OULUN AMMATTIKORKEAKOULU

Vesa Peuhkuri

PRIMARY OPEN-ANGLE GLAUCOMA: CASE STUDY

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Vesa Peuhkuri
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ABSTRACT

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Purpose: This study aims to evaluate the potential of teleophthalmology in glaucoma screening at optometrists' appointments.

Methods: This clinical case example study describes how teleophthalmology was used in a primary open-angle glaucoma patient's follow-up assessment and management at an optical chain-owned practice in 2022. A literature search was conducted using PubMed, Cochrane, and Springer in January 2022. One hundred thirty-one (n = 131) texts were retrieved, and twenty-seven (n = 27) articles were deemed eligible for full-text review. Twelve (n = 12) studies were included in the literature review.

Results: Teleophthalmology can provide high-quality screening and effectively target primarily at-risk groups. The case study patient was previously diagnosed with glaucoma and has risk factors. In the case study patient´s visual acuity was 20/25-2 in both eyes, and topography revealed moderate astigmatism in both eyes. The patient's intraocular pressures were between average values, and the papilla OCT revealed no significant glaucomatous defects. Visual fields on the right had no defects, but the left field had unreliable measurements. Teleophthalmology equipment and conventional slit-lamp examination provide high sensitivity and specificity for optometrists' to detect glaucomatous defects, according to the literature. This single case study could not verify the time and cost savings suggested in the literature. Teleophthalmology provided an effective tool for patient education and annual follow-ups, as the literature suggested. Based on the literature, if optometrists have higher education or have got special training, their ability to detect glaucomatous defects is better than without education or special training.

Conclusion: Primary open-angle glaucoma is a relatively slow progressive and multifactorial disease. Optometrists have an excellent understanding of vision-related problems, and together with teleophthalmology, they may be able to provide primary open-angle glaucoma follow-ups. The role of education for optometrists is the key to high-quality primary open-angle glaucoma follow-ups.

Keywords: glaucoma, primary open-angle glaucoma, teleophthalmology, teleglaucoma, optometrist, optometry

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1 INTRODUCTION

Primary open-angle glaucoma (POAG) is the most common form of glaucoma in Caucasian and African ethnic origin, and there is no gender variation (Kanski & Bowling 2015). The risk factors are elevated intraocular pressure, age, family history, myopia, and systemic diseases like hypertension and diabetes (Jindal & al. 2021). Glaucoma is the leading cause of irreversible blindness, and early detection and annual screening are essential to slow down glaucomatous defects (Steinmetz & al. 2021).

According to Cambridge Dictionary, the word “tele” comes from ancient Greek, and it means “over a long distance, done by phone, or on or for television.” (Cambridge University Press 2022a). The growing demand for glaucoma care has increased teleophthalmology to manage long-term patients (Odden & al. 2020). First telemedicine’s first innovation was discovered in the 1960s. This innovation was two-way phone communication between doctors and patients (Ertel M, Kahook M, and Capitena Y, 2021). The history of teleophthalmology started as early as 1987 in the Johnson Space Center in Houston, USA. The team wanted to monitor retinal vessels in space in real-time by a portable video funduscopy (Kumar & Yogesan 2006).

Kawaguchi and his team described a lack of trained ophthalmologists, affecting developed and developing countries (Kawaguchi et al., 2018). Resnikoff, with his team, stated that the number of ophthalmologists was 2015 232,866 (Resnikoff & al. 2020). In developed countries density of ophthalmologists, means was 76.2 per million population. Instead of developing countries, density was a mean of 3.7 per million population. According to the study global aging population growth rate is 2.9%, and the global ophthalmologist growth rate is 1.2%. Conway and his coworkers described a shortage of ophthalmologists all over the globe, and the aging population is a big challenge in this decade (Conway, Forristal, Treacy & Duignan 2021). Teleophthalmology reduces travel times and costs and gives better access for patients to people who live in rural areas. Glaucoma management in teleophthalmology is excellent because follow-up can be done in a short interval to assess glaucoma progression. Lam and coworkers have noticed that teleophthalmology improved the efficacy of glaucoma management (Lam PY 2021).

This study described the optometrist's capacity to provide glaucoma follow-up services in Finland and the use of teleophthalmology. In this study, the researcher included glaucoma guidelines and teleophthalmology guidelines in glaucoma, including equipment. This study investigated the diagnostic accuracy of teleophthalmology and time and financial savings. Patient satisfaction has been taken into account.

2 THEORETICAL BACKGROUND

2.1 Teleophthalmology has benefits and possibilities to manage open-angle glaucoma

2.1.1 Glaucoma Guidelines

The International Council of Ophthalmology published glaucoma guidelines. This paper describes open-angle and closed-angle glaucoma guidelines (Gupta Neeru & al. 2015). In this study, the researcher focused only on open-angle glaucoma guidelines. Gupta and his team stated that the anterior chamber angle is open, and no other pathologies are found. Elevated intraocular pressure (IOP) and visual field (VF) damages are not enough to make a diagnosis for open-angle. It does not necessarily mean that the patient has open-angle glaucoma. The team pointed out that most patients are unaware of undiagnosed glaucoma. Glaucoma screening could be helpful, but the group stated that mass screening for glaucoma is not recommended. Primary eye care providers must ask for detailed ocular, medical, and family history. This detailed history must have been asked in in-clinic assessment or teleophthalmology (Gupta Neeru & al. 2015).

Table 1 History Checklist (Gupta Neeru et al., 2015, p. 4)

Chief Complaint	Age, Race, Occupation	Social History
Possibly of Pregnancy	Family History of Glaucoma	Past Eye Disease, Surgery, Trauma
Corticosteroid Use	Eye Medications	Systemic Medications
Drug Allergies	Tobacco, Alcohol, Drug use	Diabetes
Lung Disease	Heart Disease	Cerebrovascular Disease
Hypertension/Hypotension	Renal Stones	Migraine
Raynaud's Disease	Review of Systems	

The current care glaucoma guidelines in Finland for diagnosis are based on evaluating optic nerve pathologies, the thickness of the neuroretinal rim, VF defects, raised IOP, and anterior chamber pathologies (The Finnish Medical Society Duodecim, The Finnish Ophthalmologist association, The Finnish Glaucoma Society (SGS) & Working group set by authors 2014). However, guidelines stated that diagnostic criteria have no unambiguous and widely accepted definitions. The Finnish medical society recommends screening for patients who have raised IOP, glaucomatous defects in the eye, or one or several risk factors, as Gupta with his team noticed (Gupta Neeru & al. 2015). The Finnish medical society does not recommend population-wide glaucoma screening.

Primary care providers do comprehensive eye exams as a glaucoma evaluation. Gupta and his team made international recommendations for assessments and equipment to detect glaucoma. A comprehensive eye exam is an excellent way to detect glaucomatous defects in the patient's vision. To prevent visual loss in open-angle glaucoma, making correct diagnoses and educating and informing patients about their disease and treatment possibilities are essential. Primary eye care providers must tell patients understandable ways to motivate them to treat and manage their disease.

Table 2 Glaucoma Assessment and Equipment needs (Gupta Neeru et al., 2015, p. 5)

Clinical Assessment	Minimal Equipment	Optional Equipment
Visual Acuity	Near reading card or distance chart with five standard letters or symbols Pinhole	3- or 4- meter visual acuity lane with high contrast visual acuity chart
Refraction	Trial frame and lenses Retinoscope, Jackson cross-cylinder	Phoropter Autorefractor
Pupils	Penlight or torch	
Anterior Segment	Slit lamp biomicroscope Keratometer	Corneal pachymeter
Intraocular Pressure	Goldmann applanation tonometer The portable handheld applanation tonometer Schiotz tonometer	Tonopen Pnemotonometer
Angle Structures	Slit-lamp gonioscopy Goldmann, Zeiss/Posner goniolenses	Anterior segment OCT Ultrasound biomicroscopy
Optic Nerve	Direct ophthalmoscope Slit-lamp biomicroscopy with handheld 78 or 90 diopter lens	Fundus photography The optic nerve image analyzer Confocal scanning laser Optical coherence tomography Scanning laser polarimetry
Fundus	Direct ophthalmoscope Hend mounted indirect ophthalmoscope with 20 or 25 diopter lens Slit-lamp biomicroscopy with 78 diopter lens	12 and 30 diopter lens 60 and 90 diopter lens
Visual Field	Manual perimetry or automated white on white perimetry	Frequency doubling technology Short wave automated perimetry

2.1.2 Teleglaucoma Guidelines

Teleophthalmology in glaucoma, or teleglaucoma, is a growing trend in the 2020s. During COVID-19 forced and made it faster to adapt to manage and screen glaucoma. Gan, with his team, described three models: screening, diagnostic consultation, and long-term treatment monitoring (Gan & al. 2020). The first is screening for asymptomatic patients to evaluate their glaucomatous damage. However, they found that screening the whole population is insufficient. They stated it is more effective to screen patients with a higher risk of getting open-angle glaucoma, including race, age, or systemic diseases (Gupta Neeru & al. 2015). Thomas with his team noticed that teleglaucoma screening is less sensitive but more specific than in-clinic assessment (Thomas & al. 2014).

Nikolaidou and Tsaousis stated that they overcome the challenges of distance teleophthalmology by offering screening, consultation, and long-term monitoring (Nikolaidou & Tsaousis 2021). The second is to consult the glaucoma specialist for examinations via the internet to reduce patient travel in diagnostic consultation. More than half of glaucoma patients can be managed via teleophthalmology (Gan & al. 2020). Community optometrists can reduce ophthalmologists' burden to handle more than half of glaucoma patients. The ophthalmologists have more time to concentrate rest of their patients, e.g., severe or advanced glaucoma. The third option is long-term monitoring. Monitoring is a good option when the glaucoma is in a stable situation. The patients can treat in-clinic when necessary. Gan noticed that using a slit lamp with a camera, non-ophthalmologist could perform postoperative screening after glaucoma surgeries. Guidelines for glaucoma are not at the same level as diabetic retinopathy (DR). DR has very standardized procedures compared to glaucoma guidelines. Managing and screening glaucoma have significant variability in different regions. Primary eye care providers should follow teleglaucoma guidelines as they follow DR guidelines to ensure that patients get proper treatment and eye care. Teleophthalmology requires appropriate devices and software to handle glaucoma effective way. Several technology companies can afford artificial intelligence (AI) to screen and manage glaucoma. The personnel needs continued education for devices and understanding of the disease; that is the way to get high-quality images and examinations. Personnel plays a significant role in asking about the history of patients or any eye-related disorders. The authors stated that devices for teleophthalmology are expensive and need good economic status. Gan and his team noticed that it takes around 100,000 $ to establish a good screening program for glaucoma with proper devices and software. To get significant benefit investment, the program must effectively be used. It needs to be a mobile unit for smaller populations or community optometrists in rural areas center city. It is proven that teleglaucoma is still very cost-effective for public health care and patient with reduced traveling time and cost. Gan described that every program with teleophthalmology in glaucoma depends on goals, population, provider preferences, and community resources. They summarized a table that proposed making a good teleophthalmology test for glaucoma (Gan & al. 2020).

Table 3 Equipment with teleglaucoma (Gan et al., 2020 pp. 553 - 554)

History	Medical, ocular, general health and family,
Visual Acuity	
Visual Fields	Need for baseline or detecting progressive VF loss.
	Humphrey and Octopus
Intraocular Pressure	iCare ONE or iCare Home
Pachymeter	Ultrasound or OCT or Scheimpflug photography
Anterior Chamber Imaging or Gonioscopy	OCT and Scheimpflug photograpy
	Slit lamp gonioscopy
Fundus Photography	Optic nerves pathologies and retina
Retinal Nerve Fiber Layer (RNFL)	OCT and Heidelberg retinal tomography
Additional test	Refractive error and color vision

According to Walsh and his team, COVID-19 has affected access to ophthalmology services, particularly among older adults in New Zealand. The Royal Australian and New Zealand College of Ophthalmology (RANZCO) published guidelines for teleophthalmology in 2020 (The Royal Australian and New Zealand College of Ophthalmologists (RANZCO) 2021). Guidelines stated teleophthalmology is a possible choice of consultation but does not replace in-clinic assessment. However, since the lockdown began in New Zealand, teleophthalmology has become a more prevalent, mainly store-forward model (Walsh, Chiong Hong, Johnson Chalakkal & Ogbuehi 2021). Guidelines limit devices, e.g., they must have not older than three years. Walsh and his team founded glaucoma-based teleophthalmology services that have complicated calculated costs. Glaucoma cannot detect by a single test, which is highly sensitive and specific. Diagnosis of glaucoma needs several expensive types of equipment or a high-quality, comprehensive eye exam with OCT or VF. It has been reported that machine-only screening for glaucoma has 90 % or higher sensitivity and is cheaper than in-clinic screening.

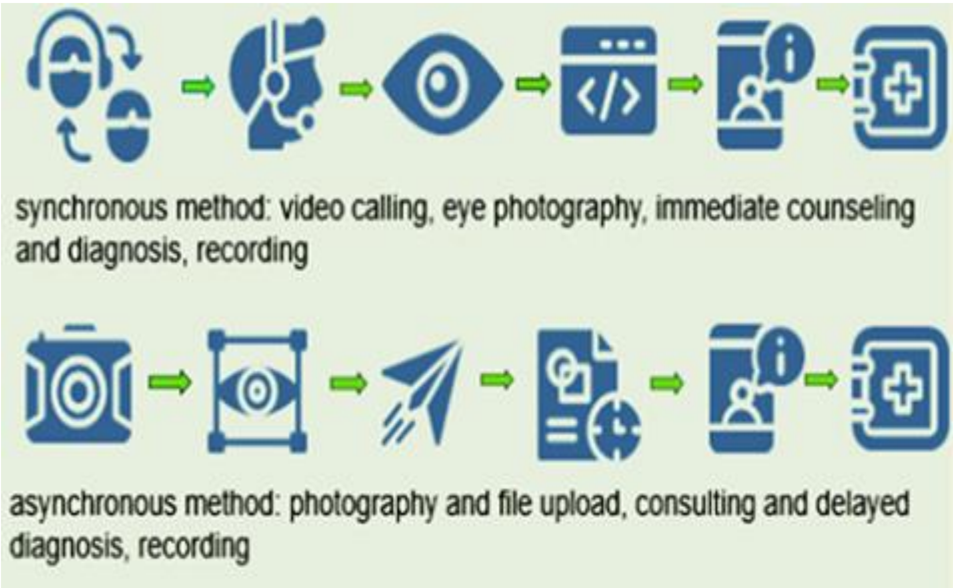
2.1.3 Glaucoma Screening and Management with Teleophthalmology

Due to travel restrictions and quarantine, the COVID-19 pandemic has increased the demand for teleophthalmology services. According to the survey made by Ertel with his team, almost 80 % of primary eye care providers used teleophthalmology during the pandemic (Ertel, Kahook, and Capitena Young, 2021). Nikolaidou and her coworker have noticed a few methods used in teleophthalmology (Nikolaidou & Tsaousis 2021). There are named synchronous, asynchronous, and hybrid methods. The synchronous method means live video calling with eye examinations, counseling, and diagnosis. This method is similar to in-clinic assessment, and the model provides the virtual human touch. The patients get tests during a video call with a diagnosis. This model has limitations in ophthalmology, where most trials are made with a slit lamp. If the slit-lamp examination is made, the user of the slit-lamp must have been experienced and well-trained. Ophthalmologists and optometrists have this kind of capability to provide a high-quality exam with a slit lamp. This model offers an excellent way to provide education and increase understanding of the state of glaucoma. This model requires the same time at least two personnel work. An optometrist, nurse, or technician makes tests, and an ophthalmologist provides a diagnosis and treatment plan. Asynchronous methods could be more effective, and it is more popular. An optometrist, nurse, or technician made tests in another location, and an ophthalmologist gave a management plan afterward (Delgado & al. 2019).

Kesary, with his team, noticed the third method, including both synchronous and asynchronous methods. The optometrist could make a comprehensive eye exam with additional device measurements like OCT. An optometrist may give prediagnosis, and later on, the ophthalmologist makes the final decision with management and treatment plan (Kesary & Sathyamangalam 2016). Data will be collected from various examinations, and ophthalmologists can make a video call or write a letter to the patient and inform the results. Ertel describes that this model is most similar to in-clinic assessment. Also, the video call can be made by an optometrist who has already known patients. The main difference between these is the time for diagnosis and consulting (Ertel & al. 2021). Nikolaidou and her team informed that optometrists have the technical knowledge and the capability to take and grade examination results and make live video calls. Examination with a slit-lamp and measuring intraocular pressure can offer more information than technological measurement (Nikolaidou & Tsaousis 2021). Teleophthalmology is an excellent way to access those where health care is limited or inaccessible (Nikolaidou & Tsaousis 2021).

Caffery and his team stated the problem of an aging population and the growing demand for ophthalmic services (Caffery, Taylor, Gole & Smith 2019). Ophthalmic diseases require proper time assessment and treatment, occasionally at quick intervals. Teleophthalmology is an excellent tool for providing eye care services in rural areas. They described three models, asynchronous, synchronous, and hybrid. The model depends on screening, urgent assistance, or consultation. They reported investment in ophthalmic devices and a significant need for skilled personnel, which is a success factor in providing high-quality ophthalmic services. Also, there are technical problems like calibration errors or connection errors. Personnel must have a great understanding of the anatomy of the eye and knowledge of the most common eye diseases. This allows good eye health care and decreases false-positive findings.

Figure 1 Synchronous and asynchronous methods of teleophthalmology. (Nikolaidou and Tsaousis, 2021 p. 2)



Ertel found that a combined model with synchronous and asynchronous is the perfect way to manage glaucoma and decrease the number of patients in-clinic assessment. Teleophthalmology offers excellent education tools for surgeons, ophthalmologists, optometrists, and patients (Ertel, Kahook, and Capitena Young, 2021). Providers can share data anonymously with colleagues for educational purposes. Patients can also share data with their physicians to be aware of their health conditions. Teleophthalmology shows its best when data is acceptable anywhere to get proper treatment all over the globe.

