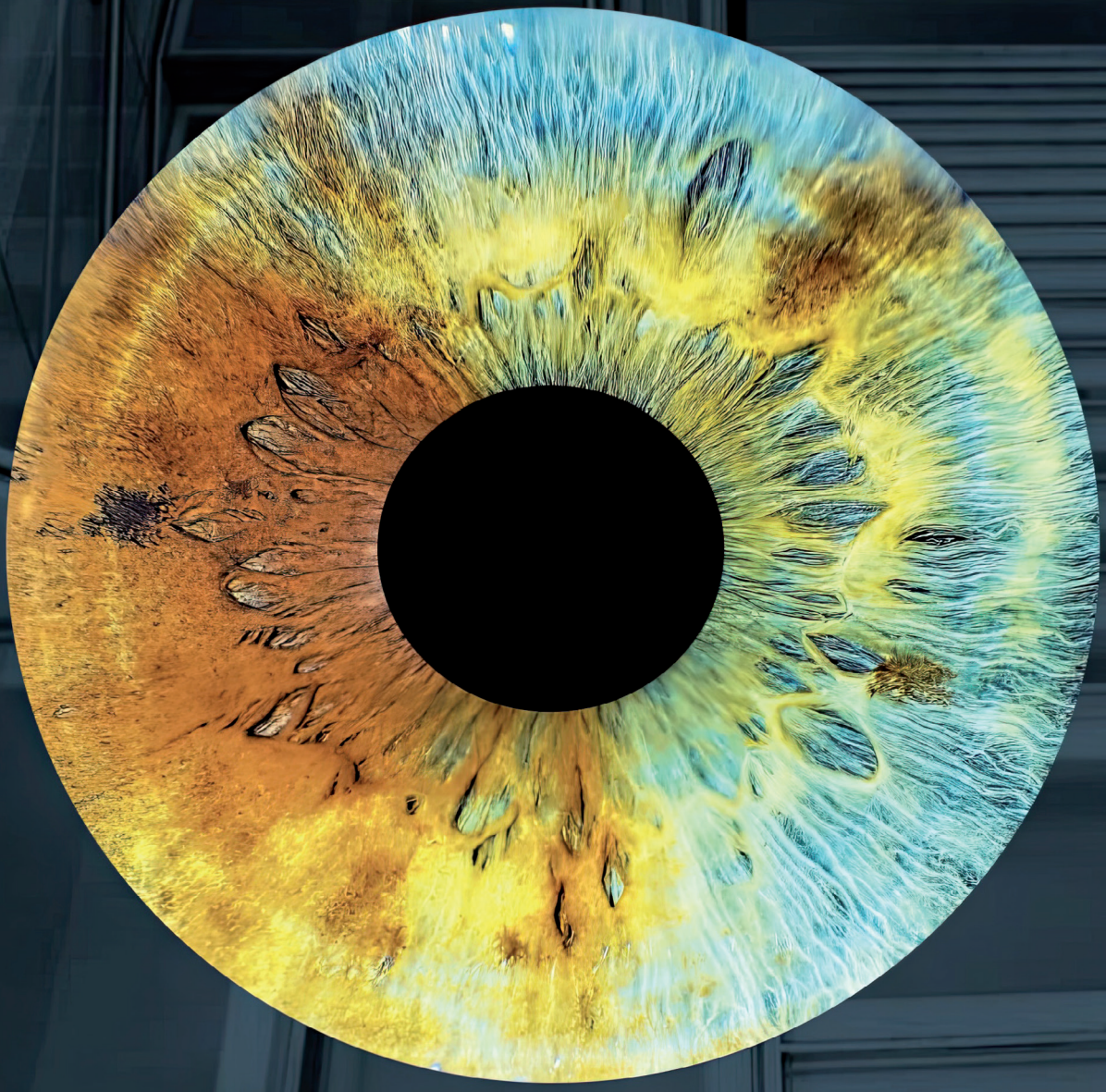
PHOTOABLATIVE IRIDOPLASTY

Therapy & Cosmetics



Atlas

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Dedication

“ Thanks for ten years of support and believing in the impossible ”

To:

Lucía and Carmina

Pedro and María

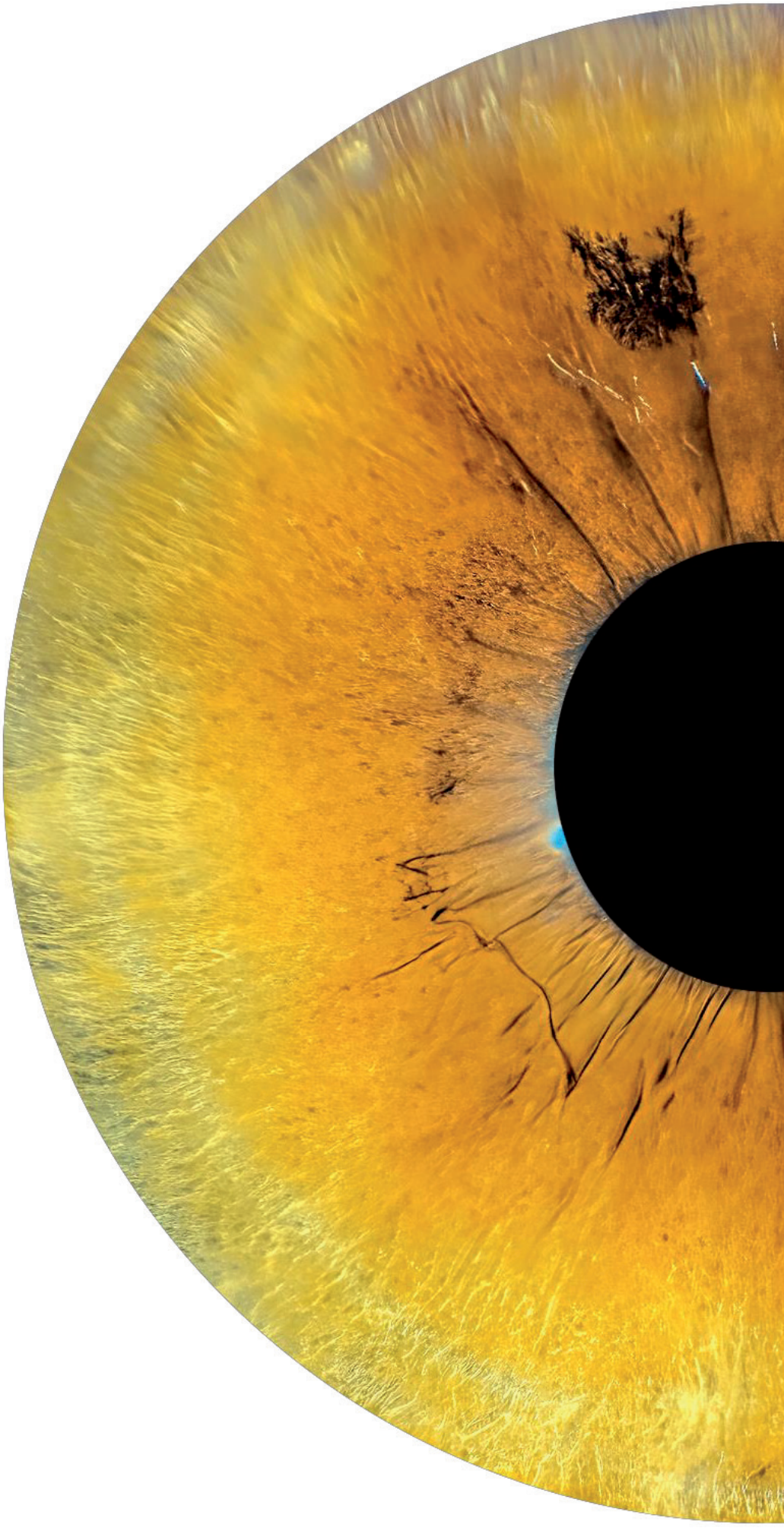
Toni, Josep, Roger, Marisa,

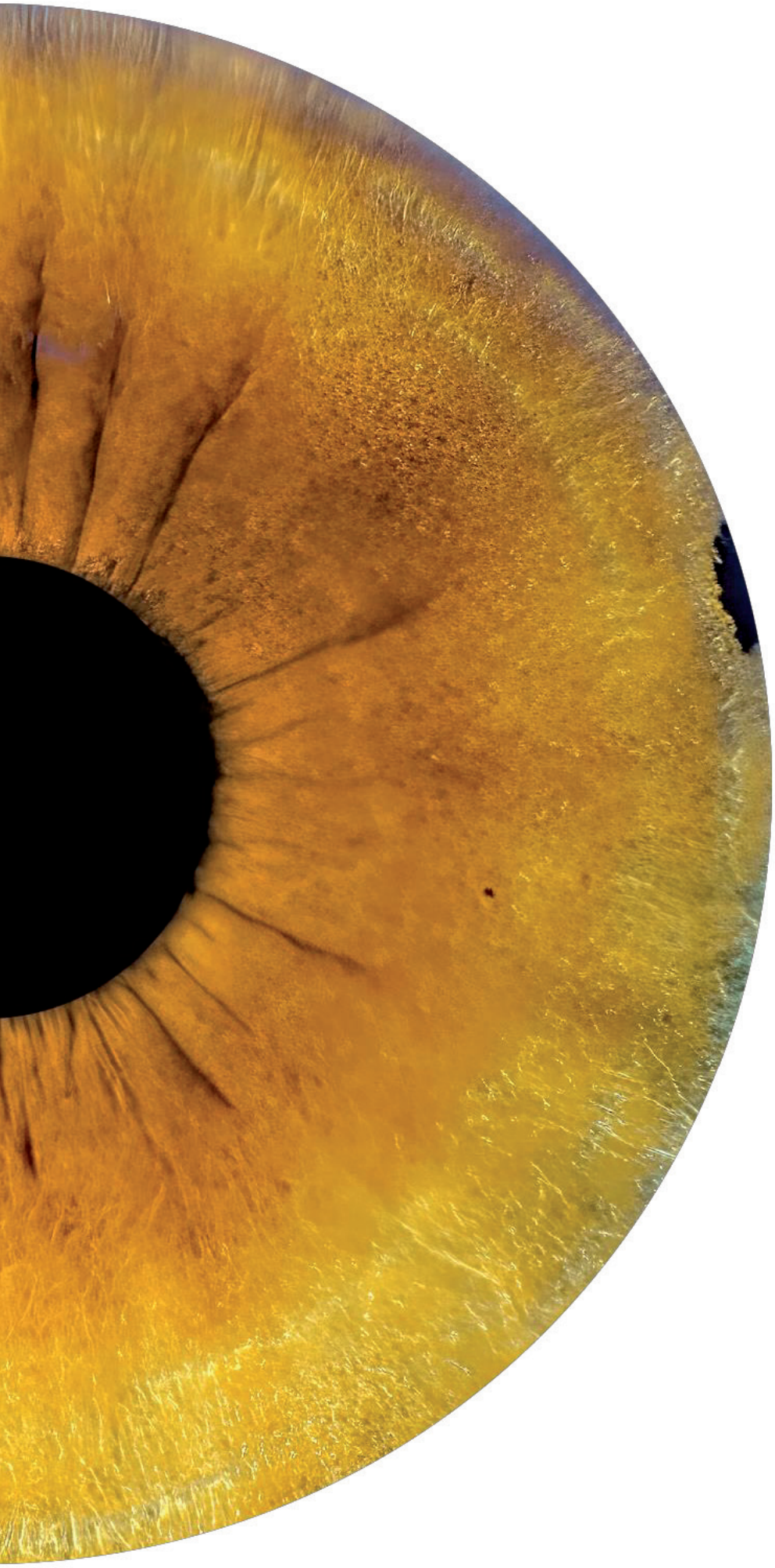
Rosangela, Victoria

Acknowledgment

Eyecos Team, Barcelona (Spain)

I would like to express my sincere thanks to the staff of the Eyecos Clinic, who have worked tirelessly in this laborious study, as well as to collaborating researchers, as pathologists, geneticists, programmers, optical engineers, industrial engineers, physicists and mathematicians, designers, photographers, technicians, and endless self-sacrificing professionals.





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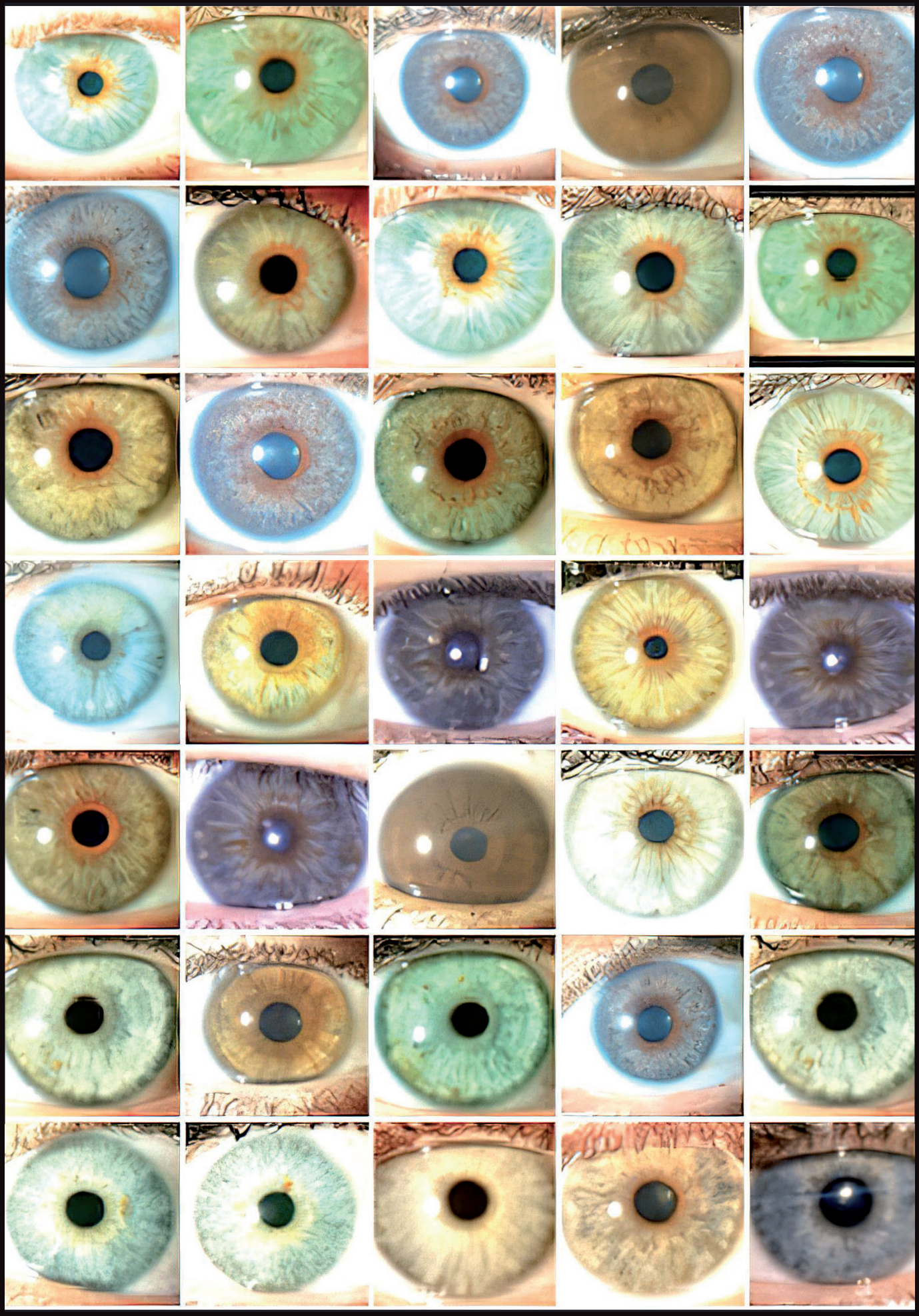
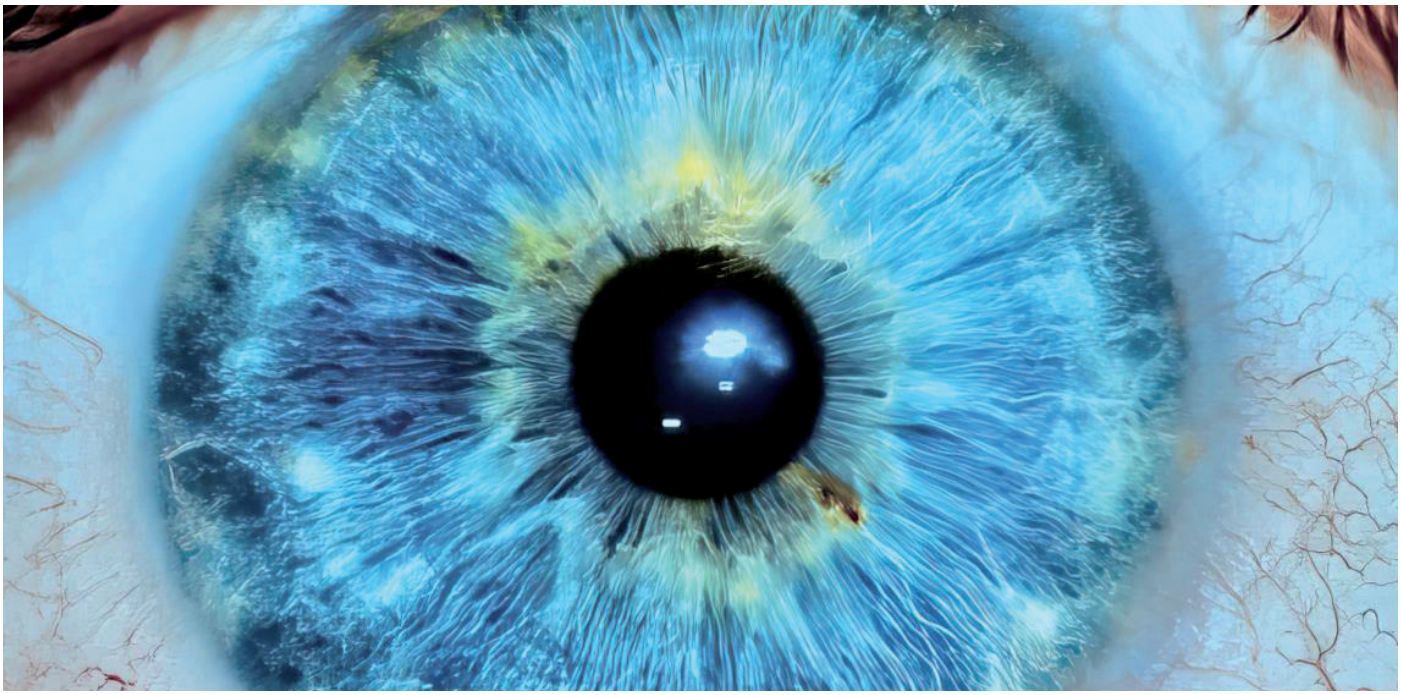


PART 1

INTRODUCTION
CHAPTER 1 EYE COLOR

1 1.1 Eye color level 1



Humans greatly appreciate originality, uniqueness, singularity, rarity and exoticism, as goods prized for their scarcity and the meaning of power that they involve. The eyes, the first traits explored when meeting a person, are a powerful tool for communication, for seduction and even as a power source. And the rarer the color, the more effective their subliminal message. The least common eyes are the result of a specific genetic trend or even of a disease. The eyes are called “mirrors of the soul”, and although we do not realize it, they are continually used to express emotions, moods and even to make others to fall in love. The eyes although we do not realize it, they are continually used to express emotions, moods and even to make others to fall in love.

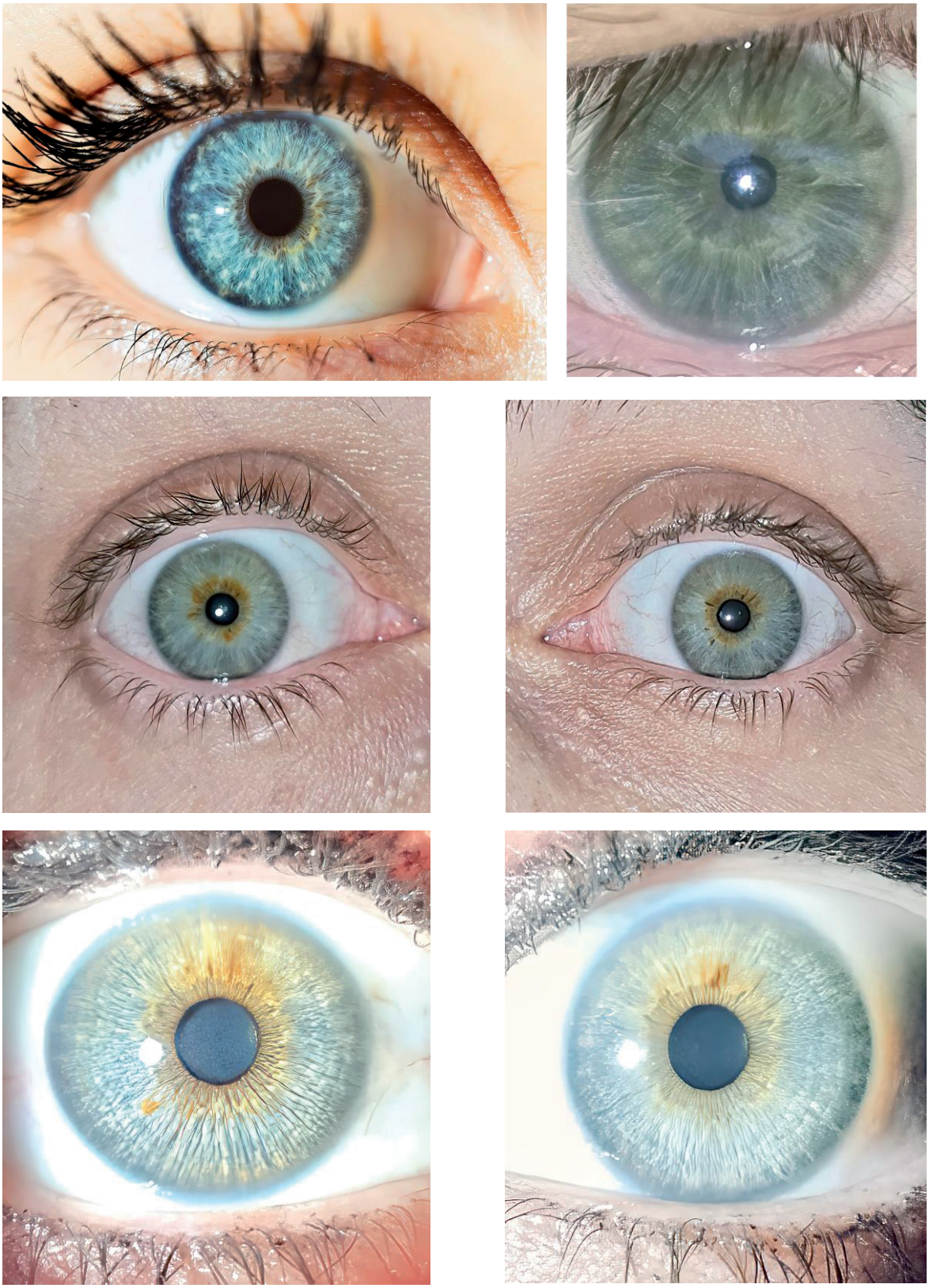
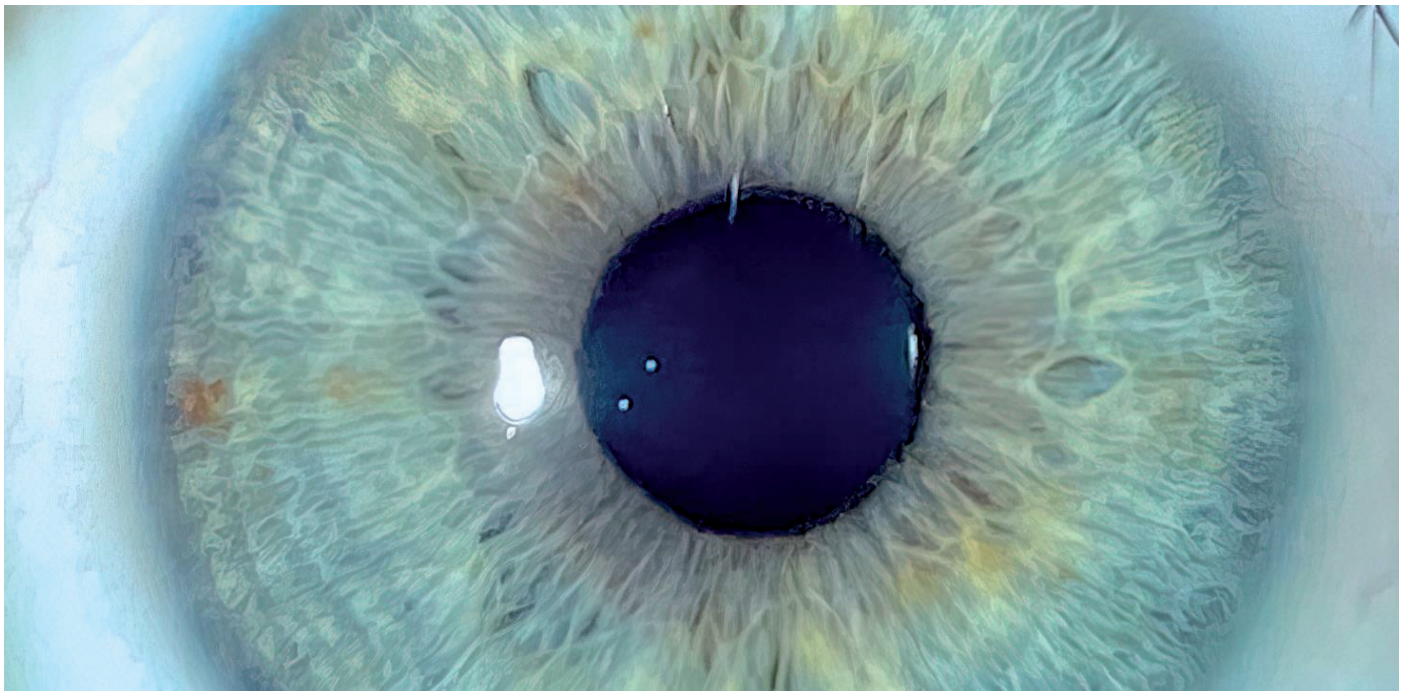


FIGURE 1: Level 1 examples

1 1.1 Eye color level 1



The eye color is a genetic trait that is determined by the amount and distribution of melanin in the iris. There are three elements that contribute to give iris coloration: posterior epithelium melanin, the stroma melanin and anterior epithelium melanin. Besides melanin, lipochrome also acts in the process of pigmentation. There are two types of melanin, eumelanin, with dark brown appearance, and pheomelanin, which is reddish- yellowish. Posterior epithelium pigment is always eumelanin, present in large quantities. Therefore, the color of the eyes is determined by the anterior epithelium pigment and the stromal tissue density. In the world there is a relative uniformity in eye color, brown being the most frequent.

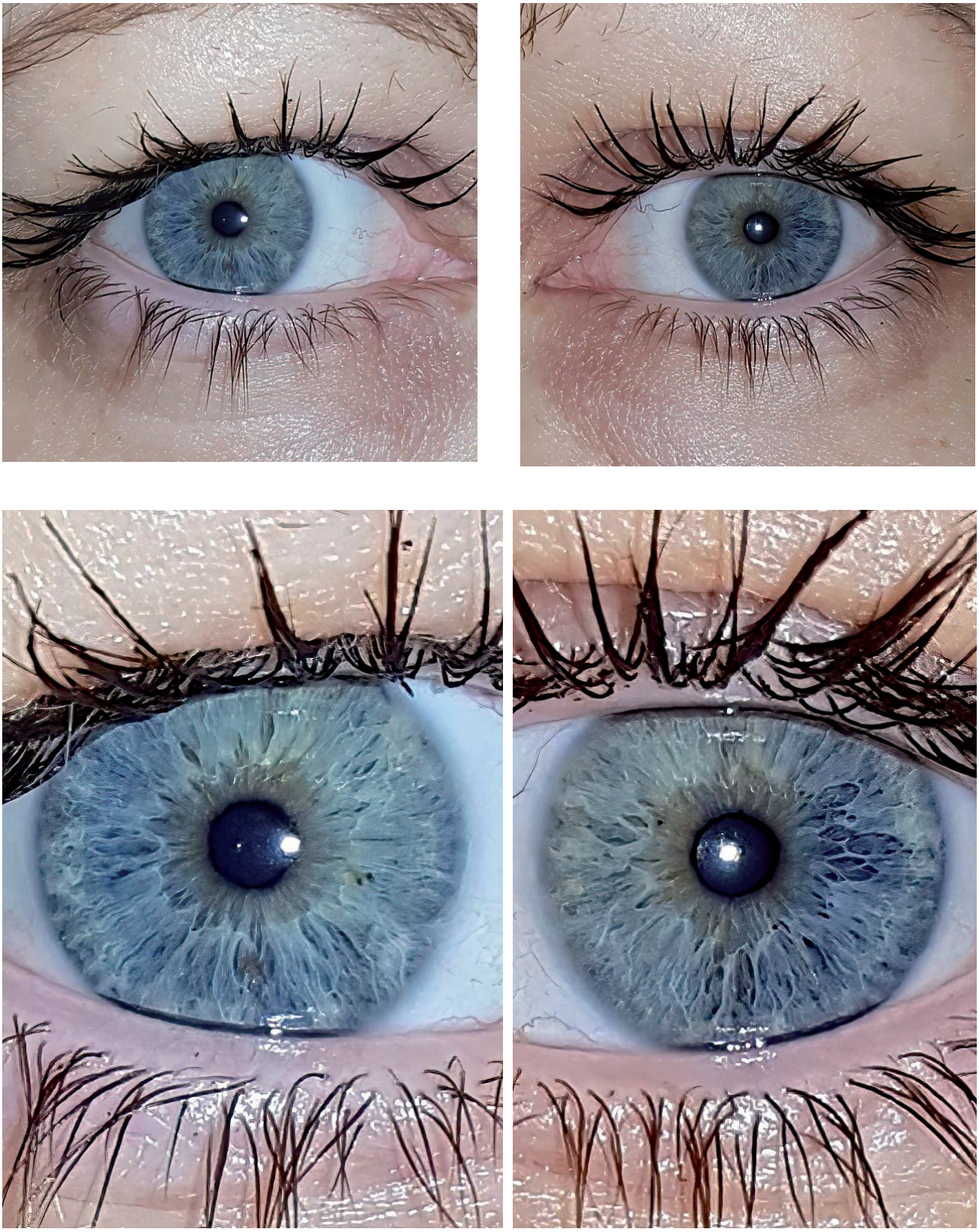
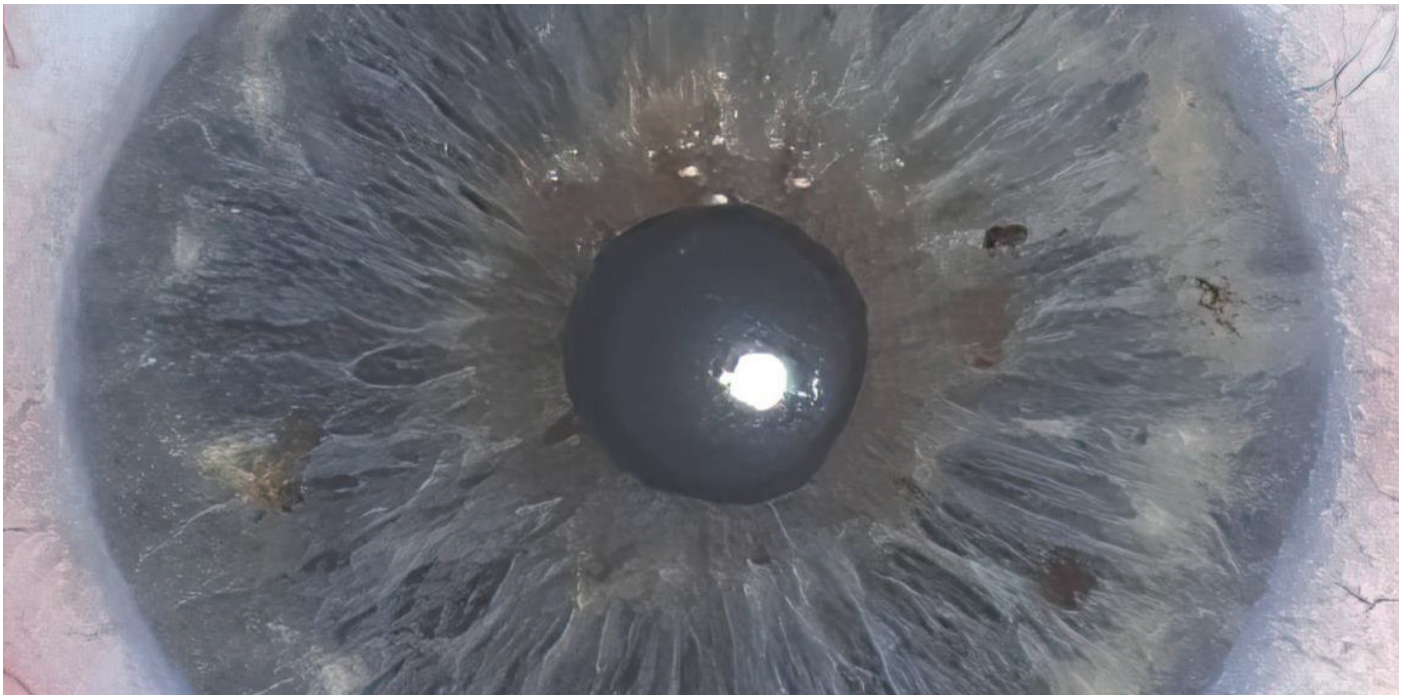


FIGURE 2: Level 1 examples. Bright eyes by high collagen

1 1.1 Eye color level 1



However, the exception is Europe, where a diversity have been generated that encompasses the hazel, green, blue and gray. Reasons were made of natural selection, hybridization with Neanderthals men, and even sexual selection (Luigi Cavalli - Sforza), according to which the brightest and gaudiest colors would have involved advantages when choosing a mate.

Many babies are born with blue or brown eyes. But newborns can have any eye color. As a baby grows, melanin continues to develop. If a blue-eyed newborn develops more melanin in their irises, their eyes might darken or turn brown or hazel.

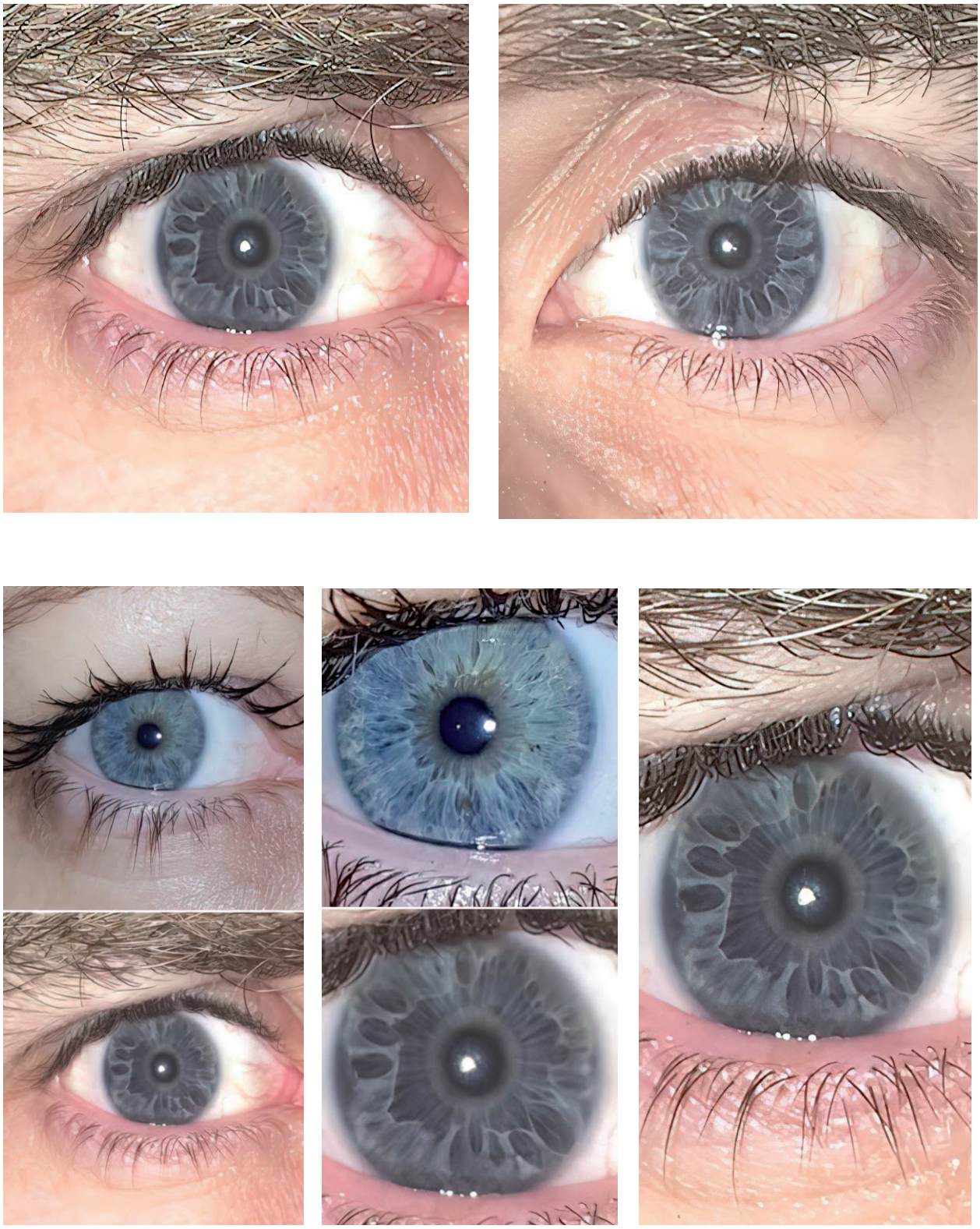
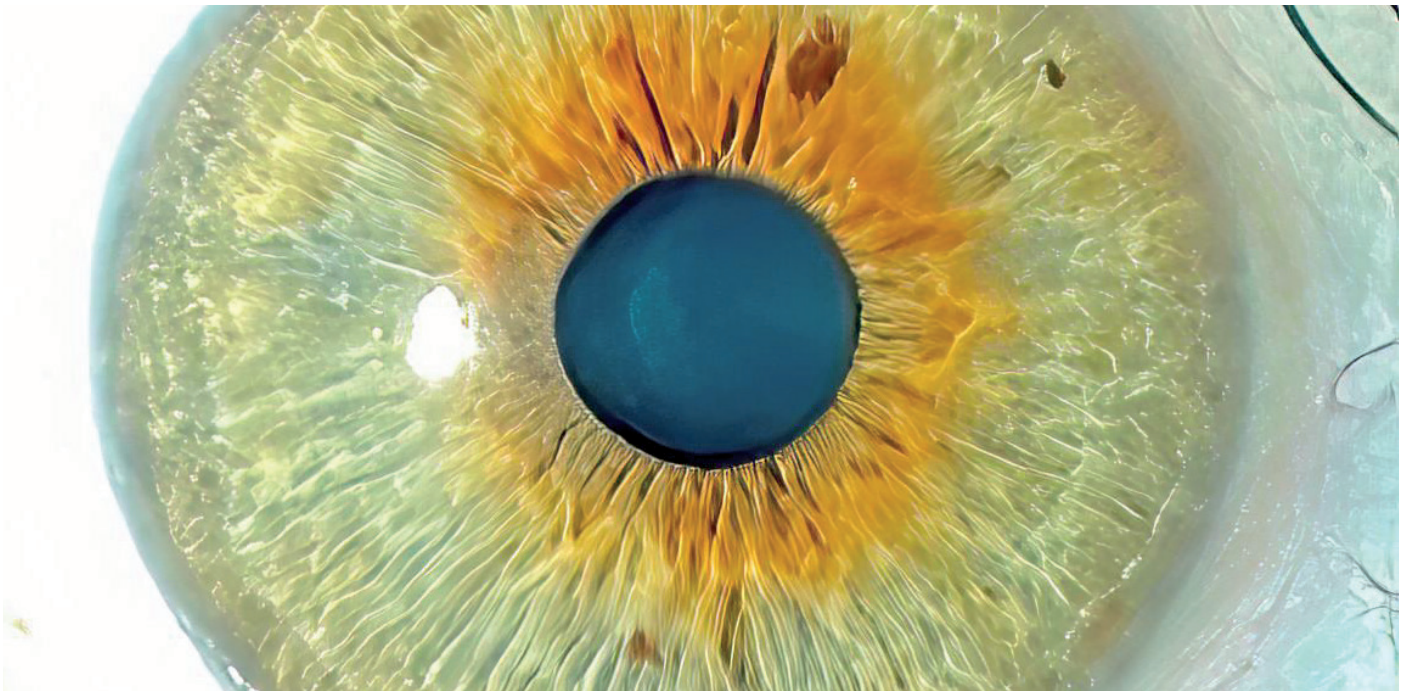


FIGURE 3: Level 1 examples. Dark eyes by low collagen

1 1.1 Eye color level 2



This change usually happens in the baby's first year. But it can take up to a few years for eyes to turn the color they'll be for the rest of their life.

Eye colors usually stay the same throughout a person's lifetime. Certain health conditions and disorders can cause changes in eye color. Eye color might appear to change a bit from time to time. For example, eyes might look like they're a darker shade of blue if you're wearing a blue shirt. The change in colors happens when light reflects off of objects around you.

Some people have a ring of darker pigment around the outside of their iris. Providers call this a limbal ring. It can fade and become less noticeable with age.

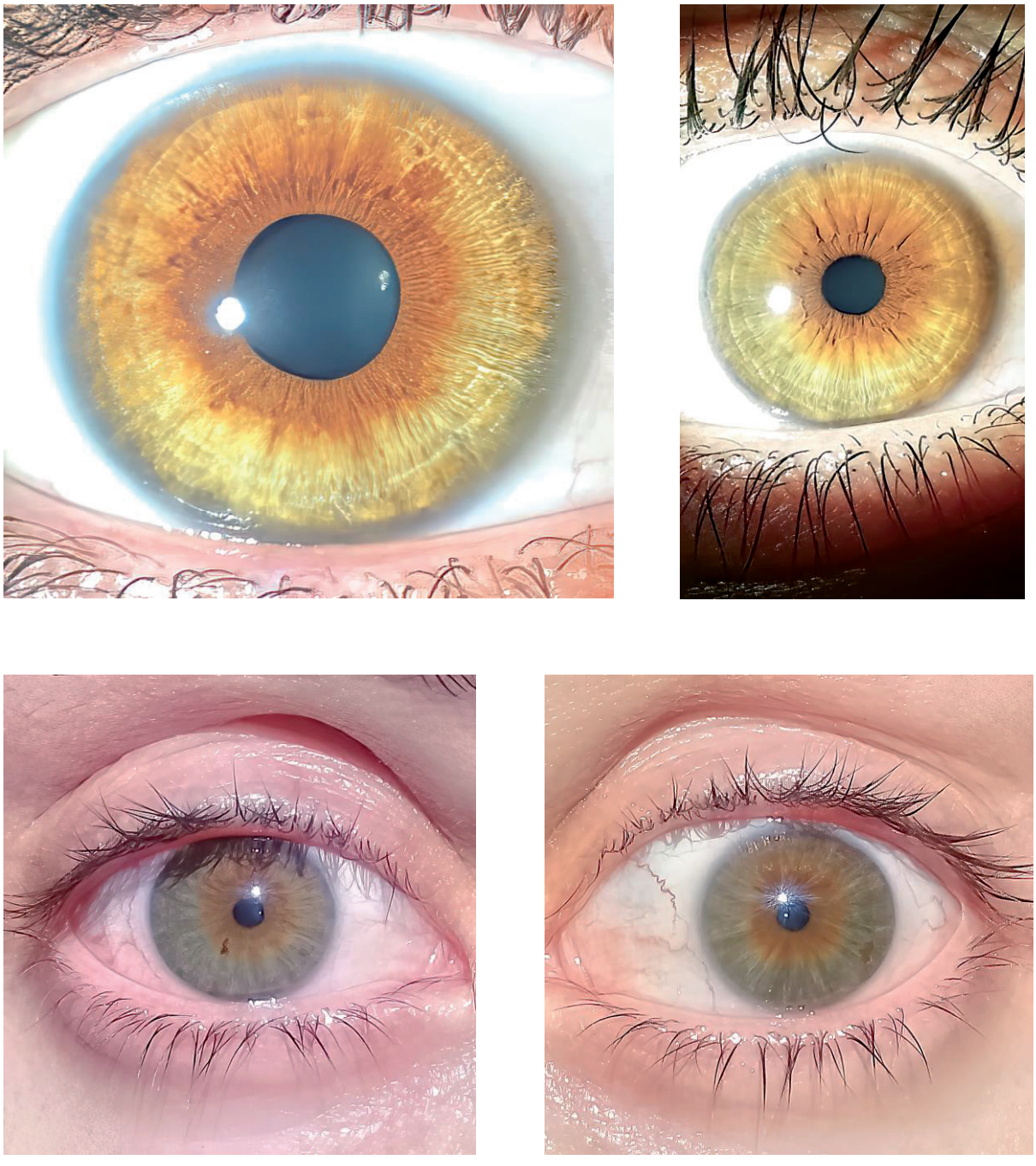
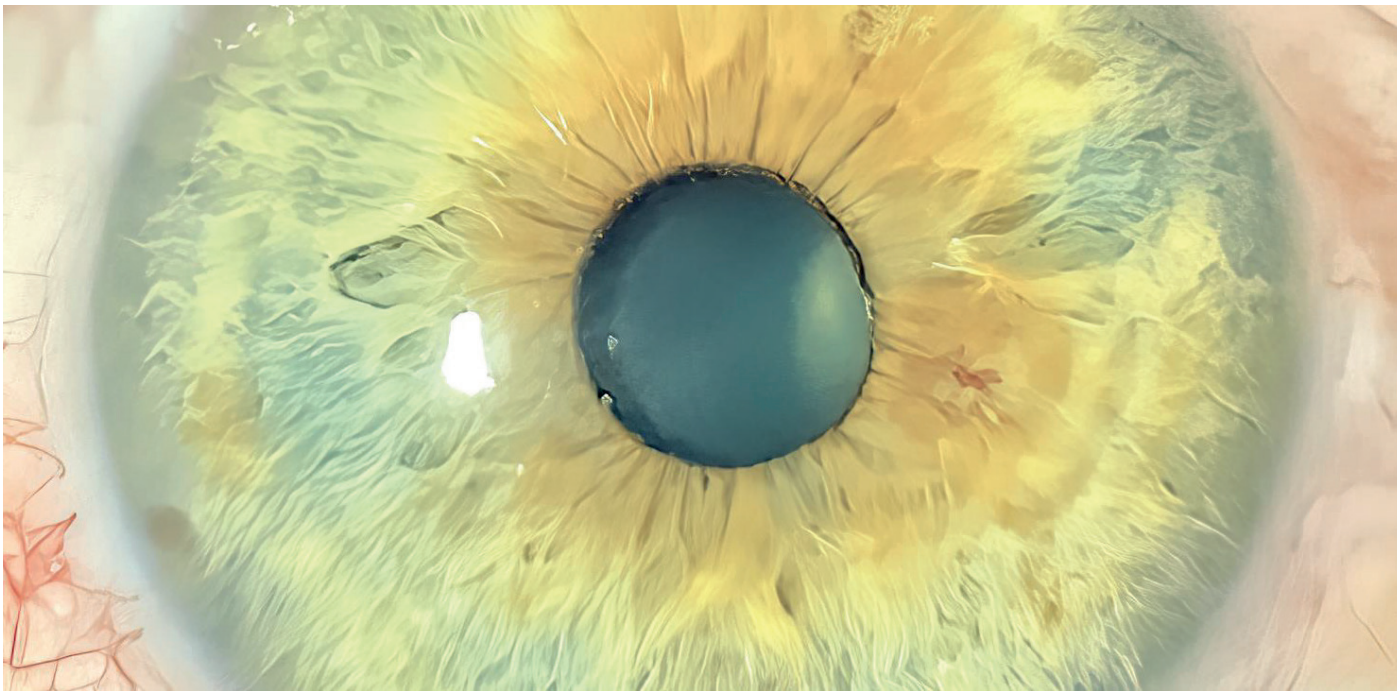


FIGURE 4: Level 2 examples. Orange eumelanin

1 1.1 Eye color level 2



A condition called heterochromia causes the iris to be different colors.

People with this condition may have different colors within one eye (for example, the iris may be half one color and half another). Or they may have a different color in each eye. Most often, heterochromia results from a harmless gene change. It usually happens sporadically, which means there aren't any other symptoms or health problems that happen with it. Rarely, heterochromia can result from an injury or disease, such as a tumor in the eye.

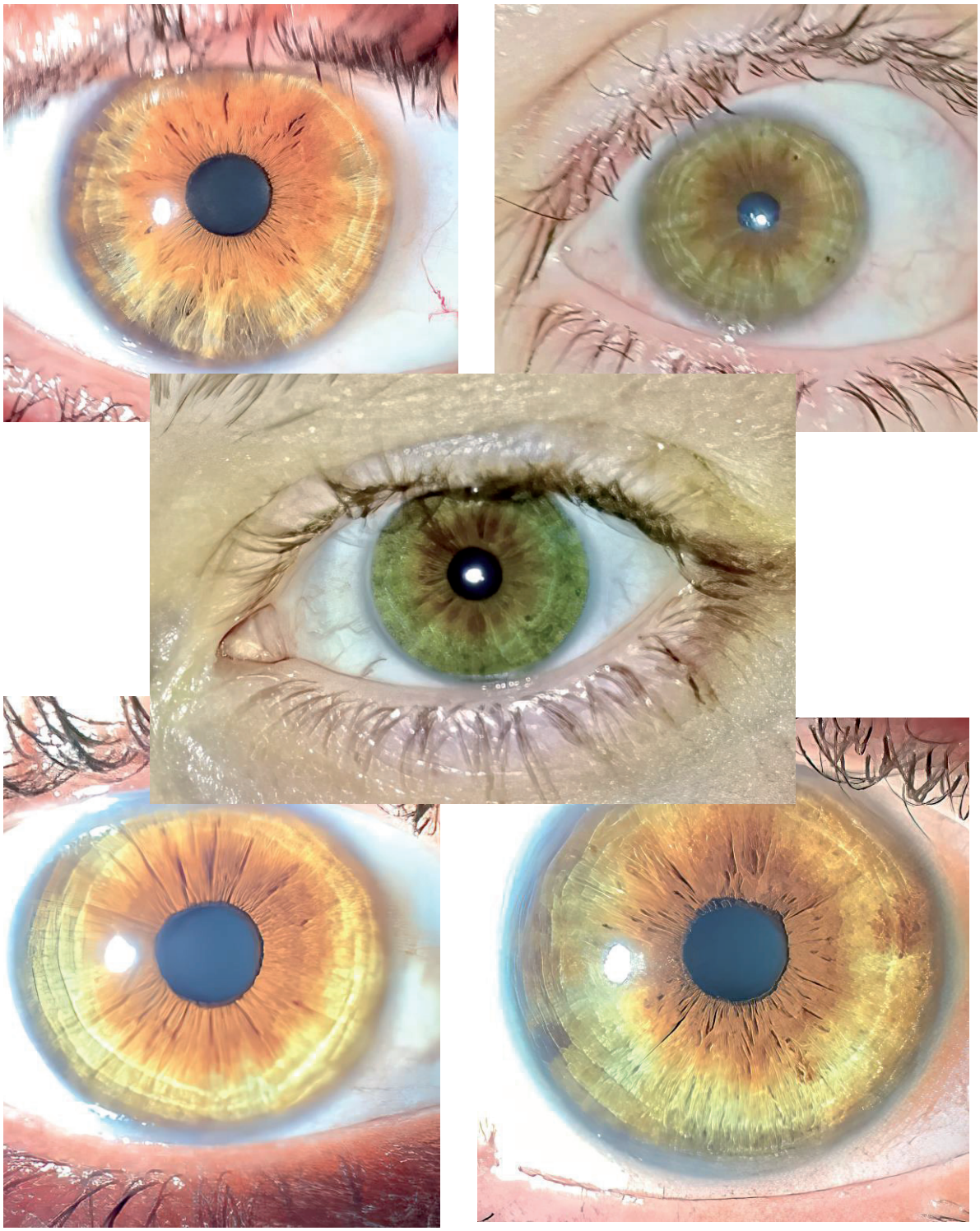
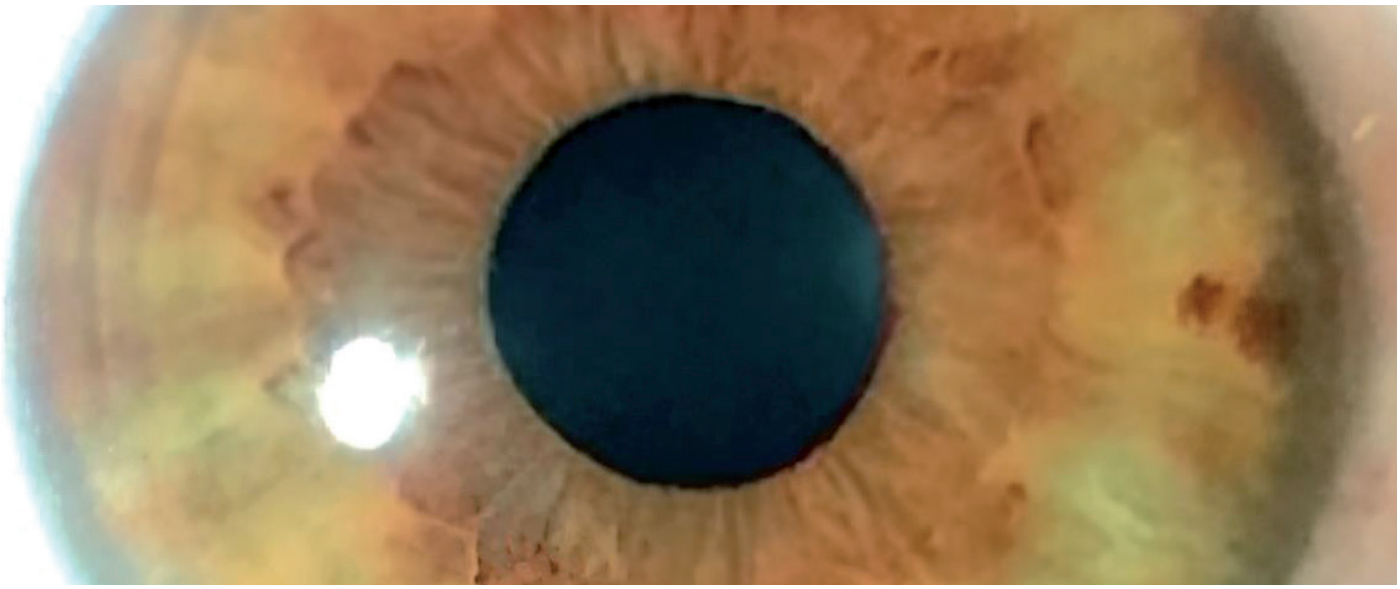


FIGURE 5: Level 2 examples. Yellow feomelanin

1 1.1 Eye color level 3



About 10,000 years ago, everyone in the world had brown eyes.
Scientists believe that the first blueeyed person had a genetic mutation that caused the body to produce less melanin. Today, about half of the people in the United States have brown eyes. Eye colors range from very light blue to dark brown. Some eyes also have flecks or spots of darker or lighter colors mixed in.
Eye colors can be many different shades of:

•**Amber,** which some people describe as copper, gold or very light brown.

•**Blue or gray**, which occurs when someone has no pigment (melanin) in the front layer of the iris. Around 1 in 4 people in the U.S. have blue eyes.

•**Brown**, which is the most common eye color in the world.

•**Green**, which is the least common eye color. Only 9% of people in the United States have green eyes.

•**Hazel**, a combination of brown and green. Hazel eyes may also have flecks or spots of green or brown. In the U.S., about 18% of people have hazel eyes.

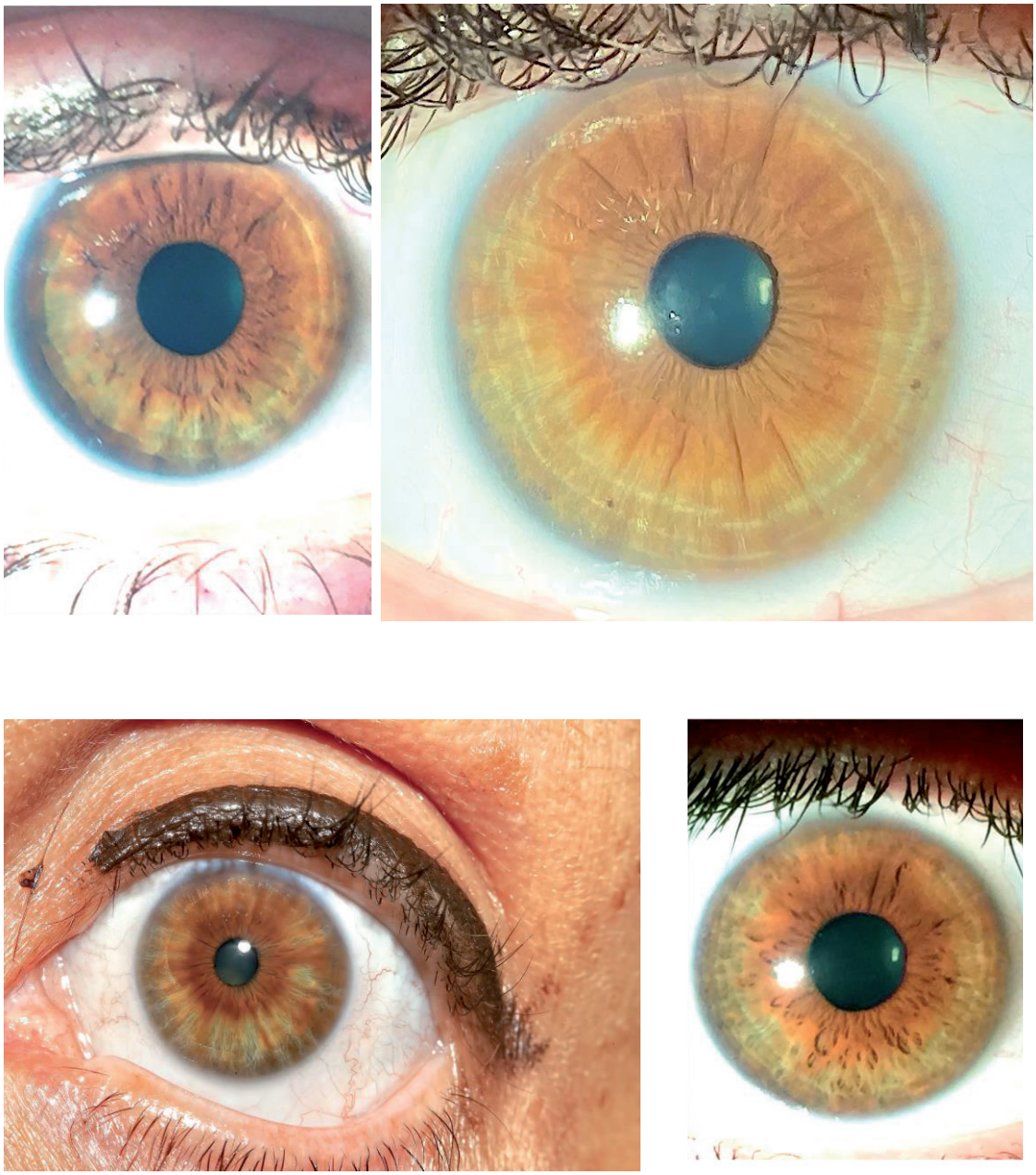
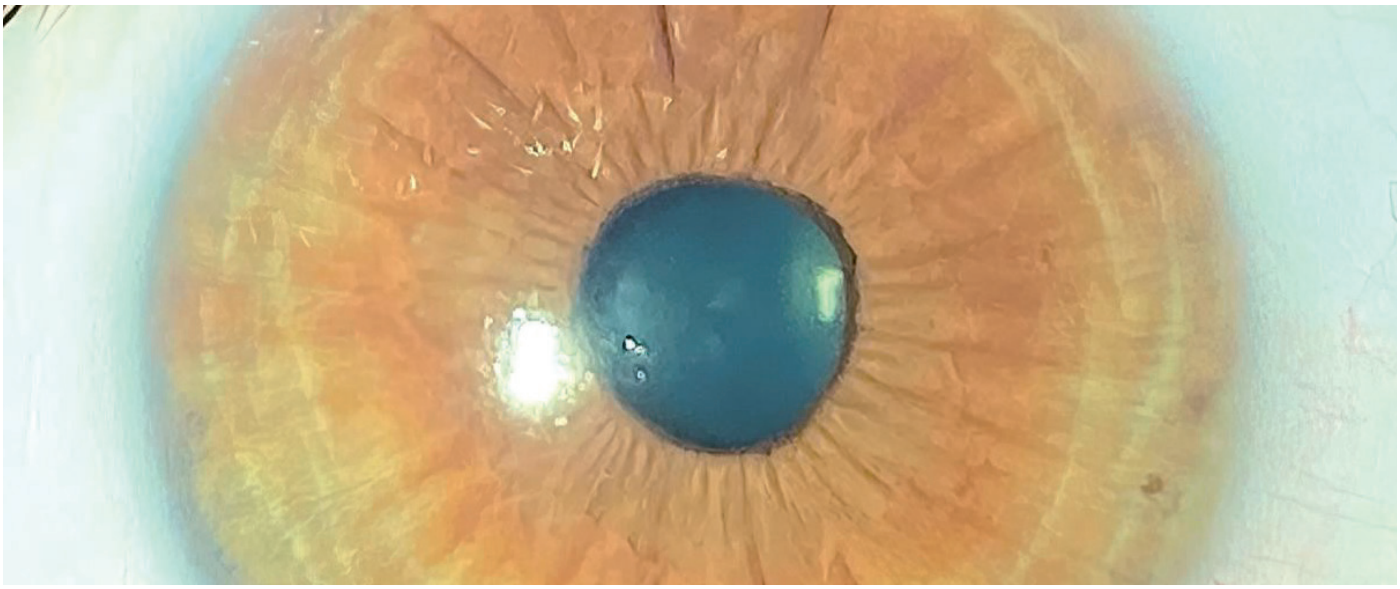


FIGURE 6: Level 3 examples. Eu and feo melanin

1 1.1 Eye color level 3



Brown is the most common eye color both worldwide and in the United States, with more than half of people in the world having brown eyes.

Because of where later genetic mutations originated, lighter eye colors almost exclusively exist among populations with European ancestry.

Brown eyed-genes are also generally dominant, meaning a person with brown eyes who produces a child generally has a greater than even chance of producing a child who also has brown eyes.

The second most common eye color is blue, with an estimated 17 percent of the world´s population having blue eyes. Blue-eyed genes are generally recessive. It was once believed two blue-eyed people could not produce a browneyed child, meaning it was previously thought it might be a sign of infidelity if a child attributed to such a couple had brown eyes. This is not valid, and the reality is more complicated. It isn't common for two blue-eyed parents to produce a brown-eyed child, but it is possible.

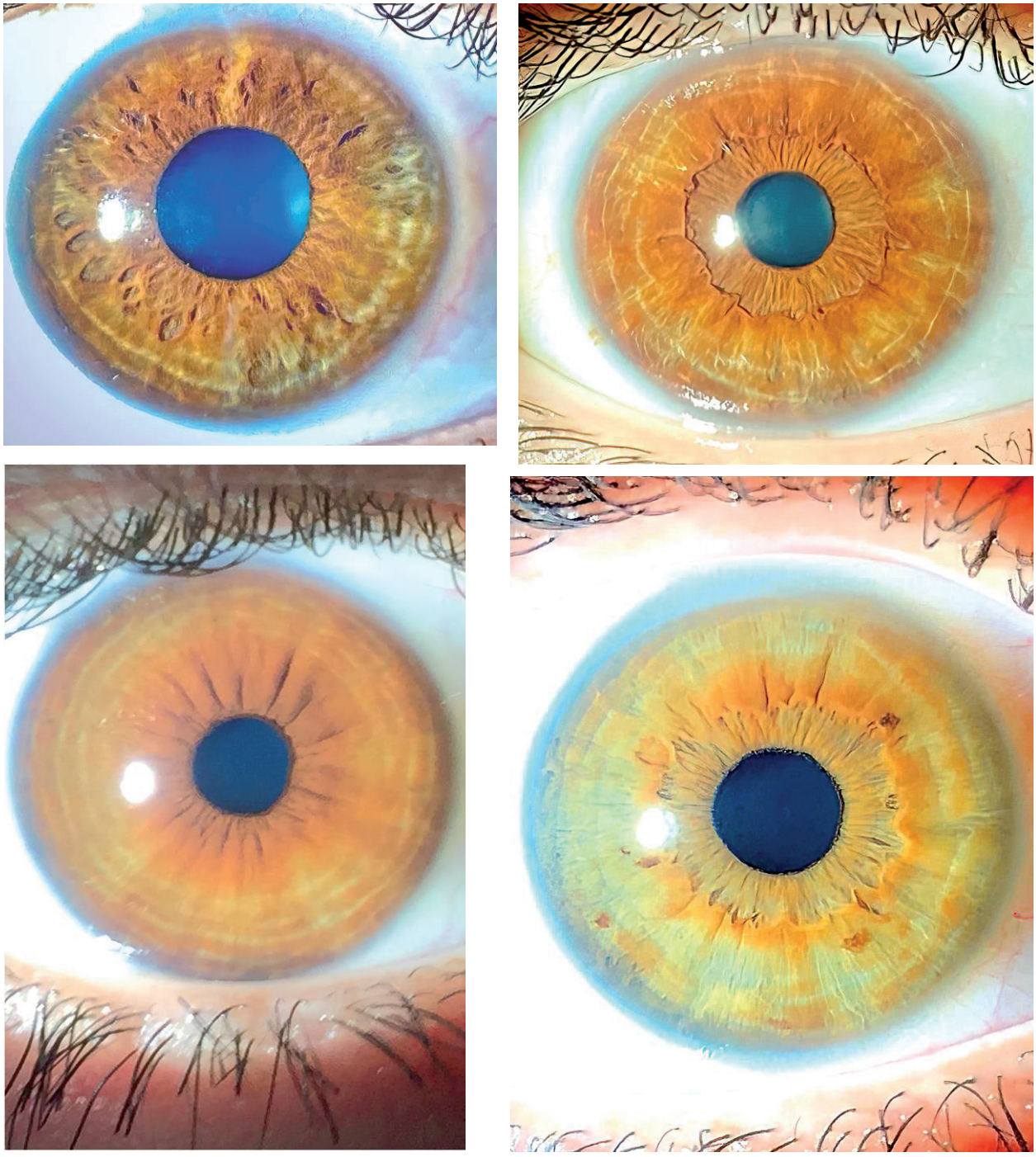
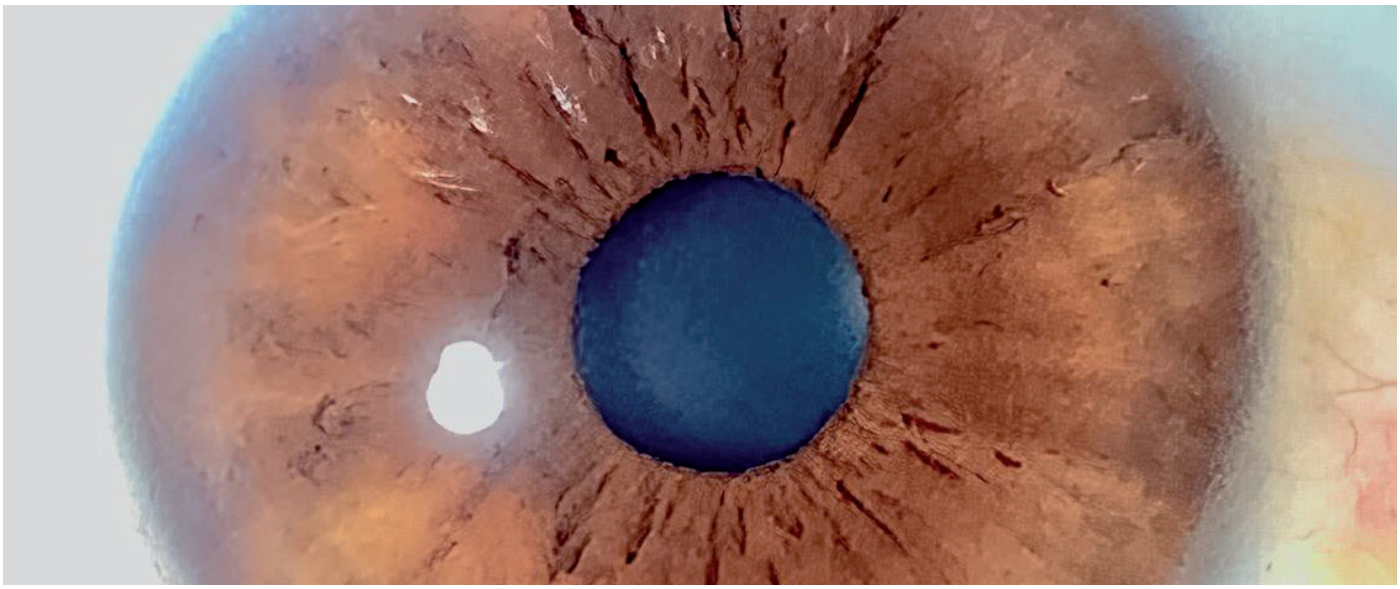


FIGURE 7: Level 3 examples. Eu, Feomelanin and Lipocrome

1 1.1 Eye color level 4



When discussing rare eye colors, it is common for people to bring up other colors they're likely to have still seen in the general population of their community or at least on television. Eye colors such as green and hazel are rare, but they aren't actually, the rarest.

The rarest eye colors are the result of extremely uncommon genetic mutations. For example, a mutation in the FOXC2 gene is thought to be the reason some people are born with violet eyes.

Another rare eye color, which might be called pink or red, is the result of albinism. A person born with albinism has almost no melanin in their skin, hair, and irises. In addition to giving a person naturally very pale skin and bright blonde or white hair, this also means their eyes have an unusual reddish or pinkish hue, although this unfortunately has the side effect of making them very sensitive to sunlight.

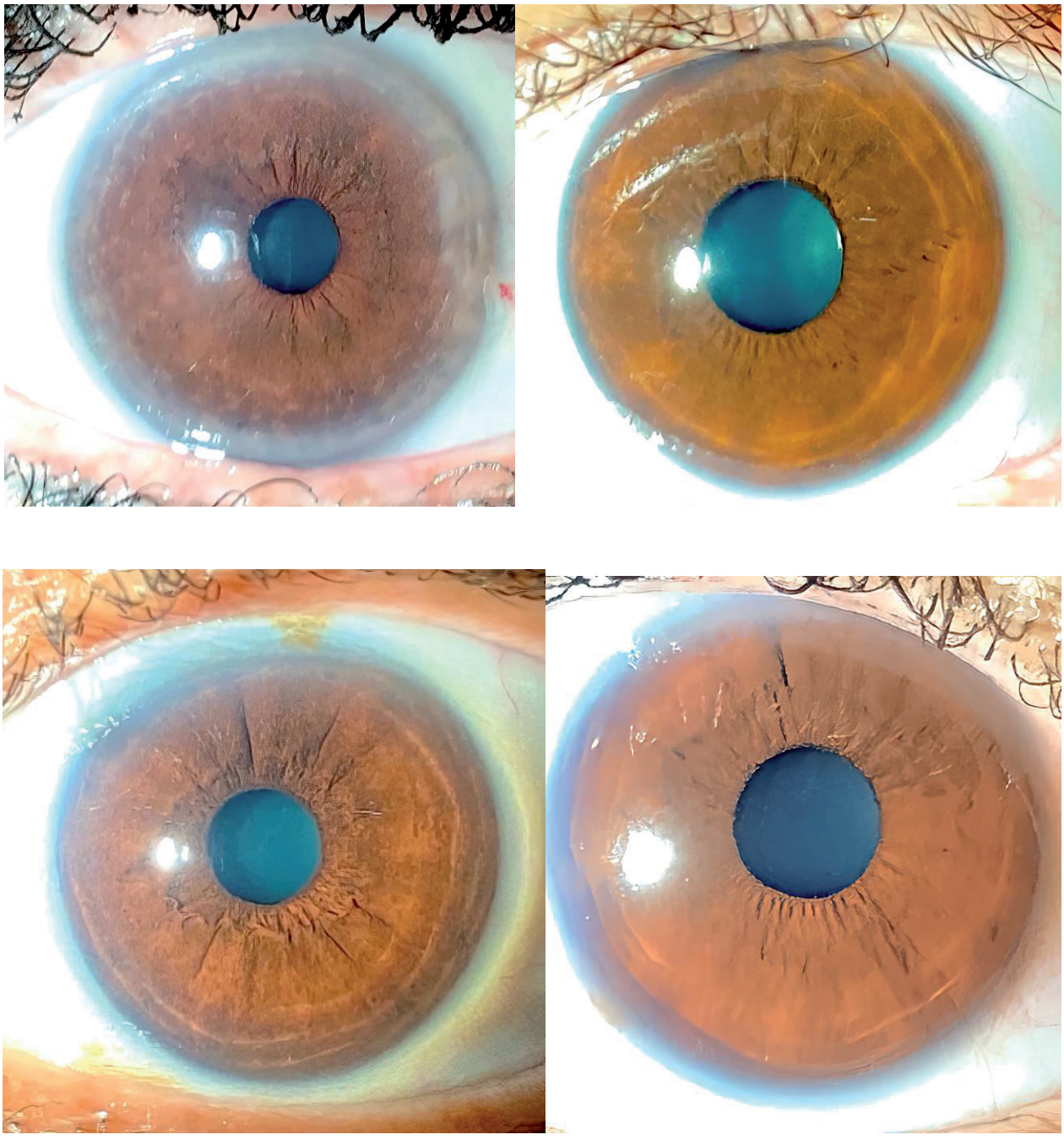
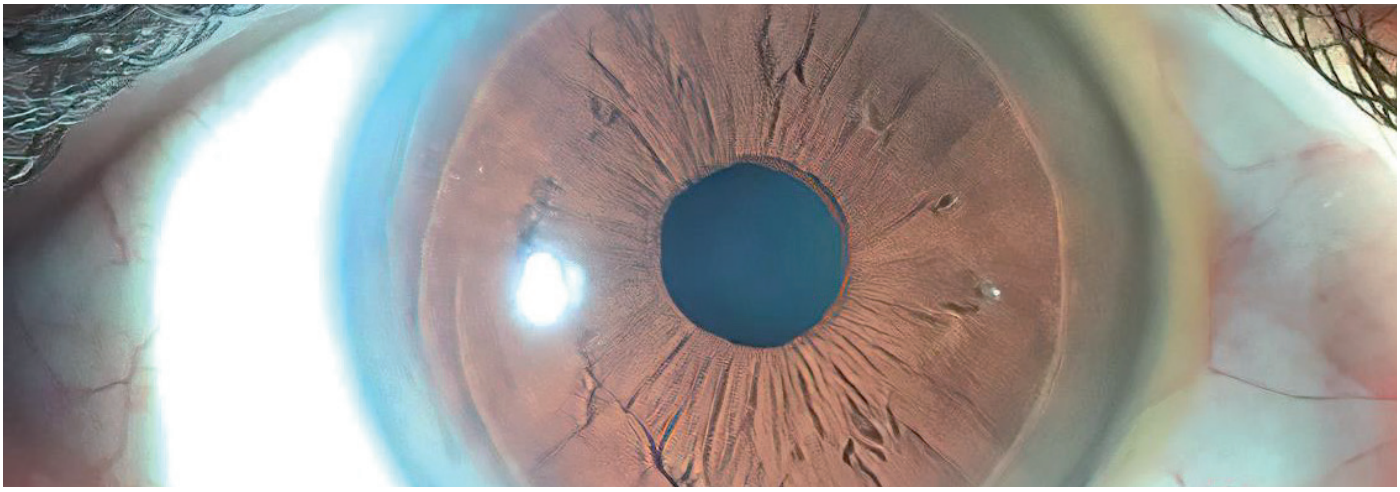


FIGURE 8: Level 4 examples. Eumelanin

1 1.1 Eye color level 5



Because of the, sometimes simplified, way concepts like genetics and Darwinism are taught, we might reasonably assume there is a survivalbased reason various eye colors developed and survived in various human populations. While research is ongoing, this doesn't seem to be the case. Of all eye colors, brown seems to be the only one that could be called "advantageous" from a survival perspective. While more research is needed, darker irises are linked to a number of health benefits, including these: Reduced risk of macular degeneration and lower melanoma risk Lighter eyes may have some advantages too, but they are also linked to certain health and addiction risks. People with lighter eyes may have the following: A lower chance of developing vitiligo, a higher risk of abusing alcohol and greater light sensitivity, especially among people with albinism.

Notably, the potential differences in health impacts between different eye colors are almost certainly slight. The reason different eye colors have managed to survive is largely because they didn't significantly impact the survivability of the early humans who developed them.

