deficit in visual attention has been suggested as an additional risk factor (Leonard et al., 2002; Peterson & Pennington, 2012; Vidyasagar, 2019). Reading requires both spatial and temporal integration of multiple still-pictures from fixations across several saccades. Correct sequencing of letters during reading is an extensive task for the brain, and problems with this sequencing are not solely due to a phonological deficit (Leonard et al., 2002; Vidyasagar & Pammer, 2010; Williams & Lecluyse, 1990). Recent longitudinal studies have added knowledge about other important correlations between cognitive functions and reading performance (Peterson & Pennington, 2012; Vidyasagar, 2019). These may contribute to a broader understanding of the aetiology of dyslexia and help with early diagnosis and recognition of the problem. For instance, it has been suggested that visuo-spatial memory could be an early marker of literacy skills in transparent orthographies like Norwegian (Nergård-Nilssen & Eklund, 2018).

There is evidence for both visual and oculomotor deficits in dyslexia (Bucci et al., 2008b; Stein, 2014). These deficits are most often attributed to a dysfunction of the magnocellular pathway, specifically a visuospatial attention deficit (see for instance (Stein, 2014)). However, there is no consensus with regards to the presence of a visuospatial deficit in dyslexia. For instance, Lukov et al. examined 110 adults and children with dyslexia and/or attention deficit, and found that all types of dyslexia were in fact dissociated with attention problems (Lukov et al., 2014). Vidyasagar have suggested that there are two possible explanations for dyslexia in addition to a phonological deficit. One is a deficit in visual spatial attention and the other is a deficit in synchronised neuronal oscillations which are essential for communication between brain areas (Vidyasagar, 2019). The latter may contribute to the understanding of the prevalent comorbidities between dyslexia and other developmental disorders, due to impaired cerebellar functions (Nicolson et al., 1999; Stoodley & Stein, 2013).

Atypical eye movement pattern has been frequently observed in dyslexics during reading (Kulp & Schmidt, 1996; Rayner, 1998; Rommelse et al., 2008). It is generally accepted that the eye movements reflect the visual processing and not the actual ability to move the eyes. However, research in this area has not concluded whether the oculomotor disorder is primary or secondary to the decoding problem (Quercia et al., 2013). Eye movement control is frequently examined in studies but there is no clear consensus about the associations with dyslexia.

The "visual attention" construct is extremely broad but measures of saccades can provide a useful operationalisation of this construct (Kowler et al., 1995). It follows that measures related to the integrity of saccadic control provide a test of the hypothesis that visual attention contributes towards dyslexia. A deficit in visuospatial attention can therefore be indexed through an increase in saccadic latency (Bellocchi et al., 2013). There have been a number of studies that have measured saccadic latency in dyslexia to test the hypothesis that saccadic latency is reduced in dyslexics. These studies have not yielded consistent findings: both longer (Biscaldi et al., 1998; Bucci et al., 2008a), similar (Bucci et al., 2014) and shorter (Bednarek et al., 2006) saccadic latencies have been reported in dyslexia.

The allocation of visual attention through eye movements also requires fixation to remain stable once a visual target has

been acquired through a shift in eye position. It has been proposed that the fixation instability observed in children with dyslexia reflects decreased cognitive control rather than oculomotor dysfunction per se (Vagge et al., 2015). This interpretation is supported by the fact that children with dyslexia have normal eye movements when they perform tasks with control demands similar to reading but without the "cognitive" component (Hutzler et al., 2006). However, Kapoula, Bucci and their colleagues have published several studies on the neurophysiology of eye movements in dyslectic children, and they have found that dyslexics have poor binocular coordination of saccades, during a saccade the eyes show more variable conjugacy and after the saccade they have larger drift resulting in fixation instability (Bucci et al., 2008a; 2008b; Jainta & Kapoula, 2011; Kapoula et al., 2007). Other studies have suggested that children with dyslexia have unstable binocular fixation (Castro et al., 2008; Vagge et al., 2015), and monocular instability has also been reported (Biscaldi et al., 1994; Fischer, 2012). These findings suggest that unstable fixation might be prevalent in a population of children with dyslexia.

The aim of this study was to investigate if saccadic latency and fixation stability were different in children with developmental dyslexia (DD) and typically developing children (TD) when performing a non-reading task. We used two different eye-movement paradigms: the saccadic step task and the saccadic gap task. We used these two paradigms as different tasks can result in different saccade latencies. When observers are instructed to look at a central fixation point and then make an eye movement to a visual stimulus presented in the periphery, this is often referred to as a visually guided saccade (Rommelse et al., 2008). When the central fixation point is extinguished at the same time as the stimulus appears, the task is called the step task. In general, the latency of visually guided (step) saccades in healthy adults is around 200 ms with a standard deviation of about 10% (Holmqvist et al., 2011). When a central fixation point is extinguished before the peripheral stimulus is presented, saccadic latency decreases, and this is known as the gap effect. It is assumed that saccades in the gap task are more reflexive and influenced to a lesser degree by higher level cognitive processes compared to saccades in the step task (Kristjànsson2011, 2011). It has also been reported that step latency decreases as the child gets older whereas gap latency does not change significantly with development (Bucci et al., 2012).

The relationship between accommodation, visual acuity and fixation stability have been investigated previously (Evans et al., 1994; Vikesdal et al., 2020; Wahlberg-Ramsay et al., 2012; Ygge et al., 1993). Some individuals with dyslexia exhibit a reduction in acuity compared to controls, and lower levels of accommodation amplitude has been reported (Evans et al., 1994; Vikesdal et al., 2020; Wahlberg-Ramsay et al., 2012; Ygge et al., 1993). In a previous study we found that degraded visual acuity and active accommodation (induced by adding positive and negative refractive lenses) resulted in a decrease in fixation stability, suggesting that uncorrected refractive errors might be a contributing factor to poor fixation stability. In contrast, saccadic latency was independent of changes to visual acuity and accommodation (Vikesdal & Langaas, 2016a).

The lack of consistency in previous studies made it difficult to generate formal hypotheses about the expected findings. Nevertheless, previous research has indicated that some, but not all, children with dyslexia may have poor fixation relative to their peers (Raymond et al., 1988). We also predicted that the children with dyslexia would not show saccadic abnormalities, based on evidence showing that dyslexia is a phonological problem (Norton et al., 2015). Moreover, the fact that children with specific motor difficulties do not show saccadic abnormalities (Gonzalez et al., 2016; Sumner et al., 2016) suggested it would be unlikely that children with dyslexia would have problems with the sub-cortical systems associated with saccade generation. We tested these predictions in an empirical study of saccadic eye movements and fixation stability in children with and without dyslexia.

Materials and methods

Study Sample

In Norway, developmental dyslexia is typically diagnosed when the child is around age 10–11, after children are referred by their teacher to the local Educational and Psychological Counselling Service. This is a governmental body responsible for the investigation and counselling of children with learning difficulties. Children with confirmed developmental dyslexia (DD) who attended the local Educational and Psychological Counselling Service during the study period were invited to participate. An age-matched control group of typically developing children (TD) was recruited from the same school catchment areas through information meetings with parents at school and advertising in the local newspaper. Twenty-three DD and 17 TD children participated with informed consent. Children gave verbal assent, and the primary carer signed the informed consent. The experiment was conducted in accordance with the Declaration of Helsinki ("WMA Declaration of Helsinki - Ethical Principles for Medical Research Involving Human Subjects", 2013), and was approved by the Regional Committees for Medical and Health Research Ethics.

Participants were all healthy with normal vision, no developmental disorders (besides dyslexia), no prematurity, no history of neurological disease or use of medication, and Norwegian was their primary language. Participants were tested with a linguistics test for detection of language problems ("Språk 6–16"). This test is standardised for Norwegian school children and consists of several subtests, including measurements of reading speed, phonological ability and verbal short-time memory (Ottem & Frost, 2011). Children were included in the DD group if the Educational and Psychological Counselling Service had diagnosed them with dyslexia and their phonological ability score from the linguistics test was below 1 *SD* of the mean. Children were included in the TD group if they had no history of dyslexia or reading problems and scored within the normal range (mean ± 1 *SD*) on all subtests of the language tests.

All participants had a thorough optometric examination including cycloplegic refraction, logMAR visual acuity, stereoacuity, accommodation and binocular vision assessment. Accommodation and binocular vision were tested and analysed according to established clinical criterion (Scheiman & Wick, 2002). The test procedures are described in a previous publication (Vikesdal et al., 2020). The preferred sighting eye was determined by a sighting test at distance (6 m) and near (40 cm). Sighting tests have high test-retest reliability, and the vast majority of studies agree that there is a sighting-preferred eye for each person (Mapp et al., 2003; Rice et al., 2008). This sighting test is recommended for determining the eye to track when measuring eye movements (Holmqvist et al., 2011), and has been reported as being clinically repeatable (Rice et al., 2008).

Procedure

Children were brought to a dimly illuminated room for testing. Participants sat in a firmly mounted chair 100 cm from a computer screen adjusted in height, so the eyes were in line with the centre of the screen. A chin- and forehead rest was used to minimise head movements. The stimuli were presented on a fast phosphor monitor with a 100 Hz refresh rate (Phillips 20T), size 56 cm (22″) and a resolution of 1024×768 pixels. The background on the monitor was dark grey with an even luminance

of 22 cd/m^2 across the screen. The stimulus was light yellow, with an even luminance of 276 cd/m^2, thus the contrast level was 92%.

Participants performed saccades and fixations in oculomotor paradigms including both the step- and gap tasks. In the step task, each trial started with the appearance of a fixation cross (side length 0.4°) at the centre of a computer screen. After one second, the fixation cross was extinguished and simultaneously, the stimulus (a dot 0.2° in diameter) appeared in one of eight possible stimulus positions chosen at random (see Figure 1). The stimulus was visible for 2 seconds. The gap task was identical to the step task, except there was a 200 milliseconds (ms) gap between the fixation cross extinguishing and the appearance of the stimulus. In both tasks, participants were instructed to look at the stimulus as quickly and accurately as possible. They performed two practice runs prior to the experiment and there were breaks between the tasks. There were 48 trials in the step task and 48 trials in the gap task. Depending on the ease of recording and the need for breaks, the experiment lasted 10 to 20 minutes for each subject.

