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Scleral Lens Fitting in the Nordic Countries

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Scleral Lens Fitting in the Nordics – A Survey Study

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ABSTRACT

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Purpose

The aim of this study was to identify to what extent scleral lenses were being fitted in the Nordic countries and compare scleral lens fitting patterns in the Nordic countries.

Methods

An online-based questionnaire was designed to identify the number of optometrists fitting scleral lenses and when this lens modality was chosen by the optometrists in Denmark, Finland, Norway, and Sweden. The questionnaire included questions for optometrists fitting scleral lenses and for optometrists not fitting scleral lenses, asking about their willingness to fit this lens type. The survey was conducted from June to October 2021. This study did not require IRB approval since it did not involve collecting or analysing patient data. The collected data underwent descriptive statistical analysis.

Results

301 responses were analysed. 64% were from Sweden, 18% each from Finland and Norway, and no respondents from Denmark. 42% of the respondents were fitting scleral lenses, and a majority used this lens modality as a treatment for Dry Eye Disease. The major reason for not fitting scleral lenses was a lack of knowledge.

Conclusions

This study shows a significant interest among contact lens fitters in Nordic countries in starting to fit scleral lenses among practitioners not already fitting this modality. 63% of the optometrists who were not fitting scleral lenses would consider fitting this lens type if there was an easily accessible way to learn how to fit these lenses.

Keywords: scleral lenses, contact lens fitting, keratoconus, dry eye disease, Nordic countries.

CONTENTS

1 INTRODUCTION

The scleral lens has a long history. The literature describes the scleral lens as the first contact lens used, and its history began in 1887 when the glass-blown scleral lens was made (Barnett et al., 2021a, 270). Since then, there has been an immense evolution until today's modern scleral lens currently being used.

Today, there is new knowledge and modern techniques to produce the lens, as well as improved lens material with high oxygen permeability (Bergmanson et al., 2016). Modern instruments are available to help the contact lens fitter evaluate the cornea and the sclera, simplifying the fitting. This, I believe, has led to safer scleral lens wear and an increase in the use of scleral lenses among contact lens fitters during the last decade or two.

The scleral lens, fitted with bearing only on the conjunctiva and sclera, makes it very suitable for ocular surface disease and all types of irregular cornea. The scleral lens vaults even a highly irregular cornea, thus making it possible to fit this lens for corneas with high irregularity. (Van Der Worp, n.d., 4) For these patients, the lens becomes crucial to obtain better visual quality and a better quality of life.

For most patients with an irregular corneal disease, for example, Keratoconus, a rigid lens can be the only way to achieve better visual acuity. A scleral lens can also postpone or even prevent the need for a corneal transplant in cases of advanced keratoconus. (Koppen et al., 2018.)

Thus, the importance of scleral lenses for the individual, health care, and society. Without this lens, many cannot work or drive a car. Fitting patients with scleral lenses is very rewarding, which is why I find a personal interest in fitting scleral lenses and educating optometrists on how to fit this lens modality.

There has been a significant development in the Scleral lens during the last 20 years, making the scleral lens more common (Morgan & Efron, 2022; Rathi et al., 2015). The former scleral lenses were larger than 20 mm in diameter and were more difficult to fit, and there were complications such as hypoxia (Barnett et al., 2021b, 270).

According to the Scope Study, the use of modern scleral lenses (mini-scleral lenses) has increased globally over the last one or two decades (J. Harthan et al., 2018). Woods et al. (2020) concluded in their study that scleral lens fitting has increased since 2011. The escalation in the number of studies on scleral lenses since 2010 underscores a burgeoning interest and fitting of these lenses (Bergmanson et al., 2016.) A review of the Cochrane Library using the search term "scleral lens" illustrates this trend, with only four trials conducted before 2015 compared to a significant increase to fifty-two trials since 2015.

I have not found literature or studies focusing on the use of scleral lenses in the Nordic countries. The purpose of this work is to investigate to what extent scleral lenses are fitted in Nordic countries, helping patients benefit from this type of lens. Furthermore, this research seeks to find out if there is an interest among clinicians in the Nordic countries for this lens modality, and if so, what would make them include scleral lenses as an option for their patients. This thesis intends to explore the extent to which scleral lenses are prescribed, to provide an in-depth analysis of scleral lens fitting, and to identify variations and similarities among the Nordic countries.

2 THEORETICAL BACKGROUND

This section includes scleral lens history, geometry, fitting, indications, and prescribing, as well as a review of studies on scleral lens fitting.

2.1 Scleral Lens History

The first seeds of the idea of a contact lens are said to be Leonardi da Vinci's drawing of a head in a bowl of water, dating back to 1508, and René Descartes' description of a glass tube on the eye in 1636 (Efron, 2018, 3). The first scleral lenses were manufactured in 1887 (Barnett et al., 2021b, 270) and have since developed into the modern scleral lens used today.

The first scleral lenses did not include any power but were merely used for managing ocular surface disease on traumatised eyes. The lens was used for medical reasons and, at the start, was made by artificial eye makers. Eye makers had spread from Egypt to Europe. Eye loss was not rare at this time due to eye trauma and infection. (Barnett & Johns, 2018, 2.) Friedrich Müller fitted a glass-blown scleral lens on a patient who was missing his upper eyelid after surgery and needed eye protection (Kurt E Östlund, 1980, 6 - 12).

Adolf Fick, a German Ophthalmologist, tried glass-blown scleral lenses on keratoconic and aphakic patients. In 1889, Eugene Kalt, an ophthalmologist in Paris, described the use of contact lenses as "orthopaedic appliances" in treating keratoconus. (Barnett & Johns, 2018, 6 – 7.) However, Kalt used lenses with a diameter of 11 mm (Östlund, 1980, 13) meaning a corneal rigid lens by today's definition.

In 1912, Zeiss made its first trial set of scleral lenses for ophthalmologists and, four years later, a trial set with scleral lenses intended for keratoconus. The early scleral lenses were not always well tolerated, and ocular problems were not uncommon. One such issue was Sattler's veil, referring to foggy vision caused by corneal oedema. (Östlund, 1980, 9.)

August Müller-Gladbach in Kiel designed a scleral lens for himself to correct his ametropia of 14 dioptres myopia. Due to intolerance, the lens could only be worn for 30 minutes at a time. (Östlund, 1980,7.)

Zeiss managed to produce impression-made scleral lenses by blowing glass against a mould. Despite being at the forefront of scleral lens innovation, Zeiss stopped producing lenses in the early 1940s due to happenings in Europe at that time. (Barnett & Johns, 2018, 8-9,19.)

In the 1930s, a noteworthy breakthrough in plastic materials emerged, influencing the evolution of contact lenses. The invention of polymethyl methacrylate (PMMA) marked a substantial development and was gradually incorporated into the production of contact lenses (Barnett & Johns, 2018, 14).

Another significant milestone in the history of scleral lenses occurred in 1938 when C.W. Dixie & Son Ltd. in London manufactured a lathe-cut scleral lens using PMMA material. This innovation resulted in a significant weight reduction, approximately 60% less than the glass lenses produced by Zeiss. (Barnett & Johns, 2018.)

The 1970s meant the evolution of soft contact lenses, which decreased the interest in scleral lenses. However, soft contact lenses could not fully correct irregular corneas; therefore, some interest in scleral lenses remained. (Barnett & Johns, 2018, 2.)

The Holden and Mertz study, published in 1984, revealed the amount of oxygen required to prevent corneal oedema when using contact lenses. This led to further development and advancement of the lens materials used for rigid lenses (Barnett & Johns, 2018, 28). Gas-permeable materials were invented and have kept evolving to this day. During the 1980s, scleral lenses were manufactured in gas-permeable material, decreasing the unwanted physical issues that scleral lens wear had previously caused (Barnett et al., 2021b, 270-271).

Several influential figures have contributed to the evolution of scleral lenses. Two of the ones playing significant roles in developing the scleral lens in modern times are Don Ezekiel and Ken Pullum. Don Ezekiel first described fitting rigid gas permeable scleral lenses in Australia in 1983, which improved ocular health and resulted in more comfortable lens wear. Ken Pullum continued the

development of rigid gas permeable scleral lenses at Moorfield's Eye Hospital in England, which inspired other eye care professionals. (Barnett & Johns, 2018, 6.)

During the 1990s, the corneo-scleral and the mini-scleral lenses were introduced, and several mini-scleral lens brands were put on the market during the first and second decades of the 21st century. To mention some, Onefit, Paragon CRT, Senso Sclera, and SLC Conica were all launched in 2012. (Barnett & Johns, 2018, 35-36.)

Compared to glass-blown scleral lenses, with poor reproducibility, followed by moulded scleral lenses, today's scleral lenses are much different. The modern scleral lenses are manufactured using computerised lathe-cut machines, making it possible to produce modern lens designs with high precision and reproducibility. (Rathi et al., 2015.)

2.2 Scleral Lens Geometry

Prior to the introduction of the mini-scleral lens, the scleral lenses had a rather daunting size, with diameters ranging from 20 to 25 mm. The modern scleral lens is often much smaller, commonly with a diameter between 14.0 to 18.0 mm and up to 20 mm in some cases. The term mini-scleral lens refers to a sclera lens with a diameter within the 14-18 mm range (Van Der Worp, n.d. 2015, 2-3.)

A corneo-scleral (or semi-scleral lens) differs from the scleral lens and is not a topic of this research. The corneo-scleral lens has bearing both on the cornea and the sclera and a higher degree of tear exchange due to its edge lift. The fitting and indications differ from a scleral lens. (Van Der Worp, n.d. 2015, 3.)

In 2019, the Official Guide to Scleral Lens Terminology was published. It defines a lens fitted with no bearing on the cornea, completely vaulting it, landing on the conjunctiva, as a scleral lens. Regardless of the size of the lens. According to Michaud et al., 2020, "*A* lens fitted to vault over the entire cornea, including the limbus, and to land on conjunctiva overlying the sclera" (Michaud et al.,

2020, 530). The term mini-scleral lens is no longer to be used as a standard term for a scleral lens, according to the Official Guide of Scleral Lens Terminology (Michaud et al., 2020, 530).

The scleral lens consists of a central optic zone (A), transition zone (B), and landing zone (C). (Michaud et al., 2020, 531) Fig.1. These parts of the lens, combined with the sagittal height and the diameter of the lens, can be adjusted and often customised to properly fit the eye.

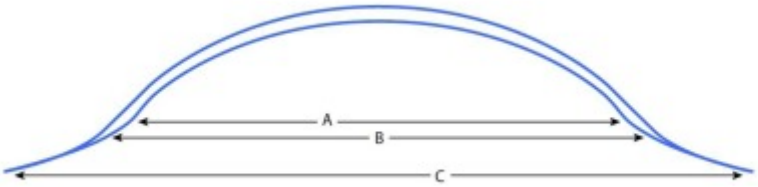

FIGURE 1. Describing parts of a scleral lens. Central optic zone (A), transition zone (B), and landing zone (C) (Michaud et al., 2020, 531)

The power of the lens is found in the central optic zone. It has a radial curvature and a zone diameter. It can be defined by the back optic zone (BOZ) and front optic zone (FOZ), which, as with all contact lenses, creates the power of the lens. Changes in the radius (base curve) of the optic zone are made to optimise the fit and vision. The centre thickness of the lens is measured in the centre of the optic zone. (Barnett et al., 2021a, 271.)

The transition zone combines the optical zone with the landing zone, vaulting the limbal area. The landing zone is the peripheral zone where the lens lands on the conjunctiva and is sometimes referred to as the haptic of the lens. (Van Der Worp, n.d., 18 – 20.)

The sagittal height of the scleral lens is a number describing the height of the lens. It is specified by the manufacturer and refers to a cord measured from the overall lens diameter to the highest point of the lens, meaning the total height of the lens from the top to the edge of the lens. More correctly, and a value more applicable for the lens fitter, would be the actual height of the lens where the lens lands on the eye. This is referred to as the Primary Functional Sagittal Depth (PFSD) Fig. 2. Michaud et al., 2020, 532).