2.1.4 Teleophthalmology Measurements in Glaucoma

In Northern Alberta, Canada, Glaucoma services had proposed a model with collaborative care and teleglaucoma (Kassam & al. 2013). These groups included ophthalmologists, which were comprehensive and subspecialty, and optometrists. Their aim was creative, diverse, apolitical, patient-centered, evidence-based, and trying new ideas. Patients' risk factors for glaucoma were also considered in their glaucoma state. Patients were divided into different groups decisions were made by glaucoma specialists. The optometrist sent all the patients´ information after the eye exam to a specialist via the internet. The optometrist made a comprehensive eye exam with medical and ocular histories. An eye exam includes a slit-lamp examination, intraocular pressure (IOP), visual fields (VF), central corneal thickness (CCT), and fundus 3D photographs. The authors mentioned that gonioscopic for angle structures and optical coherence tomography (OCT) would be beneficial but not essential. Also, Heidelberg retinal tomography (HRT) was not included. Glaucoma specialists check all patients' data and make management recommendations to an optometrist who made follow-up controls or was referred to ophthalmologists. This model has an excellent opportunity to screen low-risk glaucoma patients by their community optometrist and give more chair time for moderate, severe, or advanced glaucoma patients in ophthalmologist appointments. This model reduced traveling costs and time because most glaucoma patients can be in a normal follow-up state.

Teleophthalmology in glaucoma management has increased because devices are more able to connect to the internet and are easy to use, according to Strouthidis and his team (Strouthidis, Chandrasekharan, Diamond & Murdoch 2014). The newest machines can produce standardized data in the record, but older devices' data must insert manually. There are more user-friendly devices for glaucoma screening: portable handheld tonometers, e.g., ICare One and Icare Home. ICare Home is for domestic use around-the-clock measurements.

In The Peterborough scheme study, optometrists made a comprehensive eye exam including medical, ocular, and family history and the following test: best-corrected visual acuity including refraction, slit-lamp examination for anterior segment, anterior chamber (AC) depth via Van Herricks and or gonioscopy. IOP is measured by the Goldmann tonometer and central corneal thickness (CCT). Also, a VF was made, and a posterior segment examination with a slit lamp in dilated pupils and fundus photography (Roberts, Rughani, Syam, Dhingra & Ramirez-Florez 2015). Peterborough’s model followed guidelines of glaucoma and teleglaucoma.

Court and Austin have operated in a virtual clinic system (Court & Austin 2015). Their model is for all newly referred patients and those patients who need follow-ups. An internally accredited ophthalmic nurse with non-medical staff examinates patients in this model. Their examinations are virtually supervised by a consultant ophthalmologist who is made the clinical decision. They used the patient's clinical history, made slit-lamp examinations, measured IOP, photographed optic disks, and took VFs. The optometrist did not involve in this study, but Court and Austin stated that optometrists could bring more safety and efficiency to glaucoma patients. Optometrists have an excellent understanding of vision-related problems. They can get higher sensitivity and specificity values in detecting glaucoma.

Owsley and his team want to improve glaucoma screening for African Americans because glaucoma primarily causes blindness in that population (Owsley & al. 2015). The program was optometrist-led in the teleophthalmology system and focused on low-income people. The optometrist did a comprehensive eye exam with dilated pupils, and additional tests were OCT, VF, and fundus photography. The optometrist made a pre-diagnosis and pre-management plan. The glaucoma specialist afterward reviewed all data and sent it with or without correction to an optometrist, who proceeded follow-up plan. This model reveals how to improve medical personnel knowledge. At the start of projects, there can be increased pre-diagnosis or pre-management plans, but later adjustments tend to decrease. The importance of education and feedback from ophthalmologists is significantly high. If feedback is high quality and continuous, the ophthalmologists may reduce their pre-diagnosis or pre-management plans.

Kesary and Sathyamangalam have noticed that teleophthalmology providers’ users used mobile tele-eye units (Kesary & Sathyamangalam 2016). They reported that the teleophthalmology system used stereoscopic digital disc images and slit-lamp examinations, including history taking, corneal pachymeter, VF, OCT, and HRT. Optometrists made tests, and the patient got a video call from hospital experts about their results. According to teleglaucoma guidelines, these mobile units follow guidelines correctly and have an excellent opportunity to screen glaucoma.

Hark and her coworkers studied and performed teleophthalmology in primary care offices and Health Centers (Hark & al. 2017). They focus on high-risk glaucoma populations, like African-Americans over 40 years old and Caucasians over 65 years old. They also added over 40 years old Asians. The group took two fundus images in undilated pupils and one anterior image. They measured blood pressure, BMI and HbA1c. They asked for medical and ocular history and family history of glaucoma. Also, they took visual VA and IOP with the iCare tonometer. They set records if IOP was 30 or over; the patient was sent directly to an ophthalmologist. Suspicious optic nerves were evaluated by the following factors: If the vertical cup-to-disc (C/D) ratio was more than 0.65 in the large disc and more than 0.50 in the small disc. The second factor was if rim width was lower than 0.20 in any area, including optic disc notches. The third factor was the C/D vertical asymmetry of more than 0.20 between the eyes. The fourth was disc hemorrhage, nerve fiber defect, or beta zone peripapillary atrophy with suspicious rim thinning. Data was sent to a retina reader and a glaucoma specialist. After the reader and specialist reviewed patient data, approximately one-third were invited for a second visit for a comprehensive eye exam. During the second visit, the research team asked again patient's medical, ocular, and family history. They make comprehensive eye examinations in undilate or dilate pupils. They measured the best-corrected visual acuity (BCVA), made a slit-lamp examination, and measured IOP with a Goldmann applanation tonometer. Also, CCT was measured, and anterior chambers were evaluated with gonioscopy. The VF was tested, and the ophthalmologist reviewed all data. He made diagnoses and treatment plans, whether medical-surgical or observation. The ophthalmologist made a comprehensive eye exam on the third visit with ocular, medical, and family history. The ophthalmologist tested VA and made a slit-lamp examination of the anterior segment. IOP was measured, fundus examination was dilated pupils, the CCT was measured, and the VF was made. In this study, the community ophthalmologist adjusted treatment if needed and made recommendations for follow-ups. Technicians took all of the examinations in the study, and ophthalmologists made comprehensive eye exams. Optometrists did not involve in the study. Glaucoma specialists could review data to confirm the diagnosis and treatment plan. The study noticed that 28.5 % of participants had suspicious optic nerve, and ocular hypertension has nearly 7 %. This strongly underlined that focusing on screening for risk groups is effective.

Labiris and his team describe problems with the aging population and the benefits of internet-based eye care (Labiris, Panagiotopoulou, and Kozobolis, 2018). The group stated that teleophthalmology could also be used in the prevention, research, and learning. Teleophthalmology is an excellent way to use real-time surgical telementoring in complex procedures. Also, education in teleophthalmology is beneficial. Teleophthalmology's benefits include shorter examination than in-clinic, and the non-ophthalmologist can screen for eye diseases. Glaucoma specialists have easy access and provide professional treatment and management options when using digital images and reviews. The devices are relatively expensive, and personnel education is a high priority. Labiris noticed that the most common personnel were ophthalmologists. Teleophthalmology involved 18 studies, and optometrists were in 8 studies. In glaucoma management and treatment, ophthalmologists play the leading role, but optometrists could be another medical working group to work with the glaucoma screening and management team. Laribis and his team made the table how what tests have been done in glaucoma screening in Europe. According to methods, only 9 cases were involved in slit-lamp examinations, and 20 had fundus photography. Only three gonioscopy studies have been engaged, and IOP has measured only 14 cases. VFs were made in 10 cases, and VA was measured in only 3 cases. RNFL imaging and OCT part were minimal, although new technology devices are widely spread. This reveals that most studies were inadequate according to guidelines for glaucoma by ICO and teleglaucoma. However, the most common personnel were ophthalmologists, and the second were optometrists. These two groups do comprehensive eye exams daily with VA, gonioscopy, IOP, and slit-lamp examinations in the anterior and posterior parts of the eye. This problem may be due to a significant role in the studies of general practitioners (GPs), trained nurses, and technicians.

Table 4 Screening methods in glaucoma in studies in Europe (Labiris, Panagiotopoulou, and Kozobolis, 2018, p.316)

Test	Cases
Slit-Lamp examination anterior or fundus	9
Binocular dilated indirect ophthalmoscopic examination	3
Gonioscopy	3
Fundus photography – mydriatic or non-mydriatic	20
Video fundus or anterior part	8
Goldmann applanation tonometer	12
Perkins hand held-contact applanation tonometry	1
Air tonometer	1
RNFL imaging	3
Visual field Humphrey or Octopus	10
Pachymeter	1
Video conference	7
Advice via phone	2
Snellen or LogMAR acuity	3
Eye monitoring camera snapshot	2
Amsler test	1
Focimetry	1
OCT	1
Fluorescein angiography	1

Modjtahedi and his coworkers used teleophthalmology for glaucoma screening for two years with 225 patients (Modjtahedi & al. 2018). Glaucoma suspects have been detected in-clinic assessment, and they followed patients annually. The technicians measured VA and IOP in follow-ups and made OCT on RNFL. Patients were referred to an optometrist or ophthalmologist if they had glaucoma or suspected glaucoma diagnosis. The authors stated how important an optometrist is to help ophthalmologists and glaucoma specialists burden health care.

Lam and coworkers describe what ophthalmologic measurement types were used in teleophthalmology studies (Lam PY 2021). They made the following tests: fundus images, automated VF, IOP, VA, slit-lamp examination, and CCT. They noticed that questionnaires on patients' history and symptoms and OCT were helpful in screening and management of glaucoma. They stated that more miniature operator-dependent devices should think of objective results. This underlined that personnel should be included optometrists who can evaluate device results and consider referrals.

Zapata, with his team, screened retinal and optic disc diseases with handheld nonmydriatic cameras in health centers (Zapata & al. 2021). Technicians took examinations and diagnoses made by a team of ophthalmologists. The patient got the result of tests and recommendations afterward. In their study, glaucomatous findings were lower than average, and the primary reason may be the age of the patients. They stated that monitoring eye diseases with non-mydriatic cameras is effective and efficient. This system is inadequate because it examined only optic nerves according to glaucoma guidelines. It is an excellent way for DR screening, but glaucoma is multifactorial, and the optic nerve photo is insufficient. Adding optometrists to make comprehensive eye exams in this study can increase the detection of glaucomatous defects. As early has noticed, whole population screening for glaucoma is unsuitable, but focusing on the right high-risk population could be effective.

According to the study, teleophthalmology requires well-trained personnel due to imaging and knowledge of the disease, and optometrists can handle this work well (Ertel & al. 2021). Teleophthalmology needs a group of equipment (Ertel, Kahook, and Capitena Young, 2021). First is IOP measurement, Goldmann is the gold standard for IOP, but the rebound tonometer is also good. The author noticed that CCT, OCT, VF, and topography are essential. A good slit-lamp examination is the principle of an excellent comprehensive eye exam. Mobile phone apps are more common for screening purposes, e.g., optic nerve and DR.

2.1.5 Diagnostic Accuracy in Teleophthalmology

In Manchester Royal Eye Hospital, a study where patients with glaucoma were referred directly to specially trained optometrists in the community instead of general practitioners (GP) (Henson, Spencer, Harper & Cadman 2003). Their purpose was to reduce false-positive referrals to the hospital. Each optometrist went special training program. Eighteen optometrists were sought in this program, and 15 optometrists were accredited. A glaucoma specialist supervised all patient data after optometrists made a comprehensive eye exam. In total, 194 patients passed the program, and cost savings were £17 per patient visit. Manchester Royal Eye Hospital has a 40 % reduction in new glaucoma referrals, and waiting time was reduced from 2 – 3 months to 2 weeks. This model provides faster referral lines to hospital care to avoid unwanted defects in patients´ vision. A Group of optometrists can be taught and accredited in similar programs among their original daily work. They can work as a community optometrist but still offer hospital-level eye care with new technology devices. Well-trained optometrists can reduce work in a hospital in low-risk glaucoma patients and give more time in hospitals in moderate or severe glaucoma patients.

The UK government started transferring glaucoma management from HES to the community optometrist (Ang, Ng, and Azuara-Blanco, 2009). Before transfer in 2006, Scotlands hospital made a study to investigate optometrists' ability to detect glaucoma. The study was six months long, and 303 referrals joined in. After an optometrist's comprehensive eye exam, patients were classified into four groups: 1. Glaucoma – optic disc and visual field defects. 2. Glaucoma suspect – borderline case despite IOP. 3. Ocular hypertension – raised IOP but normal optic discs and visual fields. 4. Normal. Ang and his group noticed that accuracy in diagnosing glaucoma where higher when IOP measurement, optic disc assessment, and VF testing were performed according to ICO glaucoma guidelines (Gupta Neeru & al. 2015). During the study, the optometrist didn't use gonioscopy or corneal pachymetry, which are mandatory exams, according to Gupta. Ang, with the team, stated that refraction is not mandatory according to new general ophthalmic services (GOS), and optometrists can decide which tests are appropriate. This study noticed that applanation tonometry proportion has increased from 18.8 % to 50.0 %. They noticed that true-positive referrals have remarkably increased from 18.0 % to 31.7 % and that false-positive referrals have decreased from 36.6 % to 31.7 %. Optometrists can improve their referral rates by following guidelines and making mandatory tests in a comprehensive eye exam. Guidelines are essential to produce high-quality eye care and increase professionalism. Decreasing the rate of detecting glaucomatous defects means leaving out critical or non-critical elements. Optometrists can improve their work using the "gold standard -test" as a Goldmann tonometry

In the UK, the National Institute of Clinical Excellence (NICE) published guidelines that optometrists refer patients to hospital eye service (HES) if measured IOP is 21 mmHg or above (National Institute of Clinical Excellence 2009). NICE has published a newer glaucoma guideline with an IOP level of 24 mmHg (Shah & al. 2017). IOP level 21 mmHg increases patients significantly upon secondary care glaucoma services all over the UK. The glaucoma refinement scheme was created in 2008, and a glaucoma consultant led it (Trikha, Macgregor, Jeffery & Kirwan 2012). Specialists recruited six specialist optometrists in the local community. Optometrists made the following tests: VF, IOP with Goldmann applanation tonometer, and fundus photograph. The glaucoma consultant reviewed all data in the virtual clinic, and one of three outcomes will be followed. The first outcome was no follow-ups, and the second was the appointment in the hospital for glaucoma services. The third was patients, followed by a community optometrist. The optometrist asked following risk factors: medical, ocular, and family history. IOP was measured with non-contact tonometry (NCT) or Goldmann applanation tonometer. Slit-lamp examinations included optic disc assessment, anterior chamber depth, pseudoexfoliation or pigment dispersion findings, and central visual field. All data were identified and analyzed by the research team. The study noticed that optometrists' ability to detect glaucoma or ocular hypertension was moderate. Trikha and his team noticed that guidelines were not all parts familiar to optometrists. The group described that if the optometrist followed guidelines, it improved the detection rate of glaucoma even higher. This underlined how important it is to follow the recommendations and guidelines. The authors praised how a glaucoma consultant-led scheme can improve the quality of eye care. One glaucoma consultant can lead a group of optometrists and supervisor their work with glaucoma patients. At the beginning of the glaucoma program, consultants had more supervisor work, but the workload should have been decreased due to increased experience, education, and understanding. This needs motivated and skilled optometrists to perform their best and continue education in their professional life.

Verma, with his team, has 273 patients in their study (Verma, Arora, Kassam, Edwards & Damji 2014). Of these patients, 31% have glaucoma, and 42% are suspect. The rest of the patients have healthy eyes or other diseases than glaucoma. High numbers of glaucoma in the study due to inclusion criteria were over 50 years old, African-American or Latino, myopia, family history of glaucoma, systemic risk factors such as steroids, and suspicious features of the optic disc or VF. Community optometrists or medical doctors reviewed all patients. The authors discussed that almost half of patients diagnosed with glaucoma could be treated remotely. In Alberta, optometrists can prescribe glaucoma medications with a co-operated ophthalmologist. Optometrists may start medications for glaucoma patients, and teleophthalmology is an excellent tool for supervisors by ophthalmologists. However, an increased number of patients required in-clinic examination, possibly due to inclusion criteria. They stated that glaucoma is hard to analyze because it has a multifactorial eye disease. They found in this study that teleophthalmology gives higher clinical suspicion settings than in-clinic. This may be due to the AI of devices and data they provided being primarily objective. Also, they found this was an efficient and faster way to patients than in-clinic examination.

Thomas and the team found that teleophthalmology has moderate diagnostic accuracy than in-clinic assessment (Thomas & al. 2014). They stated that teleophthalmology provides more specific but less sensitive diagnostic accuracy than conventional eye exams. The disc vertical cup-to-disk ratio was in substantial agreement. Thomas and the team found a study from India that stated that teleophthalmology compared to in-clinic was moderate in diagnosing glaucoma. Glaucoma diagnosis sensitivity was 72.1 %, and specificity was 81.82 % (Gupta, Kumar S, Dagar, et al., 2013). Thomas and coworkers noticed that teleophthalmology's waiting times were significantly shorter than in-clinic assessments. Travel time and cost were lower than in-clinic assessment. The authors discussed that teleophthalmology has several ways to conduct the examination. Teleophthalmology provides different models, which can be done with various follow-ups. This means that the provider can follow, e.g., neural retinal rim thickness in the optic nerve or VF progressive defects every six months and comprehensive eye exams annually with additional tests.