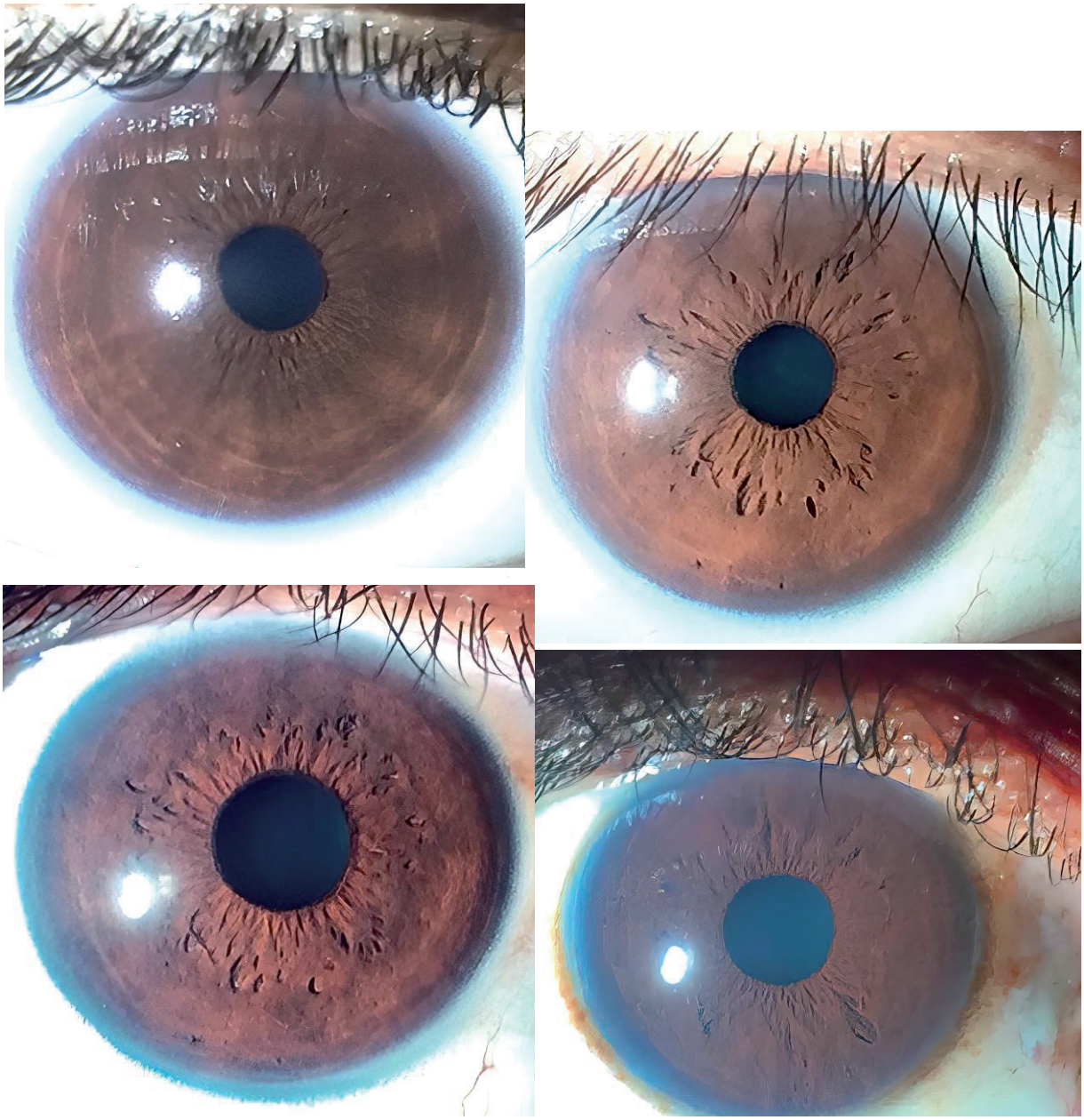


FIGURE 9: Level 4 and 5 examples. Eumelanin. Gerontoxon

1 1.2 Distribution maps

People of European descent show the greatest variety in eye color of any population worldwide. Recent advances in ancient DNA technology have revealed some of the history of eye color in Europe.

All European Mesolithic huntergatherer remains so far investigated have shown genetic markers for light-colored eyes, in the case of western and central European hunter-gatherers combined with dark skin color.

The later additions to the European gene pool, the Early Neolithic farmers from Anatolia and the Yamnaya Cooper Age/Bronze Age pastoralists (possibly the Proto- Indo-European population) from the area north of the Black Sea appear to have had much higher incidences of dark eye color alleles, and alleles giving

rise to lighter skin, than the original European population

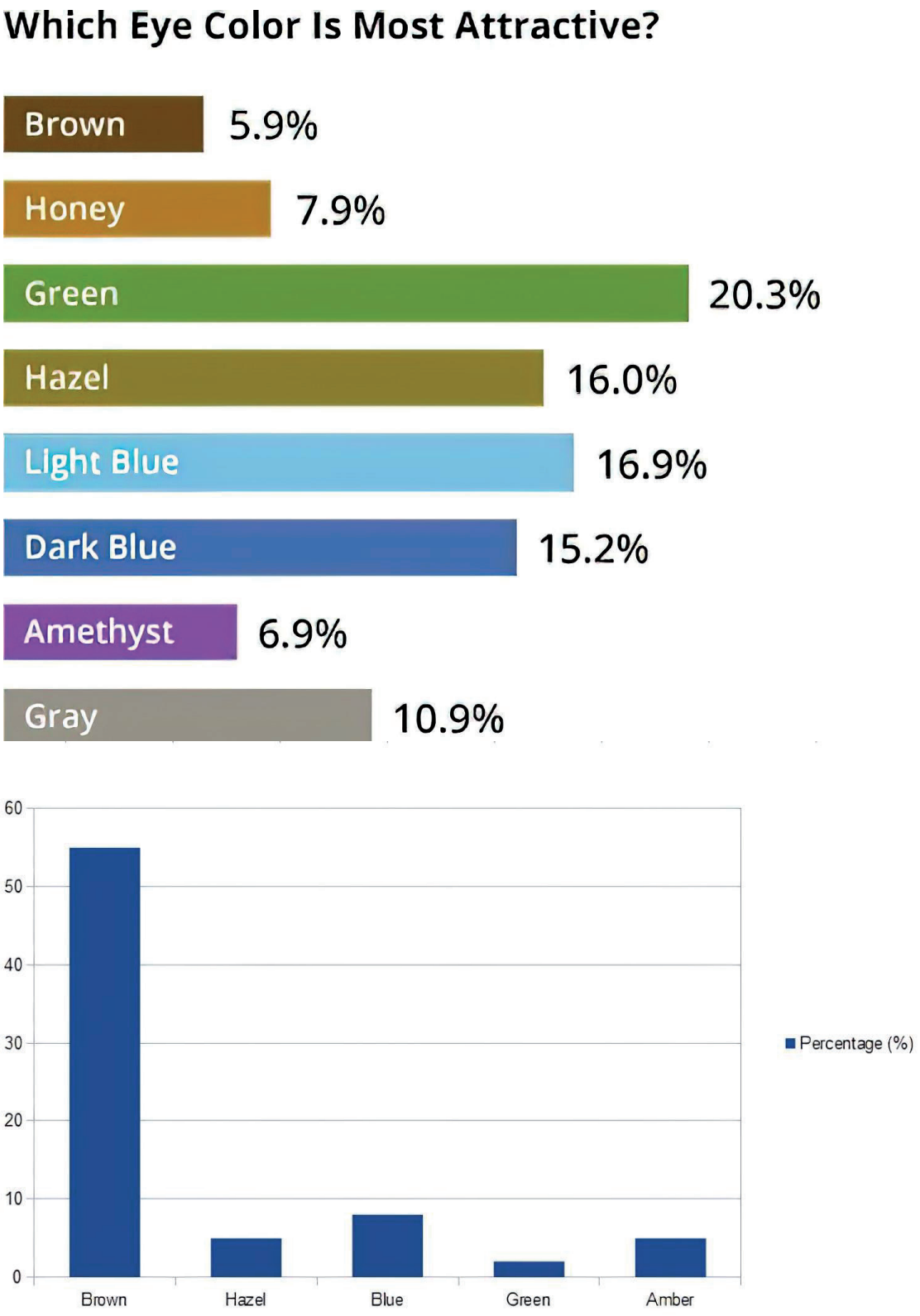
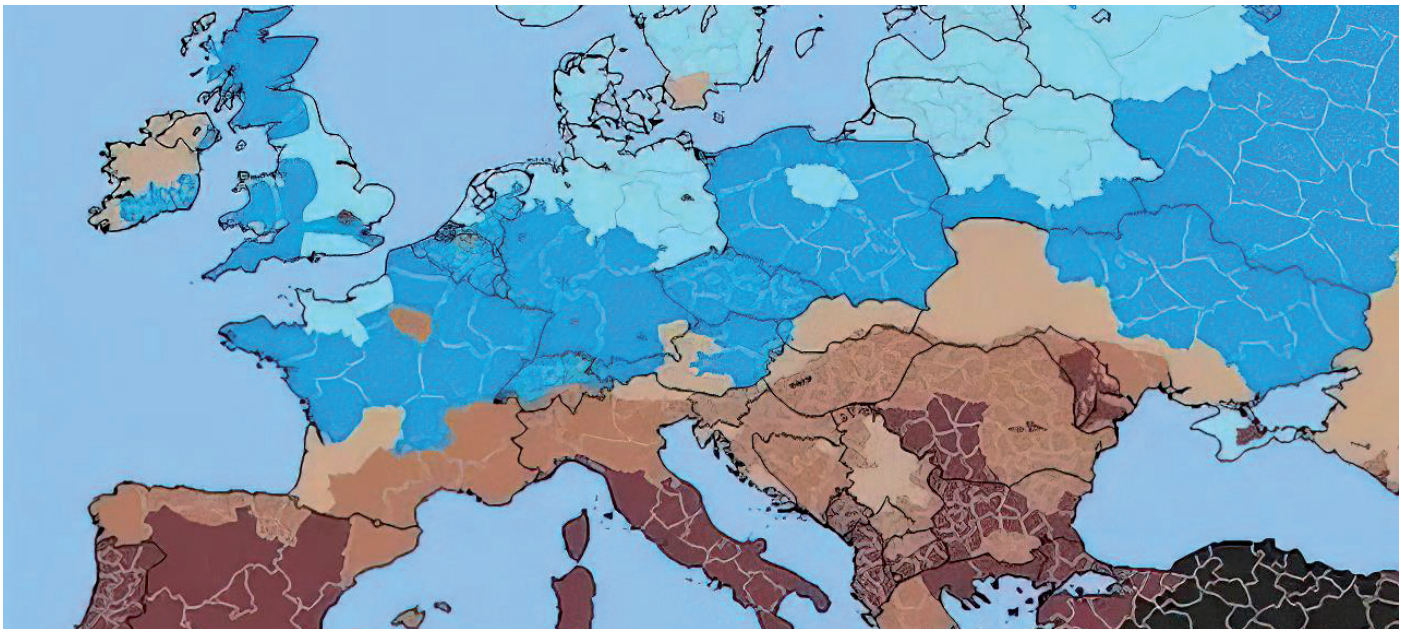


FIGURE 10: Eye color preferences and global color distribution

1 1.2 Distribution maps



With few exceptions, all mammals have brown or darklypigmented irises. In humans, brown is by far the most common eye color, with approximately 79% of people in the world having it. Brown eyes are common in Europe, East Asia, Southeast Asia, Central Asia, South, West Asia, Oceania, Africa and the Americas. Light or medium-pigmented brown eyes can also be commonly found in South Europe, among the Americas, and parts of Central Asia, West Asia and South Asia. People with amber/hazel color are found in Pakistan and Balkan region, as well as in Hungary, Southern France, Italy, and to a lesser degree in the Iberian Peninsula, Southern Cone and Middle East. Green is the most common in Northern , Western and Central Europe. Blue eyes are common in northern and eastern Europe, and the 16.6% of the total US.

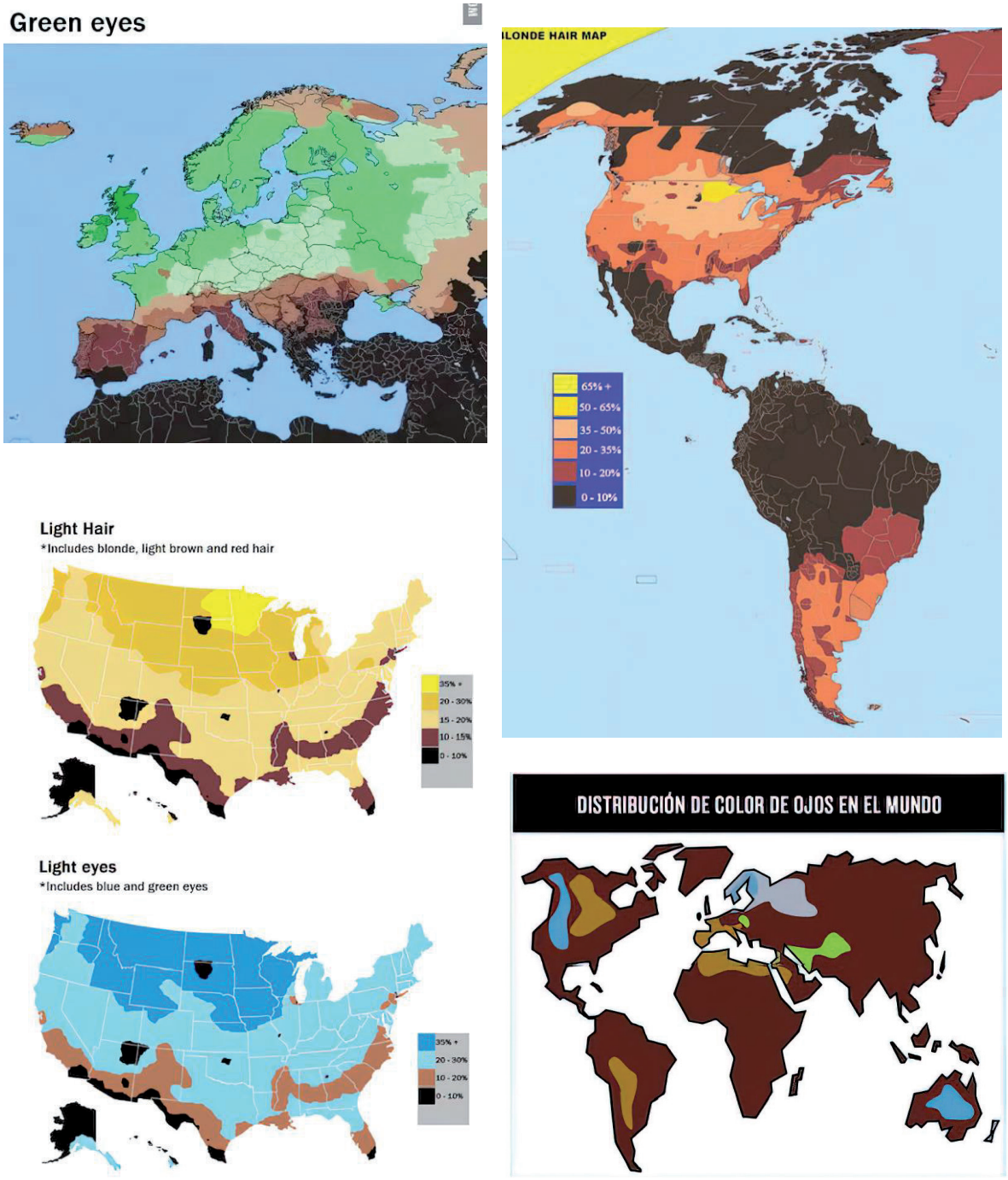
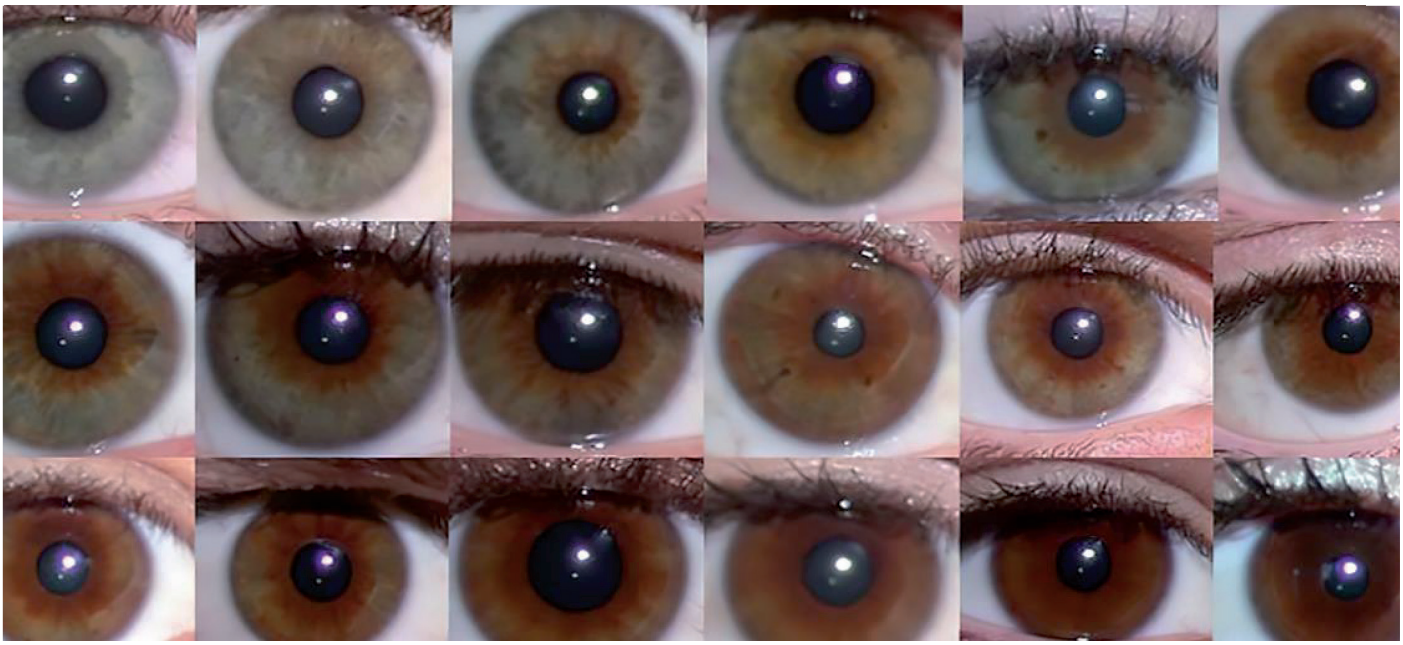


FIGURE 11: Worldwide eye color distribution

1.3 Melanin types



Melanin is a substance in your body that produces hair, eye and skin pigmentation. The more melanin you produce, the darker your eyes, hair and skin will be.

The amount of melanin in your body depends on a few different factors, including genetics and how much sun exposure your ancestral population had. There are three different types of melanin, including:

•**Eumelanin.** There are two types of eumelanin: black and brown.

Eumelanin is responsible for dark colors in skin, eyes and hair.

People with brown or black hair have varying amounts of brown and black eumelanin. When there's no black eumelanin and a small amount of brown eumelanin, it results in blonde hair.

•**Pheomelanin.** This type of melanin pigments your lips, nipples and other pinkish parts of your body. People who have equal parts eumelanin and pheomelanin have red hair.

•**Lipochrome** is a yellowish pigment and is responsible for the color seen in some eyes. Individuals with green eyes have slightly more lipochrome in their eyes.

FIGURE 12: Types of melanin on skin and eyes

1.3 Melanin types

Brown eyes result from a relatively high concentration of melanin in the stroma of the iris, which causes light of both shorter and longer wavelengths to be absorbed. Amber eyes are of a solid color and have a strong yellowish/golden and russet/coppery tint. This may be due to the deposition of the yellow pigment called lipochrome in the iris. Hazel eyes are due to a combination of Rayleigh scattering and a moderate amount of melanin in the iris' anterior border layer. The green color is caused by the combination of: 1) an amber or light brown pigmentation in the stroma of the iris (which has a low or moderate concentration of melanin), with: 2) a blue shade created by the Rayleigh scattering of reflected light. Green eyes contain the yellowish pigment lipochrome. Blue eyes have low concentrations of melanin in the stroma of the iris. Rayleigh scattering in the stroma results in a Tyndall blue effect that varies with external lighting conditions.

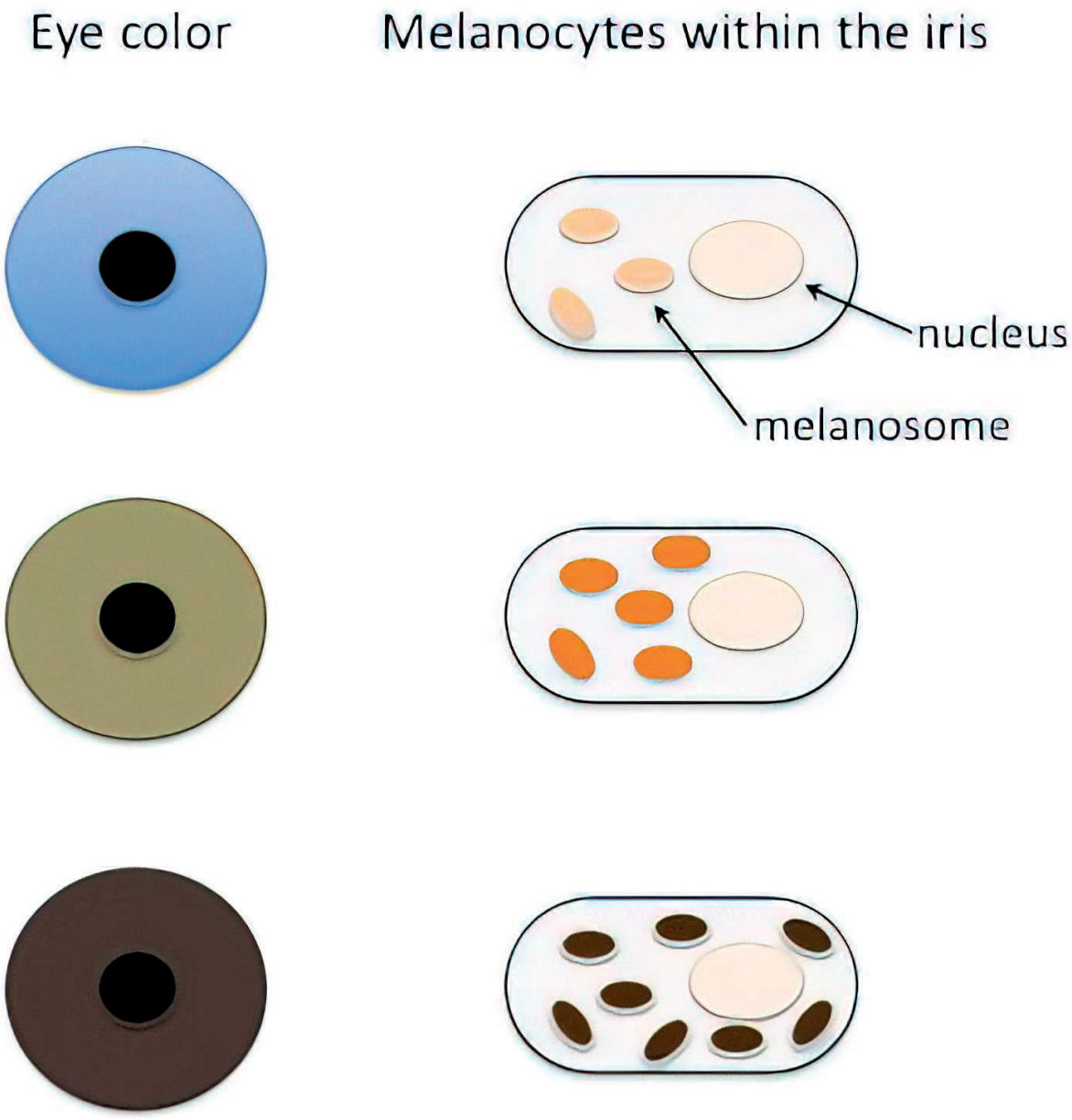
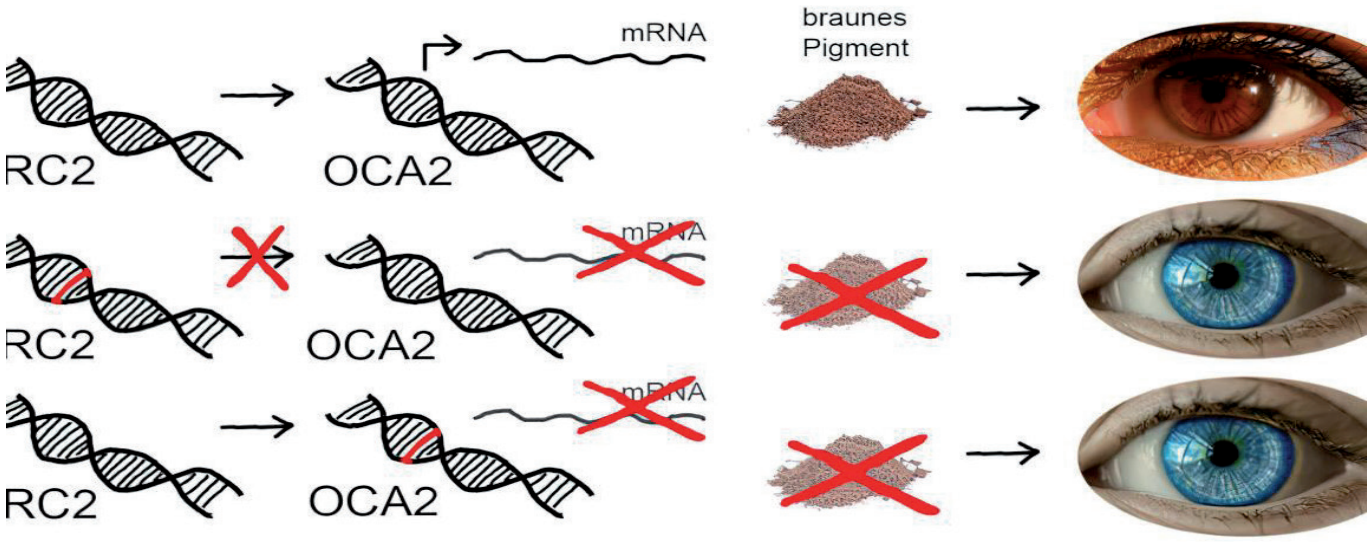
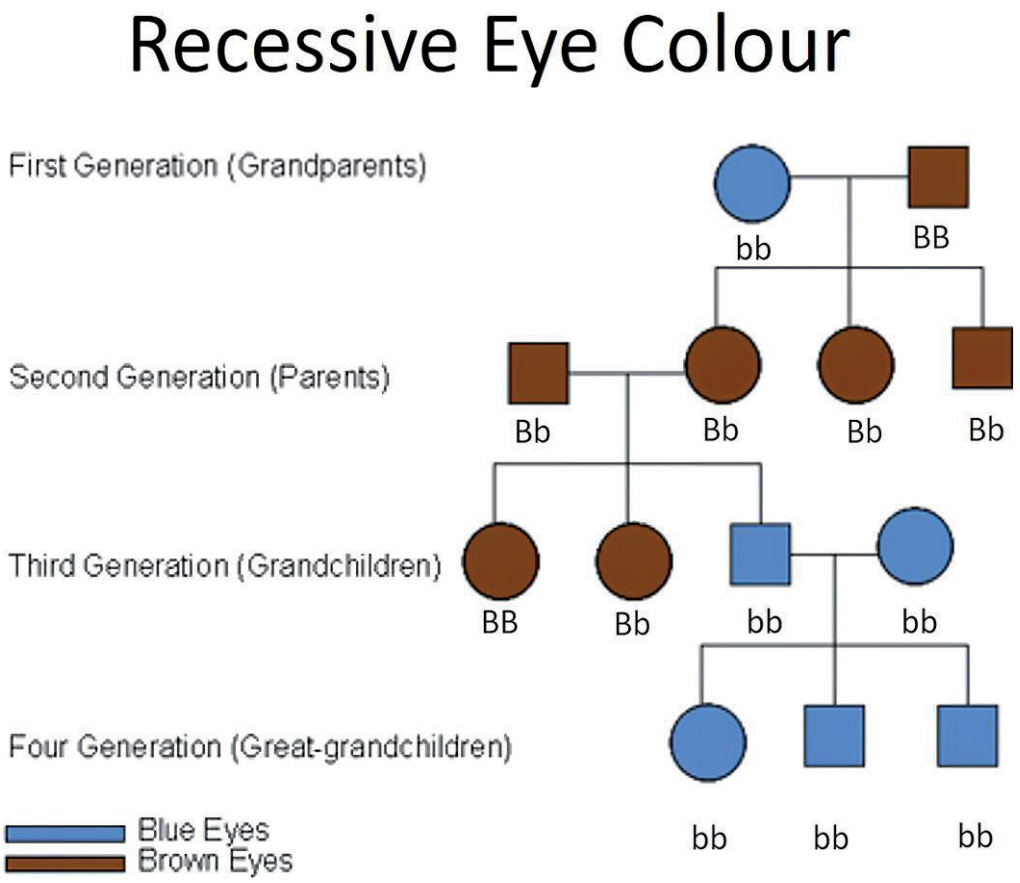


FIGURE 13: Eye color differences due to density of melanosomes

1 1.4 Genes & Chromosomes



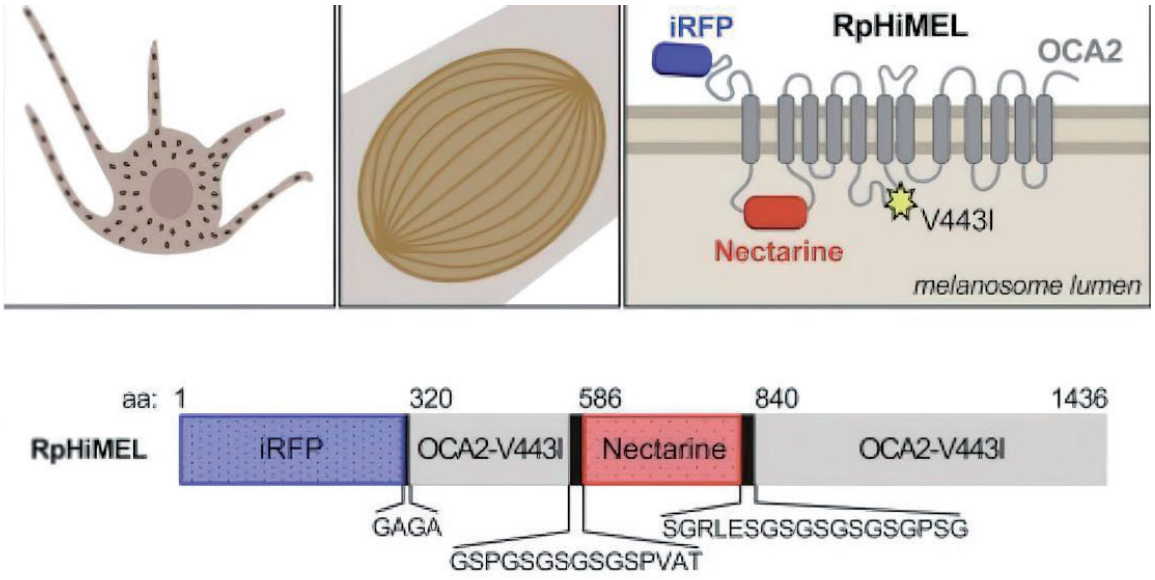
There is evidence that as many as 16 different genes could be responsible for eye color in humans; however, the main two genes associated with eye color variation are OCA2 and HERC2, and both are localized in Chromosome 15. The gene OCA2, when in a variant form, causes the pink eye color and hypopigmentation common in human albinism. Different SNPs within OCA2 are strongly associated with blue and green eyes. A specific mutation within the HERC2 gene, a gene that regulates OCA2 expression, is partly responsible for blue eyes. Other genes implicated in eye color variation are SLC24A4 and TYR.



Gene name	Effect on eye color
OCA2	Associated with melanin producing cells. Central importance to eye color.
HERC2	Affects function of OCA2, with a specific mutation strongly linked to blue eyes.
SLC24A4	Associated with differences between blue and green eyes.
TYR	Associated with differences between blue and green eyes.

FIGURE 14: Eye color genes and chromosomes. Blue eyes recessive pattern

1.4 Genes & Chromosomes



Most of the genes associated with eye color are involved in the production, transport, or storage of a pigment called melanin. A particular region on chromosome 15 plays a major role in eye color. Within this region, there are two genes located very close together: OCA2 and HERC2. The protein produced from the OCA2 gene, known as the P protein, is involved in the maturation of melanosomes, which are cellular structures that produce and store melanin. The P protein therefore plays a crucial role in the amount and quality of melanin that is present in the iris. Several common variations (polymorphisms) in the OCA2 gene reduce the amount of functional P protein that is produced. Less P protein means that less melanin is present in the iris, leading to blue eyes instead of brown in people with a polymorphism in this gene.

A region of the nearby HERC2 gene known as intron 86 contains a segment of DNA that controls the activity (expression) of the OCA2 gene, turning it on or off as needed. At least one polymorphism in this area of the HERC2 gene has been shown to reduce the expression of OCA2 and decrease P protein production, leading to less melanin in the iris and lighter-colored eyes.

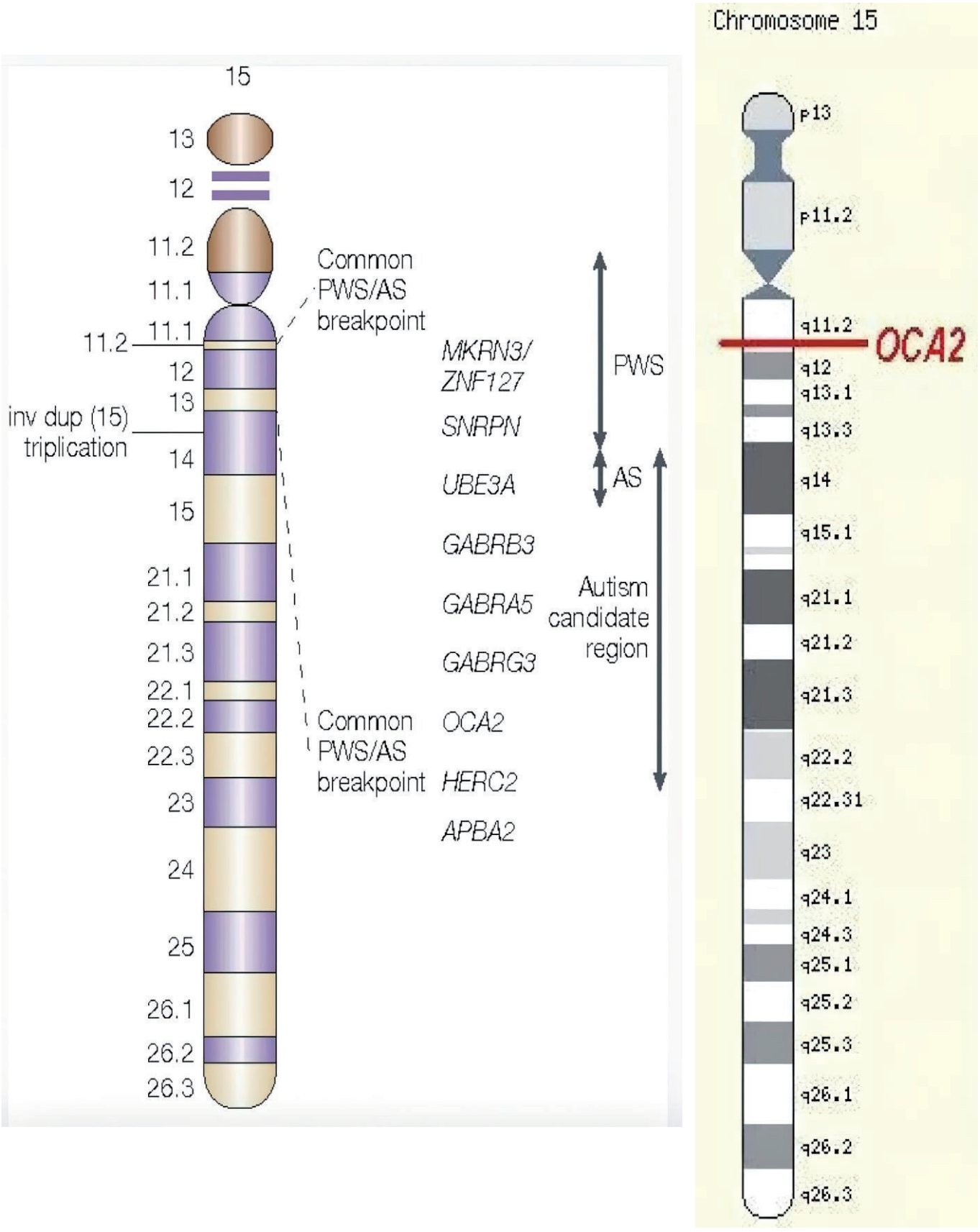
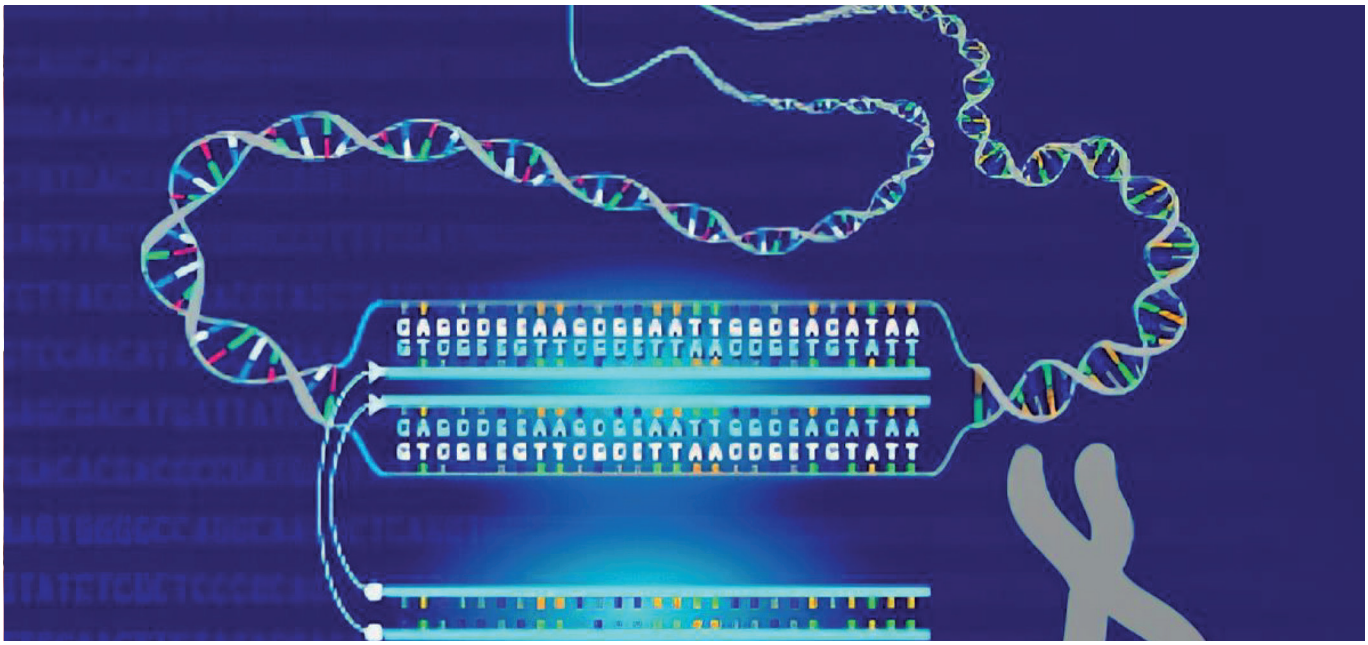


FIGURE 15: Chromosomes and genes involved on eye color

1.5 Glaucoma test



Glaucoma is a complex disease resulting from a mix of genetic and environmental factors. Family history is an important risk factor for glaucoma.

In primary open-angle glaucoma, the most common type of adultonset glaucoma, close relatives of affected patients are almost 10 times more likely to develop glaucoma than in the general population, underscoring a strong genetic basis.

A physical map of the GLC1A genomic region is now available, and the actual GLC1A gene might be identified in the near future. Nevertheless, open-angle glaucoma is a genetically heterogeneous entity, and additional loci have been mapped or proposed. Identification of open-angle glaucoma genes should provide invaluable clues to the disorder's pathophysiology.
It could also aid in conceiving novel therapeutic agents and broadening the screening of atrisk subjects.

Gen	Alelos	Resultados	
		wtwt	wtvt
ATOH7	rs1900004	CC	
SIX1/SIX6	rs10483727	TT	
CDKN2B	rs1063192	TT	
TMCO	rs4656461		AG
CAV1/CAV2	rs4236601		

Gen	Alelos	Resultados
ATOH7	rs1900004	CC
SIX1/SIX6	rs10483727	CC
CAV1/CAV2	rs4236601	GG
CDKN2B	rs1063192	TT
TMCO	rs4656461	AA

Polimorfismos genéticos y cálculo del riesgo asociado

RESULTADO:

Su puntuación de riesgo es de:
3.93

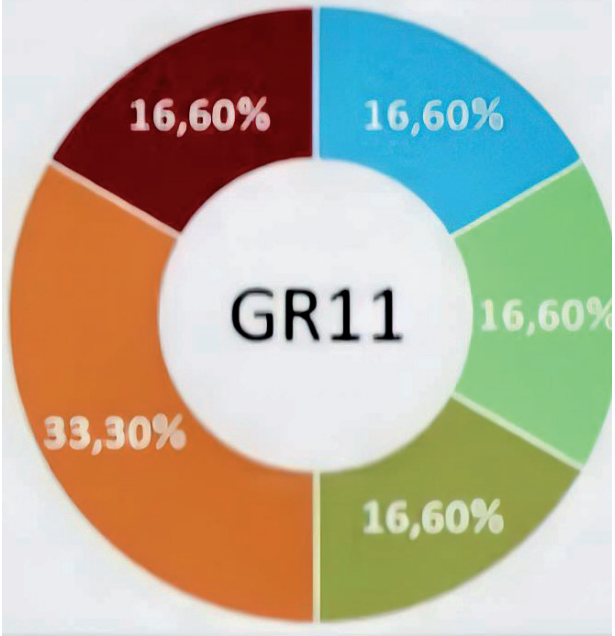
GEN (SNP [1])	GENOTIPO	COMENTARIO
LOXL1 (NG_011466.1)		
rs3825942	GG	Asociado a riesgo alto
rs12914489	GG	Asociado a riesgo medio
rs16958477	CC	Asociado a riesgo medio

Su Riesgo: 5,53%

Gen	Alelos	Resultados
ATOH7	rs1900004	CT
SIX1/SIX6	rs10483727	TT
CDKN2B	rs1063192	CC
TMCO	rs4656461	AA
CAV1/CAV2	rs4236601	AG

FIGURE 16: Positive glaucoma genetic test. Genes affected

1.5 Eye color test



There are at least a dozen eye color-related genes that scientists know of. And there are plenty more they don't know about yet.

AncestryDNA looks at four wellstudied markers linked to eye color in the TYR, OCA2, and HERC2 genes, and near the SLC24A4 gene. Pattern at these genetic markers is what determines eye color result.

Some people have markers linked only to light eye color. Some have markers tied only to dark color. And others have a combination of both light eye color markers and dark eye color markers. The scientists used powerful mathematical algorithms to find the smallest subset of these SNPs that could be used to predict eye colour accurately and found six that predicted blue and brown eye colour with just over 90% accuracy.

The accuracy of the test is lower — just over 70% — for eyes of other colour.

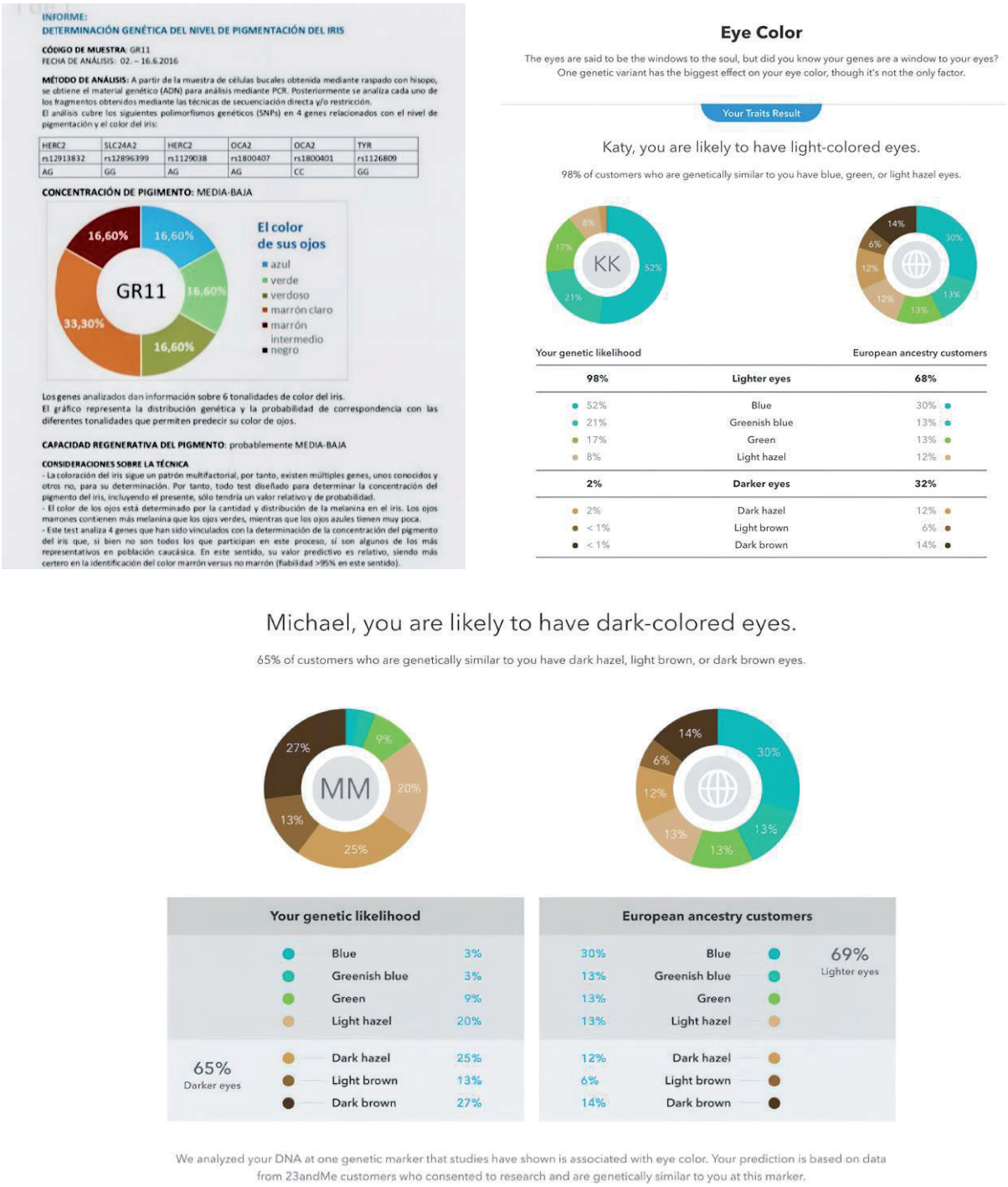
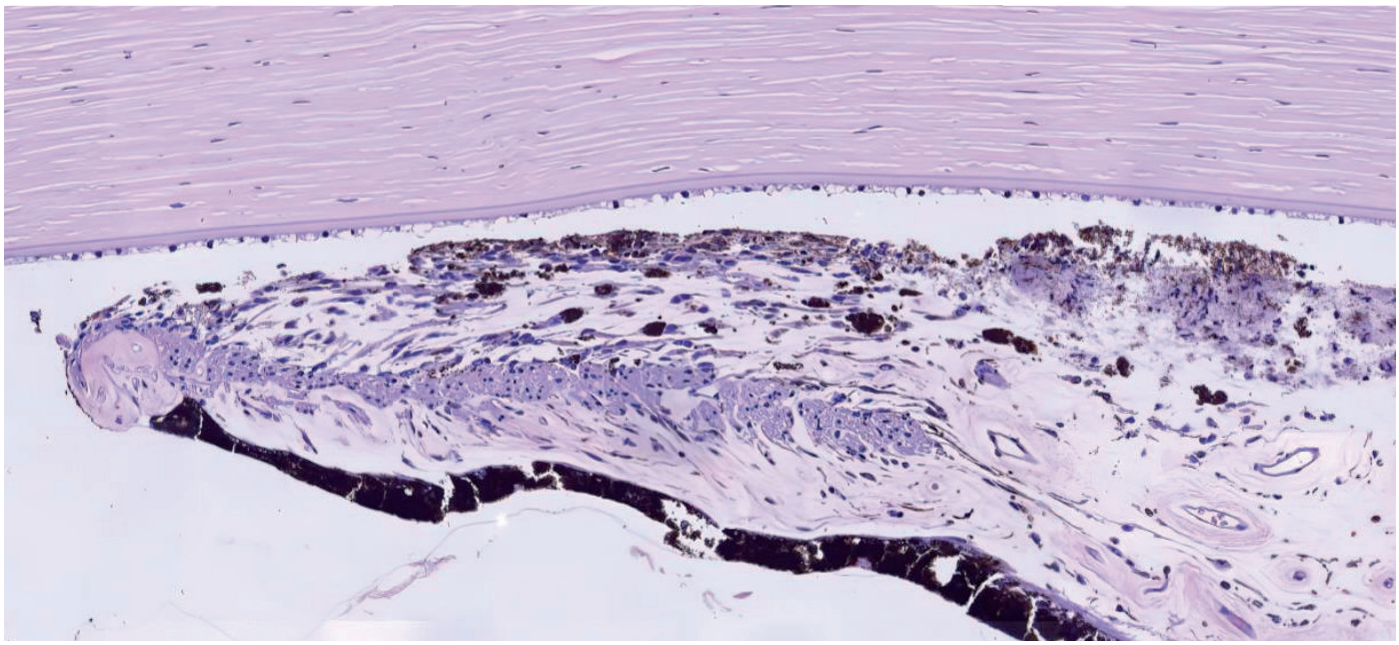


FIGURE 17: Several examples of Eye Color genetic test

1.6 Iris Histology



The histology of iris is considered to be very specific and unique in general and varies in different individuals according to their inheritance. These cellular composition and distribution in the iris tissue are very variable according to the iris color. The unusual and specific characteristics of iris histology is also very different from other organs.

Consists of stroma and posterior epithelial lining (two closely apposed epithelial layers, with numerous melanosomes); contains sphincter muscle within stroma that controls pupil. Regulates amount of light reaching pupil; muscles of iris dilate or constrict pupil in response to parasympathetic or sympathetic nerve impulses; normal diameter of pupil is 1 - 8 mm.

Color is due to number of stromal melanocytes; blue irises have few stromal melanocytes; brown irises have numerous melanocytes.

The anterior surface/border of the iris is a thin layer of fibroblasts and collagen, without being covered by endothelium or epithelium which make the iris float and be exposed to the Aqueous Humor and its contents. This effect also participates in the light reflection and the emerging observable color of the iris. It also facilitates the constant movement of the iris due to light and

accommodation and the constant exposure to the molecules and signaling pathways and the immune privilege condition in the anterior chamber.

The layer beneath the fibroblasts composed of melanocytes with variable pigment which is different in different color eyes. These melanocytes have very specific characteristic that make them very different from other types of melanocytes such as skin melanocytes. For example, the iris melanocytes do not respond to UV exposure (No tanning) due to lack of, or nonfunctioning specific Melanocortin receptor (MC1R). Iris melanocytes do not transfer as many pigment organelles (melanosomes) into neighboring cells as in the skin.

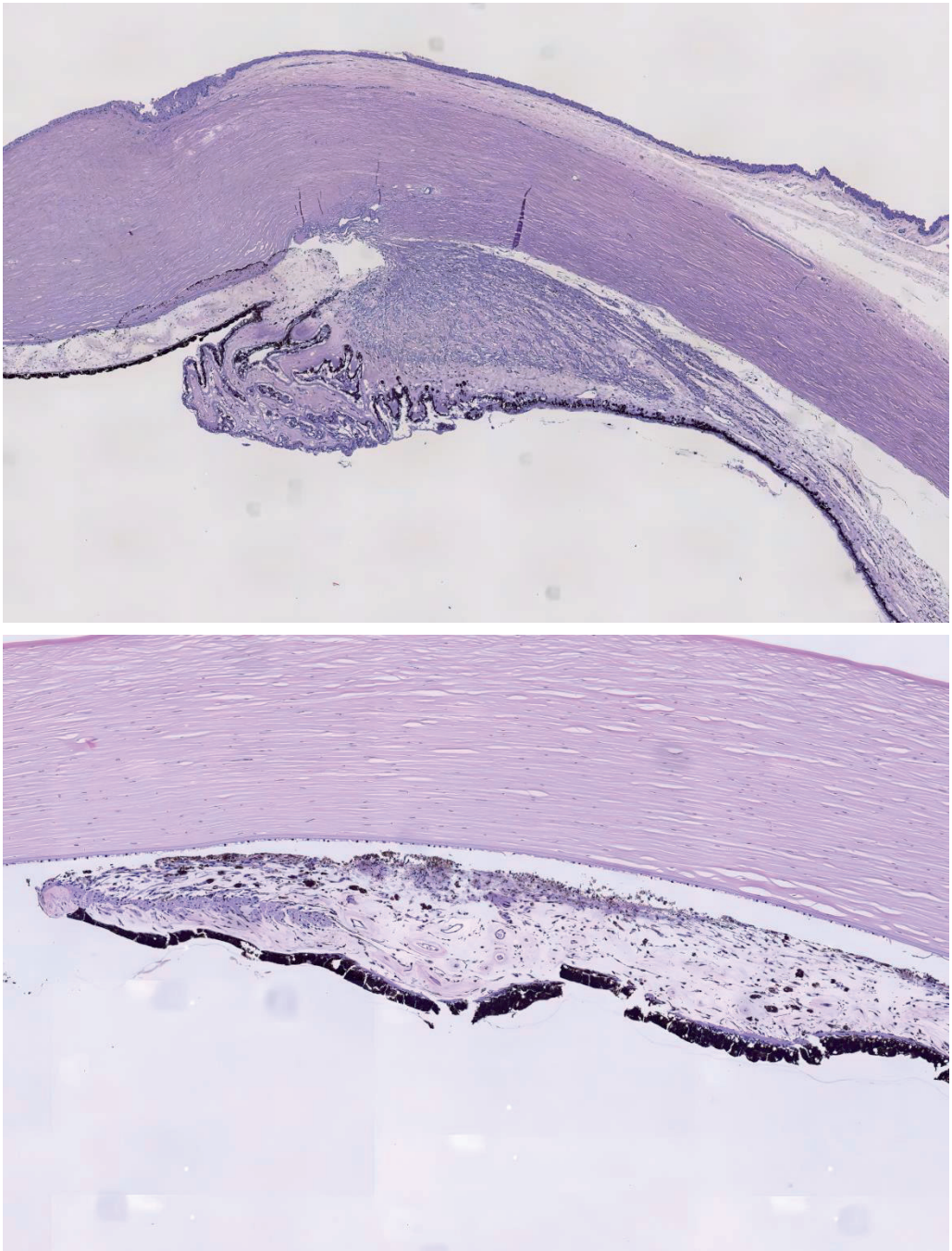
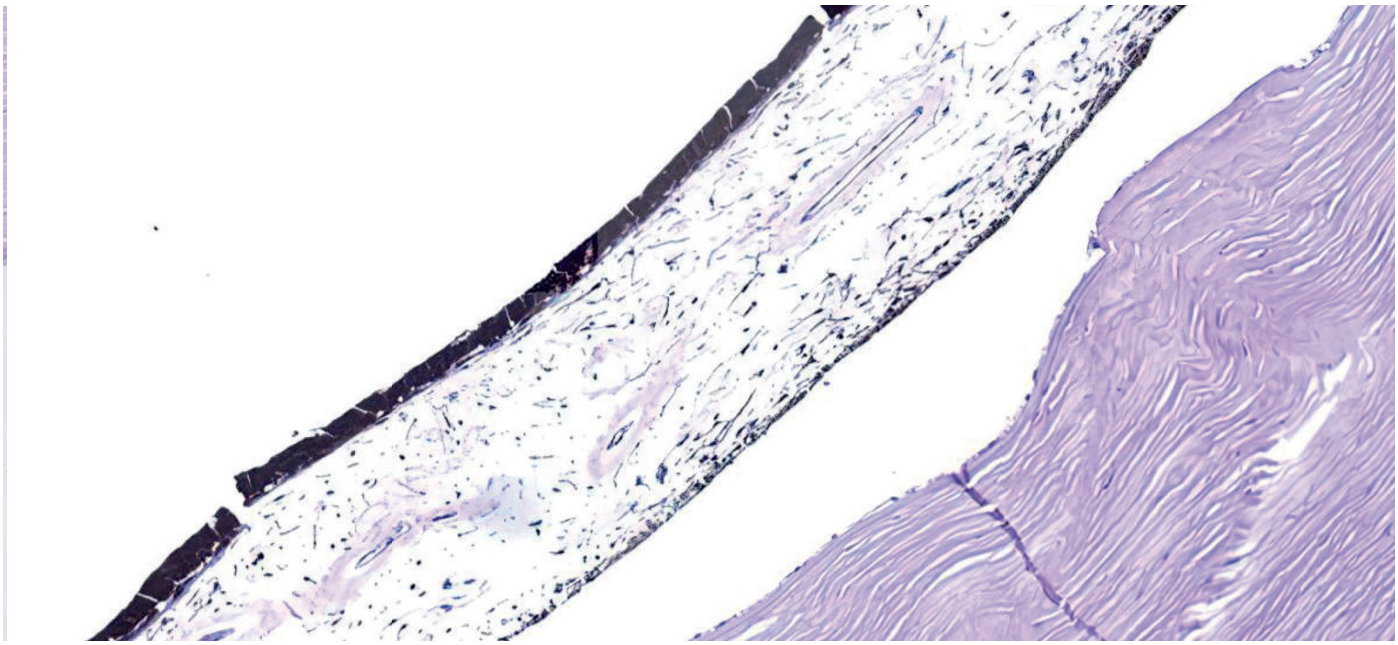


FIGURE 18: Hystological layers of iris

1.6 Iris Histology



Everyone has the same number of melanocytes. However, they produce different amounts of melanin. This is what causes different eye colors. Sufficient amounts of melanin will make your iris brown. According to scientists, everyone used to have brown eyes. However, an unusual mutation occurred about 10,000 years ago that turned off the pigmentation on the outer part of the iris. The reduced amount of melanin in the iris allows light to pass through and gets scattered by collagen fibers deeper in the iris. When the light is reflected back, it gives the eyes a bluer color.

Depending on the extent of pigmentation, the color can range from light blue to dark brown. Common eye colors include blue, green, hazel, or brown. Nowadays, iris color is an inherited trait.

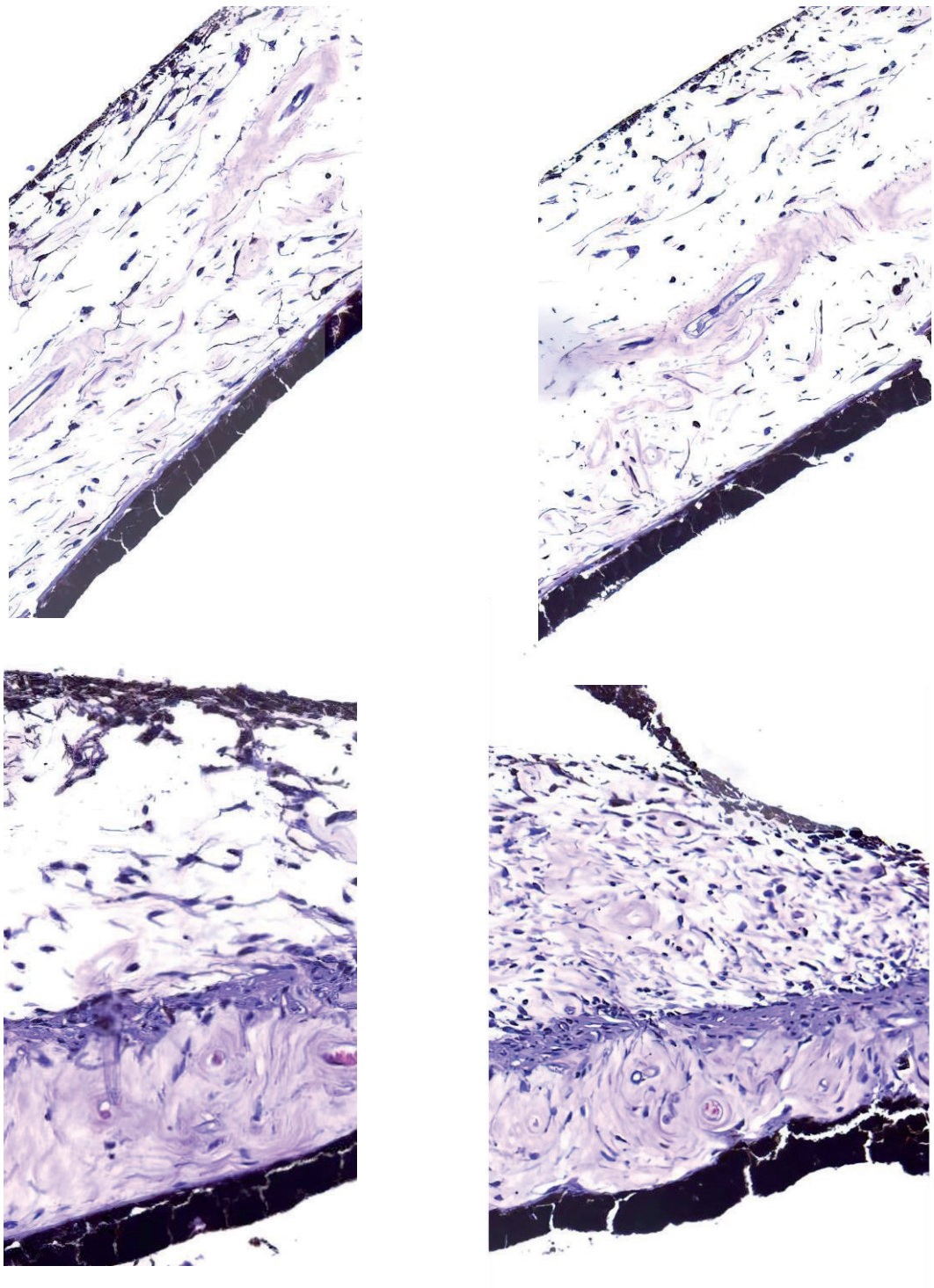


FIGURE 19: Thin front layer, thick stroma and black back layer

1.7 Classification

The Martin-Schultz scale, developed from the Martin scale, is one standard color scale commonly used in physical anthropology to establish more or less precisely the eye color of an individual; it was created by the anthropologists Rudolf Martin and Bruno K Schultz and in the first half of the 20th century. The scale consists of 20 colors (from light blue to dark brown-black) that correspond to the different eye colors observed in nature due to the amount of melanin in the iris. In order to have a simpler and practical table, we first introduced a four levels classification, and later a new one with five levels, from less to more pigmentation.

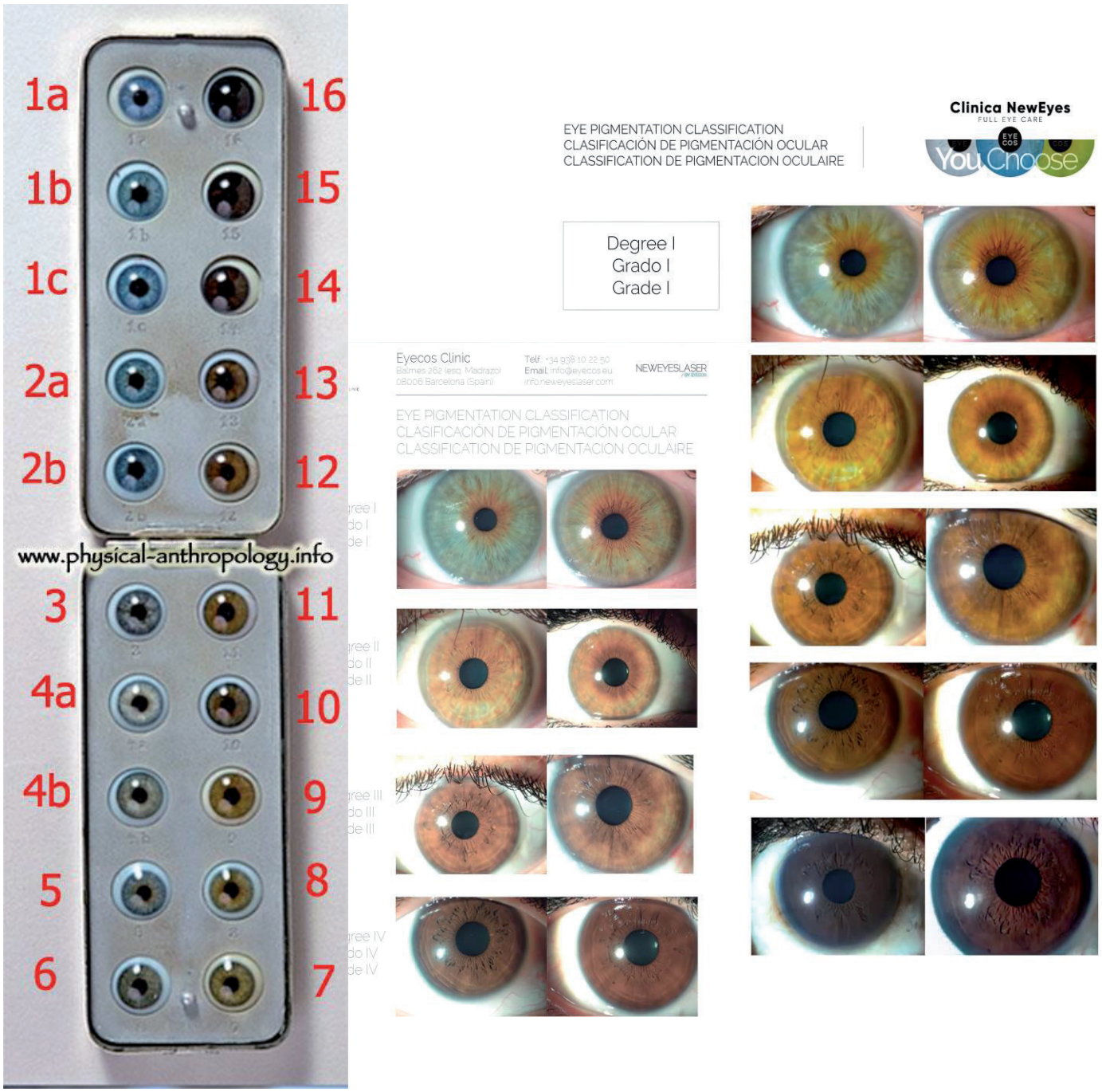
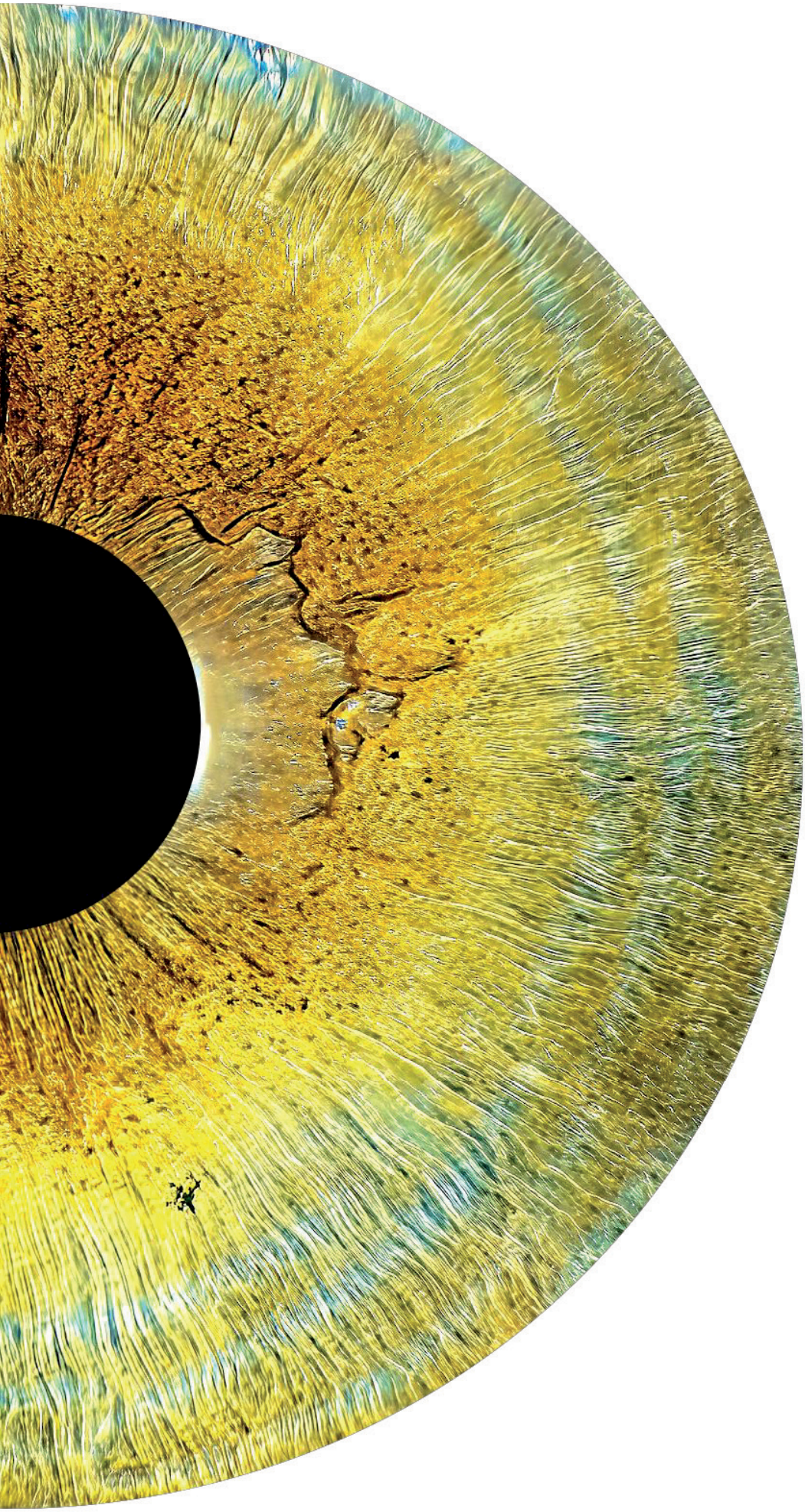


FIGURE 20: Martin Schultz scale and two Eyecos classifications

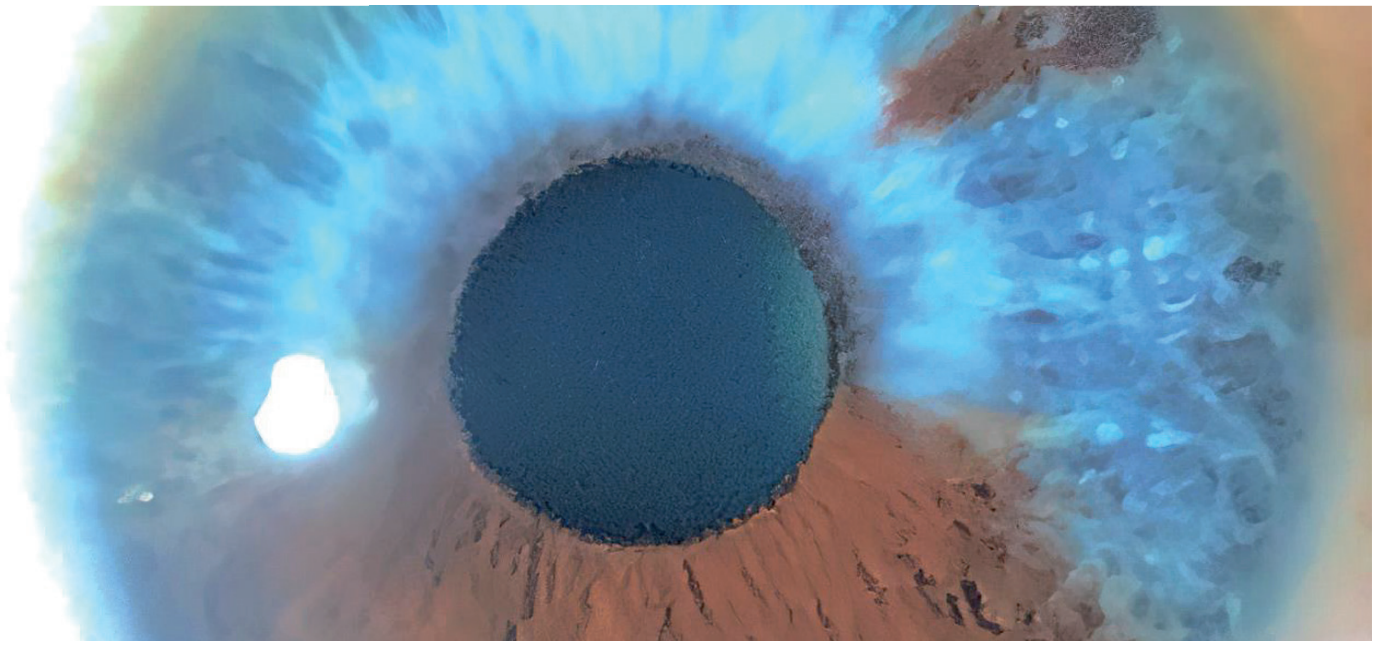


PART 1

INTRODUCTION

CHAPTER 2 PATHOLOGIES

1 2.1 Congenital Heterochromia



Heterochromia is when a person's irises are different colors. There are a few kinds of heterochromia. Complete heterochromia is when one iris is a different color than the other. When part of one iris is a different color than the rest of it, this is called partial heterochromia. Central heterochromia is when there is an inner ring that is a different color than the outer area of the iris. There are many types and causes of heterochromia.

An infant can be born with it or develop it soon after birth. In these cases, it is called congenital heterochromia.

In most cases, children born with heterochromia will experience no other symptoms.

They do not have any other problems with their eyes or general health. However, in some cases heterochromia can be a symptom of another condition.