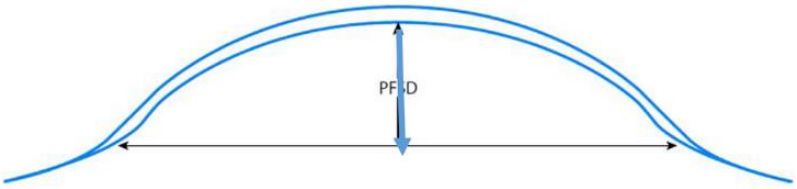

FIGURE 2. Showing Primary Functional Sagittal Depth (PFSD) (Michaud et al., 2020, 532)

Current scleral lenses are manufactured using modern techniques such as computerised lathe cut machines, and the lenses are made in material with high oxygen permeability. This results in a lens that more closely correlates with the shape of the eye, higher oxygen delivery to the cornea, and ocular health improvement. (van der Worp et al., 2014a.)

2.3 Scleral Lens Fitting

The Scleral Lens is fitted to align the sclera, bearing only on the conjunctiva and the sclera and leaving the cornea untouched. Between the lens and the cornea, there is a fluid reservoir, making it possible to fit even a highly irregular cornea. The fluid reservoir helps to even out irregularities of the corneal surface, and the fluid reservoir also keeps the cornea moistened, making the scleral lens beneficial for patients suffering from dry eye disease (DED). Because the scleral lens lands only on the sclera, more precisely on the conjunctiva on top of the sclera, it is a lens suitable for a sensitive cornea. The fact that the edges are positioned mainly under the eyelids, not interfering with the lid margin, makes the lens more comfortable than a rigid corneal lens. (Vincent, 2018, 141.)

The scleral lens used to be fitted only by a few specialists and only for severe cases of corneal irregularities. However, it is now a modality used by not only a few optometrists but also fitted to regular eyes. (Bergmanson et al., 2016.)

Fitting procedures for scleral lenses contrast with those for rigid corneal lenses and soft contact lenses. The foundation of the fitting procedure is common for all contact lens fittings regarding an eye examination, including eye refraction, keratometry readings, HVID (horizontal visual iris

diameter) measurement and checking the health status of the eye. Scleral lens fitting does not require instruments other than those used for fitting regular contact lenses. The eye care professional requires a slit lamp biomicroscope, and other instruments can be helpful but not necessary. (Barnett & Fadel, n.d.,10.) However, the fitting process can be facilitated using other instruments, such as OCT (to be described subsequently).

The main distinction between a scleral lens and other lens modalities is that it, as earlier mentioned, has bearing only on the conjunctiva, indirectly the sclera, and does not touch the cornea. The space between the cornea and the lens results in a fluid reservoir. This fluid reservoir consists of saline instilled into the lens prior to insertion. This fluid reservoir acts as a moisture chamber. The scleral lens is stable on the eye with no or minimal lens movement when blinking, creating an optimal foundation for good vision. (Van Der Worp, n.d.)

The goal of the scleral lens fitting is finding a lens with a sagittal height appropriate for the eye being fitted, creating a space (fluid reservoir) between the lens and the cornea that is approximately 100-300 microns thick after the lens has settled on the eye, having clearance also over the limbal area, and a landing zone aligned with the conjunctiva/sclera. (Barnett & Johns, 2018) (Barnett et al., 2021b.) Figure 3 shows a scleral lens with a fluid reservoir between the lens and the cornea.

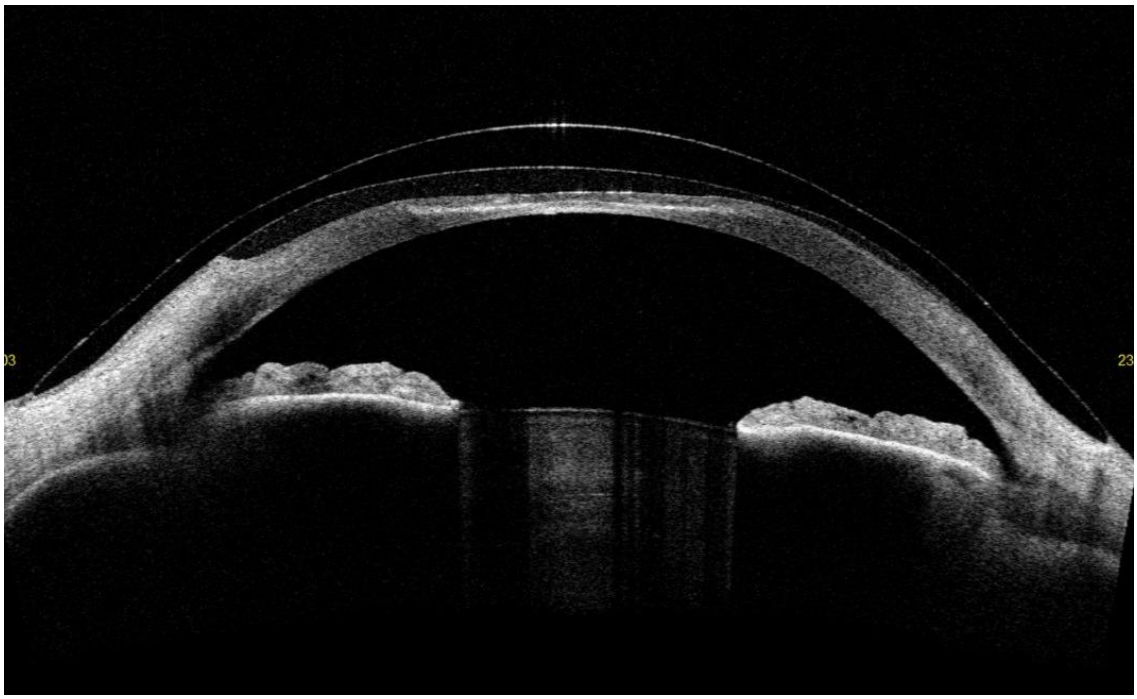

FIGURE 3. This is an OCT picture of a scleral lens on an irregular cornea, creating a fluid reservoir between the lens and the cornea. Photo: Oscar Hagelberg.

The ideal thickness of the fluid reservoir may vary based on diverse sources and fitting guidelines corresponding to distinct lens designs. The fluid reservoir consists of isotonic saline solution, and its thickness will affect the oxygen transmitted to the cornea. A study made by Michaud et al. 2012 describes how the lens material, lens thickness and thickness of the fluid reservoir under the scleral lens, all in combination, result in the total oxygen reaching the cornea during scleral lens wear (table 1). The study shows that the optimal thickness of the fluid reservoir to aim for is 100-200 microns in order to avoid hypoxia, thus safe daily scleral lens wear.

TABLE 1. Shows predicted values of dk/t of a scleral lens with a lens material of Dk 150, according to Michaud et al. The grey area shows results that fulfil the Holden and Mertz criteria of 24 dk/t, and the green box indicates a result that also satisfies the Harvitt and Bonanno criteria of dk/t required for daily lens wear. (Michaud et al., 2012, 268)

Dk=150	Clearance (µm)	100	150	200	250	300	350	400
Lens thickness (µm)								
250		34.3	28.2	24.0	20.9	18.6	16.6	15.0
300		30.8	25.8	22.2	19.5	17.4	15.7	14.3
350		27.9	23.7	20.7	18.3	16.4	14.9	13.6
400		25.5	22.0	19.3	17.2	15.6	14.2	13.1
450		23.5	20.5	18.2	16.2	14.8	13.5	12.5
500		21.8	19.2	17.1	15.5	14.1	13.0	12.0

The scleral lens is fitted with a fluid reservoir thickness large enough for the lens to settle over time. As the lens settles, the thickness of the fluid reservoir decreases by 100-200 microns during the day. Basu et al. suggested that the optimal amount of fluid between the central cornea (central clearance) and the lens is 200-400 microns because the amount of clearance tends to decrease over time. (Basu et al., 2022.)

To judge the thickness of the fluid reservoir, it is compared to the thickness of the lens using an optic section and white light in a slit lamp biomicroscope. To simplify the evaluation of the thickness of the fluid reservoir during the fitting process, fluorescein can be instilled together with the saline that the lens is filled with prior to application. (fig. 4)

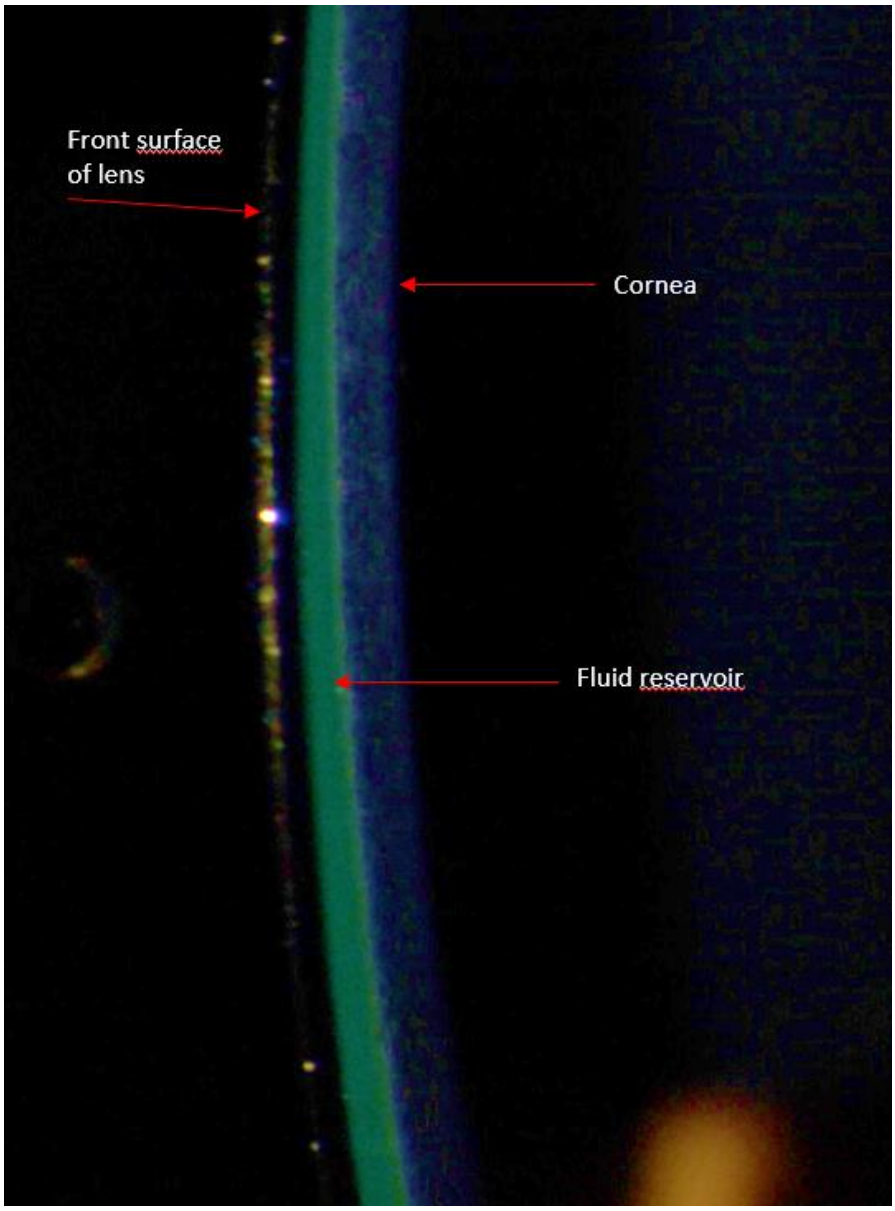

FIGURE 4. Showing the saline with fluorescein in the fluid reservoir between the lens and the cornea. (Photo: Eva Zschüttig Wigh)

Another method is using Optical Coherence Tomography (OCT) to measure the thickness of the fluid reservoir. OCT can also be used to evaluate the limbal area and the landing zone.