The researcher admits that false-negatives number is a significant problem (Strouthidis & al. 2014). When evaluating stereo photographs, the authors found a fair agreement between interobserver and glaucoma specialists. The researcher compared HRT and OCT for glaucoma classifications. They didn't find any considerable advances between devices for diagnostic accuracy. Strouthidis noticed that a small disc diameter with an atypical form might provide false glaucomatous defects when measuring HRT. This stated how multifactorial glaucoma has, and several tests are needed to verify the correct diagnosis. According to the team, perimetry tests should be fast to order and easy to use for teleglaucoma purposes. Frequency doubling technology (FDT) offers early to moderate glaucoma sensitivity between 35 % to 93 %, but sensitivity is more than 97 % in advanced glaucoma. There are too broad sensitivity scales in the early stage of glaucoma, but accuracy is almost perfect for detecting glaucomatous defects later in the disease. Teleophthalmology is best for early glaucoma, and FDT does not offer ideal tools to detect glaucomatous defects alone. The authors compared time-domain OCT (TD-OCT) and spectral-domain (SD-OCT). They found that SD-OCT diagnostic accuracy is better, but there are no significant differences between systems. They stated that OCT is widely used for posterior and anterior eye examinations. If primary eye care providers with their teleophthalmology team can reduce the false-negatives number in regular glaucoma screening, the system can save glaucomatous defects in the long run. The team reported that teleophthalmology could be used in postoperative controls in real-time video via a slit lamp.

Wright and Diamond analyzed data of 24,257 patients and compared diagnostic accuracy between optometrists and glaucoma specialists (Wright & Diamond 2015). Optometrists divide patients into five different categories according to their glaucoma state. The kappa statistic value was moderate at 0.69, and the agreement level was 87 %. The glaucoma specialist classifies 3084 patients as less urgent categories than optometrists. The more urgent category classified by a specialist was 1631 patients. The study had many participants and showed society and medical personnel that optometrists could detect glaucomatous defects. As the authors stated, optometrists classify patients in more urgent categories than glaucoma specialists. The study indicated that if a glaucoma specialist supervises optometrists who work with teleophthalmology, it will decrease false positives.

Roberts and his coworkers stated that referral rates have increased to detect glaucoma (Roberts & al. 2015). To help primary eye care hospitals, they provided a model in that community optometrists did comprehensive eye examinations. The optometrist did not discuss the final diagnosis or outcomes with the patient, but they made suggestions for diagnosis and follow-ups. They compared optic nerve head appearance, VF interpretation, diagnosis, and outcomes. The consultant ophthalmologist reviewed masked data, and the level of agreement was recorded after diagnosis and outcomes. Patients later got a letter where outcomes and diagnoses were described. When evaluating the optic nerve, almost one-third of images were unreadable due to media opacities, which can be the primary thing of unsuccessful teleophthalmology.

Kesary and Sathyamangalam have noticed that image quality plays a significant role in teleophthalmology (Kesary & Sathyamangalam 2016). When evaluating optic nerves, sensitivity was 58.8 % to 61.0, and specificity was 80.4 % to 83.5 %. When comparing the VFs, the numbers were 85.2 % to 78.1 % and 80.4 % to 83.5 %. Agreement level of diagnosis was 47.5 % to 64.6 % and non-significant agreement levels were 28.4 % to 23.2 %. Depending on the optometrists' level, the agreement level of clinical outcomes was 49.1 % to 69.5%, and the non-significant disagreement level was 18.7 % to 21.0 %. The authors stated that the scheme was significantly cost-effective and hard to predict. In this study, acceptability was not examined, but it reveals an important value among patients. Differences in agreement level between optometrists vary only a little; the biggest difference was the diagnosis. This may be due to the difficulty of diagnosing glaucoma and how experience comes with the right decisions. Optometrists got the highest agreement level from VF, and it is underlined how important it is to take VF or confrontation fields during a comprehensive eye exam to detect glaucoma. Optometrist clinical outcomes were fair or moderate and should be higher for quality eye exams. It is important to notice that optometrists evaluated optic nerves with a slit-lamp, and ophthalmologists evaluated optic nerve photos. With a slit-lamp, the visual is 3D but in the photo is 2D. Visual impact with a slit-lamp is easier because height and other dimensions are better to see, and media opacities can be avoided more successfully than teleophthalmology.

Teleophthalmology can prioritize patients to get proper care at the right time scheduled. Kesary and Sathyamangalam describe teleophthalmology can producing the same clinical outcome as in-clinic assessment (Kesary & Sathyamangalam 2016). Even though the government funds teleophthalmology services in developed countries, there are narrow roads because acceptance and politics play a critical role in developing countries.

Labiris and his team's literature searches found that teleophthalmology offers diagnosis with almost the same accuracy as in-clinic assessment (Labiris, Panagiotopoulou, and Kozobolis, 2018). They stated that glaucoma screening and follow-ups showed a high agreement between optometrists with teleophthalmology and conventional glaucoma examinations. An optometrist can produce glaucoma management with increased true-positive and decreased false-positive. They have reported a 40 % reduction in false-positive cases and significant cost savings when using optometrist-based referrals. Researchers have found limited awareness of glaucoma and the need for education; however, teleophthalmology patients have a greater understanding of glaucoma than in-clinic patients.

Artificial intelligence (AI) and deep learning (DL) subtypes can help significantly manage glaucoma. According to Cambridge Dictionary, deep learning means "a type of artificial intelligence that uses algorithms (= sets of mathematical instructions or rules) based on how the human brain operates" (Cambridge University Press 2022b). Glaucoma is a heavily image-based ophthalmology field, and AI solves these challenges. Li and his team describe that algorithms have low specificity and sensitivity when analyzing the poor quality of fundus images (Li & al. 2018). The authors wrote that detecting less severe glaucoma, suspect and early glaucoma, can be hard for DL. To detect glaucomatous defects, DL is better when glaucoma is more severe. When combined with AMD, detecting glaucoma by DL can be complicated, and myopic eyes are hard to analyze. For Caucasians, the risk of getting POAG is greater than 65 years old or over, cataract is typical at that age, and the chance for artifacts is higher. The authors of this study have noticed that detecting early glaucoma using OCT with DL has higher specificity than other machine learning methods. AI can be helpful with teleophthalmology because various algorithms have been created to detect retinal sensitivity, reliability parameters, and age-matched controls. Writers mentioned that current algorithms could not differentiate between non-glaucomatous defects and artifacts. The study stated that DL needs an excellent quality of examinations to detect glaucomatous eyes. If the quality of tests is poor, the lower specificity and sensitivity go. DL has a better capability to detect moderate and severe glaucomatous eyes but a lower capability to detect early glaucomatous defects. Also, sensitivity and specificity go lower when other eye diseases are found, e.g., age-related macular degeneration and diabetic retinopathy or high myopia (Mayro, Wang, Tobias Elze & Pasquale 2020).

Teleophthalmology for screening purposes is better in the early stage of glaucoma. African Americans have a higher risk of getting POAG after 40 years old (Kanski & Bowling 2015). The possibility of other eye diseases is lower except for high myopia or sedentary lifestyle-induced eye disease. Li with his team stated that their DL outperformed their comparison group of ophthalmologists in detecting glaucomatous defects by looking only at visual field images (Li & al. 2018). Authors noticed that primary eye providers use differential devices and tests to diagnose glaucoma patients correctly. DL's role in detecting glaucoma or various eye diseases will be more significant in the future. Still, the measurement method and algorithms must be better to avoid artifacts or other eye-related disorders. According to Du and his team, many studies have developed machine learning algorithms to identify glaucoma (Du, Li & Hu 2018). The algorithm usually takes the posterior eye's cup-to-disc ratio, fundus images, VF, and OCT results. The researchers noticed the diagnosis range in machine learning devices from 63.7 % to 93.1 % (Du, Li, and Hu, 2018). The diagnostic range is broad, but the detection rate is reasonable in the optimal situation.

Annoh and coworkers discussed that well-prepared community eye care plays a critical role in managing the high demand for hospital eye services (Annoh et al., 2019). In 2006, Scotland started a system where optometrists could perform comprehensive eye exams and send referrals to specialists. The Scottish Government and National Health Service (NHS) made a model that produces higher-quality referrals. System decreased in false-positive rates in primary open-angle glaucoma. In 2012 government put over £ 6.6 million to provide digital communication between optometrists and HES. This was magnificent aid from the government to community optometrists to shorten queues and improve high-quality eye care services. They reported dramatically reducing waiting times from 6 – 9 months to 6 – 12 weeks in the six years. To improve optometrists' abilities and education, the University of Edinburgh, with the Royal College of Surgeons and NHS Education for Scotland, provided a master's degree (MSc) in Primary Care Ophthalmology in 2014. Cooperation with the university and government created a system for more primary eye care providers to handle the aging population's eye-related problems. In the future, this is a very convenient way for patients, and it would reduce costs for the government.

Odden, with his team, conducted a study of two fellowship-trained glaucoma specialists (MDs, GS) and two optometrists who have worked in the glaucoma team for nine years (Odden & al. 2020). In this particular study, they analyzed 399 eyes. Optometrists or ophthalmologists did a comprehensive eye exam, and the team reviewed masked data afterward. The team classified eyes as progressive or unstable and not progressed. They noticed a fair agreement level between in-clinic and teleophthalmology for each reader. The authors discussed that other studies with the same method to study in-clinic and teleophthalmology have a moderate agreement level. The study does not recommend teleophthalmology as the only option for screening and managing glaucoma, but it could be a combination of in-clinic and teleophthalmology.

Lam and his coworkers have found three studies investigating the clinical agreement between teleophthalmology and in-clinic (Lam PY 2021). They found a fair agreement between ophthalmologists and glaucoma specialists for screening purposes. Eventually, a contract between peripapillary atrophy and disc hemorrhage was fair. The agreement was substantial when using FDT. In screening, sensitivity was variable, and specificity was fair in diagnosing glaucoma. The researchers found fair to moderate agreement between the two groups in glaucoma management. In management, fair specificity and sensitivity were uncertain. Lam and his coworkers discussed teleophthalmology challenges and limitations. The glaucoma specialist stated that it is hard to make clinical decisions according to images provided by other medical staff. This underlines the need for combinations of follow-ups between teleophthalmology and in-clinic assessment. Comparing the newest technology with a standard comprehensive eye exam may reveal old habits. However, a comprehensive eye exam is the best way to diagnose glaucoma correctly because it is a multifactorial eye disease.

Nikolaidou and Tsaousis found the importance of using devices by primary eye providers (Nikolaidou & Tsaousis 2021). The use of devices must be smooth and professional. Education of personnel is a high priority for professional eye health care. Primary eye care providers must provide safe and familiar teleophthalmology meetings with elderly patients who are less familiar with newer technologies. Personnel must respect their patient to tackle their fears of technology and inform of measurements. Challenges can slow examinations and narrow the advantages of teleophthalmology.

Teleophthalmology benefits glaucoma specialists; they get more chair time for patients who need face-to-face appointments (Ertel M, Kahook M, and Capitena Y, 2021). Teleophthalmology provides lower false-positive referral rates for screening purposes and risk populations with similar accuracy to in-clinic assessment. Ertel recommended teleophthalmology for screening large populations; it is effective and has a low proportion of false positives. Ertel stated that teleophthalmology also offers the management of glaucoma, exceptionally low-risk patients in an early stage. Glaucoma is a relatively slow progressive disease, and teleophthalmology is safe to manage. However, according to Ertel, community optometrists have an excellent role in managing glaucoma via teleophthalmology's high detection rate for glaucoma. The comprehensive eye exam part of teleophthalmology made by an optometrist has a high rate of detecting glaucomatous defects.

New technology improves the optometrist's ability to detect pathologies (Conway & al. 2021). This study has selected relevant studies according to geographic selection. Conway found that optometrists increased to make correct diagnoses after continuous training in their literature study. Another Conway study noticed that involving community optometrist who works with eye diseases released 1,400 clinic slots in one year for HES. Conway and his coworkers noticed that specialist optometrists could reduce hospital referrals at a high agreement level with ophthalmologists in the community. In the Cambridge Community Optometry Glaucoma Scheme (GOGS), optometrists with a particular interest (OSI) in glaucoma did a comprehensive eye exam for suspect glaucoma patients (Keenan, Shahid, Bourne, White & Martin 2015). After the optometrist eye exam, the patient's data underwent virtual electronic review by a glaucoma specialist—the project aimed to drop as many false-positive referrals as high as 65 %. When comparing OSI and non-OSI, hospital discharge rates were 18 % compared to 49.5 %. The groups had a 91.5 % agreement level when comparing OSI and ophthalmologist decisions. GOGS stated how vital continuing education is for optometrists. The Community and Hospital Allied Glaucoma Evaluation Scheme (CHANGES) decided to divide low-risk glaucoma referrals to OSI and high-risk glaucoma referrals to HES. The consultant made a virtual review of the optic disc images to detect false negatives. Glaucoma consultants verify 15% of the patient's suspicious optic nerves, which OSI has decided as normal optic nerves. However, none of these patients have been found with glaucoma after re-examinations.

CHANGES stated that an experienced optometrist could reduce hospital referrals and be as effective as a clinical consultant review(Keenan & al. 2015). In Western Australia, an optometrist-led teleophthalmology service in rural areas. They used a fundus camera, slit lamp, OCT, VF, and live video after examinations with a consultant ophthalmologist. The project goal was to shorten waiting and waiting time and costs for various eye-related problems. They noted heterogeneity between optometrists, partly skills and equipment. The optometrist's diagnostic accuracy improved due to continuous education during the project. Patient satisfaction was high or very high during the service. The authors stated that younger people were more familiar with new technology than older ones (Host, Turner, and Muir, 2018). The authors noticed that those general practitioners were unfamiliar with the system and privacy issues. They stated that optometrists were familiar with new technologies (Johnson, Meyer, Yazar & Turner 2015). In The Netherlands was The Share-Care Glaucoma Screening Project in teleophthalmology performed by optometrists in the community. They performed retinal nerve fiber analysis with GDx and made referrals to patients. Well-experienced GDx technicians analyzed optometrist referrals and decided to refer them to a hospital or follow up with the optometrist.

The authors noticed that optometrist's ability to make the right decision increased during the project (de Mul, de Bont, Reus, Lemij & Berg 2004). Conway and his team discovered a study from India where 54,751 patients underwent a comprehensive eye exam with teleophthalmology in 1.5 years. They stated that optometrists have a critical role in detecting early-stage pathology. Patients' benefits were reduced cost of care and travel time. Conway said community-based optometrists play a crucial role in minimizing the burden of HES. A multidisciplinary team can handle increased and aging patients. According to the authors' research, community optometrists can make comprehensive eye exams and detect glaucomatous defects in high sensitivity and specificity. Optometrists must have a high level of particular interest, e.g., OSI, or their education should have continued their whole career and a broad understanding of glaucoma. This reveals how optometrists can help society and individuals with their work.

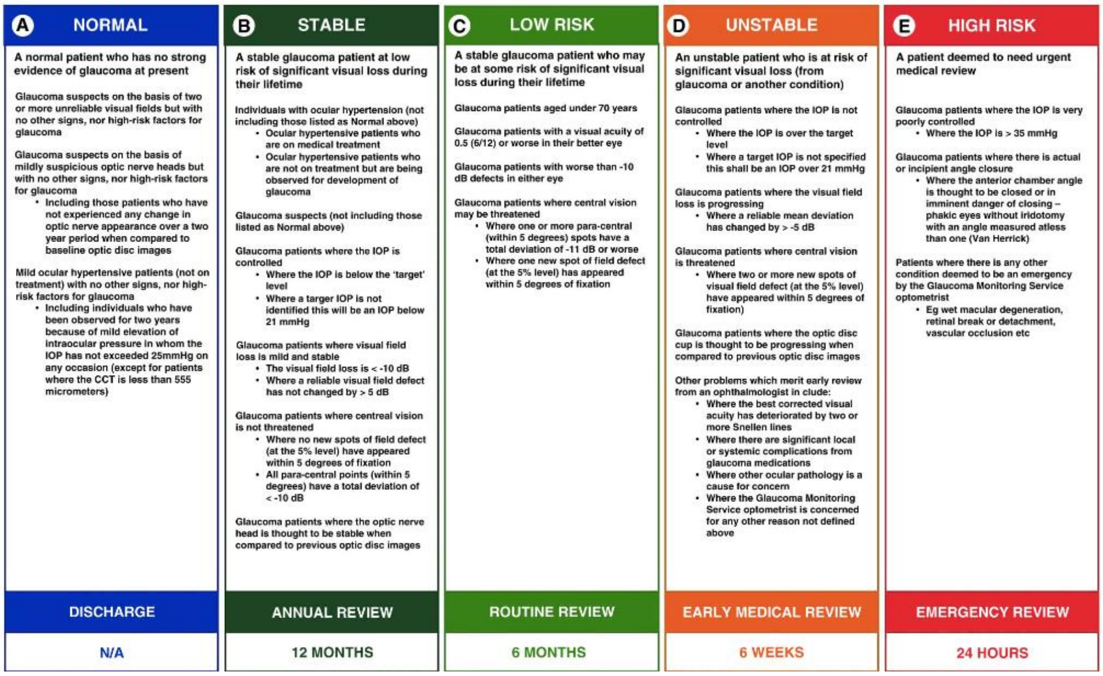
2.1.6 Use of Teleophthalmology in POAG Screening

In the Canadian model, authors claimed teleglaucoma is not suitable for all. When patients have very high IOP, glaucoma is advanced, and angle-closure glaucoma is hard to treat remotely.

Glaucoma in secondary etiology is potentially challenging to manage except in-clinic (Kassam & al. 2013). Secondary etiology must treat first, e.g., cataracts with post-operation follow-up, and the subsequent follow-up may use teleophthalmology. Cataract surgery makes room for narrow angles and may reduce IOP. The Canadian model divided OAG and angle-closure glaucoma (ACG) suspected according to risk factors, followed by optometrists or ophthalmologists' comprehensive eye exams. The patients were divided into multiple categories: normal, low-risk OAG, moderate risk OAG, high-risk OAG, or ACG suspect after a comprehensive eye exam according to their medical history and eye exam results. Optometrists followed normal patients, low-risk OAG, or moderate-risk OAG. Ophthalmologists followed high-risk OAG and ACG suspect patients. According to the legal aspect in Canada, all patients were reviewed by a glaucoma specialist who made a management and screening plan. Providers and patients were satisfied with the collaborative care pathway, and society benefits too with finances and reduced times.