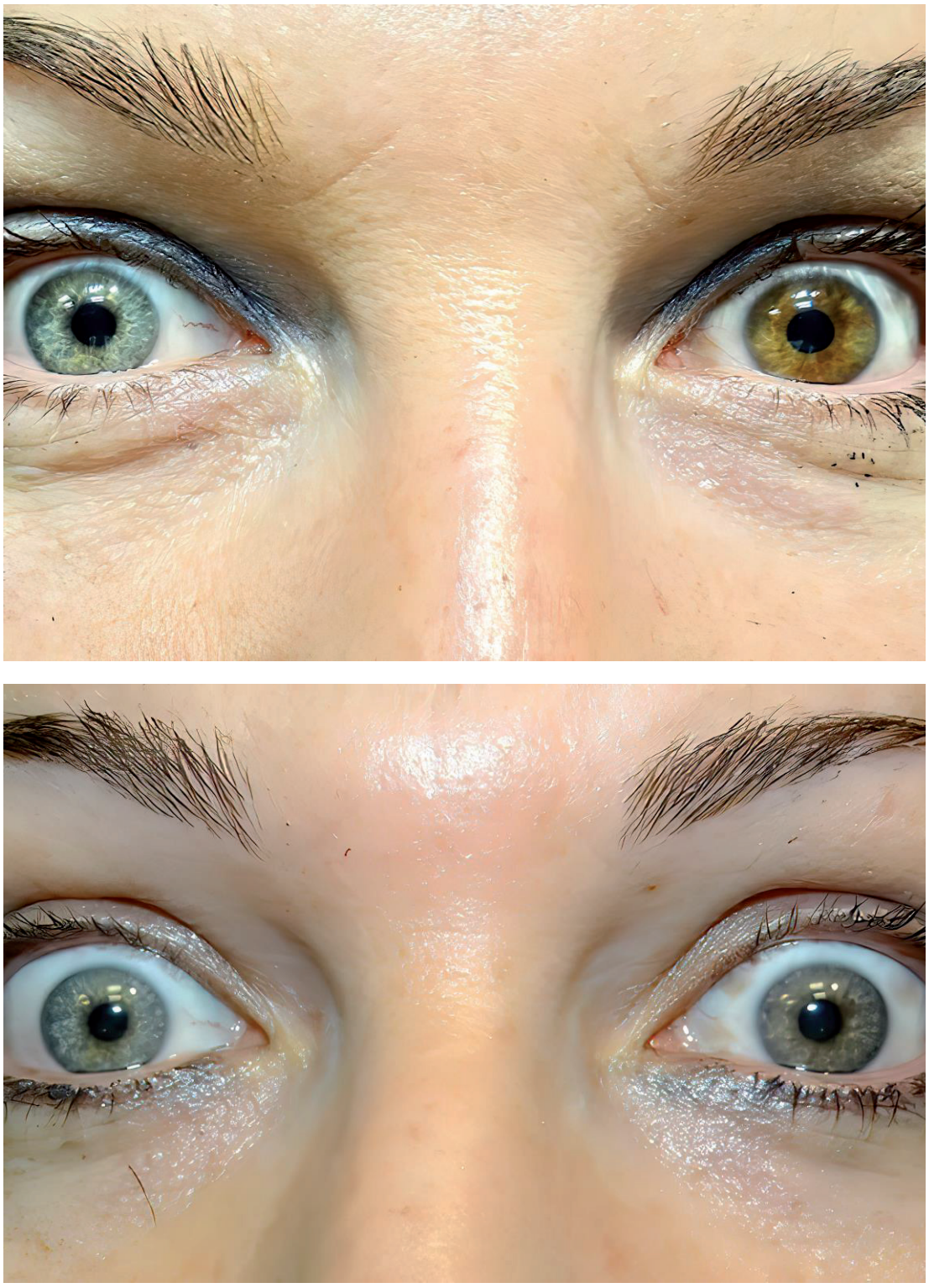
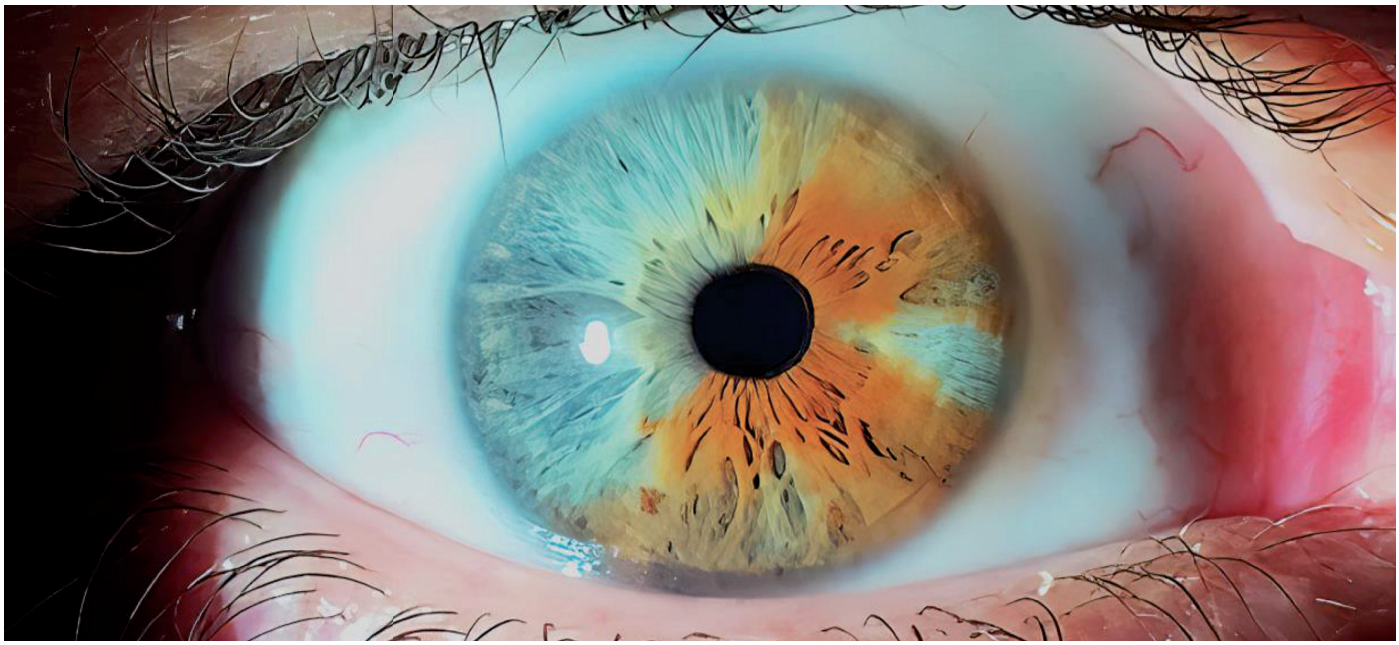


FIGURE 21: Congenital unilateral full heterochromia

1 2.1 Congenital Heterochromia



Heterochromia is classified primarily by onset: as either genetic or acquired. Although a distinction is frequently made between heterochromia that affects an eye completely or only partially (sectoral heterochromia), it is often classified as either genetic (due to mosaicism or congenital) or acquired, with mention as to whether the affected iris or portion of the iris is darker or lighter. Most cases of heterochromia are hereditary, or caused by genetic factors such as chimerism, and are entirely benign and unconnected to any pathology, however, some are associated with certain diseases and syndromes. Sometimes one eye may change color following disease or injury.

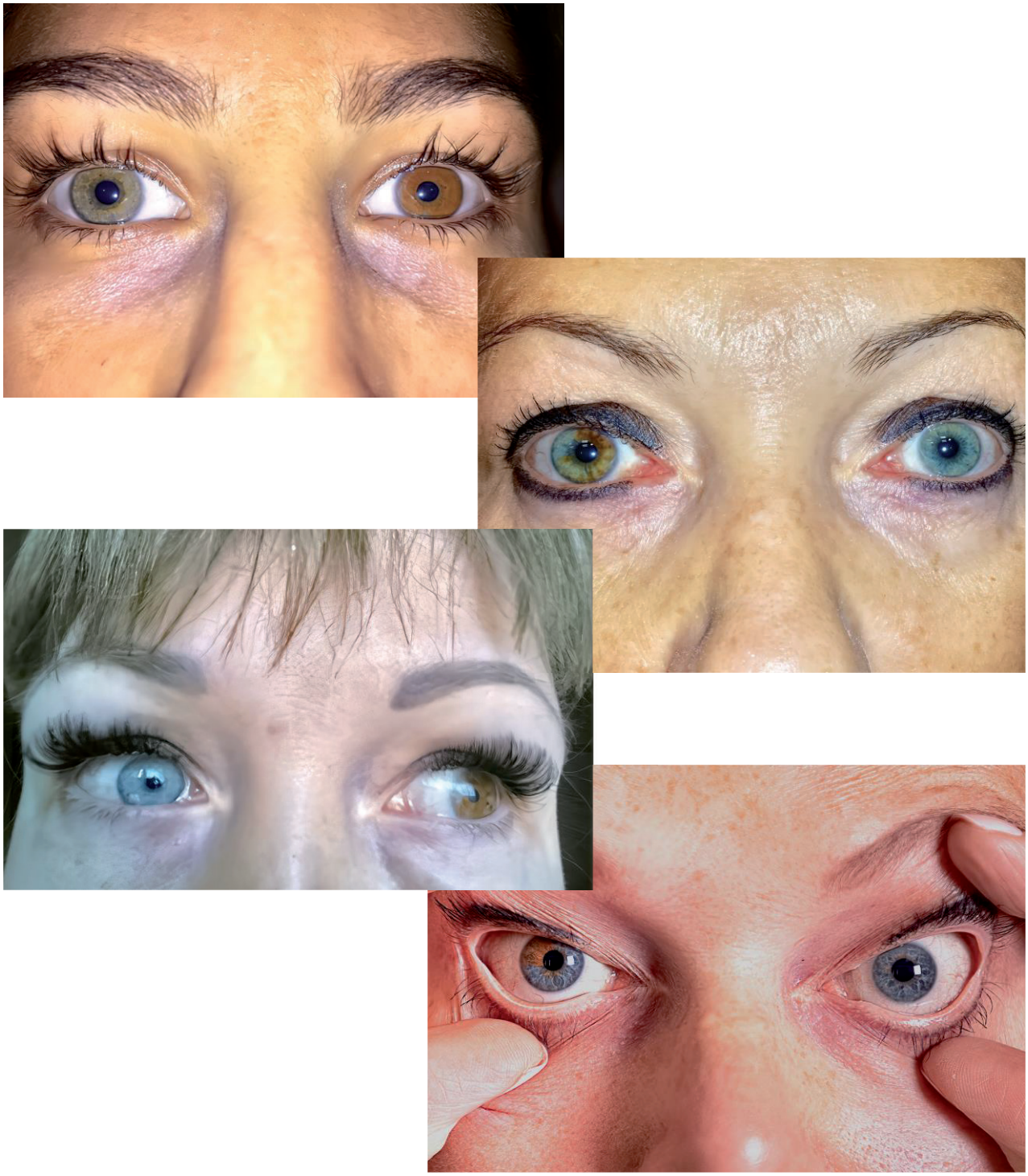
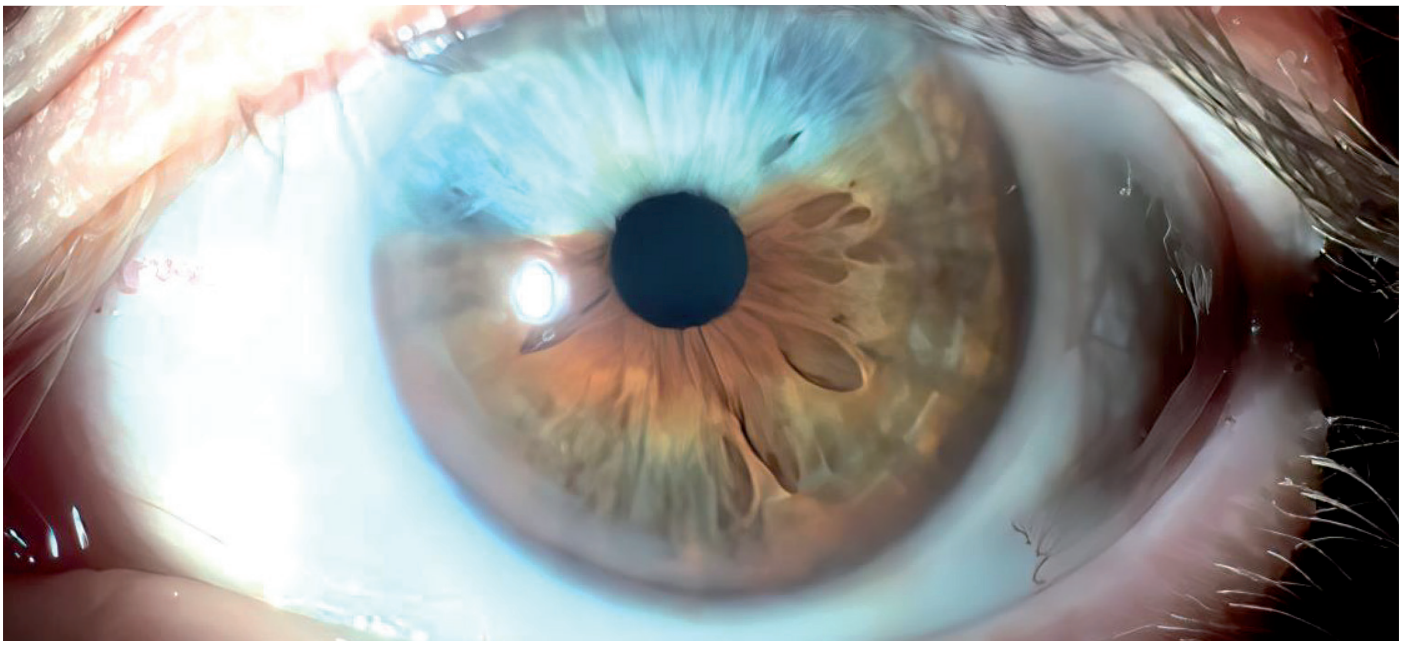


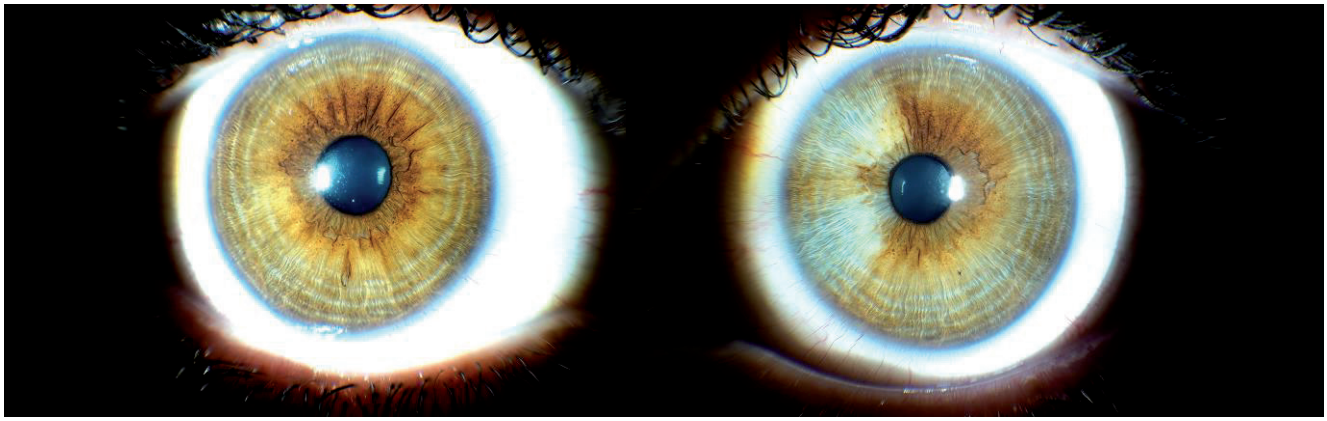
FIGURE 22: Congenital unilateral partial heterochromia

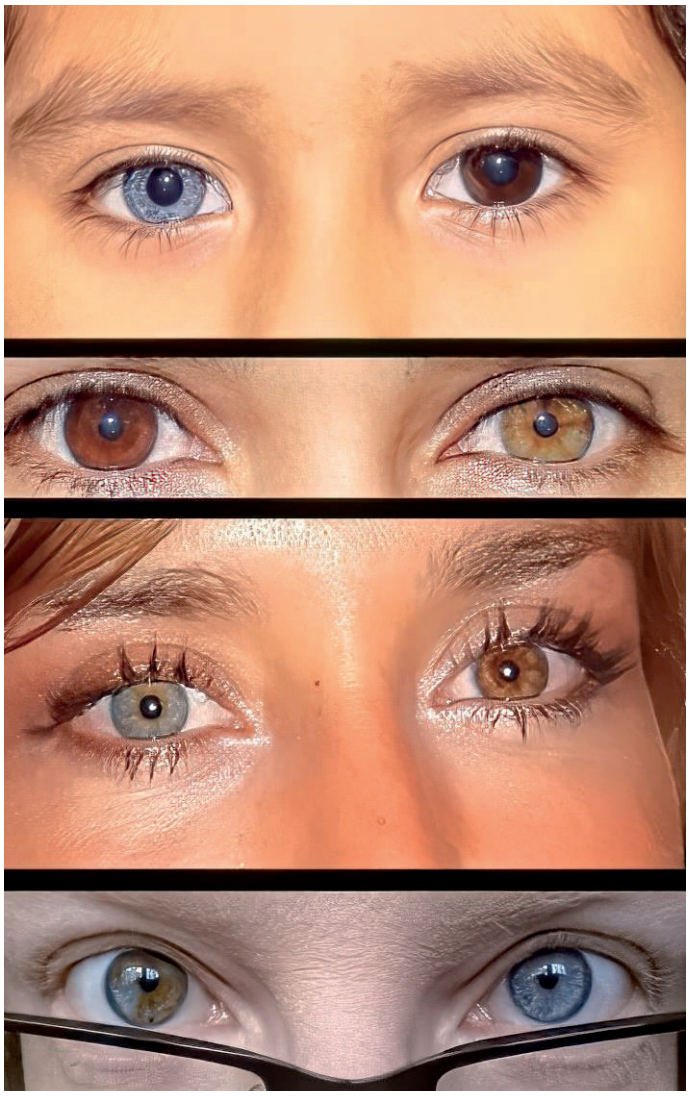
1 2.1 Congenital Heterochromia

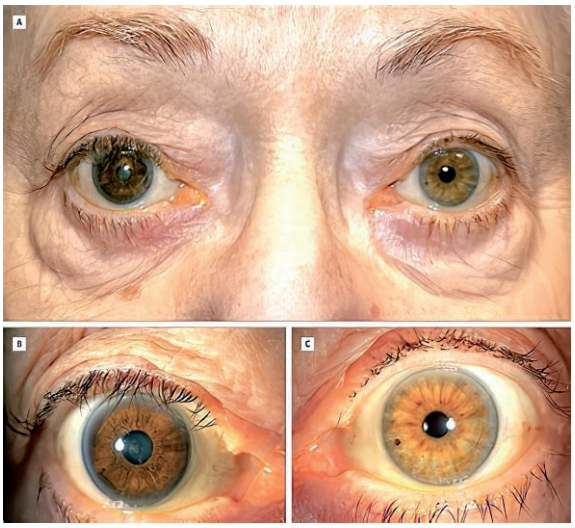


Partial heterochromia is most often a benign trait of genetic origins, but, like complete heterochromia, can be acquired or be related to clinical syndromes. In sectoral heterochromia, areas of the same iris contain two different colors, the contrasting colors being demarcated in a radial, or sectoral, manner. Sectoral heterochromia may affect one or both eyes. It is unknown how rare sectoral heterochromia is in humans, but it is considered to be less common than complete heterochromia. Central heterochromia is also an eye condition where there are two colors in the same iris; but the arrangement is concentric, rather than sectoral.

The central (pupillary) zone of the iris is a different color than the mid-peripheral (ciliary) zone. Central heterochromia is more noticeable in irises containing low amounts of melanin.







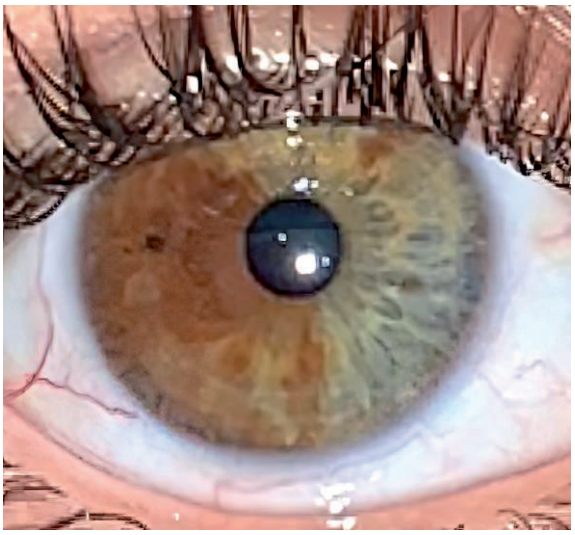
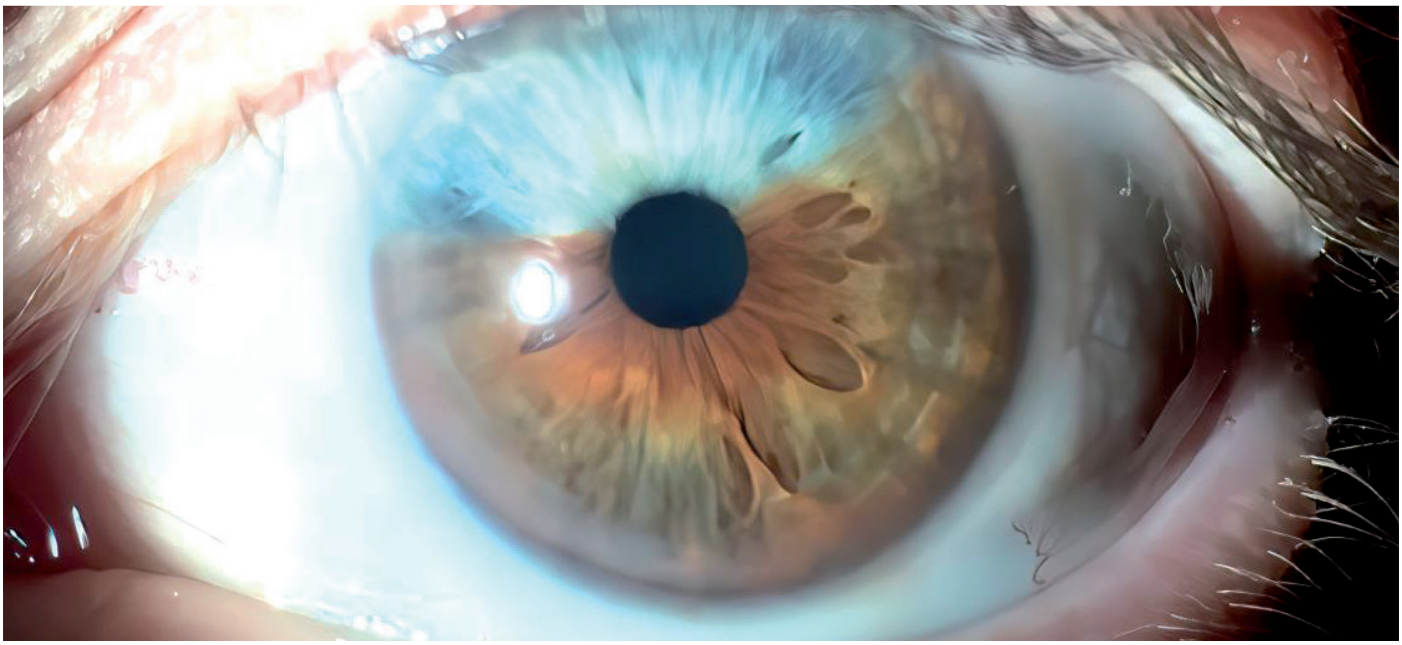


FIGURE 23: Congenital unilateral heterocrhomies

1 2.1 Congenital Heterochromia



Heterochromia of the eye was first described as a human condition by Aristotle, who termed it heteroglaucos.

Notable historical figures thought to have heterochromia include the Byzantine emperor Anastasius the First, dubbed dikoros (Greek for 'having two pupils). "His right eye was light blue, while the left was black, nevertheless his eyes were most attractive", is the description of the historian John Malalas. A more recent example is the German poet, playwright, novelist, scientist, statesman, theatre director, and critic, Johann Wolfgang Goethe. The Alexander Romance, an early literary treatment of the life of Alexander the Great, attributes heterochromia to him. In it he is described as having one eye light and one eye dark. In the Ars Amatoria, the Roman poet Ovid describes the witch Dipsas as having 'double pupils'.

The Roman jurist and writer Cicero also mentions the same feature of 'double pupils' as being found in some Italic women. Pliny the Elder related this feature to the concept of 'the evil eye".

The twelfth-century scholar Eustathius, in his commentary on the Iliad, reports

a tradition in which the Thracian Thamyris (son of the nymph Argiope), who was famed for his musical abilities, had one eye that was grey, whilst the other was black. W. B. McDaniel suggests that this should be interpreted as heterochromia.

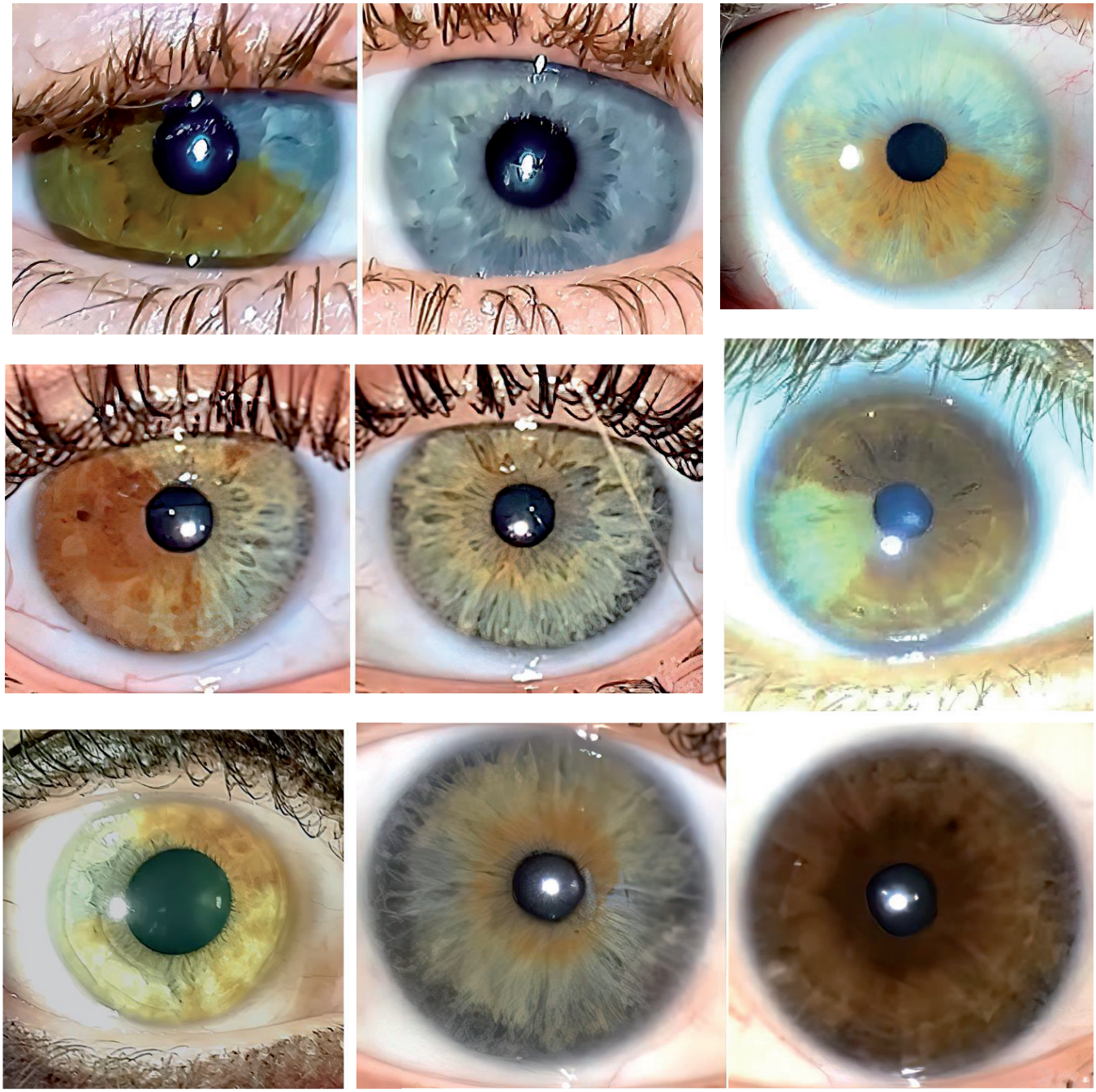


FIGURE 24: Congenital unilateral heterochromies

2.1 Celebrities

Many celebrities with differentcolored eyes have complete heterochromia. This occurs when one iris is an entirely different color than the other. While it's typically congenital, meaning it's present from birth or early childhood, it can also occur later as the result of an eye injury, disease or use of certain medications. Mila Kunis had one hazel eye while the other had a blue tint. What many people don't know is that Mila Kunis's heterochromia was a result of an eye infection called chronic iritis. One of Max Scherzer's eyes is light blue and the other is dark brown, making him a perfect example of complete heterochromia.

Sectoral heterochromia, also called segmental or partial heterochromia, describes when different segments or wedges of color occur within one iris.

This typically varies in intensity and can occur in one eye or both. In one of Kate Bosworth's eyes, the bottom portion of the iris is a hazel mixture of green, brown and amber. One of Jane Seymour's eyes is green (or hazel, depending who you ask) and the other has some green and a lot of brown.

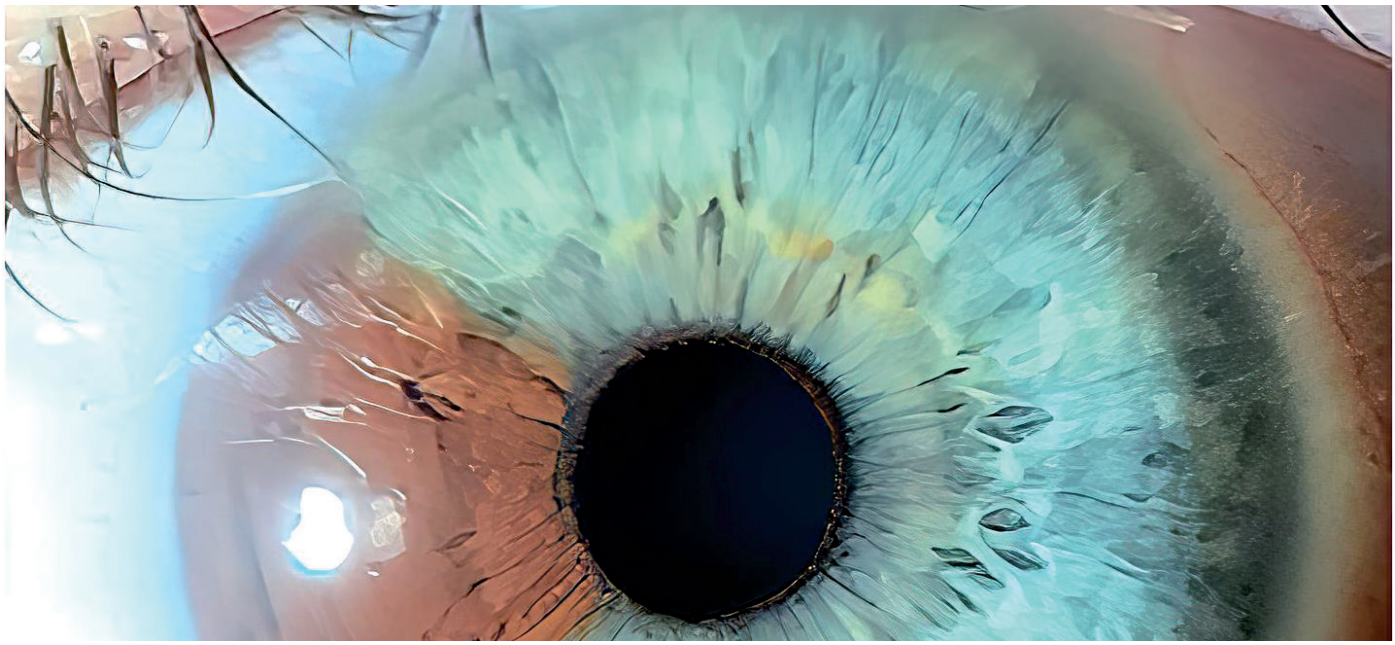
Central heterochromia is characterized by having one color focused around and radiating from the pupil. The Game of Thrones star Emilia Clarke has dark

blue irises with a hazel ring around her pupils — all hail the Mother of Dragons!

David Bowie's eye color was blue, but his anisocoria caused one of his eyes to appear almost black because his pupil was so large.

FIGURE 25: True and fake celebrities heterochromy

2.2 Multi Nevi



A nevus is a common, colored growth on or in the eye. Sometimes called a freckle of the eye, it is similar to a mole on your skin. A nevus (plural: nevi) can be in the front of your eye, around the iris, or under the retina at the back of the eye.

A nevus is made up of cells called melanocytes. These cells produce melanin, the pigment that colors our hair, skin and eyes. Most of the time, melanocytes are spread evenly throughout body tissue. Sometimes, though, these cells can clump together and form nevi.

People can be born with harmless eye nevi. A pigmented spot that develops later in life is usually harmless as well but may have a greater risk of becoming cancer.

An eye nevus needs to be watched regularly by an ophthalmologist because, like a skin mole, it could possibly develop into cancer of the eye.

There may be an association b tween exposure to ultraviolet (UV) light and developing nevi. Wearing sunglasses that protect eyes from UV light is always recommended.

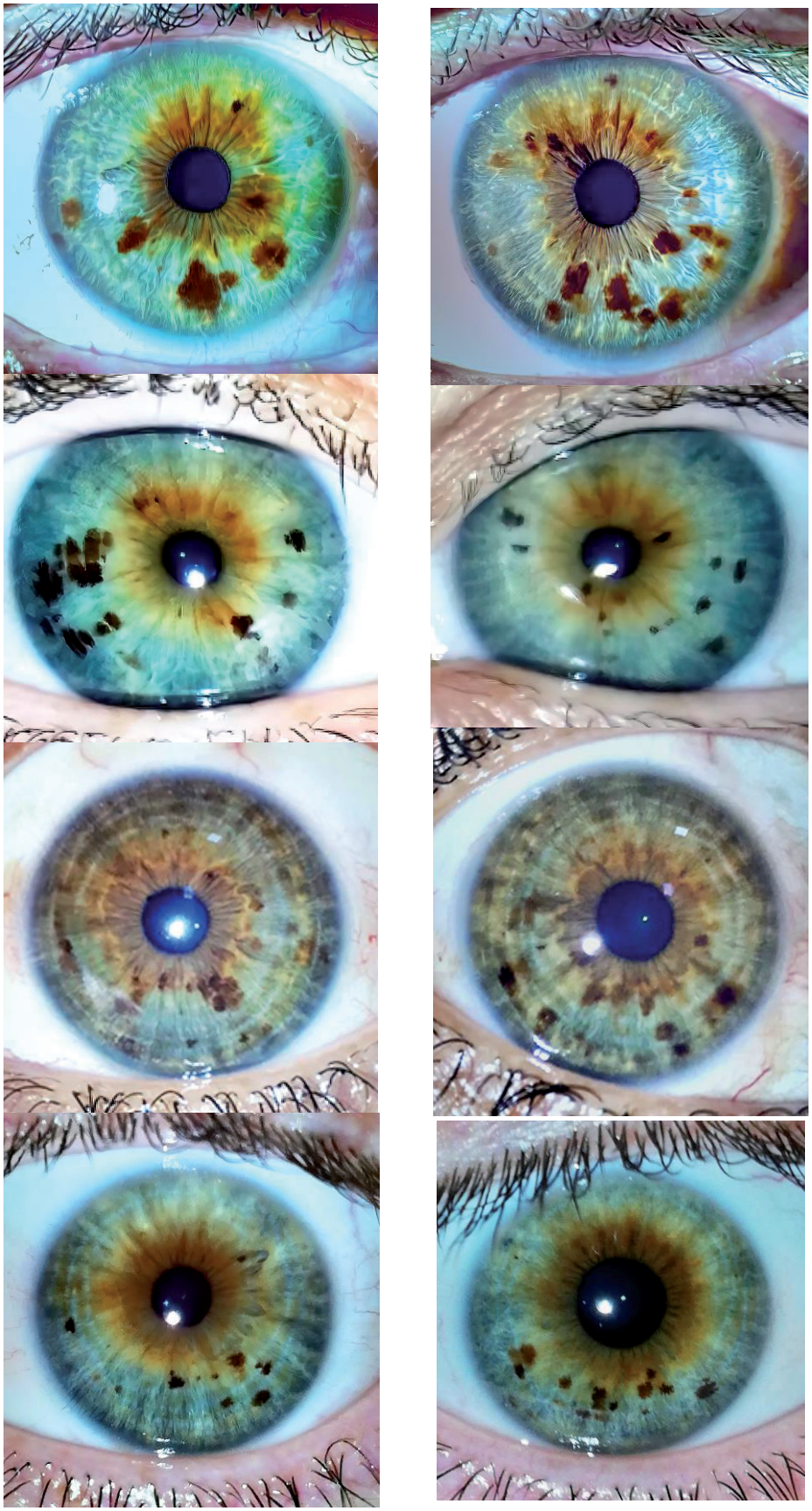
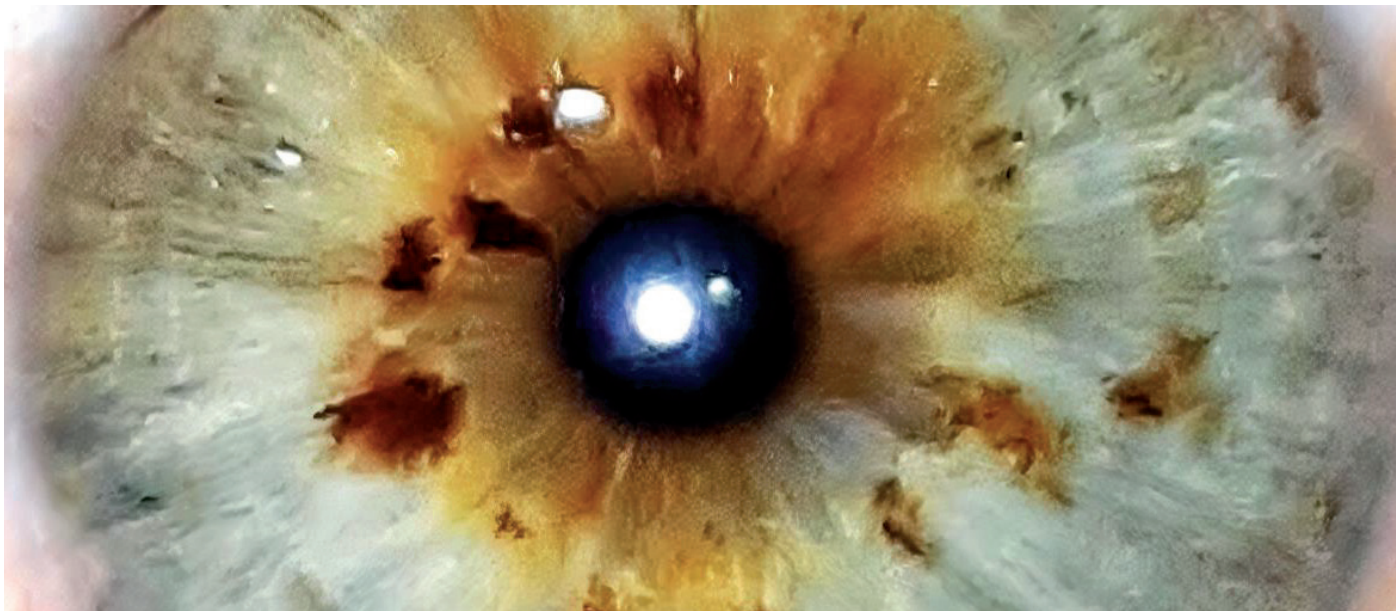


FIGURE 26: Multinevi

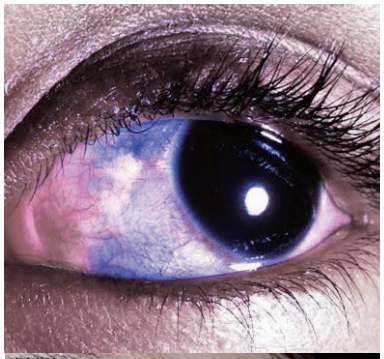
12.2 Nevus

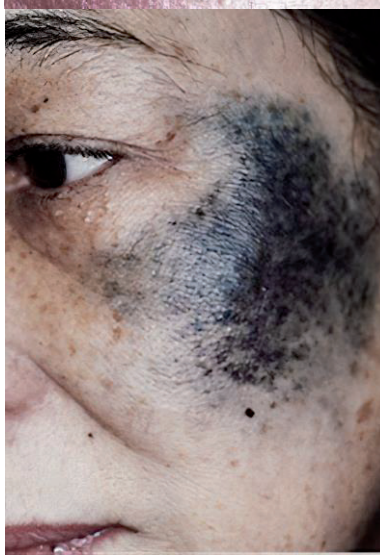


Nevus of Ota is a condition where hyperpigmentation occurs around the eye and sometimes in the eye itself. Hyperpigmentation is when some patches of skin are darker than the surrounding skin.

Nevus of Ota is also known as oculodermal melanocytosis.

It's a type of dermal melanocytic hamartoma, which means there are an increased number of melanocytes, or melaninproducing cells, in the tissues.





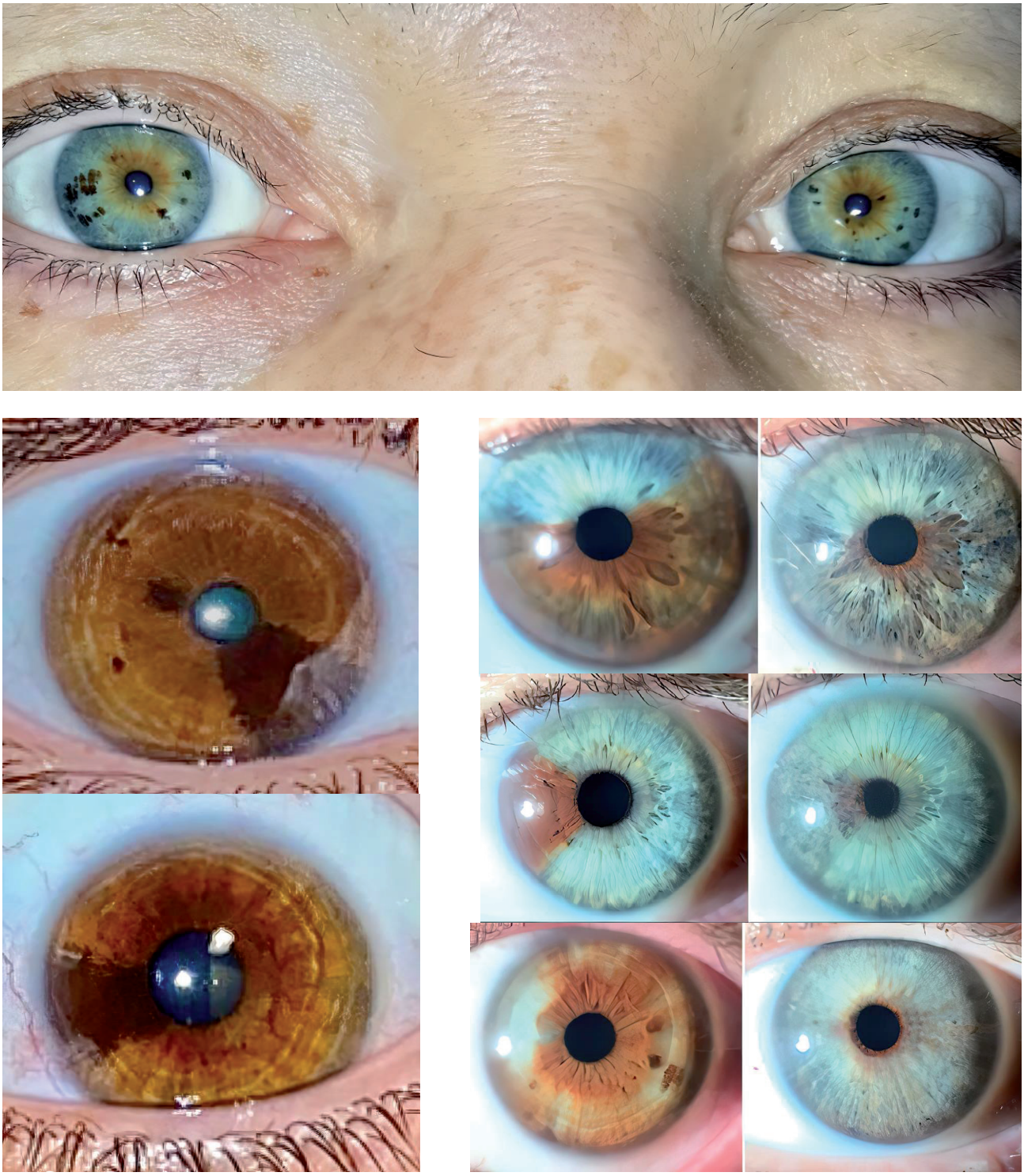


FIGURE 27: Left: Ota Nevus. Right: partial heterochromies

2.3 Albinism

Ocular albinism is a genetic condition that primarily affects the eyes. This condition reduces the coloring (pigmentation) of the iris, which is the colored part of the eye, and the retina. , which is the light-sensitive tissue at the back of the eye. Pigmentation in the eye is essential for normal vision.

Ocular albinism is characterized by severely impaired sharpness of vision (visual acuity) and problems with combining vision from both eyes to perceive depth (stereoscopic vision). Although the vision loss is perm nent, it does not worsen over time. Other eye abnormalities associated with this condition include rapid, involuntary eye movements (nystagmus); eyes that do not look in the same direction (strabismus); and increased sensitivity to light (photophobia). Many affected individuals also have abnormalities involving the optic nerves, which carry visual information from the eye to the brain.

Unlike some other forms of albinism, ocular albinism does not significantly affect the color of the skin and hair.

People with this condition may have a somewhat lighter complexion than other members of their family, but these differences are usually minor.

The most common form of ocular albinism is known as the Nettleship-Falls type or type 1. Other forms of ocular albinism are much rarer and may be associated with additional signs and symptoms, such as hearing loss..

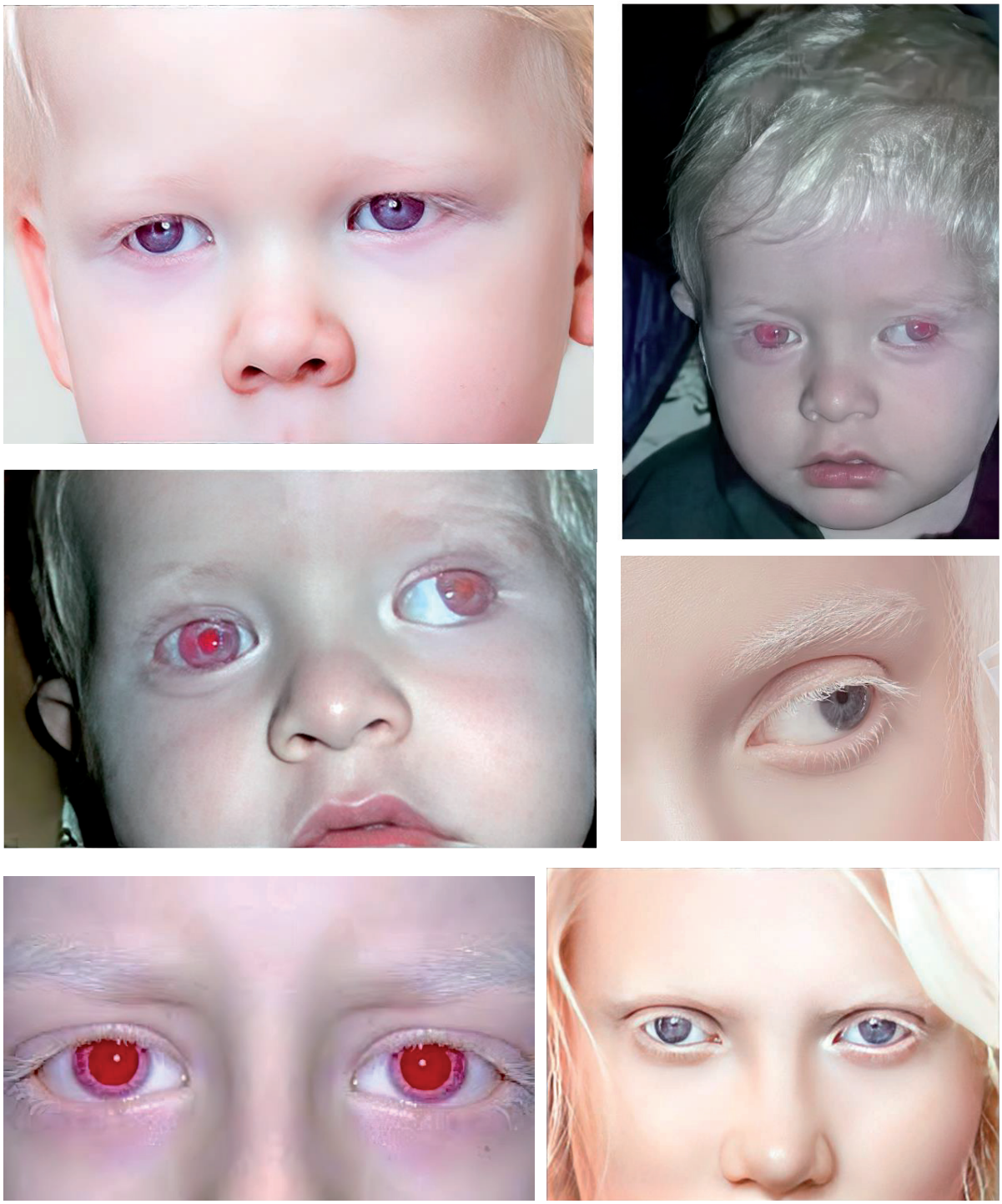


FIGURE 28: Full lack of melanin on childrem with albinism

12.3 Albinism

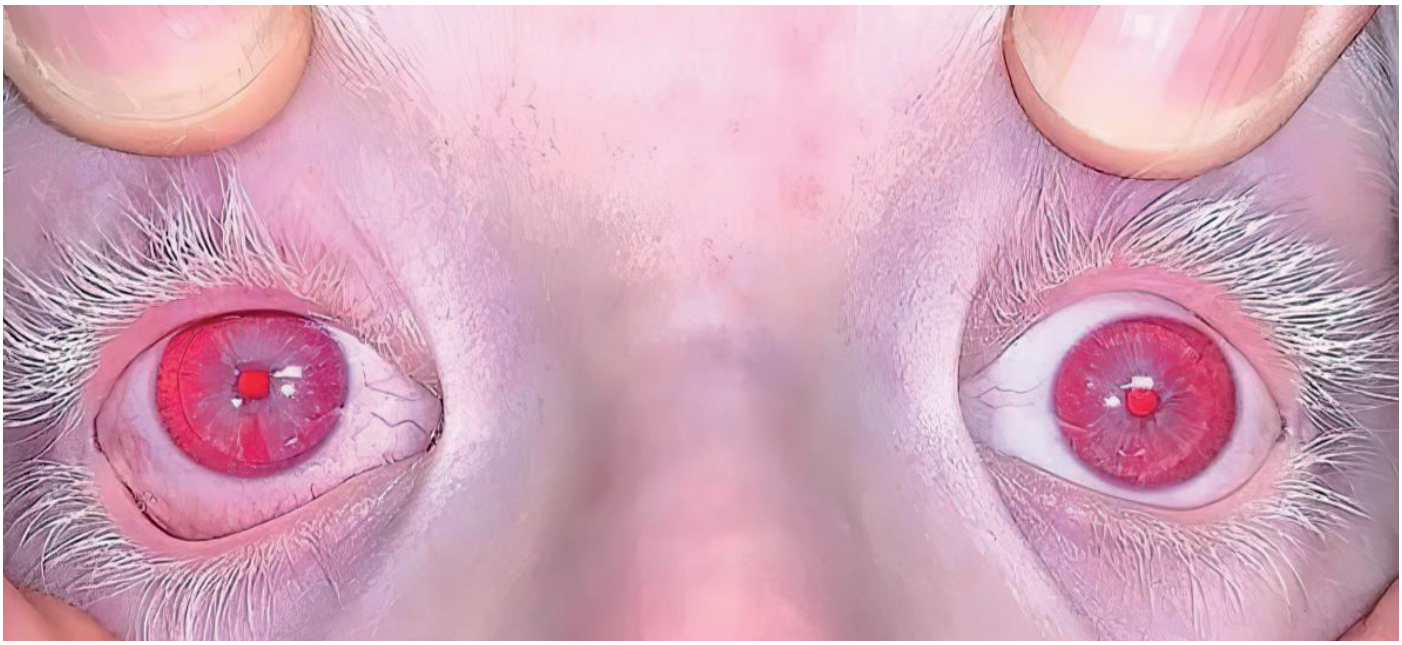
The most common form of this disorder, ocular albinism type 1, affects at least 1 in 60,000 males. The classic signs and symptoms of this condition are much less common in females. Ocular albinism type 1 results from mutations in the GPR143 gene. This gene provides instructions for making a protein that plays a role in pigmentation of the eyes and skin. It helps control the growth of melanosomes, which are cellular structures that produce and store a pigment called melanin. Melanin is the substance that gives skin, hair, and eye their color. In the retina, this pigment also plays a role in normal vision.

Most mutations in the GPR143 gene alter the size or shape of the GPR143 protein. Many of these genetic changes prevent the protein from reaching melanosomes to control their growth. In other cases, the protein reaches melanosomes normally, but mutations disrupt the protein's function. As a result of these changes, melanosomes in skin cells and the retina can grow abnormally large. Researchers are uncertain how these giant melanosomes are related to vision loss and other eye abnormalities in people with ocular albinism.

Rare cases of ocular albinism are not caused by mutations in the GPR143 gene. In these cases, the genetic cause of the condition is often unknown.

FIGURE 29: Full lack of melanin on skin, hair and eyes albinism

12.3 Albinism



Ocular albinism type 1 is inherited in an Xlinked pattern. A condition is considered Xlinked if the mutated gene that causes the disorder is located on the X chromosome, one of the two sex chromosomes. In males (who have only one X chromosome), one altered copy of the GPR143 gene in each cell is sufficient to cause the characteristic features of ocular albinism. Because females have two copies of the X chromosome, women with only one copy of a GPR143 mutation in each cell usually do not experience vision loss or other significant eye abnormalities. They may have mild changes in retinal pigmentation that can be detected during an eye examination.

The lack of pigment in the eyes causes various vision problems: Reduced visual acuity from 20/60 to 20/400 and sometimes as good as 20/25 in African-Americans, Nystagmus – involuntary back-and-forth movement of the eyes, Strabismus – With ocular albinism, the color of the iris of the eye may vary from blue to green or even crossed eyes or "lazy" eye, and Sensitivity to bright light and glare.

Brown, and sometimes darkens with age. However, when an eye doctor examines the eye by shining a light from the side of the eye, the light shines back through the iris since very little pigment is present. There may be areas of the

iris which have very little pigment.

The main problem with the eye in ocular albinism is in the fovea, small area of the retina which affords acute vision. With ocular albinism, the fovea does not develop completely, presumably because melanin pigment is needed for the growth processes that normally occur before birth. Therefore, the eye cannot process sharp light images. Because the fovea does not develop well, it is difficult to correct vision completely with glasses.

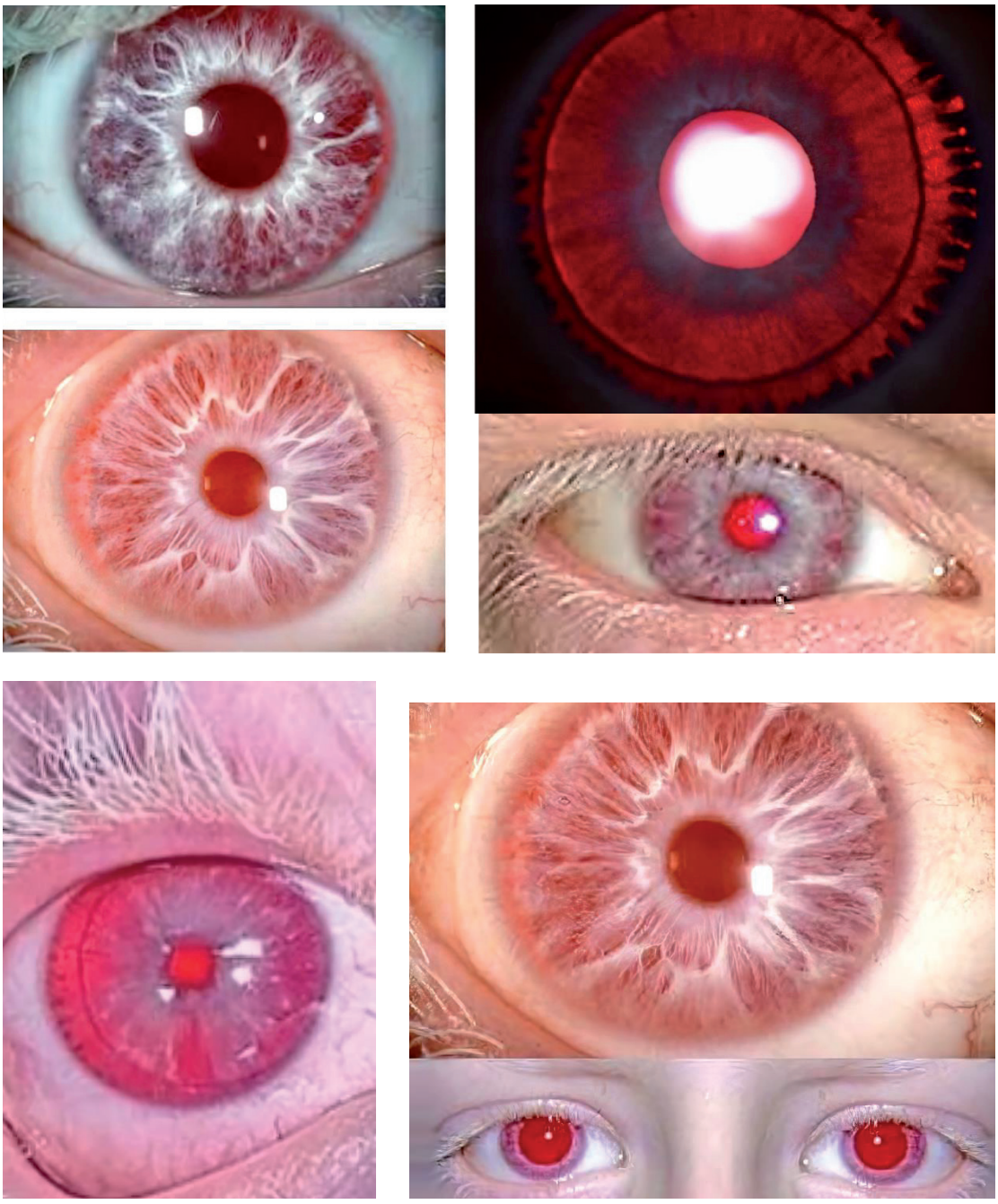
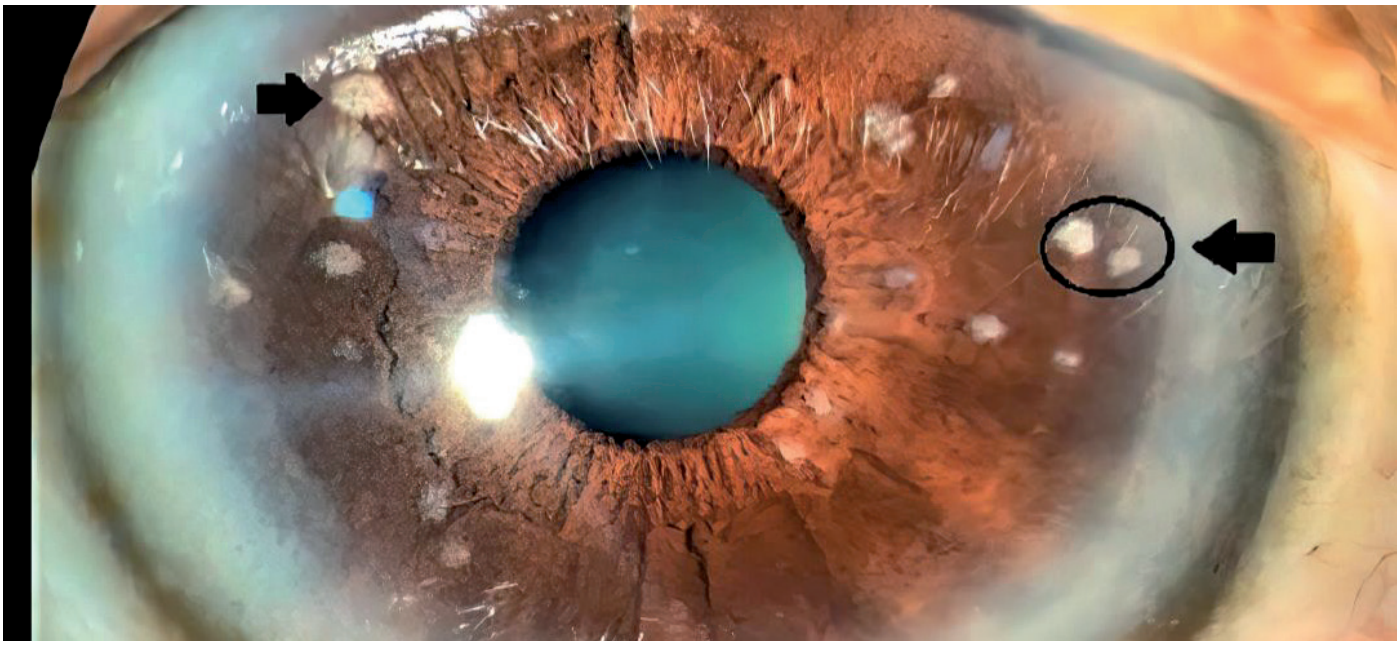


FIGURE 30: Red retinal reflex on albinism

2.3 Vitiligo



Vitiligo is a skin depigmentation disorder caused by the autoimmune destruction of cutaneous melanocytes. Several ocular abnormalities, including uveitis, dry eye, glaucoma and retinal diseases, have been documented in patients with vitiligo.

Slit lamp fundus examinations reveals significant abnormalities in 57.5% of vitiligo patients compared with 6.3% of the controls. Abnormalities include retinal hypopigmentation, retinal hyperpigmentation, iris nevus, iris depigmentation, elevated disc, tigroid fundus and conjunctival nevus. Differences also are noted in central macular thickness measured by optical coherence tomography.

Melanocytes in the retinal pigment epithelium and uveal tract share common developmental origins, physiology and morphology with those in the skin and protect against ultraviolet light.

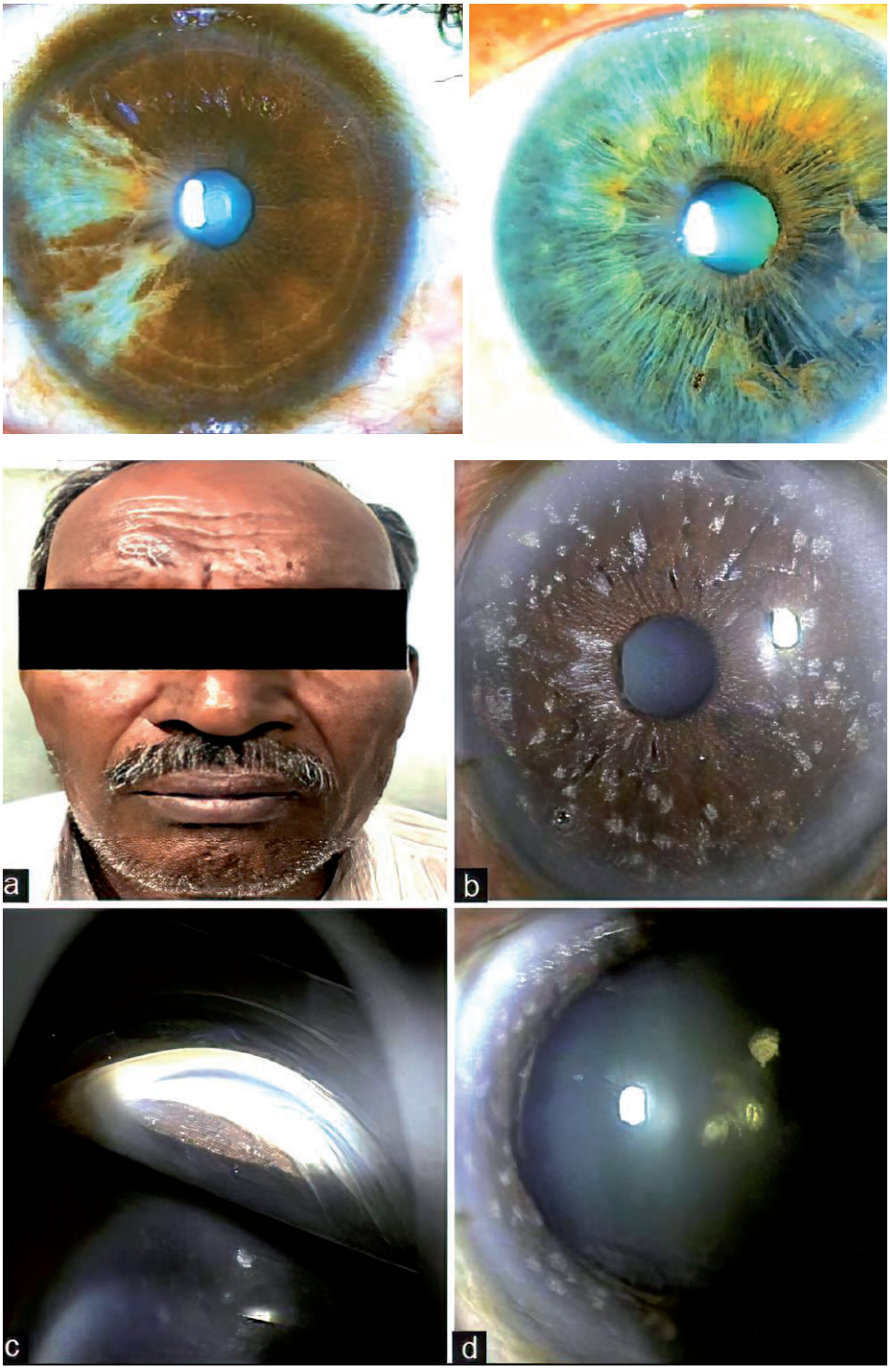
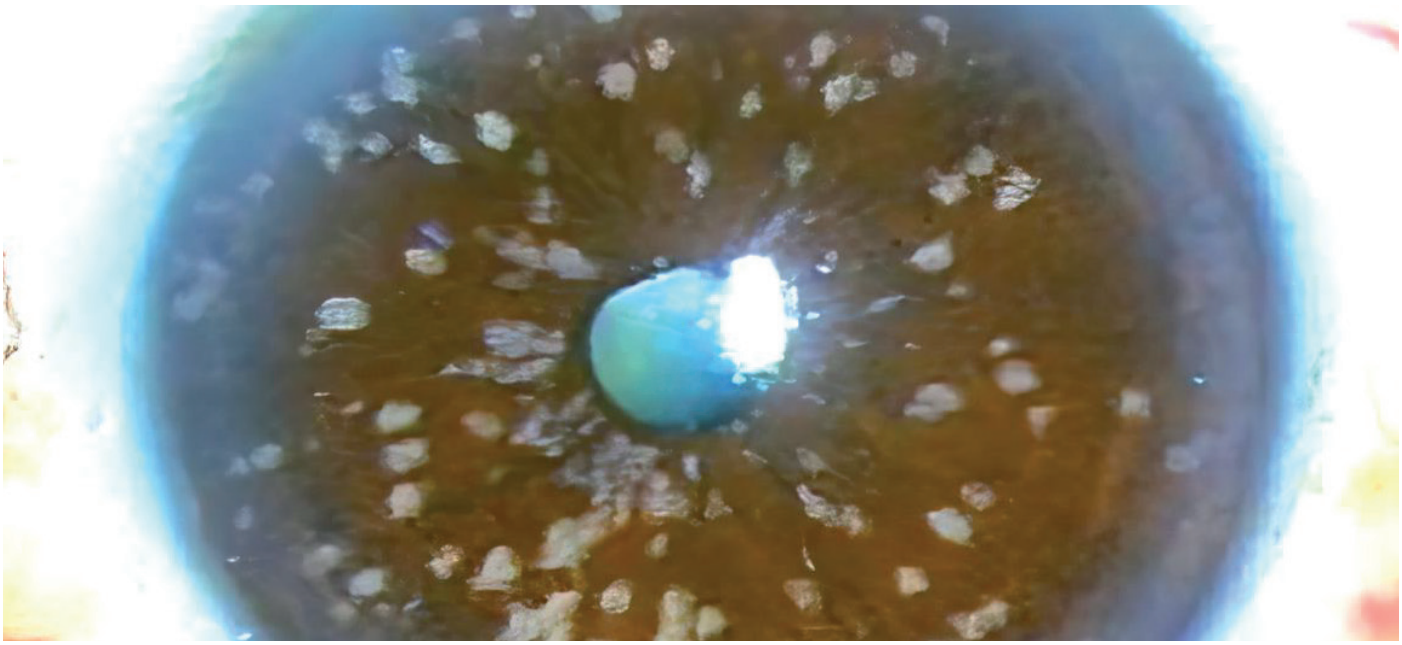


FIGURE 31: White iris spots and blue parts on Vitiligo

2.3 Vitiligo



Ocular problems may be closely connected to vitiligo as the depigmentation process in vitiligo patients can influence ocular melanocytes resulting in alterations in macular thickness, iris and retinal pigmentation. However, no impairment of vision is detected since ocular melanocytes aren't involved in the detection or transmission of visual pathway.

Vitiligo, characterized by white lesions on the skin, affects about 1% of people worldwide, including 1 million to 2 million people in the United States. Nonsegmental vitiligo usually develops gradually in adulthood and makes up about 90% of vitiligo cases.

Conventional treatment includes phototherapy with topical corticosteroids, calcineurin inhibitors or vitamin-D analogue. The FDA approved recently the topical JAK inhibitor ruxolitinib as the first indicated treatment for the condition. Tofacitinib also has shown promise in clinical trials.

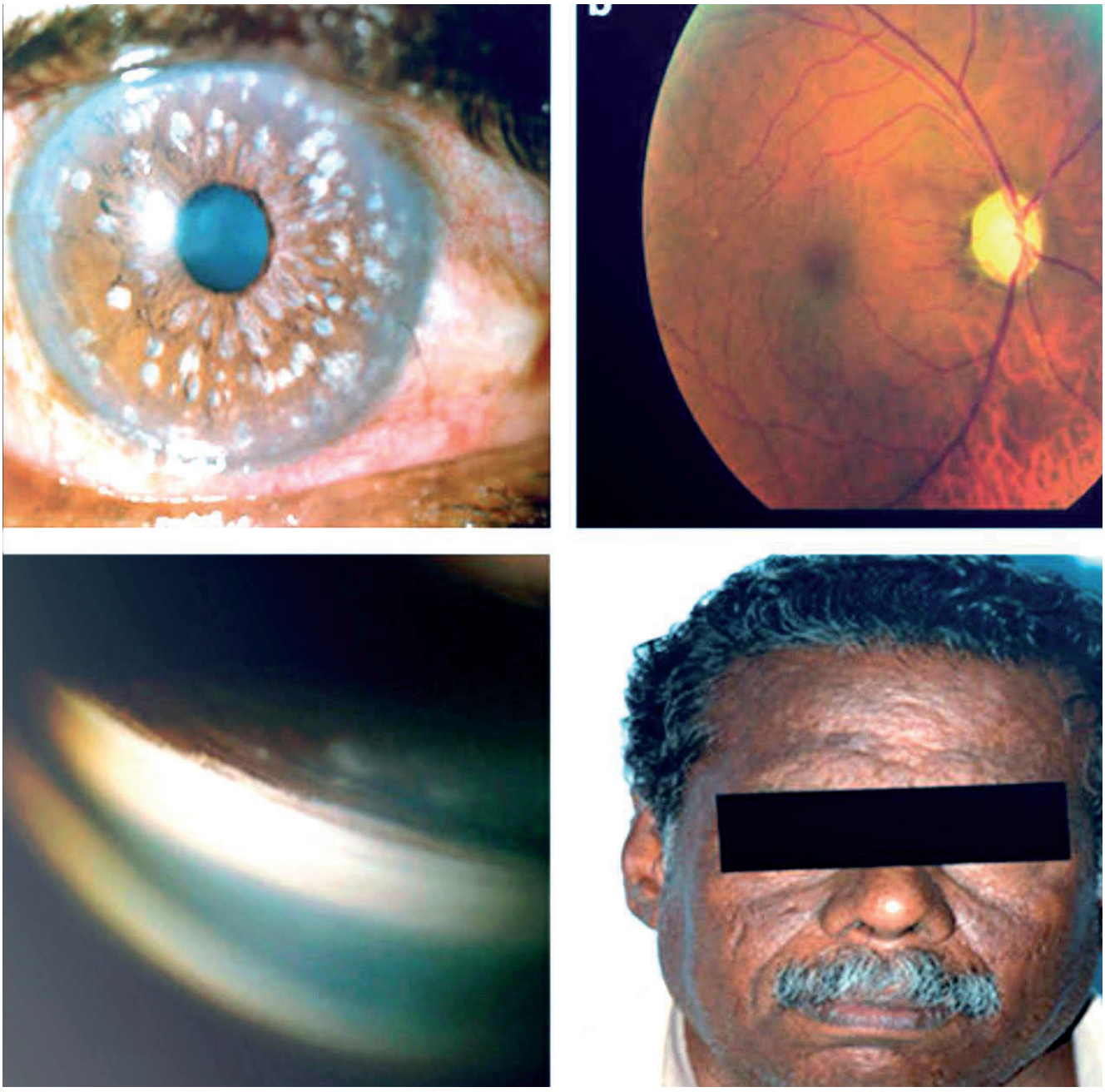


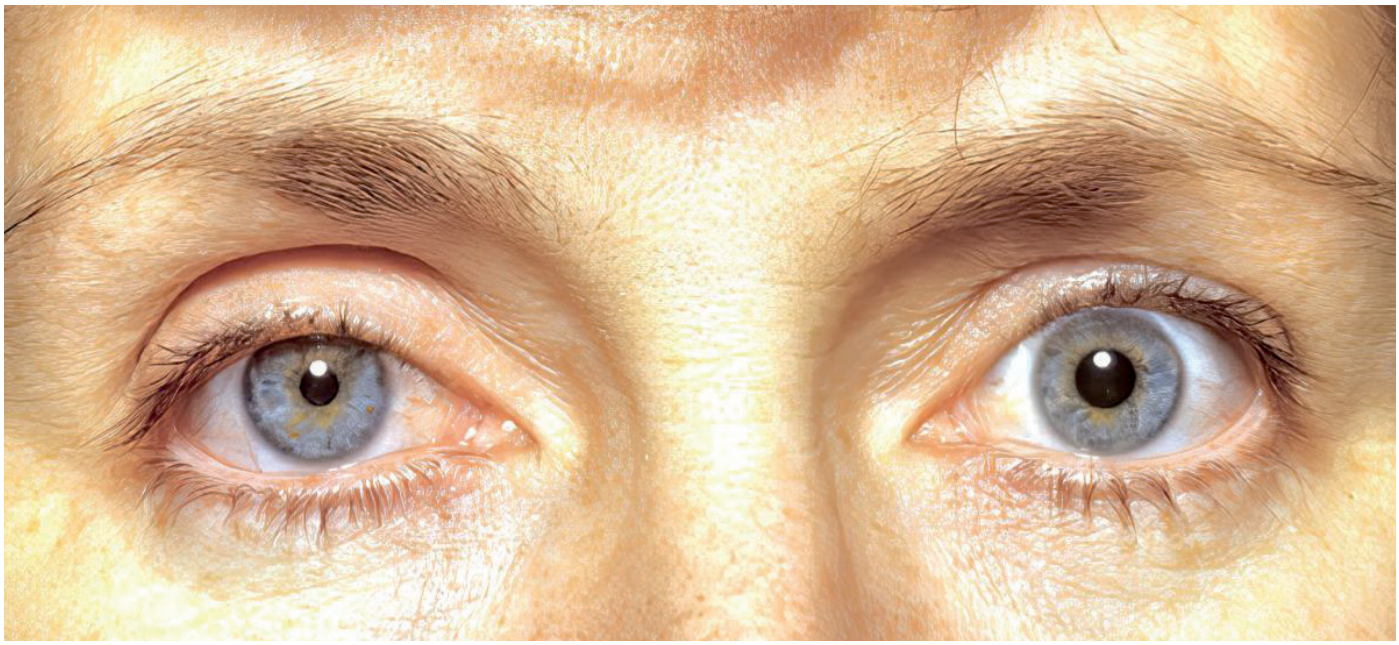
FIGURE 32: Multiple white spots on Vitiligo

12.4 Waardenburg

Waardenburg syndrome is a group of rare genetic conditions characterized by at least some degree of congenital hearing loss and pigmentation deficiencies, which can include bright blue eyes (or one blue eye and one brown eye), a white forelock or patches of light skin. These basic features constitute type 2 of the condition; in type 1, there is also a wider gap between the inner corners of the eyes called telecantus, or dystopia canthorum. In type 3, which is rare, the arms and hands are also malformed, with permanent finger contractures or fused fingers, while in type 4, the person also has Hirschsprung´s disease. There also exist at least two types (2E and PCWH) that can result in central nervous system (CNS) symptoms such as developmental delay and muscle tone abnormalities. The syndrome is caused by mutations in any of several genes that affect the division and migration of neural crest cells during embryonic development. The estimated prevalence of Waardenburg syndrome is 1 in 42,000. Types 1 and 2 are the most common, comprising approximately half and a third of cases, respectively, while type 4 comprises a fifth and type 3 less than 2% of cases. An estimated 2–5% of congenitally deaf people have Waardenburg syndrome.

FIGURE 33: Blue eyes on Waardenburg syndrome

2.4 Bernard-Horner



Horner syndrome is a condition that affects the face and eye on one side of the body. It is caused by the disruption of a nerve pathway from the brain to the head and neck.

Typically, signs and symptoms of Horner syndrome include decreased pupil size, a drooping eyelid and decreased sweating on the affected side of the face.

Horner syndrome may be the r sult of another medical problem, such as a stroke, tumor or spinal cord injury. In some cases, no underlying cause can be found. There's no specific treatment for Horner syndrome, but treatment for the underlying cause may restore nerve function.

Horner syndrome is also known as Bernard-Horner syndrome or oculosympathetic palsy. Horner syndrome usually affects only one side of the face. Common signs and symptoms include : A persistently small pupil (miosis), a notable difference in pupil size between the two eyes (anisocoria), little or delayed opening (dilation) of the affected pupil in dim light, drooping of the upper eyelid (ptosis), slight elevation of the lower lid, sometimes called upside-down ptosis, sunken appearance of the affected eye,

and little or no sweating (anhidrosis) on the affected side of the face. Signs and symptoms, particularly ptosis and anhidrosis, may be subtle and difficult to detect.

Additional signs and symptoms in children with Horner syndrome may include: Lighter iris color in the affected eye of a child under the age of 1, and change in color on the affected side of the face that would typically appear from heat, physical exertion or emotional reactions.0.