The limbal area is sensitive due to the existence of the limbal epithelium stem cells, which are responsible for maintaining good corneal health. Therefore, it is crucial to elevate the limbal area, assess the optimal amount of clearance, and avoid the adverse effect of scleral lens wear. Regarding the limbal area, the opinions on ideal clearance (fluid reservoir thickness) also differ. The consensus suggests that the fluid reservoir should not be excessive to prevent complications due to oxygen deprivation and conjunctival prolapse. (Barnett & Fadel, n.d, 17; Basu et al., 2022, 7.)

The landing zone is also an essential part of the fitting. The goal is alignment of the landing zone and the conjunctiva. An optimal landing zone is a lens that lands smoothly and aligns the scleral angle, aiming for the lens landing to be partly sunken into the conjunctiva without impinging the blood vessels. The lens must not stand off, creating an edge lift. An optimal landing zone gives good lens comfort, avoids lens suction, and leads to a stable, well-centred lens.(Barnett & Fadel, n.d.,17 – 23 ; Basu et al., 2022, 6 – 9 ; Van Der Worp, n.d., 34 – 39.) Figure 5 shows an example of a scleral lens with a well-fitted landing.

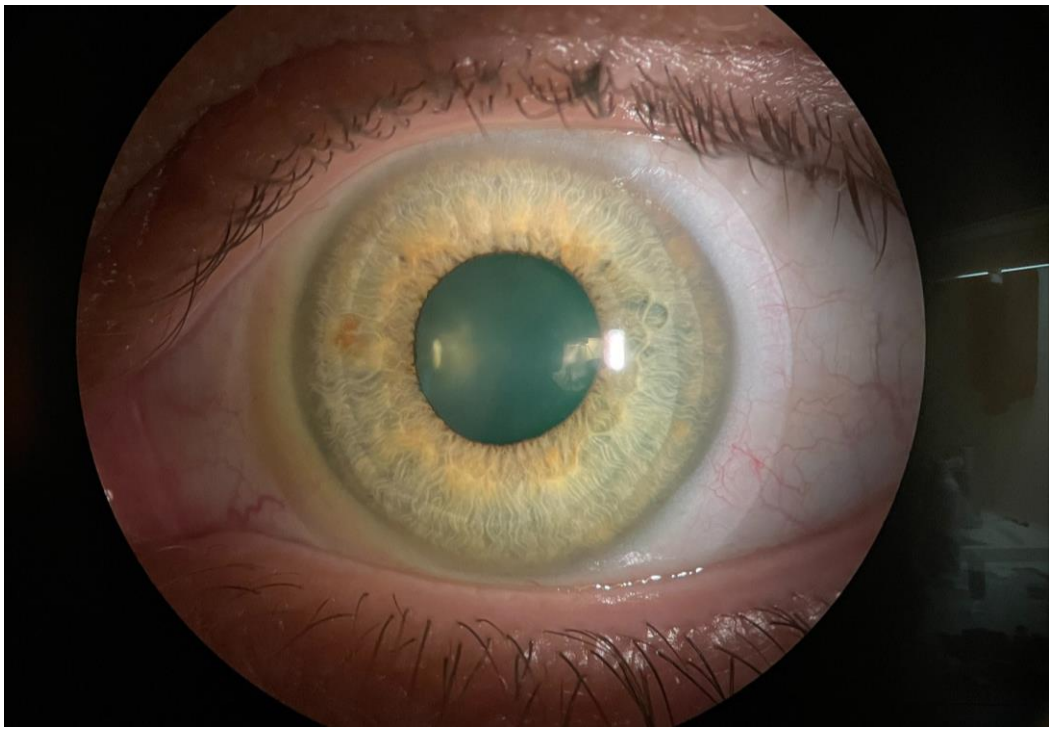

FIGURE 5. Showing a nicely fitted scleral lens on the eye. Photo: Erika Drecker

In order to achieve an optimal landing on the conjunctiva, there may be a need for a toric or even a quadrant-specific landing zone. Studies show that the majority have a scleral shape that is not spheric (Gregory W. DeNaeyer, 2020). The landing can also be affected by a pinguecula, and in these cases, a notch can be made (Barnett & Fadel, n.d.,10). (fig.6)

As with all contact lenses, it is important to follow the fitting guide provided by the manufacturer. Different scleral lens brands are designed to be fitted with some variation in regard to optimal fluid reservoir thickness.

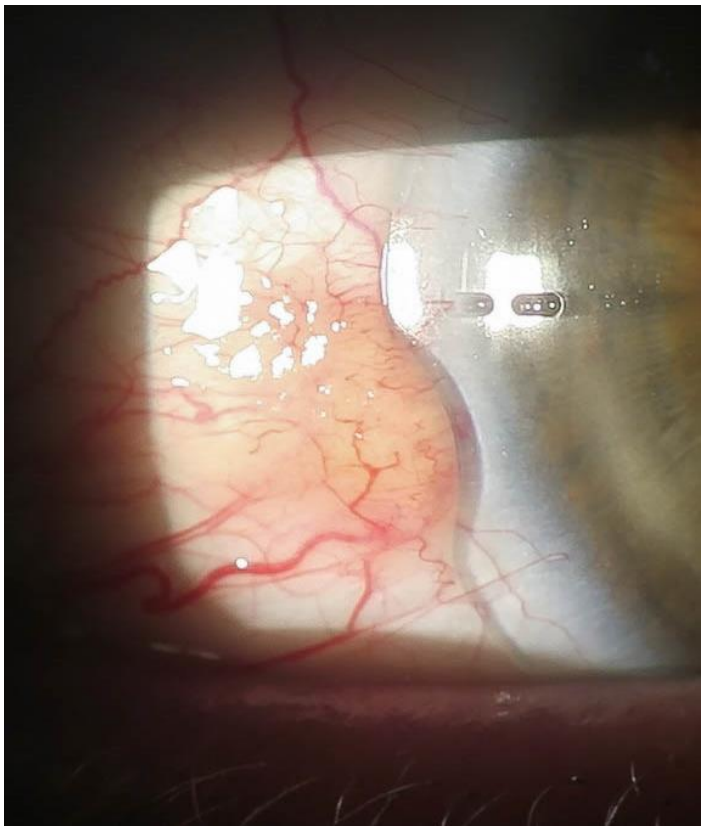

Fig. 6. Showing a notch on a scleral lens. Photo: Oscar Hagelberg.

There are different methods of fitting a scleral lens. Diagnostic lenses from a trial set are often used to assess the fit and decide which lens is optimal for the eye, and making an over-refraction. A trial lens is applied to the eye, evaluated, recalculated, and ordered according to the observations and over-refraction made. (Barnett & Fadel, n.d., ,11,23,24; Van Der Worp, n.d., 27,42.)

A second method is using moulding techniques. An impression is made of the anterior ocular surface of the eye using special equipment, and a lens is made according to this from a specialised manufacturer (Van Der Worp, n.d.,25 - 26).

The third alternative is using an instrument measuring the scleral profilometry, to evaluate the scleral and the corneal shape. This information is used to order a scleral lens from a contact lens lab. (Barnett & Fadel, n.d.,10.) A topographer can be used to measure the shape of the cornea. However, a scleral profilometry also measures the scleral shape, which is information needed in the case of scleral lens fitting.

Optimising lens material and scleral lens design have improved the result of scleral lens wear, meaning fewer adverse advents such as hypoxia (Barnett et al., 2021b, 276,279). However, another factor affecting the fitting is the evolution of instruments used during the fitting process. As a result of new technology, there is new knowledge of the anterior of the eye (Barnett et al., 2021b, 272). In everyday contact lens practice, keratometry measurements are used to choose the base curve of a contact lens. However, this measurement does not give enough information for choosing a scleral lens, as it only measures the central part of the cornea, and a scleral lens covers a much larger area and has its landing on the sclera beneath the conjunctiva.

Corneal topographers give an understanding of the shape of the cornea and can be helpful. Even though it does not give us information about the shape of the sclera, we may be able to predict its shape based on the corneal topography. Recently, new instruments measuring the scleral shape are available and can simplify the fitting process. (Barnett & Johns, 2018, 78.)

The Dutch photographer Dr Frans Jongsma invented the Eye Surface Profiler in the mid-1980s. The hardware was redesigned in 2010 and was launched in Europe in 2014. It measures the front curvature of the cornea and sclera at a diameter of 20 mm. (Barnett & Johns, 2018, 78.)
This instrument (fig. 7) helps the scleral lens fitter to find an appropriate trial lens or to order a lens using the measurement obtained from the eye profiler.

FIGURE 7. The Eye surface profiler instrument measures the corneal and scleral shape. Eaglet Eye. (Source: Eaglet Eye)

Oculus Pentacam is another instrument available that can measure the scleral shape, and the eye care professional can order a scleral lens accordingly. (fig 8)

FIGURE 8. Oculus Pentacam. (Source: Oculus)

OCT (optical coherence tomography) is another technical improvement for the eye care professional. An anterior OCT measurement gives a picture and a measurement of the fluid reservoir thickness between the cornea and the lens. It can also supply the scleral lens fitter with pictures of the profile of the landing zone, facilitating the judgement of the lens fit. (Barnett et al., 2021b.) (fig.9)

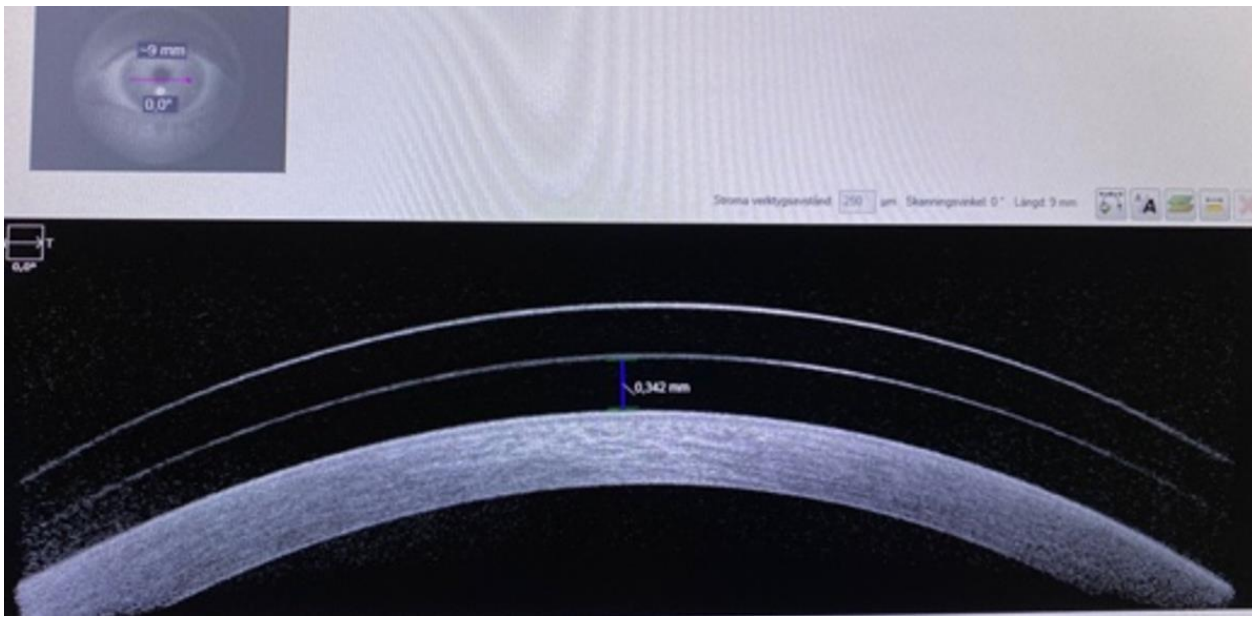

FIGURE 9. OCT of a scleral lens showing central clearance. Photo: Multilens

Today, numerous scleral lens designs are available to optometrists fitting this modality. The lenses can be ordered front toric, multifocal, with toric periphery, limbal adjustment, and several different options to customise the lens. Fenestrations and notches can be made to optimise the fit even more. (Barnett et al., 2021b, 274.)