Wright and Diamond conducted an extensive study that included 24 257 glaucoma reviews in the UK (Wright & Diamond 2015). The researchers aimed to tackle the aging population's eye-related challenges with community optometrists. The clinics were managed by an optometrist and a personnel group of technicians in this system. According to compressive eye exam results, Optometrists slotted patients into five categories: 1. "Normal" – no evidence of glaucoma. 2. "Stable" – low risk of lifetime blindness in glaucoma. 3. "Low risk" – stable glaucoma and moderate risk of lifetime blindness. 4. "Unstable" – requiring evaluation by a glaucoma specialist in 6 weeks. 5. "High risk" – emergency visit to a glaucoma specialist. Patients were informed that the supervisor, a glaucoma specialist, may change the category that the optometrist had chosen in the first place. Optometrists have a significant role in slotting patients into proper categories in this system. The ophthalmologist can supervise several optometrists' work in this system, making more time for more severe glaucoma patients.

Figure 2 Five-step glaucoma management algorithm (Wright and Diamond, 2015, p. 314)



Sapru, with her team, stated that community-based glaucoma screening should target populations with high risk for glaucoma, e.g., race, age, or systemic diseases (Sapru & al. 2017). They noticed many new glaucoma-related cases in their patients compared to the whole population. In the general population, glaucoma in 2010 was estimated at 1.9 %, and their study from 17 % to 23 % have glaucoma-related cases. Targeting teleophthalmology screening in the risk population is a significant way to find new glaucoma cases and avoid glaucomatous defects. This significant proportion of new glaucoma-related cases underlined that screening targeting high-risk populations effectively uses teleophthalmology.

Modjtahebi and his team stated it is vital to use teleophthalmology in glaucoma because, typically, progression is slow in the early stage (Modjtahedi & al. 2018). New technologies like OCT can detect first glaucomatous defects, and screening should be targeted in high-risk glaucoma populations to avoid several vision losses.

Teleophthalmology's great benefit is managing low-risk patients and taking more time for high-risk patients to get proper treatment for their disease (Caffery & al. 2019). Targeting teleophthalmology in risk patients can be critical to low-risk and high-risk patients. When screening and management focus properly, cost and time can be saved.

Odden and the team followed the Mayo Clinics' model of dividing patients' correct categories and making follow-up plans for optometrists and glaucoma specialists (Odden & al. 2020). The model has been divided into three categories: mild, moderate, and severe or advanced glaucoma—the progression taking into account risk factors and optic nerve changes into VF or OCT. Glaucoma specialists divide the patients into different categories. Optometrists evaluate every 3 – 6 months, and glaucoma specialists every 1 – 3 years. Optometrists have a significant role in this model, and they make referrals to specialists to change categories or different follow-up plans whether glaucomatous defects have altered or progressed. This dual system is effective and interacts to provide high-quality eye care, and it has a lower risk of avoiding falsely categorized patients.

Ertel with his team found that optometrists who view optic nerve images and visual fields at low-risk glaucoma patients can decrease false-positive referrals to hospital services (Ertel, Kahook, and Capitena Young, 2021). They noticed that focusing on teleophthalmology in high-risk glaucoma patients is an effective route to finding new glaucoma patients. A high agreement level in diagnosis between in-clinic and teleophthalmology has been noticed. Their study stated how important it is to focus on screening in the right population to identify ocular hypertension or early glaucomatous defects. Authors have seen a nearly 80 % decrease in cost using teleophthalmology instead of in-clinic assessment. It is vital to examine anatomical structures and functional vision and evaluate them.

Mahabadi and his coworkers stated that glaucoma screening is effective when focusing correct population (Mahabadi, Foris & Tripathy 2022). It is not practical to screen the whole population to detect early glaucoma. A primary risk factor is an age and African Americans over 40 years old and Caucasian over 65 years old. African Americans, West African, and Afro Caribbean have an increased risk of getting open-angle glaucoma. Systemic diseases and family history is also significant factors. Refraction error and increased IOP are risk factors.

2.1.7 Cost and Time Efficiency in Teleophthalmology

Trikha, with the team, describes that a virtual clinic is much quicker than an in-clinic assessment, and waiting time is reduced from 2 – 3 months to four weeks (Trikha & al. 2012). The capacity of the eye clinic was released by 1400 slot in a year, and the cost savings were £ 244,200 in a year for Portsmouth Hospitals. The virtual clinic took only four hours a week for the supervisor consultant.

Kassam and his team were happy with their Canadian model, which reduced public health care costs and improved efficiency in treating glaucoma patients (Kassam & al. 2013). They have found that teleglaucoma may save patients money and travel time, particularly in Canada's rural or northern parts. Kassam, with his team, mentioned that different provinces may vary legal problems and that optometrists could not work as the author's model proposed. The authors discussed that the collaborative care model is an excellent step for patient care. They suggested that all stakeholders come to the same table, e.g., ophthalmologists, optometrists, primary-care physicians, nurses, ophthalmic technologists, and the health ministry. The team can work together in patients' best interest and work efficiency and do their best as professionals to tackle future problems. Education is essential for the non-ophthalmic community, who may not be familiar with glaucoma, and ophthalmologists and optometrists should lead this.

Thomas and her coworkers stated that teleophthalmology is more cost-effective in glaucoma screening (Thomas & al. 2014). They are divided into human resources, information technology, and diagnostic equipment. Teleophthalmology was more cost-effective than an in-clinic assessment to detect glaucoma. Thomas found their literature searches that the main advantages were decreased travel time to the hospital and increased access to hospital eye care. A significant factor was patients saving in costs. Teleophthalmology has a shorter time from hospital to returning home than in-clinic assessment.

Thomas and her group noticed that teleophthalmology has 80% less cost than in-clinic assessment, increasing 20 % referrals to an ophthalmologist (Thomas, Hodge, and Malvankar-Mehta, 2015). Teleophthalmology is more sensitive and less specific than in-clinic assessments. Hark and coworkers noticed that using teleophthalmology for glaucoma screening was cost-effective, and despite the low cost, the researcher got markable good results (Hark & al. 2017). Sharafeldin and his coworkers describe that teleophthalmology's additional cost comes from training staff personnel, equipment, services to devices, software, internet connection, and referrals when needed (Sharafeldin & al. 2018).

Gunn and his team surveyed the UK to lead consultant ophthalmologists to virtual glaucoma clinics (G Gunn & al. 2018). Over 92 % of respondents rated glaucoma virtual clinic efficiency at least similar to in-clinic care—almost one-third rated efficiency as very good. Nearly half of the respondents have not run a virtual glaucoma clinic. The primary reason was the lack of adoption of insufficient personnel, over 70 %. Almost half answered inadequate space, and around one-third lacked time or money to educate non-medically qualified personnel. Nearly a quarter was a great concern to missing pathology, and one of the fights considered lack of face-to-face conversation. Two of third of respondents uses virtual clinic. Most respondents use virtual clinics for patients with lower-risk glaucomas, such as ocular hypertensive patients. Almost one-third of the third operates virtual clinics for patients with stable open-angle glaucoma regardless of severity or treatment. Virtual clinics are running mainly clinical technicians. They underlined the importance of a teleophthalmology clinic led by a consultant ophthalmologist who supervises the clinic's personnel and quality of examinations. Gunn and his team stated the meaning of educating patients about glaucoma and disease state. The patients are more accepting of teleophthalmology when knowledge is excellent or outstanding.

Gianfranco and his coworkers stated that harmonizing teleophthalmology laws is not expected due to different regulations in countries (Gianfranco, Mauro, and Gioia, 2019). Europa Union (EU) can make basic rules of teleophthalmology for a patient who needs cross-border treatment and management. They stated that education and learning are significant aspects of teleophthalmology.

Sommer and his coworkers described teleophthalmology offers cost-effective and faster management or screening of eye diseases than in-clinic assessment (Sommer & Blumenthal 2020). They highlighted that rural areas with limited access or medical care, e.g., due to COVID-19, have the most benefits of teleophthalmology. During a lockdown when conventional hospital care has restricted access, acute eye diseases which need emergency management and treatment have prolonged. This also increased psychological outcomes. Authors noticed that teleophthalmology offered accuracy and consistency compared to in-clinic assessment. In the future, teleophthalmology will use more DL algorithms for diagnosing purposes and may provide more accuracy than human ability. Authors are concerned about teleophthalmology cybersecurity and patient privacy. Also, legal, ethical, medico-legal, and regulations must be updated. An experienced specialist and the academic world should regulate and accept teleophthalmology guidelines.

Lam with coworkers could not find articles that testify to the cost-effectiveness of glaucoma management (Lam PY 2021). They found articles that describe the time effectiveness of glaucoma management. They noticed that waiting time was almost half compared to in-clinic assessment, 88 days to 45 days. They found out also that patients' time in-clinic versus remote estimates were more effective. They stated that the time of patients was well spent. The researchers also found that high clinical device prices and limited bandwidth decrease the use of teleophthalmology in developing countries. The new technology has provided significant technical innovations like handheld devices and more precious devices.

Law and legislation have a significant role in teleophthalmology becoming more common (Ertel, Kahook, and Capitena Young, 2021). GPRS must be in mind and primary eye care providers' liability concerns.

2.1.8 Patients Satisfaction with Teleophthalmology

Patient satisfaction is a non-medical reason, but for individuals, this can be the main reason for choosing teleophthalmology instead of in-clinic. A big part of patient satisfaction is the ease of access and registration. Personals' friendliness and how easy the overall appointment was are key to better patient satisfaction. According to the study level of satisfaction is better when the parking space is accessed (Li, Powell, Hooper & Sheidow 2015).

In their surveys, the Court and Austin have written that they have identified who had started glaucoma management via the virtual clinic (Court & Austin 2015). The authors noticed that virtual clinic follow-up patients have more glaucoma knowledge. This reflects the importance of educated on patients in their every visit to in-clinic assessment or teleophthalmology. They have made a leaflet on glaucoma, which increases understanding of glaucoma. Their study found that satisfaction is at the same level in teleophthalmology and in-clinic assessment. In this system, nurses called several times to patients for their results and got an education about their eye disease. Court and Austin got high satisfaction with their glaucoma service regardless of whether they were in-clinic or teleophthalmology services. Patients were enthusiasts of new technologies and kept high-quality eye care as in-clinic assessment for teleophthalmology services.

Kesary and Sathyamangalam have gathered seven studies that measured patient satisfaction in teleophthalmology services (Kesary & Sathyamangalam 2016). They reported very high satisfaction in teleophthalmology services. The satisfaction level was between studies 87 % to 99,8 %, and they reported equal satisfaction between teleophthalmology and in-clinic assessment. The primary purpose of teleophthalmology is to provide access for those who have difficulties moving or live further in eye care hospitals. Kesary and Sathyamangalam demonstrate the efficiency and suitability of teleophthalmology, where an imaging system is helpful for diagnosis. Teleophthalmology measurements provide a short examination time in digital imaging, and other than ophthalmologists can screen for eye diseases.

Hark stated in her study; that all participants were satisfied or very satisfied with their visit (Hark & al. 2017). Most participants said it was very convenient and would come again. Also, they recommended this kind of screening to other people.

A pilot study in teleophthalmology from Finland was performed for glaucoma patients first at a university hospital for the control group and one year later in a rural healthcare center (Tuulonen & al. 1999). In a healthcare center, patients were examined by ophthalmic residents and GP. For ophthalmic services, both groups have equal satisfaction. In the teleophthalmology group, 96 % wanted the subsequent follow-up in their healthcare center instead of a university hospital. The main reason was the reduction in travel costs and time. Tuulonen and her team noticed that examination costs were equal, but traveling costs were reduced. Rural health care centers have a poorer quality of images than university hospitals.

Patients experienced a high level of help, and very convenient to use this program (Modjtahedi & al. 2018). They would use it again and recommend it to others, and they liked how professional the personnel was.

The authors reported that the cost was less than 10 € per patient. Technicians' satisfaction was high because the test was fast and straightforward (Zapata & al. 2021).

Teleophthalmology is highly popular among patients. (Ertel & al. 2021)The study reported that teleophthalmology patients have better knowledge of their disease than in-clinic assessment. The team stated that community optometrists have better opportunities to screen and educate glaucoma patients.

3 THE PURPOSE, OBJECTIVES, AND TASK OF THE RESEARCH DEVELOPMENT WORK AND THE DIFFERENT STAGES

3.1 Purpose

This case study describes the assessment and management of a patient with primary open-angle glaucoma. Based on the literature discusses how primary eye care providers use teleophthalmology services and what the optometrist´s role is in providing these services in Finland.

3.2 Research Question

How can optometrists use teleophthalmology to provide glaucoma follow-up services based on global literature and using an example case study?

3.3 Summary Description of the Experimental Design

This single case study report involved the clinical assessment and management of a 58-year-old Caucasian male who presented to optical chain-owned practice and eye hospital on the 2nd of February 2022 for an eye examination. Visual fields were tested in the eye clinic at the central public hospital at Lappeenranta on the 3rd of February, 2022. Cornea and digital fundus photos were taken optical store at Lappeenranta on the 9th of February, 2022.

This was a single case study, and the researcher collected all data anonymously on-site while the patient was seen at the practice. Therefore, a separate IBR approval was not needed. The research method was qualitative.

3.4 Specific Aims

3.4.1 Specific Aim 1

To conduct a comprehensive literature review on how primary eye care providers have used teleophthalmology screening for glaucoma patients.

3.4.1 Specific Aim 2

To perform a single case study example for primary open-angle glaucoma patient to describe optometrists´role in glaucoma follow-up services in Finland.

3.5 Methodology

3.5.1 Literature Search and Appraisal

The literature search was aimed to identify existing evidence and possible information gaps in the existing studies. The studies were selected based on the initial PubMed, Cochrane, and Springer searches. The initial literature search of systematic reviews (with or without meta-analysis), clinical guidelines, and selected references that were not peer-reviewed on systematic reviews were carried out on the 21st of January 2022 using subject terms: teleophthalmology AND glaucoma; teleglaucoma, and tele* AND optometrist. Other languages than English were excluded from the search and with no date restriction.

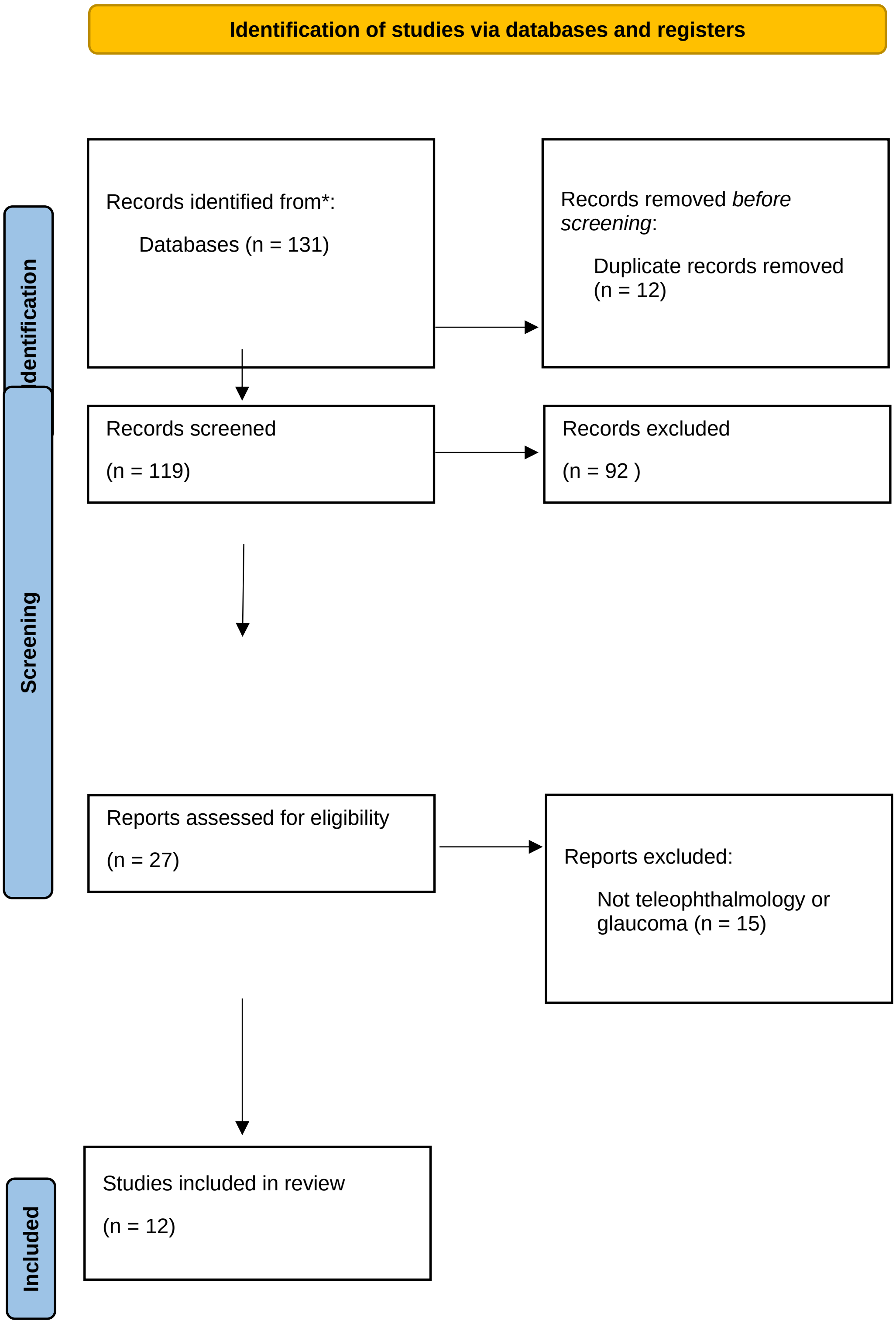
The initial literature search included only systemic reviews with or without meta-analysis.