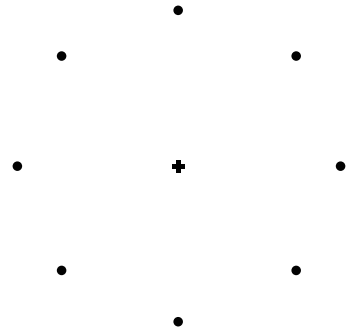

Figure 1: *Possible stimulus positions, placed at the vertices of a regular octagon, 5° from the fixation cross. Stimulus positions were the same in both the step task and the gap task.*

Eye movements were recorded with both eyes open to allow both accommodation and vergence as in natural viewing. Vertical and horizontal positions of the preferred sighting eye were measured with an IScan ETL-300 video-based eye-tracking system, which had a temporal resolution of 8 ms and a spatial resolution of 0.161° (RMS) (Vikesdal & Langaas, 2016b). Prior to each experimental session, the eye-tracker was calibrated by the presentation of five 0.5° boxes, located in the centre and in the four corners of a square subtending 20°×20°. Eye position data, with accompanying time stamps, were exported for post-experimental analysis.

Data Analysis

The first trial of each task and trials where the participant blinked were not included in the analysis.

Saccades

Saccadic latency is the time between stimulus appearance and saccade onset. Saccade onset was defined as the time at which eye velocity exceeded 20°/s and lasted for more than 32 ms (i.e. four consecutive eye tracker sampling points). A trial started with the child fixating the central fixation cross and finished when the child had fixated the indicated position, thus each trial elicited one saccade (the return saccade for next trial was not included in the analysis). Premature saccades (latency ≤ 120 ms) and directional errors were counted, but not included in the saccadic latency and duration calculations.

Fixation

Fixation on the saccadic target was defined as starting 80 ms after saccade offset and ending 80 ms prior to saccade onset as saccadic suppression typically persist for approximately 80 ms (Holmqvist et al., 2011). Each trial elicited one fixation period. In order to ensure homogeneity of fixations across trials and participants, fixation durations lasting less than 50 sampling points, or 400 ms, were excluded from the analysis.

The bivariate contour ellipse area (BCEA) was used to define the stability of fixation. BCEA refers to the area in which the eye is positioned for a given percentage of time, and is a reliable measure of fixation stability with good internal consistency (Vikesdal & Langaas, 2016b). To approximate normal distribution for analysis purposes, logBCEA including 68.2% of highest density points was used (Amore et al., 2013; Cesareo et al., 2014). Horizontal and vertical standard deviations of the eye position (σH and σV), as well as fixation duration, were also reported.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics version 22 (IBM Corp., New York, USA). The α level was set at 0.05. The One-Sample Kolmogorov-Smirnov test was performed to check for normality. Multivariate Analysis of Variance (ANOVA) and Mann-Whitney U tests were used to compare between-group differences in parametric and non-parametric data sets respectively. Pearson's correlations were used to identify associations between variables.

Results

Participants

Of the recruited children with dyslexia, three were excluded because they had diagnosed attention disorders, one was excluded because of possible neurological disease and two children were excluded because their sub-scores on language testing were within the normal range. As a result, 17 children (three females) were included in the developmental dyslexia (DD) group, and 17 children (seven females) in the typically developing (TD) group. The DD group were aged between 9 and 13 years, and the TD group were aged between 8 and 12 years. There was an increased prevalence of hyperopia and accommodation insufficiency in the DD group compared to the TD group, however no single optometric measure was significantly different between groups, for details see (Vikesdal et al., 2020). All DD children had significantly lower score on all sub-scores on language testing except from Grammar (see Table 1).

Table 1: *Language testing data.*

Group	Sum-score	Phonologic ability	Grammar	Decoding	Reading speed
TD	105.8	10.8	11.0	11.2	12.4
(n=17)	(± 10.5)	(± 1.8)	(± 2.4)	(± 2.1)	(± 3.4)
DD	89.9	5.6	9.8	5.9	6.2
(n=17)	(± 13.0)	(± 1.9)	(± 2.8)	(± 2.4)	(± 2.1)
p-value	< 0.01	< 0.01	0.21	< 0.01	< 0.01

Note: Mean values for all participants, ± standard deviation (SD) for the other variables. Scores are scaled such that mean = 10 and *SD* = 3 in a normal population (for sum-score: mean = 100 and *SD* = 15). All subtests except grammar were significantly different between groups.

Saccades

In total, 2677 valid saccade trials were analysed (1405 in the step task and 1272 in the gap task). The mean (± *SD*) number of trials in each task per participant was 38.8 (± 4.6) saccades (range 26–46). The number of included trials was similar across groups. The mean saccadic latency, number of premature saccades, and directional errors were extracted for all participants (see Table 2). Saccadic latency was normally distributed in the gap task (p=0.200), but not in the step task (p=0.027). Mann-Whitney U showed that there were no significant differences

Table 2: *Saccade data.*

Group	Step task				Gap Task			
	Latency (ms)	Premature saccades (number)	Direction errors (number)	Valid trials (number)	Latency (ms)	Premature saccades (number)	Direction errors (number)	Valid trials (number)
TD	227.1	0.1	1.6	42.9	204.3	0.9	7.4	36.6
(n=17)	(± 7.3)	(± 0.3)	(± 1.5)	(± 1.7)	(± 7.8)	(± 1.3)	(± 4.2)	(± 4.8)
DD	230.9	0.6	2.0	39.7	205.2	0.4	4.9	38.2
(n=17)	(± 4.7)	(± 0.9)	(± 1.9)	(± 3.4)	(± 7.3)	(± 0.6)	(± 4.6)	(± 5.0)

Note: Mean values for all participants, ± standard error (*SE*) for saccadic latency, and standard deviation (*SD*) for the other variables. There were no significant differences between groups.

between DD and TD groups for any of the included saccade parameters.

Fixations

In total, 2601 valid fixation trials were analysed (1301 in the step task and 1300 in the gap task). The mean (± *SD*) number of trials in each task per participant was 38.2 (± 5.0) fixations, range 18–46. The number of included trials was similar for each group. All fixation parameters were normally distributed (p=0.200) except for σV in the gap task (p=0.002). Table 3 shows the mean logBCEA, mean fixation duration and standard deviation of eye position (σH and σV) for all participants.

An ANOVA was used to test for differences between DD and TD groups, and showed that fixation stability was significantly poorer in the DD group compared to the TD group in both the step task and the gap task. Horizontal deviation of eye position was also greater in the DD group in both tasks. Figure 2 shows examples of fixations plots from four participants. To look for associations between fixation stability and visual acuity or accommodation, Pearson's correlations were performed. There was no correlation between fixation stability and either visual acuity or the accommodation amplitude. We have previously reported that participants with dyslexia more frequently have hyperopia and/or accommodation insufficiency (Vikesdal et al., 2020). However, these participants performed no differently from participants without these deficits – thus the reduction in fixation stability could not be explained by any optometric factor.

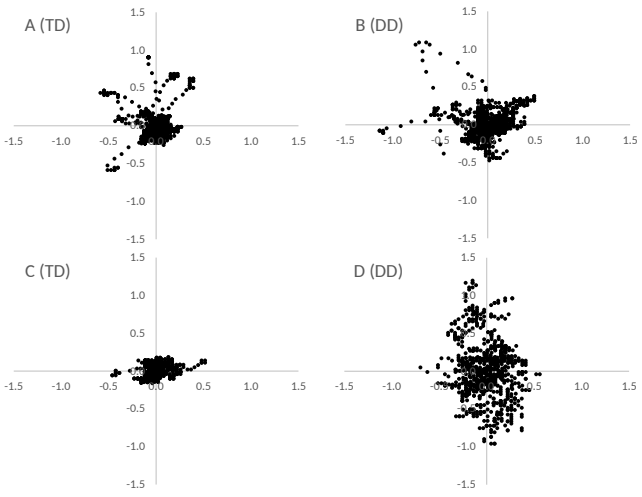

Figure 2: *Examples of fixation plots from TD participants with logBCEA = 2.56 ± 0.10 (A) and logBCEA = 2.17 ± 0.11 (C), and DD participants with logBCEA = 2.68 ± 0.13 (B) and logBCEA = 2.97 ± 0.14 (D). The x- and y-axes denote degrees of visual angle away from stimulus position.*

Pearson's correlations were also performed to look for associations between fixation stability and saccade parameters, which showed no correlation between fixation stability and either of the saccadic parameters.

Discussion

This study found no difference in saccadic parameters between children with and without dyslexia. Both groups had shorter saccadic latency in the gap task than in the step task, with a similar size of the expected gap effect. This suggests that disengaging visual attention is not problematic in this sample of children with dyslexia. In contrast, Bednarek et al. (2006) found that saccadic latency was shorter in children with dyslexia compared to controls, a difference that disappeared with central or peripheral cues. However, Bednarek et al.'s study included saccade latencies below 120 ms which could have biased their data. It has been suggested that saccade latencies have a bimodal distribution and that the so-called "express saccades" (with latencies below 120 ms) are more reflexive compared to "regular" saccades (Kristjànsson2011, 2011). Thus, previous conflicting findings of shorter saccade latencies in children with dyslexia may be due to increased prevalence of reflexive eye movements and not an actual increase in the regular saccadic latency. Reflexive saccades are not considered voluntary, and thus represent a different feature of oculomotor control, which is why we did not include these saccades in the present study. The findings do suggest that saccadic abnormalities are neither a necessary nor sufficient feature of dyslexia. It is unsurprising that children with dyslexia show abnormal saccades when reading (given that, by definition, they have a reading difficulty), but our findings are consistent with other reports of children with dyslexia having normal saccades when the cognitive demands of reading are removed (Hutzler et al., 2006).

Fixation stability was poorer in children with dyslexia compared with the typically developing children in both the step task and the gap task. Contrary to what was expected from our previous study (Vikesdal & Langaas, 2016a), fixation stability was not associated with visual acuity or accommodation measures. This suggests that factors other than refractive errors and accommodation ability are important to the stabilisation of gaze. It is well-known that the rate of microsaccades can be inhibited voluntarily. However, stability of fixation position does not always result after voluntary inhibition of microsaccades, which indicates that slow drifts play a large role in the stability of fixation (Rolfs, 2009). It has been suggested that poor stability may be created by gaze holding systems (e.g. vergence or the vestibular system) and that decreased stability may reflect noise in these systems (Otero-Millan et al., 2014). Even though fixation stability was measured monocularly, the test situation allowed for binocular viewing. Previous research has shown that dyslexics may have problems with binocular coordination after a saccade, which can lead to monocular instability (Bucci et al., 2008b). The findings in the present study support this finding.