An important step is also teaching the patient lens handling. The scleral lens differs from other lens modalities in the way it is applied and removed. Correct lens handling and care are crucial factors to achieve a functioning scleral lens wear. (Fadel, n.d.,203.)

2.4 Scleral Lens Indications

There are multiple clinical indications for prescribing a scleral lens. This lens modality, creating a smooth rigid surface covering the entire cornea, is beneficial for an irregular cornea, including corneal ectasia (keratoconus, keratoglobus, pellucid marginal degeneration), post keratoplasty, and post-refractive surgery. The fluid reservoir beneath the lens helps ocular surface disease conditions such as dry eye, Sjogren's syndrome, and Steven Johnson's syndrome. The rigid lens material and the fluid between the lens and the cornea can correct an astigmatism in a better way than a soft contact lens. The lens being stable on the eye also makes it a good option for multifocal correction for presbyopes. (Barnett et al., 2021b, 271,282.)

Recently, scleral lenses have become an important treatment alternative in patients with irregular cornea (Schornack et al., 2019, 6) due to their proven stable centred position resting on the sclera instead of the cornea and their improved comfort compared to other contact lens modalities. However, according to previous studies, scleral lenses are still not widely used due to the lack of commercial availability (J. S. Harthan et al., 2021; M. Schornack et al., 2019).

The scleral lenses used today are helpful in many cases and have many advantages. Some of the advantages are good comfort and the possibility of masking an irregular cornea (van der Worp et al., 2014b, 240). According to the study conducted by Schornack et al. in 2019, the primary indication for prescribing scleral lenses among optometrists was an irregular cornea. The largest patient

group (87%) had an irregular cornea, followed by ocular surface disease (8%). Although respondents from 26 countries participated in the study, most were from the United States. As with a rigid corneal lens, the scleral lens gives good visual acuity, but in contrast to the rigid corneal lens, the scleral lens gives good initial comfort, similar to a soft contact lens. The possibility of fitting any corneal topography, the excellent optics created with a rigid lens surface accomplishing better visual acuity, and good initial comfort make the scleral lens a very good option for many types of eyes.(Fadel & Kramer, 2019; Macedo-De-araújo et al., 2022; M. M. Schornack, 2015.)

Scleral lenses have mostly been recommended for eyes with corneal irregularities, such as Keratoconus and Pellucid Marginal Degeneration, eyes that have undergone refractive surgery or eyes with an ocular surface disease, such as Sjögren Syndrome and Graft Versus Host Disease. Scleral lenses are, however, also helpful for patients with dry eyes. Literature of more recent dates states that Scleral lenses can also be beneficial for eyes without disease, i.e., eyes needing correction but with a healthy and regularly shaped cornea. (Barnett et al., 2021b; van der Worp et al., 2014b; Vincent, 2018.)

2.5 Studies on Scleral Lens Fitting

Studies report on scleral lens fitting and assessment strategies globally, but more often in the United States than studies made in Europe. The SCOPE study (The Scleral Lenses in Current Ophthalmic Practice: An Evaluation) was a worldwide online survey in 2015 among practitioners who had already fitted at least five patients with scleral lenses. The study focused mainly on the type of scleral lenses that were fitted, size and design, and to what type of patients, that is, the practitioner's fitting patterns. Scleral lens management was also investigated, asking what patient recommendations were given for lens filling and cleaning. A significant portion (71%) of the respondents were from the United States, but data was collected from more than 40 other countries. The results demonstrated an increased number of scleral lens fitters in the past decade. (J. Harthan et al., 2018; M. Schornack, 2017.)

The SCOPE study group conducted another survey in 2017 among attendees at the Global Specialty Lens Symposium (GSLS) in Las Vegas, Nevada. 95 optometrists replied, and the results

revealed that 58% had been fitting scleral lenses for less than five years and 42% for more than five years. The more experienced fitters used new instruments more frequently than novice fitters.

Woods et al. (Woods et al., 2020) provided insights from a comprehensive global survey conducted by The International Contact Lens Prescribing Survey Consortium spanning from 2000 to 2019. The study aimed to ascertain the prevalence and pattern of scleral lens fitting worldwide. Data collected from contact lens practitioners across 40 countries revealed that scleral lenses were predominantly prescribed as specialty contact lenses, primarily for older demographics. Additionally, the survey highlighted a substantial surge in scleral lens utilisation since 2011. Scleral lenses represented only 0.76% of the reported contact lens fits, with significant variation observed between countries, ranging from 0% to nearly 6%.

Since 2001, Contact Lens Spectrum has annually compiled an international overview of contact lens prescribing. With a total of 71 countries participating since the turn of the century, it tracks global prescribing trends. Data collection involves proactive submissions from practitioners detailing ten contact lens fits conducted after the survey period's commencement, including patient demographics, lens specifications, and care regimens. The collected data are presented in seven lens categories: rigid lenses, ortho-k, daily disposable hydrogel, daily disposable silicone-hydrogel, reusable hydrogel, reusable silicone-hydrogel, and soft extended-wear lenses. The report 2022 highlights a decrease in the rigid lens category from 2001 to 2011. However, this lens group has reported no decrease in the last 12 years. Scleral lenses are included in the rigid lens category, and the report reveals that the number of scleral lenses is increasing in the rigid lens category. (Morgan et al., 2023.)

To what extent scleral lenses are prescribed is affected by contact lens practitioners' knowledge, and the increased interest in scleral lens fitting has impacted optometry education. This is described in the study performed by Harthan J et al. (2023). A survey was made among fourth-year optometry students in the United States 2020, investigating what year in the education scleral lens education was performed and to what extent. Most students reported receiving didactic scleral lens education, but the study reported insufficient clinical skills among the students. (J. Harthan et al., 2023.)

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

3.1 Purpose of the Research

The purpose of my research was to investigate to what extent scleral lenses are fitted in the Nordic countries and what the most common diagnosis is when prescribing scleral lenses in this region. The intention was to explore the fitting patterns in the Nordic countries and investigate similarities and differences between the countries.

3.2 Statement of the Research Question

What are the fitting patterns of scleral lenses among optometrists in the Nordic countries?

3.3 Study Objectives

3.3.1 Study Objective 1

To develop a survey comprising questions that align with the purpose of the study.

3.3.2 Study Objective 2

Distributing the survey to obtain a representative sample of the target population, maximising response rates and minimising bias, thereby enhancing the representativeness of the sample and the generalizability of the study findings.

3.3.3 Study Objective 3

To analyse the survey answers using descriptive statistics.

4 IMPLEMENTATION OF THE RESEARCH DEVELOPMENT WORK

4.1 Methodology

A survey study was designed to identify the extent of scleral lens fitting and fitting patterns in the Nordic countries. All contact lens practitioners in the region were invited to participate and respond to an online-based questionnaire to identify the number of optometrists fitting scleral lenses and when this lens modality was chosen by the optometrists in Denmark, Finland, Norway, and Sweden. The questionnaire included questions for optometrists fitting scleral lenses, as well as to optometrists not fitting scleral lenses, asking about their willingness to fit scleral lenses. Data collection spanned from June to October 2021. Given the absence of patient data collection or analysis, Institutional Review Board (IRB) approval was deemed unnecessary. The collected data underwent descriptive statistical analysis.

4.2 Development Methods and Data Collection

4.2.1 Study Objective 1

In order to develop a survey comprising questions that align with the purpose of the study, investigating the fitting pattern of scleral lenses and how many optometrists in the Nordic countries are fitting scleral lenses, an online survey is to be designed. An online anonymous questionnaire with multiple choice questions (Appendix 1) aims to identify the number of optometrists fitting scleral lenses and when this lens modality is chosen. The questionnaire will be constructed in English and designed to explore optometrists' current use of scleral lenses and their willingness to fit scleral lenses. Google Forms is the format to be used, allowing the respondents the possibility to translate the questions to a language of their choice, and making the survey easily accessible. Optometrists who fit any type of contact lenses will be invited to participate in the questionnaire, including up to 16 questions. The aim of the questions is to explore the number of contact lens fitters in the Nordics

that are currently using scleral lenses. Moreover, the goal is to reveal the interest among practitioners in starting to fit scleral lenses. All respondents will first encounter four introductory questions, followed by two additional questions tailored for practitioners who do not fit scleral lenses and 12 questions designed specifically for those who fit scleral lenses. The initial questions will pertain to nationality, workplace, and whether or not the respondent is fitting scleral lenses. The intention is to investigate differences and similarities among the respondents in regard to these objectives. The following questions include topics on instruments used in the contact lens fitting process, indication of scleral lens use, and adverse findings on follow-up visits. The final question addressed to eye care professionals fitting scleral lenses will be an open-ended question, allowing practitioners to express their preferences for future scleral lens options. The questionnaire will undergo testing among a selected group of optometrists prior to distribution, and any necessary adjustments to the questions will be made accordingly.

4.2.2 Study Objective 2

To obtain a representative sample of the target population, maximise response rates, and minimise bias, the survey will be distributed equally to the optometry organisations in four Nordic countries: Denmark, Finland, Norway, and Sweden. Additionally, it will be shared on Facebook with Optometry groups in the mentioned countries, inviting all contact lens fitters in these nations to participate.

The survey will be uniformly distributed to the four countries to prevent potential variations in results arising from differences in survey distribution methods. The survey will remain open from May to November 2021.

4.2.3 Study Objective 3

The data collected will be analysed using descriptive statistics. The results are to be presented in section 4.5.1.

4.2.4 Research Development Actors

The cooperative partner for this research work is Multilens AB, Skinnefjällsvägen 1, 435 25 Mölnlycke, Sweden. Multilens is a Swedish company that designs, produces, and sells special optics, both spectacle lenses and contact lenses. Their involvement as a project partner aimed to gain insights into scleral lens fitting patterns among optometrists in the Nordic countries and to anticipate potential changes in the future. This information will contribute to product development, expansion of their portfolio, and planning of specialised courses for optometrists in the region.

4.3 Reliability of the Research Development Work

The theoretical background for the thesis was collected to provide a solid framework for this research, to validate the necessity of the research, and to furnish a basis for comparing the findings obtained from this study. There have been previous scientific studies on scleral lenses; however, they have not focused on the Nordic countries. This survey study serves as a pivotal snapshot, capturing the prevailing landscape at the time of conducting. By delving into the scleral lens fitting practices within the Nordic region, it aims to fill the existing gap in the literature and shed light on a segment hitherto unexplored. Through a systematic examination of the survey data, this research contributes valuable insights into the current status and trends of scleral lens fitting within Nordic countries.

4.4 Ethicality of the Research Development Work

The guidelines of the Finnish National Board on Research Integrity were followed, using good scientific practice. This survey study did not need IRB approval since it quantified clinical service-related patterns without including patient data. It is pertinent to clarify that while I am employed by Multilens, I did not receive any payment from the company for conducting this survey study, thus eliminating any potential conflict of interest.

4.5 Evaluation of the Research Development Work

The data from the online questionnaire collected was analysed using descriptive statistics, focusing on the research question and the further aims of this study. The result is presented below. Jörgen Gustafsson, the mentor in this project, was involved during this process and contributed valuable insights.

Multilens played a peripheral role as a cooperative partner in this project, and there was no economic benefit for the author of this thesis. Their involvement aimed to gain insights into scleral lens fitting patterns among optometrists in the Nordic countries and anticipate potential changes in the future. The result of this study may contribute to product development, expansion of their portfolio, and planning of specialised courses for optometrists in the region.

4.5.1 Results of the Survey

The online survey resulted in 301 respondents answering the questionnaire. All questions are available for review as Appendix 1.

The first question in the questionnaire was, “In which country are you working?” No Danish optometrists responded to the online survey, and the majority of the replies were from Swedish optometrists. 64% of the respondents were from Sweden, 18% from Finland, and 18% from Norway. This result is shown in Figure 10.