Inclusion criteria: were glaucoma and the use of teleophthalmology.

Exclusion criteria: were a non-glaucoma or a non-teleophthalmology. Non-English literature was excluded.

Only English literature was selected, and widely accepted clinical guidelines were considered. Grey literature was chosen after additional search and careful content evaluation.

PRISMA 2020 (Page & al. 2021)



3.6 Conduction of the Case Study

This single case study presented how an optometrist can do a comprehensive eye exam on a POAG patient in Finland. A comprehensive eye exam included medical, general, and ocular history. This study’s purpose is to describe the optometrist´s ability to make POAG patient follow-ups.

4 IMPLEMENTATION OF THE RESEARCH DEVELOPMENT WORK

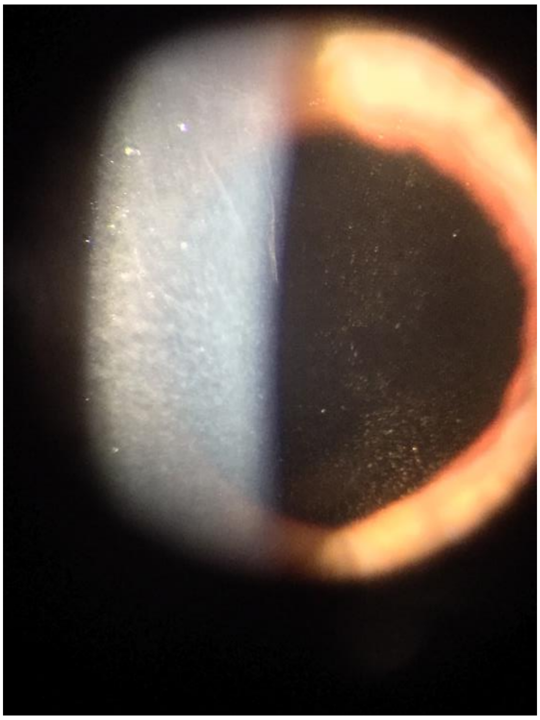
4.1 Case Study

4.1.1 Clinical Case Report

A fifty-eight-year-old caucasian male presented for a comprehensive eye exam. He was working as a teacher. A chief complaint was that he adjusts his head and neck to see clearly at near and intermediate distances. The side complaint was redness in both of his eyes. He has noticed that he needs good light to achieve a good vision to near. His vision without glasses was poor, and he could not manage without them. He uses only one pair of progressive glasses and sunglasses with powers. He has no history to use of contact lenses. He denied strabismus or double vision, floaters or flashes, and lazy eye. The last visit was an optometrist IOP control in December 2021. An ophthalmologist he visited last time in April 2021. The general practitioner (GP) visit was in November 2020, when he had gingivitis and secondary disease pneumonia. The previously available health check was eight years ago. He has sleep apnea, and he uses a CPAP machine every night. He has hypertension and uses two medications, Losartan and Amlodipine. Atorvastatin is for the treatment of hyper cholesterol. He had smoked until august of 2020 and utilized alcohol regularly. He denies the use of drugs. Another disease of general health he denies. He had cataract surgery on the right eye in 2013 and on the left in 2021. Both surgeries have been done in the eye clinic at the central public hospital. He had been diagnosed in both eyes with primary open-angle-glaucoma in 2020. He uses one drop of Lumigan in both eyes nightly. Oftan gel is in everyday use in both eyes for dry eyes. His mother had age-related macular degeneration, and his grandmother and grandmother's sister on his mother's side had a history of glaucoma. A cataract also had a common finding in his relatives.

His visual acuity with current spectacle powers was 20/25-2 in the right eye and 20/40-2 in the left eye. He mentioned he must adjust his head to see better on his left eye during an eye exam. Trial frames were used in an eye exam. Refraction powers were the same in his right eye, but he had a moderate astigmatism increase in his left. His visual acuity improved significantly on his left eye to 20/25-2. There was also an adjustment of the cylinder axis by 13 degrees. Visual acuity to near was 20/25 in both eyes. Worth lights were four dots, and the dominant eye was left. In the cover test, there was very slight esophoria in every gaze to distance, and in the near, there was very small exophoria in every gaze. An extraocular muscle test revealed the full range of motion without pain or diplopia. Pupils were equal, round, and reactive to light, with no afferent pupillary defect noted. The size of the pupils in light was 3,5 mm / 3,5 mm, and in the dark, 5 mm / 5 mm. The red cap revealed that the right eye's vision is darker than the left's. Ishihara color test was conducted, and the test result was 24/24. Confrontation fields bypass because the visual field test was already scheduled for the next day. Slit-lamp biomicroscopy revealed normal adnexa and lashes. Palpebral was slightly, and bulbar conjunctiva was moderate red. There were no findings on papillary or follicles. Meibomian glands were normal, and punctas were in a normal position. The corneas found a slight Krukenberg spindle and traces of cataract surgery incisions. Above of cornea were both eyes with greyish parts above of vision axis.

Figure 3 Kruckenberg spindle



One drop in each eye of fluorescein was installed. Goldmann applanation tonometry measured 16 mmHg od and 15 mmHg os. One drop in each eye of obucain was installed. Van Herick was grade four in both eyes, and gonioscopic revealed a ciliary body, and no significant pigment was found in the anterior chamber angle. Both iris have iridodonesis, but it has no subjective harm to the patient. One drop in each eye of tropicamide was installed. Both IOLs had slight posterior opacification, and the vitreous had no significant floaters. Optic nerves were pink, round, and healthy.

Peripapillary atrophy was noticed in both eyes. The cup size on the right side was 0.3, and on the left was 0.2. The macula areas have a group of druplets and a few soft drusens. The middle periphery and periphery have no significant findings.

Figure 4 Right fundus

Figure 5 Left fundus

On the same day were, additional tests made in the same office, and the results are found in the appendix. Papilla OCT (Optopol Revo NX, Poland) showed average test results in both eyes, and the trial was reliable. Only rim areas were abnormally broad on the left and abnormally thin on the right. However, the machine algorithm has not found actual boundaries of the optic nerve on the left eye, and the rim area is wider than it should be. Right eye cup depth was abnormal depth. Macula OCT revealed average thickness in both eyes and finding of soft drusens.

Corneal topography showed thickness levels within normal limits in both eyes. The cornea has severe anterior astigmatism of 2.3 D in both eyes and very low posterior astigmatism of 0.2 D in both eyes. Elevation in the posterior cornea in the superior nasal in the left and superior nasal in the right was abnormally high in both corneas. It can be a misreading of the device. Another test was made with different topography (Alcon Allegro Topolyzer, USA). Posterior elevation was average with the second device. Traces of incision of cataract surgery are found in the left topography. In thickness and sagittal curvature, it is thick in the cornea's hazy part and is deeper. Anterior OCT was made, and it showed an open angle in every segment in both eyes and no other significant findings. The IOL-master test was completed even though the patient had undergone cataract surgery in both eyes (Zeiss IOLMaster 500, Germany). K-reading was almost identical compared to the topography test. There was a severe measurement error in axial length in the right eye. The left eye axial length was 25.16 mm, and the right eye length was 18.48 mm. The test was made several times on the right eye, and only one measure was equal to the left eye. The anterior chamber depth was abnormally high in both eyes, od 6.51 mm and os 5.42 mm.

Visual fields were made the following day in the eye clinic at the central public hospital. Fields were tested Humphrey 24 – 2C. The right eye visual field was no defects, and the test was reliable according to the quality index given by the device and compared to the previous VFs. On the left eye, the nurse selected the wrong additional lens because the autorefractor print was corrupted, and the nurse was unsure whether it was a plus or minus lens. The automated perimetry test was reliable according to the quality index given by the device but unreliable compared to the previous VFs. The inferior part in the Bjerrum area had a scotoma. The third visit for the patient was an independent optometrist who performed cornea, papilla, and macula photos for the case study.

4.1.2 Differential Diagnosis

- Dry eye
- Pigmentary glaucoma
- Ocular hypertension
- Dry AMD
- High myopia
- Pseudophakia

4.1.3 Discussion

The patient had two systemic diseases in the case study: hypertension and hypercholesterolemia. He had smoked several years before he got diagnosed with POAG. Several of his relatives have been diagnosed with glaucoma, and he had a history of high myopia before cataract surgeries. He was almost 60 years old, and he had been diagnosed with sleep apnea. According to the literature, these are risk factors that increase the risk of getting diagnosed with POAG (Gupta Neeru & al. 2015). Literature suggested that glaucoma screening should be focused on risk groups (Zapata & al. 2021). It would be beneficial for undiagnosed patients to see optometrists for a comprehensive eye examination if they have risk factors for POAG.

The patient's eyeglasses were not updated. The left eye´s prescription had changed, and there were more astigmatism compared patient´s spectacles. Literature suggested minimal and optional equipment in glaucoma assessment (Gupta Neeru & al. 2015). An optometrist can do a comprehensive eye exam and update the patient's spectacles during annual glaucoma follow-up or regular appointments. According to Finnish law, optometrists cannot independently prescribe spectacle if there is a history of eye surgery or if the patient may have or diagnosed with eye disease (Finland's Ministry of Justice).

Literature suggested that combination methods, synchronous and asynchronous, between teleophthalmology and in-clinic assessment were beneficial (Kesary & Sathyamangalam 2016). The case study patient had visited an optometrist´s appointment to measure only IOPs and had an ophthalmologist appointment in the same year. An optometrist´s appointment should have made a comprehensive eye exam with additional tests, e.g., OCT. It would have increased the reliability of the examination and provided more information about the progression of the patient´s glaucoma. However, after this case study, a comprehensive eye examination with additional measurements could be sent to the ophthalmologist for review. The ophthalmologist can verify pre-diagnosis or adjust treatment plans.

The patient used Lumigan drops for glaucoma and Oftan gel moisturizing gel. The patient may have dry eye symptoms, redness in both eyes, or eyes that had toxicity effects in Bimatoprost. Potential side effects include, e.g., redness over conjunctiva and itchy or red eyes. Increasing the use of Oftan gel or changing the glaucoma medication is advisable to avoid eye redness. The patient's IOP was 16 mmHg on the right and 15 mmHg on the left. Medication has kept the pressure level between average values but has had moderate side effects.

The patient's binocular vision and extraocular muscle test were normal findings. Pupils were normal, and there were no relative pupillary defects (RAPD). The red gap test revealed a slightly darker red on the right than on the left. Ishihara's test went smoothly and fast, and there were no defects on the color test.

In this single example case study, the patient had been diagnosed with primary open-angle glaucoma in 2020 and experienced cataract surgeries in 2013 and 2020. Biomicroscopy revealed on corneas endothelium findings a Krukenberg spindle. Based on the literature, pigments are from iris-lens zonular contacts. However, the human eye lens has an axial length of 4mm thick and an IOL lens thickness of under 1mm (Forrester, Dick, McMenamin, Roberts & Pearlman 2020). Therefore, there was more room after cataract surgeries, and it was unlikely that the Krukenberg spindle had formed after being diagnosed with primary open-angle glaucoma. Pigment dispersion risk factors are, e.g., young Caucasian males (Kanski & Bowling 2015). The patient had a history of high myopia, and the anterior chambers were probably deep before cataract surgeries. It was likely that open-angle glaucoma was the correct diagnosis, but it is debatable whether it was a primary or secondary open-angle glaucoma. The patient had no significant pigment in the anterior chamber angle, and iris transillumination was not seen. The anterior chamber was open, and the ciliary body was seen clearly. According to the literature, there are more indications for primary open-angle glaucoma than secondary open-angle glaucoma (Kanski & Bowling 2015).

The optic nerve´s cup size was within normal limits, and peripapillary atrophy in zone alpha was in both eyes. There were mild glaucomatous defects on optic nerves. However, OCT revealed optic nerves' rim area difference between eyes. The right rim was just below average, and the left was just above average. The right optic nerve´s cup depth was abnormally deep, and the left`s cup depth was within normal limits. The difference between cup depths was suspicious, and further measurements were needed.

There was a correlation between the right eye´s IOP results, optic nerve cup size or rim thinning, and the visual field. The visual field on the left was unreliable due to human error, but optic disc appearance and IOP correlated. There weren´t correlations between the left eye visual field and optic nerve head. The left optic nerve had no rim area defects on the superior part, and the visual field had inferior scotoma. Data from the visual field were inconsistent on the left side because there was an error between plus and minus lenses when it was performed. After the test, the patient reported to the nurse that dots were more blur on the left than right. There were defects in the left eye in the inferior Bjerrum area. Compared to previous ones in 2021 and 2020, defects were not seen. The right eye had false-positive errors of 6 % and false-negative errors of 0 %; therefore, the right eyes visual field test was reliable. The left eye had false-positive errors of 0 % and false-negative errors of 6 %; therefore, the left eye's visual field was reliable. However, the left eye had Bjerrum area scotoma in the inferior part, which may have been conducted due to a false additional lens sphere lens or false head position in the chin or forehead rest. New visual fields should be ordered to confirm results. Confrontation visual field testing should be included in the exam to detect possible VF defects. Based on the literature, optometrists were able to make pre-diagnosis on POAG patients after a comprehensive eye exam (Conway & al. 2021). The literature has mentioned that a comprehensive eye exam increased diagnostic accuracy and false-positive and false-negative numbers were better with teleophthalmology than without a comprehensive eye exam (Ang & al. 2009).

Both macula OCTs revealed dry AMD and a group of druplets more on the left, and the right thickness of the macula was level in early glaucoma level. The patient had a history of smoking and hypercholesterolemia. Risk factors are also white race and family history (Kanski & Bowling 2015). Glaucoma status was good, but primary eye care providers must follow future changes in the macula area. Amsler card was a good test for the possible wet AMD for the patient to follow up regularly for possible changes in the macula. The patient had mild signs of hypertensive retinopathy: tortuous arterioles and arteriovenous nicking. Hypertensive retinopathy was grade two or milder. Blood pressure should have been measured in the optometrist´s comprehensive eye exam. The patient had signs of hypertensive retinopathy, and blood pressure should be controlled regularly. Also, hyper cholesterol should have been routinely controlled; however, the fundus showed no hypercholesterolemia.

On axial measurement left length was in high myopia, and the right length was more like high hyperopia. The patient had a history of high myopia before cataract surgeries in both eyes. The measurement on the right was very suspicious, and it is unreliable. After cataract surgeries depth of the anterior chamber was abnormally high, but it is a normal phenomenon. The patient would have benefitted if he had gotten myopia control treatment in childhood. He had high myopia before cataract surgeries, and the risk of getting, e.g., glaucoma, is very high (Kanski and Bowling, 2015).

Both corneal topographies were typical, with severe anterior astigmatism. The first topography device measured elevation in the superior posterior cornea in both eyes, which was abnormally high and unreliable. The second topography device measured the posterior cornea as normal.

As the literature suggested, the need for equipment with teleglaucoma was found in almost every optometrist´s practice (Gan & al. 2020). Most community optometrists can do teleophthalmology if they have special training or a Master´s degree in optometry. According to the literature, optometrists have heterogeneity in detecting eye diseases (Keenan & al. 2015). The literature revealed that teleophthalmology improves optometrists´ ability to detect eye diseases because new devices provide plenty of data on the eyes (Labiris & al. 2018).

Based on the literature, community optometrists have excellent possibilities to perform POAG follow-up services (Ertel, Kahook and Capitena, 2021, Conway et al., 2021). The literature suggested that more than half of glaucoma patients can be managed via teleophthalmology (Gan & al. 2020). There are countries where optometrists can prescribe or renew glaucoma medications independently or supervised by ophthalmologists (Verma & al. 2014). According to the law in Finland, optometrists can only prescribe diagnostic medications (Finland´s Ministry of Justice). Based on the literature, a visit for an optometrist can be every 3 – 6 months and an ophthalmologist every 1 – 3 years. The literature suggested that optometrists acquire low-risk POAG patient follow-ups alternately with ophthalmologists (Odden & al. 2020). This model gives more chair time to glaucoma patients with, e.g., severe glaucoma.

Based on the literature, teleophthalmology's time and cost savings are benefits (Sommer & Blumenthal 2020). In this case study, the researcher did not find any aspect of saving time and cost. All the examinations were free for the patient and in his hometown. The optometrist did not get any financial support during the case study. All the appointments were booked in advance for the case study patient. Further studies are needed to confirm time and cost savings in teleophthalmology.

Teleophthalmology is not suitable for every situation; it has flaws and borders which give limited benefits. The literature suggested that teleophthalmology is not used for closed-angle or severe glaucoma (Kassam & al. 2013). RANZCO states that teleophthalmology cannot entirely replace the in-clinic assessment, but it has benefits, especially in rural areas (The Royal Australian and New Zealand College of Ophthalmologists (RANZCO) 2021). Poor quality of images prevents effective use of teleophthalmology but combining an optometrist´s comprehensive eye exam would increase accuracy in detecting various eye diseases (Strouthidis & al. 2014). Conway with his team stated the importance of education for optometrists in their work in teleophthalmology (Conway & al. 2021). Caffery with his team noticed lack of knowledge of technology could be the barrier to successful teleophthalmology services (Caffery & al. 2019). According to glaucoma and teleglaucoma guidelines, there is significant variation between studies on reliable results. This may be because guidelines are not followed, and sensitivity is lower (Trikha & al. 2012). The diagnostic accuracy between teleophthalmology and in-clinic assessment varies from fair to almost identical to in-clinic assessment (Odden & al. 2020) (Conway & al. 2021). Optometrists have tended to classify more severe glaucoma than ophthalmologists, which may be due to a lack of experience and skills (Wright & Diamond 2015). Continued learning, education, and feedback from ophthalmologists can improve optometrists' ability to classify glaucoma (Keenan & al. 2015).