Table 3: *Fixation data.*

	Step task				Gap Task			
Group	logBCEA (arcmin²)	σH (arcmin)	σV (arcmin)	Valid trials	logBCEA (arcmin²)	σH (arcmin)	σV (arcmin)	Valid trials
TD	2.51	7.42	10.18	39.6	2.48	8.17	11.75	40.5
(*n*=17)	(± 0.04)	(± 1.70)	(± 3.26)	(± 4.0)	(± 0.04)	(± 1.44)	(± 2.75)	(± 3.3)
DD	2.65	9.31	12.39	36.9	2.59	10.23	12.44	36.0
(*n*=17)	(± 0.04)	(± 1.89)	(± 3.41)	(± 6.2)	(± 0.04)	(± 2.03)	(± 3.89)	(± 4.7)
p	.021*	.005*	n.s.		.049*	.002*	n.s.	

Note: Values are mean values for all participants, ± standard error (*SE*) for logBCEA, and standard deviation (*SD*) for the other variables. *indicates significant differences between groups.

Fixation stability was not correlated with any optometric measure, nor with any saccade measure. The findings of reduced fixation stability but normal saccades in the participants with dyslexia suggest that these two systems operate independently, which is consistent with the findings from our previous study (Vikesdal & Langaas, 2016a).

The clinical consequences of the reduction in fixation stability are not obvious. The foveal region used to discriminate letters extends 1° either side of fixation, and the visual span for word recognition is much larger than this (Rayner, 1998). Thus, the reduction in fixation stability measured in this experiment is not large enough to reduce reading speed due to a temporal perception of a blurred image. Moreover, an experimental study performed on normal adult readers found that reading speed decreased with induced fixation instability (by random jittering), even though visual acuity was not affected (Falkenberg et al., 2007). Previous findings of reduced motion perception in dyslexic populations have been attributed to a lack of reading experience, and it has been found that a reading intervention targeting phonological ability improved motion perception (Olulade et al., 2013). It is possible that the poorer fixation stability found in the present experiments reflects poor cortical control because of a lack of reading experience. This possibility seems unlikely, however, as not all the children with dyslexia had poor fixation stability and yet they all had reduced experience of reading.

We suggest that the most likely explanation of the findings is that some of the children with dyslexia have general difficulties with the complex cognitive control processes that underpin saccadic response inhibition and stable fixation. This explanation is consistent with the co-morbidity known to exist between dyslexia and other neuro-developmental disorders (such as attention deficit hyperactivity disorder or developmental coordination disorder), as these other disorders have been shown to be associated with deficits in cognitive eye movement control processes (Gonzalez et al., 2016; Munoz et al., 2003; Sumner et al., 2016). Another explanation of our findings is that some of the children with dyslexia may also have difficulties with binocular coordination which may result in a temporarily unstable fixation after a saccade. This explanation is consistent with previous findings (Bucci et al., 2008b; Bucci et al., 2012), and together these explanations also reflect the multifactorial aetiology of dyslexia.

All dyslexic participants in this study had a phonological ability below the mean, however not all had poor fixation, which supports the claim that dyslexia is not solely explained by a phonological deficit. The fact that dyslexia is associated with alterations in occipito-temporal, temporo-parietal, and inferior frontal cortical areas (Richlan, 2012) is consistent with the idea that some of the higher-order cognitive eye movement control processes are likewise affected.

The finding that some children with dyslexia had fixation stability comparable with the control children (and conversely, some of the TD children had poorer stability) shows that fixation instability is neither a necessary nor sufficient feature of dyslexia. It does appear, however, that poor fixation stability is highly prevalent within the dyslexic population – an observation that is entirely consistent with the known co-morbidity between dyslexia and other neuro-developmental problems. This finding suggests that measures of unstable fixation can contribute in detection of developmental disorders including dyslexia.

Conflicts of Interest

The authors declare no conflict of interest.

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Normale sakkader men ustabil fiksering hos barn med dysleksi

Sammendrag

Dysleksi har en heterogen etiologi og rundt 5–15% av befolkningen har dysleksi. Optometriske avvik er mer vanlig blant personer med dysleksi, men sammenhengen mellom øyebevegelseskontroll og dysleksi er ikke etablert. I denne studien undersøkte vi om barn med dysleksi har redusert kontroll av sakkader eller fikseringsstabilitet, og om en redusert øyebevegelseskontroll er relatert til nedsatt synsskarphet og/eller akkommodasjon.

Trettifire barn med og uten dysleksi ble rekruttert til prosjektet. Alle deltakerne fikk en optometrisk undersøkelse og deltok i et sakkade- og fikseringseksperiment. Eksperimentene hadde to oppgaver: 'step' og 'gap'-oppgaven. Øyebevegelser ble registrert med et øyesporingskamera, og sakkade- og fikseringsparametere ble analysert separat.

Sakkade reaksjonstid, premature sakkader og retningsfeil var likt mellom barn med dysleksi og barn uten dysleksi. Derimot var fikseringer signifikant mindre stabile i dyslektikergruppen. Det var ingen sammenheng mellom sakkader eller fikseringsstabilitet og nedsatt synsskarphet og/eller akkommodasjon.

Barn med dysleksi hadde like god kontroll av sakkader som kontrollgruppen, men fikseringsstabiliteten deres var redusert sammenlignet med kontrollgruppen. Den reduserte fikseringsstabiliteten kan forklares med generelle mangler i de kognitive prosessene som ligger bak øyebevegelseskontroll, som også er funnet ved andre utviklingsforstyrrelser.

Nøkkelord: Øyebevegelser, dysleksi, fiksasjon, sakkader

Saccadi normali ma stabilità di fissazione ridotta in una popolazione di bambini con dislessia

Riassunto

La dislessia inerente allo sviluppo colpisce all'incirca il 5–15% della popolazione ed ha una eziologia eterogenea. I disturbi optometrici sono più prevalenti in una popolazione dislessica però la relazione tra controllo dei movimenti oculari e dislessia non è ben stabilita. In questo studio, abbiamo investigato dove bambini con dislessia mostrano deficit di saccadici o di fissazione e dove questi deficit sono relazionati con l'acuità visiva e/o con l'accomodazione. 34 bambini con e senza dislessia sono stati reclutati per questo progetto. Tutti i partecipanti hanno avuta un esame optometrico e saccadi e fissazione sono stato considerate. Noi abbiamo utilizzato il paradigma dei due occhi: l'esercizio del passo e del salto. I movimenti oculari sono stati registrati con un eye-tracker ad infrarossi e i parametri delle saccadi e fissazione sono stati analizzati separatamente. Latenza delle saccadi, saccadi premature, errori direzionali sono stati simili tra bambini con dislessia e bambini in fase di sviluppo. Al contrario, le fissazioni sono state significativamente meno stabili nel gruppo della dislessia. Nessuna tra saccadi e fissazione sono state associate a deficit di accomodazione o di acuità visiva. I bambini con dislessia non hanno mostrato difficoltà nelle saccadi, ma loro stabilità di fissazione è stata ridotta rispetto al gruppo controllo. Tale riduzione può essere spiegata da deficit generali nel processo cognitivo che regola il controllo dei movimenti oculari, i quali sono stati trovati anche responsabili in altro disordini del neuro-sviluppo.

Parole chiave: Movimenti oculari, dislessia, fissazione, saccadi

Imaging the tarsal plate: A Mini-Review

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Abstract

Imaging the tarsal plate and the meibomian glands (MG) grants new opportunities for ophthalmic practitioners who work in the field of the ocular surface and dry. The secretory role of MG plays a fundamental part in protecting the moisture covering the surface of the eye by creating an active shield made of meibum (lipid) which prevents tear evaporation and dry eye. The Dry Eye Workshop reports (2007 and 2016) reports that MG dysfunction is the first cause of evaporative dry eye which is also the most common cause of dry eye and ocular surface discomfort. A plethora of instruments for MG observation, diagnosis and follow-up are available in the market. It appears that infrared light technology is the most common in research and clinical practice followed by the in-vivo confocal microscopy and the anterior segment OCT.

The objective of this review is to condense the latest evidence in MG imaging by providing a narrative overview of the most commonly used technologies plus some other aspects which might guide clinicians and researchers in the field of the ocular surface and dry eye.

Keywords: Meibomian glands, Meibomian glands dysfunction, dry eye, diagnostic imaging, meibography

Introduction

"The International Workshop on Meibomian Gland Dysfunction" established the role of meibomian glands (MG) and their dysfunction (MGD) as the most common cause of evaporative dry eye. MGD was defined as *"a chronic, diffuse abnormality of the meibomian glands, commonly characterized by terminal duct obstruction and/or qualitative/quantitative changes in the glandular secretion. This may result in alteration of the tear film, symptoms of eye irritation, clinically apparent inflammation, and ocular surface disease"* (Nelson et al., 2011). Dry eye is a common ophthalmic issue of multifactorial nature where the ocular surface homeostasis is lost resulting in tear film instability, hyperosmolarity and inflammation. Additionally, ocular symptoms such as eye discomfort (e.g., gritty and sore eyes), visual quality decay and light sensitivity may be experienced (Craig et al., 2017).

As cited, one of the most frequent signs of dry eye is the tear film instability that could be related to the weak evaporative resistance of the tear film observed in presence of MGD (Bron et al., 2017). This happens when there is excessive water loss from the exposed ocular surface in the presence of normal lacrimal secretion (Lemp, 2007).