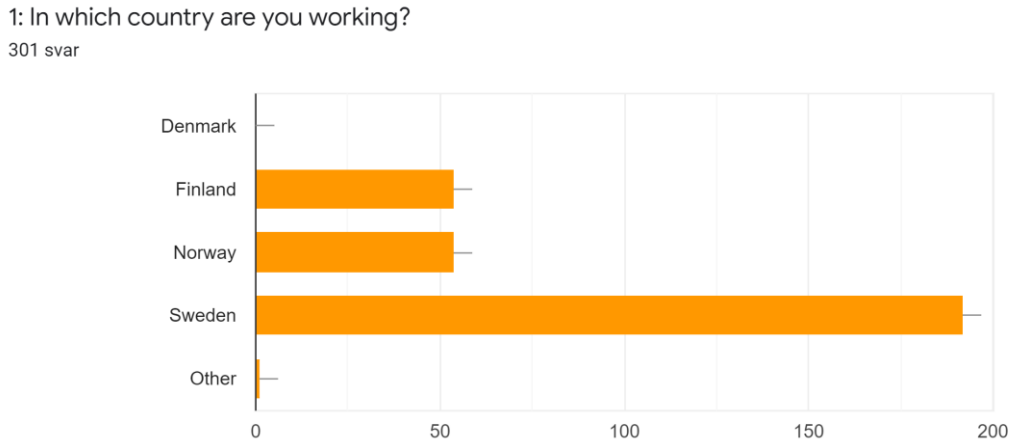

FIGURE 10. Presenting the country in which the respondents were working. n=301.

One of the primary intentions of this thesis was to determine the proportion of optometrists fitting scleral lenses in the Nordic countries. Figure 11 illustrates that 42% of the optometrists answering this survey were fitting scleral lenses.

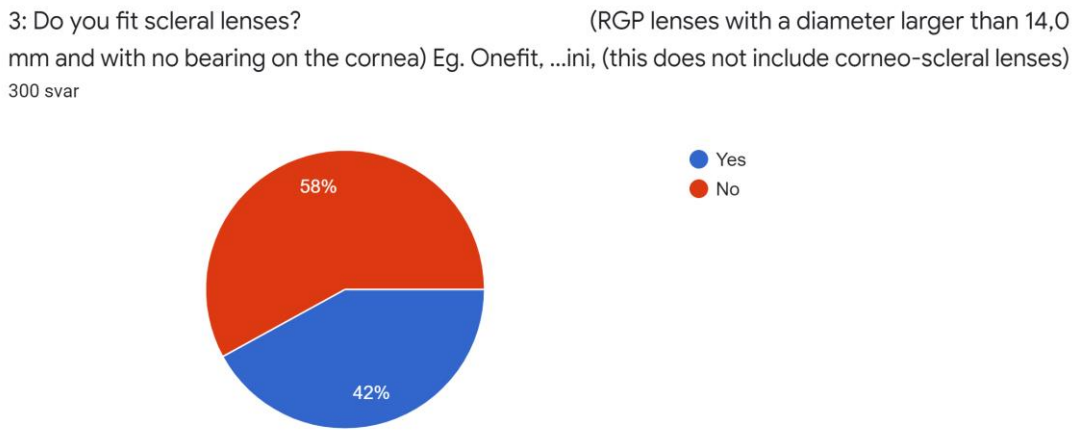

FIGURE 11. Showing the number of practitioners fitting scleral lenses in the Nordic countries.

The results of the questionnaire showed a much larger portion of scleral lens fitters in Norway than in Finland. There were equal numbers of respondents from Finland and Norway; thus, the results can be considered comparable. 12 of the respondents in Finland (22%) were fitting scleral lenses, whereas in Norway, the number of optometrists fitting this type of lens was 46 (85%). In Sweden, 36% of the respondents were fitting scleral lenses (69 optometrists), as seen in Figure 12.

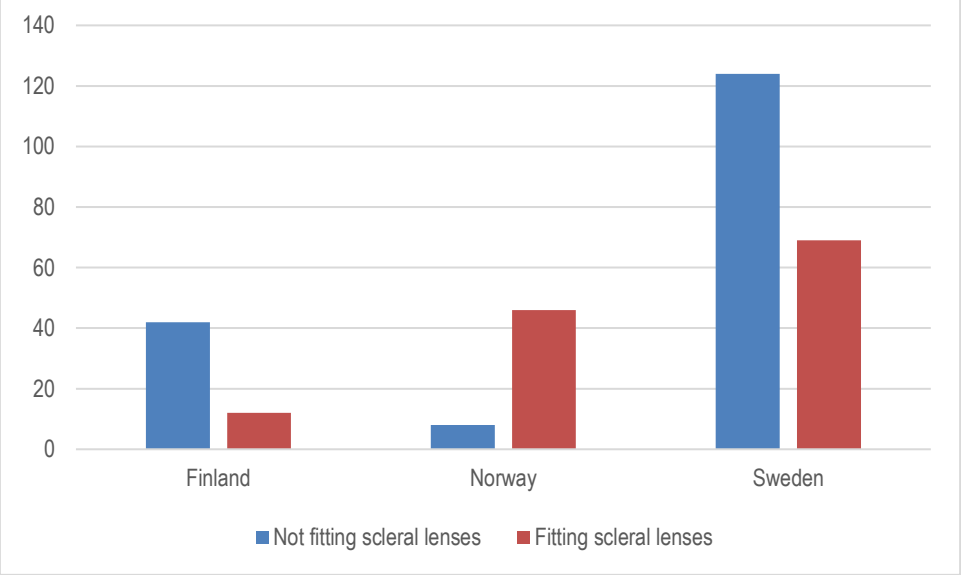

FIGURE 12. Number of optometrists fitting scleral lenses presented by country.

48% of the optometrists who responded to the survey worked in an optical-chain store. and 9% worked in an eye clinic at a hospital or a low-vision clinic. (figure 13)

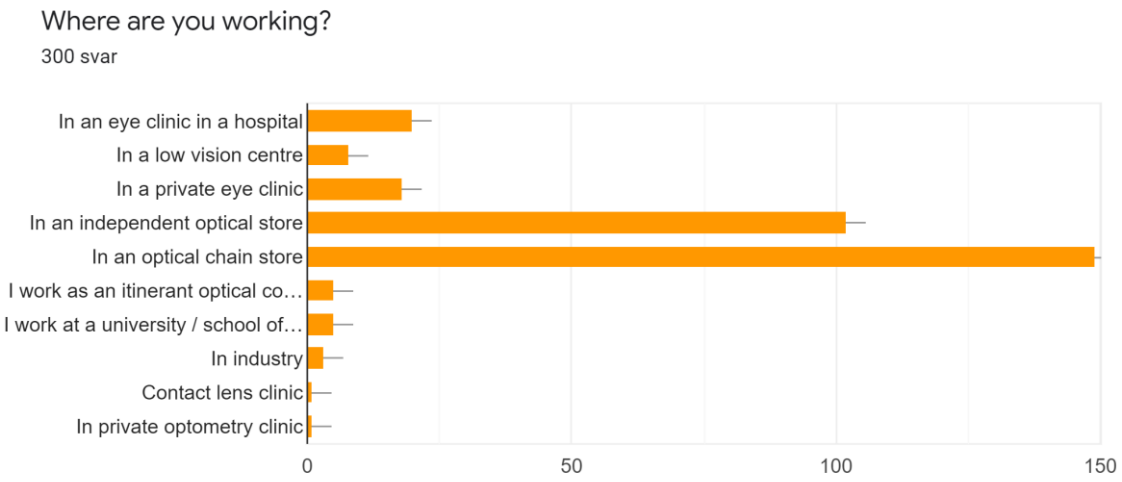

FIGURE 13. Workplace of the optometrists answering the survey questionnaire. N=300

One aim of this survey was to investigate whether there was variation in the number of scleral lens fitters across different types of workplaces. The data collected revealed a difference between Sweden and Norway. The optometrists prescribing scleral lenses in Sweden worked mainly in an independent optical store or a hospital setting. The scleral lens fitters in Norway worked mainly in an optical chain store. (Figure 14)

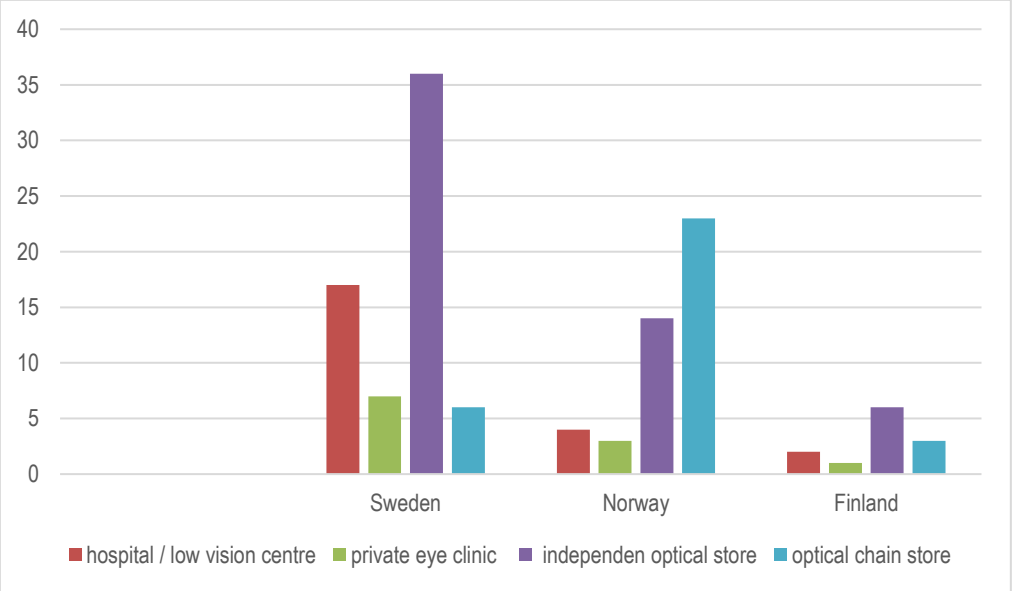

FIGURE 14. The workplace of the Scleral Lens Fitters answering the questionnaire.

The questionnaire included specific questions exclusively for optometrists already fitting scleral lenses, aiming to analyse fitting patterns among these optometrists. These questions included the time of scleral lens practice, to what diagnosis scleral lenses were recommended, and whether scleral lenses were prescribed to patients with dry eyes.

Figure 15 presents results of duration of professional experience. 70% of the respondents had over ten years of professional experience, while 17% had less than six years of practice. 41% reported having more than 20 years of experience (Fig.15).

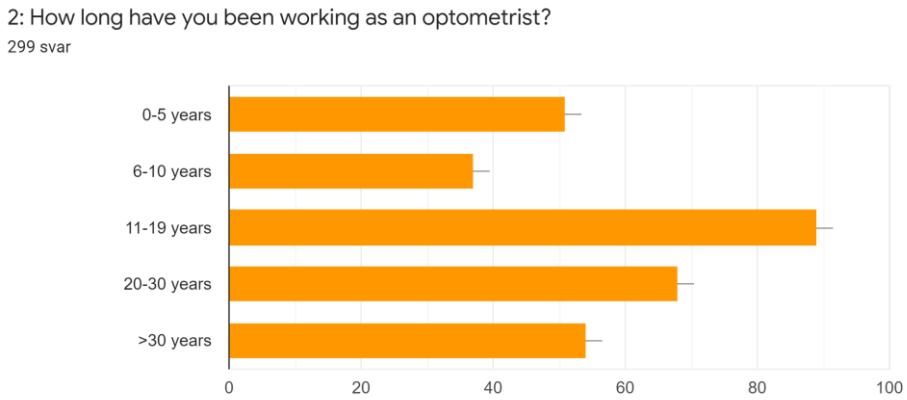

FIGURE15. Years of work experience.

When comparing the length of work experience with the number of optometrists fitting scleral lenses, 51% of those fitting scleral lenses had over 20 years of experience in optometry. It was less common for optometrists with less than ten years of experience to fit scleral lenses.