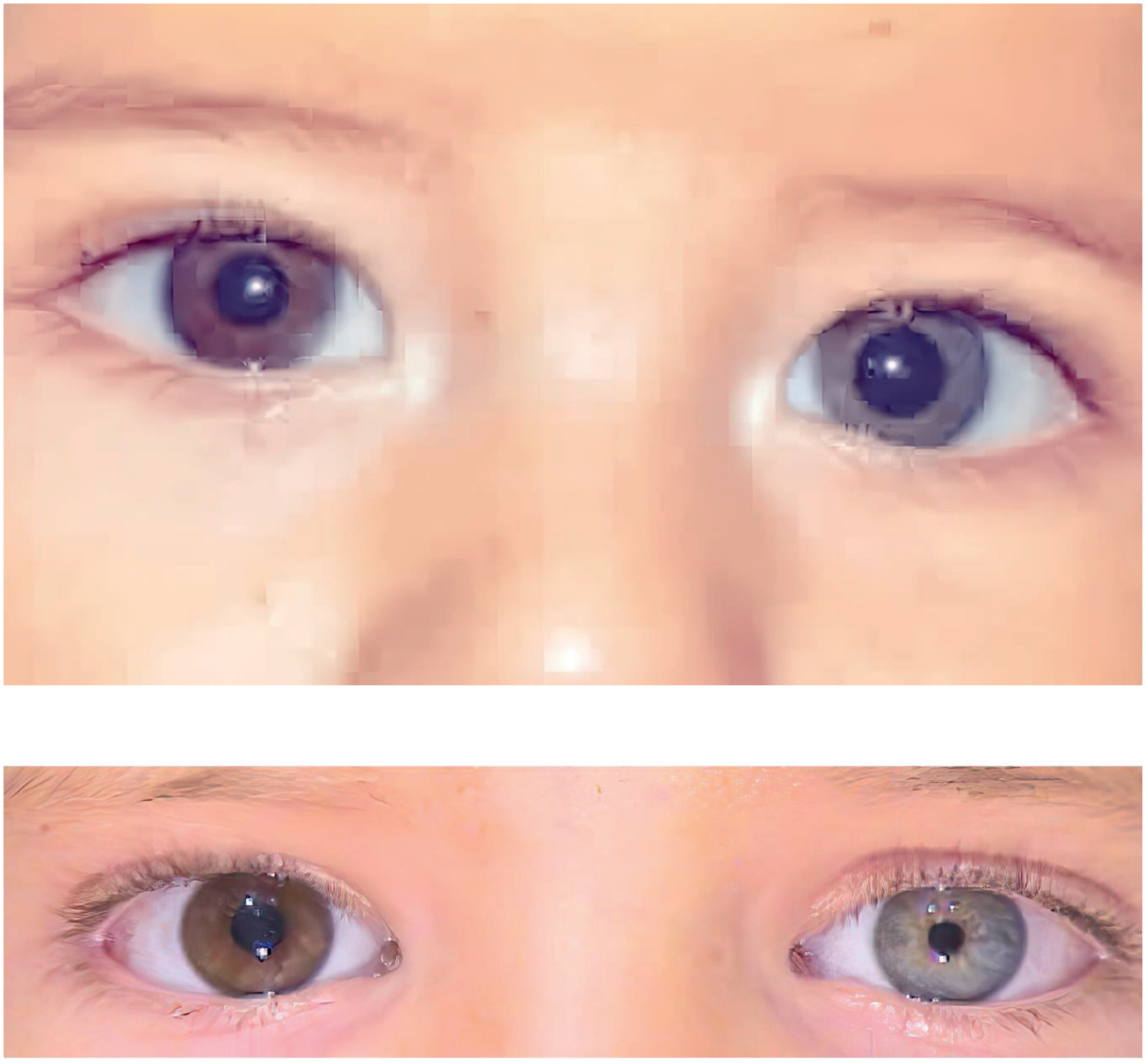
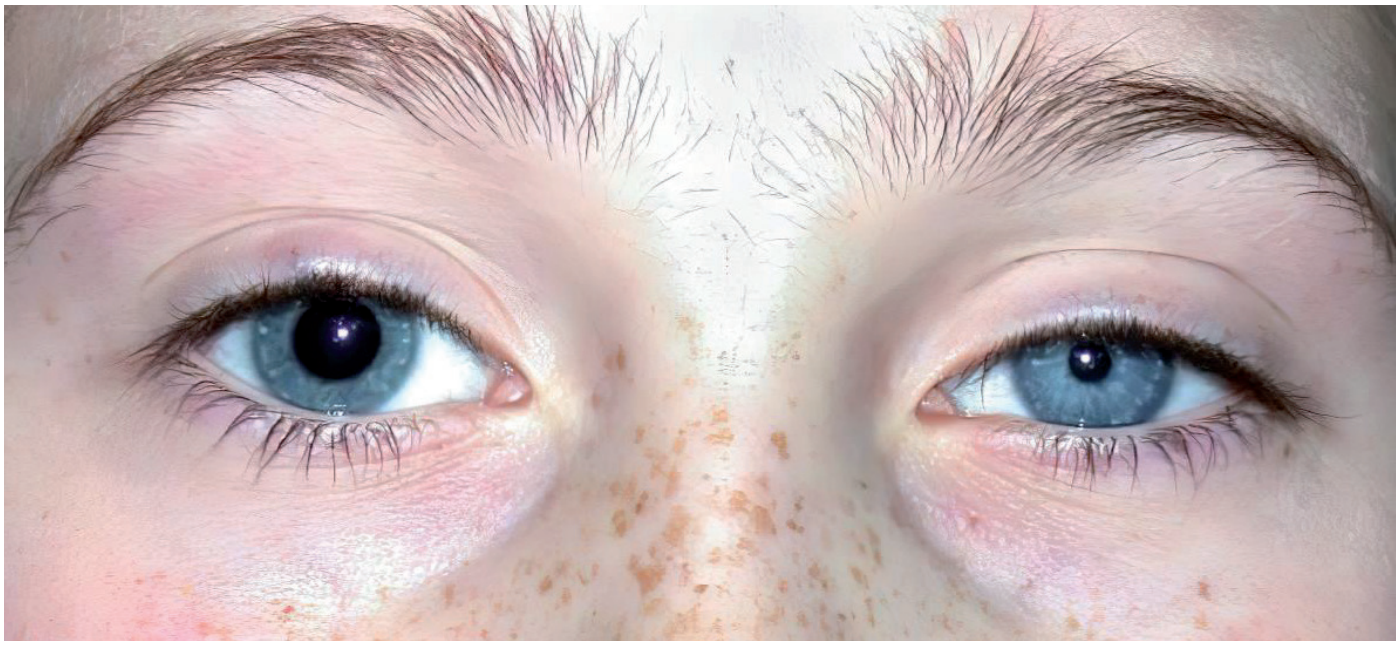


FIGURE 34: Unilateral midriasis on Bernard-Horner ayndrome

2.4 Bernard-Horner



Horner syndrome is caused by damage to a certain pathway in the sympathetic nervous system. The sympathetic nervous system regulates heart rate, pupil size, perspiration, blood pressure and other functions that enable you to respond quickly to changes in your environment. The nerve pathway affected by Horner syndrome is divided into three groups of nerve cells (neurons).

First-order neurons. This neuron pathway leads from the hypothalamus at the base of the brain, passes through the brainstem and extends into the upper portion of the spinal cord. Problems in this region that can disrupt nerve function related to Horner syndrome include: Stroke, tumor, diseases that cause the loss of the protective sheath on neuron (myelin), neck trauma and cyst in the spinal column (syringomyelia).

Second-order neurons. This neuron path extends from the spinal column, across the upper part of the chest and into the side of the neck. Causes related to nerve damage in this region may include : Lung cancer, tumor of the myelin sheath (schwannoma), damage to the main blood vessel leading from the heart (aorta), surgery in the chest cavity and traumatic injury.

Third-order neurons. This neuron path extends along the side of the neck and leads to facial skin and muscles of the iris and eyelids. Nerve damage in this region may be associated with the following: Damage to the carotid artery along the side of the neck, damage to the jugular vein along the side of the neck, tumor or infection near the base of the skull, migraines and cluster headaches, a disorder that results in cyclical patterns of severe headaches.
The most common causes in children include: injury to the neck or shoulders during delivery, defect of the aorta present at birth and tumor of the hormonal and nervous systems (neuroblastoma).

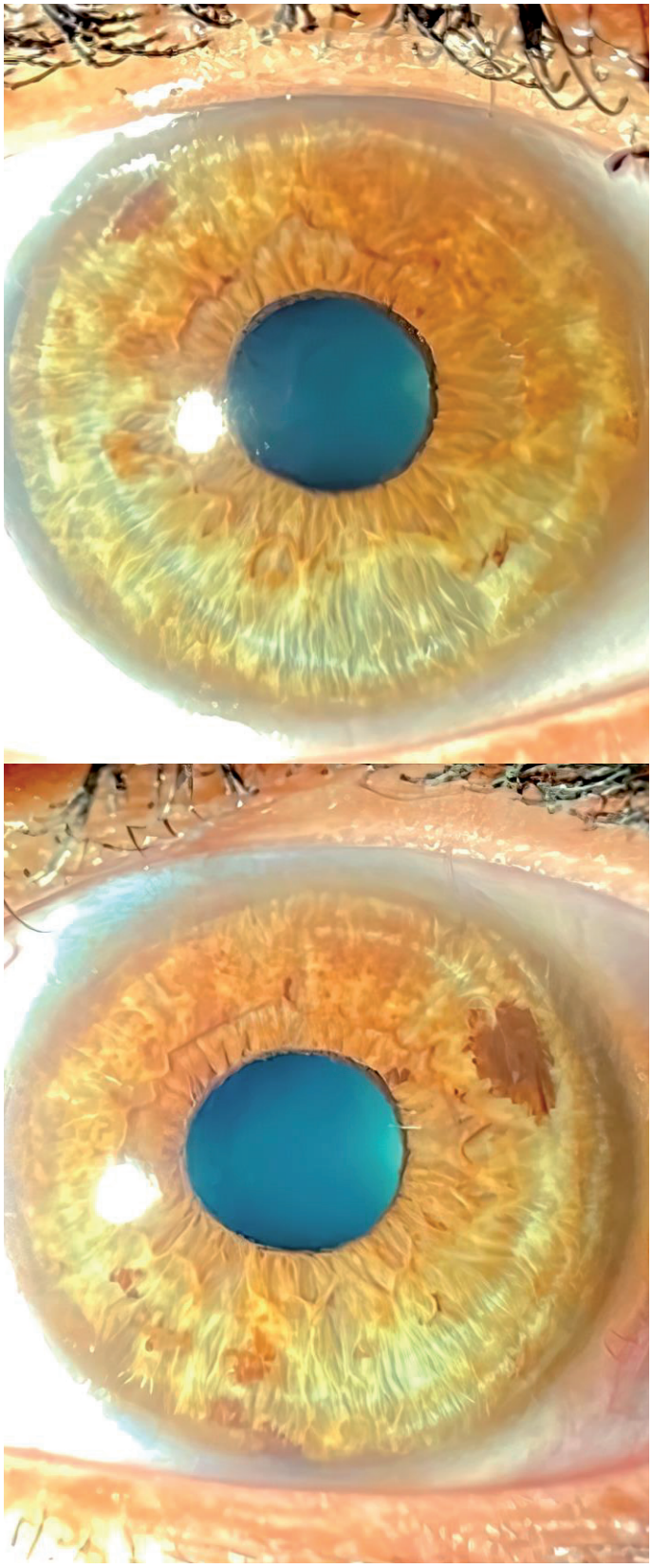
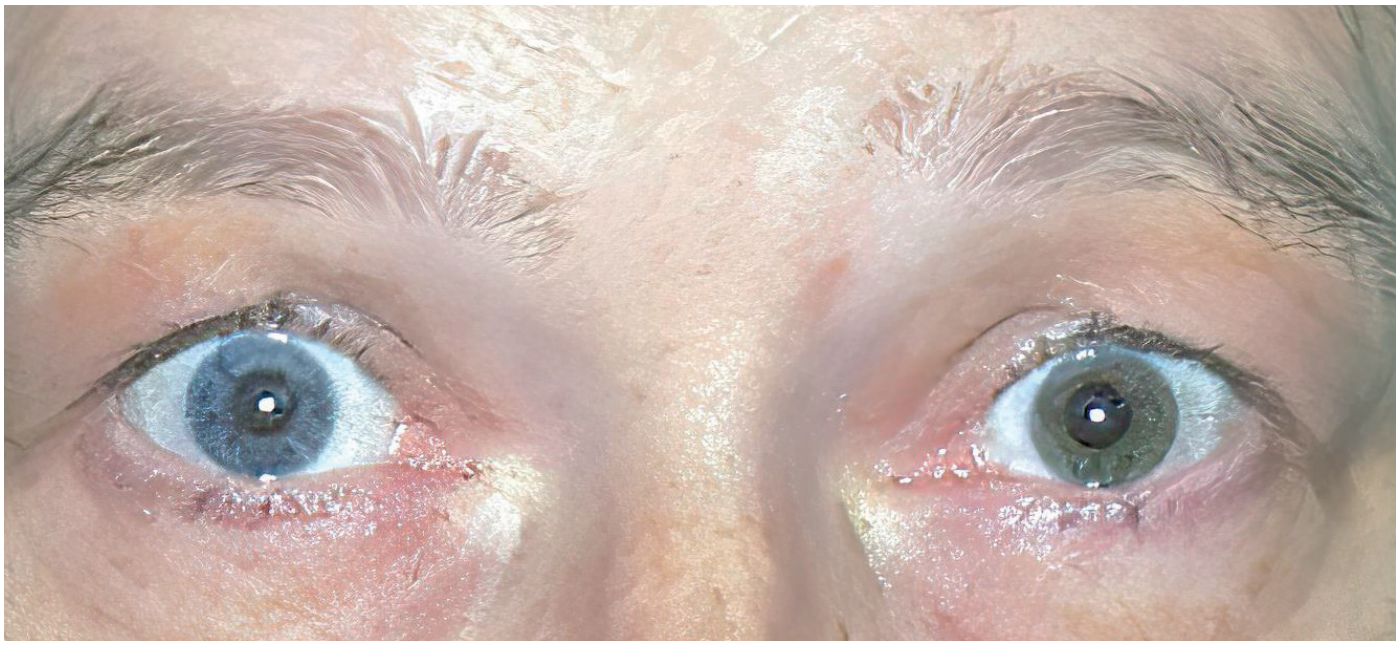


FIGURE 35: Nevus on Bernard-Horner Syndrome

12.4 Fuchs



Fuchs' Heterochromic Iridocyclitis (FHI), also known as Fuchs' uveitis syndrome (FUS), was first described in 1906 by Austrian ophthalmologist, Ernst Fuchs, who reported a series of 38 patients with iris heterochromia, cyclitis, and cataract. Since then, FHI has been further characterized as a constellation of clinical findings, which classically includes low-grade unilateral anterior inflammation with stellate keratic precipitates (KP), iris heterochromia, and prominent iris and angle vessels that bleed after paracentesis (Amsler sign).

Historical theories on the cause of FHI have associated it with sympathetic dysfunction, as well as multiple infectious etiologies such as toxoplasma, herpes simplex virus (HSV), chikungunya virus, cytomegalovirus (CMV), and rubella virus (RV). Patients with FHI are often asymptomatic for many years prior to presentation as, unlike with other anterior uveitides, they typically will have no pain, redness, or photophobia. Presenting complaints are usually secondary to cataract or vitritis. Classically, patients will present with unilateral iris heterochromia and atrophy, KP, low-grade iridocyclitis, and cataract in the absence of posterior synechiae. Only 5-10% of cases are bilateral.

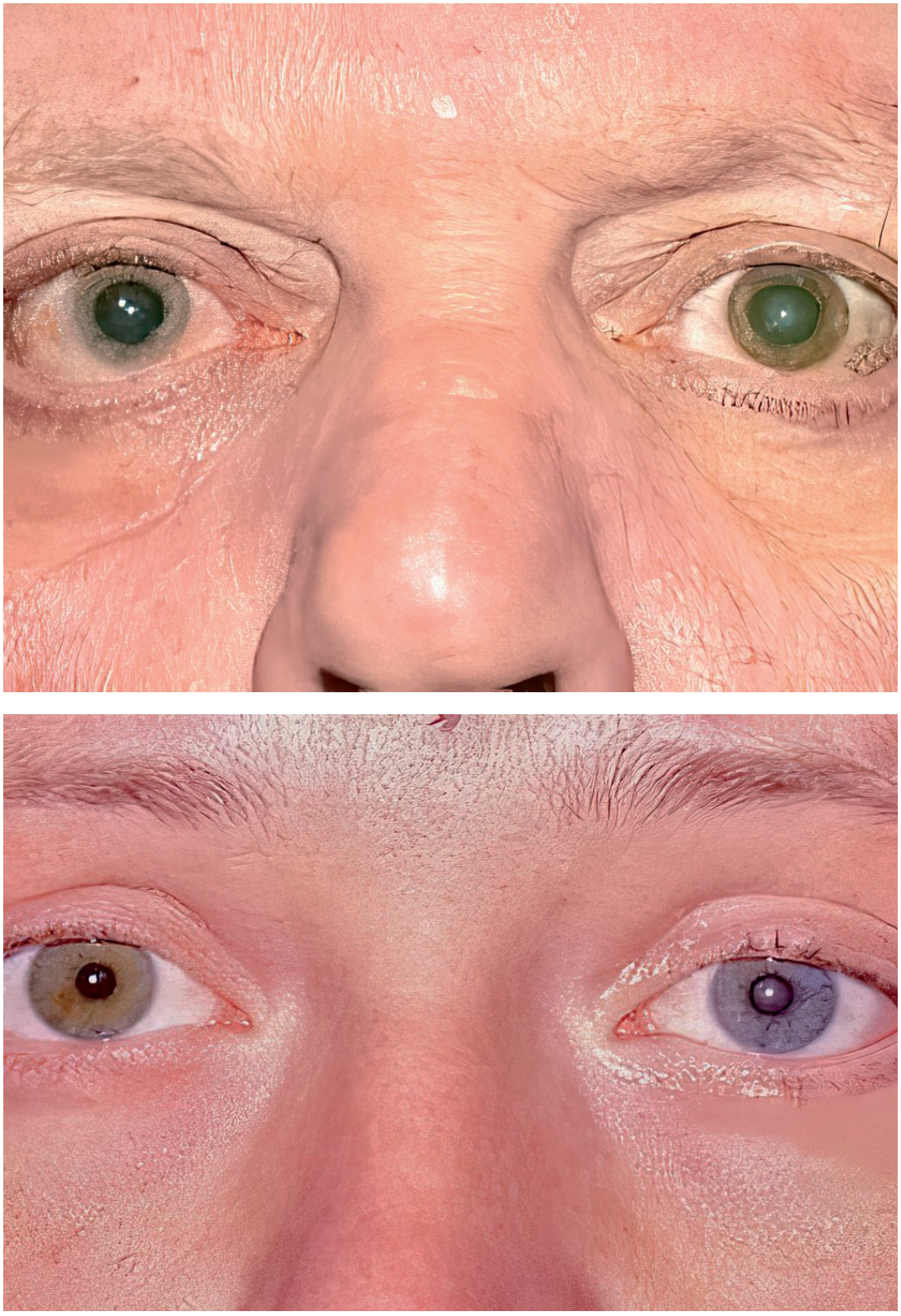
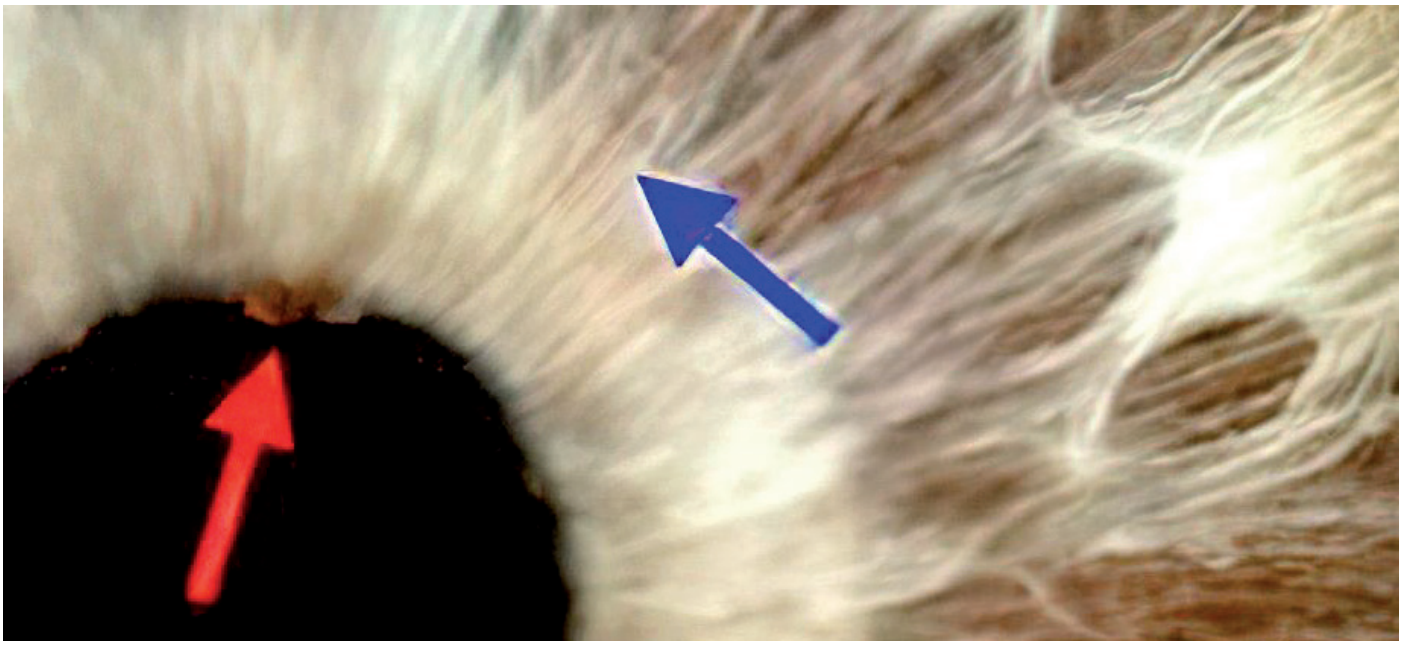


FIGURE 36: Fuchs full unilateral heterochromia

2.4 Fuchs



Iris heterochromia is seen in 75-90% of patients. The lighter-colored iris usually, but not invariably, indicates the affected eye. In patients with lightly colored iris, inverse heterochromia may be present, whereby loss of the pale anterior stroma leads to exposure of darker iris pigment epithelium. Iris atrophy often precedes heter chromia. The atrophic iris takes on a moth-eaten appearance, displaying smooth stromal architecture with loss of iris crypts.

Low-grade iridocyclitis that is not responsive to steroid therapy is a classic feature of FHI. Despite the persistent inflammation, posterior synechiae are characteristically absent. A mild vitritis with stringy vitreous is also commonly seen without the presence of cystoid macular edema.

Keratic precipitates are usually fine, stellate, and interconnected by fibrin bridges.
In contrast to other types of anterior uveitis where KP tend to cluster inferiorly within Arlt's triangle, KP in FHI tend to be diffuse, and involve the entire endothelial surface.

Cataracts are seen in all types of uveitis, however, they occur with particularly high frequency in FHI. Three-quarters of lens opacities in FHI

patients are posterior subcapsular. FHI should be considered in the differential diagnosis of any unilateral cataract in a young patient in the absence of trauma or steroid use.

Iris nodules, particularly Koeppe and Busacca nodules, can be seen in FHI and may initially lead to a misdiagnosis of granulomatous uveitis.

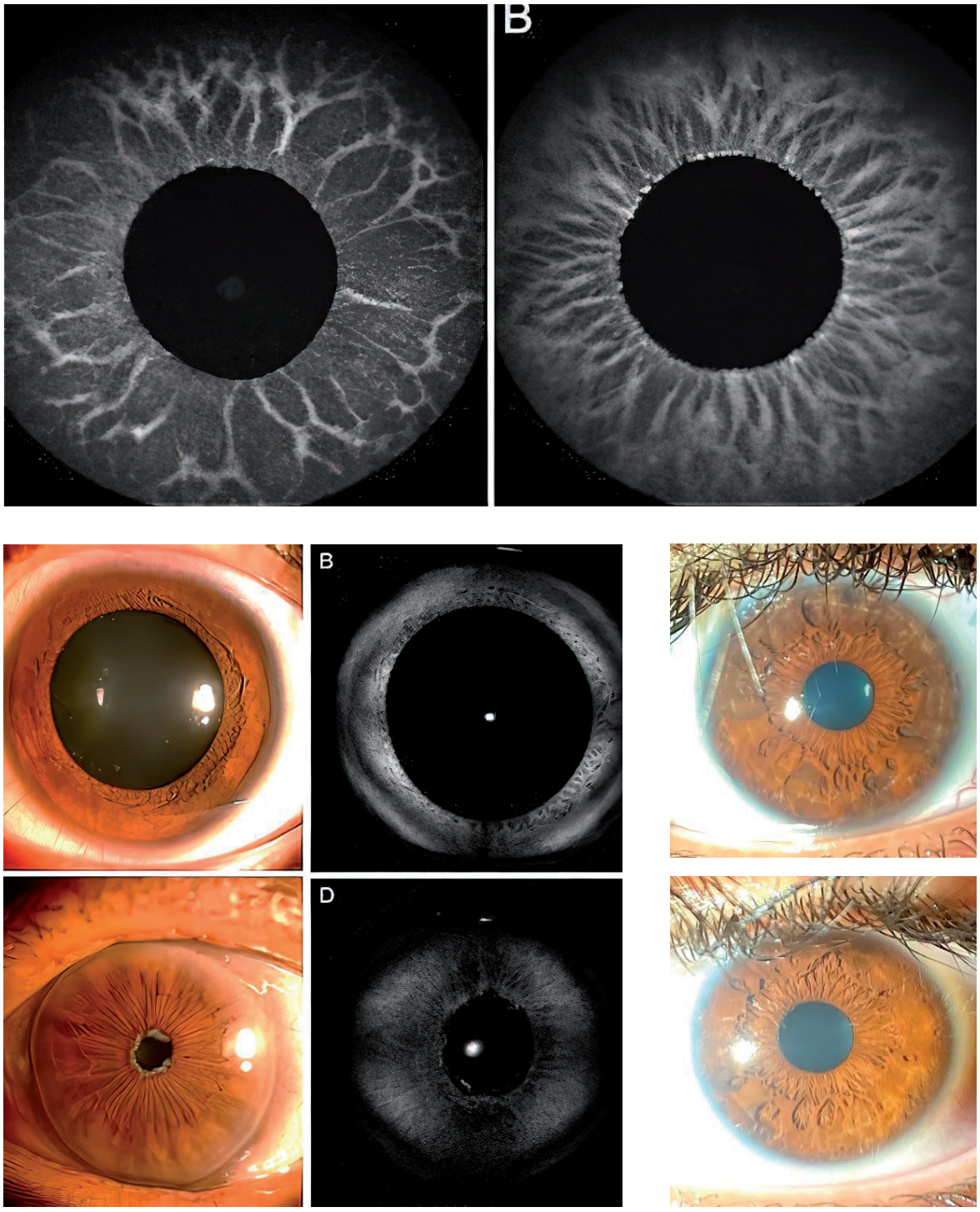
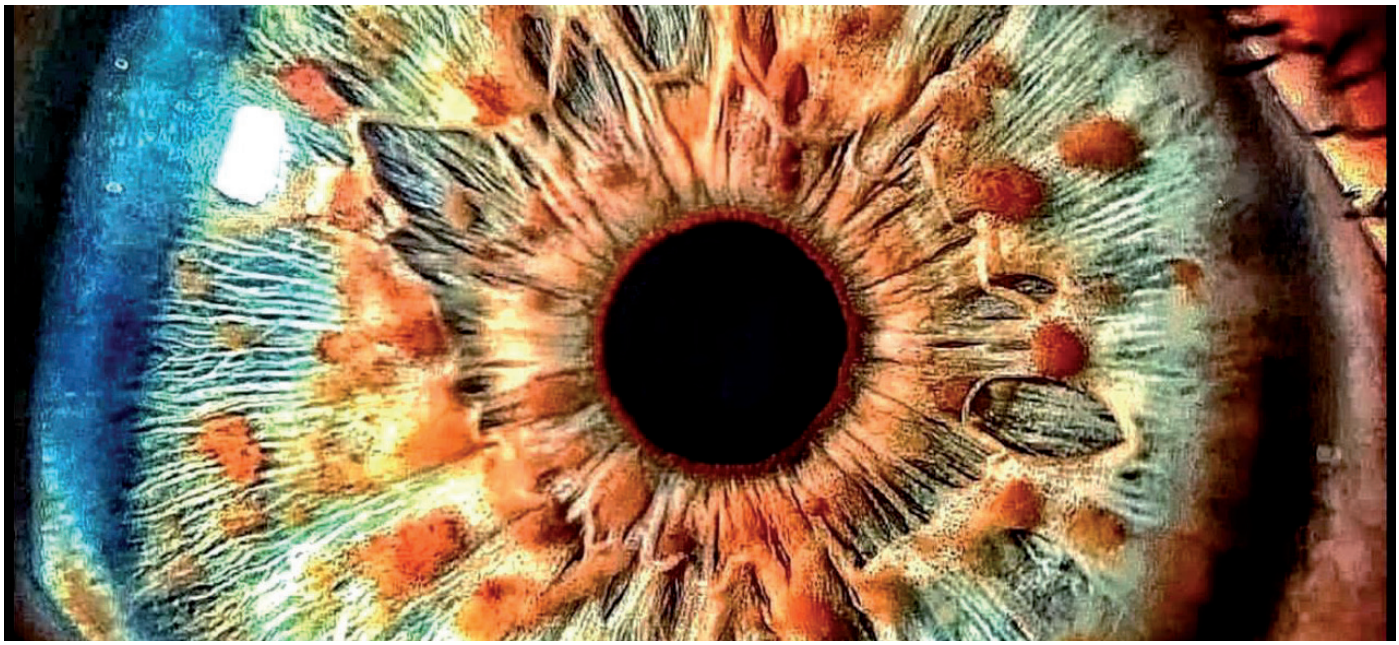


FIGURE 37: Fuchs. Chronical iris atrophy. Koeppe and Busacca nodules

12.4 Neurofibromatosis



Neurofibromatosis (NF) is a genetic abnormality that affects the cell growth of neural tissue, leading to tumor growths that impact the skin, nervous system, eyes and other organs. NF is divided into two primary subgroups: neurofibromatosis type 1 (NF1), also known as von Recklinghausen or peripheral neurofibromatosis; and neurofibromatosis type 2 (NF2), also known as bilateral acoustic neurofibromatosis and central neurofibromatosis. Both NF1 and NF2 are acquired through an inherited autosomal dominant transmission or sporadic mutation, with presentation of NF1 more common than NF2.2 As such, members of the same family with NF may have different disease presentations from each other, as they do not always carry the same gene mutations.

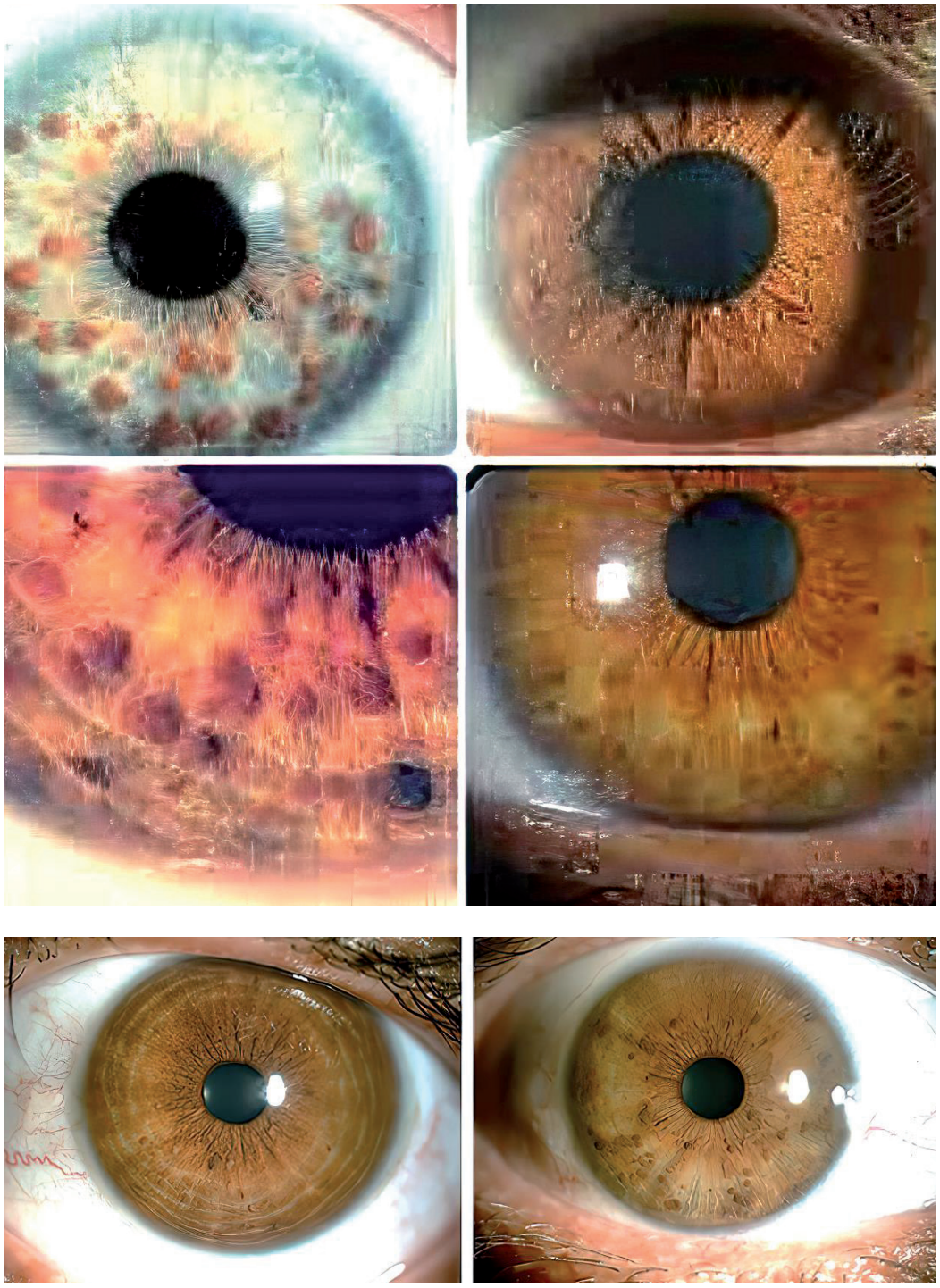
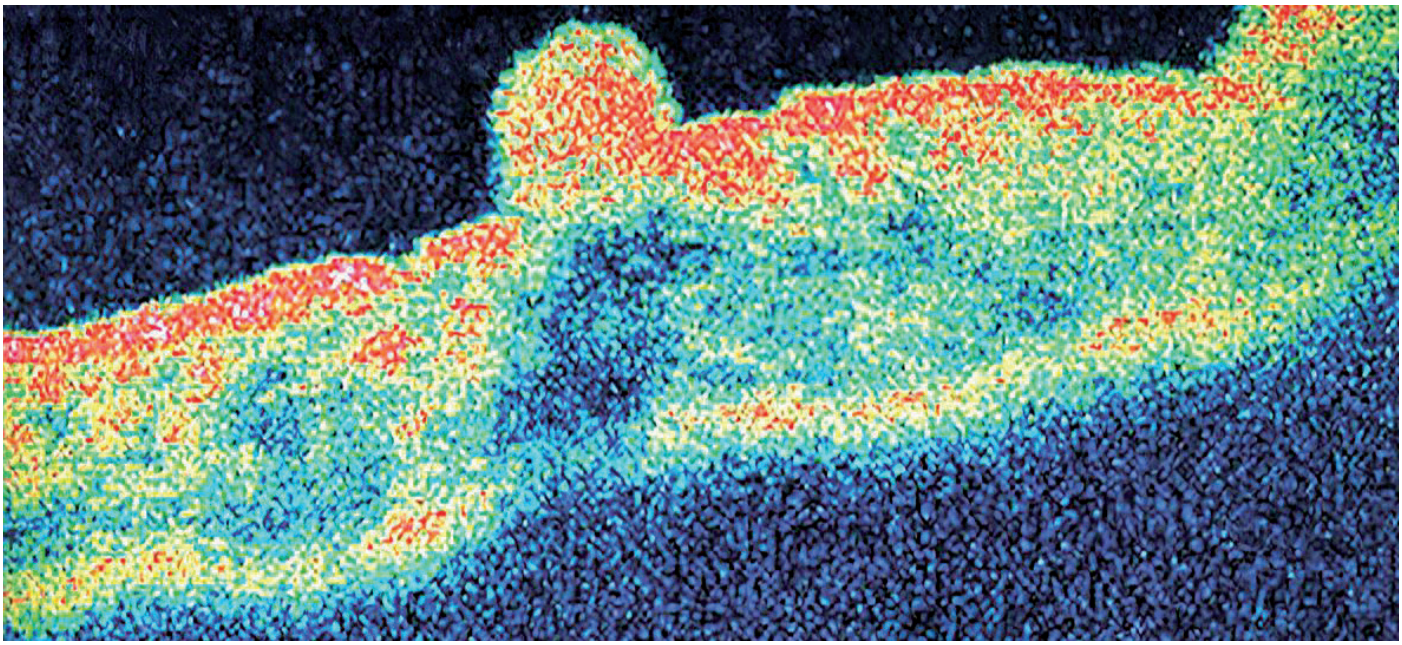


FIGURE 38: Neurofibromatosis. Multiple Lisch iris nodules

12.4 Neurofibromatosis



Neurofibromatosis 1 (NF1) Clinical features of NF1 include skin fold freckles, neurofibromas, optic pathway gliomas, Lisch nodules and the most common finding associated with the disease: café au lait spots. With respect to ocular findings, the most common diagnostic criteria in NF1 patients are Lisch nodules, which appear smooth and elevated with a clear to brownish-yellow coloration on slit lamp examination. Often, these asymptomatic lesions present inferiorly and bilaterally; however, there have been reports of unilateral presentations in segmental NF patients.7 Lisch nodules rarely cause ocular complications and patients are typically asymptomatic. NF1 patients may also present with plexiform neurofibroma, retinal tumors and optic nerve pathway gliomas.

Neurofibromatosis 2 (NF2) Schwannoma; ependymoma; m ningioma; glioma; malignant transformations are rare. Posterior subcapsular cataract/cortical wedge opacity; café au lait macules are less common. Juvenile posterior subcapsular lenticular opacity and peripheral cortical cataracts present bilaterally in 80% to 85% of NF2 patients and, in most cases, may be the first sign of NF2.Most patients are

asymptomatic, but 20% experience a decrease in visual acuity; however, surgery is rarely required. While rare in the general population, optic nerve sheath meningiomas (ONSMs) are another sign of NF2 found in up to 27% of NF2 patients.

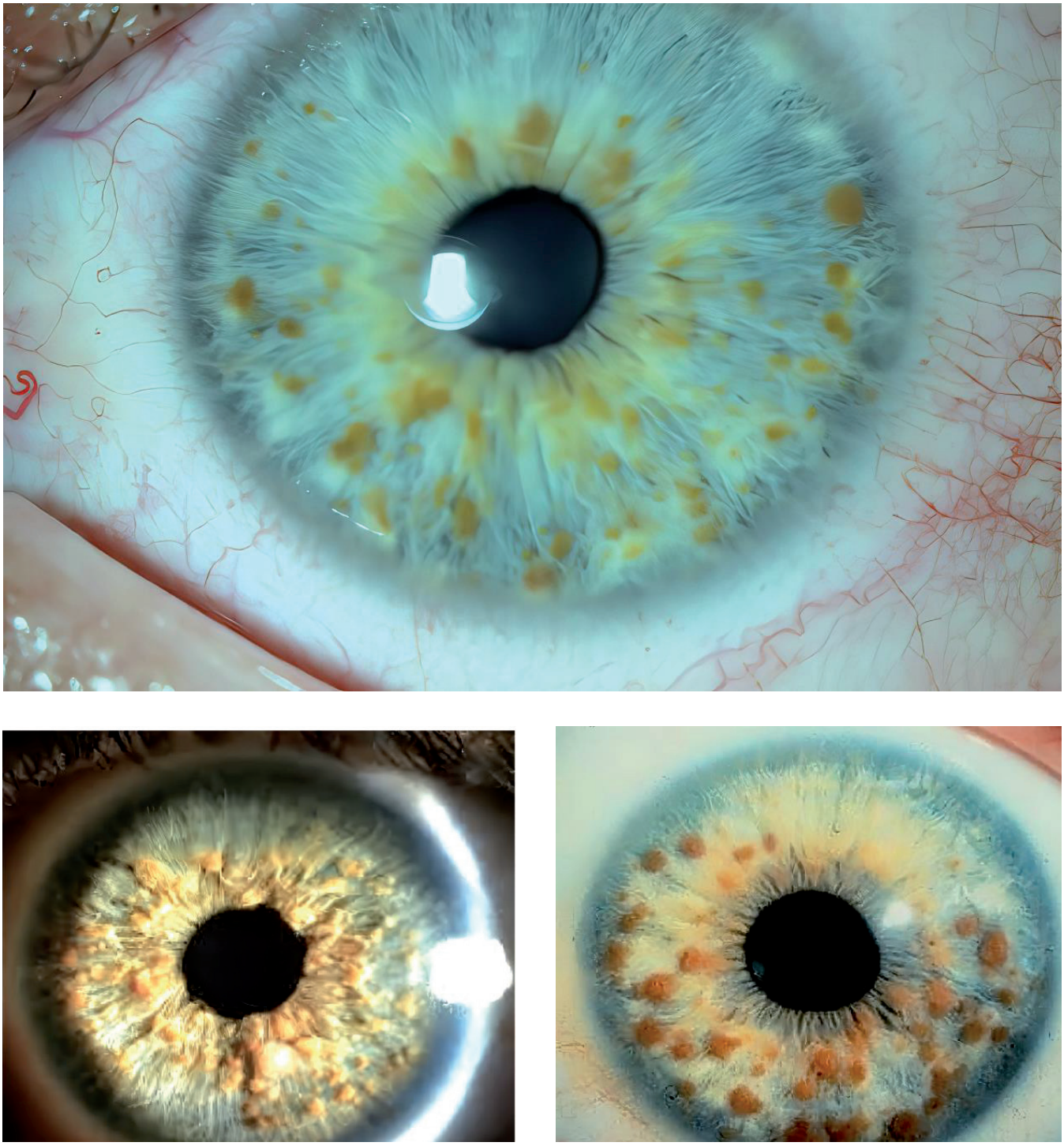


FIGURE 39: Yellow and Orange multiple Lisch iris nodules. OCT

2.4 Sarcoidosis-VKH

Sarcoidosis is one of the leading causes of inflammatory eye disease. Ocular sarcoidosis can involve any part of the eye and its adnexal tissues, and may cause uveitis, episcleritis/scleritis, eyelid abnormalities, conjunctival granuloma, optic neuropathy, lacrimal gland enlargement and orbital inflammation. Glaucoma and cataract can be complications from inflammation itself or adverse effects from therapy. Ophthalmic manifestations can be isolated or associated with other organ involvement. Patients with ocular sarcoidosis can present with a wide range of clinical presentations and severity.

Vogt-Koyanagi-Harada (VKH) disease is defined as a bilateral granulomatous panuveitis with or without extraocular manifestations affecting young adults. The clinical features of VKH disease will vary depending on stage of the disease. The four stages of VKH are the prodromal stage, uveitic stage, chronic stage and chronic recurrent stage. The prodromal stage symptoms will resemble a viral illness. Headaches, fever, orbital pain, nausea, dizziness and light sensitivity are present. The uveitic stage presents with blurred visual acuity in both eyes due to hyperemia and edema of the optic disk, and circumscribed retinal edema,

accompanied by multiple serous retinal detachments.

The chronic or convalescent stage will take place weeks after the uveitic stage. It is characterized by the development of vitiligo and choroidal depigmentation.

The recurrent stage consists of a panuveitis with acute exacerbations of anterior uveitis. It is during this phase of the illness that most of the vision threatening complications will develop (cataracts, glaucoma, subretinal neovascularization, etc.).

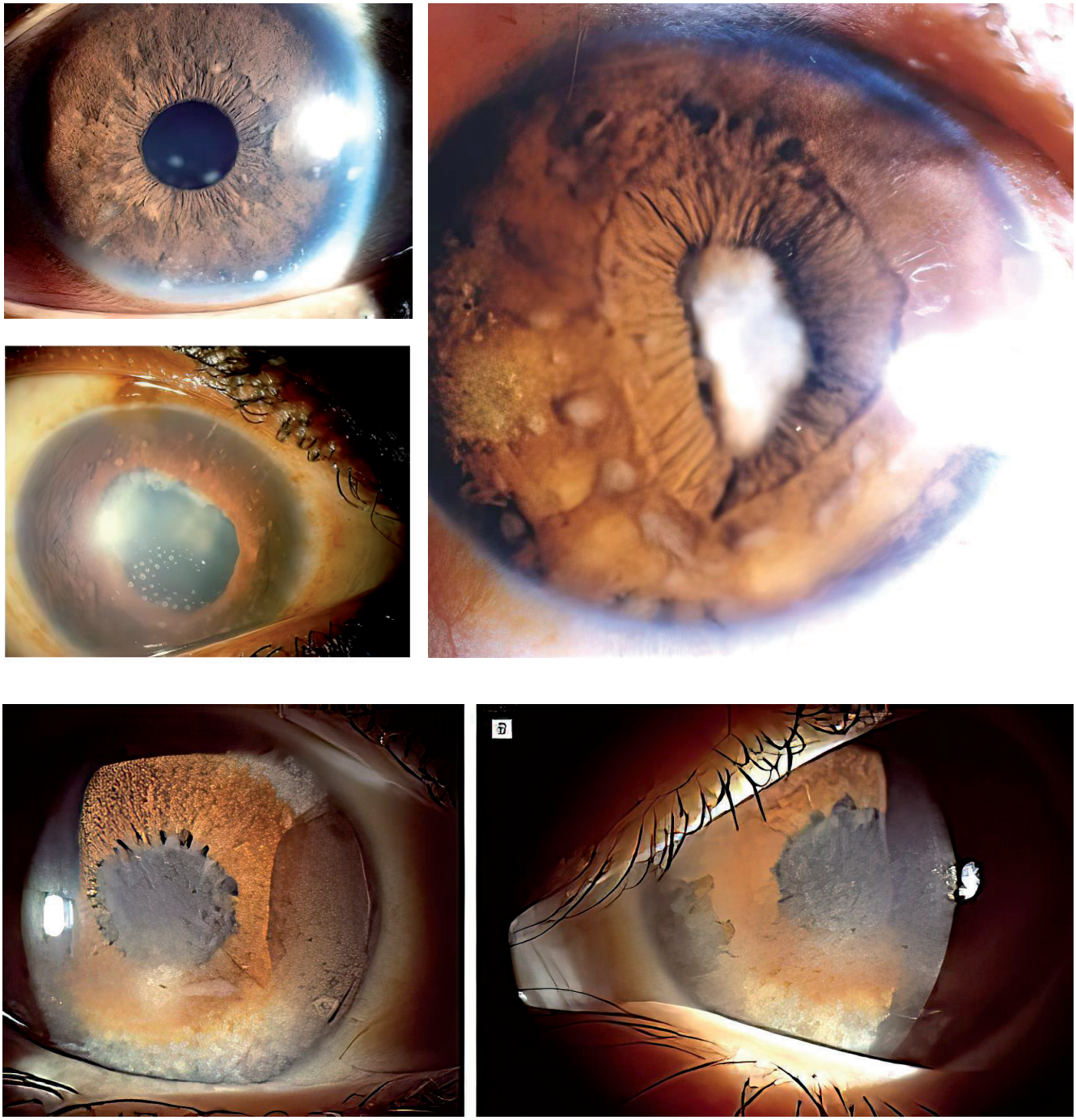
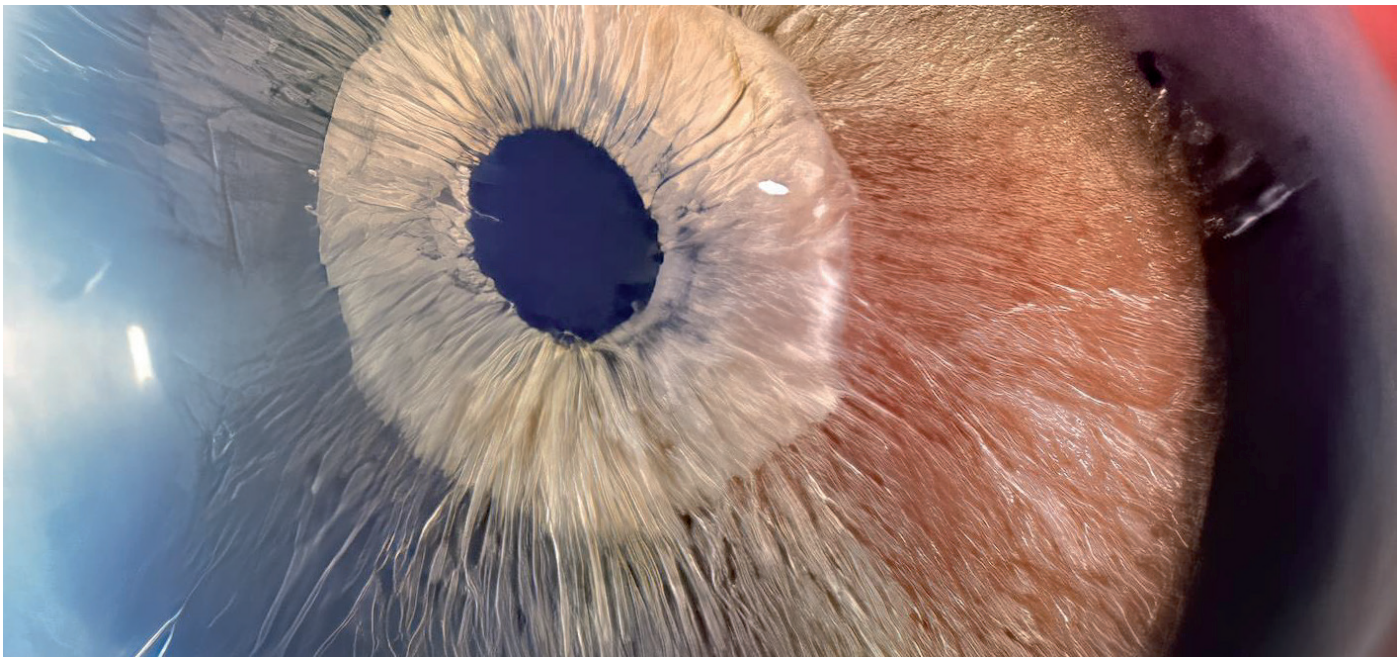


FIGURE 40: Chronical uveitis on Sarcoidosis and Vogt-KH

12.5 Peters Anomaly



Peters anomaly is one disease in a constellation of diseases that causes corneal opacity due to dysgenesis of the anterior segment during development.

Peters anomaly can cause devastating corneal opacity in an infant leading to severe amblyopia. Diagnosis involves careful anterior segment exam as well as testing for other systemic findings which would suggest Peters Plus syndrome. Treatment involves surgical intervention to establish a clear visual axis with either corneal transplant or optical iridectomy. Peters anomaly affects the iris, corneal endothelium, and Descemet's membrane, leading to Peters type I. Peters type II in addition features lens abnormalities and tend to be bilateral. 60% of those with Peters anomaly have bilateral involvement. In both forms, opacification of the cornea leads to an amblyogenic effect on an infant's developing vision. Peters Plus syndrome includes short stature, developmental delay, dysmorphic facial features, cardiac, genitourinary, and central nervous system malformations.

These systemic findings are seen in up to 60% of patients. Bilateral Peters is more strongly associated with systemic malformations (71.8%) as compared to unilateral Peters anomaly (36.8%).

Peters is also associated with many other ocular pathologies including glaucoma, sclerocornea, corectopia, iris hypoplasia, cataract, ICE syndrome, aniridia, iris coloboma, persistent fetal vasculature and microcornea.

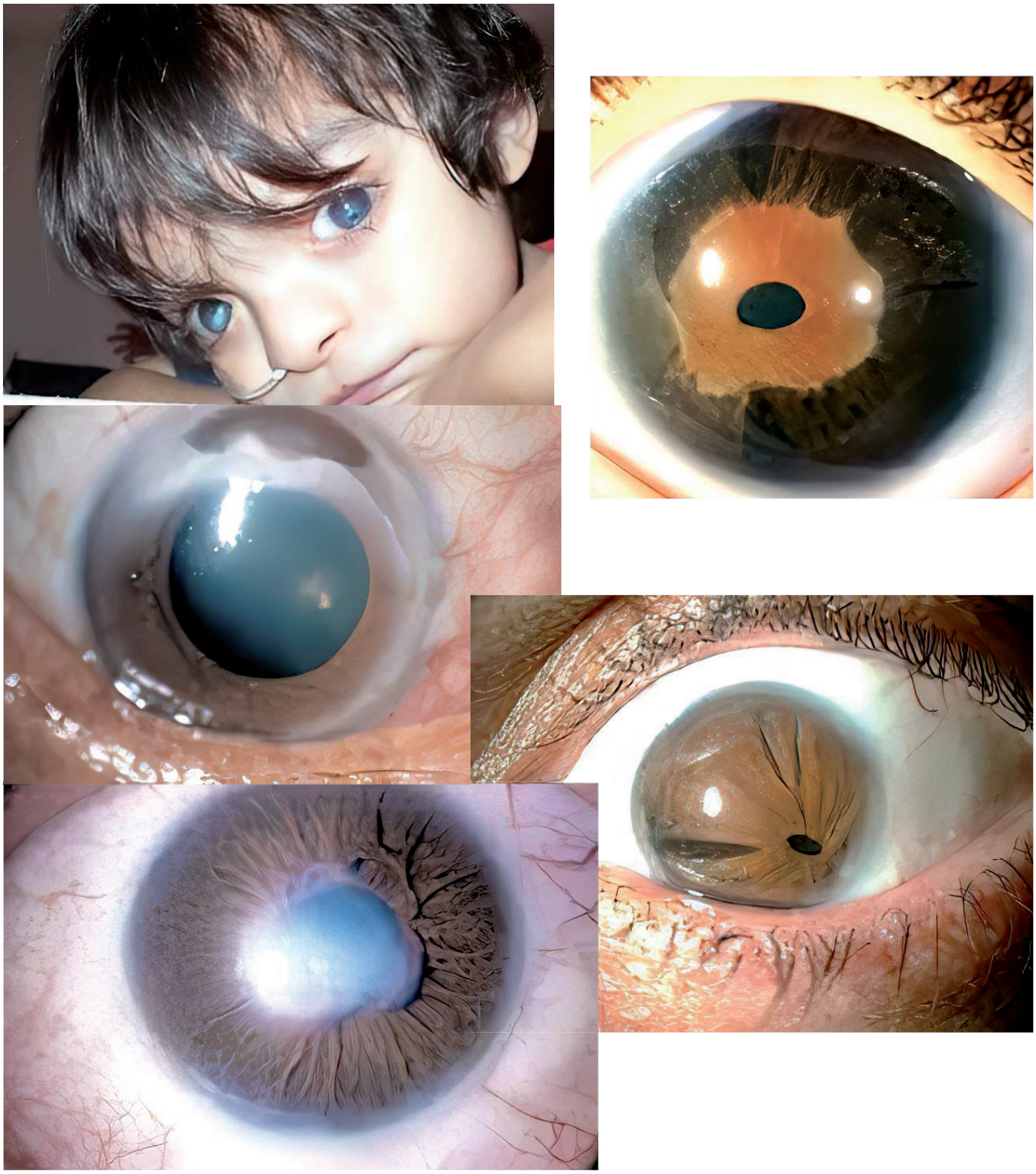
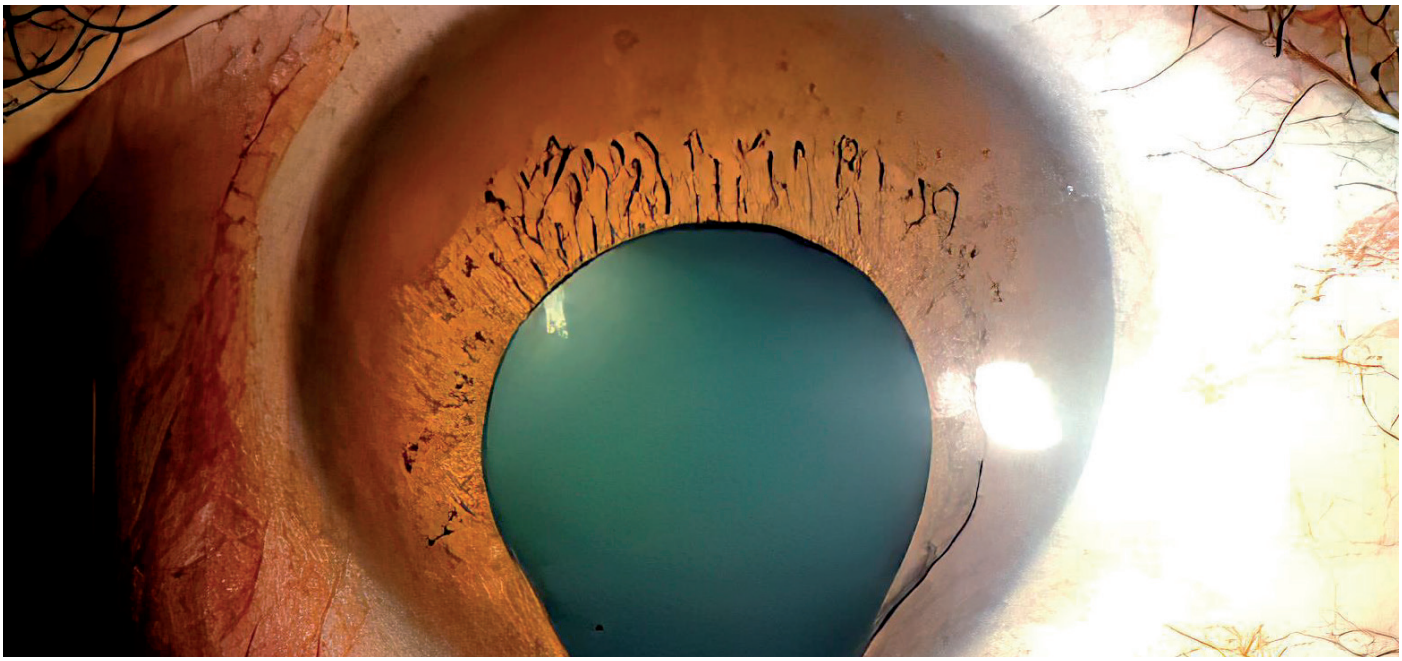


FIGURE 41: Corneal opcacities, atrophy, synechiae, corectopia in Peters

2.5 Coloboma



A coloboma is a hole in one of the structures of the eye, such as the iris, retina, choroid, or optic disk.

The hole is present from birth and can be caused when a gap called the choroid fissure, which is present during early stages of prenatal development, fails to close up completely before a child is born. The classical description in medical literature is of a keyholeshaped defect. A coloboma can occur in one eye (unilateral) or both eyes (bilateral). Most cases of coloboma affect only the iris. The level of vision impairment of those with a coloboma can range from having no vision problems to being able to see only light or dark, depending on the position and extent of the coloboma (or colobomata if more than one is present). Visual effects may be mild to more severe depending on the size and location of the coloboma.

If, for example, only a small part of the iris is missing, the vision may be normal; when a large part of the retina or (especially) optic nerve is missing, the vision may be poor.

Commonly posterior colobomata affect the inferior retina, with resultant deficit in the superior visual field. Other conditions can be associated with a coloboma.

Sometimes, the eye may be reduced in size, a condition called microphtalmia. Glaucoma, nystagmus, scotoma, or strabismus may also occur.

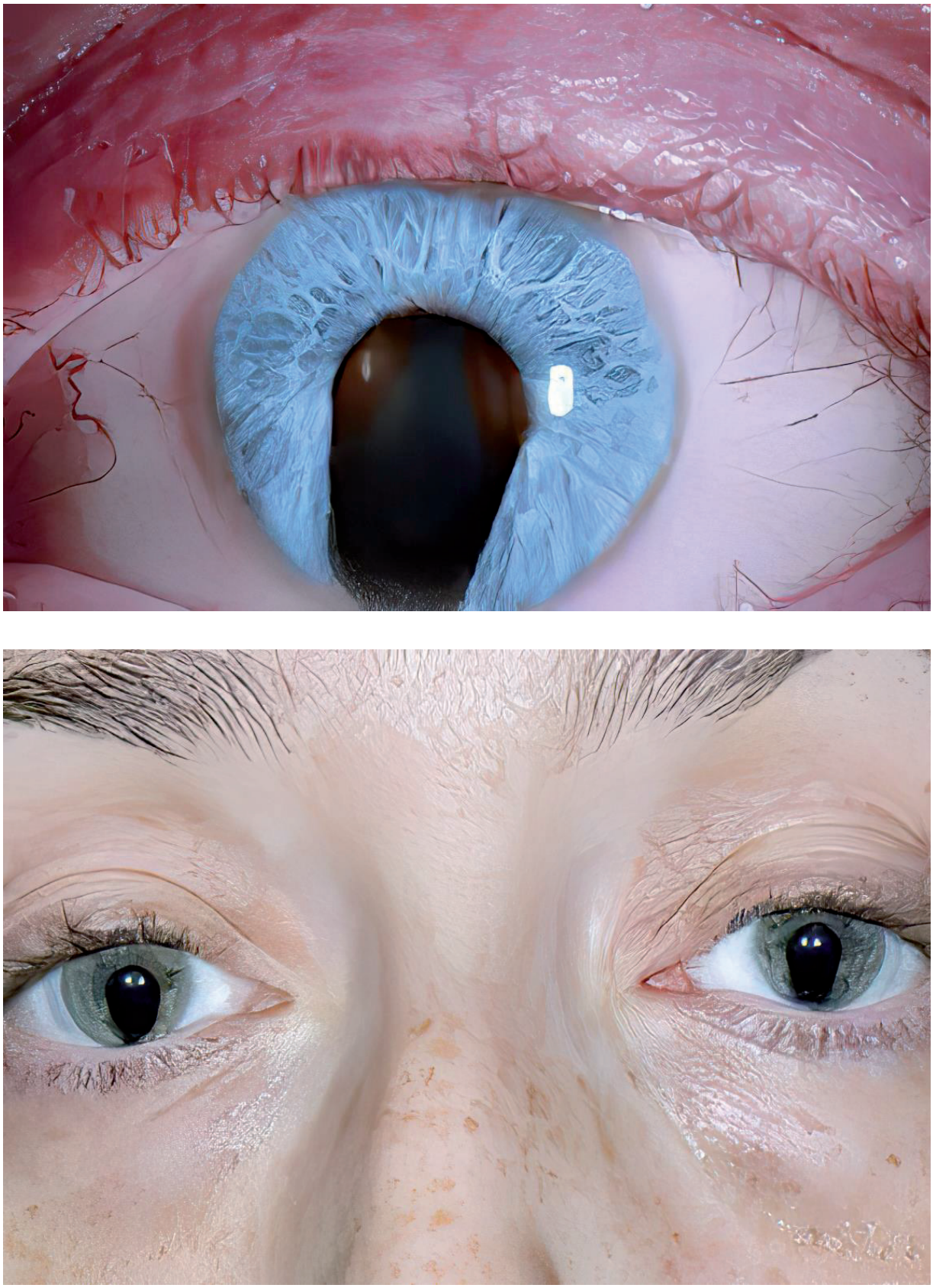
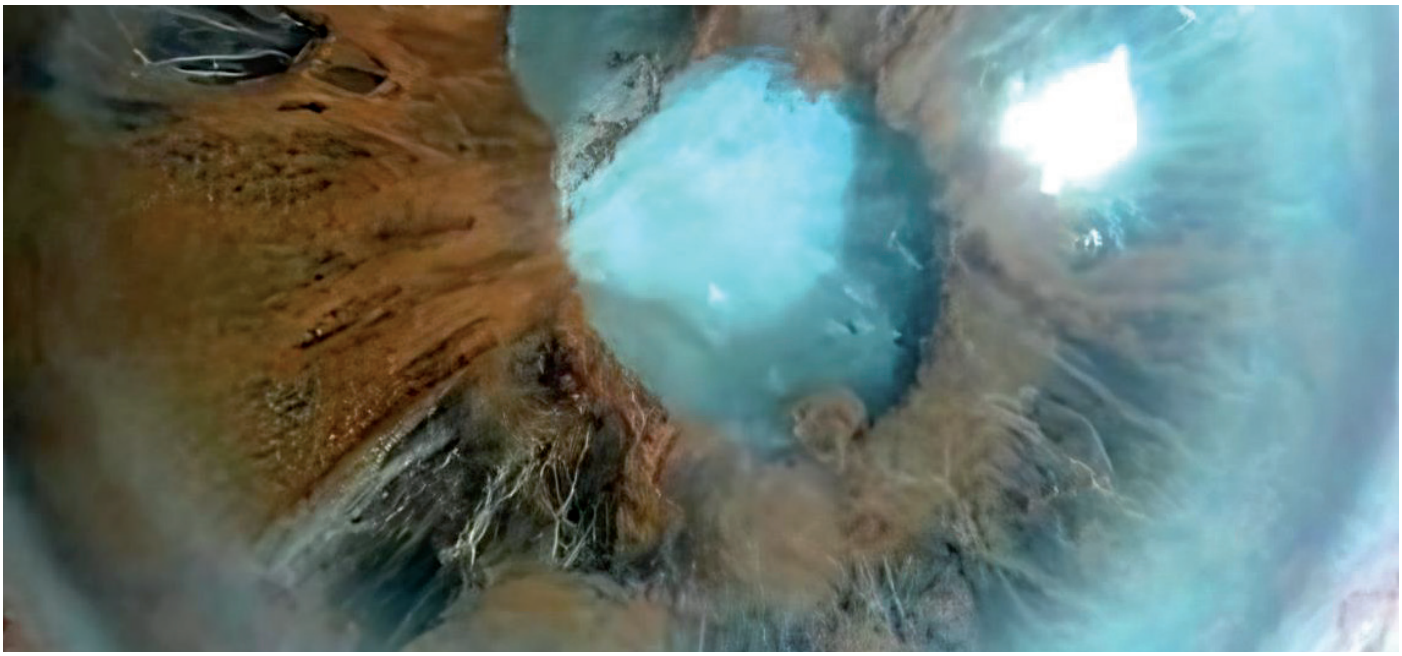


FIGURE 42: Bilateral iris coloboma

1 2.5 Rieger-Axenfeld



Axenfeld-Rieger syndrome is primarily an eye disorder, although it can also affect other parts of the body.

This condition is characterized by abnormalities of the front part of the eye, an area known as the anterior segment. For example, the colored part of the eye (the iris), may be thin or poorly developed. The iris normally has a single central hole, called the pupil, through which light enters the eye. People with Axenfeld-Rieger syndrome often have a pupil that is off-center (corectopia) or extra holes in the iris that can look like multiple pupils (polycoria). This condition can also cause abnormalities of the cornea, which is the clear front covering of the eye. About half of affected individuals develop glaucoma.

The signs and symptoms of Axenfeld-Rieger syndrome can also affect other parts of the body. Many affected individuals have distinctive facial features such as widely spaced eyes, The signs and symptoms of Axenfeld- Rieger syndrome can also affect other parts of the body. Many affected individuals have distinctive facial features such as widely spaced eyes with a broad, flat

nasal bridge and a prominent forhead. The condition is also associated with dental abnormalities including unusually small teeth. Researchers have described at least three types of Axenfeld-Rieger syndrome. The types, which are numbered 1 through 3, are distinguished by their genetic cause.

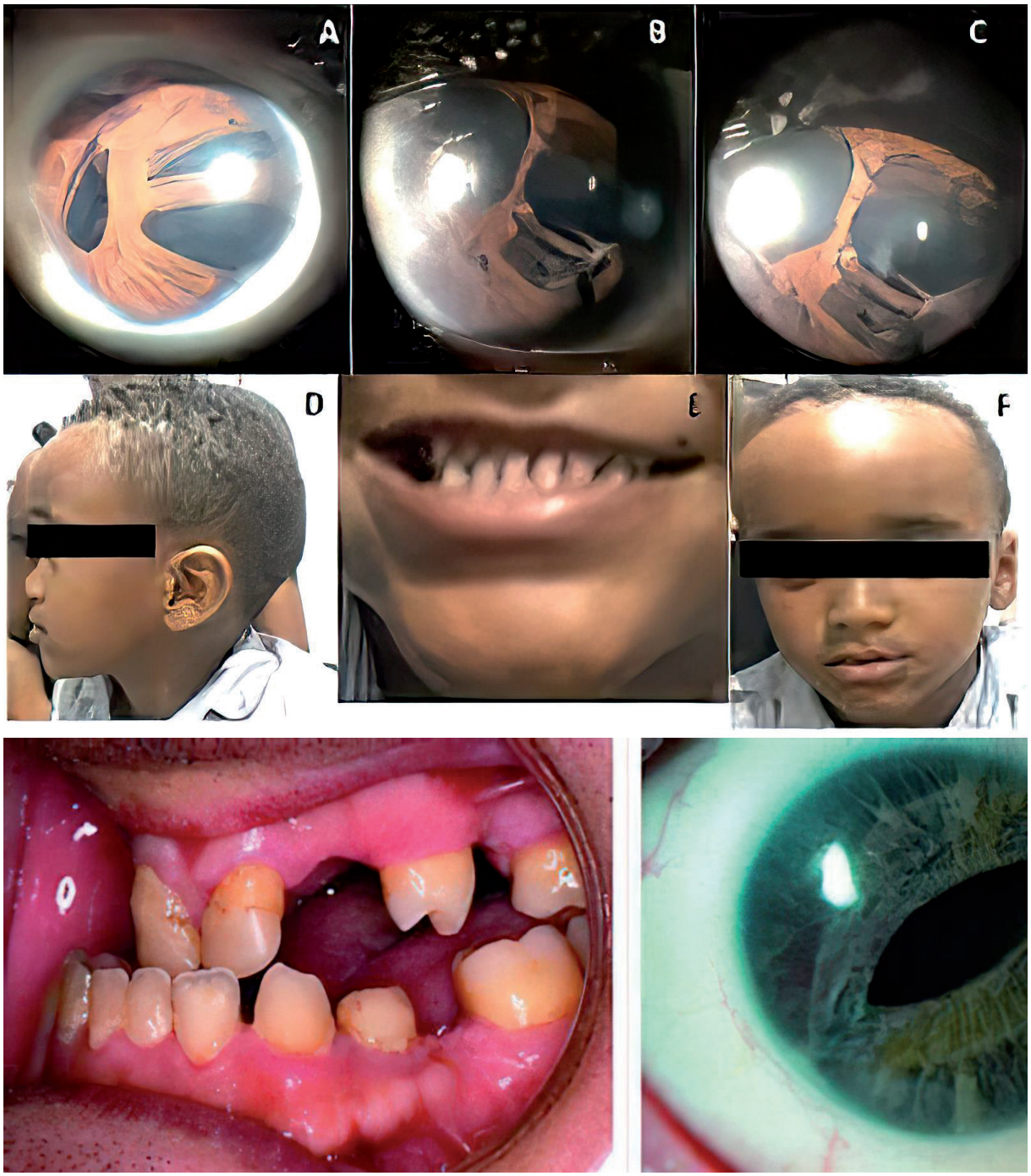
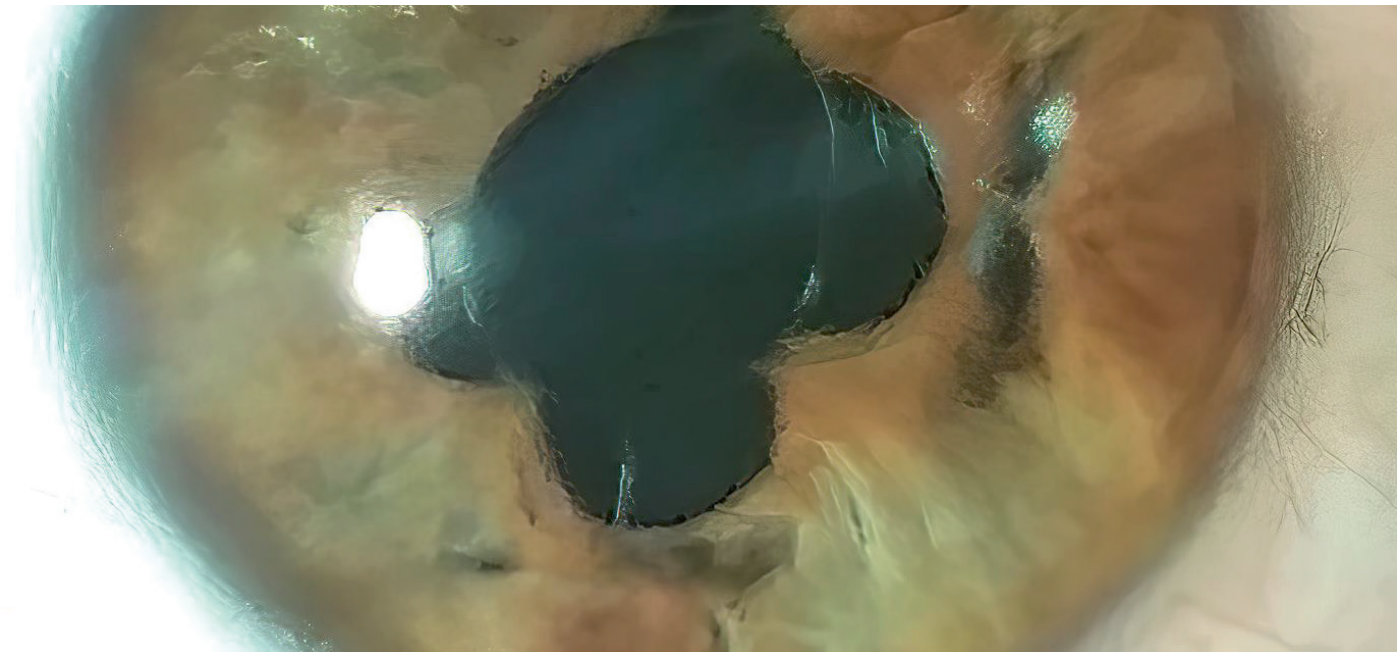


FIGURE 43: Rieger-Axenfeld Syndrome: Iris and teeth atrophy

2.6 Trauma



Trauma to the iris can present in a variety of ways depending on its location and severity. Tears at the pupillary border can damage the sphincter muscle, thus leading to an atonic, mydriatic, or partially reactive pupil. Tears at the iris root leads to iridodialysis. Furthermore, tears can be full thickness through the iris stroma or partial thickness, involving only the posterior pigment epithelium leading to trans-illumination defects. Penetrating wounds, either via foreign objects lacerating the globe or iatrogenic, surgical trauma during complex anterior segment surgery are the primary reasons for full thickness iris defects. Blunt ocular trauma is primarily responsible for iridodialysis but it may also be present with penetrating injuries. Patients at high risk for iatrogenic surgical trauma to the iris, include those with a history or a predisposition of Intra-operative Iris Floppy Syndrome (IFIS), pseudoexfoliation syndrome, or history of iritis.

The exam should also note for any iris atrophy, trans-illumination defects, synechiae, or exfoliative material in the contralateral eye. The pupillary margin should be assessed for sphincter tears, neovascularization, or ectropion

uveae. A gonioscopy exam should be performed when permitted, barring the patient does not present with an ocular laceration, to check for neovascularization of the angle or tears in the iris root, or peripheral anterior synechiae.