During recent years, clinicians and researchers have been exposed to several techniques for imaging the MG and the area of the palpebral rims. This is particularly important for observation, monitoring and diagnosing the stages of the disease as well as for treating accordingly. In general, the imaging technique is called "meibography" which comprises photographic documentation of the MG using different illuminations and technologies. Historically, meibography started in late 70s when Tapie firstly attempted observing MG structures Tapie (1977). Tapie employed an illumination probe taken from vitreous surgery coupled with a red-light filter which allowed the observation of the MG silhouette through the eyelids. However, the measurement was quite uncomfortable for the patient due to the heat emitted by the light probe and did not provide enough detail for further analysis. Later, Mathers et al. (1994) developed the first real-time video-meibography system where the practitioner could examine MG structures via VHS recordings. However, this technique required several recordings to complete the eyelid margin investigation. Through the years, the main aim of the researchers was to obtain a method for observing MG that could guarantee detailed images with minimal impact on patients' comfort. This was achieved by employing infra-red (IR) illumination as a light source and connecting the probe with a CCD camera sensitive to IR (Arita et al., 2008; Nichols et al., 2005; Pflugfelder et al., 1998). However, meibography development did not stop with IR illumination and newer approaches such as in-vivo confocal microscopy (Kobayashi et al., 2005) and optical coherence tomography have been applied for investigating the eyelids margin (Bizheva et al., 2010).

In this plethora of examination techniques, the objective of this review is to recapitulate the latest available and most commonly used technologies for MG diagnostic imaging.

Materials and methods

A systematic approach was used to perform this review. The review process is detailed in Figure 1 where identification, screening, eligibility, and inclusion steps were assessed. PubMed Search database was searched from the inception. All the records were uploaded to EndNote X9 (Thomson Reuters) to verify any duplicates. Articles assessed for inclusion in this review were identified from 1st January 2016 until 31th September 2021, using individual and combinations of the keywords detailed in the Search Strategy (Annex 1). The period considered (last 5 calendar years) was to follow up the release of the Tear Film Ocular Surface Dry Eye WorkShop 2 (TFOS DEWS II) (Craig et al., 2017) in 2017 which included the latest scientific evidences in the field of dry eye and ocular surface up to 2016.

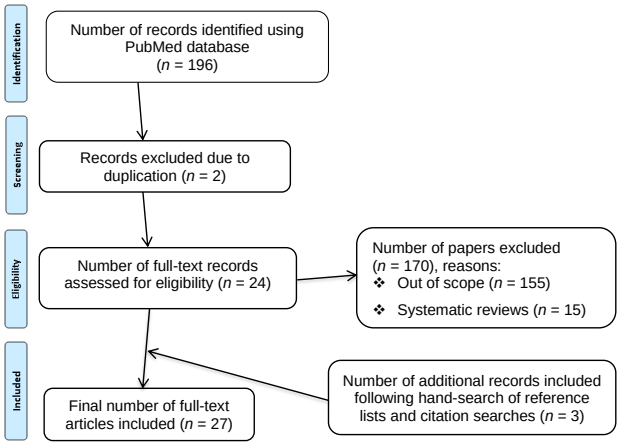

Figure 1: *Flow diagram of the literature search and selection process.*

The search terms included in the search strategy were agreed upon with two different clinicians in the field of dry eyes and MGD. In addition, papers included in the full-text screening process were subjected to a hand search of reference lists which has been conducted using Web of Science (WoS).

Studies were included if they focused on diagnostic techniques used specifically for meibomian glands evaluation and assessment. Additionally, the following eligibility criteria were considered: relevance, full-text access and studies done in humans. Criteria for exclusion were abstract only, lack of relevance, or a non-English language. The search strategy included truncation and phrase searching.

A narrative approach was considered for this review. The focus of this article is to highlight the latest evidence for the most common technologies available for MG and tarsal plate imaging.

Results

In this review the most commonly used MG diagnostic techniques are included: infrared light, IVCM, anterior segment OCT and mixed techniques. These are summarized in Table 1.

Infrared light

Meibography using infrared light (700–1000mm) works by projecting infrared (IR) light onto the everted eyelid which then is recorded via an IR-sensitive camera, removing the need for transillumination of the lid.

For the first time in 2005, Nichols et al. (2005) used a digital video technique for imaging the MG by the means of IR light. The system was composed of a Dolan-Jenner transilluminator coupled with a fibre-optic guide where images from the lower eyelids were acquired with a CCD camera. Later, Yokoi et al. (2007) and Arita et al. (2008) improved the technique by developing non-contact IR meibography which is able to scan the entire area of the MG. Currently, this diagnostic technique is the most common.

One of the most common limitations in considering IR diagnostic imaging for MG evaluation is the need to apply a fast, reliable, and objective grading system. In fact, MG dropout score is usually determined by the clinicians' ability and experience in comparing the scans with the validated grading scales available (e.g., Meiboscore, Meiboscale, etc.).

In their study, Koprowski et al. (2016) described the use of an algorithm for automatically analysing the MG IR images without the need for clinician input. Their algorithm provides a sensitivity of 99.3% (true positive rate) and specificity of 97.5% (false positive rate) allowing the clinician to differentiate between healthy subjects, at-risk subjects, and also differentiate the severity of those patients affected (25%, 50%, 75% of the surface).

However, for those clinicians unable to consider sophisticated algorithms in their clinical practice, there are several ready-to-use diagnostic imaging devices equipped with IR light for detailing the MG structure. One of the most common in the clinical settings is the Keratograph 5M (Oculus, Wetzlar, Germany) which has demonstrated validity in working with dry eye and healthy patients (Abdelfattah et al., 2015). Chen et al. (2017) considered non-contact IR meibography in primary Sjögren's syndrome (SS) patients: the authors reported a higher degree of MGD, glands dropout and eyelid margins irregularities in the autoimmune disease cohort compared to the healthy control group. Also, the study showed a higher percentage of MG atrophy in the lower eyelid in the SS group.

Again, following up on their previous study, Koprowski et al. (2017) improved their algorithm applied to IR meibography evaluation and grading: the results (which don't require operator's intervention) in terms of sensitivity increased at 98% and specificity at 100% with a faster evaluation time of only 0.4 s.

It is relevant to report the results from Wu et al. (2017) who have employed non-contact IR meibography in paediatrics cohorts by comparing children (3 to 11 years old) versus adolescents (12 to 18 years old). The authors reported no relationship in MG dropout with age nor any correlations between the glands, tear and ocular surface functions comparing the cohorts considered. Another important consideration to draw is related to the IR MG scan procedure: Maskin and Testa (2018) reported that caution has to be taken on how the inferior eyelid is pictured. Frequently, an erroneous measure could lead to eyelid distortions and altered vertical gaze directions leading to false conclusions.

Meibography should not be restricted only to a clinical setting equipped with expensive ophthalmic devices: in their study, Osae et al. (2018) reported for the first time results from Africa about MG. They demonstrated that the custom meibographer employed in their study (a cheap IR camera with a +20 D lens) can be the answer for those developing countries where premium technologies might be still limited. In contradiction with previous results (Pult & Nichols, 2012), they found a higher rate of MG loss in the upper lid compared to the lower lid. Additionally, they reported no difference between males and females considered.

Using a non-contact LipiView meibography system (TearScience Inc., Morrisville, N.C.), Park et al. (2018) demonstrated how to track partial or complete loss of the MG in thyroid eye disease (TED) patients. Thanks to the interferometry built-in technology, the LipiView determined the lipid layer thickness of these patients (average, maximum and minimum over a period of 20 s) which is considered an indirect way to observe the MG oil secretion (McCulley & Shine, 2003), and also by providing an analysis of the incomplete blink ratio. The results showed that in this particular cohort of TED patients MG loss was up to 83% and 60% in the upper and lower eyelid, respectively. Although the LLT values were normal and not predictable of higher MGD in TED patients, the incomplete blinking was recorded high as 51%.

Wong et al. (2019) compared two of the most popular MG analysers; the Keratograph 5M and the LipiView II Ocular Surface Interferometer (LVII) (Johnson & Johnson Vision, Jacksonville, FL, USA). While the Keratograph 5M uses a wide-field IR camera, the LVII can obtain MG images from three different sources: dynamic illumination, adaptive transillumination and dual-mode dynamic meibomian imaging. The dynamic illumination aims to reduce the MG glare and backscatter, the adaptive transillumination changes the light intensity to compensate for the eyelid thickness variations between patients. Finally, the dual-mode combines both dynamic and adaptive transillumination to enhance the MG visualization. The authors demonstrated that in their cohort (20 subjects, 40 images in total) despite both devices working with IR illumination, they were not interchangeable in performing MG analysis on the lower eyelid. This lack of agreement might be due to the poorer contrast and to the increased glare of the images.

Shehzad et al. (2019) developed and compared semi-automated software for MG analysis. The authors acquired 52 images from MGD and healthy patients through a CSO Sirius Topographer (CSO, Florence, Italy) which is based on a Placido disk technology with a Scheimpflug camera equipped with IR illumination. They compared the manual method (manually marking of the tarsus borders) versus semi-automated (MATLAB and Image Processing Toolboxes) and found that the first method requires at least a draw of 100 dots to determine MG (time needed 15 ± 3.4 min) versus the semi-automated which requires less than 1 minute. However, both analyses were significantly correlated ($r = 0.95$, $p < 0.001$) and there was "good" to "very good" agreement in grading the results.

Another IR illumination technique with the Scheimpflug rotating camera mounted in the Sirius Topographer: Gulmez Sevim et al. (2020) measured 130 volunteer patients with the

Table 1: *Summary of the technologies discussed in this review.*

Technology	Requirements	Applications	Advantages	Disadvantages
Infrared light (IR light)	IR light and IR-sensitive camera	Meibomian glands and tarsal plates	Quick, easy, and non-invasive	Lack of objective/automatic grading
In-vivo confocal microscopy (IVCM)	Laser scanning device	Ocular surface such as cornea, conjunctiva, meibomian glands, tarsal plates, etc.	Improved contrast and better resolution (1 μm per pixel)	Requires anaesthetic. Some patients might not tolerate the examination (anxious patients, paediatric patients, etc.). Requires training or expert operator
Anterior segment optical coherence tomography (AS-OCT)	Time-domain, spectral-domain, or swept-source indirect interferometry scanning device	Ocular surface such as cornea, conjunctiva, meibomian glands, tarsal plates, etc.	Faster and non-invasive image acquisition (up to 400,000 A-scans/second). Three-dimensional images.	Device cost. Requires training or expert operator. Lack of specific software for MG and tarsal plate analysis
		Other devices		
Meibometer	Photometer device	Tear film components (e.g., lipids)	Non-invasive	Requires a lab-suite for analysis
Red filter system (RFS)	Red filter applied to a digital slit-lamp	Meibomian glands	Non-expensive. Widely available	Level of details. Lower interobserver reliability

Sirius to explore the correlations of MGD severity with the other dry eye metrics such as the Ocular Surface Disease Index (OSDI) questionnaire, fluorescein break-up time and conjunctival straining with Lissamine green. The researchers, considering two clinicians as evaluators, found significant correlations across MGD severity, MG area of loss and all the previous metrics cited. Interestingly, while age ($r=0.21$, $p=0.015$) and atrophy ($r=0.24$, $p=0.005$) in the lower eyelid were determinants in MGD, gender was not (p range 0.66–0.95). This study remarks that MGA loss percentage measurements using a Sirius Topographer are highly repeatable (ICC values 0.994, 95% CI: 0.992–0.995, for reader 1 and 0.988, 95% CI: 0.982–0.992, for reader 2).