6% of optometrists with less than 6 years of experience were fitting scleral lenses, with a similar proportion observed among those with 6-10 years of experience. The distribution of scleral lens fitters was relatively even among the other three experience groups.

Figure 16 presents the duration of experience in fitting scleral lenses. The majority of the respondents with scleral lenses in their work portfolio reported having up to 10 years of experience in fitting scleral lenses, while a total of 13% indicated an experience exceeding 10 years in scleral lens fitting. 46% had less than five years of experience in fitting scleral lenses. In Sweden and Norway, the results were somewhat similar. In Finland, 92% of the respondents had less than five years of

experience in scleral lens fitting, meaning that there is less experience with scleral lenses in Finland.

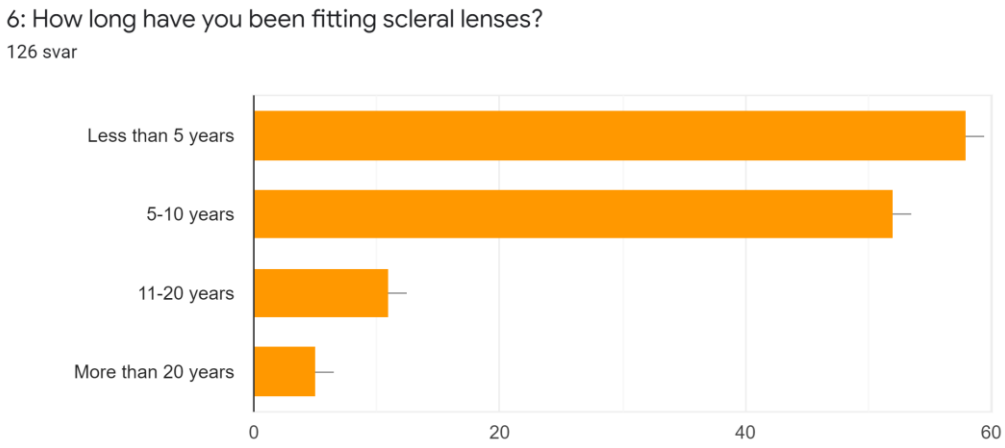

FIGURE 16. Duration of experience in fitting scleral lenses.

According to the collected data, figure 17 reveals the primary diagnosis for fitting a scleral lens. The optometrists currently fitting scleral lenses indicated a predominant use of this lens modality for patients diagnosed with Keratoconus. The second most common application was post-graft cases, followed by ocular surface disease as the third most frequent diagnosis.

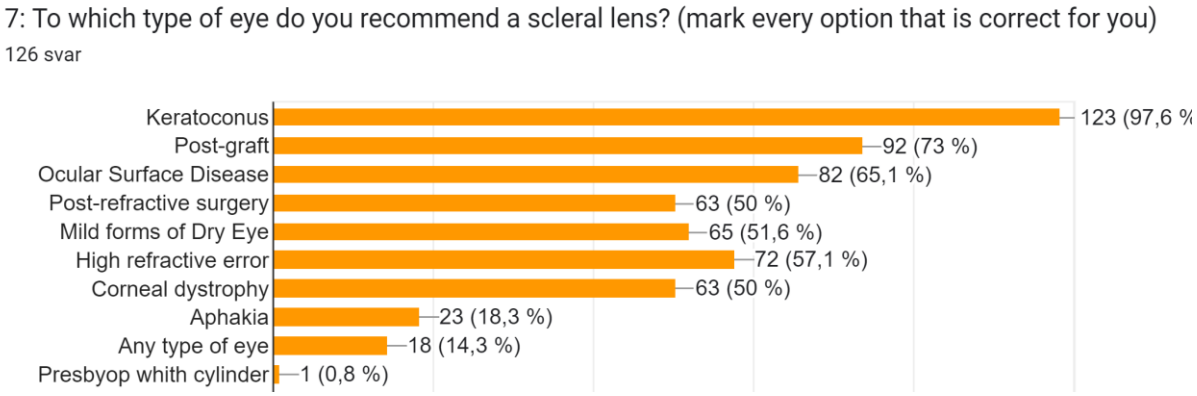

FIGURE 17. The main eye condition that was prescribed a scleral lens.

A scleral lens can be used to manage dry eye disease. The fluid reservoir of the scleral lens functions as a moisture chamber. The survey findings illustrate that there is a knowledge of this possibility. 63% reported using a scleral lens as a treatment for dry eye disease. (fig. 18)

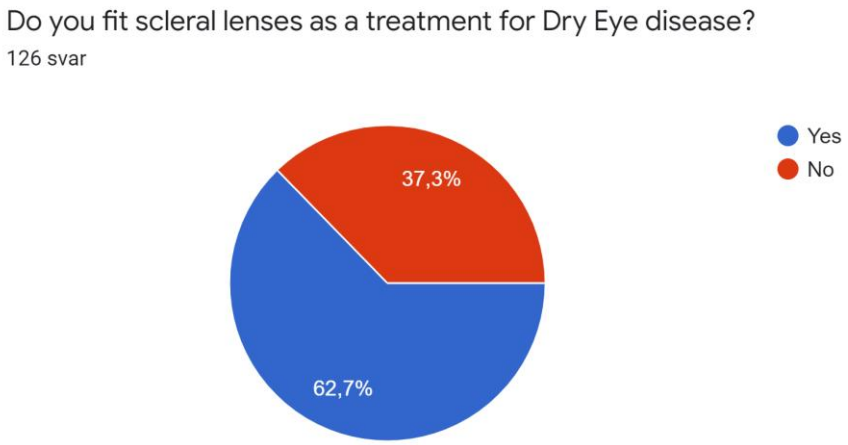

FIGURE 18: Amount of scleral lens fitters using scleral lens for dry eye disease (DED).

Comparing the Nordic countries showed that it is more common in Sweden to use a scleral lens as a treatment for dry eye disease than in Finland and Norway. 72% of the scleral lens fitters in Sweden used this lens as a treatment for dry eyes. In Norway, 49% of the fitters used this lens modality as a treatment for dry eye disease. In Finland, there was a 61% proportion. (fig. 19)

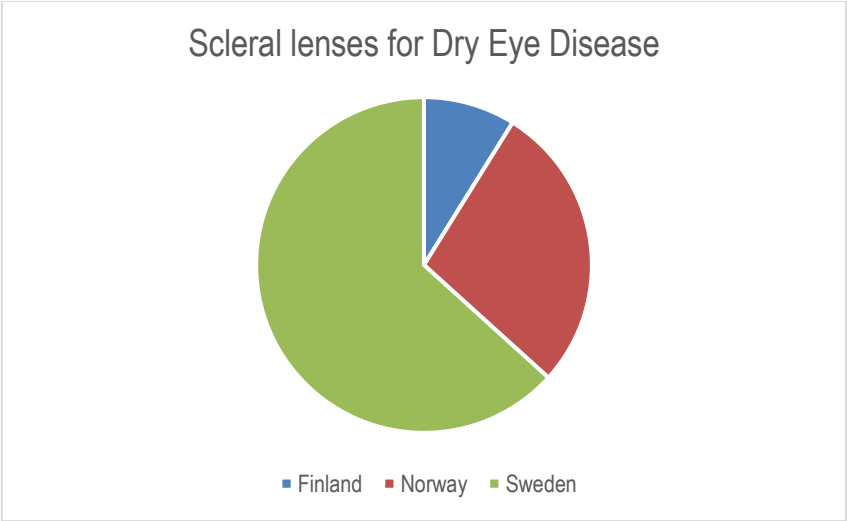

FIGURE 19. Percent of scleral lens use for dry eye disease in Finland, Norway, and Sweden.

The data collected showed similarities between the three countries in regard to which lens diameter was being used. A lens diameter of 16,0 mm or smaller was most frequently used by 90% of the respondents fitting scleral lenses. The result was equally reported in the three countries. (fig. 20)

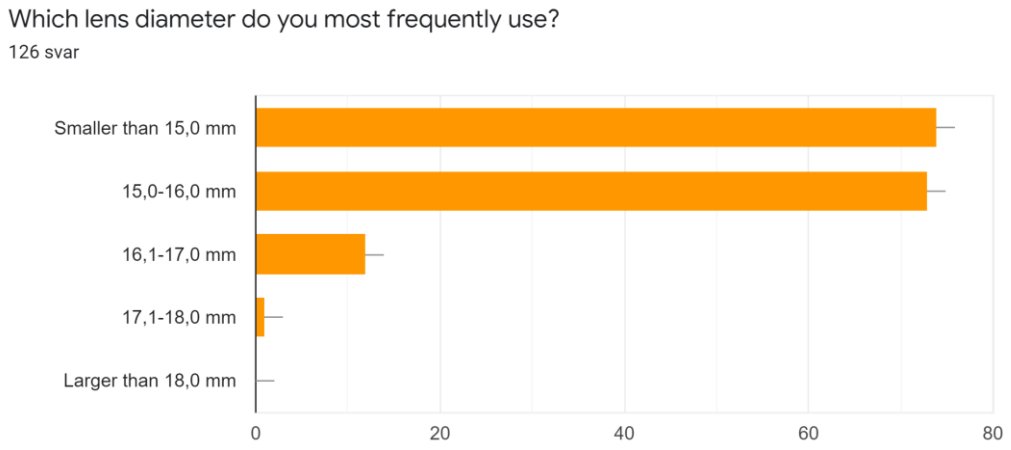

FIGURE 20. Lens diameter most frequently used.

The eye care professionals were also asked about the number of scleral lenses fitted during the last 12 months. (figure 21)

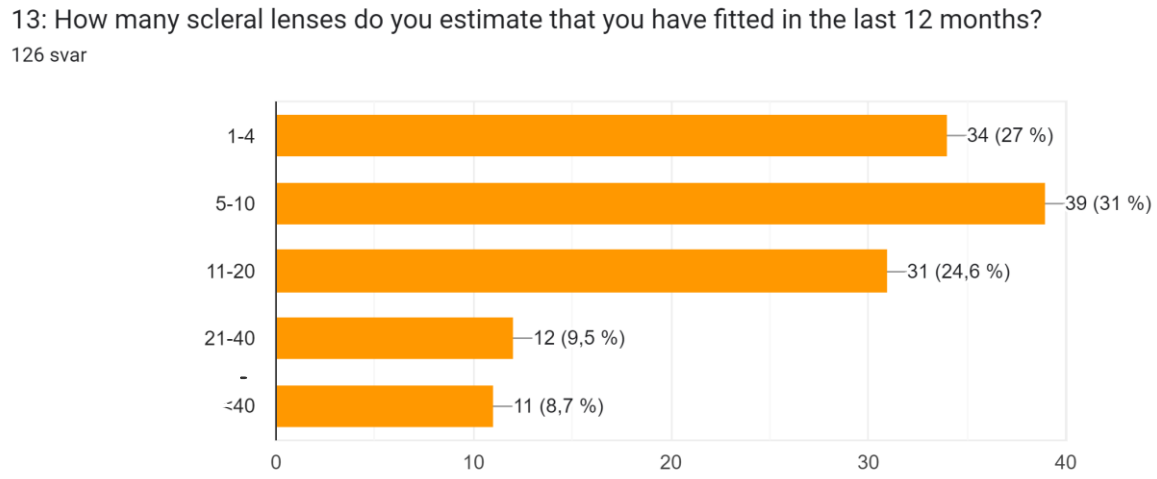

FIGURE 21. Number of scleral lenses fitted during the last 12 months.

58% of the scleral lens fitters reported having performed less than 10 scleral lens fittings during the last 12 months. 16% reported having fitted more than 20 scleral lenses, and this was mainly done by Swedish practitioners.