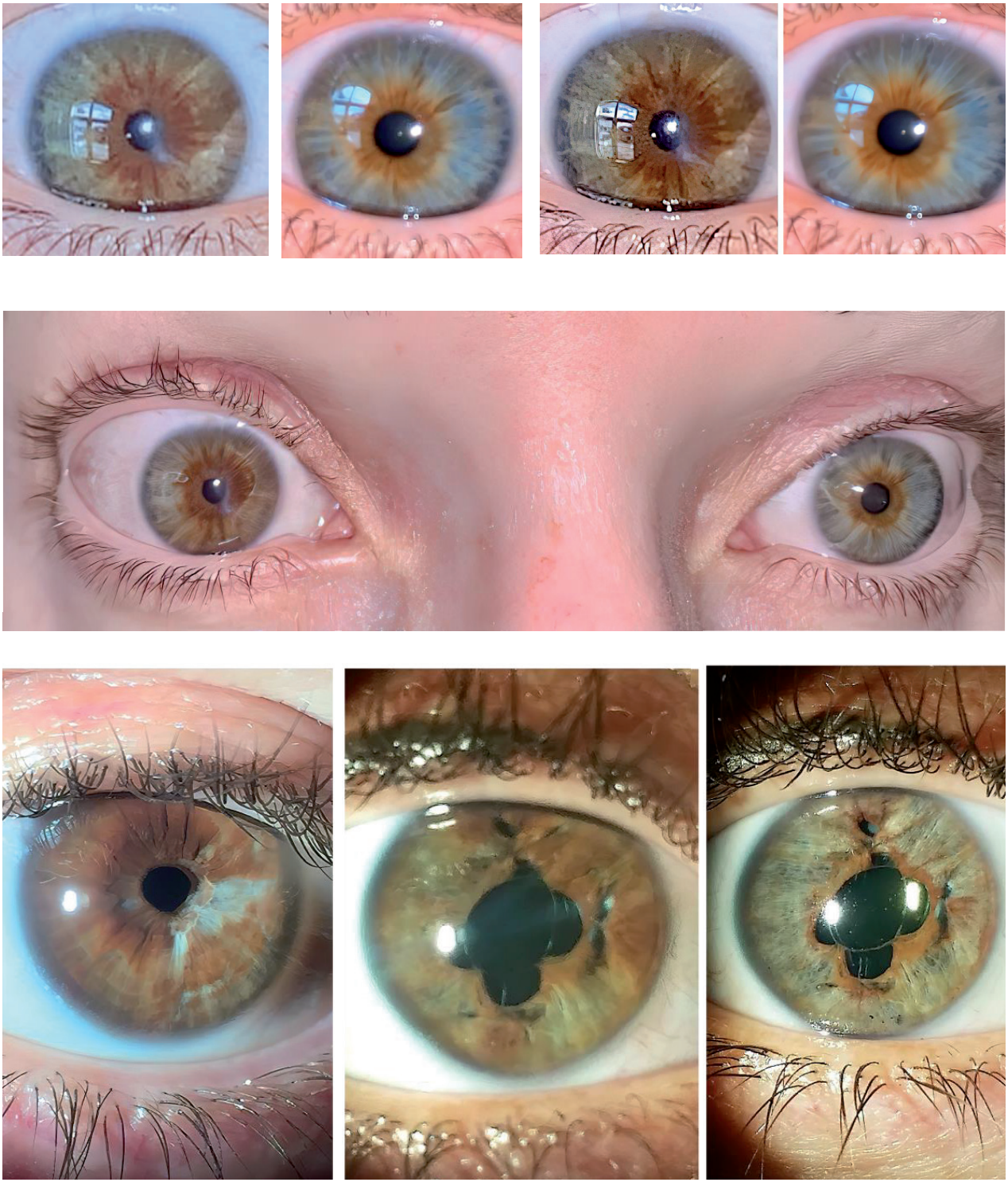
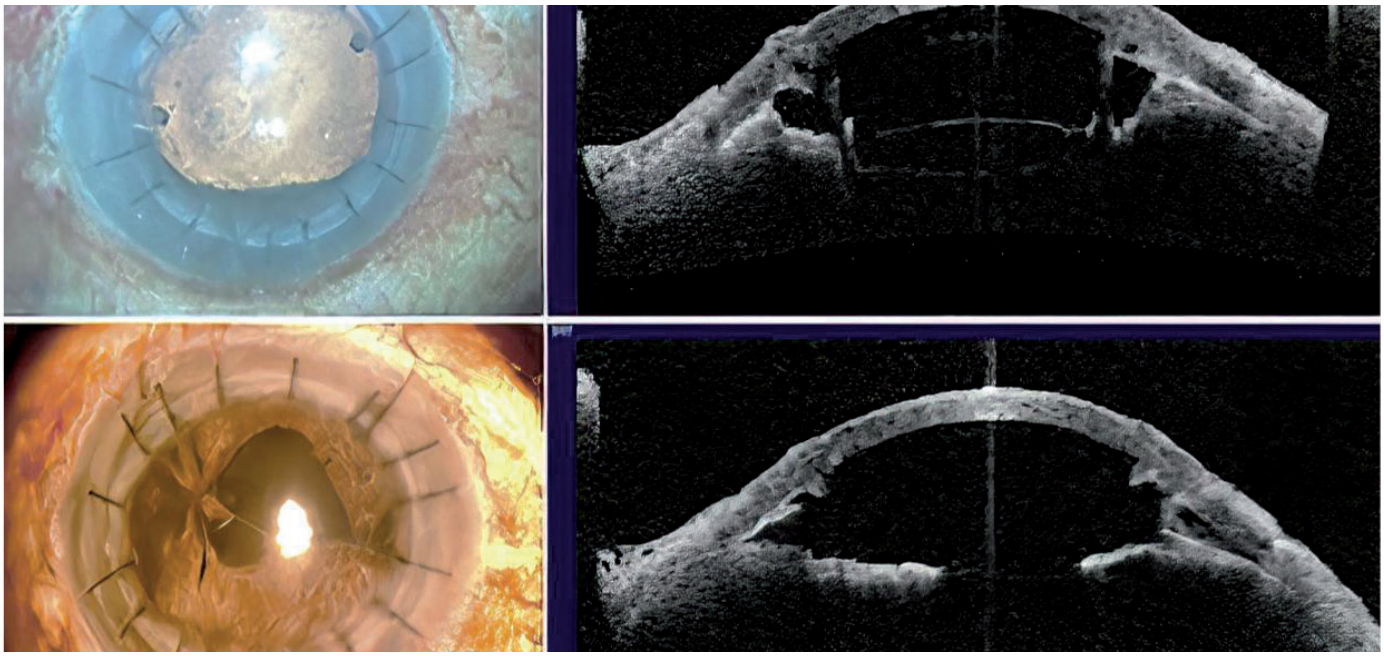


FIGURE 44: Iris damage due to corneal and intraocular trauma

2.6 Surgery



Urrets-Zavalia syndrome is an uncommon postoperative complication that was originally described after penetrating keratoplasty for keratoconus.

Consisting of a fixed dilated pupil, iris atrophy and secondary glaucoma.

It is associated with postoperative mydriatic treatment. Although the precise origin of the syndrome is uncertain, it has been proposed that ischemia of the iris can develop after raised intraocular pressure causes hypoperfusion and leave a fixed dilated pupil. For more than half a century, Urrets-Zavalia syndrome (fixed dilated pupil) has been described as a postoperative complication of ophthalmic surgery.

Since first reported as a complication of penetrating keratoplasty for keratoconus in patients receiving atropine, the characteristic features of Urrets-Zavalia syndrome have been expanded. Consists in fixed and dilated pupil. Increased intraocular pressure (IOP) in the immediate postoperative period, phakia, and air or gas in the anterior chamber appear to be the most important risk factors for Urrets-Zavalia syndrome following ophthalmic procedures.

Although surgical trauma usually produces iris atropht, we can also observe the opposite effect, that is, iris hyperpigmentation.

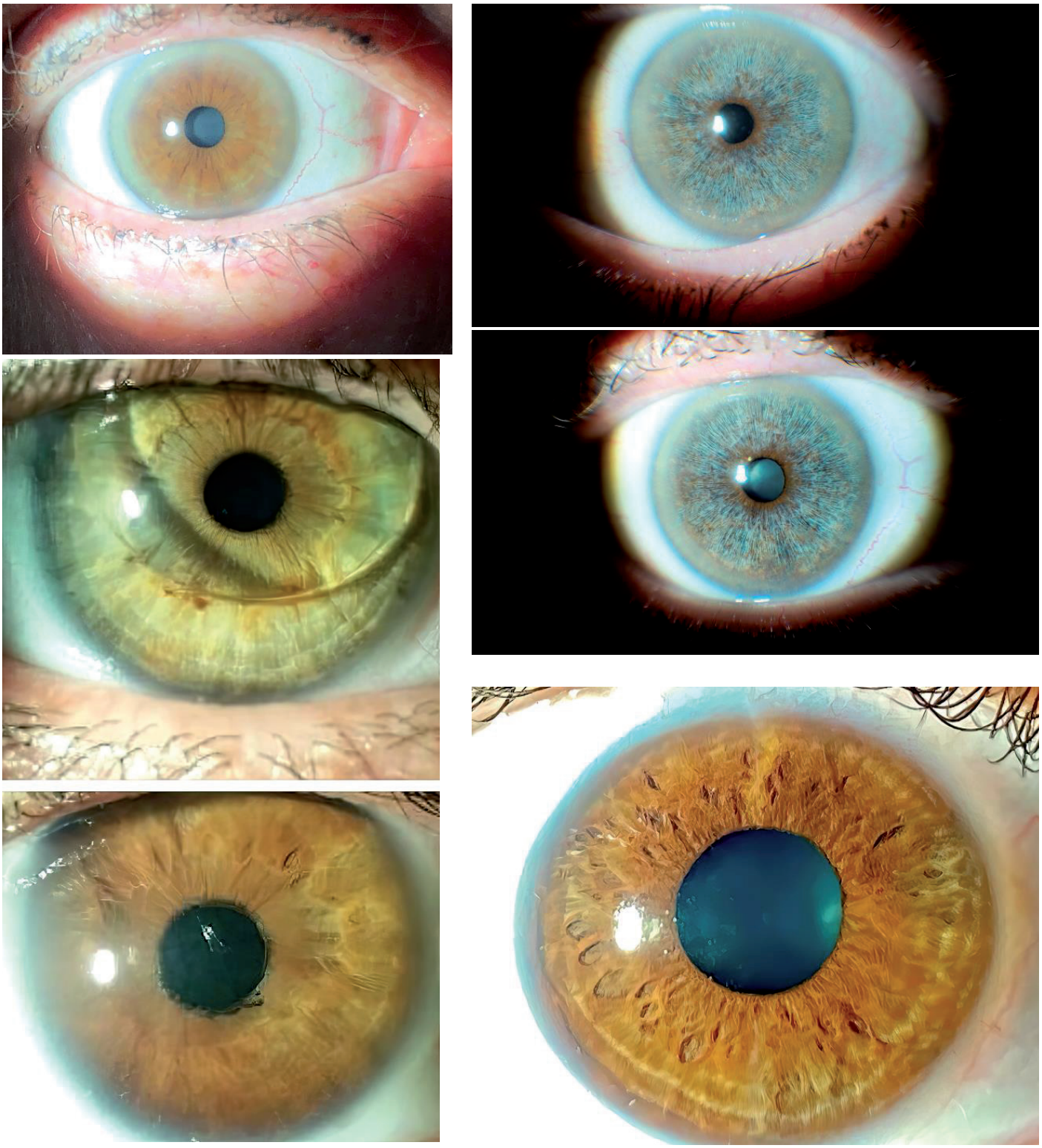
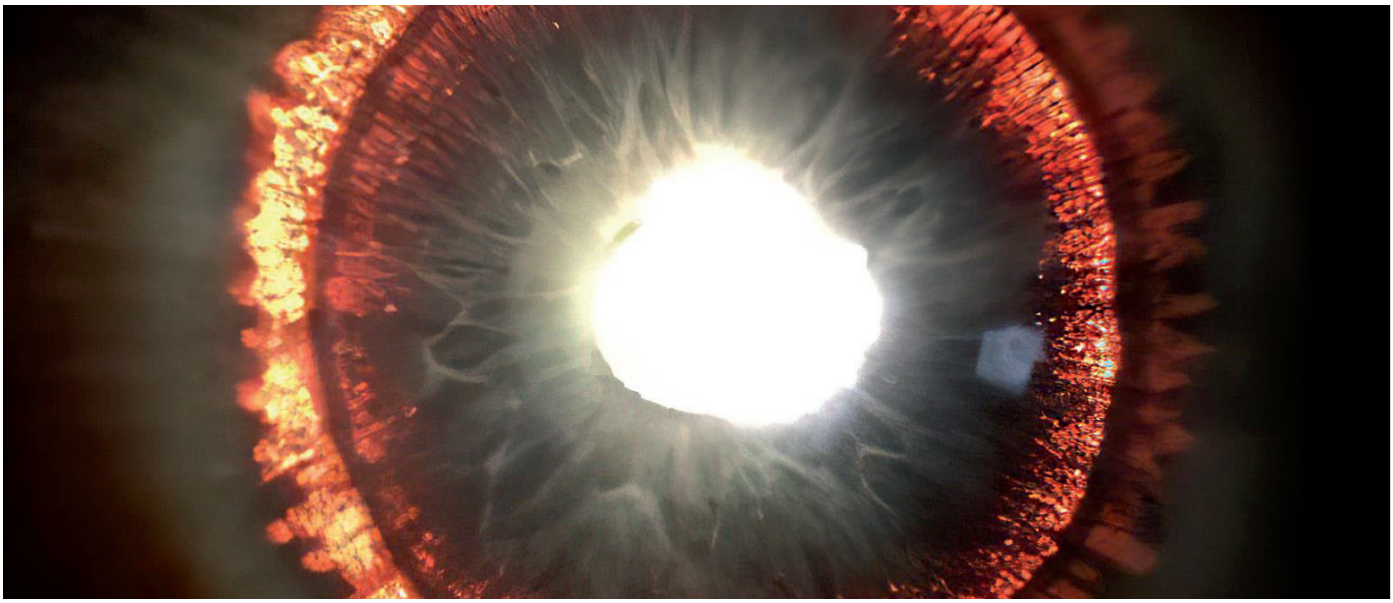


FIGURE 45: Iridoplasty after cataract surgery and lasik procedure

12.7 Glaucoma



Pigment dispersion syndrome, a common disorder in young adults, is associated with the development of pigmentary glaucoma. Studies have shown that up to 2%–4% of Caucasian Americans 20–40 years of age may be affected by this disorder with characteristic features that include loss of iris contour and loss of pigment granules from the iris. The released pigment is deposited on the structures of the anterior segment of the eye, which include the trabecular meshwork. Although generally it is accepted that the dispersed iris pigment contributes to the development of glaucoma in affected individuals, the pathogenesis of pigmentary glaucoma remains unknown. In humans, pigment dispersion can be inherited as an autosomal dominant trait, which suggests that specific gene defects may be responsible. One locus for this syndrome has been found on 7q35-q36, but the responsible gene has yet to be isolated. The high prevalence of this condition indicates that more than one gene may be responsible for this disorder. Two genes that contribute to a form of pigment dispersion syndrome and glaucoma in the DBA/2J mouse have been identified. These genes, TYRP1 and GPNMB, are involved in pigmentation and melanosome metabolism and do not ap pear to contribute to the disease in humans.

A subset of PDS patients develop signs of glaucoma related to the dispersal of pigment. This secondary glaucoma is known as pigmentary glaucoma (PG) and shares many features with POAG (elevated IOP, optic neuropathy, and visual field loss). The iris in most patients with PDS has a concave or 'backbowed' shape, which appears to be an important factor in the pathogenesis of the disease (22). Liberation of pigment from the iris produces the classic features of PDS, including defects in the iris visible by transillumination and accumulation of released pigment on the corneal endothelium, trabecular meshwork, lens and zonules.

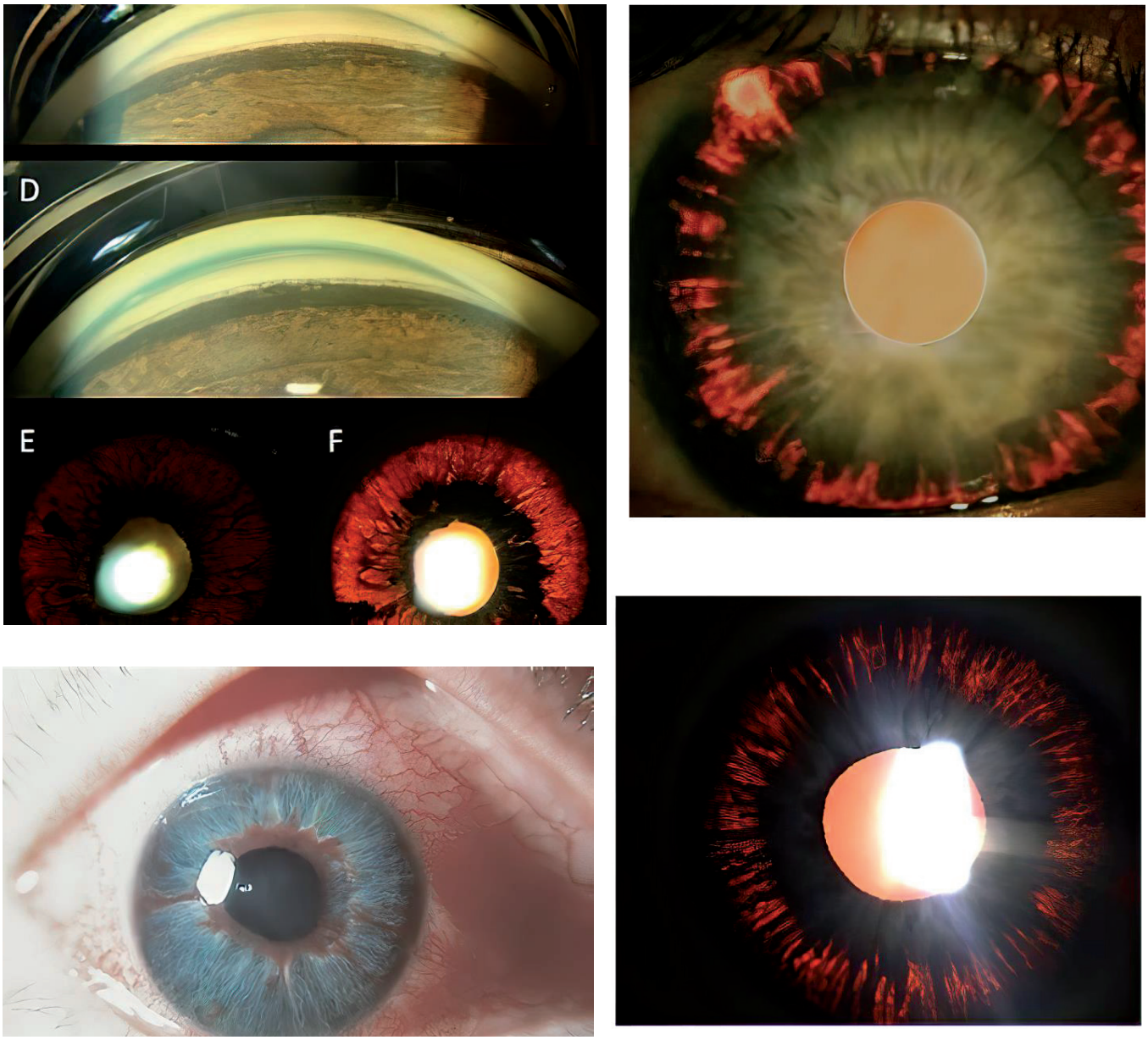


FIGURE 46: Pigmentary dispersion syndrome and secondary glaucoma

2.7 Glaucoma

Pseudoexfoliation syndrome (PEX) is a systemic disorder of the extracellular matrix that presents characteristic ocular manifestations. It is clinically diagnosed through slit-lamp visualization of white, flaky fibrillar (pseudoexfoliative) material on the pupillary margin of the iris and the anterior lens capsule. PEX may be present unilaterally or bilaterally. PEX is strongly associated with raised intraocular pressures (IOP) in up to 44% of patients and subsequent development of pseudoexfoliative glaucoma (PEG), making it the most common identifiable cause of secondary open-angle glaucoma. PEX is also associated with technically challenging cataract surgery: PEX eyes dilate poorly and have unstable lens zonules, which may lead to a higher risk of complications such as capsular bag rupture, zonular dialysis, and loss of vitreous. The exact etiology of PEX is not known; however, association with human leukocyte antigen supports that there is a genetic component to this disease.

The characteristic finding in PEX is the visualization of white, flaky, dandruff-like PEX material along the pupillary margin and anterior lens capsule. The anterior lens capsule shows a central disc and peripheral ring of PEX material with a clear intermediate zone maintained by pupillary abrasion. The central disc may be absent in up to 20% of cases, and the peripheral zone may not be completely visualized without the aid of pharmacological dilation. There may be phacodonesis secondary

to zonular weakness. The corneal endothelium may show deposition of PEX material that may be erroneously interpreted as keratic precipitates. Fine scattered pigment deposits are also present, which may form a vertical line known as a Krukenberg spindle similar to pigment dispersion syndrome. Gonioscopy should be performed in all patients suspected of PEX. PEX deposits may be visualized over angle structures. Patchy hyperpigmentation over the trabecular meshwork and Schwalbe line is observed. This hyperpigmentation may coalesce to form a band of hyperpigmentation on the Schwalbe line known as the Sampaolesi line. In unilateral cases where no PEX material is visible in the fellow eye, trabecular meshwork pigmentation may be an early sign of PEX development. Up to 20% of PEX eyes may have narrow angles predisposing them to acute angleclosure glaucoma.

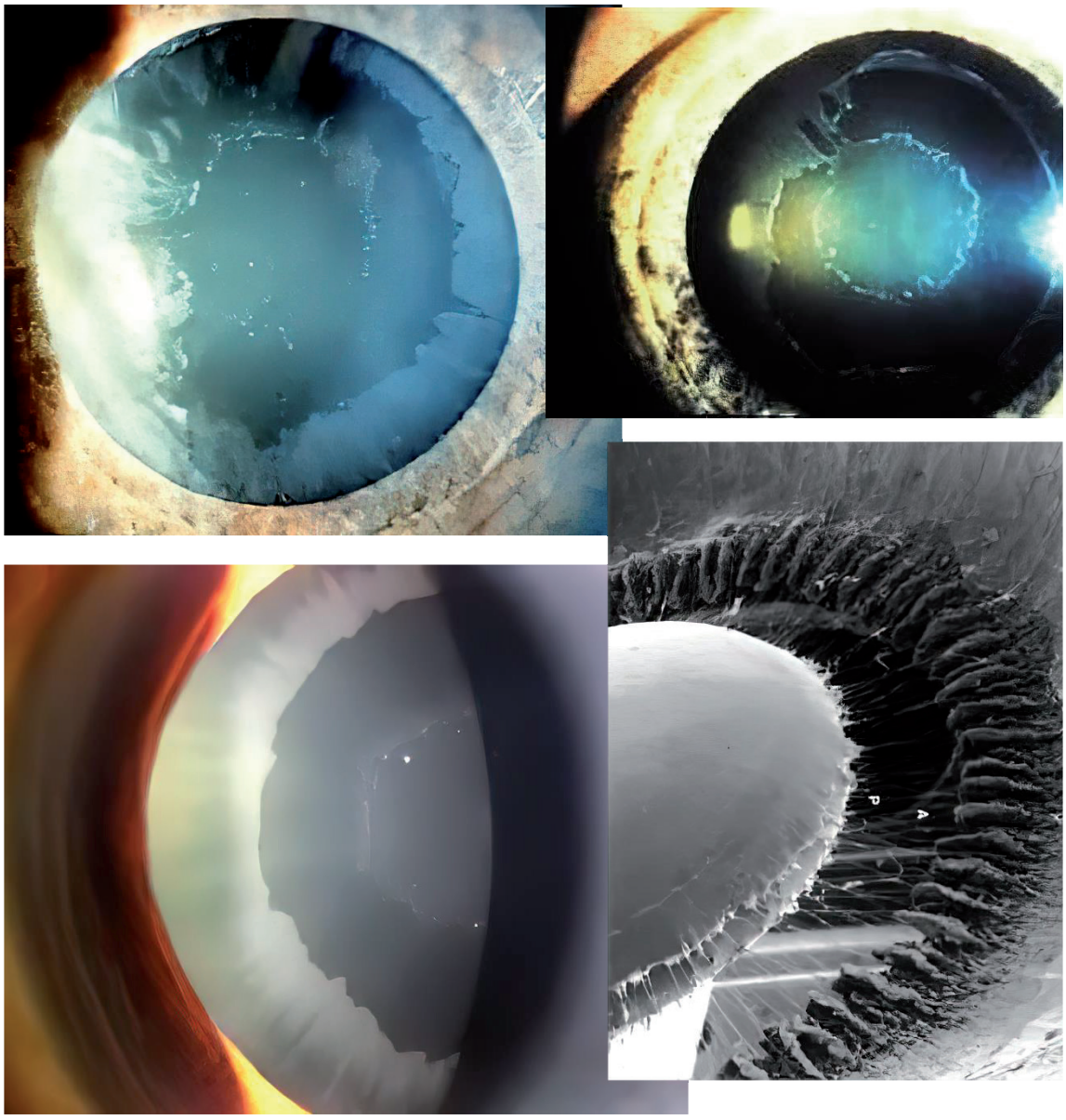
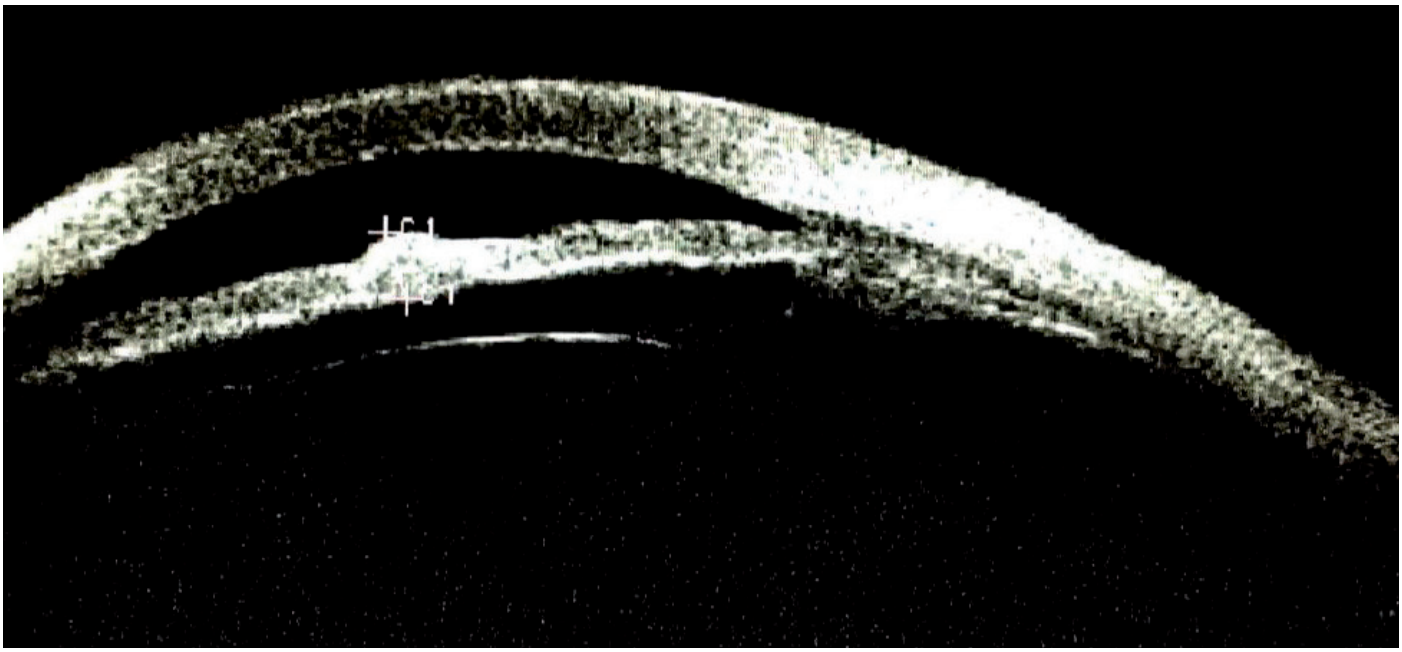


FIGURE 47: Pseudoexfoliative material on iris, zonula and lens

2.8 Melanoma



Iris melanoma is the most common primary neoplasm of the iris and account for approximately 5% of uveal melanomas. The average age of involvement lies within the 5th decade. Although there is no gender predilection, iris melanomas occur more frequently in Caucasians with a light iris versus non-Caucasions. There is no consistent evidence linking iris melanoma with UV light or environmental exposure.

Most of iris melanomas are asymptomatic and thus diagnosed at an ophthalmic routine examination. In addition to a circumscribed or diffuse iris mass, heterochromia, chronic uveitis, glaucoma, or spontaneous hyphema may occur.

There are several clinical variations including circumscribed, diffuse, and tapioca iris melanoma. Circumscribed iris melanomas appear as a variably pigmented well-defined mass in the iris stroma and is more commonly found in the inferior half of the iris. The degree of pigmentation can vary as well as the shape. Some are small and flat and others are elevated and dome shaped. Diffuse iris melanomas present with progressive iris discoloration with disappearance of iris crypts and accumulation of pigment in the anterior chamber. These can be misdiagnosed as pigmentary glaucoma or pigment dispersion syndrome. Tapioca melanoma is a name introduced

by Reese and associates to describe a variant of iris melanoma with multiple amelanotic nodules on the surface giving the appearance of tapioca pudding. There are several clinical variations including circumscribed, diffuse, and tapioca iris melanoma. Circumscribed iris melanomas appear as a variably pigmented well-defined mass in the iris stroma and is more commonly found in the inferior half of the iris. The degree of pigmentation can vary as well as the shape. Some are small and flat and others are elevated and dome shaped.

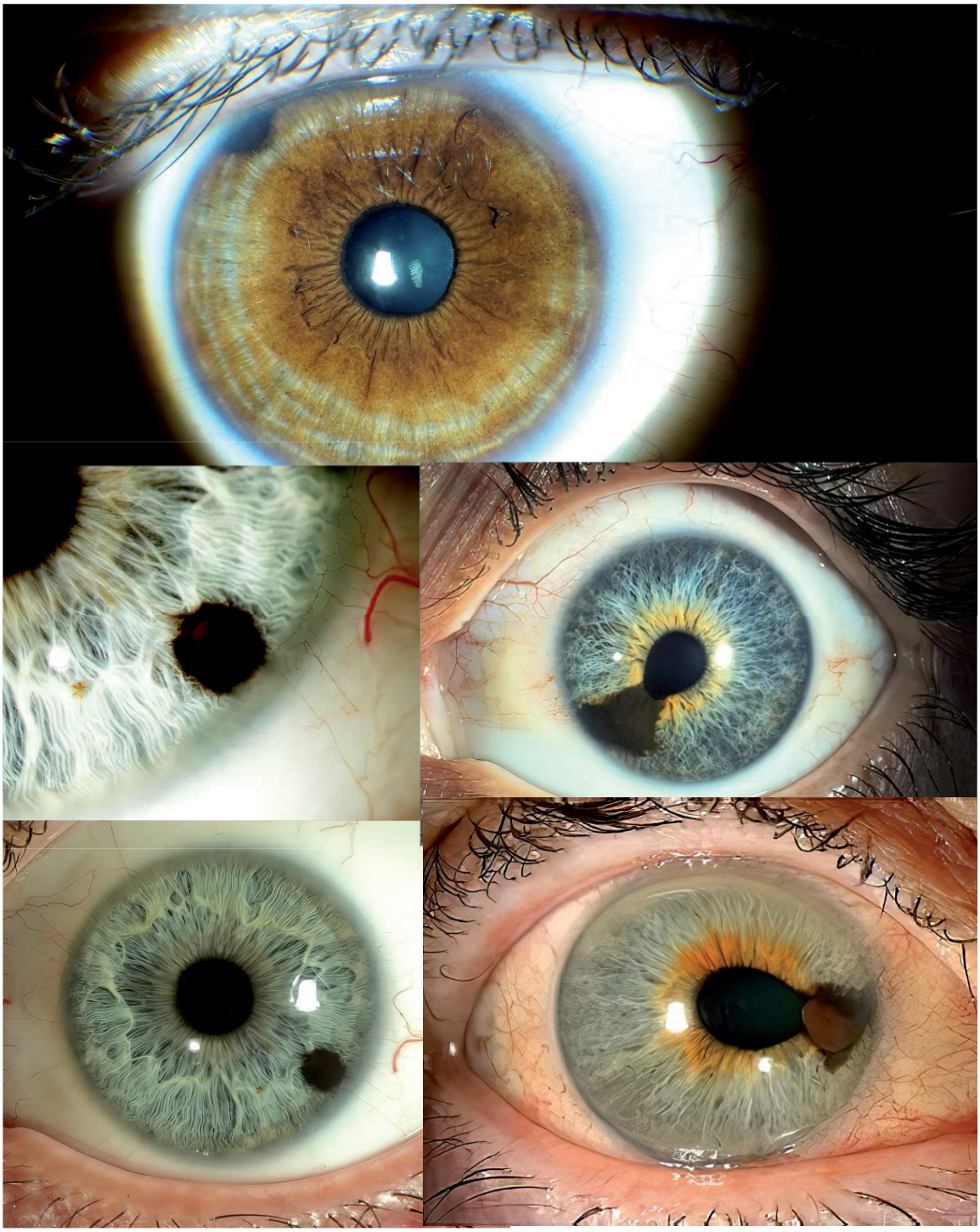
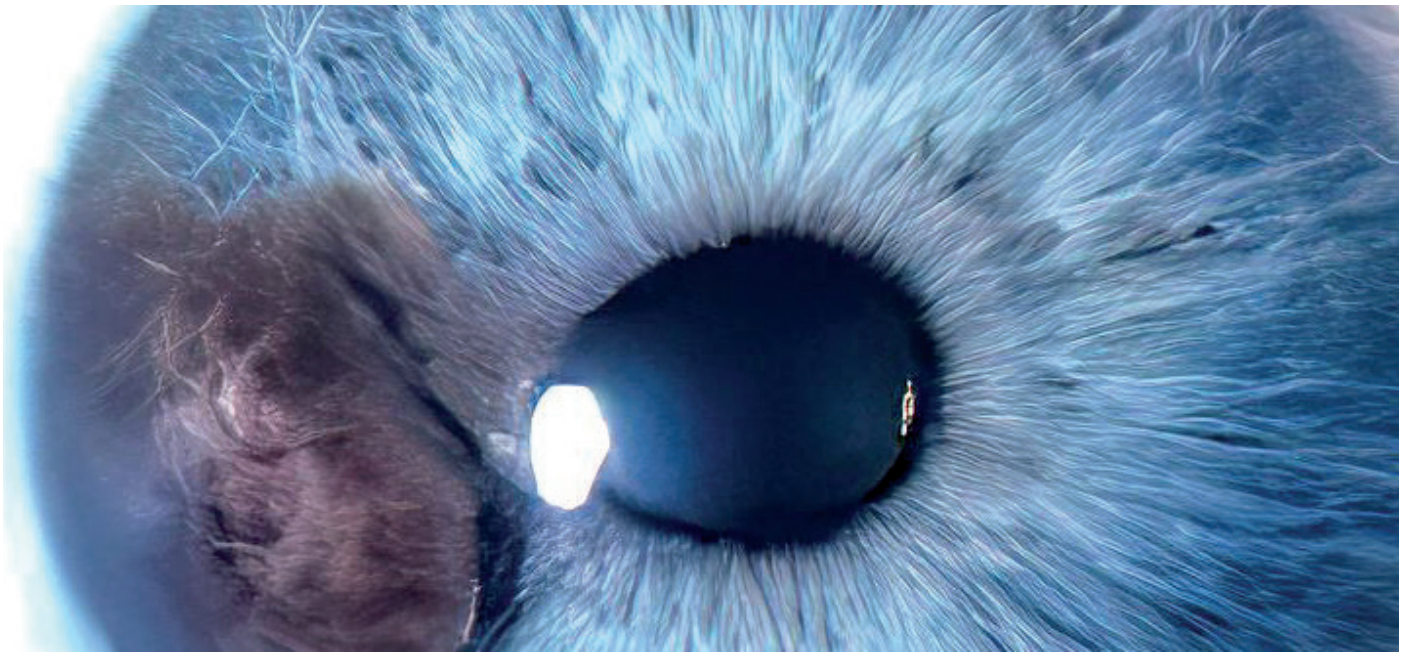


FIGURE 48: Small and medium size iris melanoma

2.8 Melanoma



Diffuse iris melanomas present with progressive iris discoloration with disappearance of iris crypts and accumulation of pigment in the anterior chamber. These can be misdiagnosed as pigmentary glaucoma or pigment dispersion syndrome. Tapioca melanoma is a name introduced by Reese and associates to describe a variant of iris melanoma with multiple amelanotic nodules on the surface giving the appearance of tapioca pudding. Photodocume tation and ultrasound examination should be obtained as a baseline value and on followup visits to document changes in size and shape.

Differential diagnosis: Iris freckle, Iris nevus, Iris melanocytoma, Iris nevus sindrome, Iris pigment epithelial cyst, Peripheral anterior synechiae, Iris foreign body, Lisch nodules, Fuch's heterochromic iridocyclitis, Latanoprost therapy, Juvenile xanthogranuloma, Iris metastasis, Leukemia, Ciliary body melanoma with anterior extension, Other iris tumors (eg. leiomyoma, rhabdomyosarcoma).

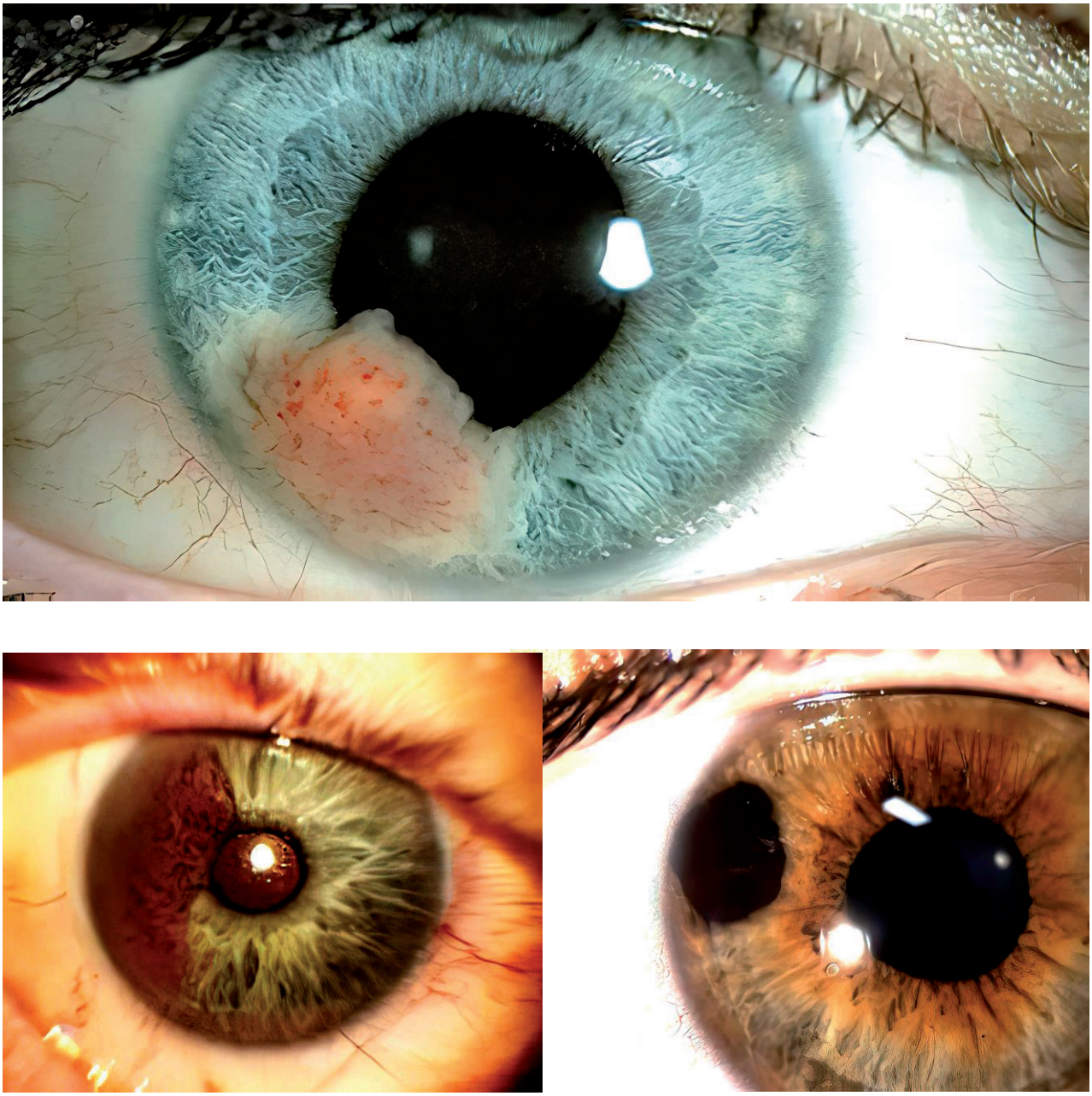
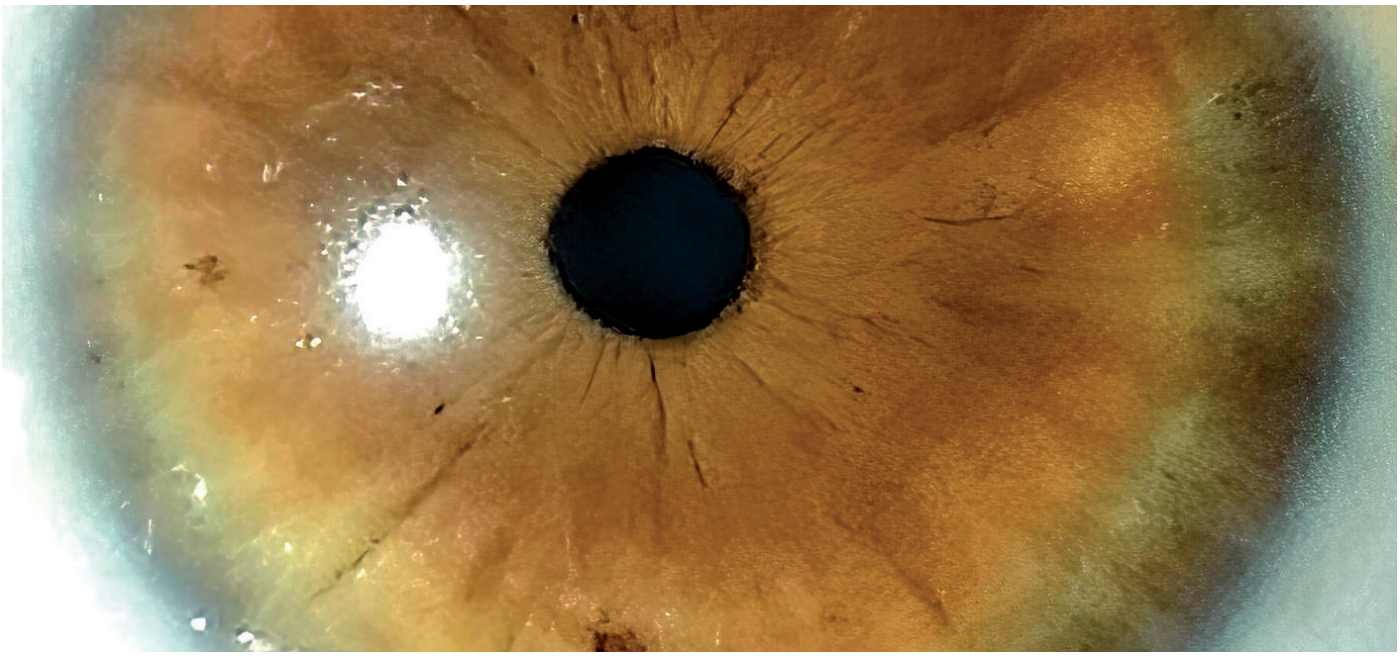


FIGURE 49: White and dark black big size iris melanoma

2.9 Prostaglandins



Topical application of prostaglandin (PG) analogues are currently the most commonly used intraocular pressure lowering drugs in glaucoma. PGs are associated with very few systemic side effects. The side effects of concern are all concentrated in the eye.

Conjunctival hyperemia is a co mon mild but transient complication. Since the development of this class of drug the most worrying and unusual side effect is a change in the pigmentation of the melanin-containing tissues close to the application site, i.e. eyelid skin, eyelashes and iris. As the prostaglandin induced iris darkening (PIID) is irreversible on cessation of the drugs it was of particular concern. The only definitive change that has been detected in the cases of PIID is a small enlargement of the size of the existing melanin granule population and it has been shown that this change in melanin granule size is sufficient to account for the PIID. These findings point to the conclusion that the darkening developed following PG use is of a purely cosmetic effect with little or no serious consequences.

The prostaglandin analogues used in lash serums work to lengthen lashes by prolonging the anagen phase (active growth phase) of the hair follicles. They also stimulate the production of melanin, which produces darker

eyelashes. Lastly, they increase the size of the dermal papilla and hair bulb, increasing lash thickness. One of the side effects that doctors noticed was that the [bimatoprost ophthalmic solution] medication was darkening the color of the patient's iris.

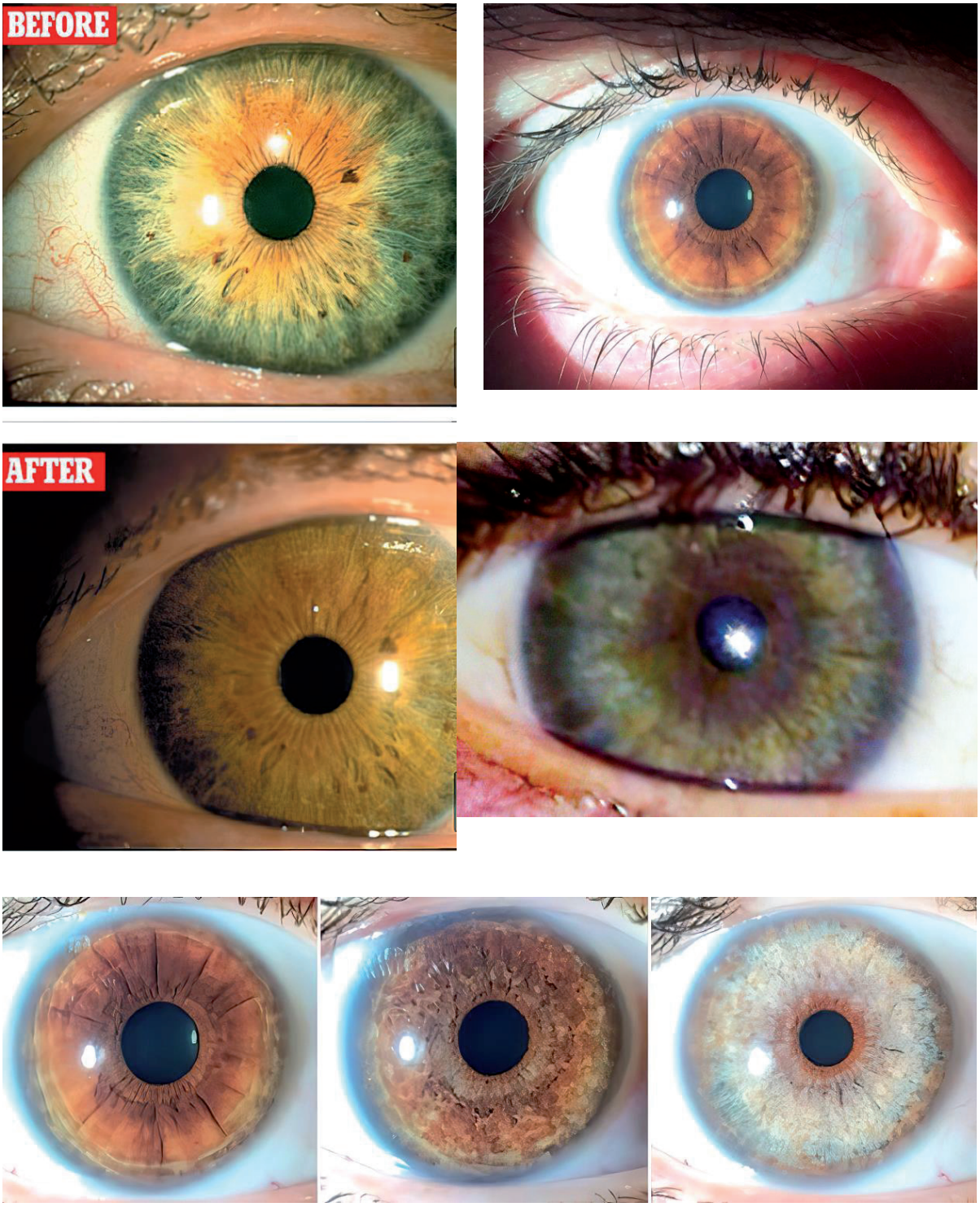
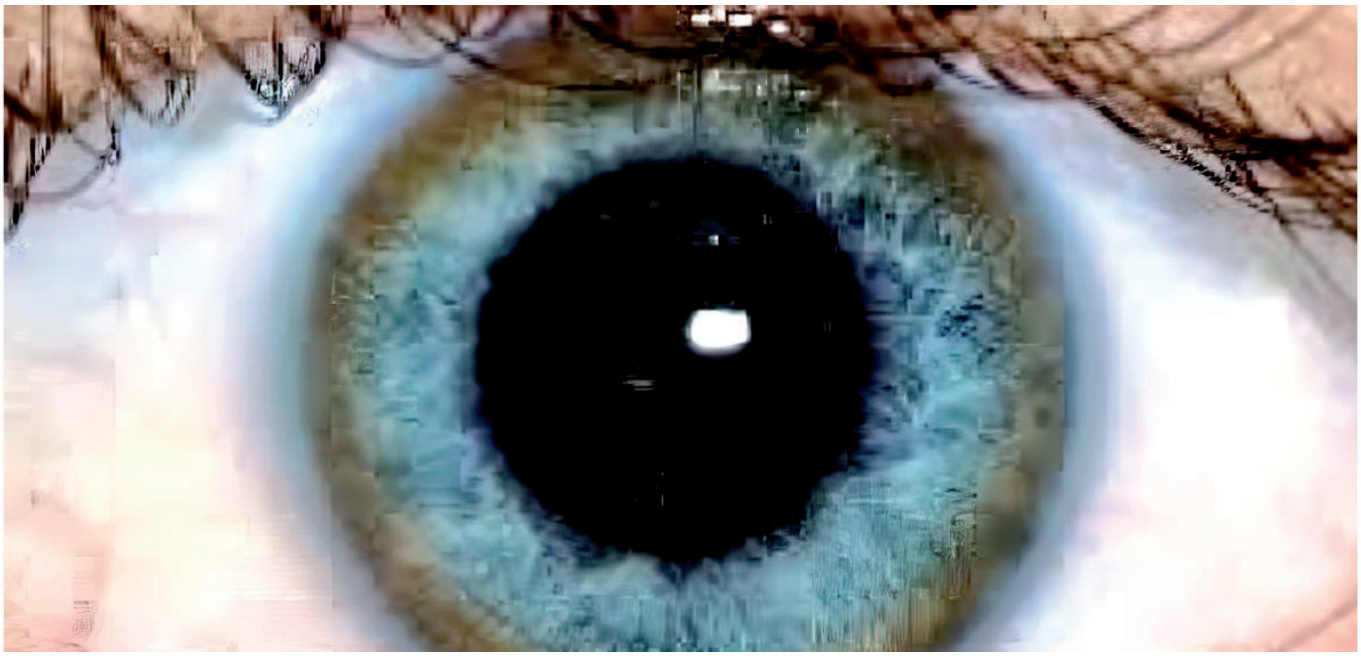


FIGURE 50: Prostaglandins increase dark melanin iris production

2.10 Pseudo-metabolic



Kayser-Fleischer rings (KF rings)are dark rings that appear to encircle the cornea of the eye. The rings, which consist of cooper deposits where the cornea meets the sclera, in Descemet´s membrane, first appear as a crescent at the top of the cornea. Eventually, a second crescent forms below, at the "six o'clock position", and ultimately completely encircles the cornea. Kayser–Fleischer rings are a sign of Wilson´s disease, which involves abnormal copper handling by the liver resulting in copper accumulation in the body. The combination of neurological symptoms, a low blood ceruloplasmin level and KF rings is diagnostic of Wilson's disease.

Arcus senilis (AS), also known as gerontoxon are rings in the peripheral cornea. It's usually caused by cholesterol deposits, so it may be a sign of high cholesterol. It is the most common peripheral corneal opacity and is usually found in the elderly where it is considered a benign condition.

When AS is found in patients less than 50 years old it is termed arcus juvenilis. The finding of arcus juvenilis in combination with hyperlipidemia in younger men represents an increased risk for cardiovascular disease.

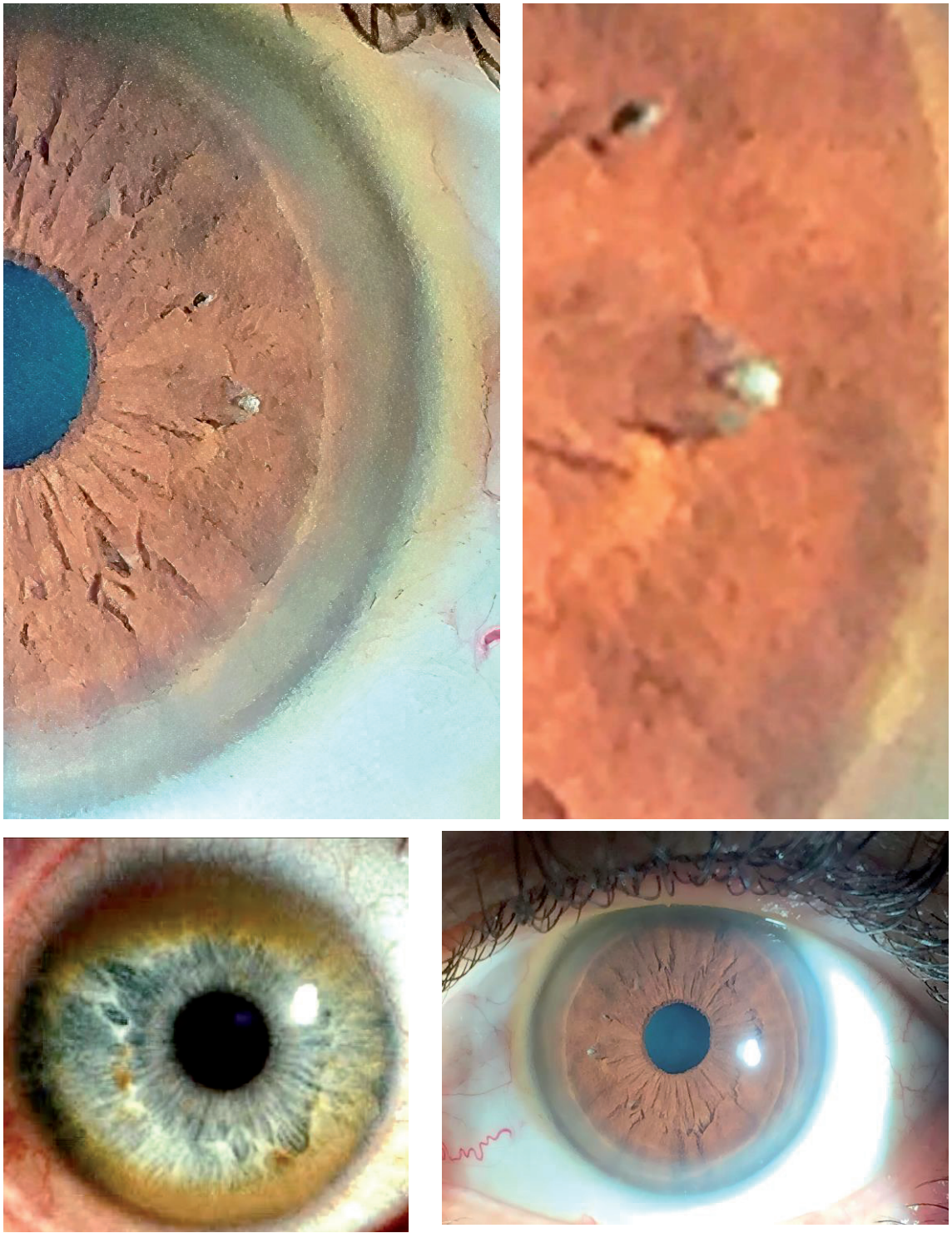
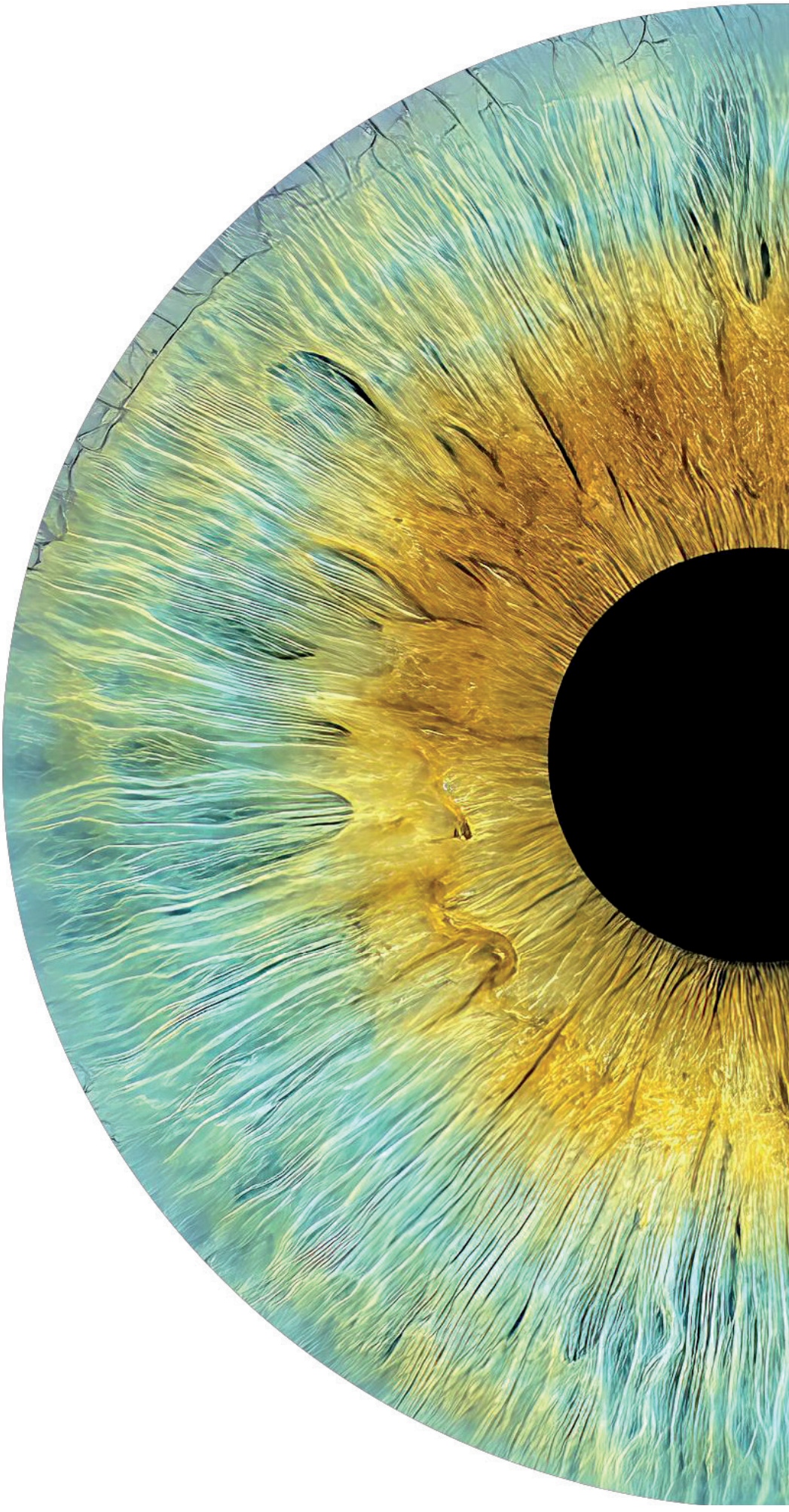
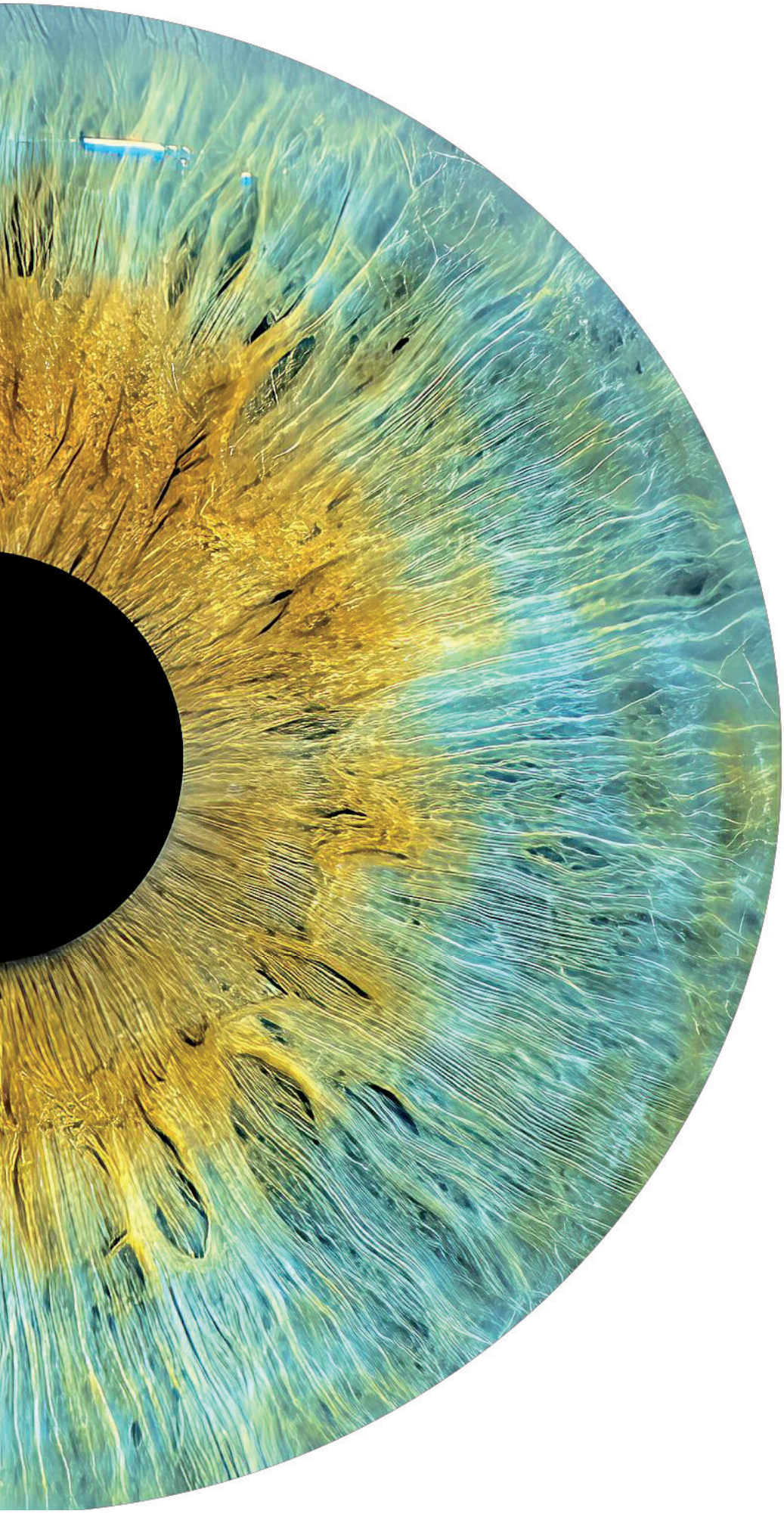
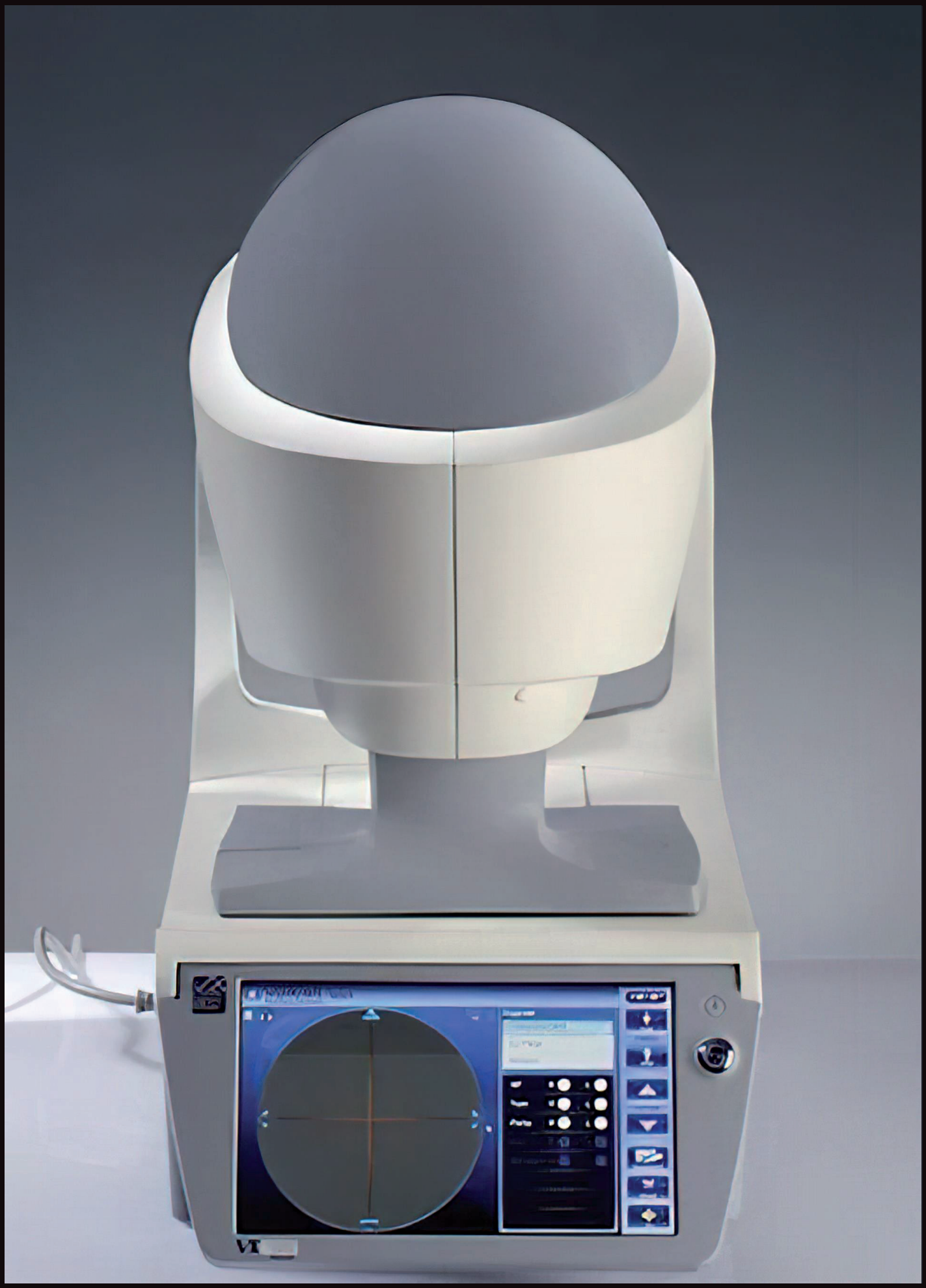


FIGURE 51: Gerontoxon by colesterol and Kayser-Fleisher rings





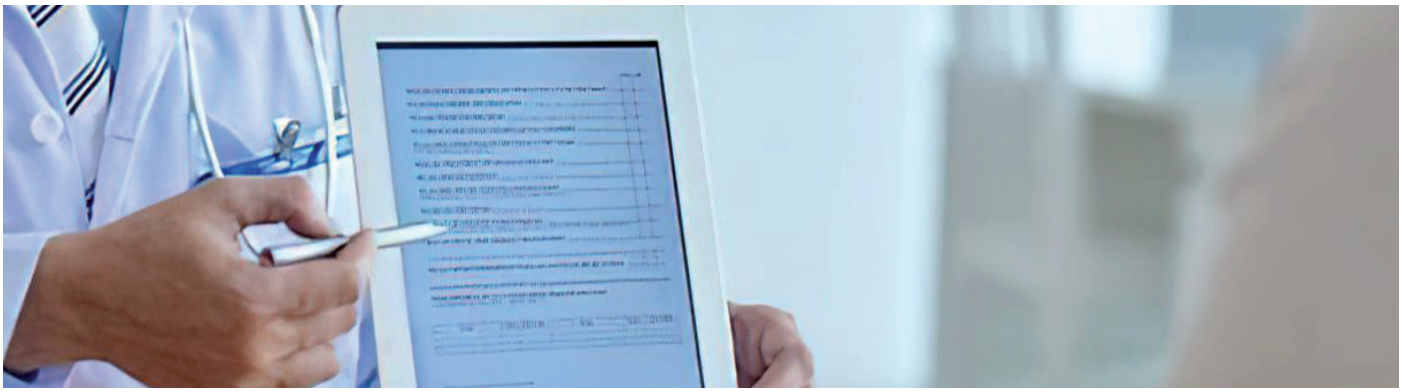


PART 2

LASER IRIDOPLASTY

CHAPTER 3 CHECH UP

2 3.1 Candidate selection



A detailed clinical history was g thered, especially focused on detecting exclusion criteria. If they were determined to be a good candidate, a general in-depth ophthalmologic examination was performed, as well as another specific one to PCI. The selection of patients was carried out in healthy individuals, over 18 years of age, with iris heterochromia (congenital-7% or acquired, secondary to topical medication-1%, trauma-0.5% or surgery-0.25%), nevus-0.25% and cosmetic cases-91%. The exclusion criteria were: under 18 years old, personal or family history of glaucoma, chronic ocular pathology (uveitis, iritis, retinopathy, trauma), systemic inflammatory, infectious, or oncological diseases, chronic vascular diseases (diabetes, Raynaud), autoimmune diseases (rheumatoid arthritis, Crohn's disease, ulcerous colitis, Behçet disease, lupus erythematosus, multiple sclerosis), serious psychological disorders or psychiatric diseases (depression, bipolar disorder, obsessive, compulsive, or paranoid patients or, in particular, those with body dysmorphia disorder). Specific cases of medical allergies or intolerances were also rejected, as well as the chronic consumption of anabolic, steroids, hormones, or drugs.

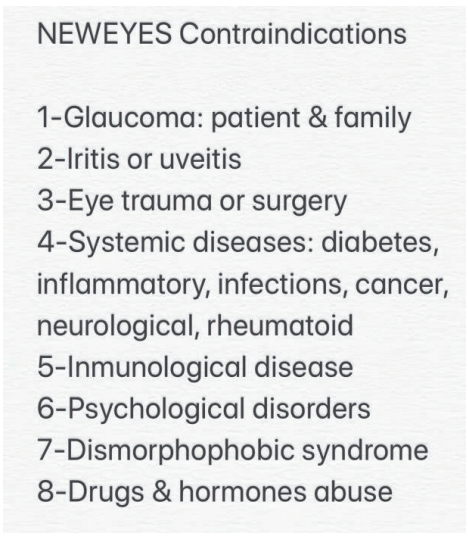
Regarding degrees of pigment tion, prior to 2019 only cases in grades I–III of the Eyecos ocular pigmentation classification were admitted, but in the final months and at present we began to accept grade IV cases, with very satisfactory results.

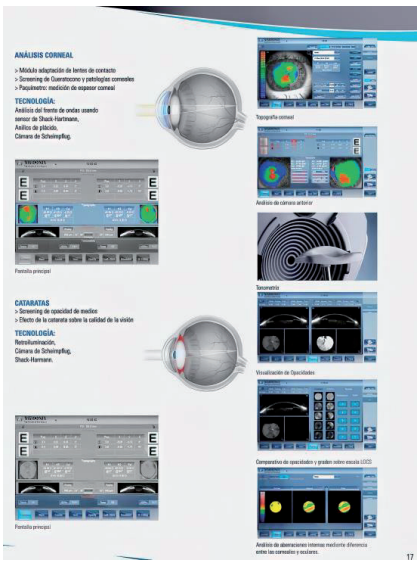
The indications to apply PCI have been alterations in iris pigmentation, which have included unilateral or bilateral, partial or complete, congenital heterochromia, single or multiple

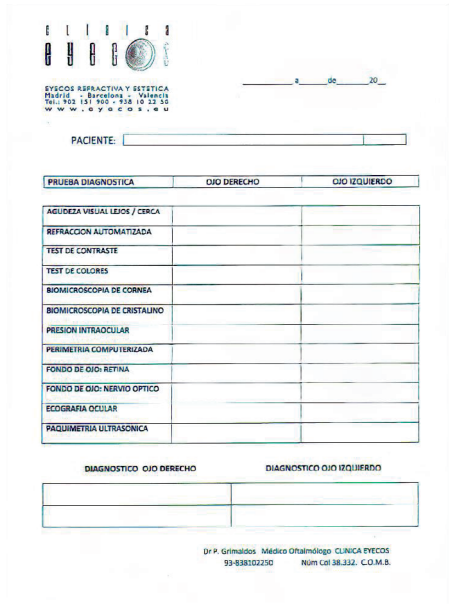
nevus, and acquired causes, secondary to trauma, surgical complications (cataracts), and due to iatrogenesis from the abuse of prostaglandin eye drops to lengthen eyelashes.

The most frequent reasons for int rested patients were purely aesthetic (close to 91% of the total), without the presence of heterochromia. It surprised us that the stated reasons were not capricious, but rather a professional need (contract requirements for image professionals like models or actors), sentimental (specific preferences of their partner) and psychosocial. The latter group was without a doubt the largest, consisting of individuals who had spent their whole life wanting the same color eyes as their family members (parents and siblings with blue or green eyes while theirs are brown), or people subject to a social discrimination based on race, who saw this technique as the solution to the issue.

In 95% of the cases, the patients came after many years of seeking information from the clinic, over the phone or via email, in patient forums, social networks, and through direct contact with the doctor. Therefore, the patients had comprehensive. information, including a detailed informed consent, and the analyses in pre- and post-laser treatments. None of the cases were compulsive or poorly considered decisions.







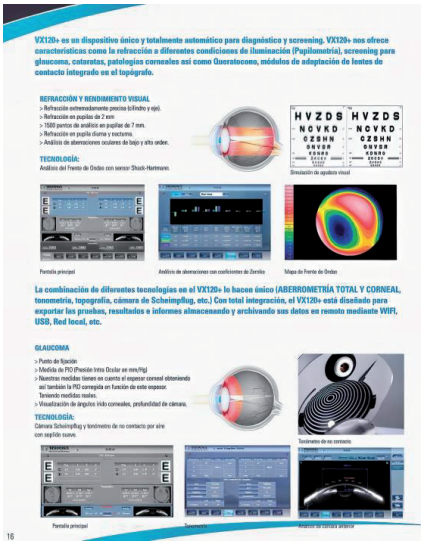
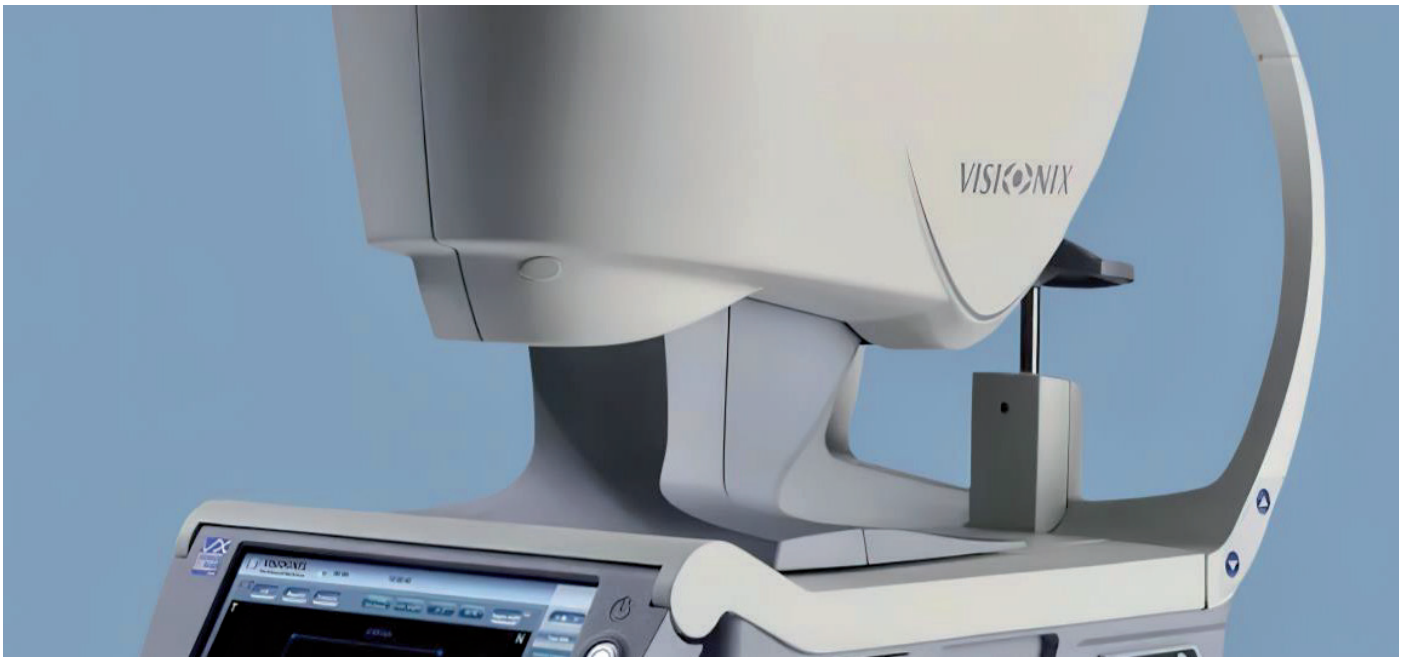


FIGURE 52: Admission criteria and screening ocular tests

2 3.2 Full eye check up



1-Wavefront assessment; the machine uses three sweeps of an infra-red incident beam to measure the refractive error, calculate the higher order aberration profile and use retro illumination to detect cataract. To minimise accommodation and pupil error, the patient views the now familiar image of a balloon. The contrast and bright colors encourage fixation even with higher errors yet to be corrected, and there are perspective clues from the contours of the road that imply, Ponzo-style, that the target is far off. The patient eye is seen on the operator screen and the pupil is easily centered by a tap on the screen before the measurements are taken.

2-Scheimpflug image capture; the patient is asked to look between two blue fixation lights while the machine captures a cross section image of the entire anterior chamber. The technique is accurate enough for individual measurements to be taken from the resultant image. These include anterior chamber depth, anterior angle, and corneal thickness across the cornea.

3-Topography; it is now that the characteristic rings on the patient side of the instrument switch on, providing a Placido ring image on the cornea from which topographic information is derived.

4-Non-co tact tonometry; finally, the machine moves vertically some way until a mirror is aligned to allow control of three consecutive air puffs, the force of which needed to applanate the cornea then being converted into intraocular pressure readings.

Summary screen: Average refractive error (for a proscribed back vertex distance, usually defaulting to 12mm) and notes its value for both mesopic and photopic condition. The summary screen also shows key topographic data, k readings in either diopters or millimeters, pachymetry values, a small anterior chamber view, and tonometry readings. The 'coefficient of aberration' tab displays each of the main higher order aberrations graphically. The HOAs are measured using a Hartmann Shack system.