Yin and Gong (2019) focused their research work on a new parameter for MG analysis: MG vagueness. In fact, some patients might present a vague and difficult to identify MG structure in both upper and lower eyelids. The newly defined index was found clinically significant with the area under the curve (AUC) over 70 with a specificity of 83% (n = 47 MGD patients). Also, MG vagueness was found significantly correlated with MGD severity at all levels, MG acinar shortest diameter ($r=-0.278$, $p=0.017$), OSDI questionnaire score ($r=-0.3271$, $p=0.001$) and tear break-up time ($r=0.405$, $p=<0.001$). Ciężar and Pochylski (2020) applied the Fourier image transformation to the MG analysis. In particular, the authors proposed two new metrics such as the "mean gland frequency" (i.e., number of glands per unit length) and "anisotropy of gland periodicity" to study the whole eyelid area. When images from healthy and unhealthy subjects were considered, nearly 100% accuracy ($n=146$ images) was achieved by the Fourier image transformation. However, the algorithm showed a limit when evaluating the "intermediate" category of MG severity: this can be explained because of the overlap between the two main categories of images (healthy and unhealthy). In fact, the categorisation of the ground-truth images on which the algorithm is based was initially decided by the expert (human-related uncertainty).

J. S. Lee et al. (2020) described the clinical accuracy of a relatively new device called Antares (Lumenis, Australia) which combines the functionality of a non-contact Placido disk topographer with an IR camera for MG imaging with the LipiView system described above. With a cohort of 33 Korean patients, the authors noted that the IR images acquired from both devices were correlated ($r=0.446$, $p=0.009$). They also reported that the Antares images were poorer in quality compared with the LipiView due to lack of contrast, lighter background, and greater reflections. The MG tortuosity parameter explored by Lin et al. (2020) in their work, highlights how MG imaging and analysis has become increasingly detailed over the past years. Based on their findings in 32 and 28 MG obstructive and healthy patients respectively, they reported that MG tortuosity of the upper eyelid can be considered to diagnose MGD due to obstruction. Sensitivity and specificity were 90% and 100% for the average tortuosity of all MGs and 80% and 100% for the average tortuosity of the central eight MGs, respectively. Therefore, we can assume from Lin et al.'s results, that MG tortuosity should be considered as a reliable sign to monitor MGD, but further studies with greater sample sizes are required.

Maskin and Alluri (2020) showed by IR illumination, the ability to locate and internally cannulate MG: the researchers progressed further by assessing the intraductal space, which can open an interesting scenario on the treatments for MG rehabilitation. In fact, the results showed that signs and symptoms such as lid tenderness and lid functionality (meibum secretion and the number of expressible glands) were improved after intraductal probing. In their study, they used a specific set of probes tested for MG ducts whose diameters were less than 110 microns and lengths were 1, 2 and 4 mm. The temporary insertion of these probes also aims to reduce MG tortuosity by straightening the ducts.

Based on 120 healthy subjects MG IR images obtained with a Keratograph 5M, García-Marqués et al. (2021) developed a new algorithm using MATLAB to objectively measure MG visibility, which should be differentiated from measuring MG loss or any previous MG metrics studied. Their outcomes showed that MG visibility could anticipate MGD which affects lipid secretion and composition. Furthermore, the algorithm is capable of classifying patients according to their MGD severity: within-subject standard deviation (Sw), coefficient of variation (CoV), and repeatability coefficient (CoR) indicated "good" repeatability even if the IR scans were manually acquired by an experienced operator. Finally, higher MG visibility might be related to a better MG status in terms of functionality, while lower MG visibility might relate to a higher MG dropout.

Despite the majority of studies included in this review being based on adult cohorts, IR illumination can be helpful also in the paediatric population. In their study, Kara and Dereli Can (2021) considered anterior segment parameters acquired with a corneal topographer equipped with IR illumination in 37 children/adolescents (age range 5 to 17) affected with isolated

growth hormone deficiency (GHD). Their findings revealed that the GHD group had up to 79.4% of MG loss despite having a similar MG morphology distortion as the healthy group (n=40).

In-vivo confocal microscopy (IVCM)

IVCM is an invasive technique to obtain detailed high-resolution images of the human ocular surface (cornea, conjunctiva, tear film and annexes). IVCM can be divided into tandem, slit, and laser scanning devices (De Silva et al., 2017). However, the most common IVCM devices are based on the laser scanning principle which is unharmful to the eye (red wavelength 670 nm) and yields optimal scans in terms of depth of focus (800–fold magnification), improved contrast and better resolution (1 μm per pixel). IVCM enables analysis of cell layers, which might show abnormalities and the presence, type and location of infections and inflammation. This provides vital additional information for patients both in the acute and chronic stages of the disease process. IVCM applications range from early detection of microbial keratitis (Hassan et al., 2019), reduction in corneal after ophthalmic surgery (Recchioni et al., 2020), assessment of rare genetic diseases (Leonardi et al., 2020), dry eye screening and diagnosis (Hwang et al., 2021), etc. In the context of MG imaging, IVCM can observe fine details of the MG anatomical structure, which might suggest any abnormalities leading to MGD. Zhao et al. (2016) explored the relationship between MG structure and dry eye metrics in a cohort of dry eye patients (n=60): they studied several new MG metrics such as MG acinar unit density (MGAUD), MG acinar unit area (MGAUA), MG acinar unit longest diameter (MGALD) and MG acinar unit shortest diameter (MGASD). Their results showed that the patients with the highest symptomatology scores (OSDI and Salisbury Eye Evaluation Questionnaire (SEEQ)) were also those with the most severe degree of fibrosis and atrophy of MGs. Additionally, all the observed MG metrics between mild and severe dry eye patients exhibit changes in cell size and density, leading to MGD. Randon et al. (2019) defined a four type MG classification based on IVCM imaging: type 0 = no MGD, type 1 = obstructive disease, type 2 = inflammatory disease and type 3 = fibrosis state. In order to define these four types, the authors considered meibum (MG secretion) reflectivity, intraepithelial/interglandular inflammation, and glandular fibrosis which showed mild correlations with the dry eye metrics such as tear osmolarity, ocular staining score (Oxford grading scheme), tear break-up time, and Schirmer test (n = 101 dry eyes and 15 healthy eyes). Finally, an initial IVCM mild type of MG classification (type 1 obstructive disease) could suggest early MG treatment (e.g., warm compress and massage, eyelid hygiene, etc.) which could avoid the worsening of patient dry eye signs and symptoms.

Controversially, S. Zhou and Robertson (2018) focused their work on confirming if the MG structures observed in previous investigations Matsumoto et al. (2008) were MG or something else. In their methods, a comparison between in-vivo and in-situ by using immunofluorescence was adopted to define that those structures believed to be MG were, in reality, rete ridges in the dermal-epidermal junction of the eyelids (e.g., epithelial extensions). Nevertheless, using quantitative image analysis (MetaMorph software), the researchers also calculated the morphologic profile of these rete ridges, although without any clarification of whether these were in related to MGD.

Maruoka et al. (2020) considered 137 IVCM images from 137 obstructive MG individuals to evaluate the performance of image processing using deep learning models in MGD diagnosis. The deep convolutional neural network (DNN) developed was able to distinguish with high sensitivity, specificity, and AUC healthy versus dysfunctional MG subjects. This automatic DNN classification poses a new frontier in ophthalmology imaging in MG because artificial intelligence will allow nearly the same classification accuracy as an expert examiner with less buy in human and economic resources.

Finally, the work by N. Zhou et al. (2020) could help clinicians to define a feasible protocol for those interested in working with IVCM in MG. The researchers suggested that the evaluation of the eyelid margin should include at least five non-overlapping single frames of rete ridges area and at least three MG openings at 20 μm depth intervals between 30 and 130 μm. However, as remarked in this study, IVCM imaging of MG should be carefully evaluated as evidence confirms that only structures such as rete ridges, MG openings and lid wiper region can be observed (Maruoka et al., 2020). Further studies are needed to determine which of the eyelid structures observed with IVCM imaging are most sensitive to MGD.

Anterior segment optical coherence tomography

Anterior segment optical coherence tomography (AS-OCT) is a non-contact imaging method that provides detailed cross-sectional images of biological tissues. It works with a similar principle as ultrasound imaging and can be used for defining structures such as ocular surface, anterior chamber, crystalline lens, etc()Jiao2019. Several types of AS-OCT technology are available and can be classified into time-domain, spectral-domain, and swept-source. They are all based on the same principle of indirect interferometry, in which a beam of light is directed into the retina. The back-scattered light distance is measured with a detector, which is then compared to a reference beam of known length to calculate the echo time delay of light. With time-domain AS-OCT, the echo time delays are measured one at a time while spectral-domain and swept-source AS-OCTs have a fixed-reference arm to generate an interference pattern of the reflected light. By using Fourier transformation, all these echo measurements can be obtained simultaneously and this has increased the image acquisition speed of these devices to up to 400,000 A-scans/second (Potsaid et al., 2010)). During recent years, modern AS-OCT technologies such as spectral-domain and swept-source have been adopted for examining the ocular surface and the tear film in dry eye disease (Venkateswaran et al., 2018). The newest AS-OCT swept-source light employs 1310 nm IR light source and makes it possible to reconstruct the three-dimensional images of the anterior segment of the eye more accurately by providing useful information before and after corneal and lens surgeries or treatment, and in determining the hereditary or infective aetiology of corneal pathologies.