In order to investigate scleral lens fitting patterns further, the respondents were asked about the instruments used during the fitting procedure. As mentioned earlier in this thesis, different instruments can be used to facilitate the fitting. A corneal topographer is useful for every contact lens fitting, as well as for evaluating the corneal shape and diagnosing keratoconus. An anterior OCT measurement is normally not used for soft lens or rigid corneal lens fitting. However, it is useful for scleral lens fitting, giving an exact measurement of the central corneal clearance and limbal clearance (fluid reservoir thickness). It is also valuable to obtain a picture of the lens fit, especially the lens landing on the conjunctiva. Figure 22 shows the use of topographer and OCT among the Nordic scleral lens fitters and illustrates that a topographer is being used to a great extent. OCT is, however, not as common. Comparing the three countries reveals a difference in the use of OCT. 55% of the Norwegian scleral lens fitters used OCT. Meanwhile, the percentage in Sweden was 34%, and in Finland, it was only 7%.

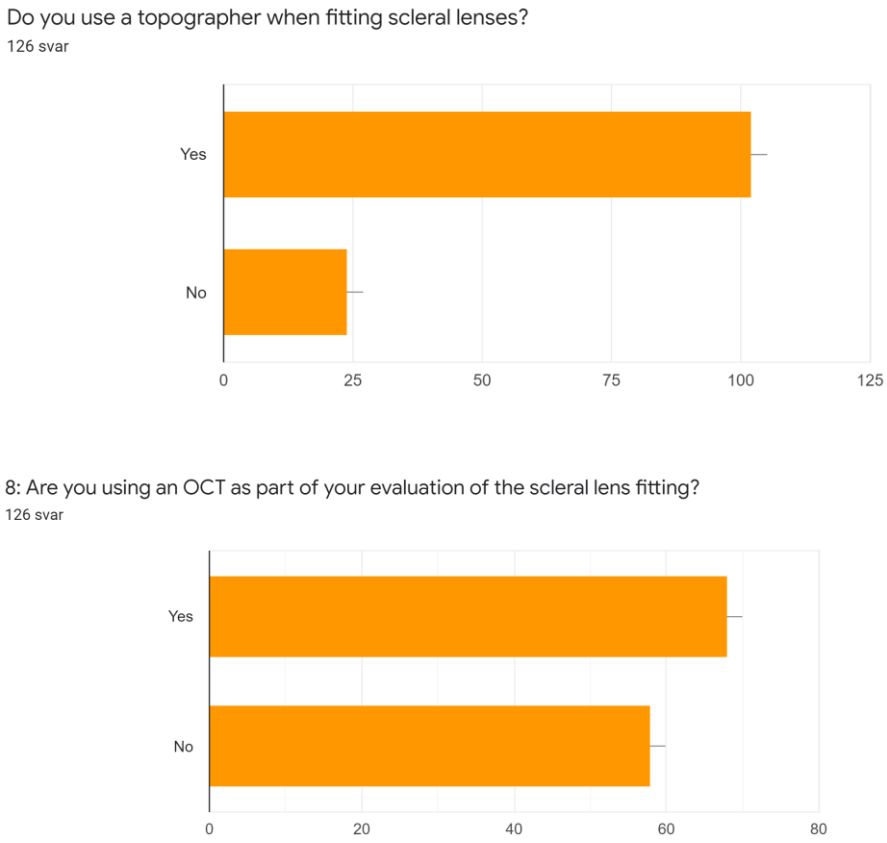

Figure 22. The use of topographer and OCT instruments. n=126

This survey also included an open question, giving the respondents the opportunity to share their ideas about future scleral lens options. 38 respondents seized this opportunity to address their wishes and ideas for new options. “Prism correction in all axis”, “more advanced customisation for complex corneas”, “total digital fitting”, and “that they would be tintable”, were some replies. Other examples were oval optic zones, wavefront-guided optics for higher-order aberrations, prism correction, 3D-printed lenses, and scleral lenses for myopia management. Many wished for the possibility of ordering a scleral lens directly from a topographer/profilometer.

The questionnaire was designed with specific questions for the respondents who did not fit scleral lenses. Among the respondents, 58% confirmed they were not currently fitting scleral lenses. The primary reason was reported to be a lack of knowledge about the fitting routine, followed by a limited encounter with patients requiring this lens modality in their clinic or optical store.

4.6 Discussion

This study demonstrates that a significant number of optometrists fit scleral lenses in the Nordic countries. Based on the respondents' answers to the survey, 42% of the eye care professionals in the Nordic countries are fitting scleral lenses. However, this study shows significant differences between the three countries. In Norway, the number of scleral lens fitters was very high (85%); in Sweden, 36% of the optometrists were fitting scleral lenses, and in Finland, only 22%.

According to the data collected, there is a higher portion of Norwegian optometrists fitting scleral lenses than in Finland and Sweden. The low number of optometrists in Norway who do not fit scleral lenses most likely do not find an interest in this lens modality. Nevertheless, a significant portion of the respondents in the Nordic countries who did not fit scleral lenses expressed a willingness to consider fitting scleral lenses if there were accessible and straightforward resources for learning about scleral lens fitting. To the question, “Would you consider fitting scleral lenses?” 62% replied: “Yes, if there would be an easy way to attend a course and learn how to fit scleral lenses”.

Looking deeper into this, country by country, the survey data shows that 44% of the Norwegian optometrists not fitting scleral lenses would consider doing so if there was an easy way of learning, whereas, in Finland and Sweden, the number was higher, around 65%.

In Sweden, 22% of the non-scleral lens fitters were not interested in scleral lenses. This portion was 33% in Norway and 16% in Finland.

The second most common reason for not fitting scleral lenses was not meeting patients who needed this particular lens type. The third reason was the optometrist not being free to choose what lenses to offer their patients.

The survey data provides insights into the work settings of optometrists in Finland, Norway, and Sweden. The survey results indicated that the majority of respondents were employed in optical stores, which could be either independent or chain stores. It is noteworthy that there were differences in the workplace locations among the Nordic countries. In Norway, optical chain stores were the most popular workplace for scleral lens fitters. In contrast, in Sweden and Finland, eye clinics, independent optical stores or hospitals, and low-vision departments were the most common workplaces for these professionals.

The data indicates a diverse range of experience levels, with professionals in the field from up to 5 years to over 30 years. Among the scleral lens fitters, a noteworthy proportion possessed substantial professional experience, with 20-30 years of experience in optometry. 51% of optometrists fitting scleral lenses had been working for more than 20 years as optometrists, meaning that most of the scleral lens fitters had extensive optometry experience, which can be seen as a safety assurance for the patients. Conversely, it was less common for optometrists with less than ten years of experience to fit scleral lenses. This suggests a correlation between years of experience and scleral lens prescribing, a trend observed consistently across the three countries surveyed. The less experienced optometrists can hopefully be inspired by colleagues and eventually find an interest in gaining knowledge in scleral lens fitting.

It is evident from the survey findings that the time of experience in fitting this lens modality is limited among most of the practitioners in the Nordic countries. The survey revealed a shorter duration of scleral lens experience in Finland compared to Norway and Sweden. Furthermore, a positive response to the question of eventually using scleral lenses in their practice is observed across all three countries and work settings.

Correlating to other studies and articles found, such as the SCOPE study and the Contact lens prescribing trends (Naroo et al., 2022; M. Schornack, 2017; van der Worp et al., 2014b), this study

revealed that keratoconus or other corneal irregularities were the main reasons for prescribing scleral lenses in the Nordic countries. A significant number of the scleral lens fitters (63%) reported using a scleral lens as a treatment for dry eye disease. The data showed that it was more common in Sweden to use a scleral lens as a treatment for dry eye disease in comparison to Finland and Norway.

To summarise the results, there were similarities among the three countries regarding the following questions: willingness to start fitting scleral lenses, scleral lens diameter being prescribed, and the use of scleral lenses for keratoconus. The results differed concerning the number of scleral lens fitters and their workplaces, the use of scleral lenses for dry eyes, and the use of OCT instruments in the lens fitting process.

When comparing the findings in this study to the SCOPE study (The Scleral Lenses in Current Ophthalmic Practice: An Evaluation) (M. Schornack, 2017), which was a worldwide online survey made in 2015, there is alignment in several areas. Correlation can be seen regarding the work setting, indication of scleral lens use, and years of scleral lens fitting. Both studies show that the majority of scleral lens fitters work in private practice. The SCOPE study showed that 63% were working in private or retail practice, and this survey, focusing on the Nordic countries, found an even higher proportion, with 79% of the scleral lens fitters situated in private practices.

The scleral lens is, without doubt, an excellent lens for corneal irregularities, and this fact can be considered known to optometrists in the Nordic countries when looking at the data from this survey made in the Nordic countries. The SCOPE study indicated that the primary reason for fitting a scleral lens was corneal irregularity, followed by ocular surface disease. This finding aligns with the results of this study. According to the SCOPE study, 10% of the fitted scleral lenses were for uncomplicated refractive error, which is a lower number than the number in this study. The reason could be that the scleral lens since 2015 has been more widely used even for uncomplicated refractive error.

The SCOPE study revealed a notable increase in the number of scleral lens fitters over the past decade, with a majority of respondents having commenced fitting scleral lenses within the last five years. This aligns with the findings of this survey, where 46% of respondents reported having started fitting scleral lenses less than five years ago and 87% within the last decade.

However, the survey made in the Nordic countries illustrates that a majority of the optometrists fitting scleral lenses had more than five years of work experience, while the data from the SCOPE study revealed that one-third of the scleral lens fitters had completed their optometry education between 2009 and 2014, i.e. had less than five years of work experience.

Similar to this study, the SCOPE study was conducted as an online survey. It encompassed data from 989 responses. The survey in this study, which focused on the Nordic countries, gathered 301 responses, yielding results that closely aligned with the SCOPE study conducted in 2015. However, a notable discrepancy emerges with respect to the preferred lens diameter. In the Nordic countries, scleral lenses with a diameter less than 16.0 mm predominate, deviating from the SCOPE study's findings, which indicate a more common use of lens diameters falling within the 15-17 mm range. Notably, our study highlights a prevalent use of lens diameters smaller than 15 mm, constituting 59% of respondents, whereas the SCOPE study reported only 18% of fitters favouring diameters smaller than 15 mm. This disparity underscores a noteworthy regional variation in the choice of scleral lens diameter between the Nordic countries and the broader SCOPE study population.

Each year, the Contact Lens Spectrum presents data from international contact lens prescribing. (Morgan et al, 2023) In 2022, 12% rigid lenses were being prescribed worldwide. Sweden reported a lower number, only 4%. This includes both corneal and scleral lenses. The report from 2021 shows that 12% of rigid lenses were prescribed during 2021 and explains that scleral lenses represent a small number of these fits: only 22%. The Netherlands presented the most significant number of scleral lens fits during 2021. (Morgan et al, 2023.)

According to the report on International Contact Lens Prescribing in 2022, the number of rigid lenses prescribed worldwide has been stable during the last decade. However, the number of scleral lenses is increasing worldwide to approximately 25% of the rigid lens fits. The exact number for the Nordic countries was not presented. Morgan & Efron describe the decline of corneal rigid lenses being fitted in the UK from 22% in 1996 to 2% in 2020. Between 1996 and 2013, scleral lenses were very rare and increased rapidly during the following eight years. (Morgan & Efron, 2022.) No study was found focusing on the Nordic countries regarding scleral lens fitting.

J.S.Harthan et al. examined the amount of time devoted to scleral lens fitting in the curriculum of optometry schools in the United States. This showed that the average allocation of time within the curriculum for scleral lenses was approximately 15% (J. S. Harthan et al., 2021.) Based on my

industry expertise, I am aware that courses focusing on scleral lens fitting are offered in the Nordic market. Furthermore, I have found that optometry schools in Finland, Norway, and Sweden incorporate scleral lens fitting into their curricula. So, in this aspect, one can argue that the Nordic countries are up to date with scleral lens use.

As described earlier in this paper, the scleral lens is a lens type with a long history. However, the modern scleral lens has only been used to a larger extent during the last two decades. Articles and studies report that the scleral lens is still evolving and growing in popularity. There are now more optometrists with knowledge of the fitting and more contact lens labs that produce scleral lenses. (van der Worp et al., 2014b.) This could have an impact on this study compared to the SCOPE study made in 2015. However, this study aligns with global trends, which show that the knowledge of scleral lenses is growing and being used to an increased extent.