Any lens opacity may be viewed by selecting, the 'opacity' tab. The wide angles can easily be seen as well as pachymetry values across the extent of the cornea. Topographic data can be displayed in a variety of ways, including a range of the maps. The tonometry readings are shown as the average of three, though outliers may be disregarded. The machine also uses the pachymetry data to show a corrected IOP value.

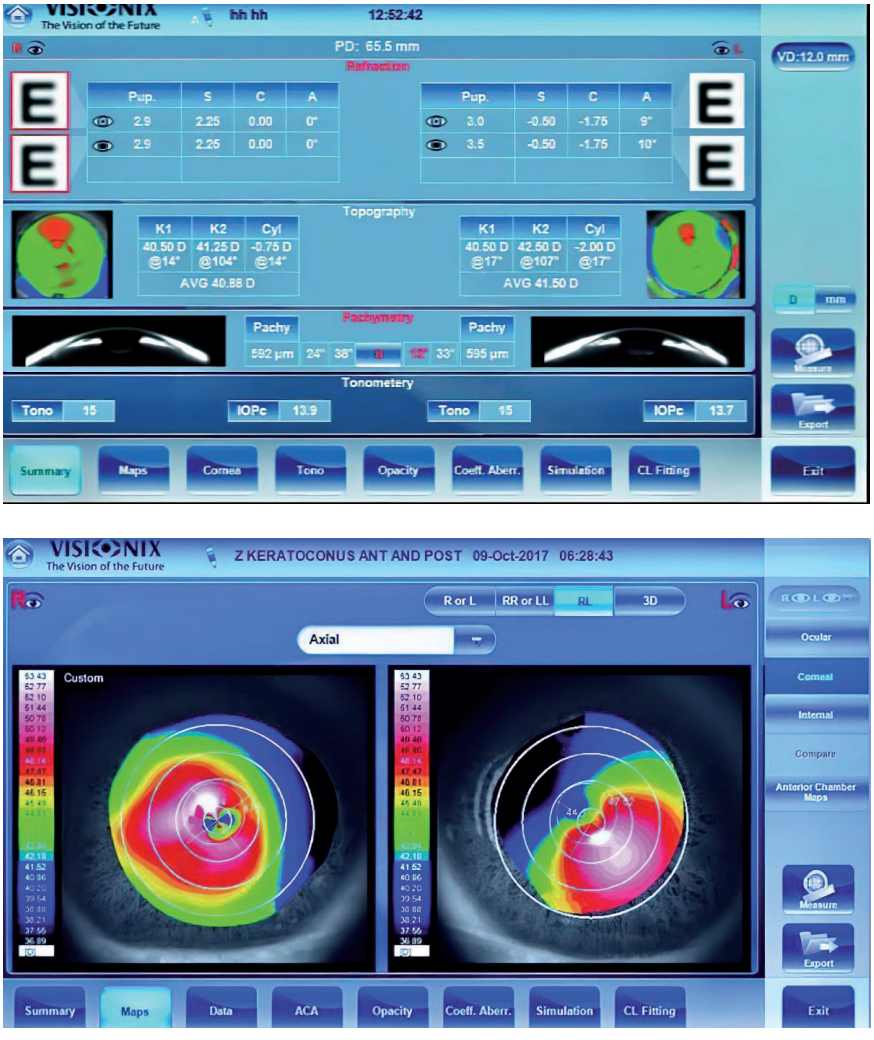


FIGURE 53: Autorefraction, aberrometry, paquimetry, topography

2 3.3 HD 4K Photography

Professional photography:

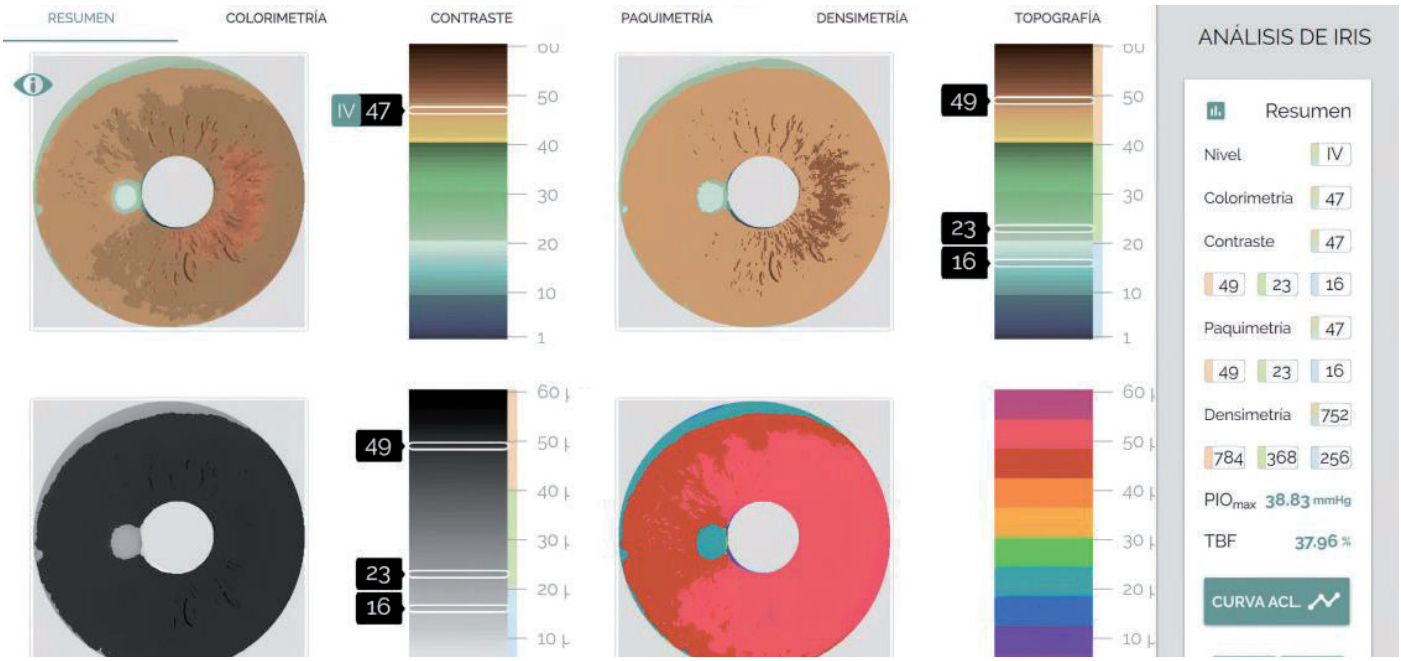
In order to take highest quality ocular photography of anterior segment and specially the iris, we use a special imaging system adaptable to the vast majority of slit lamps with 100% of the light for photography, without ray splitters and fully digital imaging system.

Technical characteristics:

Image Quality: Full HD
Connectivity: WI-FI Photo
Resolution: 24 Megapixels

FIGURE 54: High definition 4K eye photography system

2 3.4 Colorimetry & Iris Summary



We used the IRÎZ (Eyecos) scanner and Analyzer program, which provided us with the data required to adequately plan the treatment: pigmentation grade, colorimetry, color contrast, iris pachymetry, and 3D topography. The scanner consists of three modules: photography (Topcon SL-D), optical coherence tomography (OCT Topcon SL-SCAN1) and pneumotonography (Reichert M30). The Analyzer IRÎZ (Eyecos) software also calculates the physio-dynamic parameters of the aqueous humor in the anterior chamber, which are indispensable for a safe technique: maximum intraocular pressure (IOP max), clearance curve (CC) and trabecular blockage factor (TBF). These data are shown in a simplified format in the Eyecos Iris Summary.

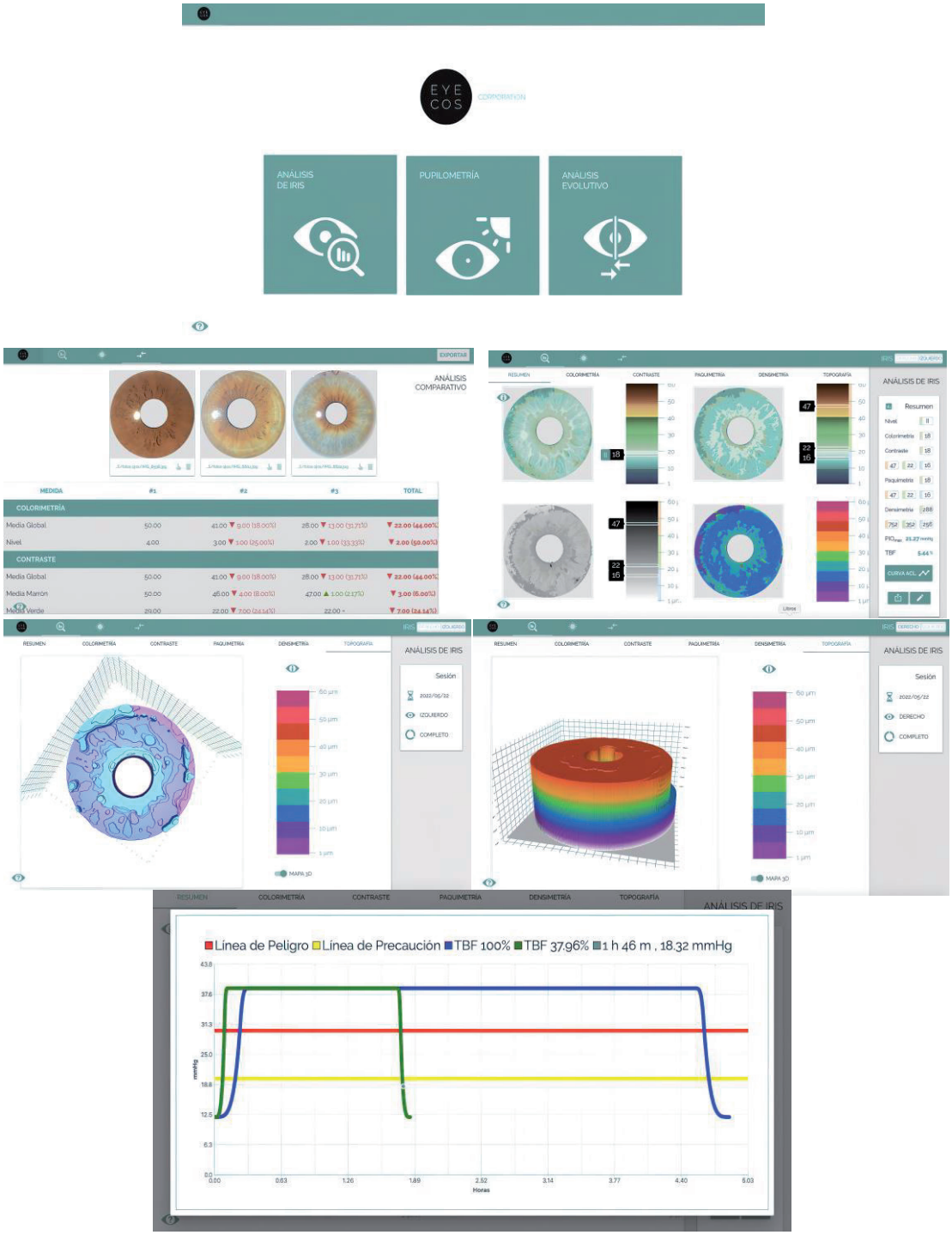
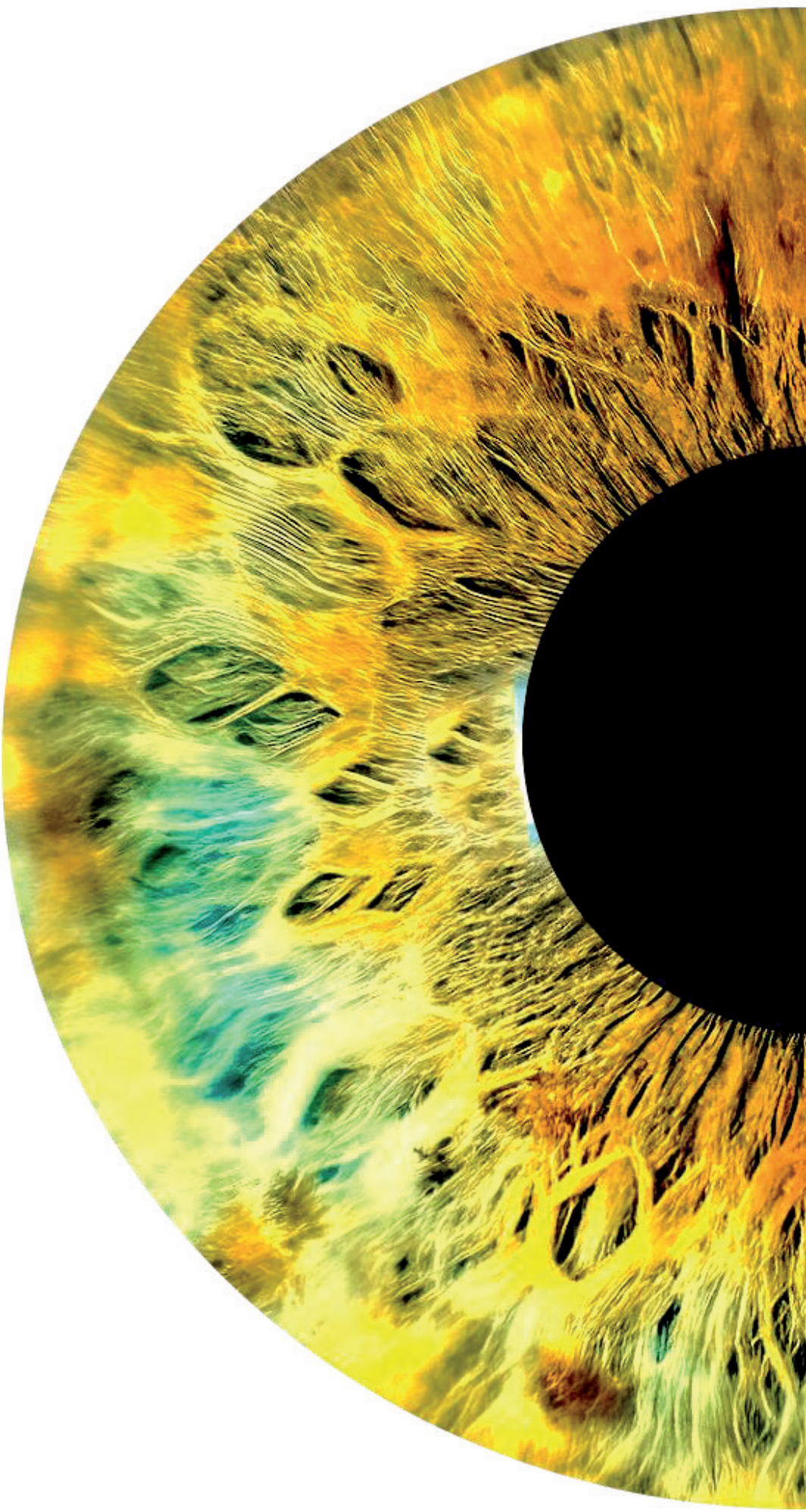
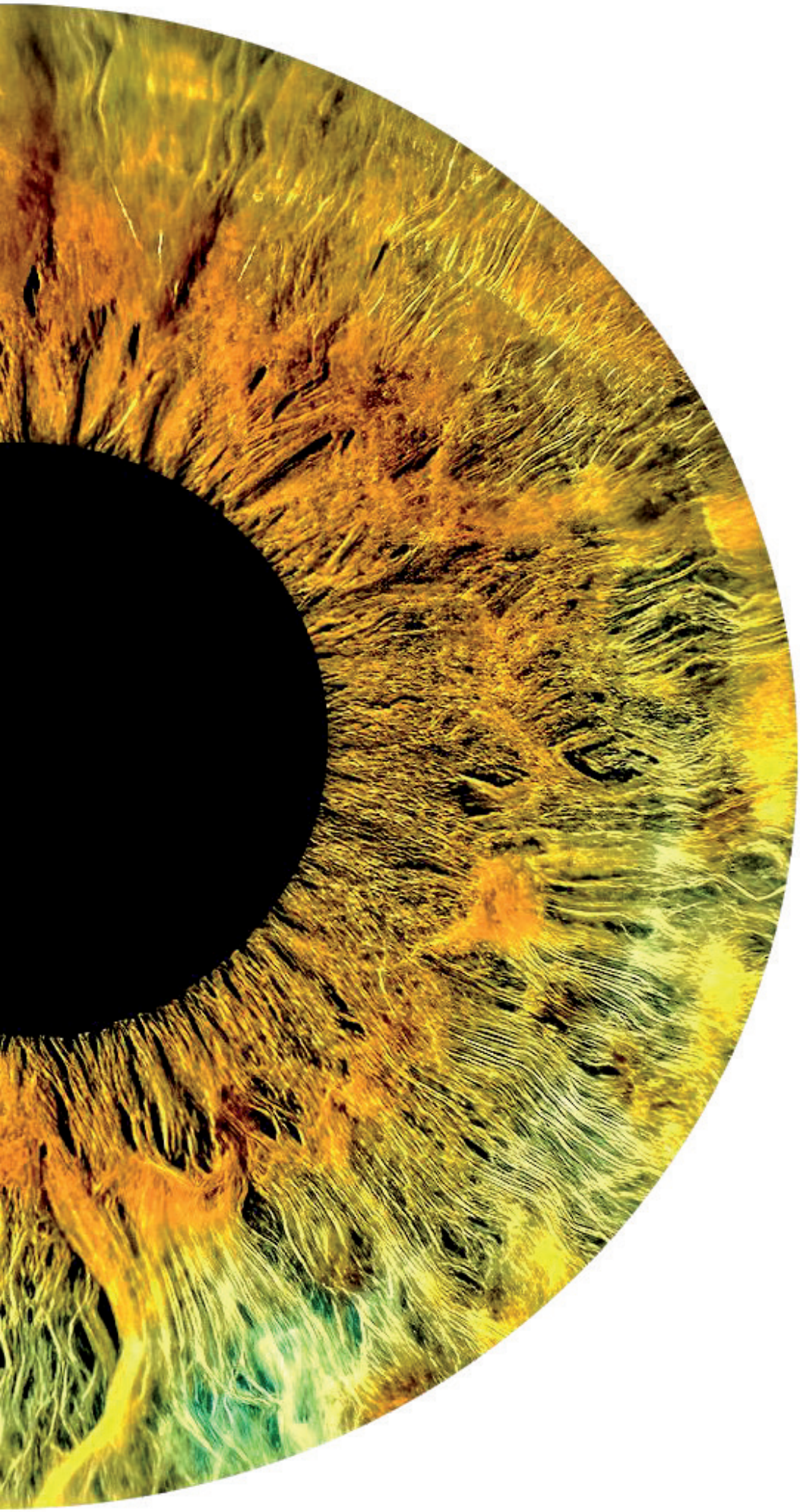


FIGURE 55: Analyzer software and Iris Summary



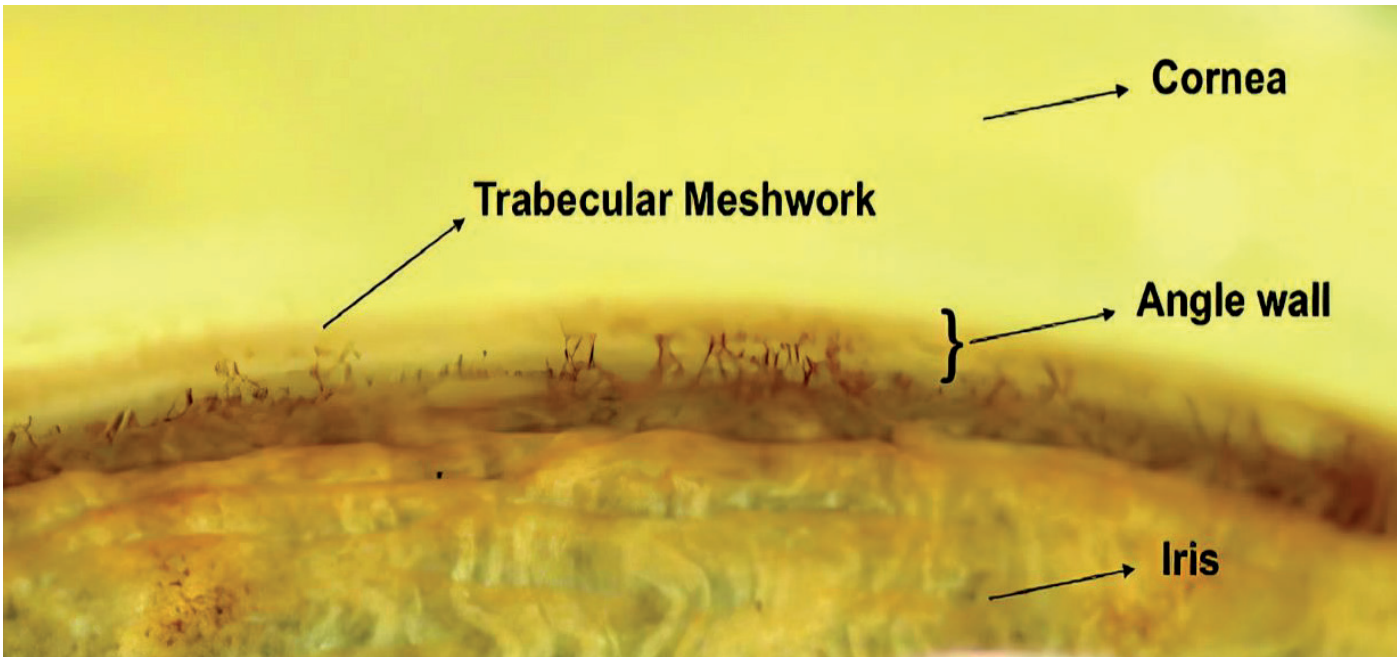


PART 2

LASER IRIDOPLASTY

CHAPTER 4 COMPLEMENTARY TESTS

2 4.1 Classic gonioscopy



Slit-lamp gonioscopy is performed through a mirror. The part of the angle that is viewed is 180° away from the mirror that is being used. The examiner must remember that the image is a mirror image. The view, unlike that seen with indirect ophthalmoscopy, is not an inverted mirror image. In slit-lamp gonioscopy, the angle seen in the superior part of the temporal mirror is the superior part of the nasal angle. Variable illumination is an advantage of slit-lamp gonioscopy. One can use diffuse illumination, focal illumination with a broad beam, and focal illumination with a narrow beam. It is helpful to vary the type of illumination and the orientation of the light. Subtle findings can best be appreciated in this manner.

By using a thin slit of light, inclined from the angle of the oculars, two separate corneal reflections are perceived—one on the inner aspect of the cornea and one on the outer. In addition to the inner and outer cornea, the narrow beam illuminates the interface between the cornea and the face of the opaque sclera. These reflections form a wedge-shaped line termed the "corneal wedge". The lines of the corneal wedge intersect at Schwalbe's line. By pointing to Schwalbe's line, the corneal wedge

locates the anterior border of the trabecular meshwork. This wedge can have a variable appearance, depending on the anatomy of the cornea and sclera. In lightly pigmented angles or in angles with a confusing anatomy, the corneal wedge will locate the trabecular meshwork when no other clear landmarks are present.

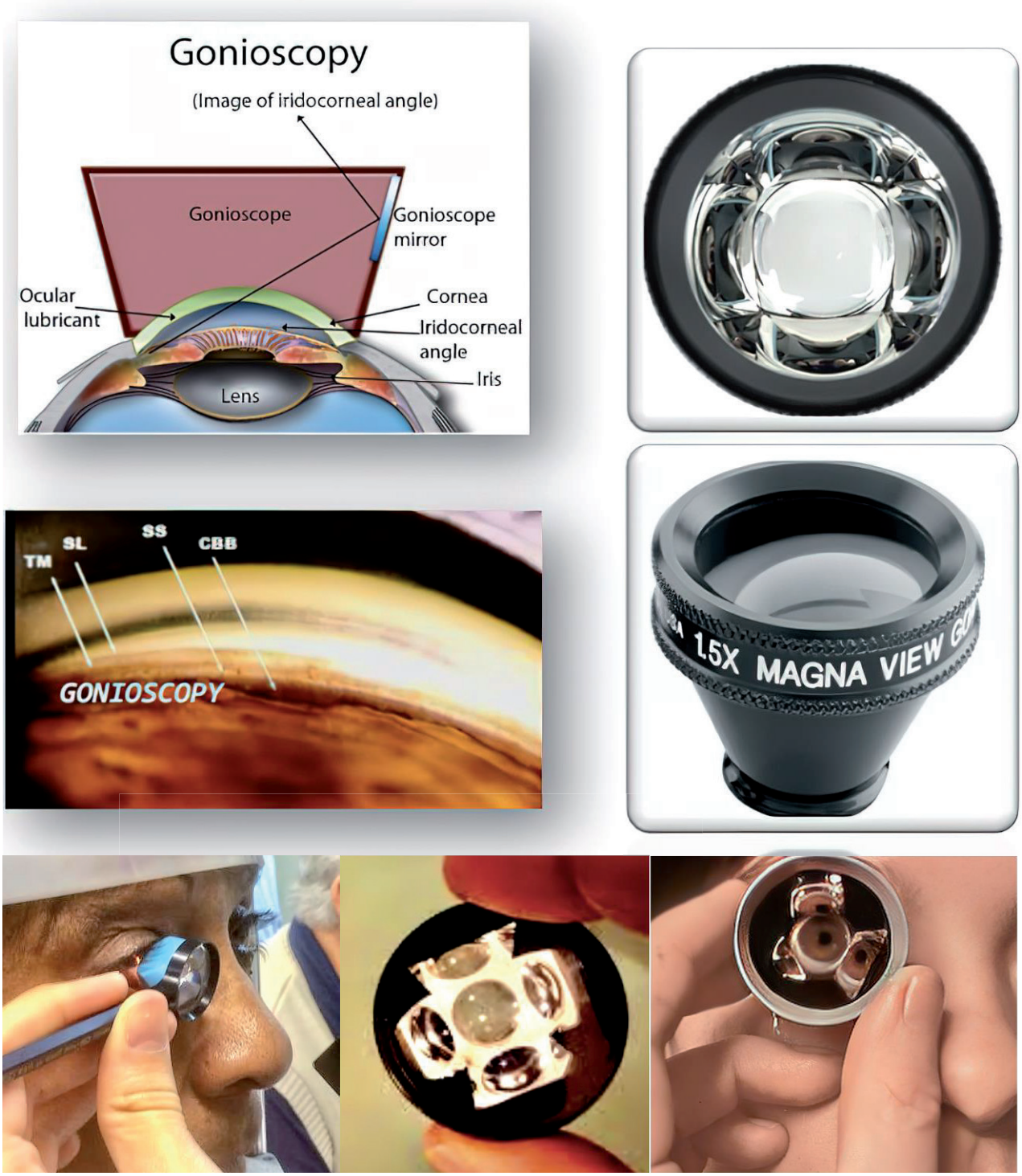
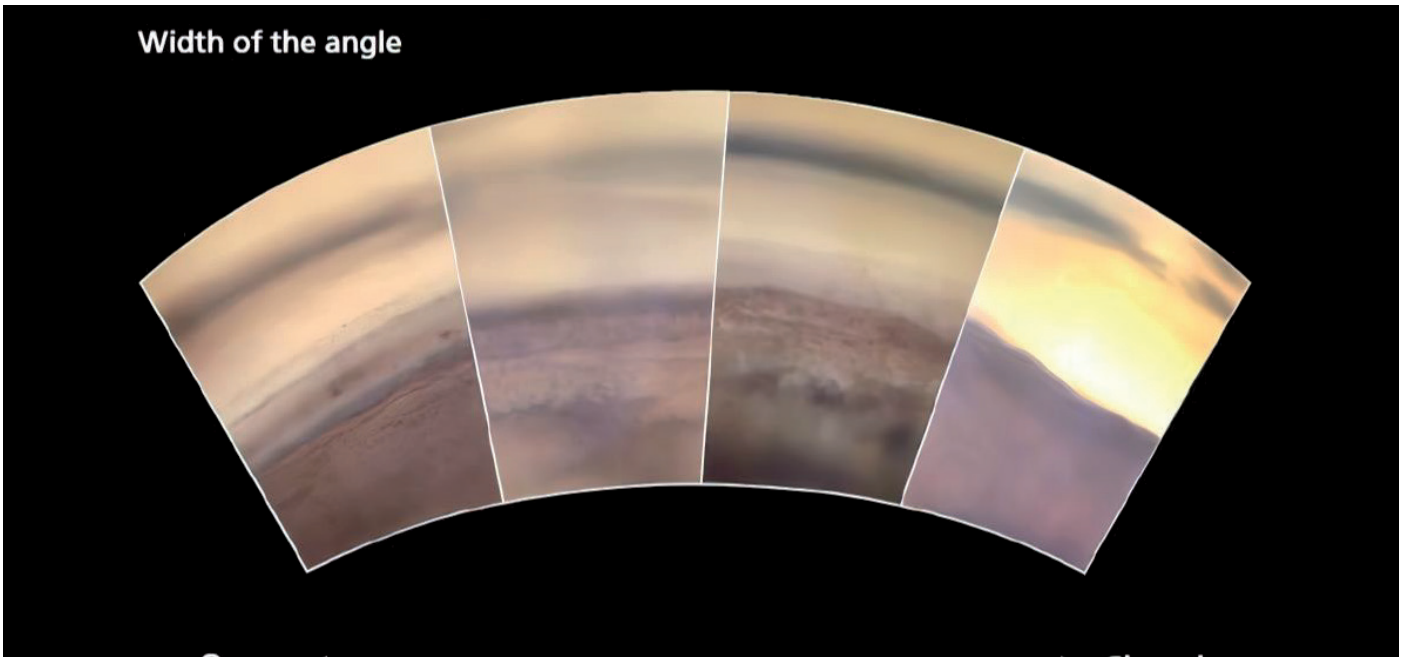


FIGURE 56: Gonioscopy by four mirror lens, with and without contact

2 4.2 Automatic GS1



The NIDEK GS-1 is the first automated gonioscopy device that can instantly document the iridocorneal angle in real-color.

Simple to use and more definitive than subjective pathology sketches, GS-1's high-resolution goniophotography not only enhances the quality of the evaluation but allows for more comprehensive follow-up. The GS-1 automatically acquires color photographs of the iridocorneal angle using an exclusive 16-mirror goniolens. The internal optical system automatically rotates and acquires color photographs of the iridocorneal angle in 16 directions, documenting the entire angle. Each direction can be captured in 17 different foci, which brings true versatility to iridocorneal angle photography. The resulting 360-degree images can be displayed as a single shot with circular or linear stitching, allowing localization of features and pathologies. The resulting highresolution color images can then be exported in JPEG, PNG and PDF files. Built with patient comfort in mind, the gel-assisted soft-contact interface ensures that the multimirror prism does not touch the cornea.

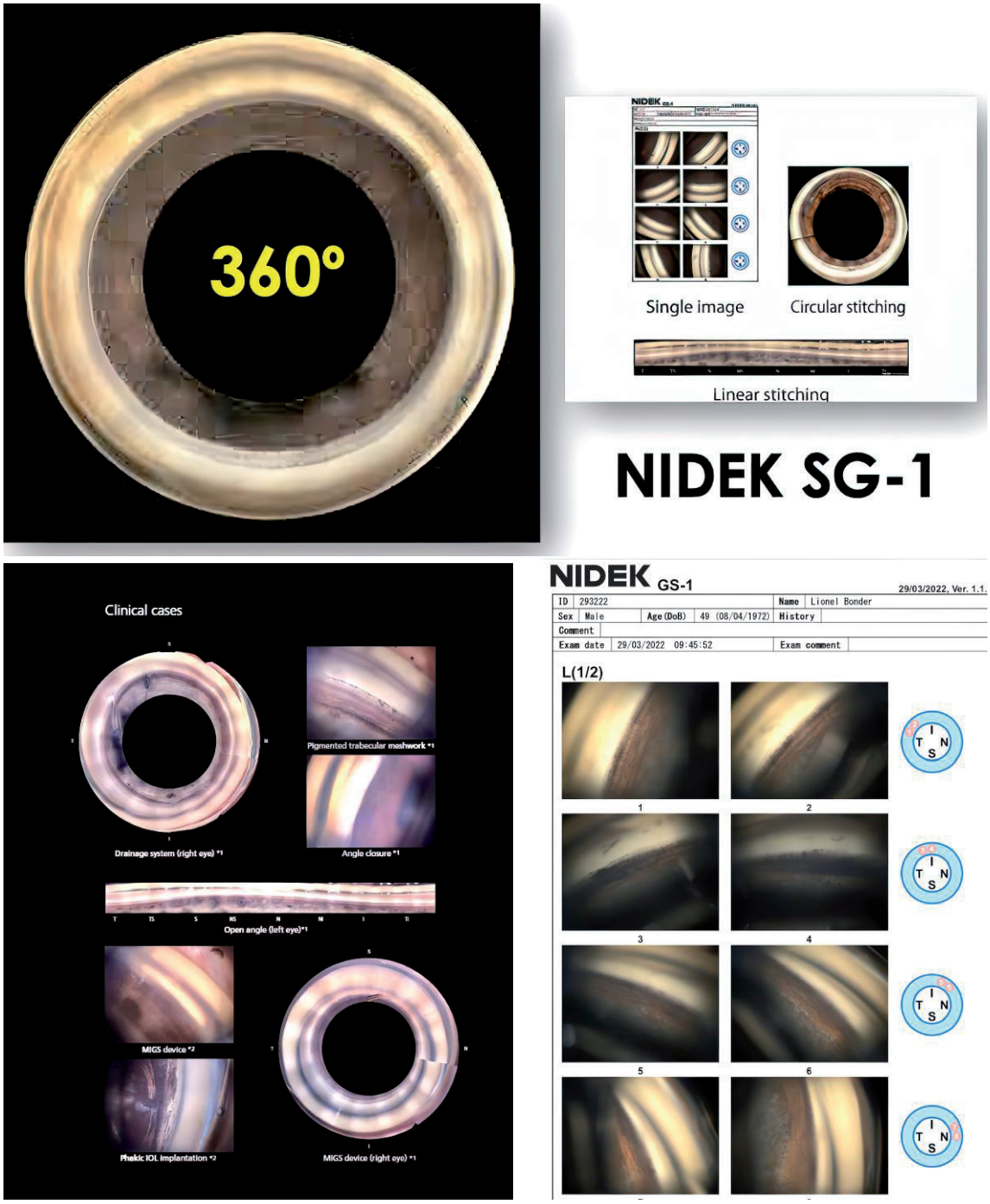
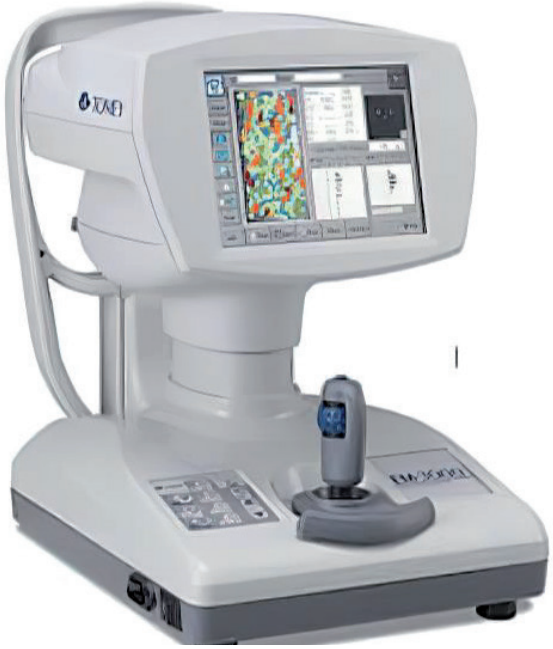
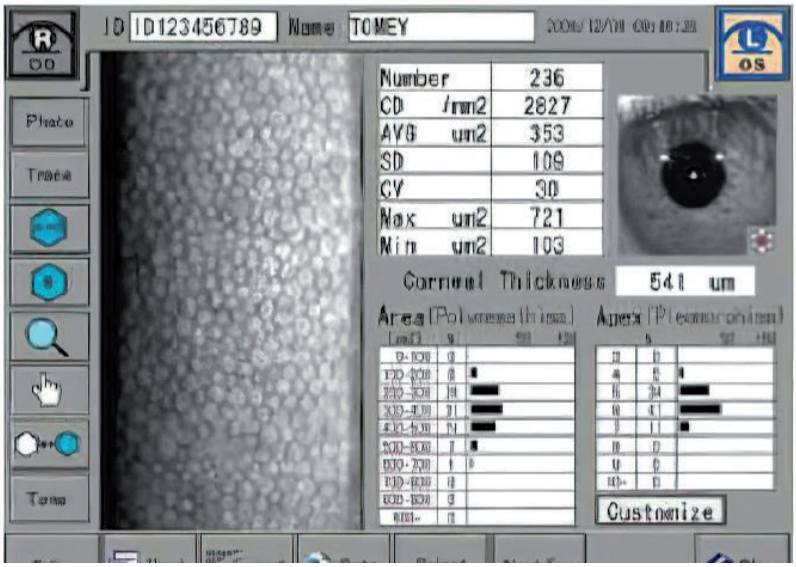


FIGURE 57: SG-1. Automatic full 360 degrees gonioscopy.

2 4.3 Endothelium





The specular light reflex with the slit lamp is a routine method of evaluating corneal endothelium in the clinics. The term 'Specular reflection' refers to a situation, where the angle of the reflected beam of light makes an equal angle with that of the incident light. The endothelial cells have a refractive index greater than 1.336 value for the aqueous humor, and hence can be imaged because the endothelial layer—aqueous interface reflects 0.022% of the projected light. The specular microscope is an optical reflection microscope where a slit of light is focused on the corneal endothelial surface and specularly (mirror-like) reflected light rays are focused onto film plane for viewing on a real-time monitor.

By virtue of its design, the specular microscope does not allow non specular light rays to be observed. The light that is reflected from the endothelial surface is collected by the same objective lens and focused onto a film plane or a video monitor screen for examination.

The human corneal endothelium does not regenerate. Hence, any focal endothelial injury/loss of endothelial cell is repaired by maintaining its continuity by migration and expansion of surviving cells. The endothelial health is interpreted with parameters such as percentage of hexagonal

endothelial cells, coefficient of variation of cell area, and endothelial cell density. An increase in the variability of cell area is termed as polymegathism. A deviation from hexagonality is referred to as pleomorphism. The percentage of hexagonal cells (pleomorphism) and the coefficient of variation of cell area increases (polymegathism) with age and endothelial cell attrition due to various causes. The coefficient of variation of mean cell area is the most sensitive index of corneal endothelial dysfunction, whereas hexagonality is a good index of progress of endothelial wound healing

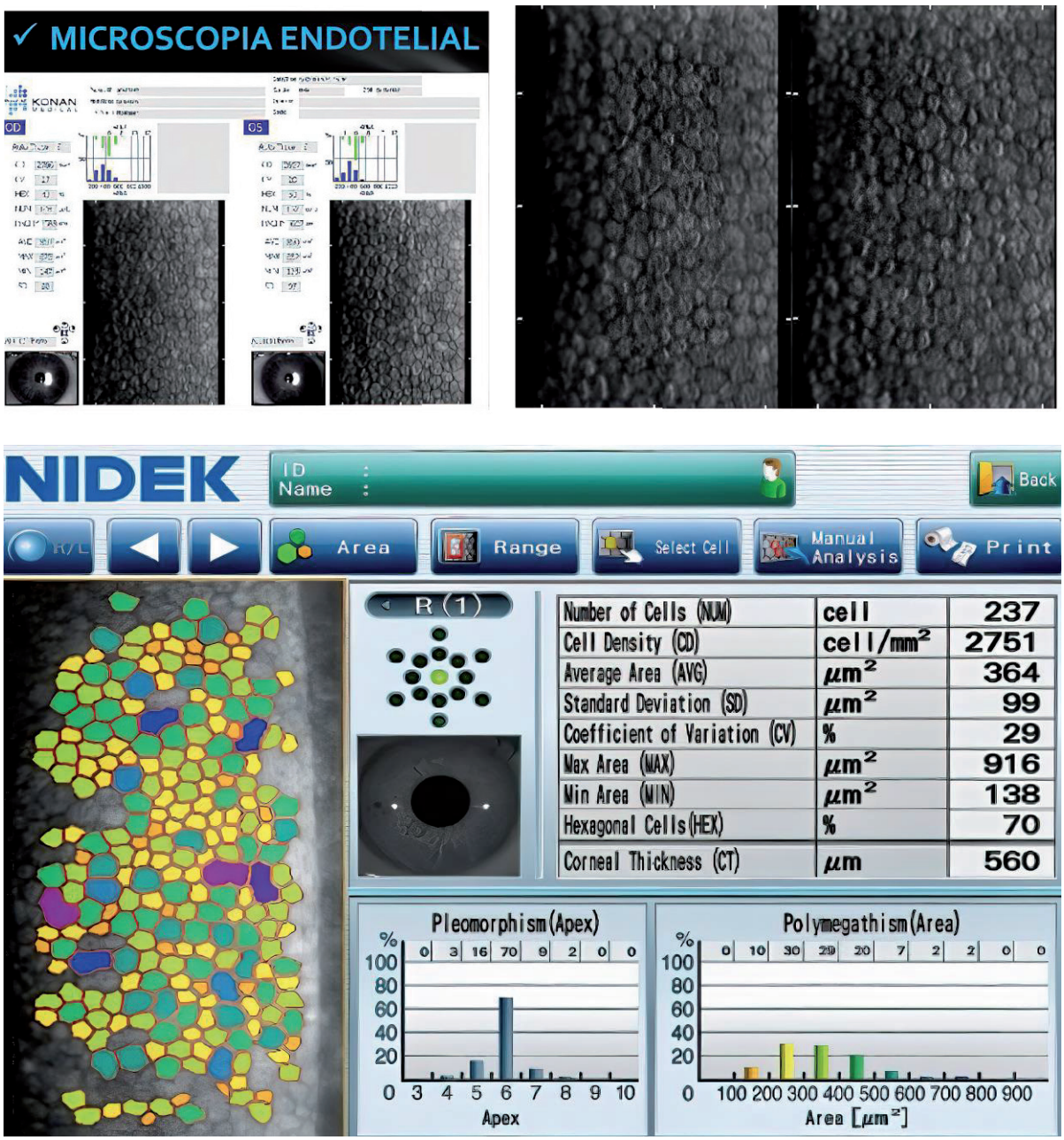
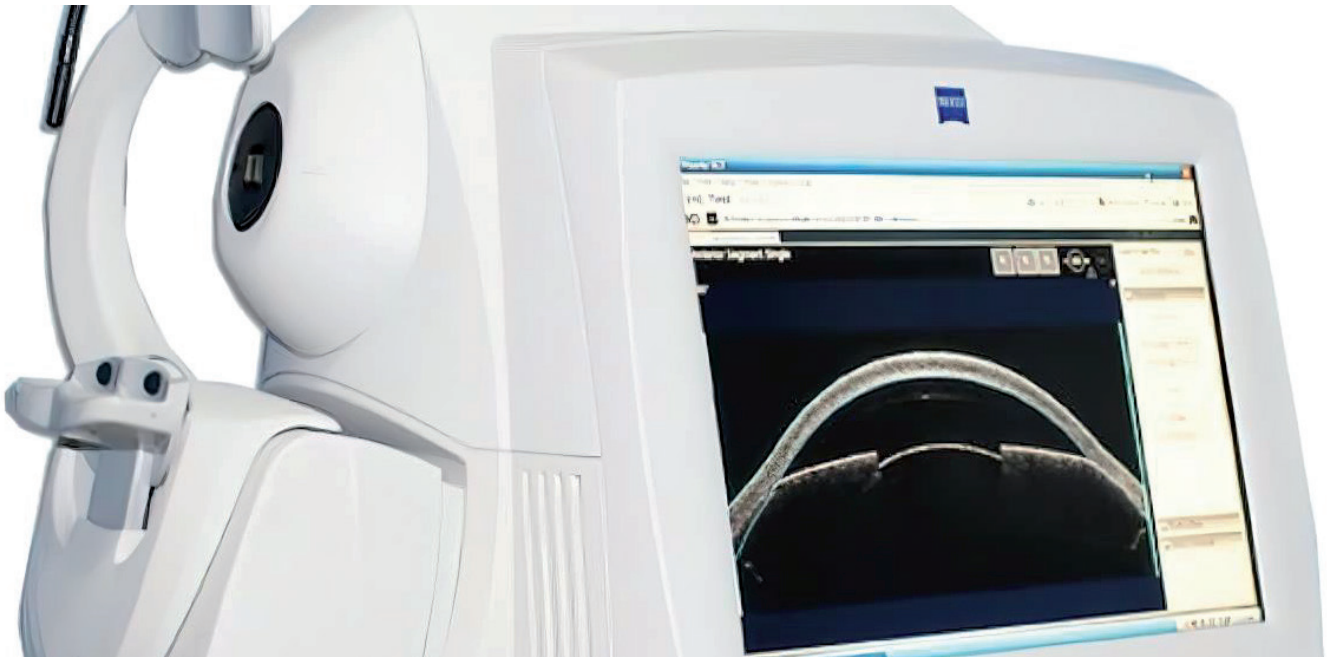


FIGURE 58: Specular microscopy: density, polimegatism and hexagonality

2 4.4 Tomography OCT



Optical coherence tomography (OCT) is a high resolution, cross-sectional imaging modality initially developed for retinal imaging. An important landmark to identify when interpreting ASOCT images is the scleral spur. This is visible as an inward projection of the sclera at the junction between the inner scleral and corneal curvatures. Apposition between the iris and the inner corneoscleral wall has been used in several studies as a qualitative method of detecting angle closure. Quantitative measurement of the AC angle is possible with in-built software in most of the anterior segment devices and also requires identification of the scleral spur.

The commonly used quantitative parameters are as follows:

1.Angle opening distance (in mm): Perpendicular distance between a point 500µm (AOD 500) or 750 µm (AOD750) anterior to the scleral spur and the opposing iris.

2.Angle recess area (in mm2): The triangular area (ARA 500 or 750) bounded by the AOD 500 or 750, the anterior iris surface and the inner corneoscleral wall.

3.Trabecular space area (in mm2): Trapezoidal area (TISA 500 or 750)

bounded by the AOD 500 or 750, the anterior iris surface, the inner corneoscleral wall and the perpendicular distance between the scleral spur and the opposing iris.

Several other quantitative parameters such as iris thickness, anterior chamber width and lens vault have also been described. Besides ASOCT, ultrasound biomicroscopy (UBM) may also be used for cross-sectional imaging of the anterior segment and the AC angle. When compared to ASOCT, UBM has the unique advantage of enabling visualization of structures posterior to the iris such as the ciliary body, zonules and the peripheral lens. However, UBM is relatively more uncomfortable, requires a highly skilled operator in order to obtain good quality images and has a limited scan width (5 x 5 mm with the traditional UBM devices).

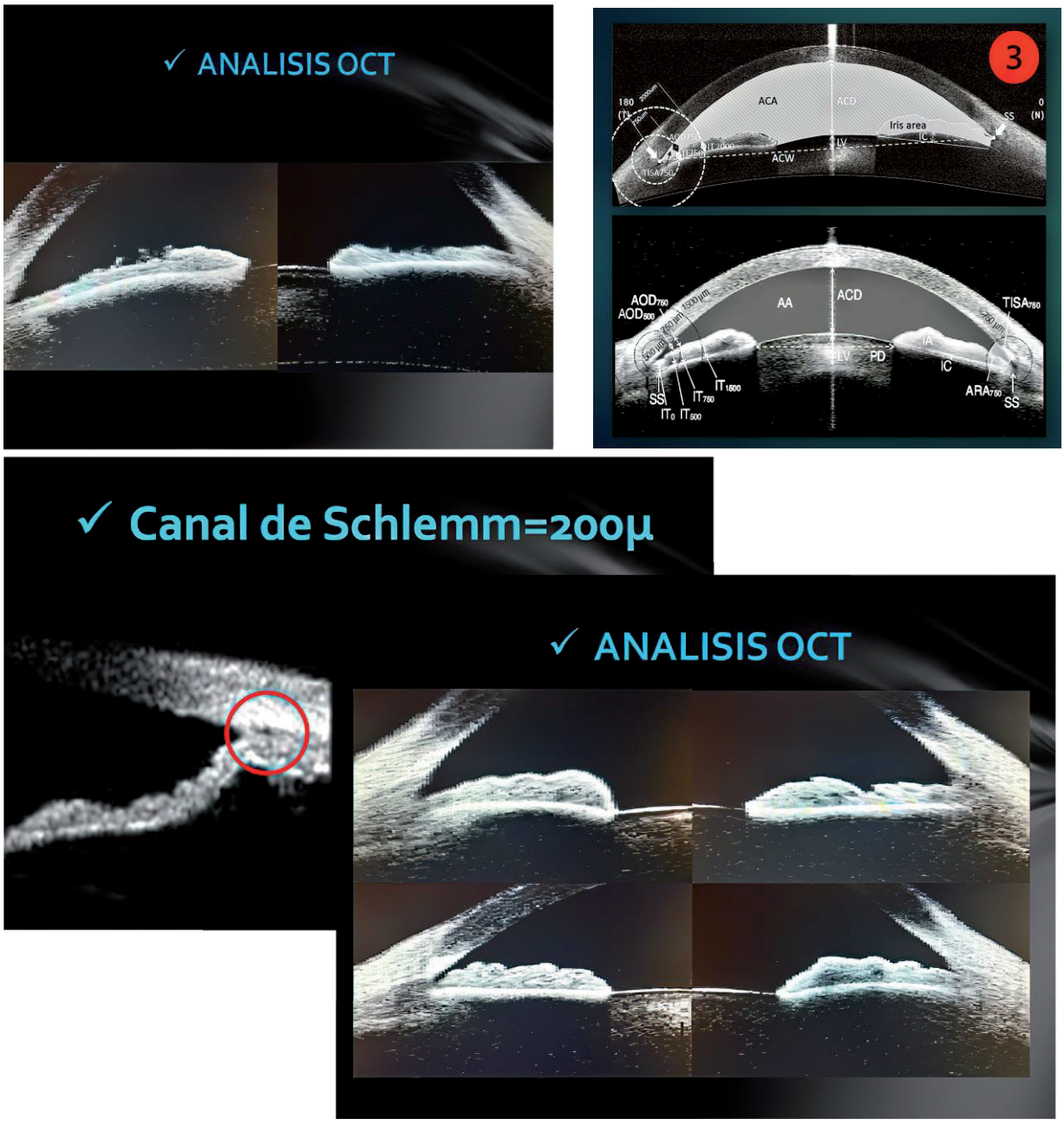


FIGURE 59: Anterior chamber OCT: volumen, angle, Schlemm channel

2 4.5 Tonography Honan

The Reichert Model 30™M Pneumotonometer is an easy to use, instrument that provides fast and accurate tonometry and optional tonography functions. The probe tip, which floats on an air bearing, is gently touched to the anesthetized cornea and a precisely regulated flow of filtered air applies force to the tip. A small (5 mm diameter) fenestrated membrane permits the air to flow through vents in the tip until it conforms to the shape of the cornea.

Increasing pressure is continually applied to the cornea until the force being applied is equal to the pressure in the anterior chamber. When these forces are in balance a pneumatic sensor records the intraocular pressure. In pulse tonometry mode, the ocular pulse waveform is charted and recorded along with IOP.

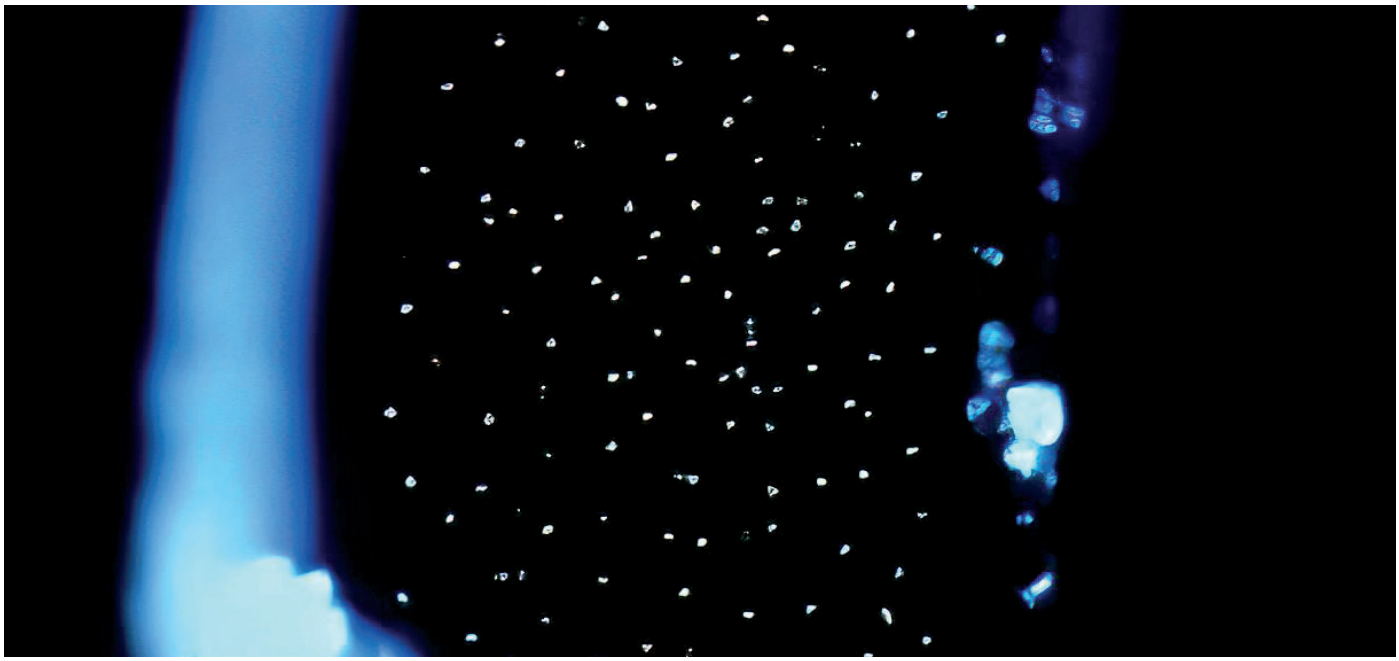
The full color display guides the operator through the measurement process and displays readings. The optional footswitch (available with the tonography kit) makes obtaining measurements even easier, freeing the operator to concentrate on handling the sensor probe. The Model 30 Pneumotonometer provides ocular pulse amplitude measurements in addition to tonometry measurements. The optional tonography mode enables

measurement of the aqueous outflow efficiency of the trabecular meshwork. Research indicates that measurements obtained with the Model 30 Pneumotonometer are less affected by corneal properties than other methods of tonometry.

The Model 30 Pneumotonometer provides ocular pulse amplitude measurements in addition to tonometry measurements. The optional tonography mode enables measurement of the aqueous outflow efficiency of the trabecular meshwork

FIGURE 60: Reichert 30M pneumotonography versus Honan tonography

2 4.6 AC Flaremeter



Existing flare photometers are based on the Tyndall effect, which requires sophisticated laser photometry. The FM-600-700 is based on the measurement principle of laser light scattering detection. The instrument uses a diode laser beam to scan a measuring window that is projected inside the anterior chamber of the eye. As an aqueous protein (component of inflammation) passes through the focal point of the laser light scattering occurs. The intensity of the scattered light (directly proportional to the amount of protein particles-flare) is detected by a photo-multiplier tube (PMT), which generates an electrical signal.

This signal is immediately digitized to eliminate outside noise interference and are processed by a computer which displays the results for user analysis. The unit of measurement employed by the FM- 600700 is "Photon Count" per millisecond.

The ocular flare analysis meter (OFAM) is a non laser photometer that uses quantitative Rayleigh scatter and absorption from visible light to compute a flare value. This study is designed to correlate OFAM measurements with qualitative measurements of flare in vitro and in vivo.

Our original proposal is the new digital flaremeter, that performs an automatic quantification of floating particles on the aqueous humor.

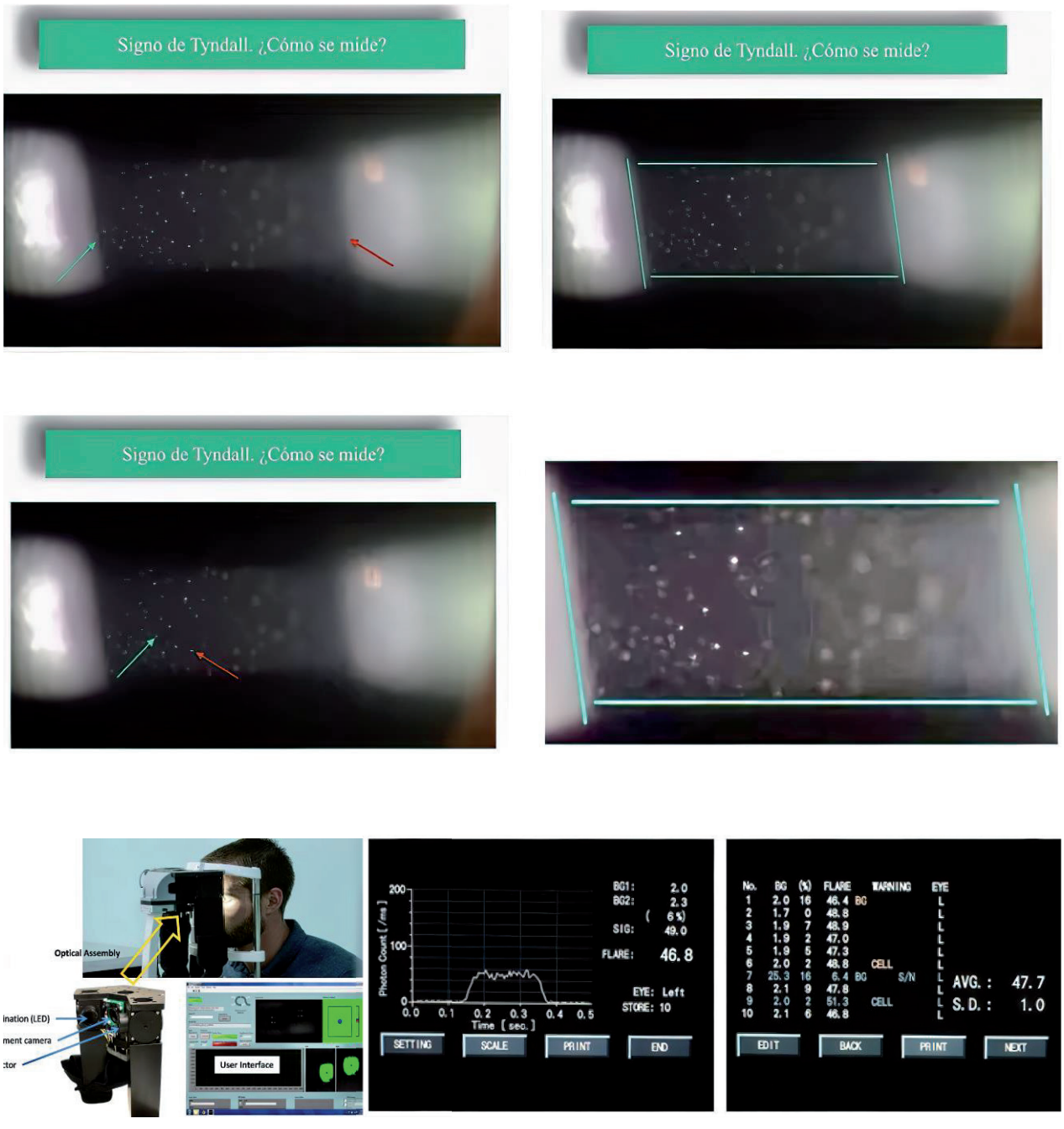
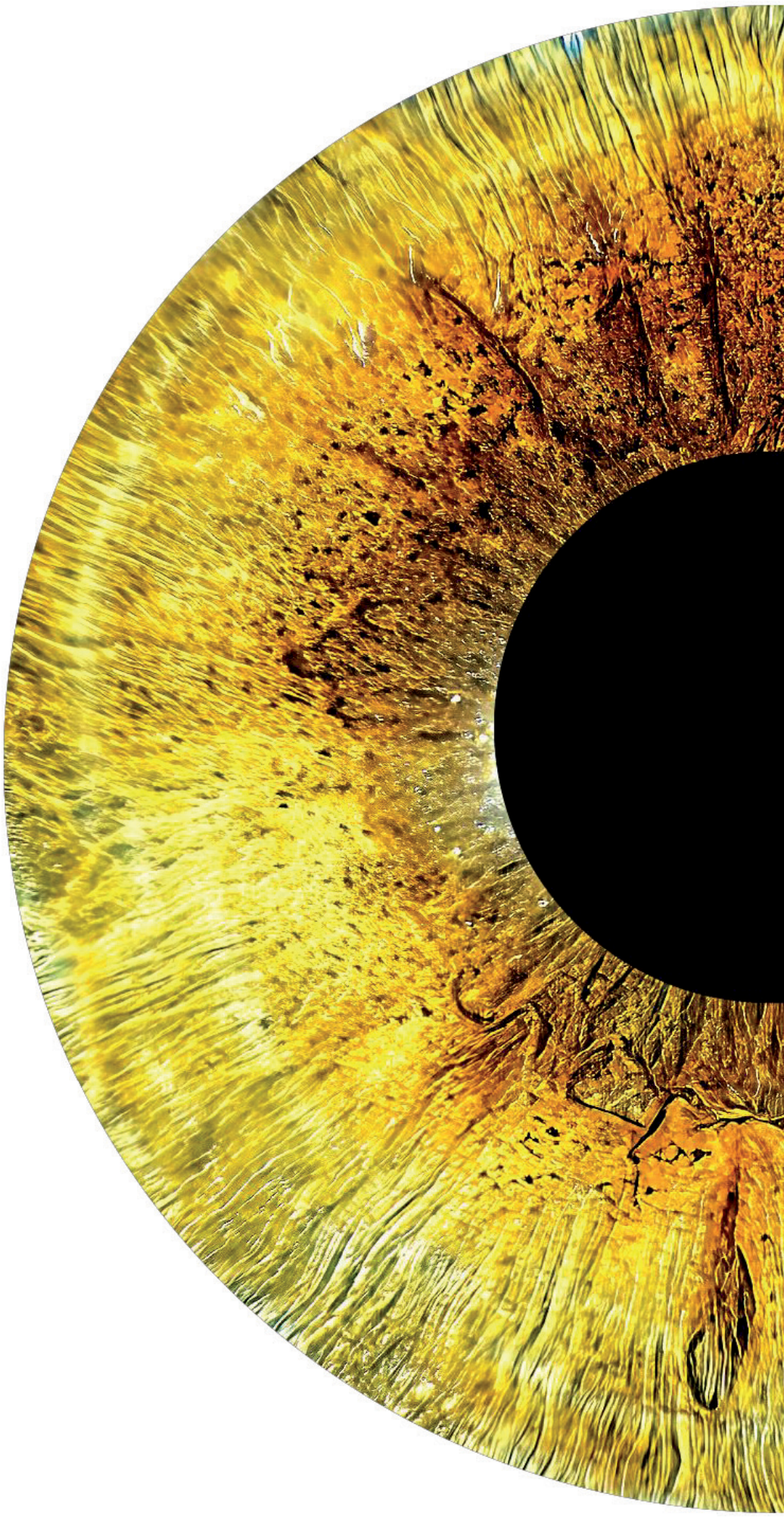
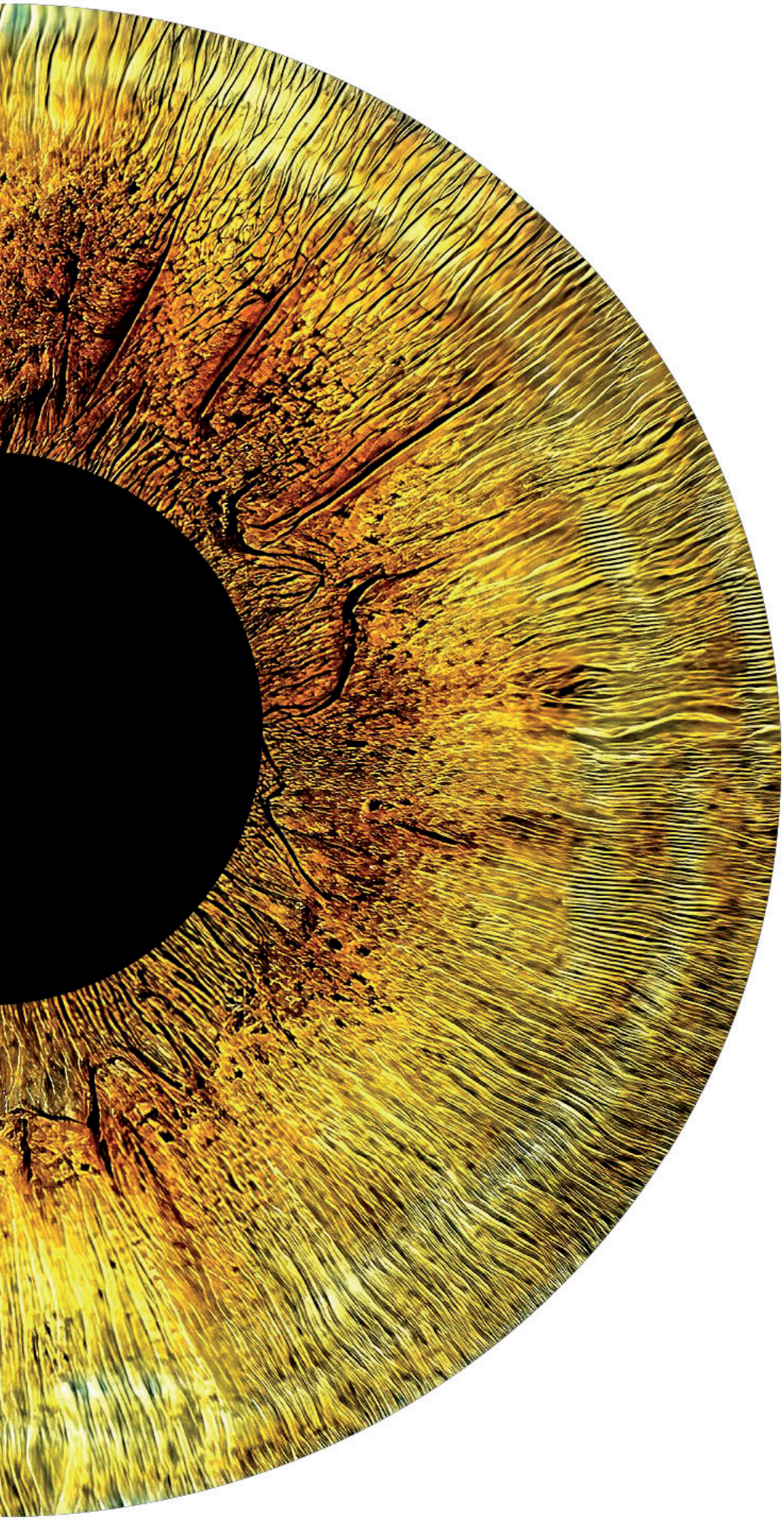


FIGURE 61: Flaremeter by laser, led light and digital analysis





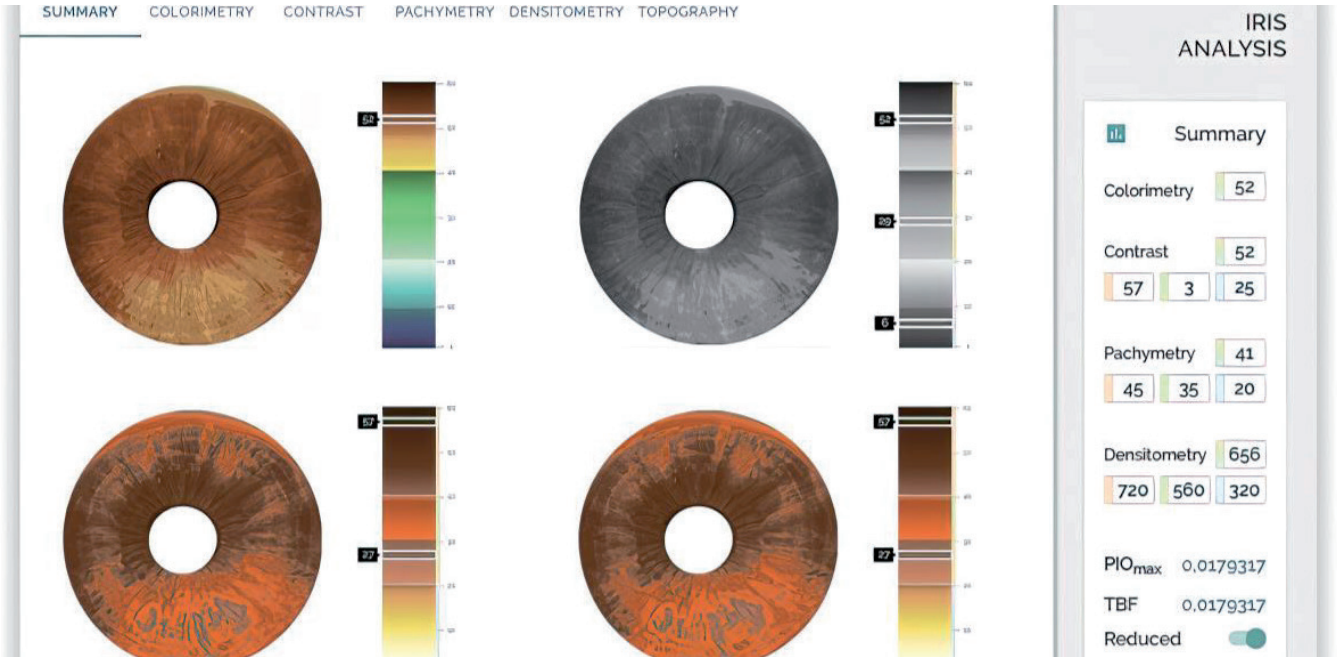

EYE COS
CORPORATION
IRÎZ Scan Analyzer

PART 2

LASER IRIDOPLASTY

CHAPTER 5 ANALYSIS SOFTWARES

2 5.1 Iris Summary



We used the IRÎZ (Eyecos) scanner and Analyzer program, which provided us with the data required to adequately plan the treatment: pigmentation grade, colorimetry, color contrast, iris pachymetry, and 3D topography. The scanner consists of three modules: photography (Topcon SL-D), optical coherence tomography (OCT Topcon SLSCAN1) and pneumotonography (Reichert M30). The Analyzer IRÎZ (Eyecos) software also calculates the physiodynamic parameters of the aqueous humor in the anterior chamber, which are indispensable for a safe technique: maximum intraocular pressure (IOP max), clearance curve (CC) and trabecular blockage factor (TBF). These data are shown in a simplified format in the Eyecos Iris Summary. Using Eyecos IRÎZ Scanner with the Analyzer program, we automatically obtain 4 graphs that describe the anterior pigmentary layer of the iris. In addition, Analyzer calculates the essential physio-dynamic parameters of aqueous humor in the anterior chamber, to guarantee the safety of the procedure.

The Eyecos Iris Summary is the key piece to perform accurate PCI procedures.

The example shows a typical case of grade 4 pigmentation with a value of 47 out of 60 (top left). The contrast calculates the average of the brown tones which is 48, 23 for green and 15 for blue (top right). In the lower left, we see the pachymetry data, and on the lower right the topography data. In the 4 diagrams a whitish spot appears corresponding to the reflection of the flash, which has been eliminated in the latest version of the Analyzer program. In the data sidebar we can see the densitometry values: 768 for brown, 368 for green, and 240 for blue (expressed in mg/ 100 ml on a scale of 0–960 mg/100 ml).

In the lowest part, we see the maximum ocular pressure value that would be reached with the complete removal of the iris surface (36.65 mmHg). Below the value of the Trabecular Blocking Factor (FBT = 33.92%). Finally, we can access to the Clearance Curve

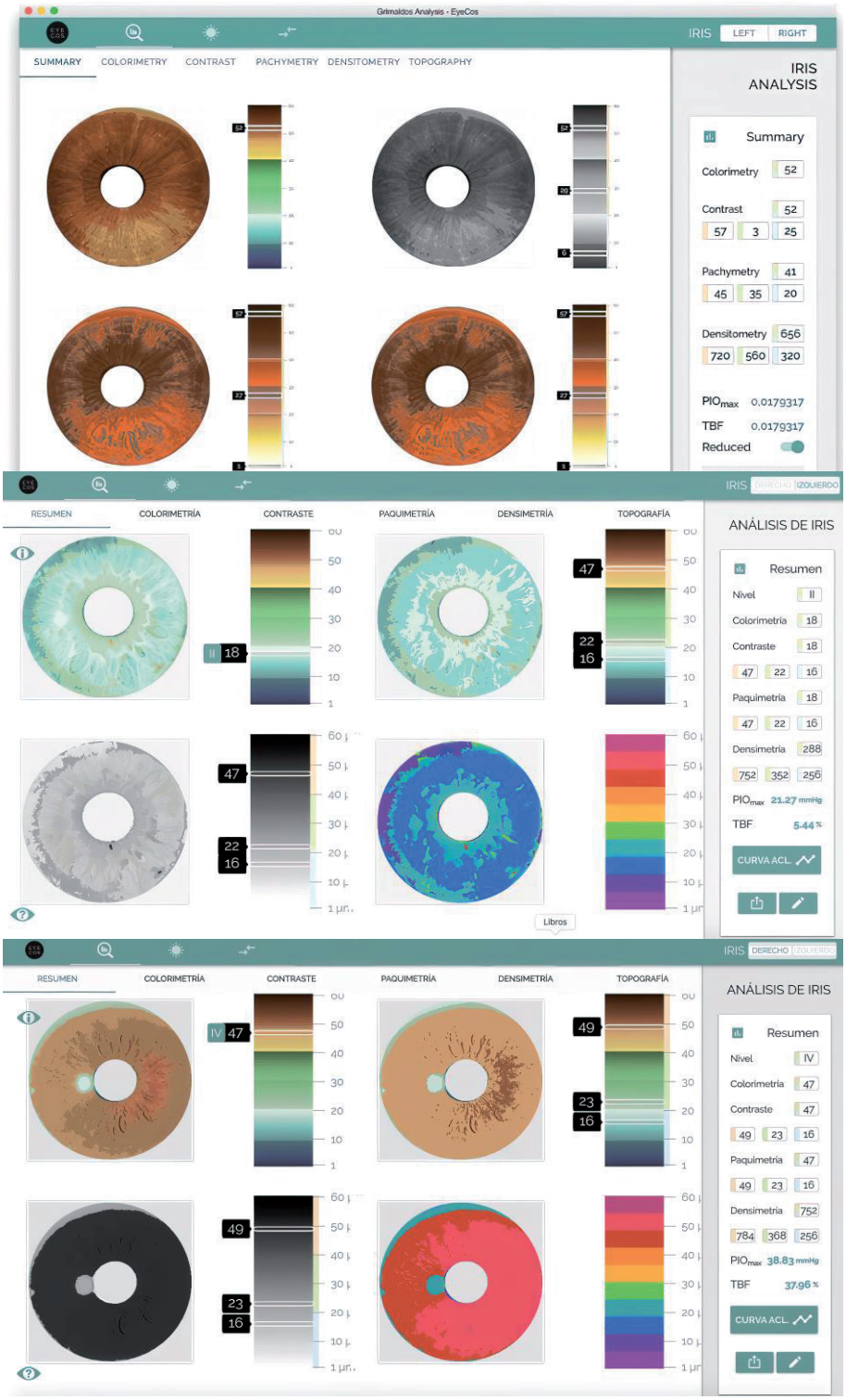
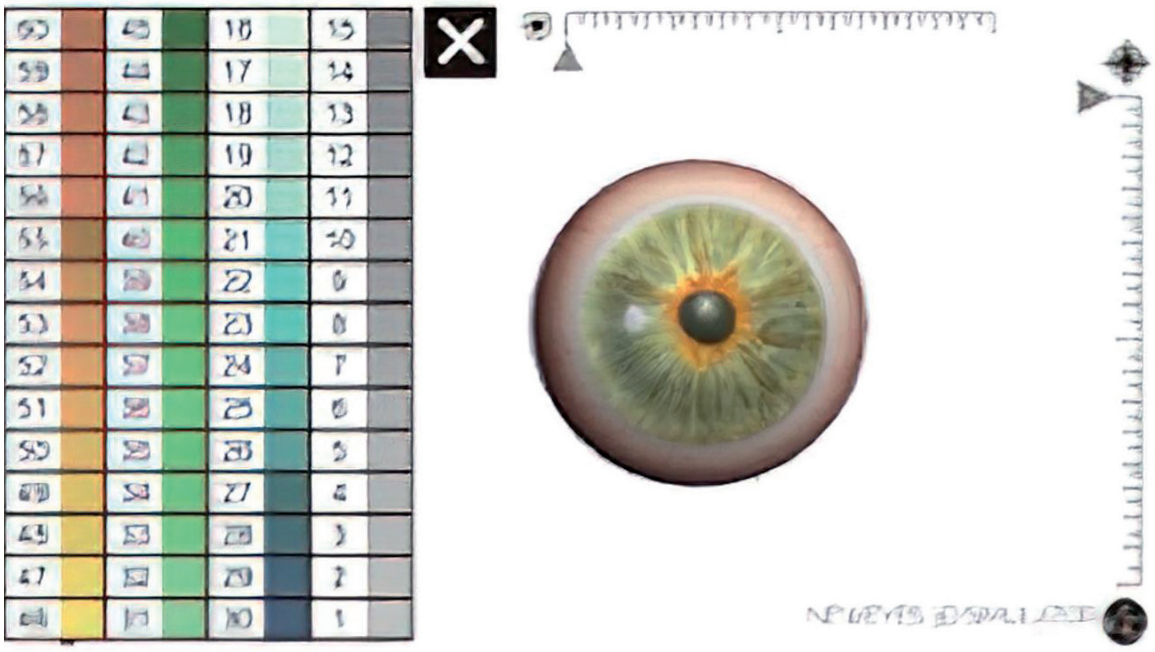


FIGURE 62: Iris Summary examples

2 5.2 Colorimetry/ Level



Colorimetry is the science of the measurement of color, replacing subjective responses of colors with an objective numerical system. It plays an important role in all areas where color generation, rendition and perception are involved. Perception of the color of an object is governed by three factors: the nature of the illumination, the optical properties of the object itself and the response of the human eye. Colorimetry quantitates these aspects and introduces the concepts of standard illumination and observers. The colorimetry of a light is intrinsically linked to the receptor for which it is intended. In the case of lighting and displays, it is of course the human eye. As a spectrometer, the eye does not perceive all the wavelengths with the same sensitivity. The retina is covered by light receptors of two types: cones and rods.