Napoli et al. (2016) used a spectral-domain OCT (840 nm, 27,000 axial scans/s, 5 µm axial resolution) to image both the upper and lower eyelids of 61 and 75 obstructive MGD and healthy patients, respectively. Essentially, their aims were to describe this technology applied to the MG imaging and to demonstrate the feasibility of using the built-in software to enhance OCT scans. More importantly, the authors were interested in reducing patients' discomfort by avoiding invasive techniques (contact meibography), and hospital costs by considering a technology already available for ophthalmic imaging of the posterior segment (Cirrus HD-OCT 4000, Carl ZeissMeditec Inc., California, USA). Their findings revealed substantial agreement with standard meibography, introducing new metrics in MG assessment such as the segmentation (MG appear divided into pieces in their row) and entanglement (MG exhibit a tangled pattern in their row). While segmentation was observed in patients with lower dropout grades (early screening of MGD), entanglement was more present in the atrophic process related to higher dropout grades (follow-up of MGD).

In their cross-sectional study, Yoo et al. (2017) considered a custom AS-OCT with a long wavelength (1310nm) and high-

speed data processing (50 kHz) to obtain 3D reconstruction images of MG in 275 cases of MGD. By comparing AS-OCT scans with IR light scans, the researchers revealed a 3-scale classification system based on MG acini and ducts (Group 1 = constricted acini, Group 2 = atrophic acini, Group 3 = no acini), which might help clinicians to further assess and treat MG patients.

Wang et al. (2020) proposed a new application of AS-OCT for patients in the early stages of MGD or completely asymptomatic: in their research, they measured the lower lid margin thickness (LLMT) from the posterior lash line to the Marx's line and compared the results with a vernier micrometre (e.g., ruler). The reason behind this methodology is that thickening of the lid margin is a common feature of MGD (Knop et al., 2011), but also of blepharitis, lid wiper epitheliopathy, etc. The results found that AS-OCT is a reliable technique (ICC = 0.83) compared to vernier micrometre for rapid and non-invasive in-vivo imaging of fine structures of the eye such as the eyelid margin.

Other devices

An indirect measurement of the current MG functionality is the photometric assessment of optical density done over a sample of lipid layer called meibometry. This measurement can be done by collecting a small sample from the lid margin with a device called meibometer and then observing through a photometer (Chew et al., 1993). The meibometer basic principle is that the light transmission is increased in presence of oil (lipid). García-Resúa et al. (2017) employed a Meibometer MB550 (Courage-Khazaka electronic GmbH, Cologne, Germany) to assess the ability to distinguish between healthy and abnormal subjects classified with two of the most common dry eye questionnaires (OSDI and McMonnies). Additionally, the authors ascertained the relationship between meibometry and break-up time (BUT) and maximum blink interval (MBI). Symptomatic subjects showed lower meibometer units (MU) than the asymptomatic with significant correlations between MU, BUT and MBI. However, further work is required, such as higher symptomatic and wider age range samples.

Another interesting approach is from S. M. Lee et al. (2019) where a red filter system (RFS) applied to a digital slit-lamp was used to obtain images from 125 eyes (upper and lower eyelids) which were then compared with the gold-standard IR meibography. All the red filter images were initially converted into black and white and adjusted for contrast/brightness before being randomly presented to two independent evaluators together with the IR scans. From their results, it is possible to ascertain that MG dropout measured with an RFS had substantial agreement (weighted $K = 0.676$, 95% CI = 0.594–0.759) with IR illumination technology. Therefore, it can be assumed that MG dropout can be considered even in absence of the gold standard IR illumination technology although with a potential limitation observed within a relatively lower inter-observer reliability.

Conclusion

In this mini-review, the latest available and most common technologies for MG diagnostic imaging were recapitulated. Relevant principles for tarsal plate imaging were discussed under four main domains for the ease of the readers. Meibomian gland and tarsal plate imaging are a valuable support for diagnosis, treatment, and follow-up of one of the most acknowledged causes of dry eye disease, the meibomian gland dysfunction.

In recent years, several new technologies have been made available for clinicians and researchers in the field of ocular surface- and dry eye disease, with the non-infrared illumination technology being one of the most common.

At this moment, the availability of devices able to image the MGs and the tarsal plates differs from setting to setting (public health vs. private sector), from clinician to clinician (ophthalmologist vs. optometrist/optician) and from country to country. It appears that the future development of less expensive devices (e.g., cheap and reliable IR cameras) might help to close the gap and offer these imaging technologies to a wider audit of dry eye patients.

On the one hand, it is true that meibography can provide images of great detail for the clinicians, but on the other hand there is still a lack of a unified method of grading and most clinicians develop and use their own grading system. For example, while classification and grading scales for MG atrophy and orifices secretion are already available thanks to the works of Arita et al. (2008) and Pult and Nichols (2012), there are still gaps in the literature about grading dilation and distortion/tortuosity of the gland.

Finally, larger population studies with wider age, gender and risk factors categories should be undertaken to reveal the efficacy of these newer devices for both clinicians', researchers' and patients' benefit.

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Avbildning av tarsalplaten: en oversiktsartikkel

Sammendrag

Avbildning av tarsalplaten og de meibomiske kjertlene (MG) gir nye muligheter for optikere og øyeleger som arbeider med fremre segment og tørre øyne. Den sekretoriske rollen til MG spiller en grunnleggende rolle i å beskytte tårefilmen ved å skape et aktivt skjold av meibum (lipid) som forhindrer tårefordampning og dermed tørre øyne. Dry Eye Workshop-rapportene (2007 og 2016) viser at MG-dysfunksjon er hovedårsaken til tårefordamping, som også er den vanligste årsaken til tørre øyne og ubehag på øyeoverflaten. Det er flere instrumenter tilgjengelig i markedet for MG-observasjon, diagnose og oppfølging. Infrarød lysteknologi er den vanligste, både innen forskning og klinisk praksis, etterfulgt av in-vivo konfokalmikroskopi og fremre segment OCT.

Målet med denne oversiktsartikkelen er å kondensere de nyeste bevisene innen MG-avbildning gjennom en narrativ oversikt over de mest brukte teknologiene inkludert andre nyere aspekter som kan bidra til å veilede klinikere og forskere innen øyeoverflaten og tørre øyne.

Nøkkelord: Meibomske kjertler (MG), MG-dysfunksjon, tørre øyne, diagnostisk avbildning, meibografi

Visualizzare il tarso palpebrale: una mini revisione

Riassunto

La visualizzazione del tarso palpebrale e delle ghiandole di meibomio (GdM) offre nuove opportunità per i professionisti della visione che lavorano nel campo della superficie oculare e dell'occhio secco a livello mondiale.

Il ruolo secretorio delle GdM gioca una parte fondamentale nel proteggere l'idratazione della parte anteriore della superficie dell'occhio creando uno scudo attivo composto di *meibum* (lipide) il quale riduce l'evaporazione e l'occhio secco. Evidenze dal popolare Dry Eye Workshop reports (2007 e 2016) dimostrano che la disfunzione delle GdM è la prima causa dell'occhio secco evaporativo la quale rappresenta la causa piu comune di occhio secco e discomfort della superficie oculare.

Una pletora di strumenti per l'osservazione, diagnosi e follow-up delle GdM sono disponibili nel mercato. Sembrerebbe che la tecnologie a luce infrarossa è la più comune in ricerca e nella pratica clinica grazie al suo anticipato sviluppo all'inizio degli anni 2000, seguita dalla microscopia confocale in-vivo e dall'OCT del segmento anteriore.

Ciònonostante, nuove tecnologie sono state messe a disposizione le quali potrebbero superare limiti quali costi e disponibilità delle stesse. L'obiettivo di questa mini-revisione è di condensare le ultime evidenze nel campo della visualizzazione delle GdM grazie ad una panoramica narrativa delle più comuni tecnologie considerando anche altri innovativi aspetti i quali potrebbero guidare clinici e ricercatori nel campo della superficie oculare e dell'occhio secco.

Parole chiave: Ghiandole di meibomio, disfunzione delle ghiandole di meibomio, occhio secco, diagnostica per immagini, meibografia.

SOPTI Meeting 2021: Abstracts

After more than a year of blockade due to the Covid-19 pandemic, it was finally possible to return to the events in the presence. The 26th National Conference of the Italian Optometric Association (SOPTI) was held in Bologna on October 10–11, 2021.

The theme of the conference was "Good practice in Optometry and Contact Lenses", with the accent on two topics: the optometric management of the patient in old age and the progression of myopia.

Four keynote speakers were invited during the conference: Prof. Rigmor C. Baraas from the University of South-Eastern Norway in Kongsberg, Prof. David B. Elliot from the University of Bradford, Dr. Fabrizio Zeri from the University of Milano Bicocca and the IACLE President, Prof. Phil Morgan, from the University of Manchester.

The abstracts from accepted posters and free papers are presented here.

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Corneal densitometry by sublayers: an alternative method for analyzing Scheimpflug images of normal or keratoconic eyes

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Abstract

Loss of corneal transparency is a key element to monitor in ophthalmic practice, as it may be symptomatic of a wide range of conditions including corneal dystrophies. The most common is keratoconus, a non-inflammatory corneal ectasia characterized by a progressive thinning of corneal tissue and formation of corneal protrusion. Densitometric analysis has recently been introduced. It is an objective and non-invasive technique capable of quantifying corneal transparency with the aid of various imaging technologies including Scheimpflug photography. Pentacam Scheimpflug, the most used instrument, calculates density of corneal layers respecting fixed depth values. This work proposes an alternative method based on segmentation of the epithelium and stroma starting from an image obtained with Sirius Tomograph (CSO, Italy).

180 images of the anterior segment of 30 subjects (24.1 ± 4.4 years) with healthy eyes and 50 images of eyes belonging to 22 subjects (28.8 ± 8.4 years) with unilateral keratoconus were analyzed. These were acquired with the Sirius tomograph (CSO, Italy). The stroma and the epithelium associated with Bowman's membrane were segmented from each tomography corresponding to the horizontal meridian. Only the central 3-mm-diameter zone was considered. The computing platform used was MATLAB. In the process, the identification of the corneal apex is obtained by the `apex.m` function. It requires the coordinates of two points respectively to the left (L) and to the right (R) of the apex. On the other hand, the function used for the segmentation in the different layers of the corneal thickness was `region3mm.m` which exploits the region-growing technique.