The case study patient was positive and curious about his eye disease. He asked many questions and was happy with all the answers during the examination. Primary eye providers must educate and explain the disease's status and how it will affect it in the future (Court & Austin 2015). Primary eye care providers must have the capability and knowledge to interpret test results and compare them to previous ones. The following comprehensive eye test for case study patients is after one year, and visual fields should verify the left eye's visual field. Primary eye care providers must remind patients of their general health check-ups. Satisfaction of patients comes primarily with how friendly and professional the personnel is (Li & al. 2015). There is no difference between teleophthalmology and in-clinic assessment. The main difference is shorter waiting and visiting times, increasing patient satisfaction.

4.1.4 Conclusions

Teleophthalmology helps optometrists screen and manage POAG patients by imaging the anterior and posterior parts of the eye during a comprehensive eye exam. Optometrists can use devices, interpret results during eye examinations, or send them to an ophthalmologist using teleophthalmology. The hybrid model with teleophthalmology and optometrist in-clinic assessment can provide high-quality examinations. The great benefit of the hybrid model is that if images' quality is poor due to artifacts, e.g., cataracts, optometrists can use a microscope and detect glaucomatous defects. AI is an excellent tool for an optometrist to help improve diagnostic accuracy, but it is sensitive to artifacts.

As the single case study example presented, optometrists getting a Master of degree in optometry can proceed with comprehensive eye exams with additional measurements. Once glaucoma has been diagnosed, other providers than ophthalmologists can play a role in managing or screening glaucoma. This system requires optometrists' higher education or special interest in eye health. Also, it may require privileges to prescribe eye medications. Especially in rural areas or smaller cities where there is a shortage of ophthalmologists comes community optometrist's role in managing and screening various eye diseases, e.g., glaucoma.

Teleophthalmology is an excellent way to educate primary eye care providers and patients. Optometrists can get feedback from glaucoma specialists, perform their examinations better, and detect better glaucotomaus defects. Optometrists can better educate their patients with teleophthalmology.

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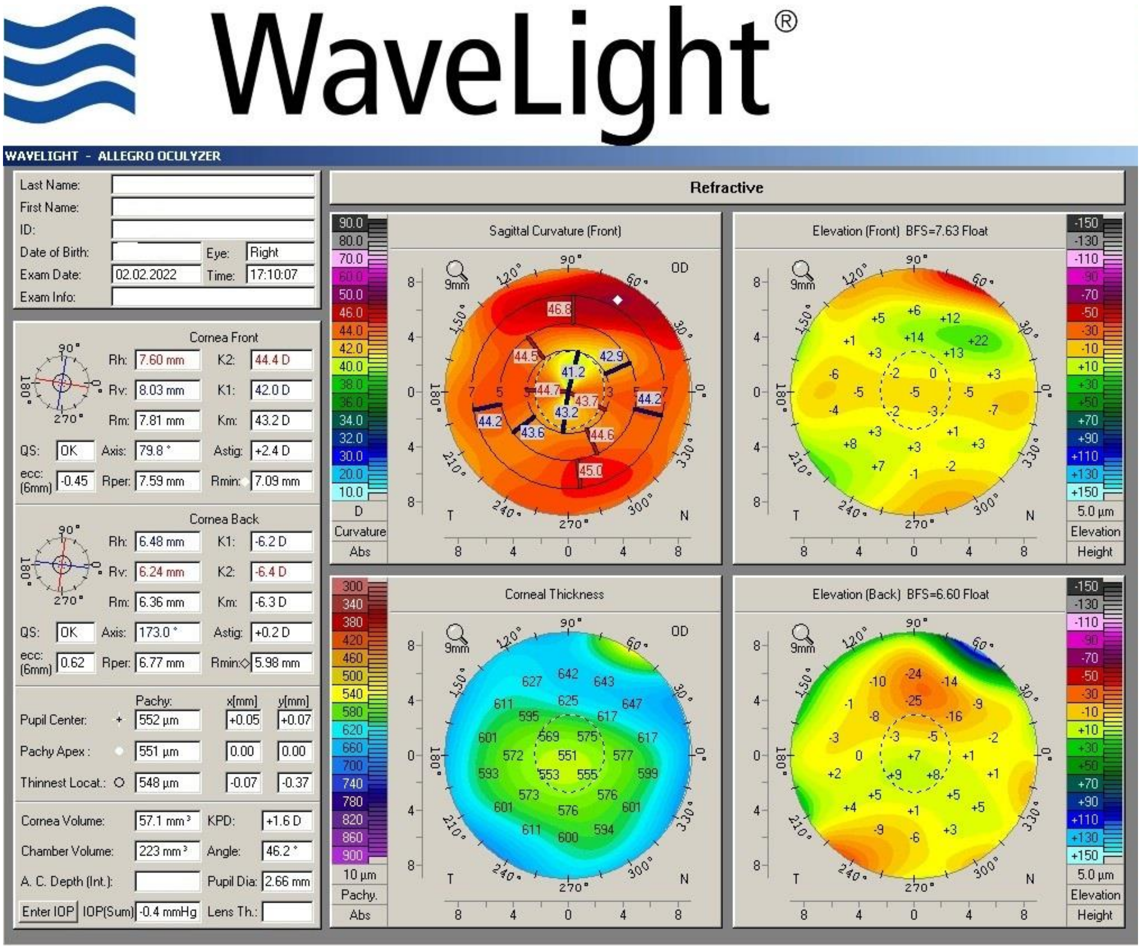
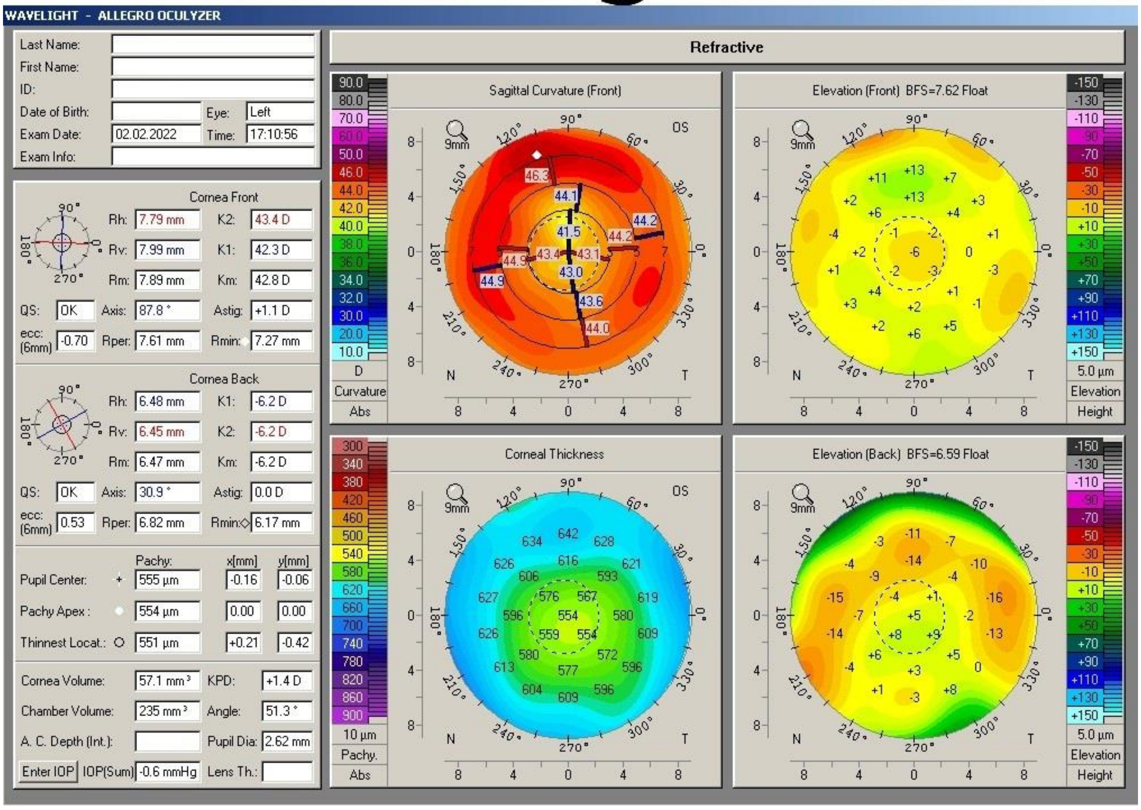
6 APPENDICES



WaveLight®


WAVELIGHT - ALLEGRO OCULYZER
Last Name:
First Name:
ID:
Date of Birth:
Eye: Left
Exam Date: 02.02.2022
Time: 17:10:56
Exam Info:
Refractive
Cornea Front
Rh: 7.79 mm K2: 43.4 D
Rv: 7.99 mm K1: 42.3 D
Rm: 7.89 mm Km: 42.8 D
QS: OK Axis: 87.8 ° Astig: +1.1 D
ecc: (6mm) -0.70 Rper: 7.61 mm Rmin: 7.27 mm
Cornea Back
Rh: 6.48 mm K1: -6.2 D
Rv: 6.45 mm K2: -6.2 D
Rm: 6.47 mm Km: -6.2 D
QS: OK Axis: 30.9 ° Astig: 0.0 D
ecc: (6mm) 0.53 Rper: 6.82 mm Rmin: 6.17 mm
Pachy: x[mm] y[mm]
Pupil Center: 555 µm -0.16 -0.06
Pachy Apex: 554 µm 0.00 0.00
Thinnest Locat.: 551 µm +0.21 -0.42
Cornea Volume: 57.1 mm³ KPD: +1.4 D
Chamber Volume: 235 mm³ Angle: 51.3 °
A. C. Depth (Int.): Pupil Dia: 2.62 mm
Enter IOP IOP(Sum) -0.6 mmHg Lens Th.:
Sagittal Curvature (Front)
Elevation (Front) BFS=7.62 Float
Corneal Thickness
Elevation (Back) BFS=6.59 Float
Curvature Abs
Elevation Height
Pachy. Abs

Name:
ID:
DOB:
Age: **58**

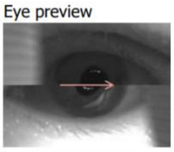
Exam date: 02/02/2022
Gender: Male
Eye: Right

Comments:

R 02/02/2022 16:41:35 TQF:
Topography 8x8 mm

ANTERIOR | SINGLE | TOPO

Eye preview



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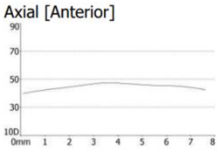

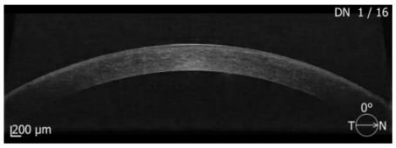

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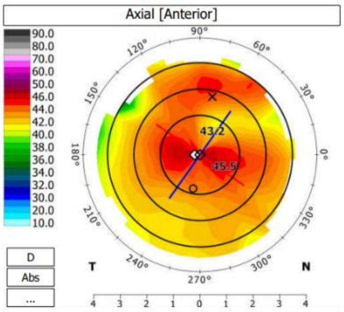
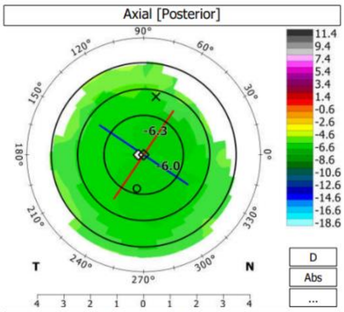


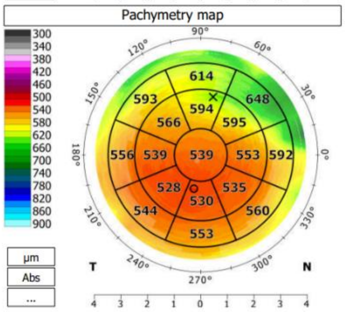
Axial [Posterior]



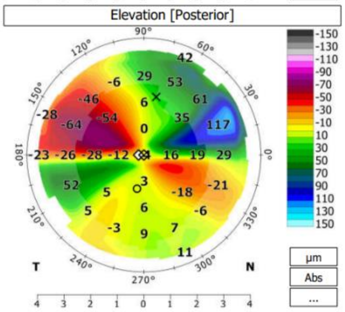
Central keratometry (SimK)

Anterior			
Kf	43.2D @ 55°	min K	46.1D @ 168°
Ks	45.5D @ 145°	avg K	44.3D
Cyl	2.3D @ 55°	Ecc	0.77
Posterior			
Kf	-6.0D @ 146°	min K	-6.3D @ 45°
Ks	-6.3D @ 56°	avg K	-6.1D
Cyl	0.2D @ 146°	Ecc	0.80
Real			
Kf	42.0D @ 55°	min K	45.4D @ 167°
Ks	44.8D @ 145°	avg K	43.4D
Cyl	2.8D @ 55°		
Central Power			
Ant	45.3D	Post	-6.2D
Real	44.4D	CCT	539µm

Pachymetry map



Elevation [Posterior]



Name:
ID:
DOB:
Age: **58**

Exam date: 02/02/2022
Gender: Male
Eye: Right

Comments:

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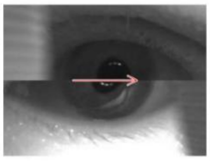
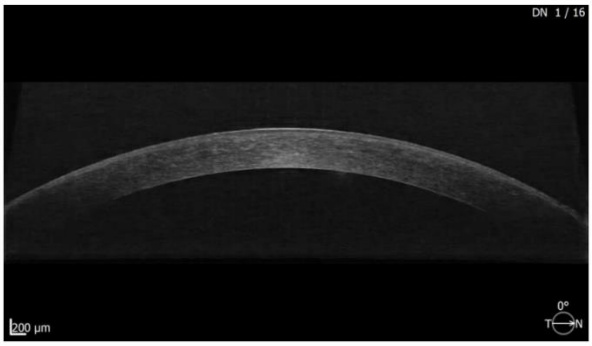
Topography 8x8 mm

ANTERIOR | SINGLE | PACHY

Eye preview

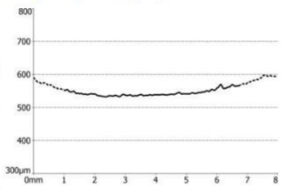




IOP Correction	0.7	mmHg
IOP		mmHg
AIOP = IOP + Correction	---	mmHg

Adjusted IOP = IOP measured + IOP Correction
*IOP Correction = 0.045 * (554 - CCT)*
Pneumotonometry Correction based on experimental values, not for clinical use.

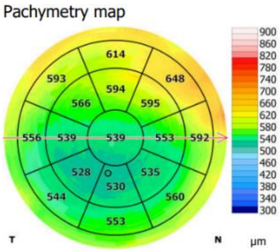
Cornea thickness graph



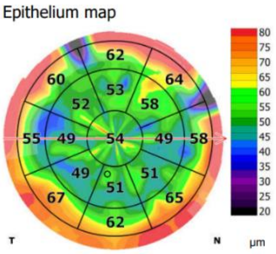
Pachymetry table

Cornea thickness within 7 mm	
Central [µm]	539
Minimum [µm] (marked as °)	518
Median [µm]	566
Min - Median [µm]	-48
Sector difference analysis	
SN - IT [µm]	67
S - I [µm]	64
ST - IN [µm]	31
T - N [µm]	-14
KPI	0.18

Pachymetry map



Epithelium map

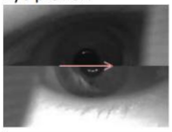


Name:		Comments:
ID:	Exam date: 02/02/2022	
DOB:	Gender: Male	
Age: **58**	**Eye: Left**	

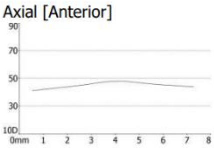
L 02/02/2022 16:42:16 TQF:
Topography 8x8 mm

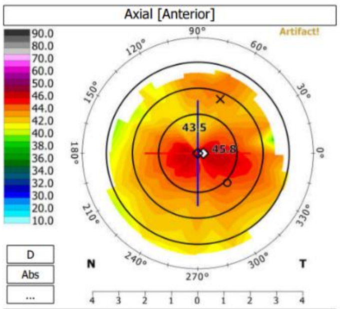
ANTERIOR | SINGLE | TOPO

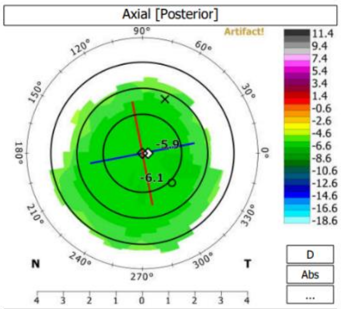
Eye preview



Axial [Anterior]

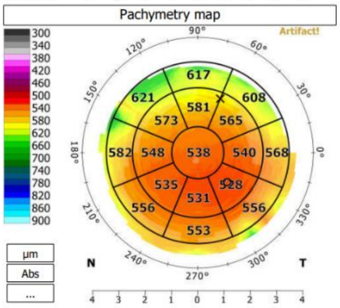


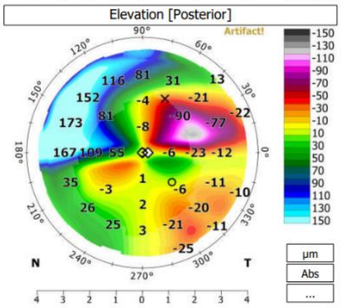




Central keratometry (SimK)

Anterior			
Kf	43.5D @ 90°	min K	45.8D @ 179°
Ks	45.8D @ 180°	avg K	44.6D
Cyl	2.3D @ 90°	Ecc	0.78
Posterior			
Kf	-5.9D @ 11°	min K	-6.1D @ 100°
Ks	-6.1D @ 101°	avg K	-6.0D
Cyl	0.2D @ 11°	Ecc	0.81
Real			
Kf	42.6D @ 100°	min K	45.2D @ 179°
Ks	45.0D @ 10°	avg K	43.8D
Cyl	2.4D @ 100°		
Central Power			
Ant	45.4D	Post	-6.0D
Real	44.8D	CCT	538µm





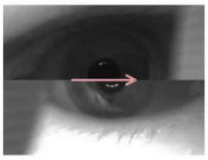
Version: 11.0.1 SOCT Copernicus REVO Device SN: 1551814/16 Print date: 21/02/2022 OPTOPOL Technology Sp. z o.o.