The cones are in charge of day vision. Their spectral sensitivity is located in the blue (426 nm), green (530 nm), and red (560 nm). The split of eye response in three spectral areas is the reason for the use of trichromatic systems, both for paintings and light sources.

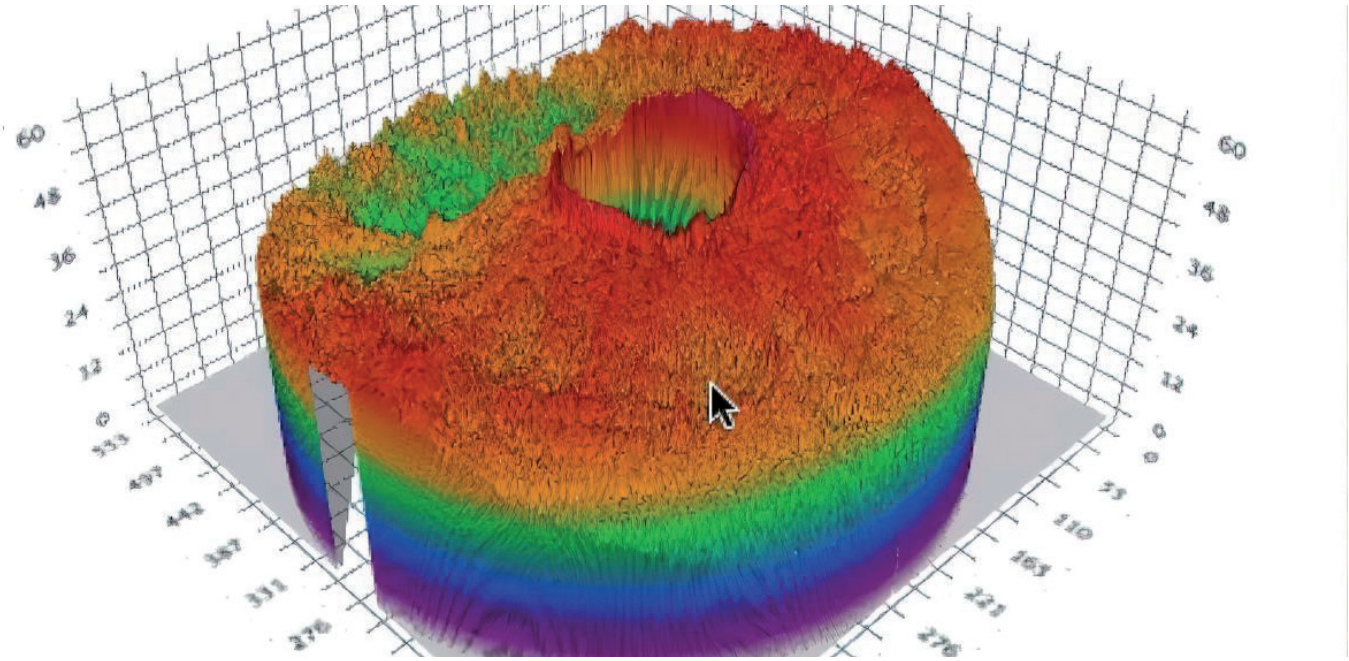
A pantone color chart shows a review of standard colors according to the Pantone color reproduction system.

It is a mostly normalized color reproduction system. Many industries, usually printing, although sometimes in the manufacture of fabrics, plastics, and colored paint, use the color space.

The Martin-Schultz scale, developed from the Martin scale, is one standard color scale commonly used in physical anthropology to establish more or less precisely the eye color of an individual. The scale consists of 20 colors (from light blue to dark brown-black) that correspond to the different eye colors observed in nature due to the amount of melanin in the iris. In order to have a simpler and practical table, we first introduced a four levels classification, and later a new one with five levels, from less to more pigmentation. However, to assess more accurately eye color, before and after laser treatment, was necessary to introduce an expanded scale from 0 to 60 degrees.

FIGURE 63: Iris Colorimetry: 60 degrees scale

2 5.3 Topography 3D



Usually, 3D Iris programs were designed to assist iridological researchers and practitioners to review the human eye using 3D landscape view. The most important aspect of viewing the eye in 3D landscape view is in determining the iris relief which can be very difficult analyze using standard photo image. A microplenoptic system was designed to capture the three-dimensional (3D) topography of the anterior iris surface by simple single-shot imaging. Within a depth-of-field of 2.4 mm, depth resolution of 10 μm can be achieved with accuracy (systematic errors) and precision (random errors) below 20%.

The ridges and folds, with height differences of 10~80 μm, on the healthy iris can be effectively captured. We introduced a novel 3D iris model and reader for iris identification. Using a set of at least two 2D images taken from different views, a small set of reliable and corresponding salient fiducial points (corner points taken from crypts, corona and serpentine rings of iris pattern) in the two images are extracted, from which a set of 3D iris salient points are constructed using triangulation. Corresponding salient points in the 2D images are found using the Random Sampling Consensus (RANSAC)

algorithm, which is robust in identifying the inlier points that correspond to each other in the different views of the iris., a denser (high resolution) set of extra a high-resolution 3D iris model is obtained.

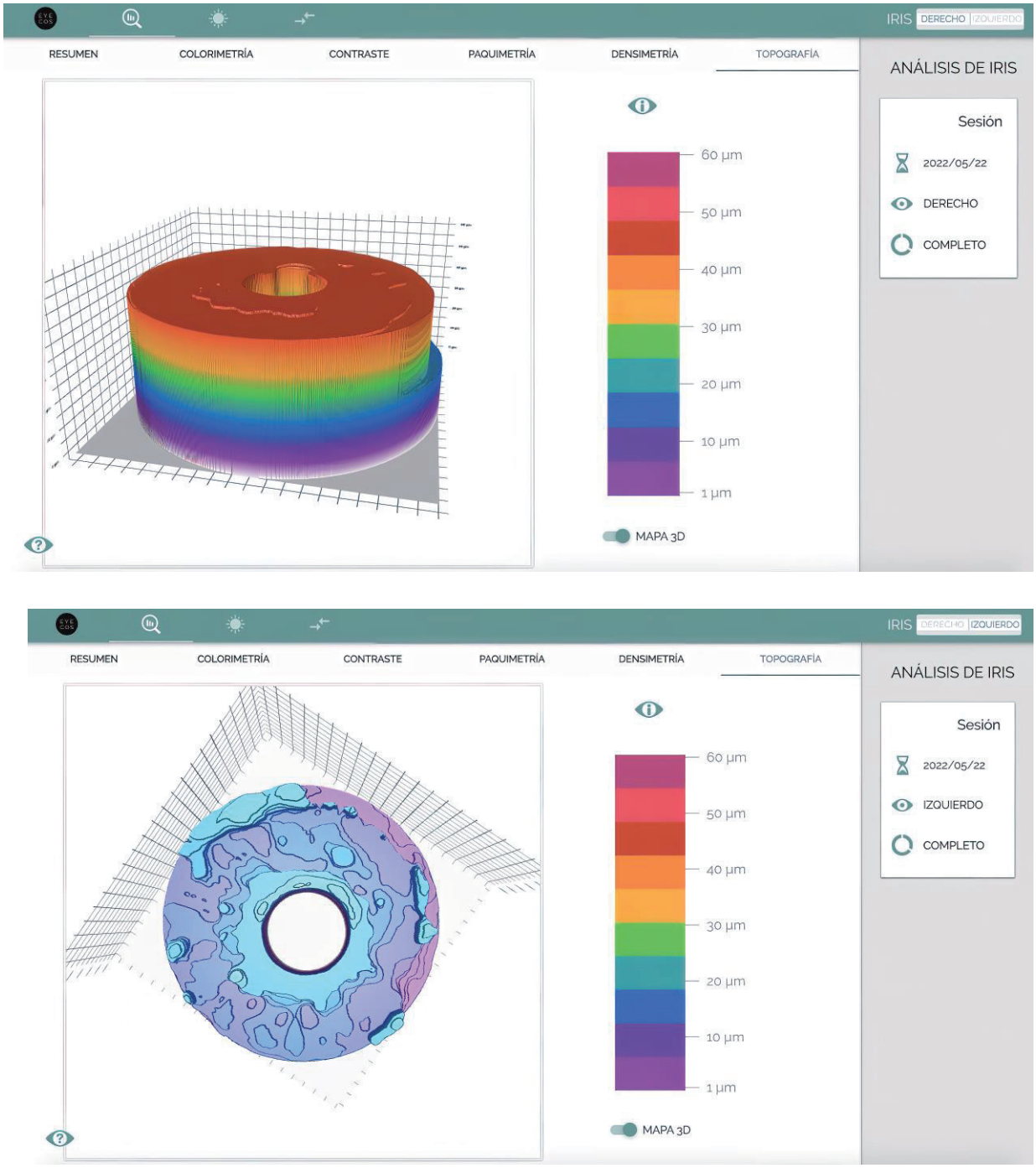
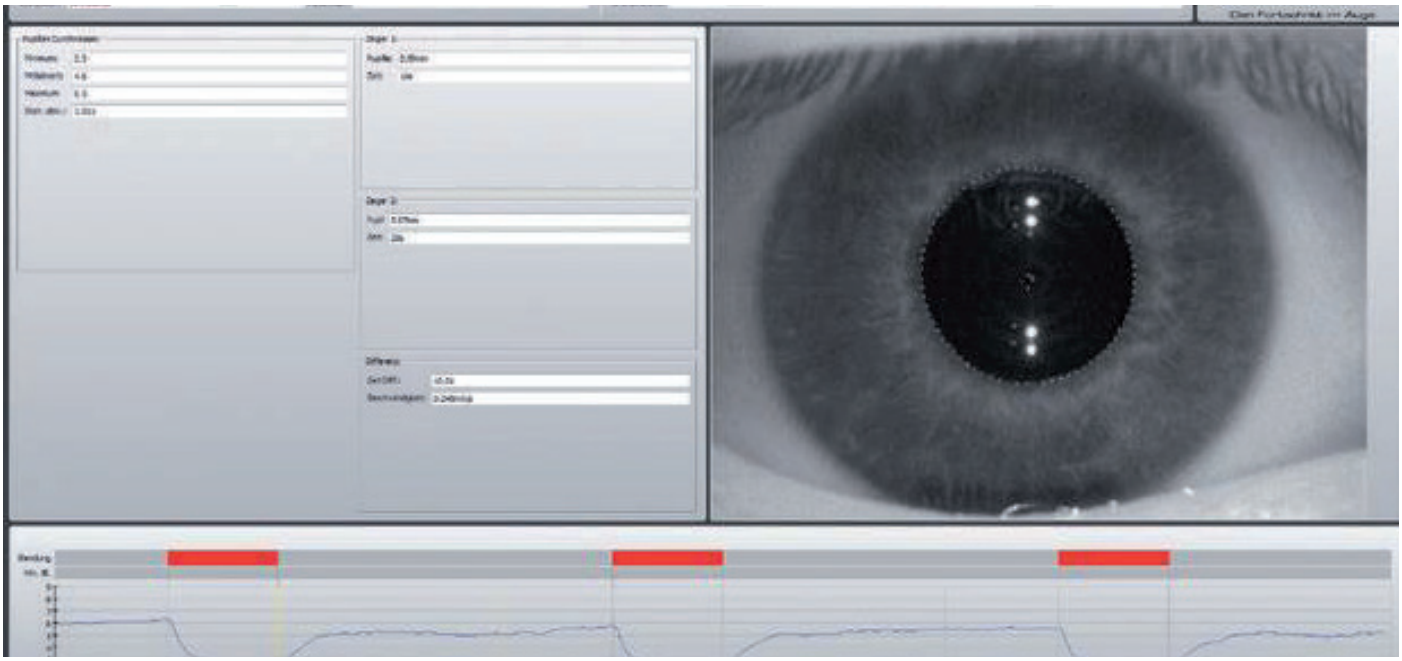


FIGURE 64: Tridimensional 3D iris topography

2 5.4 Pupilometry



VIDEO PUPILLOMETER VISIONIX VX120+

The VX120 Multi-Diagnostic Unit combines the functions of an autorefractor, a keratometer, a corneal topographer, an aberrometer, a pachymeter, VIDEO PUPILLOMETER and a non-contact tonometer combined with anterior chamber analysis into one of the most advanced and space saving instruments in your practice.

One-touch high-end refraction vision analysis, and diagnosis of the anterior chamber. Make the difference thanks to the VX120+, complete and fully automatic diagnostic screening device. Complete refraction, differentiate between day and night vision needs, glaucoma, cataract, keratoconus identification and monitoring ,fitting of contact lenses. Its multiple functions provide versatility and convenience in a smaller footprint while refusing to compromise on the resolution and accuracy of the measurements. These features combined help make the testing procedure easier for both the doctor and the patient.

Key features Visionix VX120: Autorefractor / Keratometer / Corneal Topographer / Aberrometer / Pachymeter with Anterior Chamber Analysis

Shack-Hartmann mapping method Topographer up to 100000 points High density aberrometry up to 1500 points Measures pupils as small as 2mm Automatic right / left eye movement Autotracking Automeasurement Autofocusing Based on Wavefront technology Retro-illumination – spot aberrations in the IOL and cornea scratches easily Global view of refraction aberrations EMR and VX55 digital refraction compatibility 10.4″ Color Touchscreen interface.

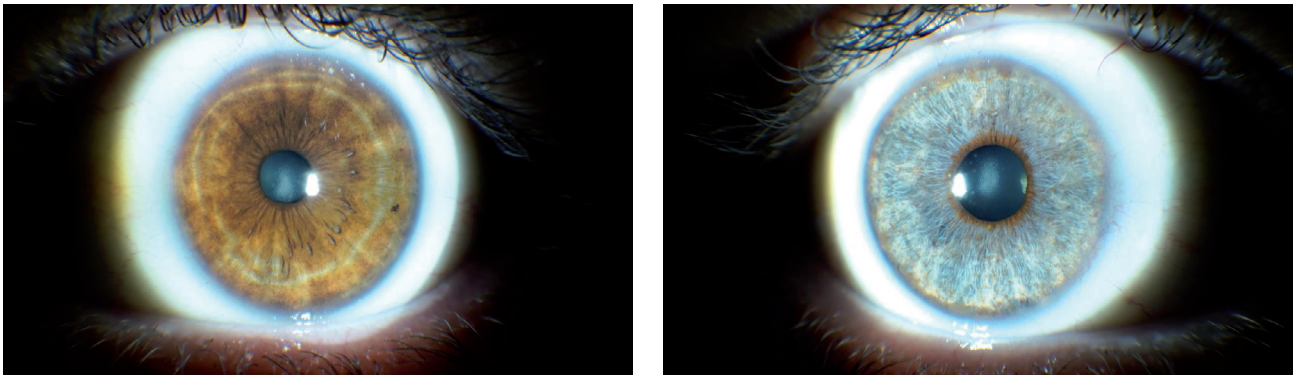
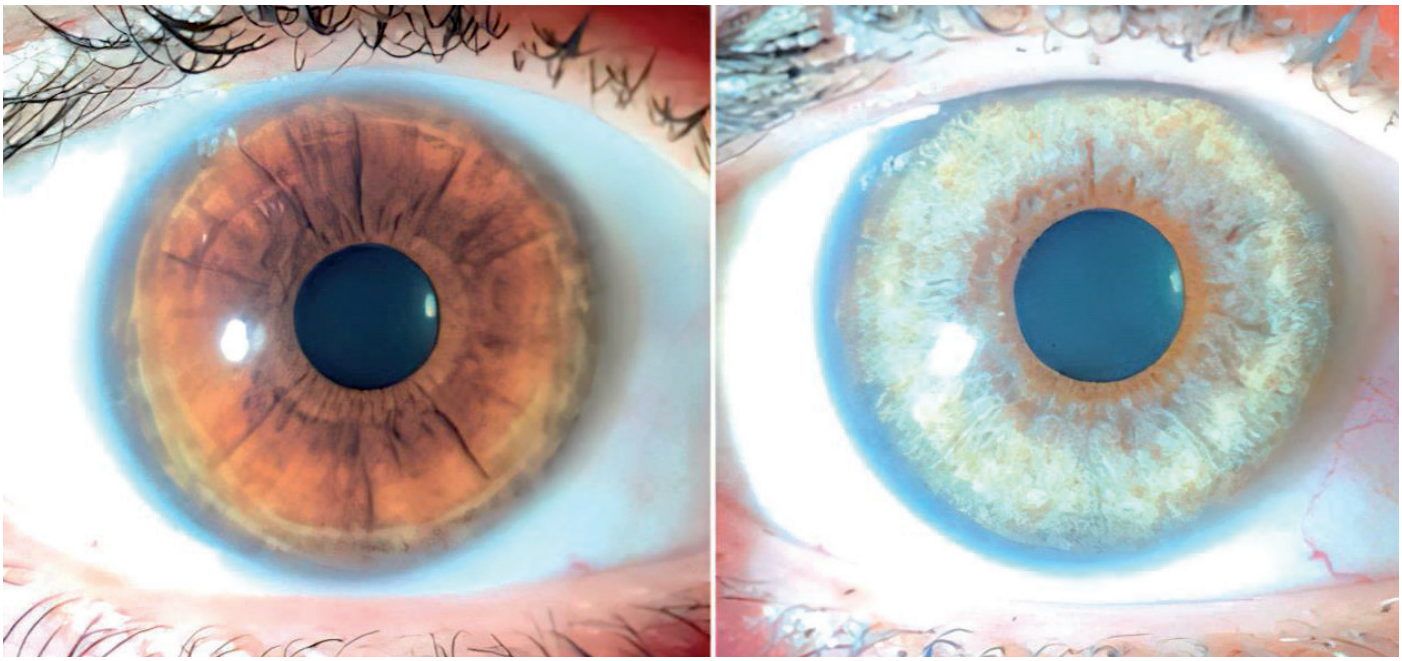


FIGURE 65: Dynamic video pupilometry

2 5.5 Comparative study



The patient is required to submit photographs of their eyes every 1–2 months using the Eye Selfie (Eyecos) application to monitor their progress. Additionally, the patients receive an ocular examination in each phase, and the IRÎZ Scanner is used in order to calculate new Iris Summaries and allow comparison with previous progress. One function lets us automatically calculate the differences obtained in grade, colorimetry, contrast, pachymetry, topography and physio-dynamic parameters of the aqueous humor. In this way, patients are certified of the efficacy, safety, and predictability of the PCI through a written or digital report.

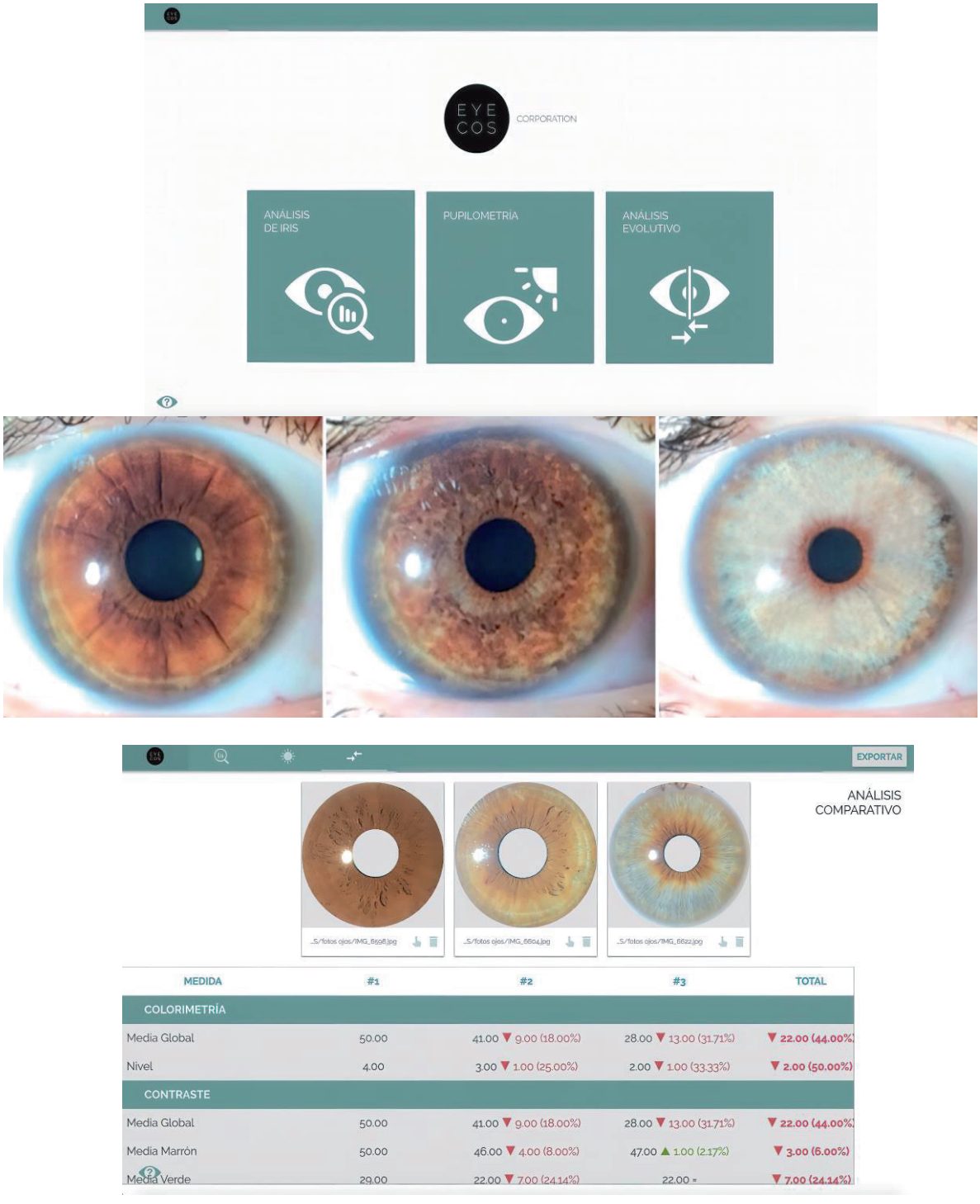
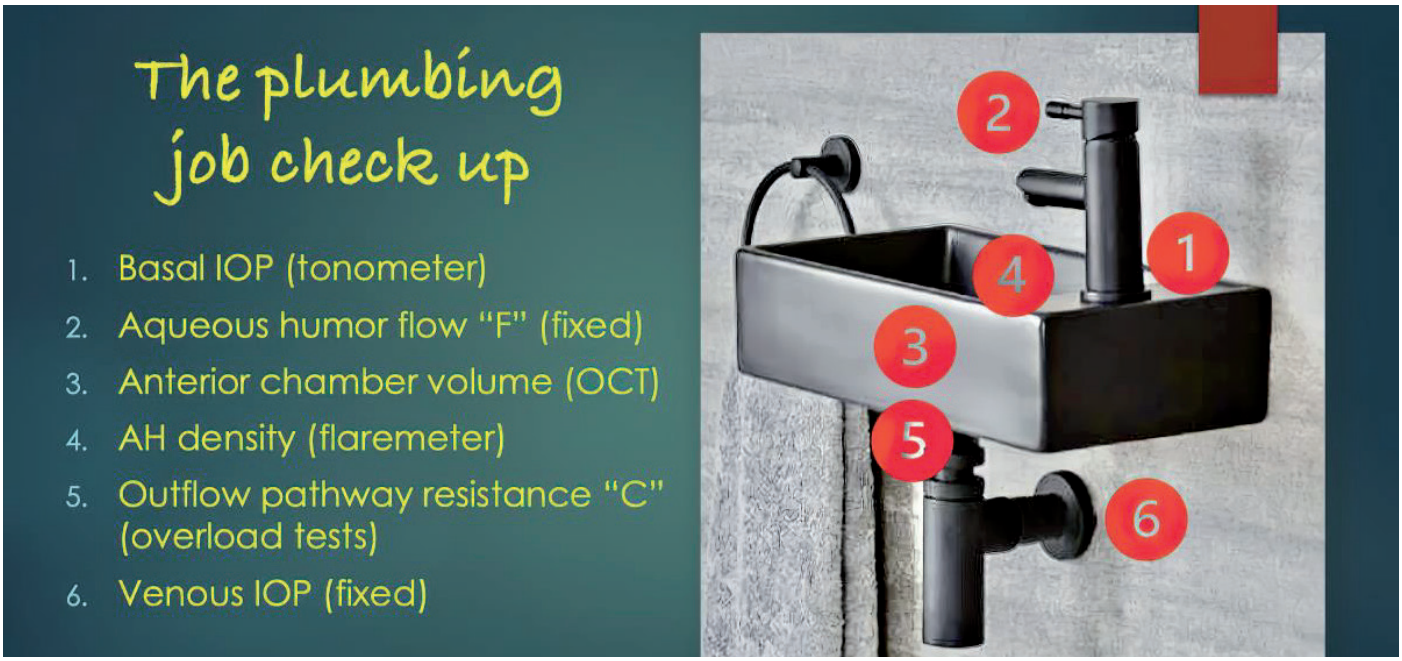


FIGURE 66: Comparative study by Analyzer software

2 5.6 Physiodynamics



The Analyzer IRÎZ (Eyecos) software also calculates the physiodynamic parameters of the aqueous humor in the anterior chamber, which are indispensable for a safe technique: maximum intraocular pressure (IOP max), clearance curve (CC) and trabecular blockage factor (TBF). These data are shown in a simplified format in the Eyecos Iris Summary.

Three are the main physio-dynamic parameters:

IOP max: Highest eye pressure limit, predicted after laser application.

TBF: Trabecular blockage factor. Probability (%) of full trabecular blockage.

CC: Clearance Curve. Recovery timeline (hours) up to reach normal IOP values.

Based on these remarkables references every laser treatment can be planned in the safest way.

New IOP formula
Grimaldos

$$IOP = IOPv + (F/C) + (\rho ha \cdot r)$$

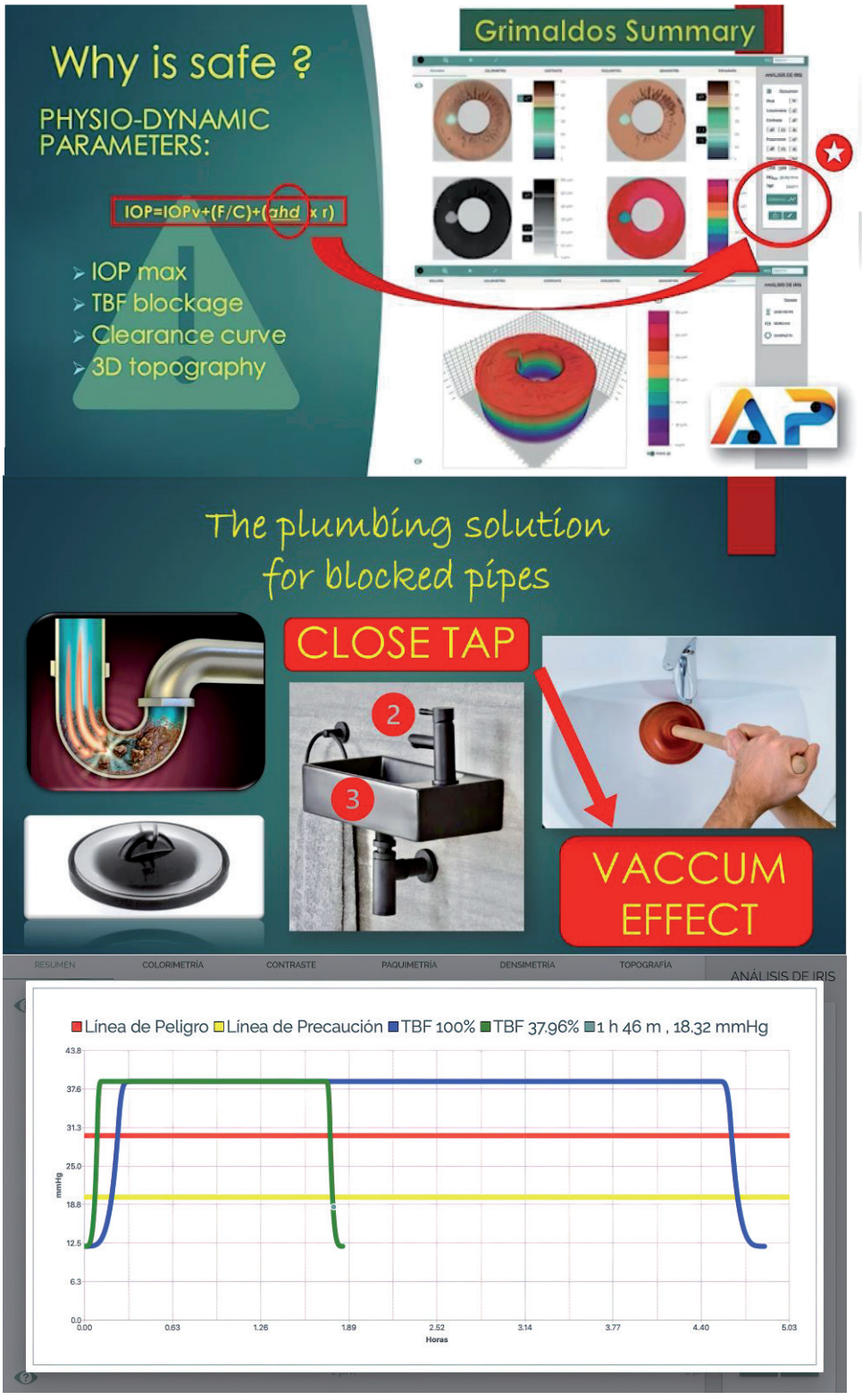
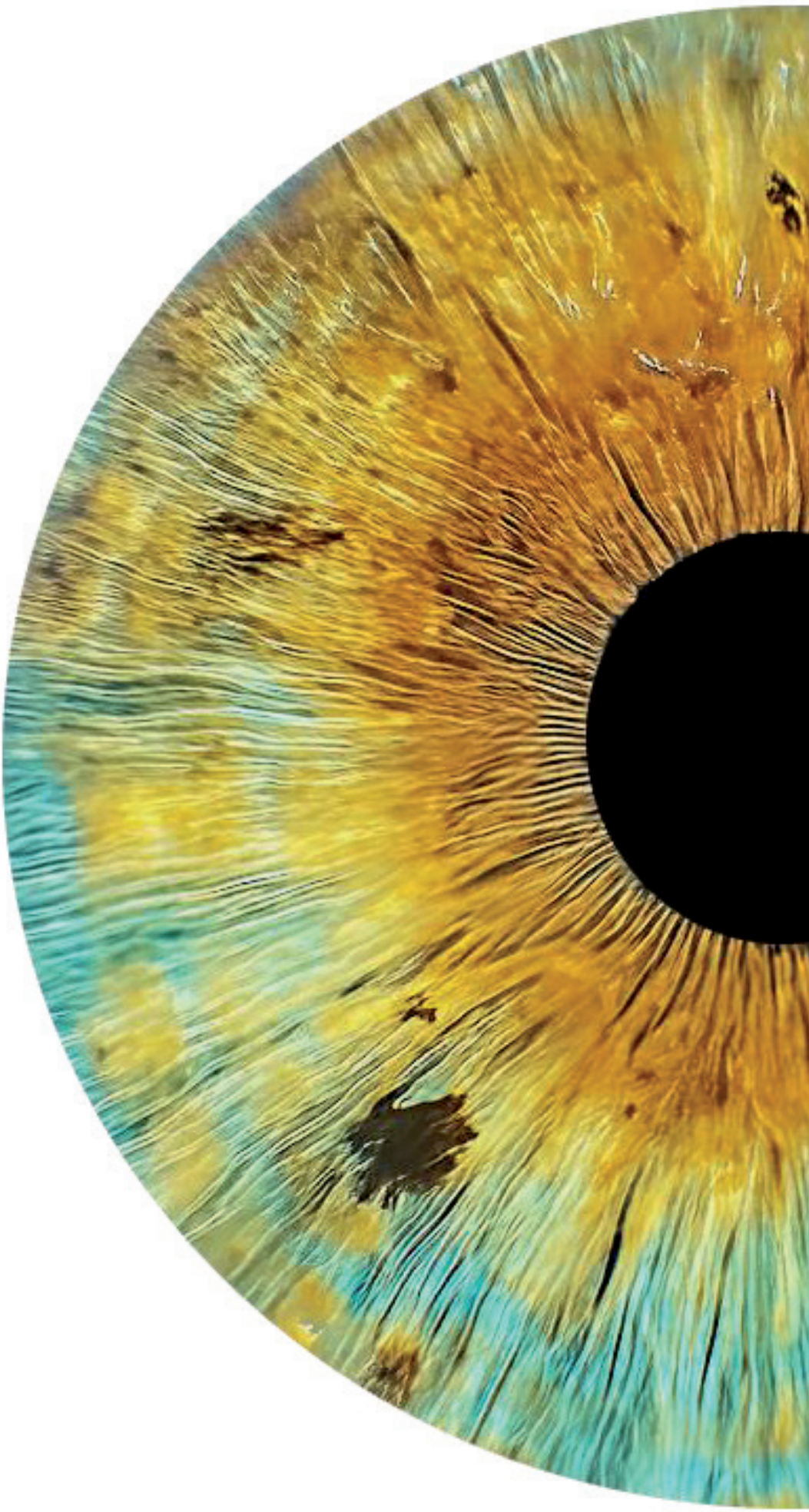
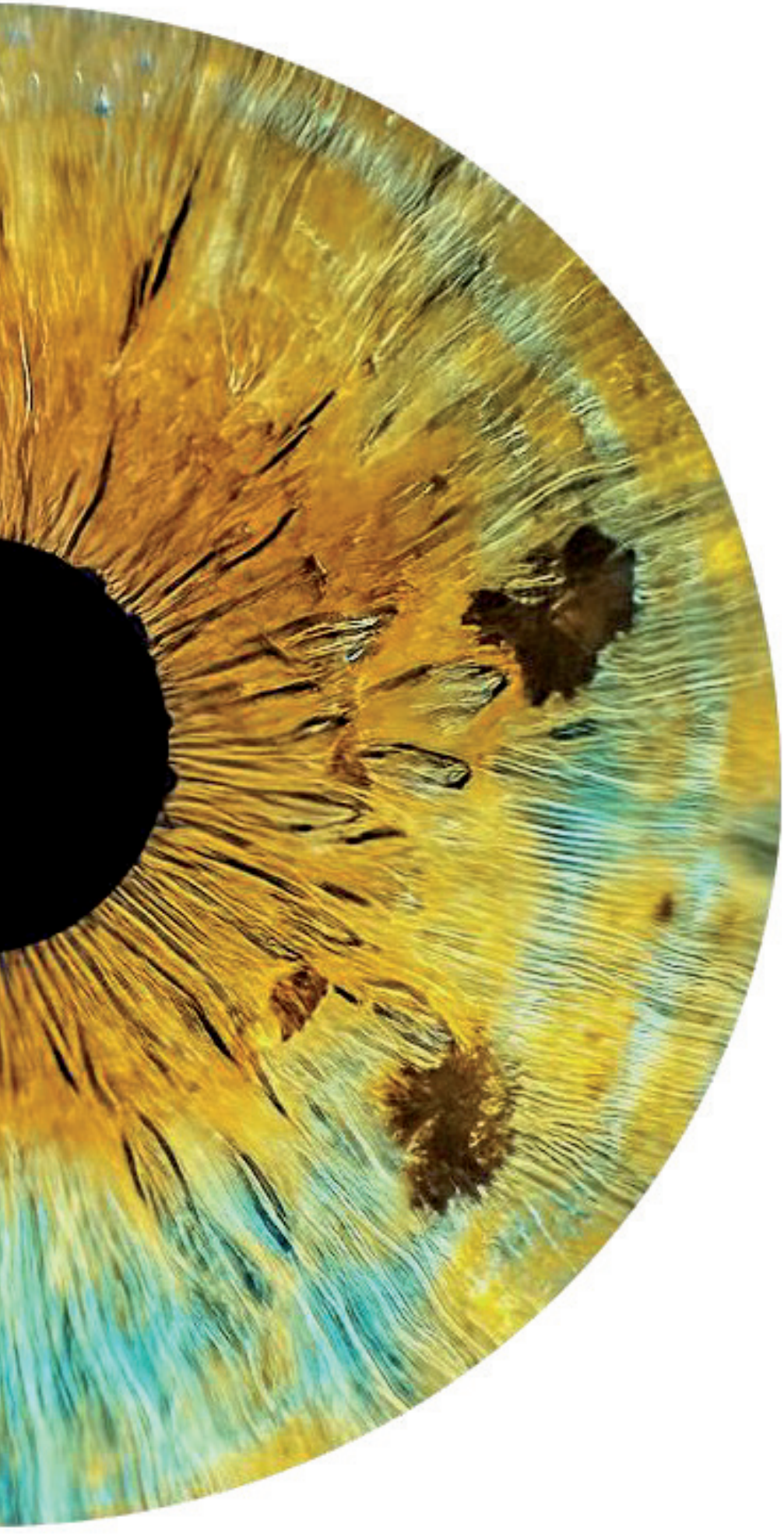


FIGURE 67: Full check up of physiodynamic parameters





IRÎZ Apps

NewEyes EyeSelfie

Scientific Predictor

NewEyes Simulator

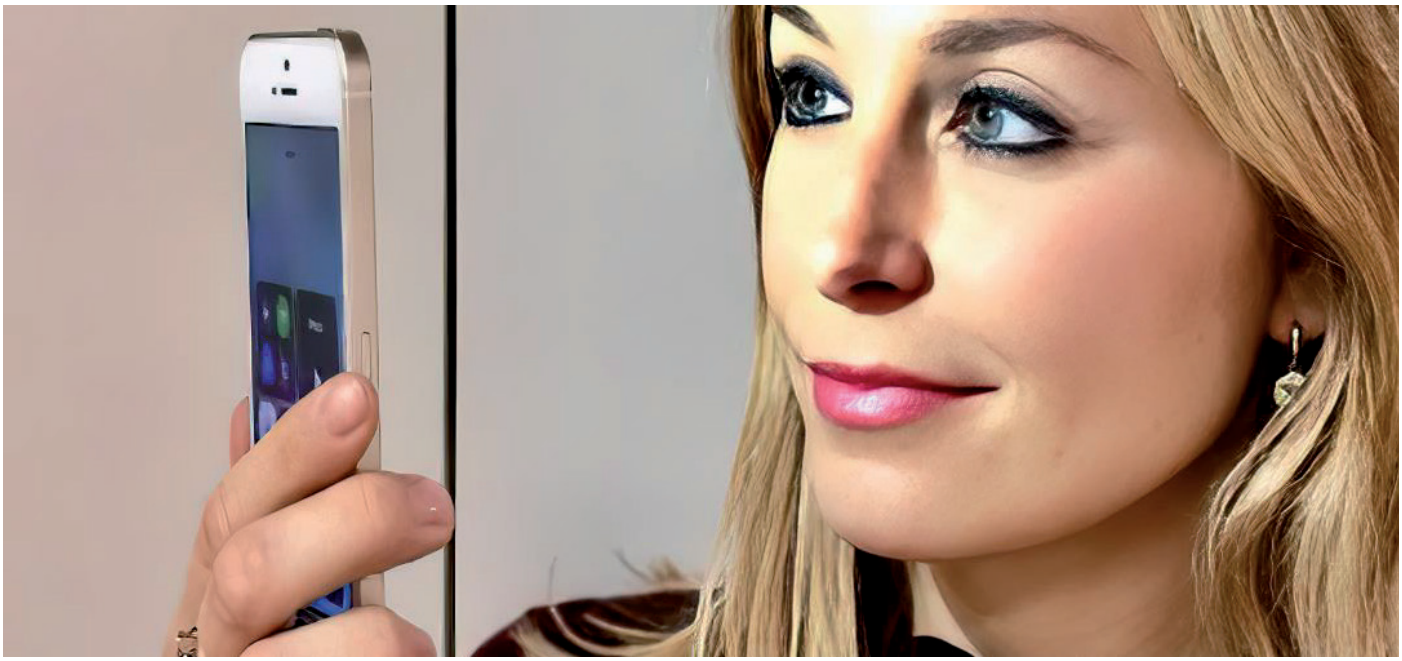
MyNewEyes

PART 2

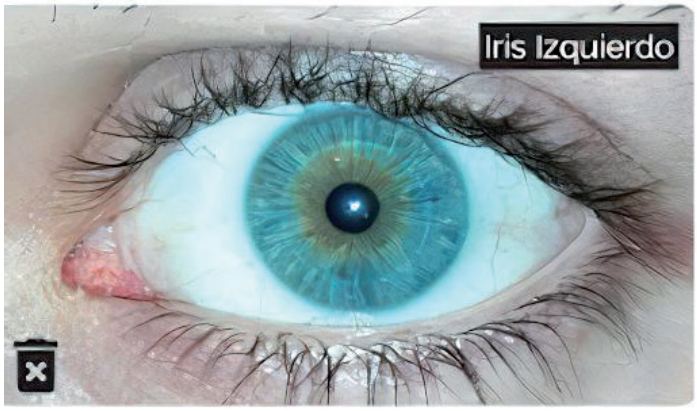
LASER IRIDOPLASTY

CHAPTER 6 APPLICATIONS

2 5.1 Eye Selfie



Eye Selfie has made it possible for the first time that a patient can take pictures of their eyes without the help of anyone and with high image quality, good focus, perfect centered and adequate lighting (Figures 25 and 26). The Eye Selfie App has finally made it possible to perform a remote diagnosis and effective follow-up.



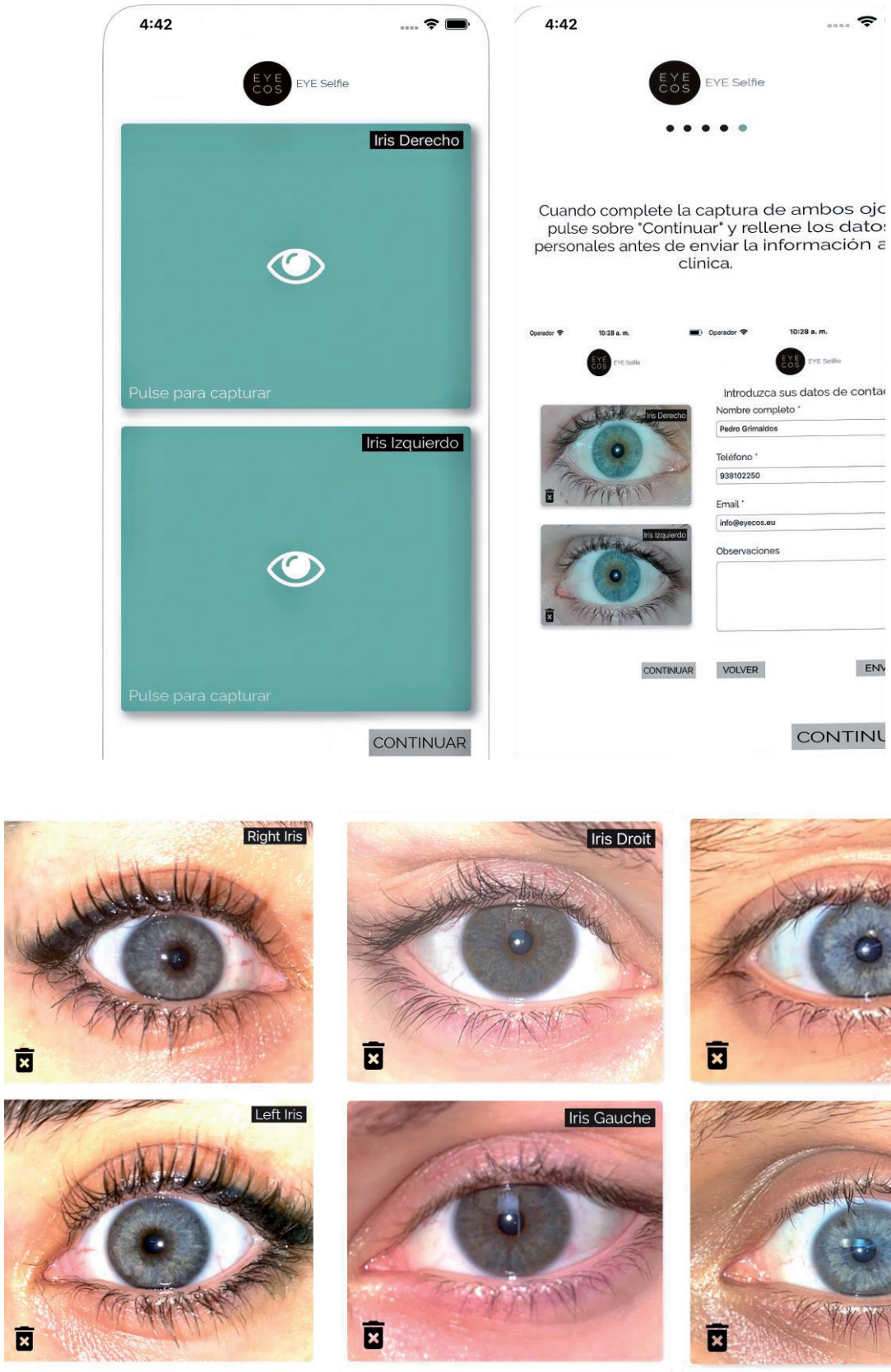
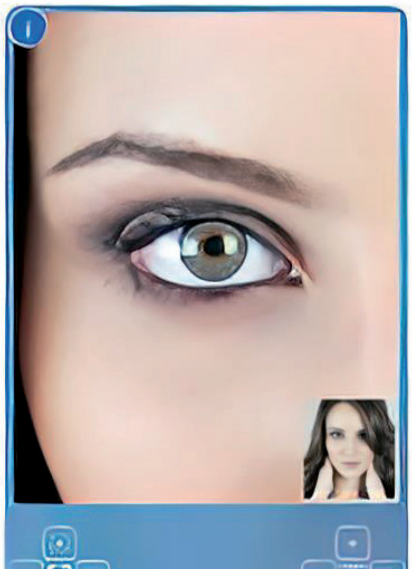
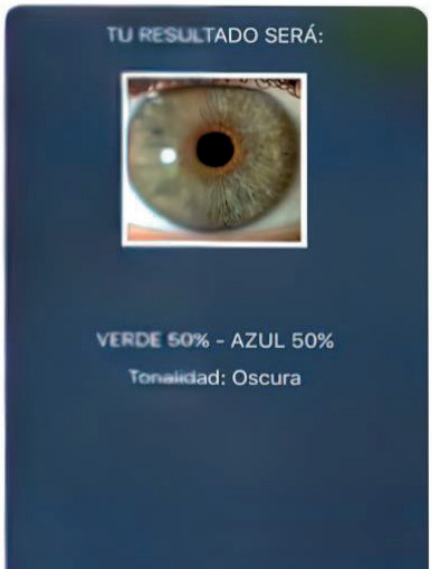


FIGURE 68: Several examples of good quality eye potos by App Eye Selfie

2 5.2 Predictor





Based on the Theory of the two genes we first develop a software and then a mobile application to calculate the result of the laser iridoplasty, taking into account the personal features with those of the parents: eye, skin and hair color (Figure 12).

However, we found cases of ignorance of the ancestors, in which the use of the Predictor program was not reliable. So we carried out research with prestigious geneticists who developed a special probe that located the genes responsible for eye color and their different melanin production capacities. The biochip test is a non-invasive method that is performed from a sample obtained by buccal swabbing and that increases reliability in the prediction based on objective data (DNA analysis) and not only based on statistical predictions, as is usually done habitually.

The genes that were studied were the HERC2, TYR, OCA2 and SLC24A4, closely related to the pigment levels of the retina.

HERC2 is a neighboring gene of OCA2 that regulates the expression of the latter and determines to a large extent the pigmentation levels of the human iris.

Certain variants in these genes

determine for example the blue color of the eye. TYR is the gene that codes for tyrosinase, one of the enzymes that regulate melanin levels.

Finally, the SLC24A4 gene is involved in the specific metabolic mechanisms of the retina.

For the analysis of these five genes, the DNA of the buccal samples is purified. The fragments of interest located within the genes mentioned above are amplified by PCR and are subsequently studied by direct sequencing or analysis of fragments with the technology established for this purpose.

As a result, specific genotypes are o tained for each person in the five genes studied, allowing the prediction of levels of iris pigmentation in each individual

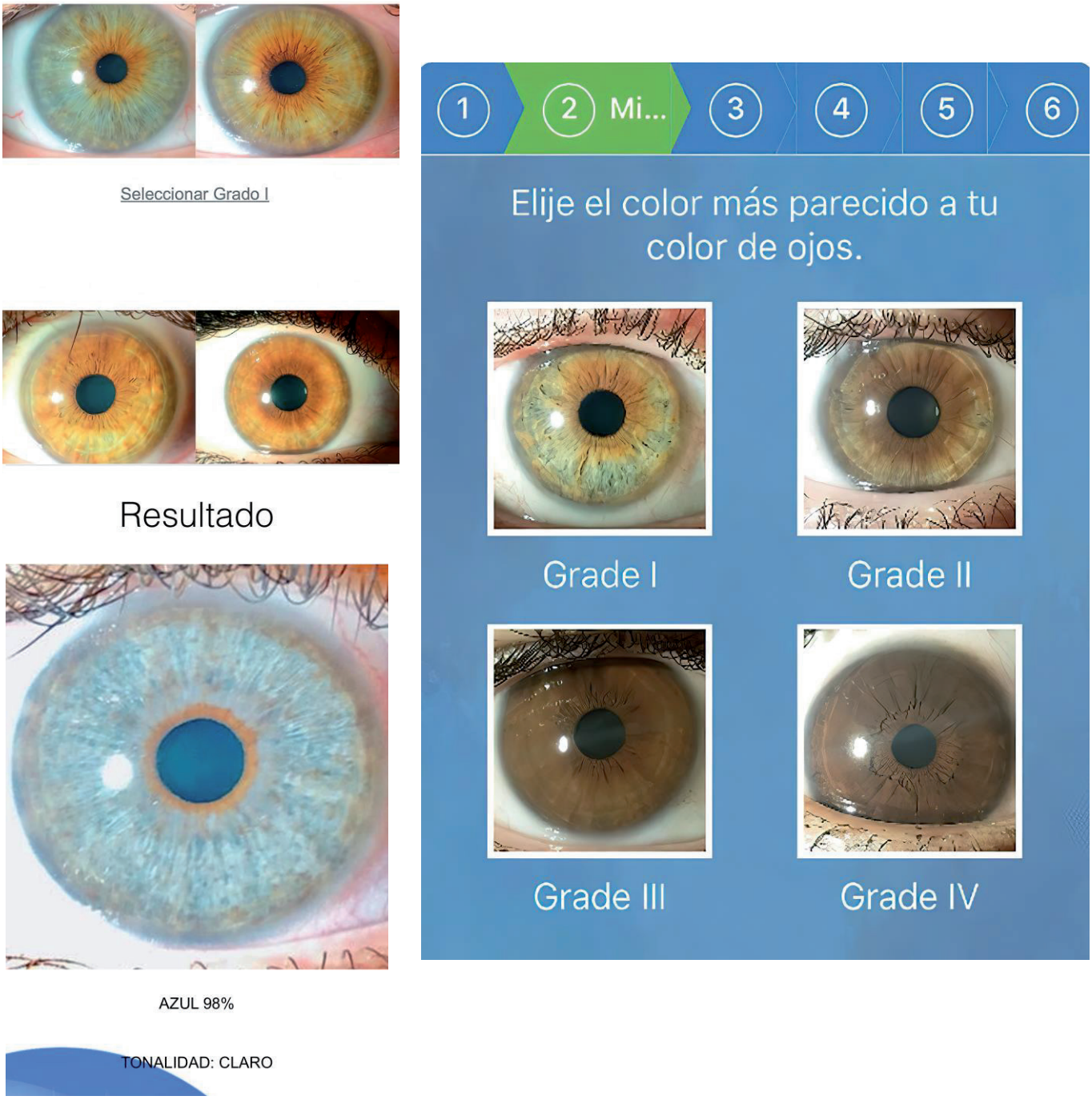
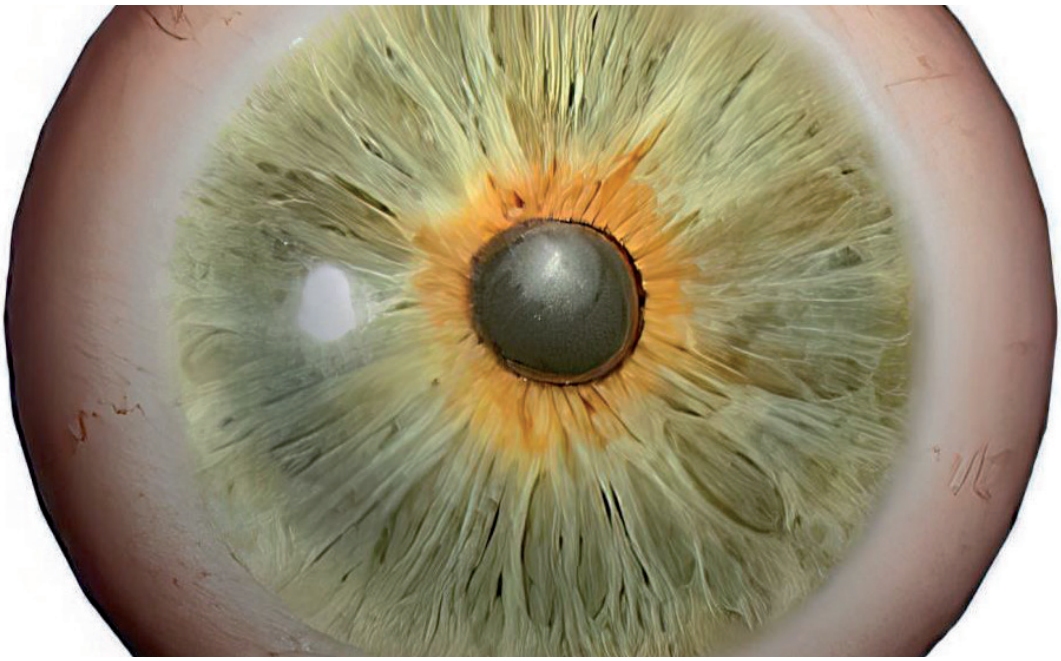


FIGURE 69: Phenotype prediction is based on familty and personal traits

2 5.3 Simulator 3D



The new App Simulator 3D is capable of generating three dimensional models of the patient's original eyes and simulations of the results predicted by the App Predictor.

App Sim 3D can also simulate the effect of ambient lighting on the appearance of eye color.

In low light the black pupil dilates and the intensity of color decreases proportionally.

Finally, this App can simulate the effect of the distance observation on the appearance of the eye color.

Eye Cos 3D Simulator App generates automatically three dimensions eye models to see final outcome. Once App Predictor calculation has be done, the patient can compare laser cosmetic effect, before and after procedure. EyeCos 3D Simulator offers a dynamic simulation to understand how changes pupil size with different light levels and has also a tool to check distance effect on eye color. A proportional relationship between far-near observation and brightness is so evident.

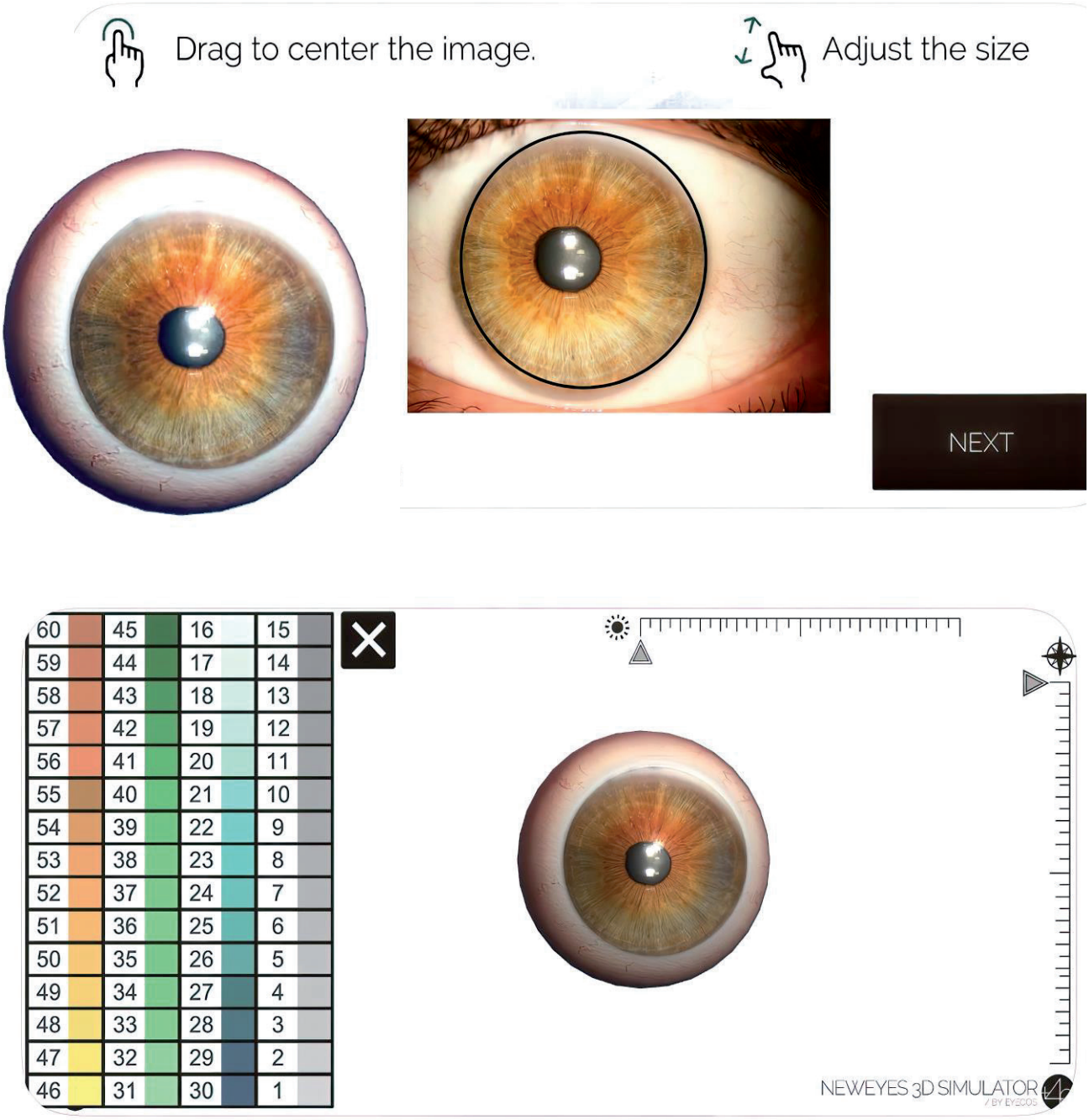
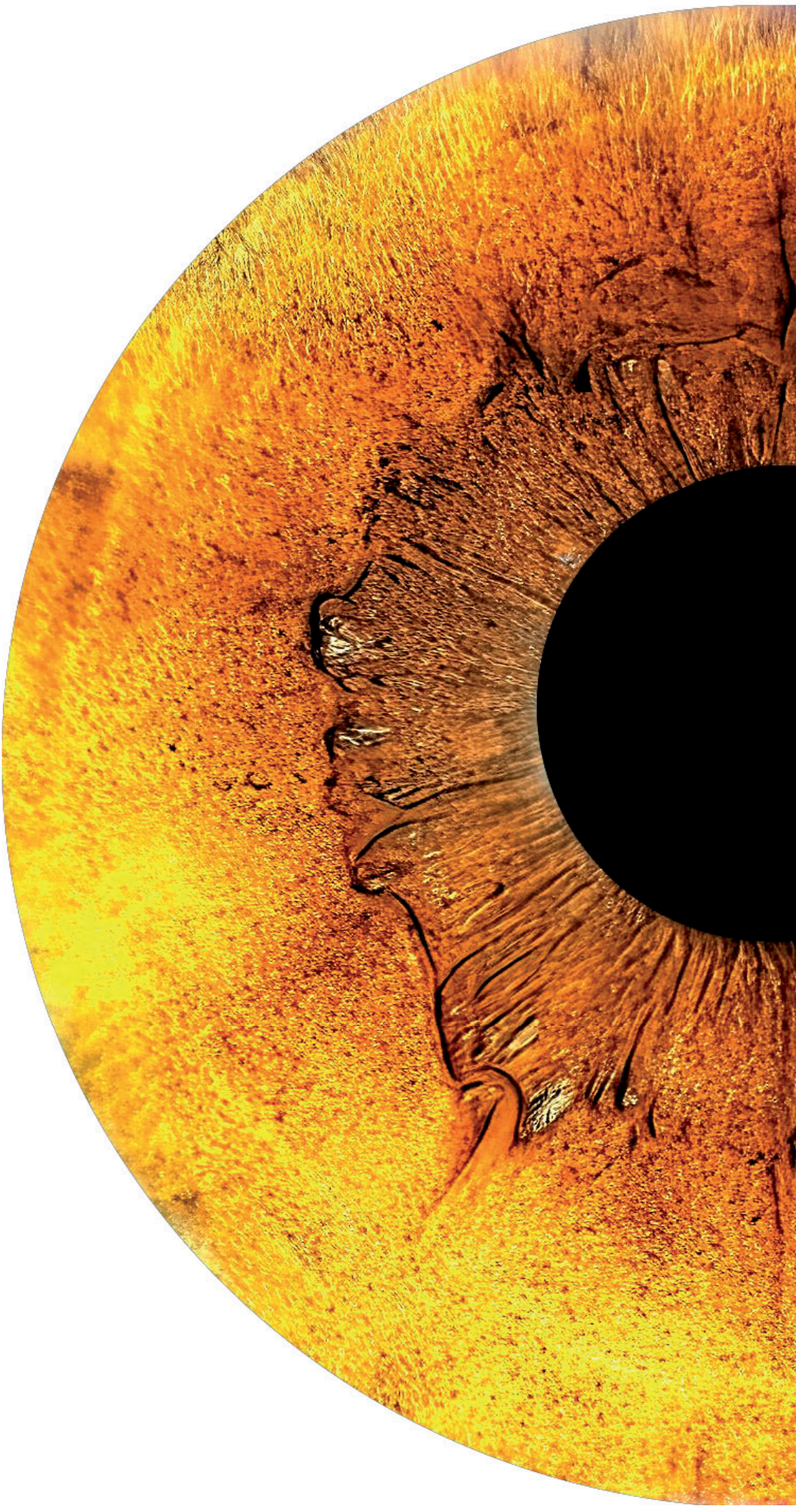
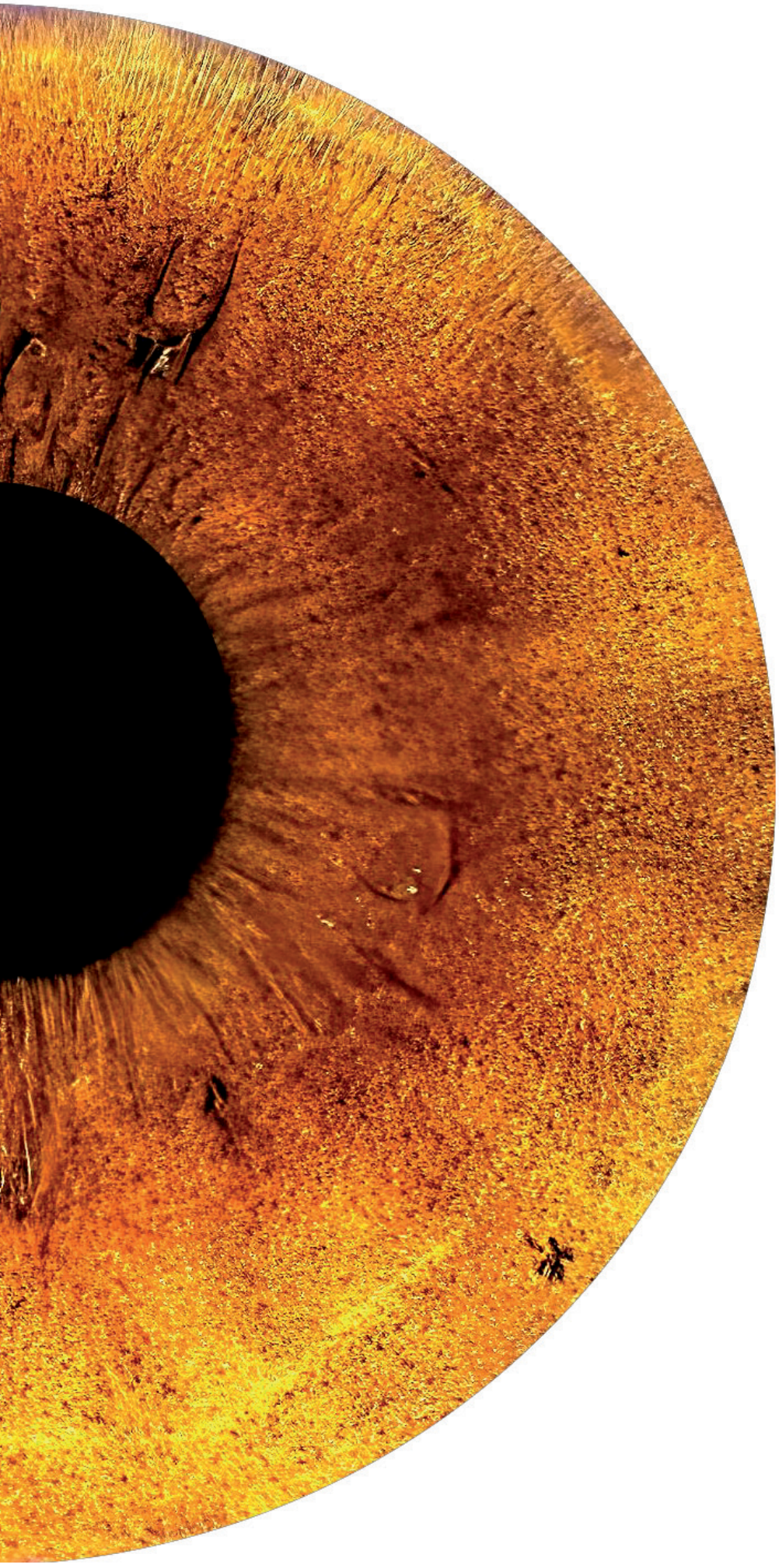


FIGURE 70: Real 3D color prediction, and light and distance influence.






EasyRet

PART 2

LASER IRIDOPLASTY

CHAPTER 7 TECHNIQUE / DEVICES

2 7.1 Medical Protocol

The medication prior to the procedure includes diclofenaco and timolol maleate drops at 0.50% every 8 h starting two days before.

As we have known for many years, the application of laser to the iris causes an inflammatory reaction similar to iritis, and laser depigmentation of the trabeculum in the SLT technique generates pressure peaks after its performance. To prevent both acute complications, previous therapy with topical antiinflammatory and antihypertensive drugs is indicated. Without the routine administration of oral anxiolytics, anesthetic drops of tetracaine and oxybuprocaine are administered. If necessary, pilocarpine 2% drops can be applied to keep pupils miotic during the procedure. VOLK capsulotomy or iridectomy lenses are used, with methylcellulose drops, to fix the ocular globe and optimize focus in the iris.

After laser sessions is also recommended diclofenaco and timolol drops every three hours. Ibuprofen pills can improve inflammatory reaction, and mydriatic drops as well. Following the final session, the dose decreases to three times a day, for seven or ten days, and then we add artificial tears with sodium heparin every 8 h for 3 months.

TODAY TREATMENT
TRATAMIENTO DE HOY
TRAITEMENT D'AUJOURD'HUI

DATE:

DICLOABAK AND TIMABAK 5mg

TIMELINE	RIGHT-DERECHO DROIT	LEFT-IZQUIERDO GAUCHE
9 h		
10 h		
11 h		
12 h		
13 h		
14 h		
15 h		
16 h		
17 h		
18 h		
19 h		
20 h		
21 h		
22 h		
23 h		
24 h		

KEEP HEAD UP, NO SPORT and RELAXED DAY
MANTENER CABEZA ALTA, NO DEPORTE y DIA RELAJADO
TÊTE DROITE, PAS DE SPORT et JOURNÉE DE DÉTENTE

DOCTOR WHATSAPP: +34 696551011

Eyecos Clinic
Calle Tuset, 23-25
08006 Barcelona (Spain)
Telf.: +34 938 10 22 50
Email: info@eyecos.eu
info.neweyeslaser.com
NEWEYESLASER

POST LASER TREATMENT

1-Dicloabak and Timabak every 8 hours/day for 7-10 days
2-Tropicamida just before sleeping just 2 nights
3-Prednisone 10mg 1 pill every morning for 4 days
4-Hyloparin every 8 hours/day for 3 months
Send eye photos by App Eye Selfie after 1-2 months
Any question by Whatsapp +34696551011
Appointment by email secretary@eyecos.eu

TRATAMIENTO POST LASER

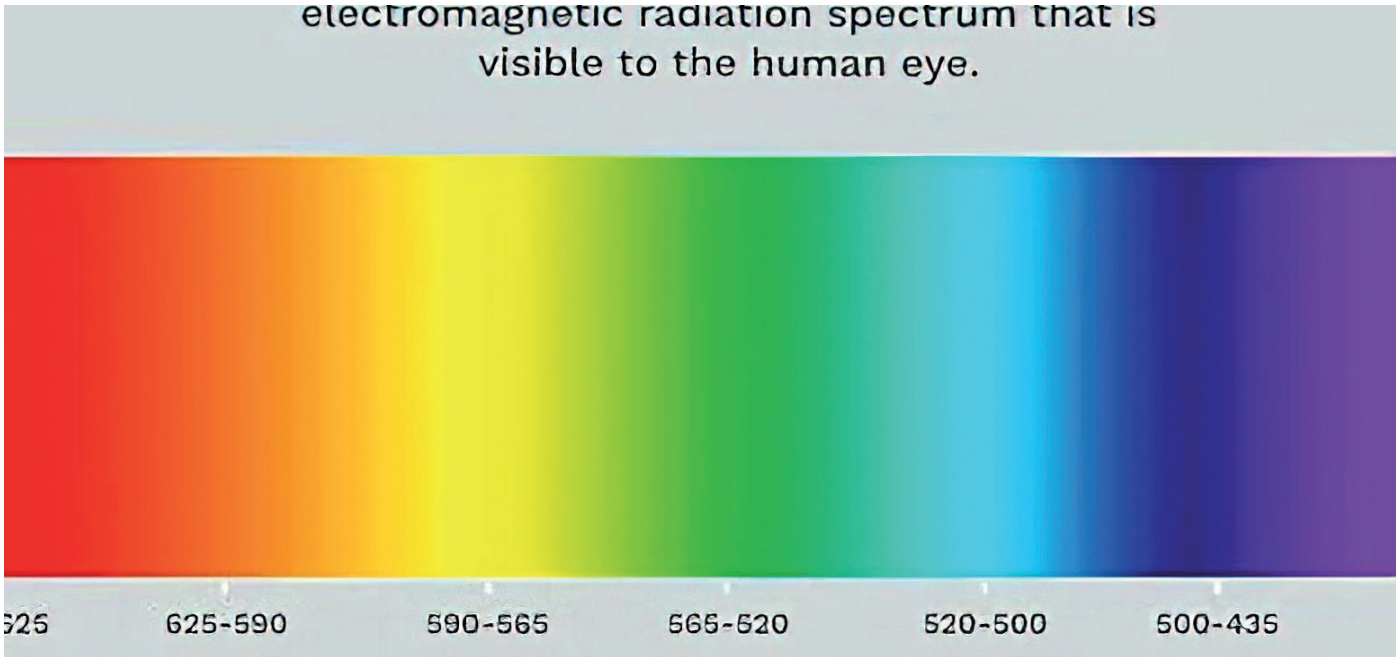
1-Dicloabak y Timabak cada 8 horas por día durante 7-10 días
2-Tropicamida justo antes de dormir solo 2 noches
3-Prednisona 10mg 1 comprimido por la mañana durante 4 días
4-Hyloparin cada 8 horas por día durante 3 meses
Enviar fotos de los ojos tras 1-2 meses con la App Eye Selfie
Cualquier cuestión por Whatsapp +34696551011
Pedir cita por email secretary@eyecos.eu

TRAITEMENT POST LASER

1-Dicloabak et Timabak chaque 8 heures/jour pendant 7-10 jours
2-Tropicamida avant de dormir seul 2 nuits
3-Prednisone 10mg 1 pilule chaque matin pendant 4 jours
4-Hyloparin chaque 8 heures/jour pendant 3 mois
Envoyer des photos des yeux après 1-2 mois avec App eye Selfie
Totute question par Whatsapp +34696551011
Rendez-vous par email secretary@eyecos.eu

FIGURE 71: Main eye drops treatment and regular medical protocol

2 7.2 Laser wavelength



In 2011 we began a research and development project on a laser iris depigmentation technique. Lasers' depigmentation potential when used in the anterior segment had been known for decades [14–20], so we decided to perform a comparative study of four types of equipment: Crystal Q-switched Nd: Yag photodisruptive laser (1.064 nm), Crystal Q-switched Nd: Yag at double frequency photothermal elaser (532 nm), semiconductor optical pump laser photothermal laser (577 nm) and the Crystal Qswitched Nd: Yag at double frequency photoablative laser (532 nm) with 3–4 ns pulses. These lasers are routinely used to perform iridotomy, capsulotomy, synechiotomy, suture lysis, membranotomy, iridoplasty, gonioplasty, pupiloplasty, and trabeculoplasty, in traumatic pathologies, congenital malformations, glaucoma, and following glaucoma and cataract surgeries.

The 532-nm Crystal Q-switched Nd: Yag laser with 3–4 ns pulses showed the best levels in efficacy, which was almost immediate (90%), safety (90%), with minimal secondary effects, and short-, mid-, and longterm high predictability: 90–95.5% (Fig. 1). Therefore, beginning in 2017, we decided to only use this laser for all iris depigmentation treatments.