Student's t-test showed that the subjective choice of points L and R does not determine significant changes in the identification of the apical coordinates. The thresholds used to segment are expressed in a grayscale from 1 (white) to 256 (black). They were 18 and 41 for the stroma, 41 and 63 for the epithelium. The segmentations obtained, introducing variations of ± 5 units to the thresholds, were classified into *adequate*, *almost adequate* and *inadequate* both for healthy and keratoconus eyes. Subsequently, the densitometric values or the stroma and epithelium were calculated by adopting two different criteria: the first referring to the extremes of the peaks identified by the intensity distribution of the pixels, the second referring to the thresholds.

The segmentations are adequate in healthy corneas with a success rate above 80%. The application of the method to corneas affected by keratoconus shows, as expected, a lower success rate around 50% (figure 1). The reliability of the `apex.m` algorithm is demonstrated. The `region3mm.m` function is more suitable for healthy corneas than corneas with keratoconus.

The densitometric results were converted to GSU (figure 1) and compared with the values reported in the studies by Dhubhghaill et al. (Ní Dhubhghaill et al., 2014) and Tekin et al. (Tekin et al., 2017) obtained from Pentacam Scheimpflug. The agreement with Tekin's study is the best among those considered, but not statistically significant. The comparison is weak because, with the Pentacam tomograph, corneal segments are evaluated for depth without recognition of different substrates.

Normal eyes (N=180)		stroma		epithelium	
		extremes	thresholds	extremes	thresholds
adequate	mean value	11,3	11,2	18,9	18,7
	SD	0,9	0,5	1,4	0,7
	%	92%		79%	
almost adequate	mean value	12,1	11,7	20,5	19,4
	SD	0,5	0,3	1,2	0,6
	%	3%		4%	
inadequate	mean value	11,9	11,6	20,0	18,9
	SD	1,3	0,6	2,4	1,0
	%	5%		16%	
Normal eyes of monolateral KC (N=25)		**stroma**		**epithelium**	
		extremes	thresholds	extremes	thresholds
adequate	mean value	11,8	11,4	19,3	18,8
	SD	1,0	0,5	1,3	0,7
	%	64%		64%	
almost adequate	mean value	11,9	11,7		
	SD	0,3	0,3		
	%	8%			
inadequate	mean value	10	10,3	21,2	19,3
	SD	2,8	1,5	6,2	0,5
	%	28%		36%	
Keratoconus eyes (N=25)		**stroma**		**epithelium**	
		extremes	thresholds	extremes (N=22)	thresholds (N=25)
adequate	mean value	11,4	11,2	19,6	19,2
	SD	0,6	0,3	1,6	0,8
	%	52%		45%	40%
almost adequate	mean value	10,2	10,4		
	SD	1,3	0,9		
	%	20%			
inadequate	mean value	13,0	12,0	20,9	19,6
	SD	1,0	0,3	3,2	0,3
	%	28%		55%	60%

Figure 1: all densitometric values are reported in GSU and divided into the analyzed samples. The percentages obtained from the classification of segmentations in adequate, almost adequate and inadequate are also reported.

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Subjective measurement of fusional vergences, dissociated heterophorias and associated heterophorias: comparison between monocular and binocular prismatic apposition

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Abstract

The aim of the study is the measure of fusional vergences, dissociated heterophorias and associated heterophorias both in the phoropter and in the open field, comparing the data obtained when the prisms are placed in front of only one eye or on both eyes. Most of the studies in the literature, in fact, compare the various measurement methods but do not make a direct comparison between monocular and binocular prismatic apposition.

The study sample included 40 subjects (age 22.5±3.1) were examined in which the lenses of the subjective refraction performed at the phoropter were worn during the tests, then balanced with Humpriss in the open field. For each subject, the following were measured from afar (6 metres) and near (40 centimeters): the smooth fusional vergences (phoropter) and jumps (open field), the dissociated heterophorias by means of the von Graefe test (phoropter) and the of Maddox modified Thoringhton (open field) and finally, the heterophoria associated for distance, through the cross and needle test both to the phoropter and in open field and the associated phrases for near through the Wesson card (phoropter) and the Mallet Unit (open field). Wilconxon's non-parametric test was applied to study the comparison between the samples, considering a significance level of 0.05 (Figure 1).

COMPARISONS	*p-value*
V_S FNEBMO – V_S FNEBBI	0,023
V_S NNEREMO – V_S NNEREBI	0,003
V_S NPOBMO – V_S NPOBBI	0,002
V_S NPOREMO – V_S NPOREBI	0,041
V_J FNEBMO – V_J FNEBBI	0,001
V_J FNEREMO – V_J FNEREBI	0,012
V_J NNEREMO – V_J NNEREBI	0,004
V_S FPOREMO- V_J FPOREMO	4*10^-4
V_S NPOBMO- V_J NPOBMO	0,001
V_S FPOREBI- V_J FPOREBI	0,002
V_S NNEREBI- V_J NPOREBI	2*10^-4
$MADDOX_{MOF}$ *VS* $MADDOX_{BIF}$	0,0455
$MADDOX_{MON}$ *VS* $MADDOX_{BIN}$	0,0062
$MALLET_{MON}$ in OF *VS* $MALLET_{BIN}$ in OF	0,001
CROSS $TEST_{MOF}$ in CF *VS* CROSS $TEST_{MOF}$ in OF	0,021
NEEDLE $TEST_{MOF}$ in CF *VS* CROSS $TEST_{MOF}$ IN OF	0,036
$WESSON_{MON}$ in CF *VS* $MALLET_{MON}$ in CA	0,002
CROSS $TEST_{BIF}$ in CF *VS* CROSS $TEST_{BIF}$ in OF	0,003
NEEDLE $TEST_{BIF}$ in CF *VS* NEEDLE $TEST_{BIF}$ in OF	0,019

LEGEND

V: Vergences
J: Jumps (open field)
S: Smooth (phoropter)
F: Far
N: Near
PO: Positive
NE: Negative
MO: Monocular prismatic apposition
BI: Binocular prismatic apposition
B: Break
RE: Recovery
OF: Open field
CF: Closed field

Figure 1: Comparisons that showed significant differences with Wilconxon's non-parametric test.

In the study, the difference in fusional vergences was greater especially on breakages and recoveries for the most part negative and for the least part positive. In dissociated heterophorias, significant differences appear only on the data in the open field, so there may be a different adaptation to the monocular prism compared to the binocular when the data is not taken at the phoropter. In the associated heterophoria, the comparison histograms showed a greater presence of exophoric subjects in a monocular condition and a greater presence of exophoric subjects in a binocular condition.

The only test that did not show significant difference in open and closed field was that of the cross, probably due to the absence of a central fusional recall. The study results show a new perspective on binocular vision investigation methods. In this regard, in order to have a more specific and broader understanding of the commonly used procedures, it would be useful to deepen the study with a larger sample both in terms of number and variety.

Contrast sensitivity measures: comparison between professional and casual drivers

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Abstract

Given the lack of evidence in the procedures defining visual standards for driving licenses and the lack of understanding of how visual decay impacts on safety and driving performance, in the study we aim to have contrast sensitivity measurements, paying particular attention to sample definition. Therefore the aim of the study is to analyze the differences between contrast sensitivity (CS) measurements obtained on a population of professional drivers (GP) and one of occasional drivers (GNP) weighting the role of binocular vision.

The subjects considered for this study are 60, of which 30 GP and 30 GNP. For the CS measurements, the Pelli-Robson subjective test in digital format was used. Before proceeding with the measures, all subjects were given a questionnaire with an indication of age, gender, profession, visual experiences driving in low-contrast conditions, number of accidents in the last year and reported data on the state of health. During the measurements all subjects wore their usual correction. First of all, visual acuity was measured, then subjective measurement of contrast sensitivity was carried out with Pelli-Robson test; the evaluation ended when the subject did not recognize at least 2 letters of the triplet presented.

The statistical analysis is presented, which shows on average better values of AV and CS for the sample of professional drivers. The statistically significant differences between the two categories and the role of binocularity for the measurement of contrast sensitivity are highlighted.

Use of comfort questionnaires in a sample of irregular cornea contact lens wearers

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Abstract

To evaluate the possibility of administering short item questionnaires created for regular cornea subjects and daily disposable contact lens wearers to irregular cornea subjects wearing any kind of contact lens (CL). To compare two questionnaires among them.

In this study, 67 subjects were involved, wearing any kind of contact lens (Rigid, Soft, Hybrid contact lenses): 32 of them

presented regular corneas (RC) and 37 irregular corneas (IC). Monocular visual acuity (VA) with spectacles (when available) and monocular VA with CL were taken.

Two questionnaires were used: the Contact Lens Dry Eye Questionnaire (CLDEQ-8), made of 8 questions, and a new questionnaire from IRSOO (Istituto di Ricerca e di Studi in Ottica e Optometria), made of 7 questions and related to evaluating vision comfort in CL wearers. Subjects were habitual CL wearers and independently filled the questionnaires, referring to the previous two weeks' CL wearing experience.

The statistical analysis used for comparing answers to both questionnaires was the Pearson's correlation coefficient (P). Comparison among VA with the different types of CL was assessed, assuming a p-value ≤ 0.05 as statistically significant.

Results and conclusions: Both questionnaires show a high correlation (P=0.73 for CLDEQ-8 and P=0.74 for IRSOO-7), for the two subgroups also: myopes (My) and keratoconus (Kc). There is no significant statistical difference ($p\text{-}value>0.05$) between VA with Soft and Rigid CL and with Soft and Hybrid CL, while the difference of VA between Hybrid and Rigid CL is statistically significant ($p\text{-}value<0.05$). Also, VA in the main Groups (RC, IC) and subgroups (My, Kc) was better while wearing CL rather than spectacles (RC 0.05 LogMAR vs 0.06 LogMAR; IC 0.09 LogMAR vs 0.27 LogMAR; My 0.04 LogMAR vs 0.05; Kc 0.09 LogMAR vs 0.29).

Both questionnaires therefore can be used in a routinary clinical practice to evaluate the use of a CL fitting quality over time or to compare the performance among different types of CL.

Kongsberg Vision Meeting 2021: Abstracts

Kongsberg Vision Meeting was held at the University of South-Eastern Norway in Kongsberg, for the 13th time, on November 16–18, 2021. The meeting was organised as a three-day meeting with a clinical day, a research day and a lighting design day. Rigmor C. Baraas, Eilin Lundanes, Ann Elisabeth Ystenæs, Ellen Svarverud, Klaus Sjøhaug and Are Røysamb organised the three-day meeting. The theme this year was *Speciality Contact Lenses and Architectural Lighting Design*. Keynote speakers for the clinical optometry day and the research day were Eef van Der Worp, Nicola Logan, Fabrizio Zeri and Daddi Fadel. The keynote speakers for the lighting day were Sylvia Pont and Manuel Spitschan. The abstracts from invited and contributed talks on the different days are presented in the order they were given.