It is reassuring to note that scleral lenses are available in the Nordic countries for patients who benefit from them. Moreover, a substantial number of optometrists express a willingness to fit scleral lenses, providing enhanced accessibility to this specialised form of vision correction.

4.6.1 Limitations of This Survey Study

The survey received responses from 301 participants, a number considered relatively low given the total population of optometrists and opticians in the surveyed countries. The questionnaire targeted optometrists or opticians fitting contact lenses in Denmark, Finland, Norway, and Sweden. While Sweden is estimated to have around 2200 opticians/optometrists, the exact number engaged in regular contact lens fitting is unknown (SACO. https://www.saco.se/studier/studieval/yrken-a-o/optiker/, n.d). It is plausible that a higher proportion of scleral lens fitters participated in the survey, as they may have been more inclined to engage with a survey tailored to their specific area of interest.

Due to the absence of respondents from Denmark, the result of this survey may not be applicable for scleral lens fitting in Denmark. Differences were revealed between the three countries: Finland, Norway, and Sweden. It is, therefore, reasonable to anticipate that there would be differences also in comparison to Denmark. The predominant portion of respondents were from Sweden, possibly affecting the results of this study.

This study does not give information about education or sex. It does not give information about the geographic location of the respondents in each country, i.e., it does not tell whether there are optometrists fitting scleral lenses spread across the countries or mainly in the big cities, for instance. It would be intriguing to explore the geographical distribution of scleral lens fitters to determine if they are evenly dispersed across the country. This information could shed light on the accessibility of scleral lens services, especially in rural areas, ensuring that patients needing such specialised care have equal access regardless of their geographic location.

The social welfare structure could affect to what extent a scleral lens is fitted, which is a field to explore more about in a further study.

4.7 Conclusion

The last decade has meant increased use of scleral lenses worldwide due to improved lens design, technology, and improved lens material. The scleral lens can improve vision and quality of life for patients with corneal or ocular surface issues, and it is therefore important that this lens modality is available to every patient in need of it.

As described earlier, the purpose of this work was to investigate to what extent scleral lenses are fitted in the Nordic countries, as well as the interest among clinicians in this lens modality and what would make them include scleral lenses in their practice.

The number of analysed responses in the survey made in this study was 301, which is a relatively low number compared to the number of contact lens fitters in the Nordic countries. However, this study shows a trend and tells us that it is currently more common among Norwegian optometrists to fit a scleral lens than among Finnish optometrists.

42% of the respondents were fitting scleral lenses and a majority used this modality as a treatment for dry eye disease. The primary reason for not fitting scleral lenses was a lack of knowledge. This study shows a significant interest among contact lens fitters in the Nordic countries to start fitting scleral lenses among those not already fitting this modality. 63% of the optometrists who were not

fitting scleral lenses would consider fitting scleral lenses if there was an easy way to attend a course and learn the fitting procedure.

The number of rigid lens fittings in the Nordic countries has been small during the last decades (Johansson, 2019), which may affect the degree to which scleral lenses are fitted. The scleral lens has undergone enormous development over the past 10-20 years and is still evolving. This means that the number of fitted scleral lenses is most likely still increasing. The information from this survey can serve as a foundation for further investigation in the Nordic countries, guiding future research in the field. Further studies are needed in scleral lenses and advert events, their effect on intraocular pressure, fitting strategies, and much more. Further studies are welcomed.

5 TIMETABLE AND BUDGET

The research project commenced in 2021. The questionnaire was developed and distributed during the spring and summer months. Data collection took place until autumn 2021, followed by data analysis, literature review, and writing throughout 2022 and 2023.

As the study was self-funded, no budget was allocated.

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APPENDICES

5.1 Appendix 1: Literature Search

The purpose of the literature search was to search for studies of modern scleral lenses aiming for background knowledge on what previous studies showed regarding scleral lens fitting.
A literature search was made to find data on scleral lens fitting using PubMed and the search terms "scleral lens" AND "fitting" NOT "intra ocular".
Applying the following search limits:

- Text availability: Full text only.
- Language: English language only.

Eligibility criteria:

- Scleral lenses

Exclusion criterion:

- Intra-ocular lenses.

There is an increased number of studies on scleral lenses from around 2007 and a more rapid increase since 2015.

To find scientific papers on scleral lenses further data was searched using search terms:
((((refractive ametropia) OR (refractive error)) OR (ametropia)) AND ((((((contact lenses) OR (contact lens)) OR (contact-lens)) OR (contact-lenses)) AND (((reusable) OR (multiple-use)) OR (multiple))) AND ((((((scleral) OR (corneo-scleral)) OR (rigid gas permeable)) OR (RGP)) OR (corneal)) OR (soft)))) AND ((treatment) OR (correction)) NOT ((((intra-ocular) OR (myopia control)) OR (disposable)) OR (intra ocular))

5.2 Appendix 2: Survey Questions

1: In what country are you working?

- Denmark
- Finland
- Sweden
- Other

2: Where are you working?

- In an eye clinic in a hospital
- In a low vision centre
- In a private eye clinic
- In an independent optical store
- In an optical chain store
- I work as an itinerant optical consultant.
- I work at a university / school of optometry.
- Industry
- Other……

3: How long have you been working as an optometrist?

- 0-5 years
- 6-10 years
- 11-19 years
- 20-30 years
- >30 years

4: Do you fit scleral lenses? (RGP lenses with a diameter larger than 14,0 mm and with no bearing on the cornea) E.g. Onefit,Misa, Senso Mini, (this does not include corneo-scleral lenses)

- Yes (continue to question 7)
- No

The questions below are for you who are not fitting scleral lenses.

5: What is your reason for not fitting scleral lenses?

- I do not meet patients/customers that ask that lens modality.
- I do not have the knowledge on how to fit scleral lenses.
- I am not able to choose which lenses we offer our customers.
- I do not fit contact lenses in my current workplace.

- I prefer fitting other lens modalities.
- Other reason

6: Would you consider fitting scleral lenes (mark what is correct for you)

- Yes, if there would be an easy way to attend a course and learn how to
- Yes, if I was free to choose what lenses to use for my patients.
- No, I am not interested in fitting scleral lenses.
- Other:

(The following questions are for current scleral lens fitters:)

1: How long have you been fitting scleral lenses?

- Less than 5 years
- 5-10 years
- 11-20 years
- more than 20 years

2: To which eye do you recommend a scleral lens? (mark every option that is correct for you)

Keratoconus

Post graft.

Ocular Surface Disease

Post-refractive surgery

Mild forms of Dry Eye

High refractive error

Corneal dystrophy

Aphakia

Any type of eye

Other:

3: Do you fit scleral lenses as a treatment of dry eye?

Yes

No

4: Which lens diameter do you most frequently use?

Smaller than 15.0 mm

15.0 – 16.0 mm

16.1 – 17.0 mm

17.1 – 18.0 mm

Larger than 18.0 mm

5: Do you use a topographer when fitting scleral lenses?

Yes

No

6: Are you using an OCT as part of the evaluation of the scleral lens fitting?

Yes

No

7: What insertion fluid to you prescribe / recommend for you scleral lens patient to use?

(to fill the lens)

Preservative free saline in a vial (Polyrinse-U / ML Saline / Unidose Saline)

Saline in a bottle

Any contact lens solution

Wetting drops

Other: _____

8: On how many of your follow-up visits in the last 12 months did you see the following findings on your scleral lens patients?

Corneal staining

Limbal staining.

Hypoxia

Neovascularization

Debris in the fluid reservoir

Conjunctival prolapse.

9: What is the most common issue that your scleral lens patients have?

Lens surface issues.

Unstable lens

Poor lens comfort

Debris in the fluid reservoir

Poor vision

My patients have not reported any issues with their scleral lenses.

Other:

10: If you refit a patient from a scleral lens to another lens modality, what is the most common reason for doing so?

I could not achieve a good fit with a scleral lens.

The eye did not tolerate a scleral lens.

Difficulties with lens handling

The lens was uncomfortable.

Visual acuity was not good enough.

The patient asked for another lens modality due to high cost.

Other: _____

11: How many scleral lenses do you estimate that you have fitted in the last 12 months?

1-4

5-10

11-20

21-40

>40

12: What scleral lens options do you hope will come in the near future?

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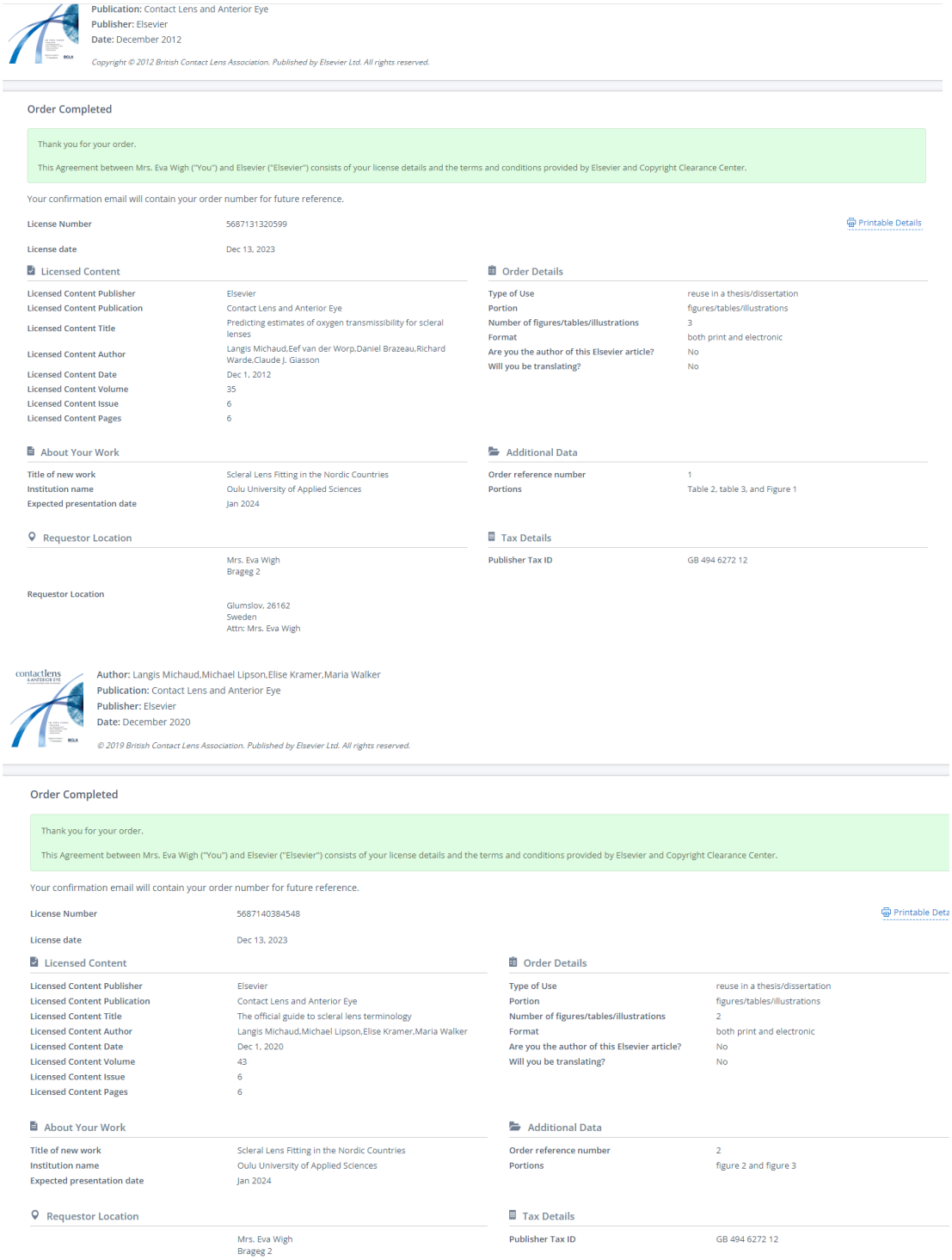

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