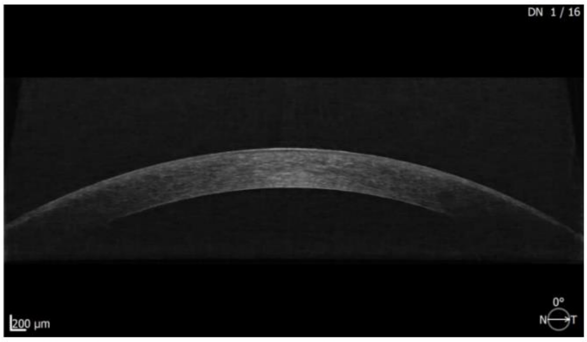
Name:		Comments:
ID:	Exam date: 02/02/2022	
DOB:	Gender: Male	
Age: **58**	**Eye: Left**	

L 02/02/2022 16:42:16 TQF:
Topography 8x8 mm

ANTERIOR | SINGLE | PACHY

Eye preview

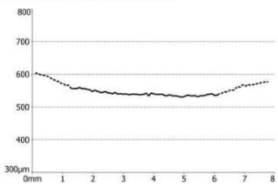




IOP Correction	0.7	mmHg
IOP		mmHg
AIOP = IOP + Correction	---	mmHg

Adjusted IOP = IOP measured + IOP Correction
*IOP Correction = 0.045 * (554 - CCT)*
Pneumotonometry Correction based on experimental values, not for clinical use.

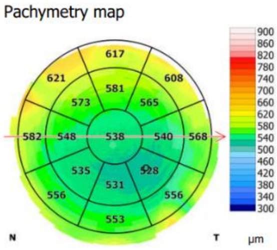
Cornea thickness graph



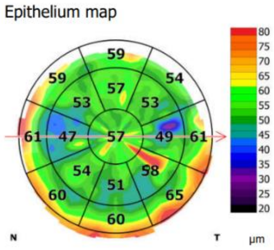
Pachymetry table

Cornea thickness within 7 mm	
Central [µm]	538
Minimum [µm](marked as °)	519
Median [µm]	559
Min - Median [µm]	-39
Sector difference analysis	
SN - IT [µm]	45
S - I [µm]	50
ST - IN [µm]	30
T - N [µm]	-8
KPI	0.19

Pachymetry map



Epithelium map



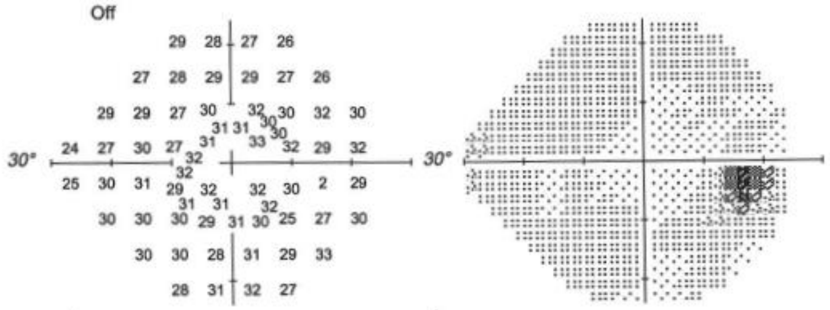
Version: 11.0.1 SOCT Copernicus REVO Device SN: 1551814/16 Print date: 21/02/2022 OPTOPOL Technology Sp. z o.o.

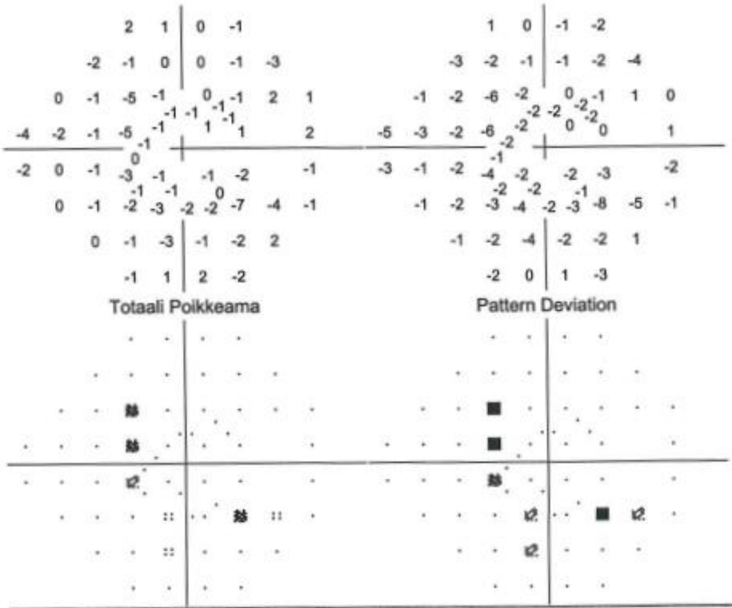
Potilas:
Syntymäaika: .1963
Sukupuoli: Mies
Potilas ID:

ZEISS

OD Single Field Analysis — Central 24-2C Kynnysarvotesti

Fixaatio Monitoir:	Gaze Monitor	Stimulus:	III, Valkoinen	Pvm:	3.2.2022
Fixation Target:	Central	Taustatiedot:	31,5 asb	Aika:	15.59
Fixation Losses:	0/0	Strategia:	SITA Faster	Ikä:	58
False POS Errors:	6%	Pupillin Halkaisija:	5,0 mm *		
False NEG Errors:	0%	Visus			
Testin kestoaika:	02:26	Rx: +1,50 DS			
Fovea:	Off				





GHT: Normaali Arvojen Sisäpuolella
VFI24-2C: 99%
MD24-2C: -1,13 dB
PSD24-2C: 1,73 dB P < 10%

:: P < 5%
P < 2%
P < 1%
■ P < 0,5%

Kommentit

Allekirjoitus

ZEISS

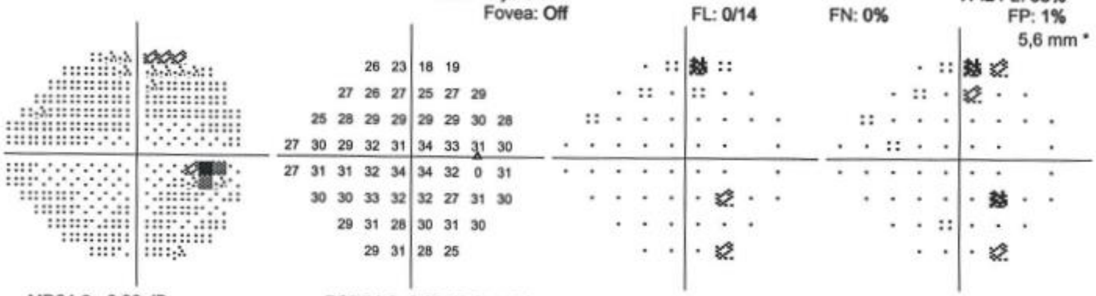
Potilas:
Syntymäaika 1963
Sukupuoli: Mies
Potilas ID:

ZEISS

OD Yhteenveto — Central 24-2, 24-2C Kynnysarvotesti

Graytone | Kynnysarvo (dB) | Totaali Poikkeama | Pattern Deviation

28.8.2020 SITA Standard GHT: Raja-arvo VFI24-2: 98%
Fovea: Off FL: 0/14 FN: 0% FP: 1%
5,6 mm *

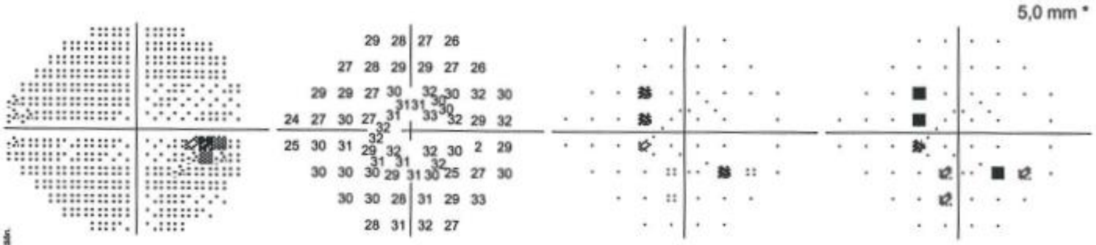


MD24-2: -0,83 dB PSD24-2: 2,02 dB P < 5%

6.4.2021 SITA Fast GHT: Normaali Arvojen Ulkopuolella VFI24-2: 91%
*** Matala Testin Luotettavuus *** Fovea: Off FL: 11/11 XX FN: 9% FP: 0%
5,1 mm *

MD24-2: -3,38 dB P < 1% PSD24-2: 2,25 dB P < 5%

3.2.2022 SITA Faster GHT: Normaali Arvojen Sisäpuolella VFI24-2C: 99%
Fovea: Off FL: 0/0 FN: 0% FP: 6%
5,0 mm *



MD24-2C: -1,13 dB PSD24-2C: 1,73 dB P < 10%

:: P < 5% P < 2% P < 1% ■ P < 0,5%

Kommentit

Allekirjoitus

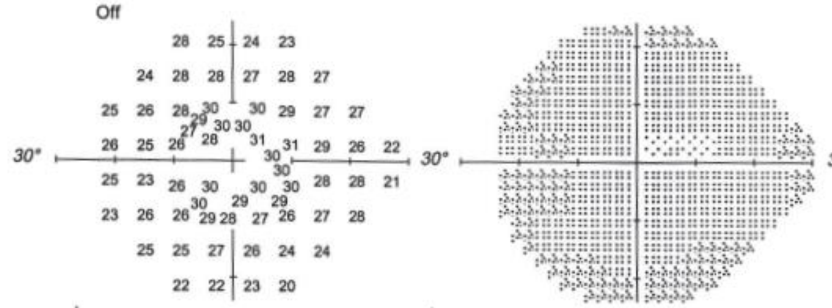
ZEISS

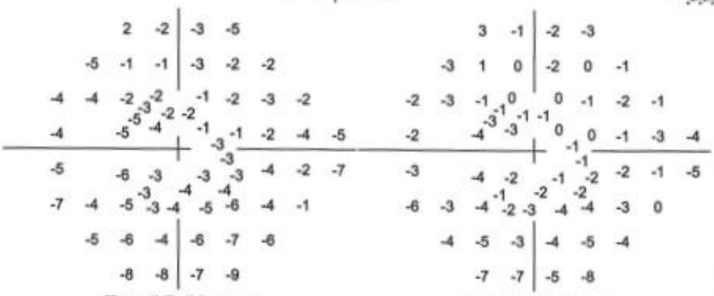
Versio 3.5.0.0 Tekijä: 02/03/2022 16:07:33 Sivu 1 of 1

Potilas:
Syntymäaika ,1963
Sukupuoli: Mies
Potilas ID:

OS Single Field Analysis — Central 24-2C Kynnysarvotesti

Fixaatio Monitoir:	Gaze Monitor	Stimulus:	III, Valkoinen	Pvm:	3.2.2022
Fixation Target:	Central	Taustatiedot:	31,5 asb	Aika:	16.03
Fixation Losses:	0/0	Strategia:	SITA Faster	Ikä:	58
False POS Errors:	0%	Pupillin Halkaisija:	5,7 mm *		
False NEG Errors:	3%	Visus			
Testin kestoaika:	02:25	Rx: +7,00 DS			
Fovea:	Off				

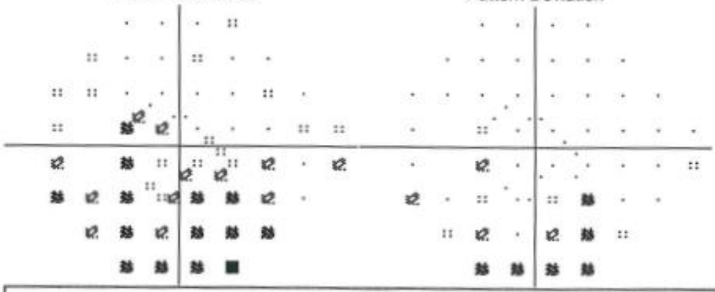




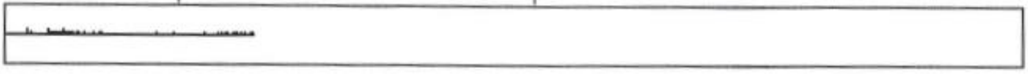
Totaali Poikkeama

Pattern Deviation

GHT: Normaali Arvojen Ulkopuolella
VFI24-2C: 97%
MD24-2C: -3,63 dB P < 1%
PSD24-2C: 2,02 dB P < 5%



- P < 5%
- P < 2%
- P < 1%
- P < 0,5%



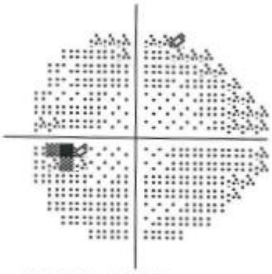
Kommentit

Potilas:
Syntymäaika: 1963
Sukupuoli: Mies
Potilas ID:

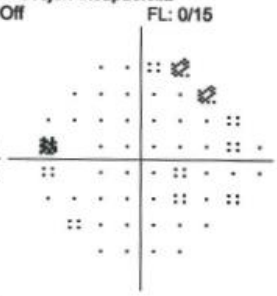
OS Yhteenveto — Central 24-2, 24-2C Kynnysarvotesti

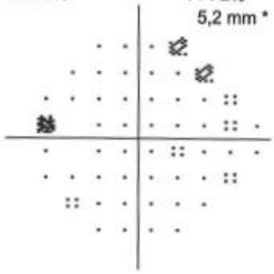
Graytone | Kynnysarvo (dB) | Totaali Poikkeama | Pattern Deviation

28.8.2020 SITA Standard GHT: Normaali Arvojen Sisäpuolella
Fovea: Off
FL: 0/15 FN: 3% VFI24-2: 98%
FP: 2%
5,2 mm *



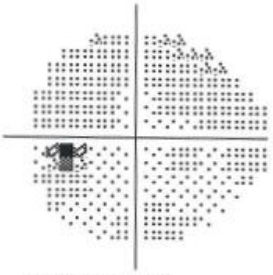
		24	23	23	20			
	31	29	28	30	30	24		
30	32	30	32	31	32	30	24	
23	27	30	32	32	31	31	25	24
27	<0	32	33	32	30	29	27	25
29	28	31	30	30	29	28	25	
	27	29	29	31	31	28		
		28	27	30	27			



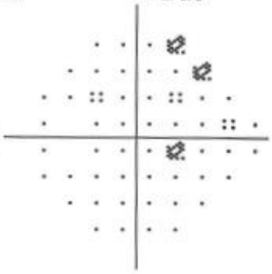


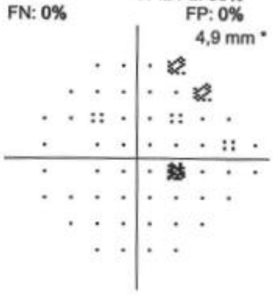
MD24-2: -1,46 dB PSD24-2: 1,98 dB P < 10%

6.4.2021 SITA Fast GHT: Raja-arvo
Fovea: Off
FL: 0/0 FN: 0% VFI24-2: 99%
FP: 0%
4,9 mm *



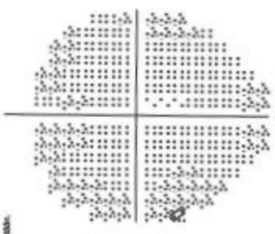
		25	28	26	22			
	27	29	30	29	28	24		
29	30	27	31	31	28	29	29	
28	30	29	31	32	31	30	27	27
33	0	32	33	32	29	31	30	26
30	29	31	31	32	32	32	31	
	31	32	31	30	31	31		
		32	29	30	29			

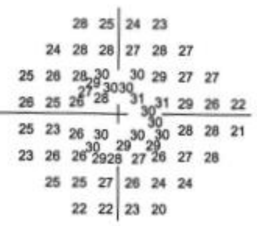


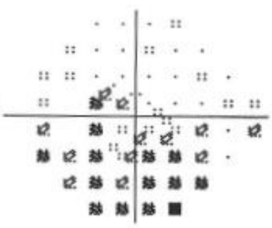


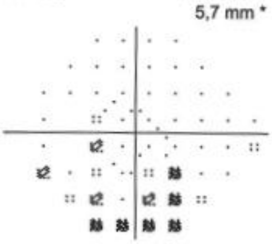
MD24-2: -0,81 dB PSD24-2: 1,56 dB

3.2.2022 SITA Faster GHT: Normaali Arvojen Ulkopuolella
Fovea: Off
FL: 0/0 FN: 3% VFI24-2C: 97%
FP: 0%
5,7 mm *









MD24-2C: -3,63 dB P < 1% PSD24-2C: 2,02 dB P < 5%

∷ P < 5% | P < 2% | P < 1% | ■ P < 0,5%

Kommentit

Allekirjoitus

Versio 3.5.0.0 Tekijä: 02/03/2022 16:07:31 Sivu 1 of 1

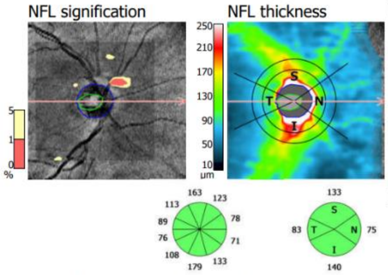
Name:		Comments:
ID:	Exam date: 02/02/2022	
DOB:	Gender: Male	
Age: **58**	**Eye: Both**	

R 02/02/2022 16:40:06 QI: 9
3D 6x6 mm

DISC | BOTH EYES

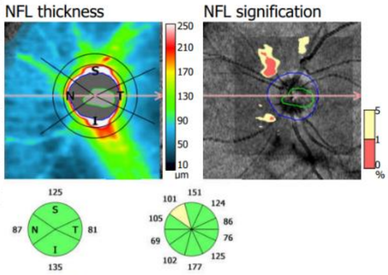
QI: 7 02/02/2022 16:38:42 **L**
3D 6x6 mm

NFL signification NFL thickness



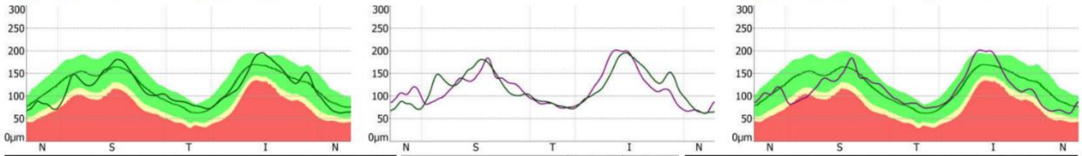
ONH parameters	Right	Left	Normal
Disc Area [mm²]	1.38	2.71	
Rim Area [mm²]	0.95	2.08	0.99 - 1.98
Cup Area [mm²]	0.43	0.63	0.00 - 0.92
Rim Volume [mm³]	0.16	0.28	0.14 - 0.54
Cup Volume [mm³]	0.09	0.06	0.00 - 0.24
Mean Cup depth [mm]	0.24	0.11	0.00 - 0.29
Max Cup depth [mm]	0.75	0.33	0.00 - 0.59
C/D Area	0.31	0.23	0.00 - 0.44
C/D vertical	0.50	0.41	
C/D horizontal	0.66	0.62	
Cup V/H	0.69	0.63	
R/D minimum	0.04	0.08	
Rim Absence [°]	-	-	
DDLS	6	5	

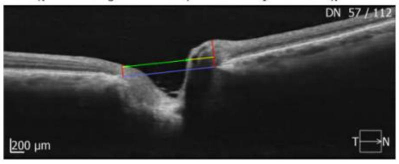
NFL thickness NFL signification



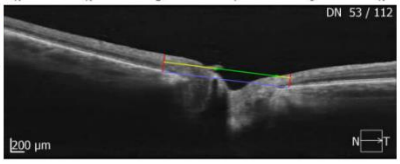
Ring diameter 2.40 mm Ring thickness 0.40 mm

Ring diameter 2.40 mm Ring thickness 0.40 mm





NFL parameters	Right	Left
NSTIN average [µm]	117	115
Std. deviation [µm]	38	37
Inter Eye Symmetry	0.83	



Version: 11.0.1 SOCT Copernicus REVO Device SN: 1551814/16 Print date: 21/02/2022 OPTOPOL Technology Sp. z o.o.