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Light and materials in the wild

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Abstract

Light is not flat. It has a spatial structure. In addition, it varies directionally and chromatically. Light interacts with materials and spaces via scattering, shad(ow)ing, (inter)reflecting, etcetera. We interact with light by moving ourselves and our eyes. How can we describe, measure, visualise and design this light, the "all we can potentially see" or "light field"? I will present the multidisciplinary "Delft light(ing) framework", that captures the spatial, directional and spectral properties of light throughout space, including material-shape-light interactions, integrating knowledge from optics, perception and design. This approach goes far beyond the surface-based approach that is still leading in many quantitative lighting guidelines. I will address how to capture physical and visual light fields in 3D space (interior and exterior). In addition, I will present studies into the interactions between light, materials, shape and space in "the wild", linking theoretical, empirical, and practical knowledge, forming a fundament for applied perception and a novel science of lighting design.

Lighting for darkness

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Abstract

When we move around in the city after dark, we need artificial light to avoid tripping over obstacles and to provide a sense of security. Until recently, outdoor lighting has been considered a good thing; only astronomers saw the flaws of widespread outdoor lighting. However, in recent years also biologist are raising their voice about the negative impact that artificial light at night (ALAN) can have on a wide range of species. Research has shown that artificial light affects insects, birds, fishes, amphibians, and even trees and plankton. This actualises the need for a new way of thinking about street lighting. Light has to be used more efficiently, with regard to energy usage and also its perceptual effects on visual appearance and sense of security. Combining knowledge of visual perception in scotopic and mesopic conditions with that of optical interactions between lighting and the environment, we will study possibilities to optimise the appearance of pedestrian paths under low-as-possible light levels.

An important part of pedestrians' sense of security is related to how other pedestrians are perceived. We are currently studying whether different light directions affect how friendly a face is perceived and how that relates to common light conditions on pedestrian paths. The study consists of three parts: A) styrofoam heads are rated under various lab light directions; B) the styrofoam heads are taken outdoor to be rated under two different common light principles. In the analysis the findings from the first and second parts will be compared and related.

Pilot results suggested that certain light conditions influenced how friendly a face looks. If this will be confirmed in our main study, this suggests how perceived safety when walking might be preserved while reducing overall light levels in a city.

Acknowledgements

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The non-visual effects of light on human physiology and behaviour: From principles to practice

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Abstract

Light enables us to see and appreciate the colourful, detailed and moving world around us. In addition to these visual effects of light, exposure to light also affects us fundamentally by modifying the production of certain hormones, such as melatonin, and synchronising our circadian clock with the external light-dark cycle. These so-called non-visual effects of light are largely mediated by a photoreceptor class, the intrinsically photosensitive retinal ganglion cells (ipRGCs), that is different from those that enable us to see, the cones and rods. The ipRGCs express the photopigment melanopsin, which is most sensitive to short-wavelength light. In this talk, I will discuss principles of circadian and neuroendocrine phototransduction and how knowledge gathered from scientific and field studies can be used to support practice in an evidence-based fashion.

Education and research in the fourth stage of lighting design

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Abstract

The third stage of lighting design focusses on assessing light arriving at the eye instead of light incident on planes (Cuttle, 2010). It needs a multidisciplinary approach, integrating fundamental knowledge and tools from optics, optometry, perception, engineering, architecture and design. It also needs an entirely different way of thinking about light, and consequentially about education and research in lighting design. And although we are still working on the third stage goals, in the meantime we entered the fourth stage of lighting design, in which sustainability is acknowledged to be an absolute precondition for any development. This fourth stage is characterised by issues such as high tech, low tech or no tech, lighting or preserving darkness, and other-than-human-perspectives. Our team proposes the following main ingredients for academic education and research in lighting design: building on a scientific fundament as presented earlier today; a design approach centred around sustainable effects on humans, flora and fauna; a didactical approach that integrates theoretical grounding with empirical testing, practical engineering, and explorative tinkering; and regular exchanges with external lighting(-related) professionals and researchers. The approach will be illustrated with examples from ongoing research and education in Delft and at USN and will be worked out to a MSc program proposal.

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Specialty Contact Lenses for Refractive Error Control

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Abstract

Our current mode of practice is to correct refractive error to improve visual function however, with recent advances in the field of myopia control and with a variety of interventions to slow myopia progression in children we can now more actively manage myopia in children. There are various contact lens designs that can be utilised to this effect. Currently hyperopia receives much less attention from research than myopia even though the impact of moderate to high levels of hyperopia especially in one eye (anisohyperopia) can lead to amblyopia and strabismus if not corrected fully at a young age as well as having a negative impact on educational attainment and visuocognitive and visuomotor skills. Studies on animals have suggested that manipulating peripheral defocus through an optical means while simultaneously providing correct axial focus can either discourage or encourage axial growth to effectively treat myopia or hyperopia respectively. Recent research has established that progression of myopia and axial growth can be significantly reduced in children and adolescents through the use of different designs of contact lenses that both correct the refractive error and impose simultaneous myopic defocus. Can this type of approach be applied to hyperopes using the converse theory whereby there is a strategy for optimal correction to encourage axial growth in hyperopia? If so could this approach complement amblyopia treatment in children by encouraging eye growth and reduction of hyperopia with associated benefits of improved binocular vision and stereopsis? This presentation will review contact lens options for myopia management in children and discuss applying a similar theory to children with hyperopia.

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College of Optometrists, UK for PhD studentship for hyperopia study, CooperVision for supply of contact lenses for hyperopia study.

Normal eye growth in adolescents from 16 to 18 years of age

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Abstract

Emmetropisation is the process in which hypermetropic children gradually become more emmetropic through development of the eye's refractive components as the eye grows. To maintain emmetropia through continued eye growth, a coordinated development of the eye's refractive components is required.

Data will be presented from a longitudinal study on normal eye growth in 16- to 18-year-old adolescents in Norway (Hagen et al., 2019), a population with a low myopia prevalence and a predominantly low hyperopic refractive error (Hagen et al., 2018). Cycloplegic ocular biometry and autorefraction data were obtained with Zeiss IOLMaster 700 and Huvitz autorefractor, respectively, and repeated after two years. Individual three-surface biconic eye models were used to calculate crystalline lens power.

The longitudinal data showed continued eye growth in 16- to 18-year-old emmetropes and low hyperopes, although they maintained a stable refractive error over the study period. The stable refractive error was maintained by a coordinated decrease in crystalline lens power when ocular axial length increased. Myopic changes in refractive error were larger in those with a more myopic refractive error at baseline and were associated with increases in vitreous chamber depth and crystalline lens power, when adjusted for sex.

Knowledge of normal eye growth, as well as performing regular measurements of ocular biometry, are essential for determining the best mode of refractive error treatment and follow-up (Németh et al., 2021), in both children and adolescents.

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Successful fitting of CL in presbyopes: the long lasting fighting between monovision and multifocal CLs

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Abstract
Presbyopia prevalence is increasing in our society as we have an aging population. According to the estimation of (Holden, 2008), one billion and 300 million people worldwide are currently affected by presbyopia. Presbyopic people have the desire to continue with lifestyle choices that do not facilitate the use of spectacles. However, CL use decreases as the presbyopia increases (Morgan, 2009; 2011) with retention rates falling from 75% to 63%, over the age of 45 years (Sulley, 2017). The presentation will be discussed the two main options available in the CL field, multifocal and monovision, and their difference in the possibility to maximize the success of CL fitting in this category of people.

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Keeping scleral lens issues and complications in perspective

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Abstract
The better understanding of the scleral contact lens (SL) dynamics on the ocular surface and the introduction of new diagnostic instruments to detect the ocular surface have permitted to comprehend better the ocular surface contour leading to the formulation of new SL designs and techniques, resulting in an increase of the fitting rate success. However, problems still occur and some of them have shown up and they are unique to SL wear. While issues related to SLs wear are reversible, they affect patients' satisfaction and lead them to discontinue ScCL use. Some may be challenging, adding to the frustration, time, and costs for both practitioner and patient. Troubleshooting problems is fundamental in SL practice particularly because most of the time, the decision to use SL represents a life-changing event for patients and problems may result in eye surgery and/or depression or psychological problems, and emotional instability. Some practitioners still remain intimidated by preconceived notions, the fitting process, and, especially, the ensue of problems and their management. As a consequence, clinicians rarely, if not at all, prescribe them. The objective of this course is to provide tips and tricks to avoid the ensue of some problems and to describe in detail issues and complications that can arise fitting SLs.

When a patient loves his scleral lens too much

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Abstract
In a case report published in SJOVS vol. 13 no. 1, 2020, we described refitting a 66-year-old male with pellucid marginal degeneration from a corneal rigid gas permeable lens to a scleral lens. At the initial visit he presented with a poor-fitting old corneal gas permeable lens on his right eye. Due to macular changes in the left eye, this eye remains uncorrected. The refit to a Onefit scleral lens was successful (Lundanes & Gustafsson, 2020). The patient was happy with lens handling, comfort and vision, and the optometrists were happy with the overall fit of the lens with no excessive clearance centrally or over limbus. The patient loved his scleral lens and wore it every day for about one year. At a routine visit the patient told us about an incident of pain 5-6 weeks earlier, occurring after sleeping with his lens for tow consecutive nights. An ophthalmologist had given him topical steroids and lubricants. After two weeks the symptoms improved, and the patient decided himself to commence lens wear. At the visit in our office we found corneal oedema, advanced epithelial defects, and reduced visual acuity, and prohibited lens wear. As glasses did not improve vision, and uncorrected visual acuity was logMAR 1.0, low vision devices were prescribed as a temporary solution. After two months the patient was cleared to commence lens wear. We refitted the patient back to a corneal rigid gas permeable lens, a Rose K2 KC, as the risk of corneal oedema was considered too high with a scleral lens. Today the patient functions well with the corneal lens, but he still misses his scleral lens and asks for the possibility to have one fitted in the future.

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