Name:
ID:
DOB:
Age: **58**

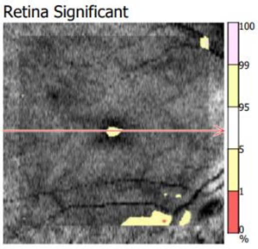
Exam date: 02/02/2022
Gender: Male
Eye: Right

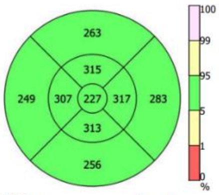
Comments:

R 02/02/2022 16:37:37 QI: 8
3D 7x7 mm

RETINA | SINGLE

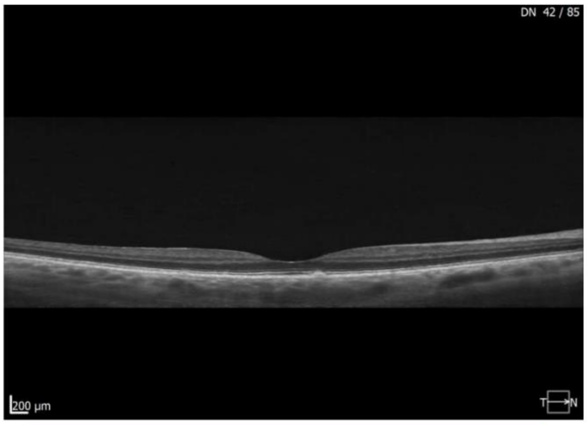
Retina Significant

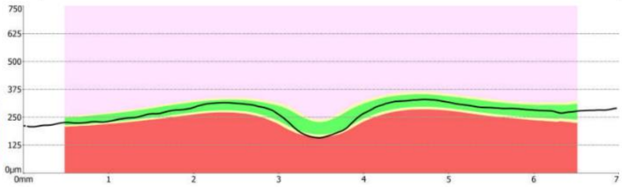




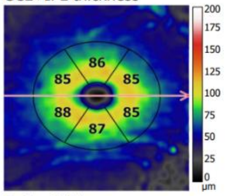
1/3/6 mm Average

ILM - OS/RPE measurements	
Minimum in Fovea [µm]	164
Central sector [µm]	227
Area thickness [µm]	273
Volume [mm³]	7.72

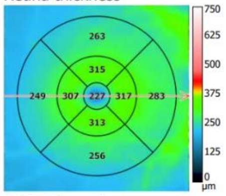




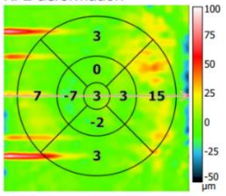
GCL+IPL thickness



Retina thickness



RPE deformation



Name:
ID:
DOB:
Age: **58**

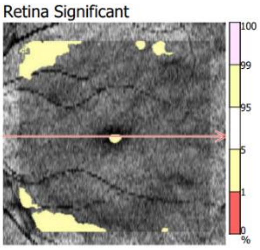
Exam date: 02/02/2022
Gender: Male
Eye: Left

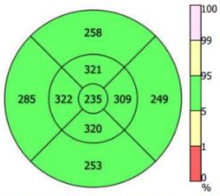
Comments:

L 02/02/2022 16:37:05 QI: 10
3D 7x7 mm

RETINA | SINGLE

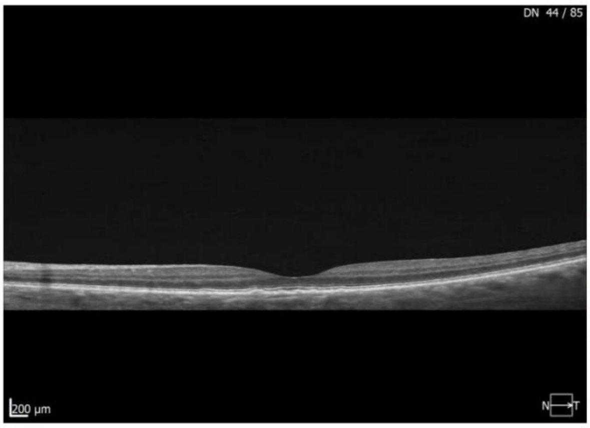
Retina Significant

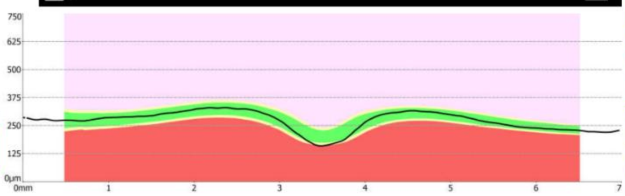




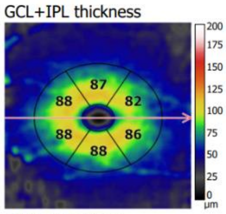
1/3/6 mm Average

ILM - OS/RPE measurements	
Minimum in Fovea [µm]	165
Central sector [µm]	235
Area thickness [µm]	273
Volume [mm³]	7.72

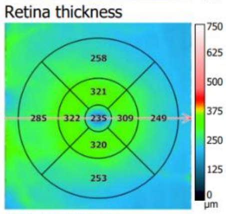




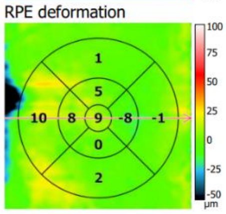
GCL+IPL thickness



Retina thickness



RPE deformation



Name:
ID:
DOB:
Age: **58**

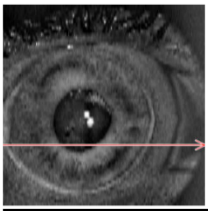
Exam date: 02/02/2022
Gender: Male
Eye: Right

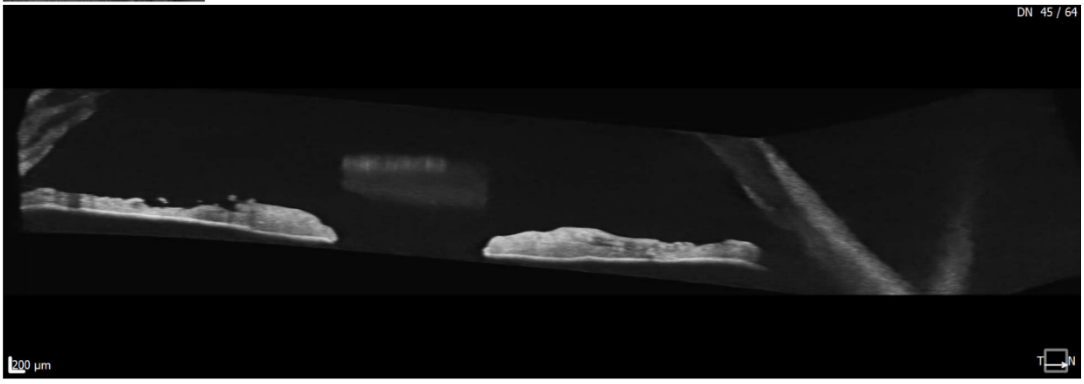
Comments:

R 02/02/2022 16:46:03 QI: 7
3D Wide 16x16 mm

ANTERIOR | SINGLE

Reconstruction





Name:
ID:
DOB:
Age: **58**

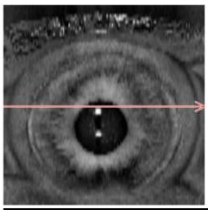
Exam date: 02/02/2022
Gender: Male
Eye: Left

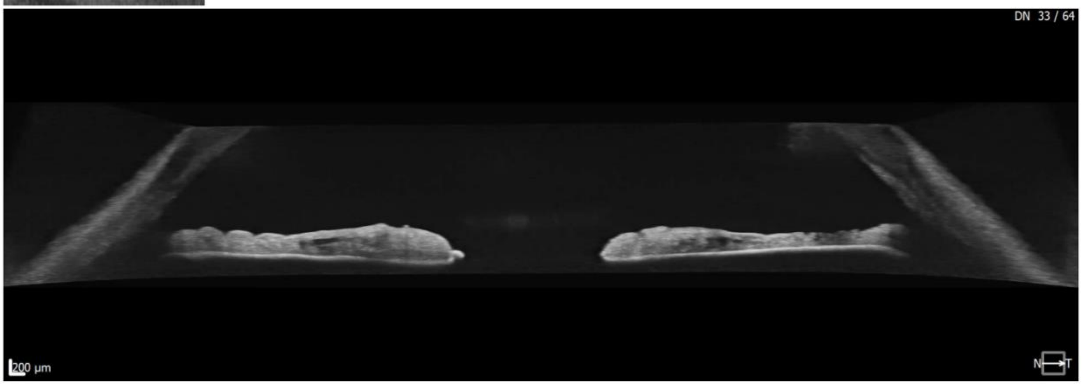
Comments:

L 02/02/2022 16:45:28 QI: 7
3D Wide 16x16 mm

ANTERIOR | SINGLE

Reconstruction





Version: 11.0.1 SOCT Copernicus REVO Device SN: 1551814/16 Print date: 21/02/2022 OPTOPOL Technology Sp. z o.o.

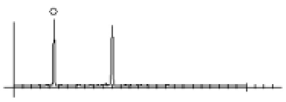
Silmasairaala Lappeenranta

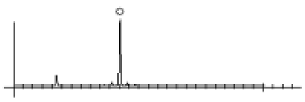
Name:
ID:
Date of Birth:
Exam Date: 02.02.2022 n: 1.3375

The readings should be checked for plausibility, as there might be pathological changes.

Axial Length Values

OD right		**OS** left	





OD				OS			
phakic				phakic			
Comp. AL: 18.48 mm			(SNR= 73.4)	**Comp. AL: 25.15 mm**			(SNR= 167.3)
AL	**SNR**	**AL**	**SNR**	**AL**	**SNR**	**AL**	**SNR**
25.13 mm	14.8	18.46 mm	3.0	25.15 mm	11.7		
18.47 mm	6.0	18.47 mm	4.0	25.15 mm	4.3		
18.46 mm	4.1	---		25.14 mm	8.3		
---				25.19 mm	3.2		
18.47 mm	2.4			25.14 mm	9.4		
---				25.16 mm	3.9		
---				18.42 mm	4.8		
18.46 mm!	1.8						
18.51 mm	2.1						

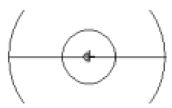
Corneal Curvature Values

OD		OS	
Avg: 41.26/44.53 D	SD: 0.02 mm	**Avg: 42.72/44.47 D**	SD: 0.00 mm
K1: 41.11 D @ 78°	8.21 mm	K1: 42.78 D @ 93°	7.89 mm
K2: 44.47 D @ 168°	7.59 mm	K2: 44.47 D @ 3°	7.59 mm
ΔD: +3.36 D @ 168°		ΔD: +1.69 D @ 3°	
K1: 41.26 D @ 80°	8.18 mm	K1: 42.72 D @ 93°	7.90 mm
K2: 44.58 D @ 170°	7.57 mm	K2: 44.47 D @ 3°	7.59 mm
ΔD: +3.32 D @ 170°		ΔD: +1.75 D @ 3°	
K1: 41.36 D @ 80°	8.16 mm	K1: 42.72 D @ 93°	7.90 mm
K2: 44.58 D @ 170°	7.57 mm	K2: 44.47 D @ 3°	7.59 mm
ΔD: +3.22 D @ 170°		ΔD: +1.75 D @ 3°	

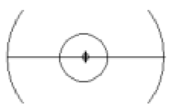
Anterior Chamber Depth Values

OD					OS				
ACD: 6.51 mm					**ACD: 5.42 mm**				
6.53 mm	6.59 mm	5.56 mm	6.49 mm	6.44 mm	5.42 mm	5.40 mm	5.42 mm	5.45 mm	5.42 mm

White to White Values



OD	OS
Error !	WTW : 12.1 mm < Fp x:-0.2mm y:+0.1 mm
WTW : 12.2 mm < Fp x:+0.2mm y:+0.1 mm	



(* = Changed manually, ! = Borderline Value)

Carl Zeiss IOLMaster® Advanced Technology V. 5.4 Printed on: 02.02.2022 at 18:04.

Silmasairaala Lappeenranta

Name:
ID:
Date of Birth:
Exam Date: 02.02.2022
Eye Surgeon: **Silmasairaala Lappeenranta**

Formula: SRK®/T
Target Ref.: plano
n: 1.3375

ZEISS

The readings should be checked for plausibility, as there might be pathological changes.

OD right	**OS** left
AL: 18.48 mm (SNR = 73.4)	AL: 25.15 mm (SNR = 167.3)
K1: 41.26 D / 8.18 mm @ 79°	K1: 42.72 D / 7.90 mm @ 93°
K2: 44.53 D / 7.58 mm @ 169°	K2: 44.47 D / 7.59 mm @ 3°
R / SE: 7.88 mm (SD = 42.89 mm)	R / SE: 7.75 mm (SD = 43.59 mm)
Cyl.: 3.27 D @ 169°	Cyl.: 1.75 D @ 3°
opt. ACD: 6.51 mm	opt. ACD: 5.42 mm
Eye Status: phakic	Eye Status: phakic

Alcon Toric SN6AT(2-9)		**Alcon AU00T0**		**Alcon Toric SN6AT(2-9)**		**Alcon AU00T0**	
A Const:	119.2	A Const:	119	A Const:	119.2	A Const:	119
IOL (D)	REF (D)	IOL (D)	REF (D)	IOL (D)	REF (D)	IOL (D)	REF (D)
43.5	-1.06	43.0	-1.11	17.5	-0.86	17.5	-1.00
43.0	-0.67	42.5	-0.71	17.0	-0.53	17.0	-0.66
42.5	-0.28	42.0	-0.32	16.5	-0.21	16.5	-0.33
42.0	**0.10**	**41.5**	**0.07**	**16.0**	**0.11**	**16.0**	**-0.01**
41.5	0.48	41.0	0.45	15.5	0.43	15.5	0.32
41.0	0.85	40.5	0.83	15.0	0.75	15.0	0.64
40.5	1.22	40.0	1.20	14.5	1.06	14.5	0.95
Emme. IOL: 42.13		Emme. IOL: 41.59		Emme. IOL: 16.18		Emme. IOL: 15.99	

Alcon AcrySof MA60AC		**Alcon MTA4UO**		**Alcon AcrySof MA60AC**		**Alcon MTA4UO**	
A Const:	119.2	A Const:	115.54	A Const:	119.2	A Const:	115.54
IOL (D)	REF (D)	IOL (D)	REF (D)	IOL (D)	REF (D)	IOL (D)	REF (D)
43.5	-1.06	35.0	-1.19	17.5	-0.86	14.5	-0.98
43.0	-0.67	34.5	-0.73	17.0	-0.53	14.0	-0.59
42.5	-0.28	34.0	-0.28	16.5	-0.21	13.5	-0.20
42.0	**0.10**	**33.5**	**0.17**	**16.0**	**0.11**	**13.0**	**0.18**
41.5	0.48	33.0	0.61	15.5	0.43	12.5	0.56
41.0	0.85	32.5	1.05	15.0	0.75	12.0	0.93
40.5	1.22	32.0	1.48	14.5	1.06	11.5	1.30
Emme. IOL: 42.13		Emme. IOL: 33.69		Emme. IOL: 16.18		Emme. IOL: 13.24	

(* = Changed manually, ! = Borderline Value)

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