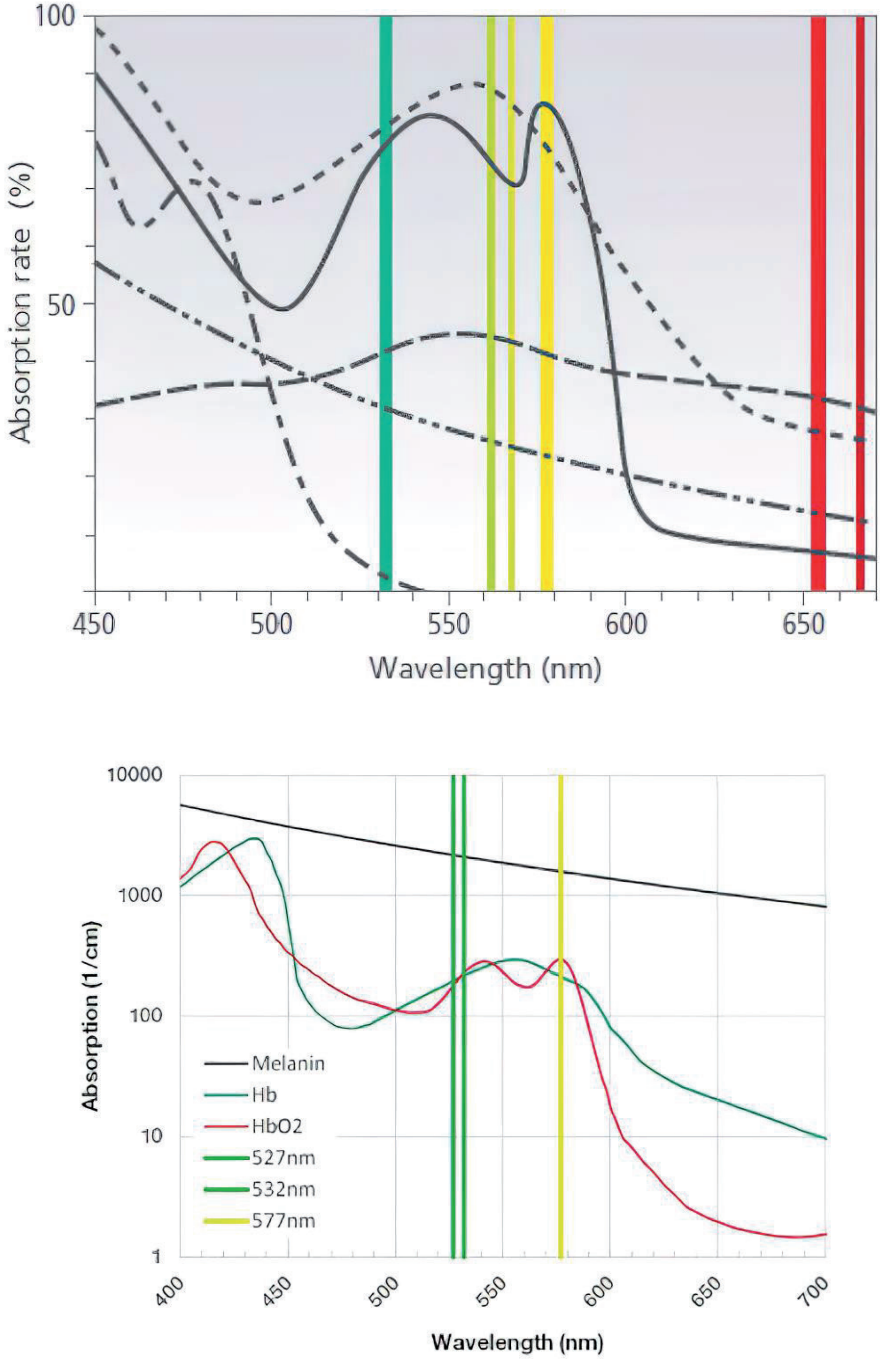
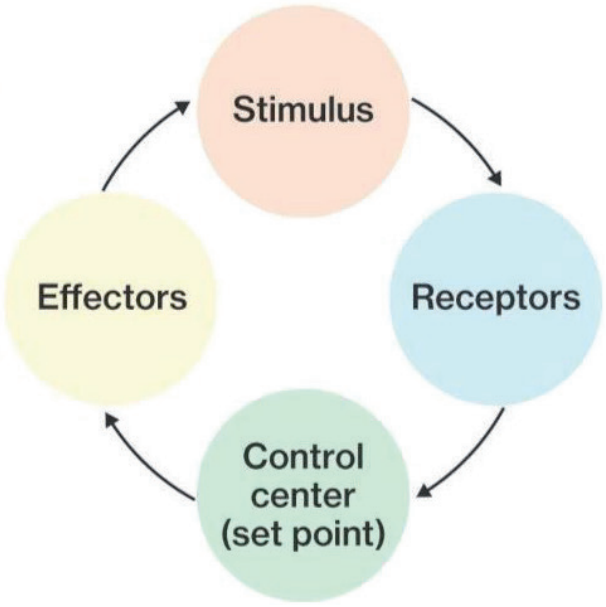


FIGURE 72: Tissue effects related to laser wavelength

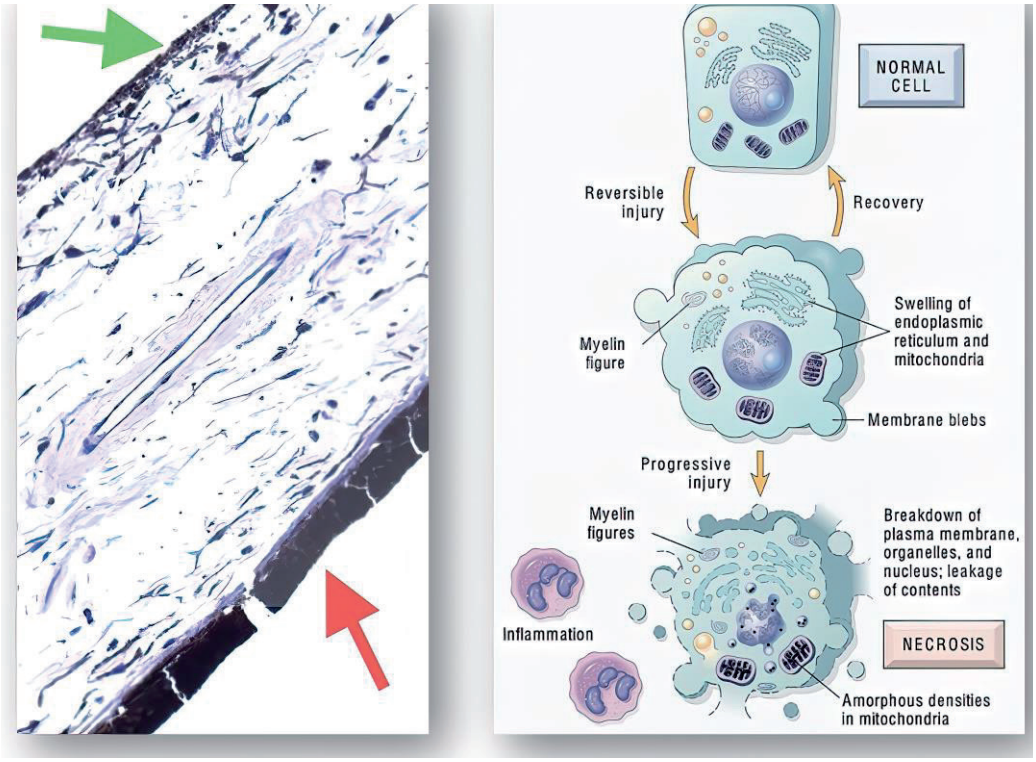
2 7.2 Homeostasis



The stages of wound healing proceed in an organized way and follow four processes: hemostasis, inflammation, proliferation and maturation. Although the stages of wound healing are linear, wounds can progress backward or forward depending on internal and external patient conditions. After you get injured, homeostasis begins in which your blood vessels are closed, and the platelets create substances that help stop bleeding through clotting. body responds to trauma by raising level of inflammation.

The blood vessels dilate after homeostasis is achieved. This allows white blood cells, nutrients, enzymes, antibodies, and other beneficial elements reach the affected area to accelerate wound healing. New healthy granulation tissue replaces the wound. It is important that your blood vessels receive enough nutrients and oxygen to form granulation tissue.

The tissue consists of a mixture of collagen and extracellular matrix, which helps develop a new network of blood vessels. Maturation or remodeling is the end stage of the wound healing process. It takes place soon after your wound has closed up. During this stage, functional fibroblasts will replace nonfunctional one and the number of blood vessels in the area will also decrease gradually.



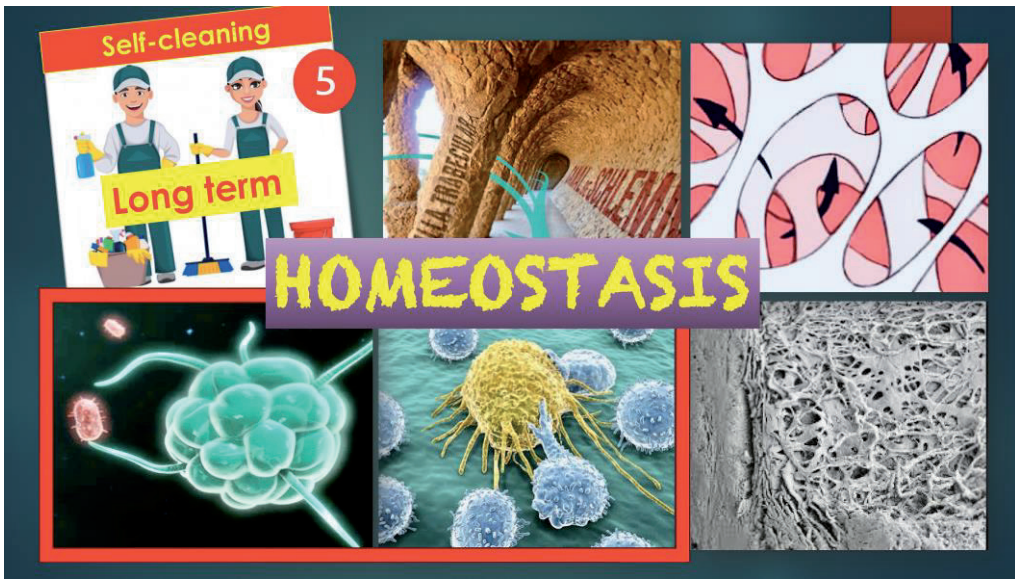


FIGURE 73: Homeostasis manages celular healing

2 7.3 Planner Program

The Planner software provides the parameters we must use according to the Analyzer software's Iris Summary: power, duration, repetition frequency, number of shots, and treatment area. We follow the guidelines indicated by Planner until the specific area of the iris has been treated. The sessions tend to take no more than 5 min. The laser's effects are painless, although the light from the slit-lamp causes discomfort.

Each phase consists of four or five consecutive daily sessions, which are repeated every 4–6 months until finalization, with the treatment completed in two or three phases.

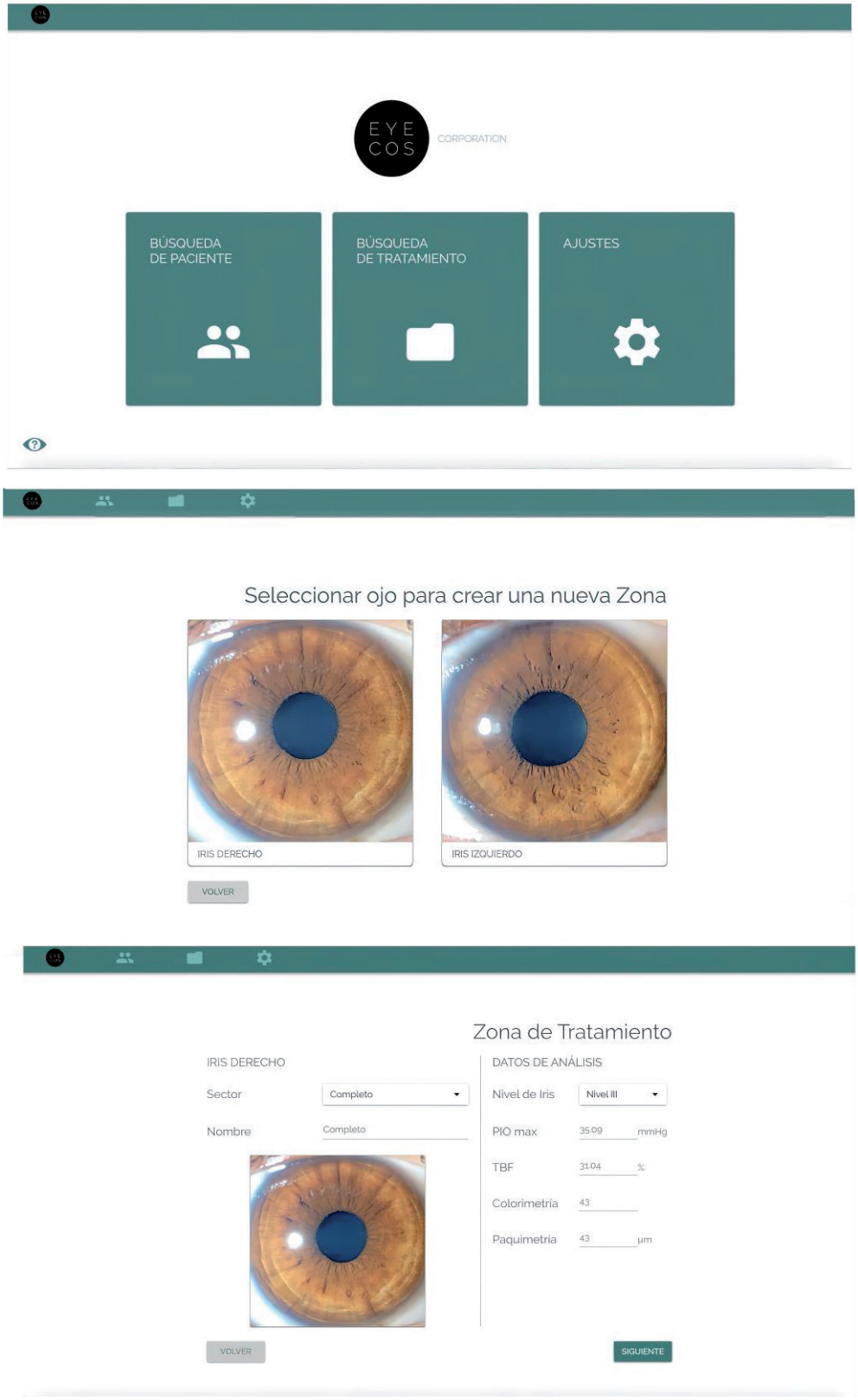


FIGURE 74: Planner program for Schedule laser sessions

2 7.3 Planner Program

New Planner Program

The purpose of the IRÎZ Workstation is the routine realization of customized laser iridoplasty. As there are no two identical irises, personalized treatments are mandatory. The differences are in the degree of pigmentation, type of melanin, thickness, topographic irregularity, pupillary function and cicatricial capacity. On the other hand, heterochromia spots must be accurately mapped in order to eliminate them accurately. After obtaining a meticulous analysis of the iris with the IRÎZ Scanner and the Grimaldos Summary Software, we have to introduce these data in the Planner Program to generate the specific treatment guideline, with number of sessions and specific parameters to be used in each case (laser type, energy).

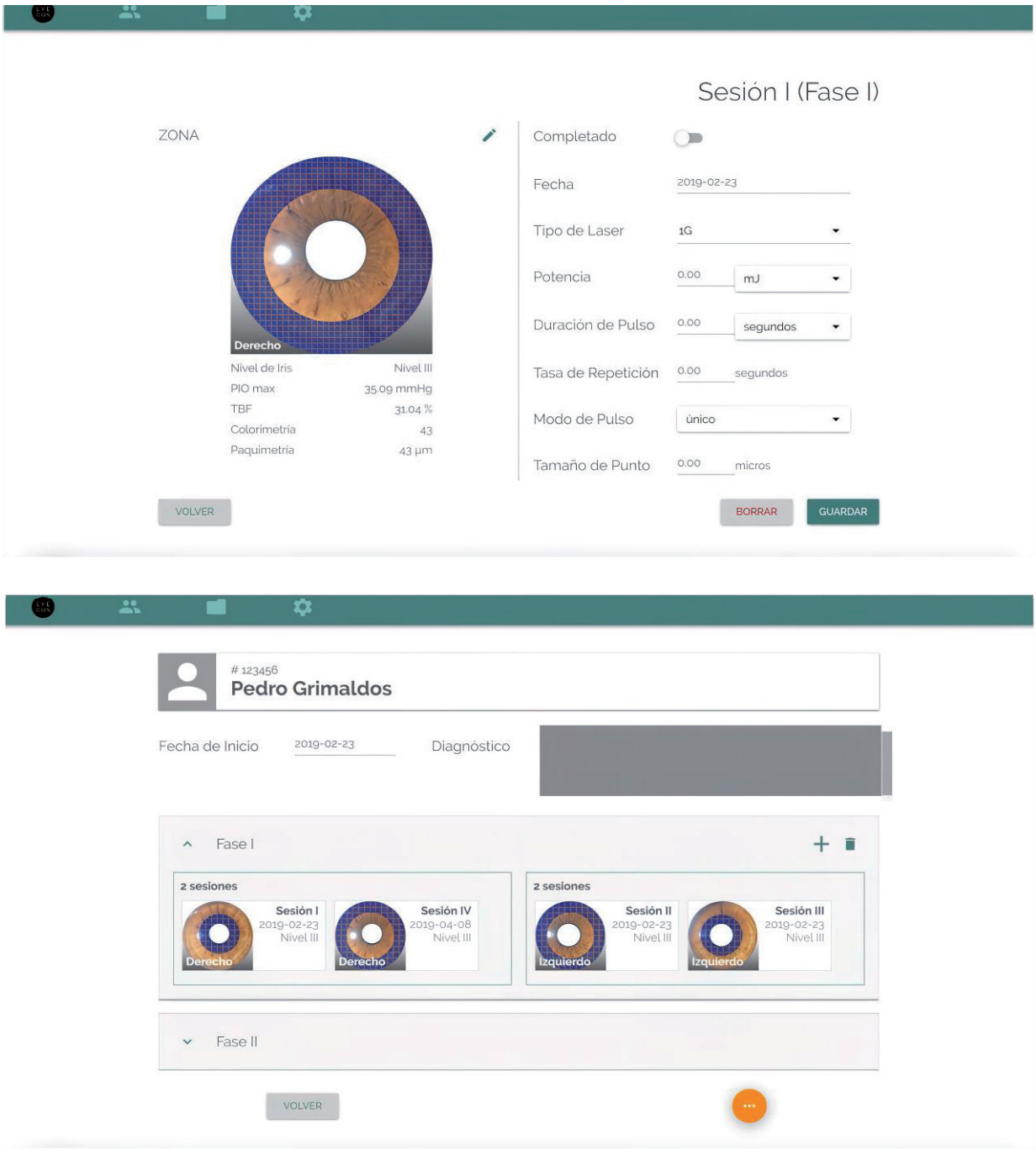


FIGURE 75: Phases and laser sessions, planned by Planner

2 7.4 IRÎZ Scanner/AS

We developed the first version of the IRÎZ Scanner which, thanks to specific software, was able to evaluate the pigmentation degree and perform colorimetry, pachymetry and 2D topography studies. The most important parameters offered by the first iris Scanner were the physiodynamic tools, which would then be optimized with the second version of the IRÎZ Analyzer.

The second version of the IRÎZ Scanner incorporates great advantages, such as a new software for capturing high quality images and its processing with the Grimaldos Summary Software, also a wide-fi eld optical coherence tomography (OCT) module and a high precision pneumatic tonometer and tonography.

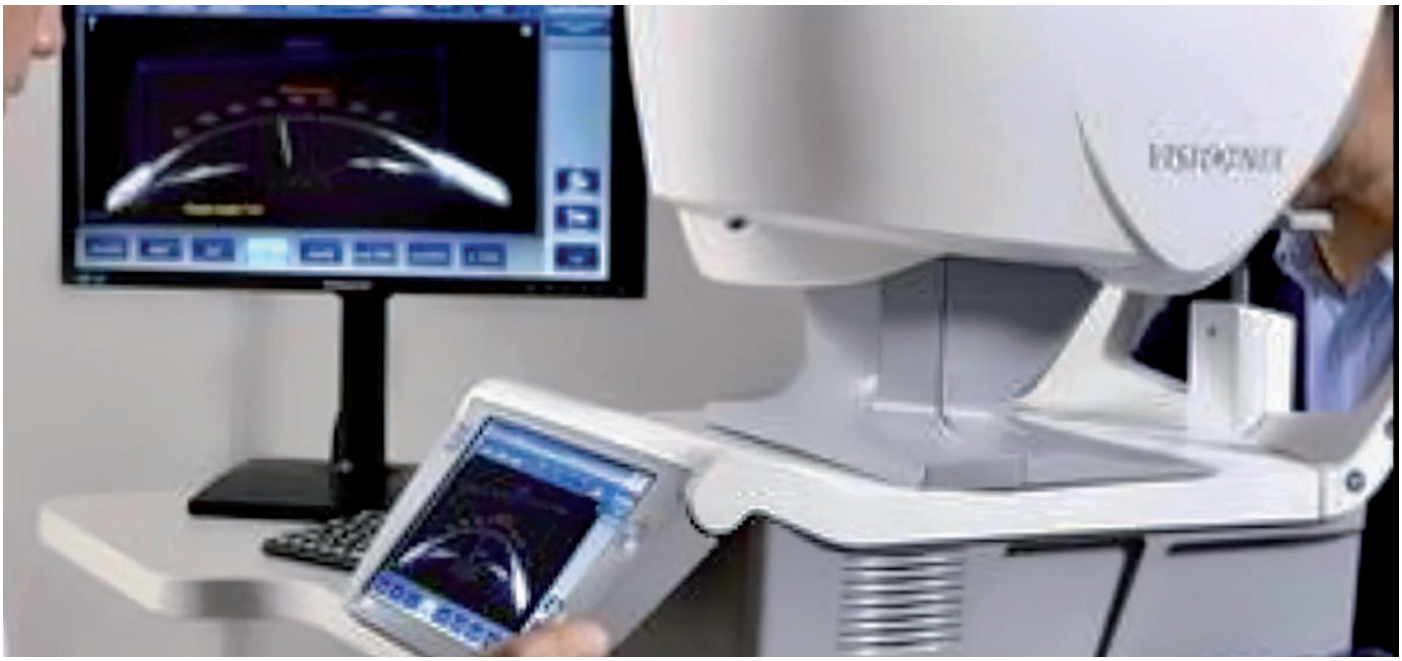
Since then, we have used the IRÎZ (Eyecos) scanner and Analyzer program, which provided us with the data required to adequately plan the treatment: pigmentation grade, colorimetry, color contrast, iris pachymetry, and 3D topography. The scanner consists of three modules: photography (Topcon SL-D), optical coherence tomography (OCT Topcon SL-SCAN1) and pneumotonography

(Reichert M30). The Analyzer IRÎZ (Eyecos) software also calculates the physiodynamic parameters of the aqueous humor in the anterior chamber, which are indispensable for a safe technique: maximum intraocular pressure (IOP max), clearance curve (CC) and trabecular blockage factor (TBF). These data are shown in a simplified format in the Eyecos Iris Summary.

The IRÎZ Scanner is asisted by complemmentary devices as: Multifunctional explorer, Air tonometer, Specular microscope and Automatic gonioscope.

FIGURE 76: Visionix, refractometer, specular and gonioscopymeter

2 7.4 Multiexplorer/ OCT



The VX120 Multi-Diagnostic Unit combines the functions of an autorefractor, a keratometer, a corneal topographer, an aberrometer, a pachymeter, and a noncontact tonometer combined with anterior chamber analysis into one of the most advanced and space saving instruments in your practice.

One-touch high-end refraction vision analysis, and diagnosis of the anterior chamber. Make the difference thanks to the VX120+, complete and fully automatic diagnostic screening device. Complete refraction, differentiate between day and night vision needs, glaucoma, cataract, keratoconus identification and monitoring ,fitting of contact lenses.
Its multiple functions provide versatility and convenience in a smaller footprint while refusing to compromise on the resolution and accuracy of the measurements. These features combined help make the testing procedure easier for both the doctor and the patient.

Key features Visionix VX120: Autor fractor / Keratometer / Corneal T pographer / Aberrometer / Pachymeter with Anterior Chamber Analysis.

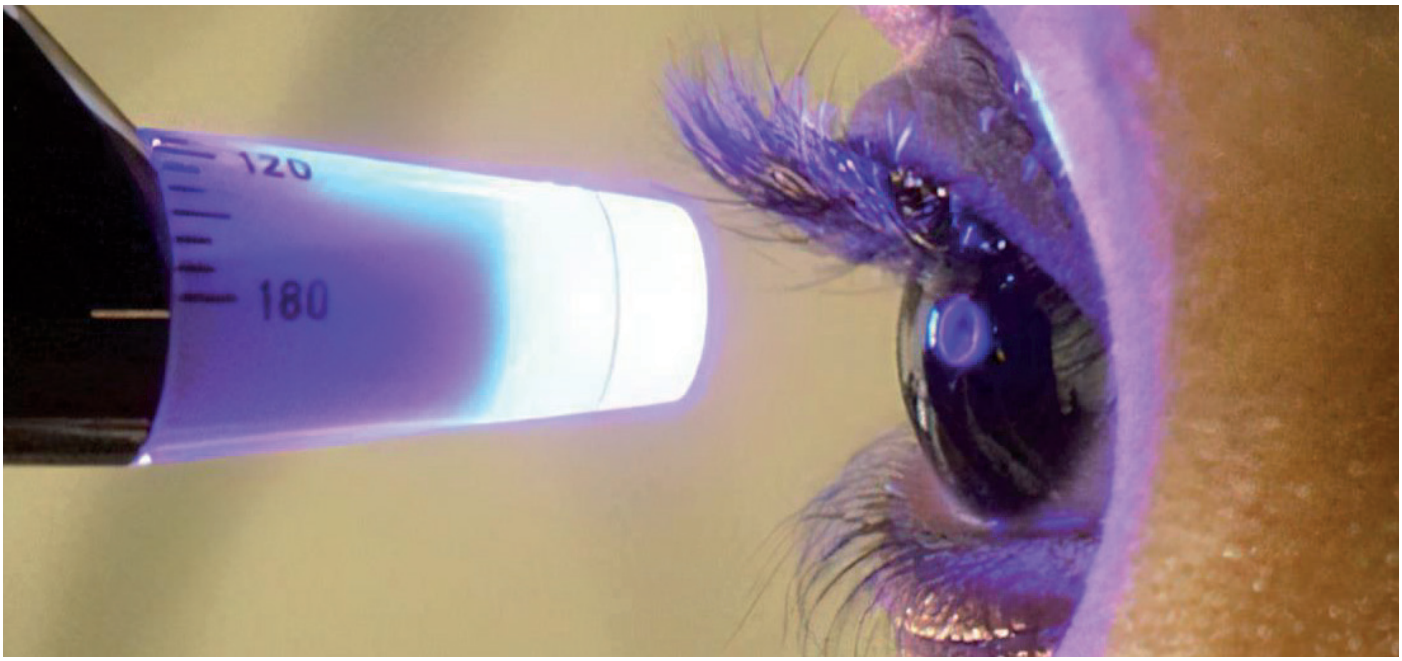
Shack-Hartmann mapping method Topographer up to 100000 points High density aberrometry up to 1500 points Measures pupils as small as 2mm Automatic right / left eye movement Autotracking Automeasurement Autofocusing Based on wavefront technology Retro-illumination–spot aberrations in the IOL and cornea scratches easily Global view of refraction aberrations EMR and VX55 digital refraction compatibility 10.4″ Color touchscreen interface.

Tomography OCT for anterior segment is a great tool to assess anatomical structures. Measure image using the Visante OCT analysis software, before and after acquisition.

Practical tools measure ocular structures-ACD, anterior chamber angles and anterior chamber diameter (angle to angle distance) Quick, reliable data for narrow angle evaluation. Corneal Imaging and Pachymetry High resolution Supported documentation for ocular health. Rapid pachymetry scan Accurate and repeatable map result for glaucoma care. New Lasik information

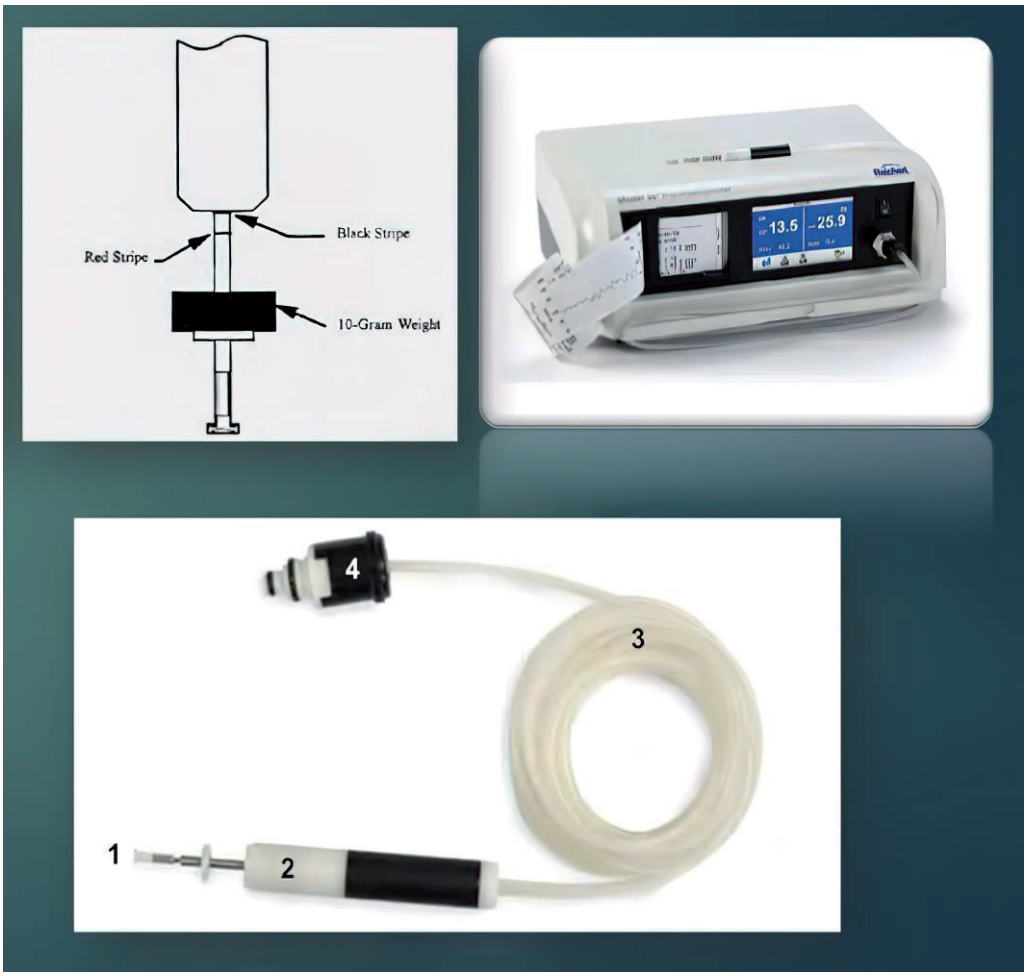
FIGURE 77: Tomography OCT for anterior chamber study

2 7.4 Tonography



The Reichert Model 30™ Pneumotonometer is an, easy to use instrument that provides fast and accurate tonometry and optional tonography functions. The probe tip, which floats on an air bearing, is gently touched to the anesthetized cornea and a precisely regulated flow of filtered air applies force to the tip. A small (5 mm diameter) fenestrated membrane permits the air to flow through vents in the tip until it conforms to the shape of the cornea. Increasing pressure is continually applied to the cornea until the force being applied is equal to the pressure in the anterior chamber. When these forces are in balance a pneumatic sensor records the intraocular pressure. In pulse tonometry mode, the ocular pulse waveform is charted and recorded along with IOP. The Model 30 Pneumotonometer provides ocular pulse amplitude measurements in addition to tonometry measurements. The optional tonography mode enables measurement of the aqueous outflow efficiency of the trabecular meshwork.

The Model 30 Pneumotonometer provides ocular pulse amplitude measurements in addition to tonometry measurements. The optional tonography mode enables measurement of the aqueous outflow efficiency of the trabecular meshwork.



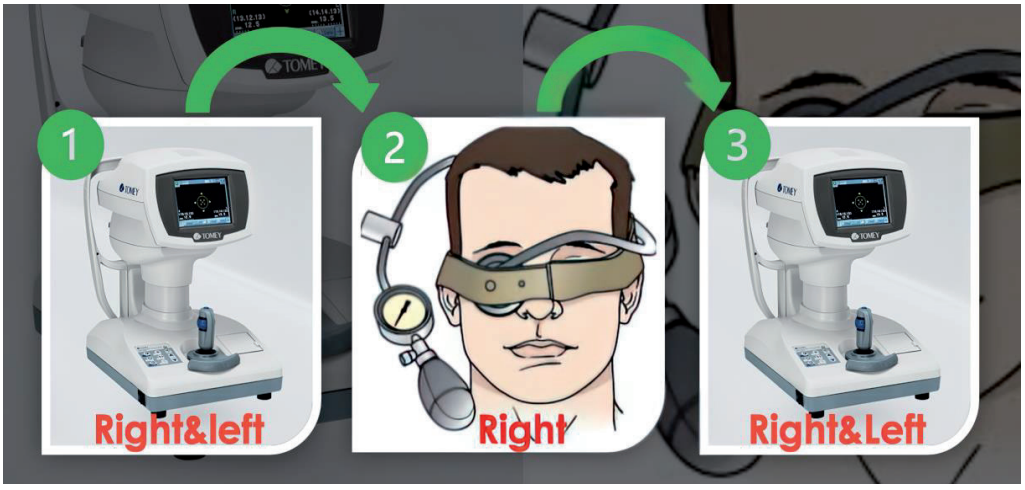
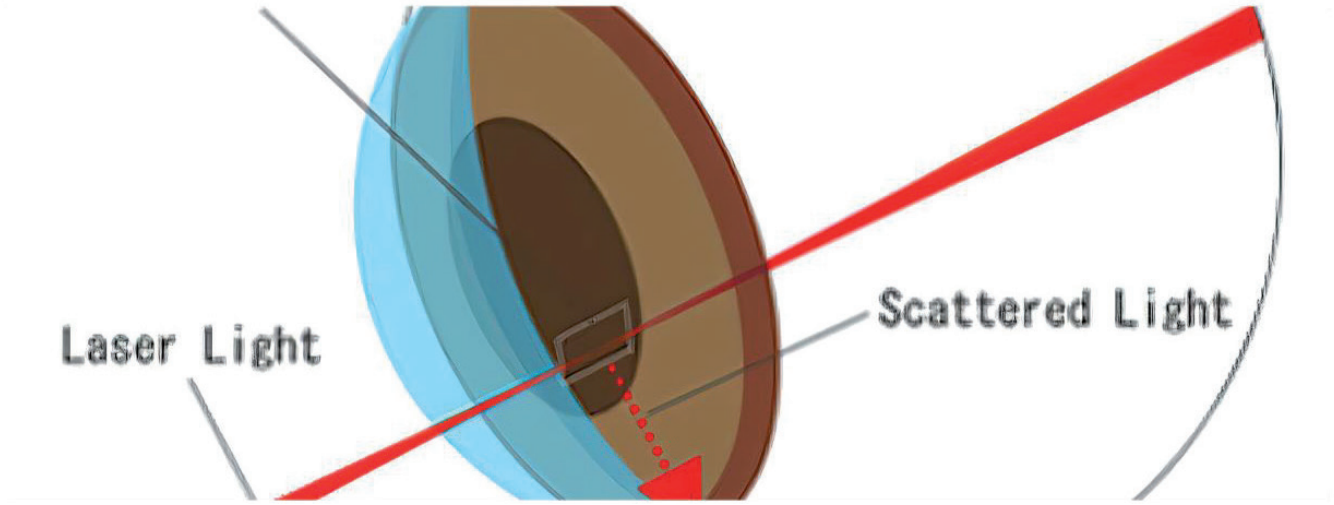


FIGURE 78: Reichert 30M pneumotonographer vs Honan tonography

2 7.4 Flaremeters



The Kowa FM-600 is based on a measurement principle of laser light scattering detection. The instrument uses a diode laser beam to scan a measurement window that is projected inside the anterior chamber of the eye. As an aqueous protein (component of inflammation) passes through the focal point of the laser light scattering occurs. The intensity of the scattered light (directly proportional to the amount of protein particles-flare) is detected by a photomultiplier tube (PMT), which generates an electrical signal. This signal is immediately digitized to eliminate outside nois interference and is processed by a computer which displays the results for user analysis. The unit of measurement employed by the FM- 600 is "Photon Count" per millisecond.

Existing flare flaremeters are based on the Tyndall effect, which requires sophisticated laser photometry. The ocular flare analysis meter (OFAM) is a non laser photometer that uses quantitative Rayleigh scatter and absorption from visible light to compute a flare value.

Our original proposal is a digital flaremeter based on objective and automatic quantification of floating

particles into aqueous humor.

Figure 1. Photograph of the OFAM device. Three LEDs (405, 465, and 525 nm) are integrated to illuminate the eye. The scattered light is collected by a photomultiplier-based detector. A camera feed is integrated with a software user interface to guide the physician to position the instrument with the patients' eye. The OFAM is mounted on a standard slit-lamp device.

FIGURE 79: Laser, led light and digital flaremeters

2 7.5 Yag/Green Lasers

Most frequent single ophthalmological lasers, used in the office, are Yag and Green.
All Lasers brands have both available, like Zeiss, Lumenis, Lightmed, Quantel, Topcon, ARC, Alcon.

Main Yag laser indications are capsulotomy (post cataract surgery) and iridotomy (narrow angle glaucoma), but also is useful to treat synechiae and iris surface, to remove superficial pigmented depots (heterochromy).

Regarding Green laser indications on anterior segment are pupiloplasty, gonioplasty, iridotomy, trabeculoplasty and iridoplasty.

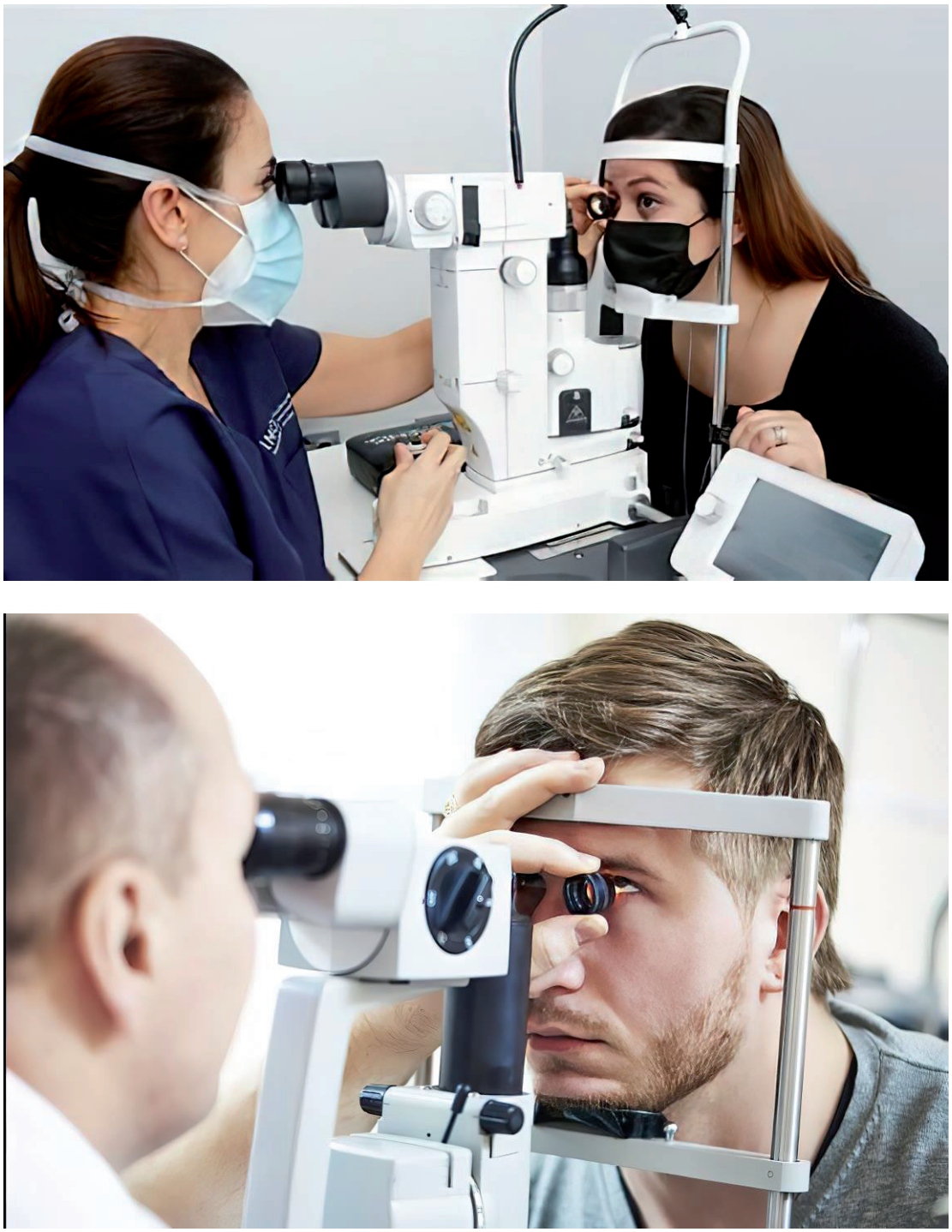


FIGURE 80: Single Yag and Green lasers

2 7.5 Thermal Lasers

Recently have been introduced very sophisticated laser platforms, mainly focused on retina procedures. After first model, Pascal (Topcon), a number of similar devices were available, like Easyret (Quantel), Truscan (Lightmed), Array LaserLink & Smart Selecta (Lumenis), Navilas (OD-OS), and others. All of these have incorporated big control panels and live video screens, but the most remarkable feature is pattern mode procedures, managed by special software, that allow to do automatic and fast sessions.

Although, main application is the retina by photothermal effect, these new platforms include another complemmentary lasers, like Yag and SLT.

Certainly, a Pascal, Easyret, Truscan or Smart Selecta multilaser are perfect devices to perform iridoplasty, because they offer all needed tools: photothermal, photodisruptive and photoablative lasers.

FIGURE 81: Photothermal micropulses combined laser stations

2 7.5 Ablative Lasers

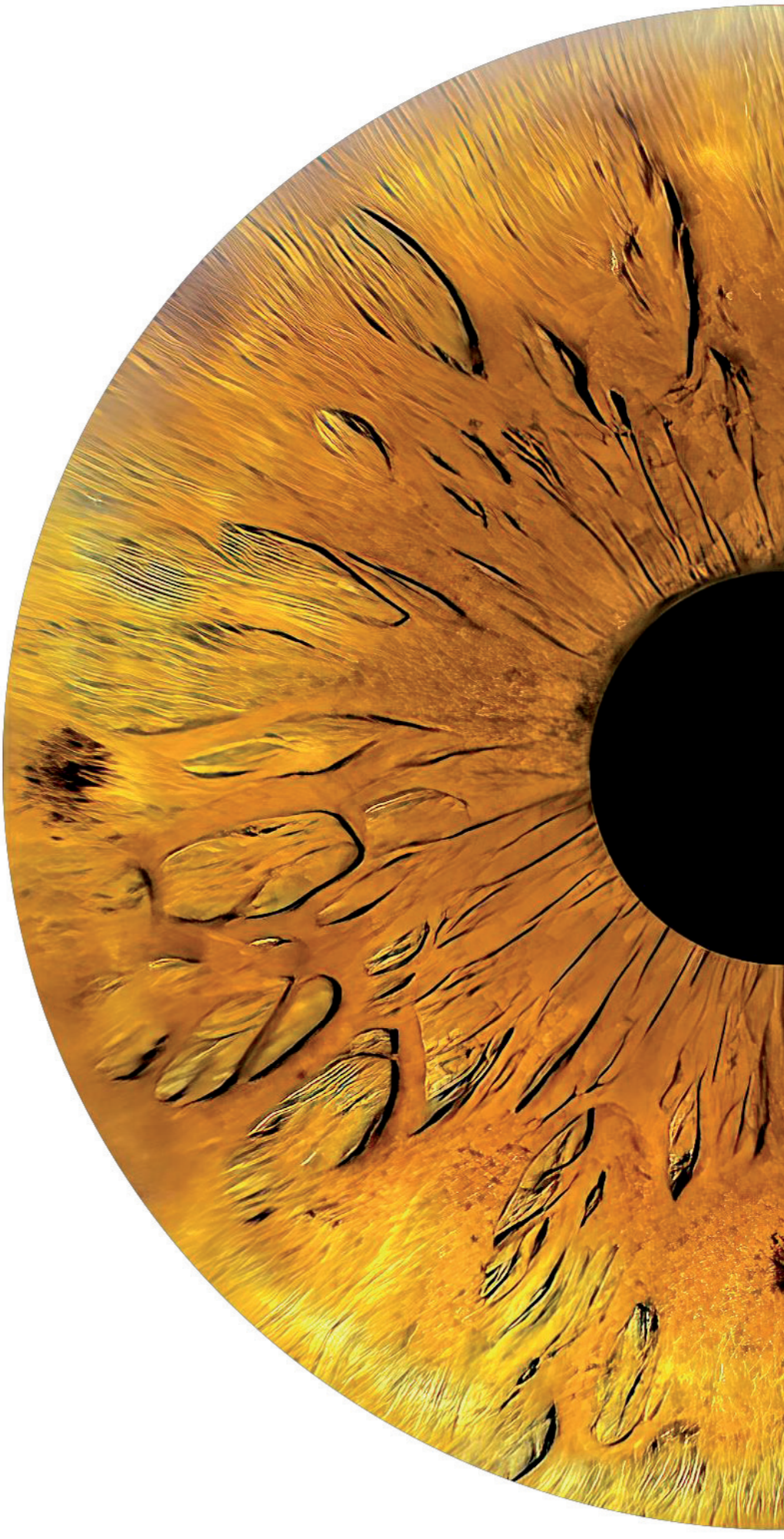
Selective laser trabeculoplasty (SLT) is a simple yet effective laser procedure that lowers the intraocular pressure (IOP) associated with glaucoma. Ophthalmologists perform the outpatient procedure in their office, and it typically takes between five and 10 minutes.

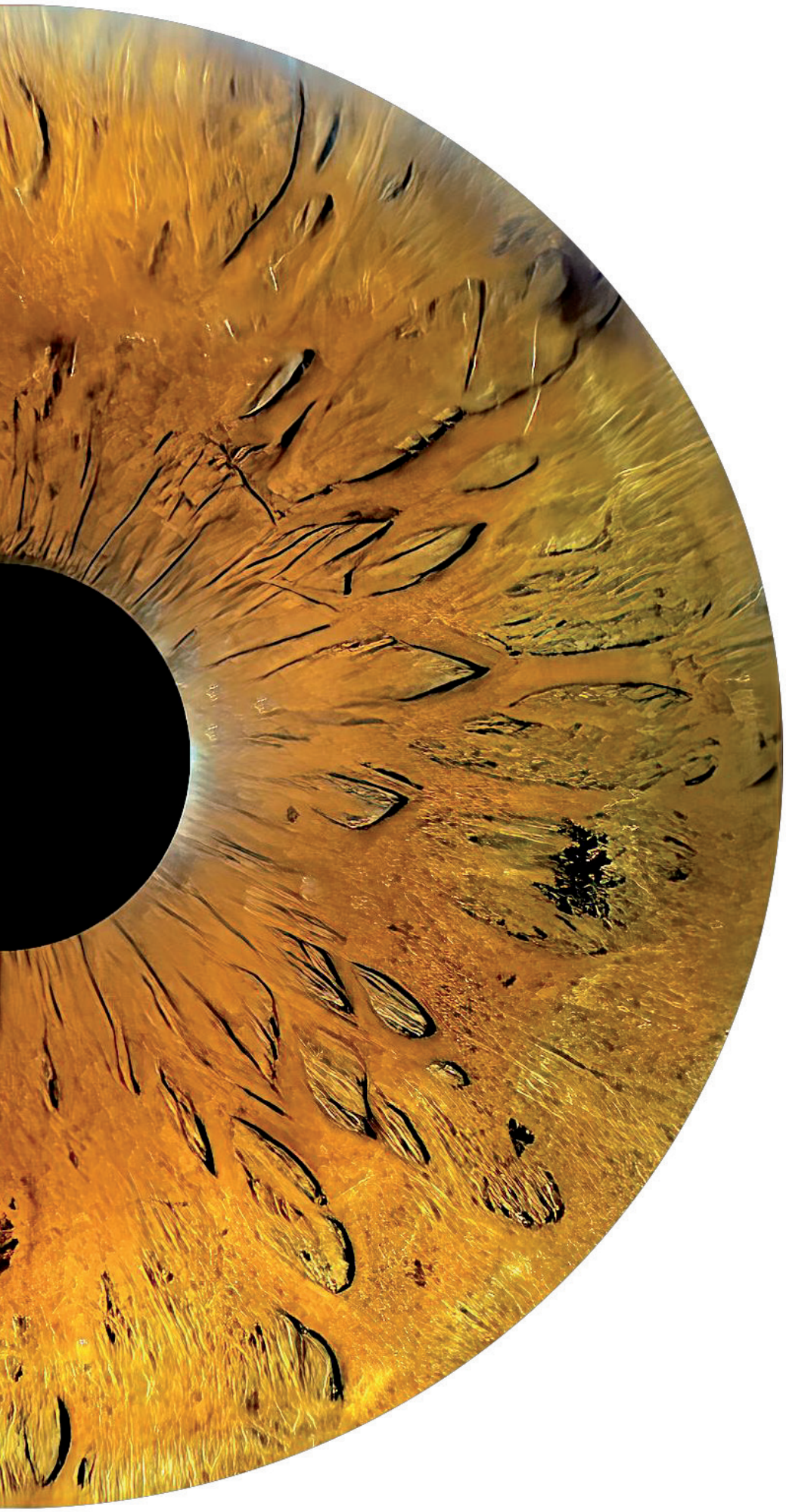
Eye doctors have used SLT since 1995 and have generated a proven track record of success. SLT works when laser energy is applied to the drainage tissue (trabecular meshwork) located in the front of the eye. This is the natural drain for fluid. SLT stimulates the trabecular meshwork through a chemical and biological change to increase the amount of fluid drained from within the eye. This lowers eye pressure.

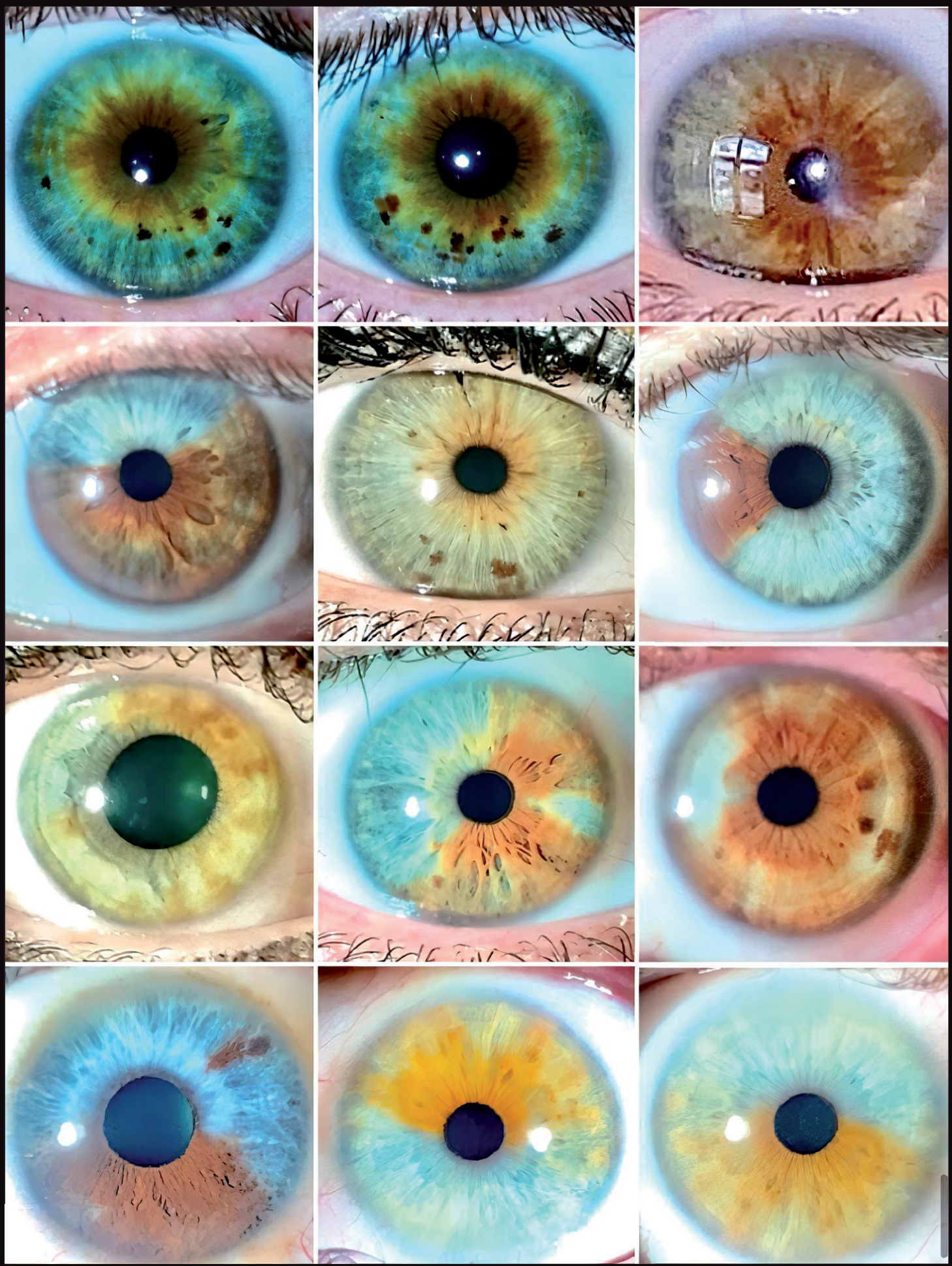
There are three types of lasers specially indicated for Trabeculoplasty: Green, SLT and MLT. Green through photothermal action, SLT is ablative and MLT has a molecular under threshold effect. Three modes are useful to perform also iridoplasty.

Main commercial brands in this field are: Ellex, Quantel, Iridex, Lumenis, ARC, Lightmed.

FIGURE 82: SLT laser stations combined to others technologies





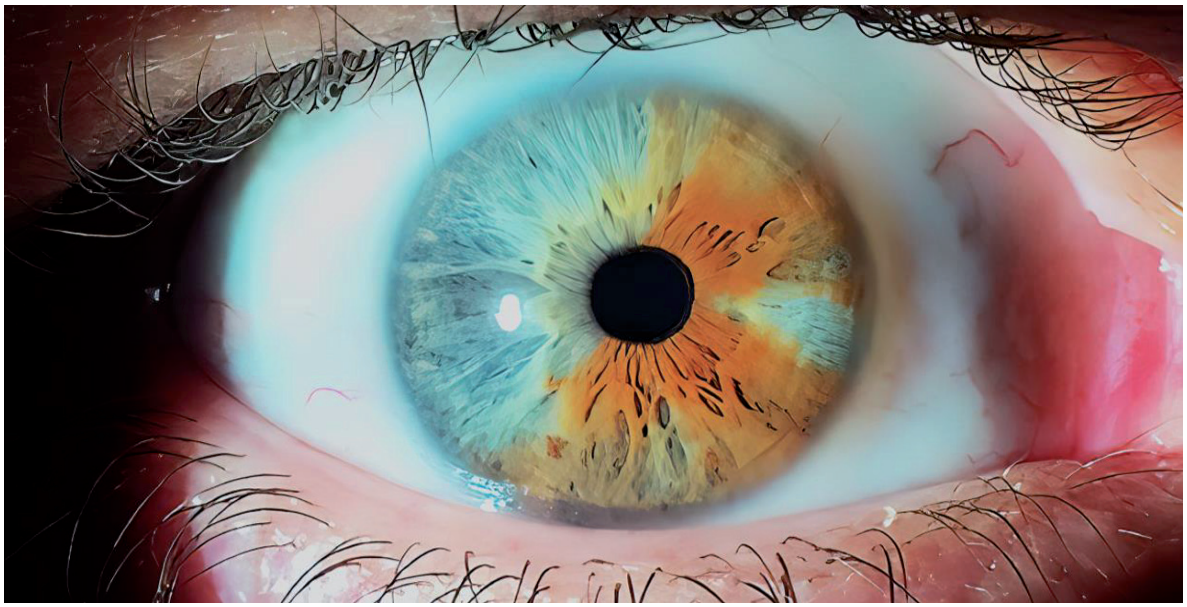


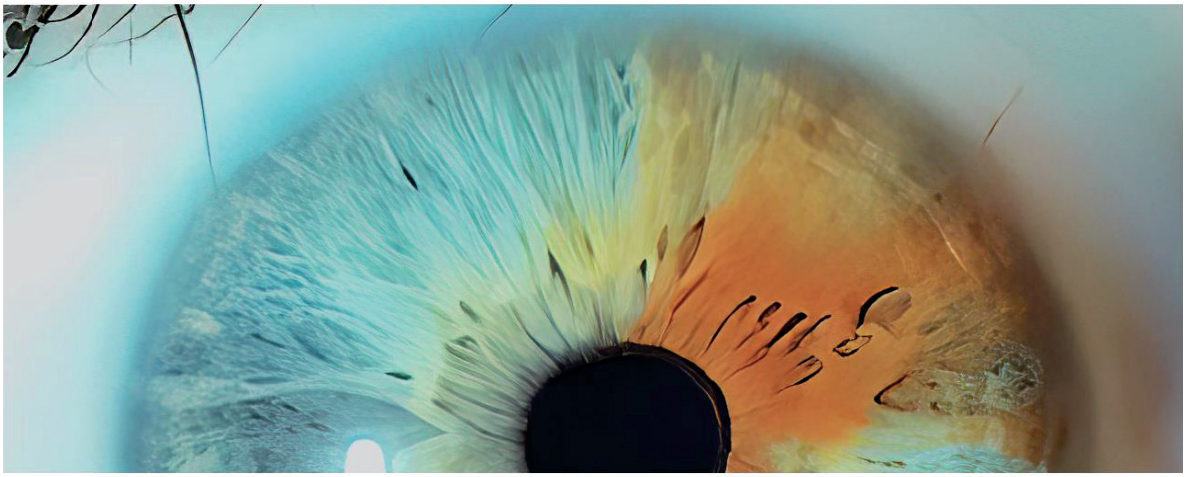
PART 3

COSMETIC RESULTS

CHAPTER 8 PATHOLOGY

3 8.1 Congenital Heterochromia





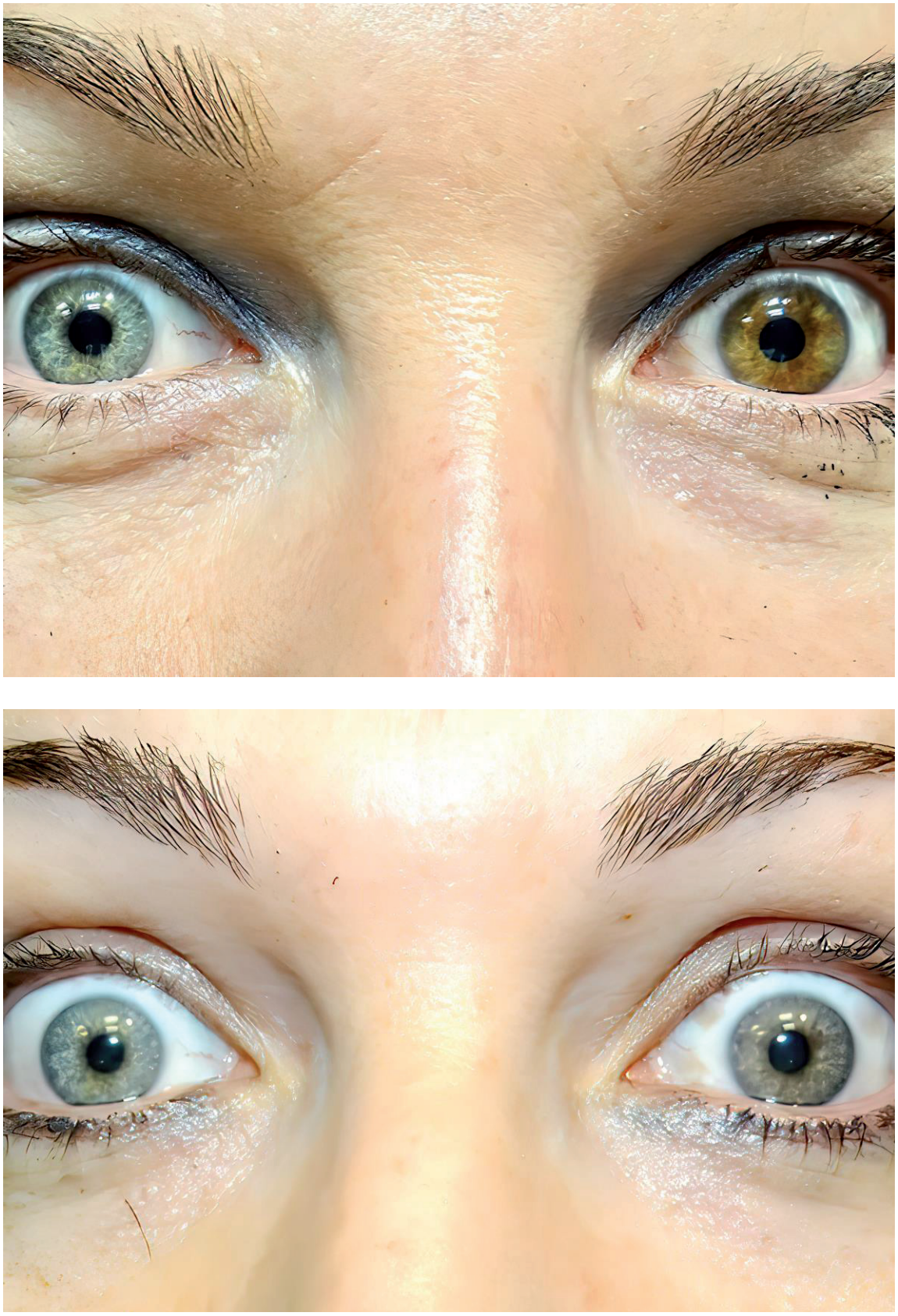
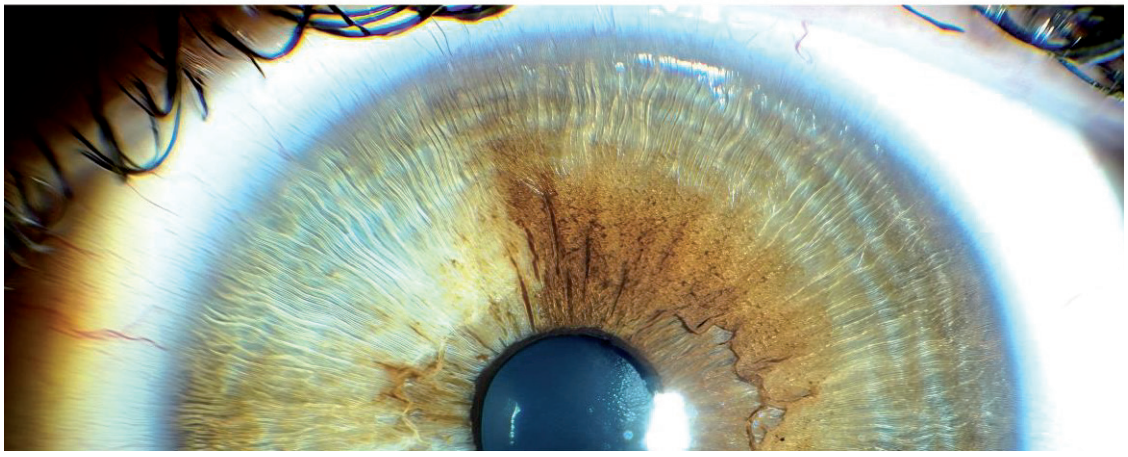


FIGURE 83: Complete melanin removal of full heterochromia

3 8.1 Congenital Heterochromia



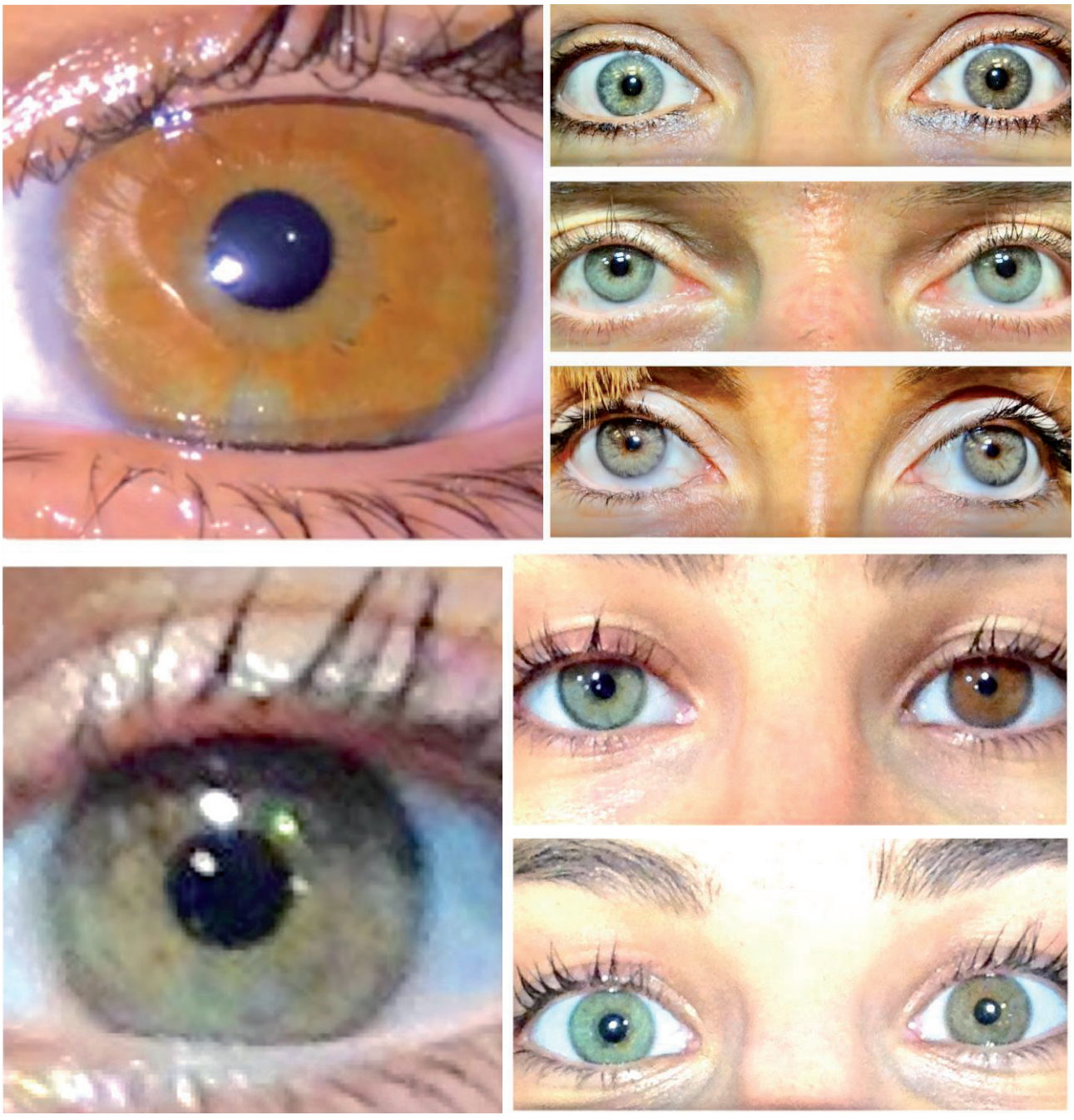
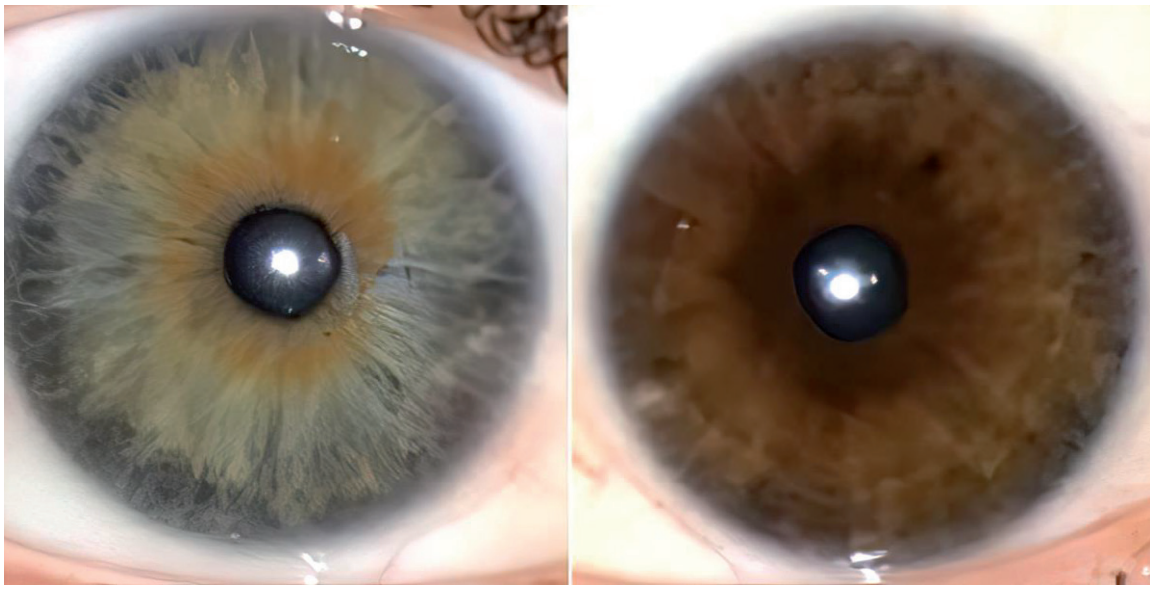
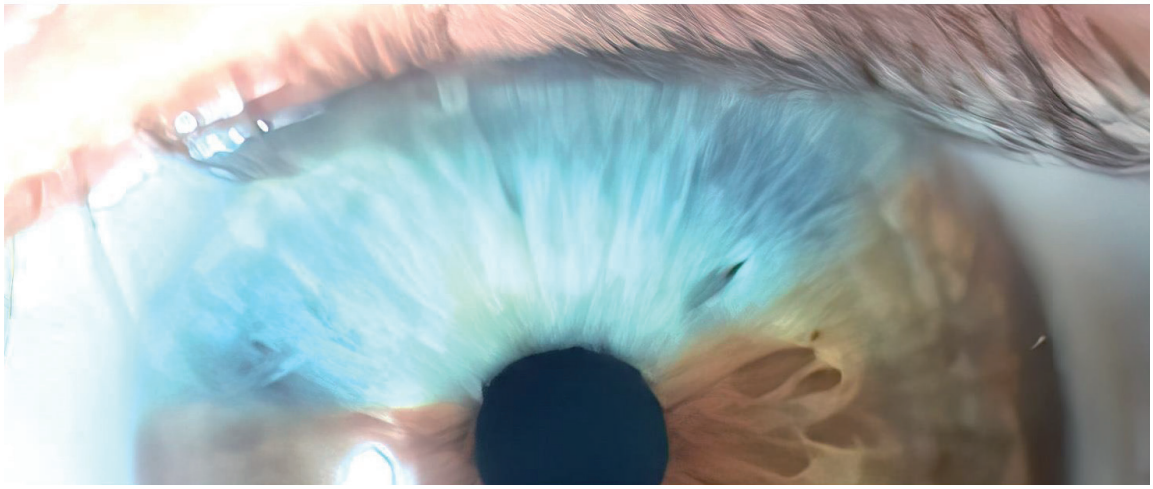


FIGURE 84: Full pigment removal of congenital heterochromies

3 8.1 Congenital Heterochromia





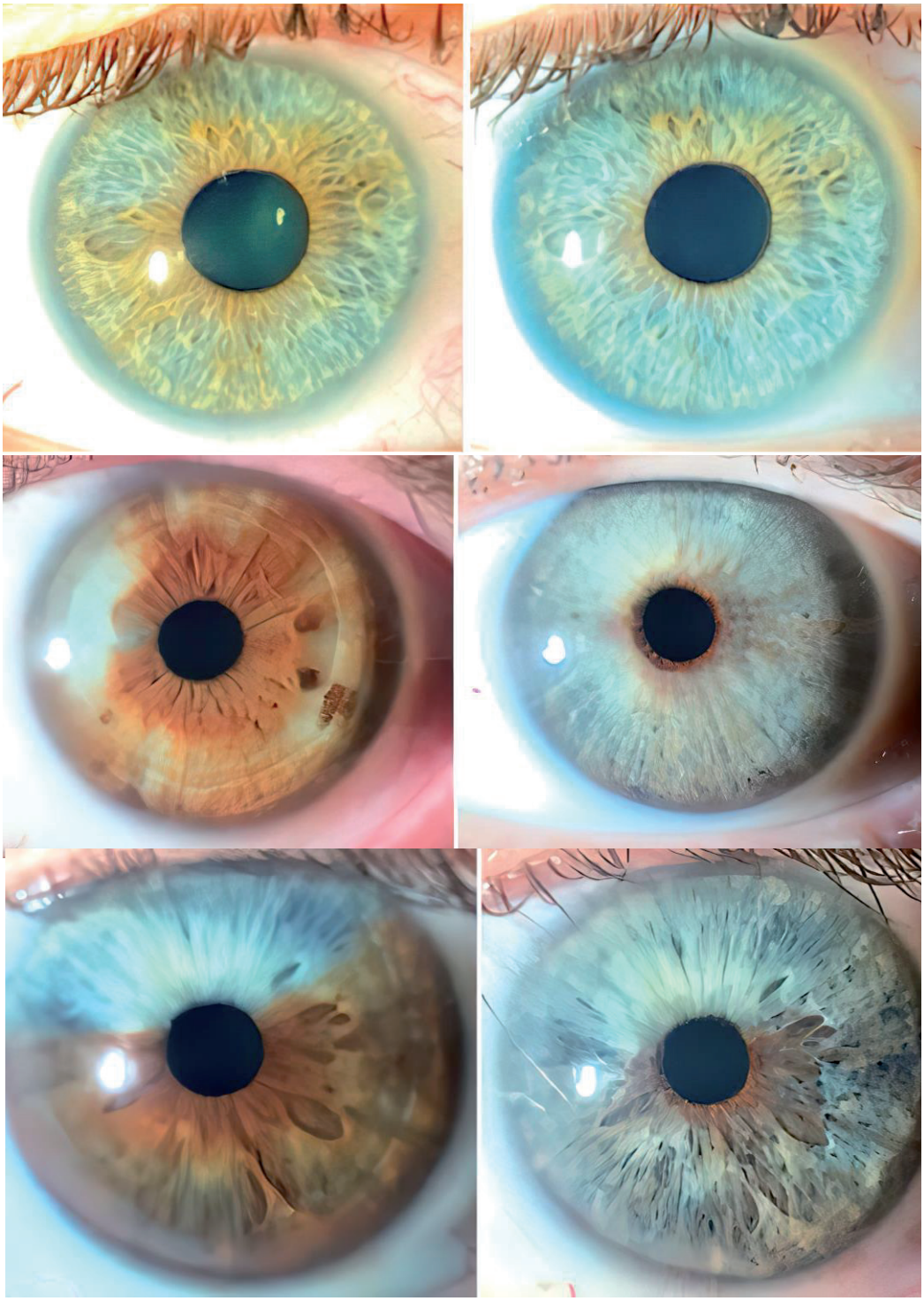
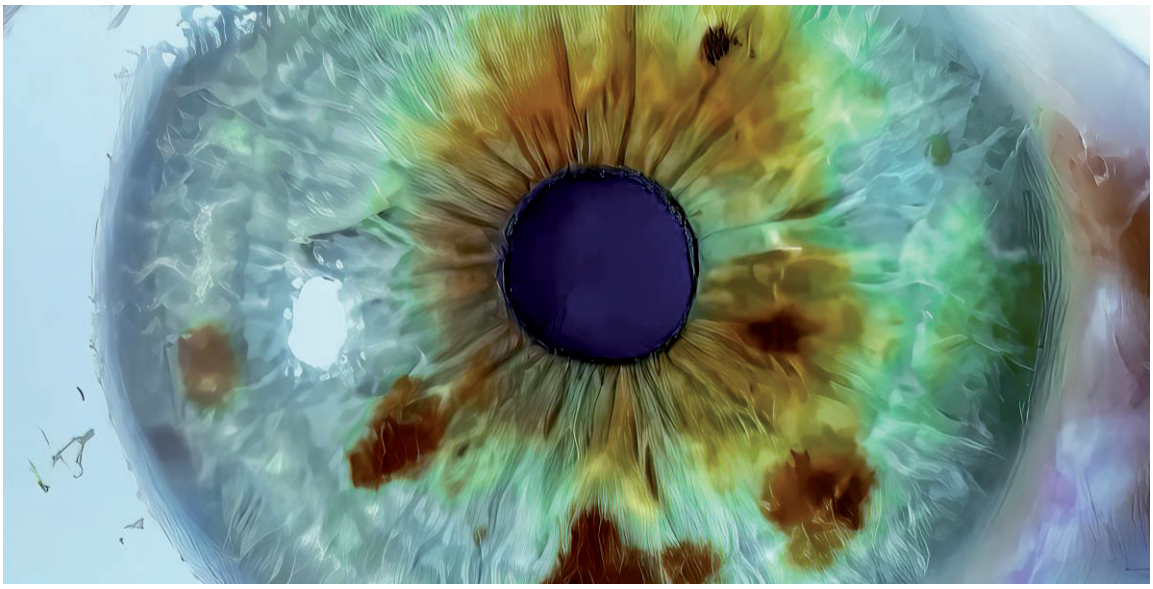
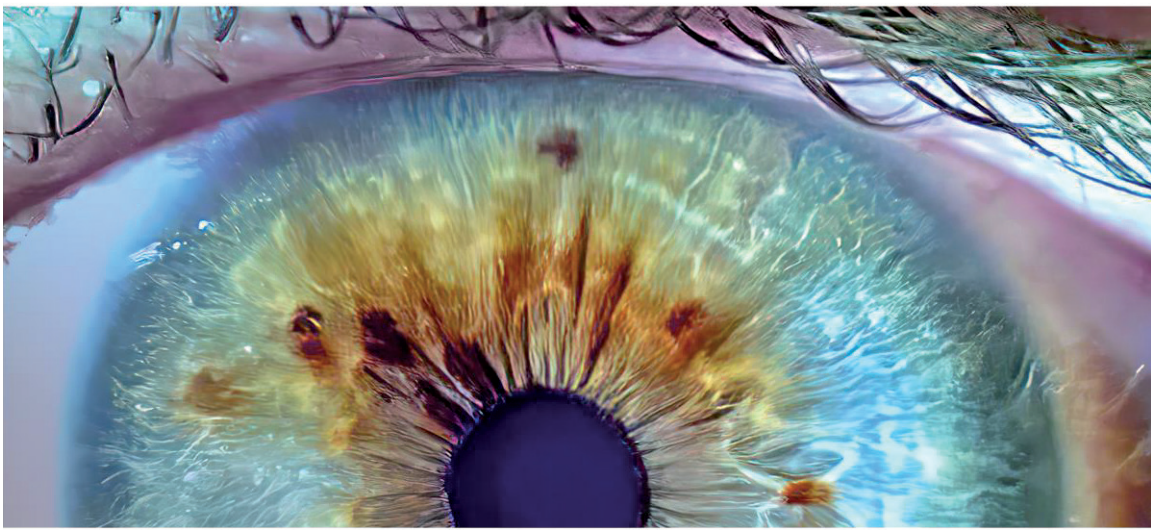


FIGURE 85: Result examples of partial heterochromies

3 8.2 Nevus





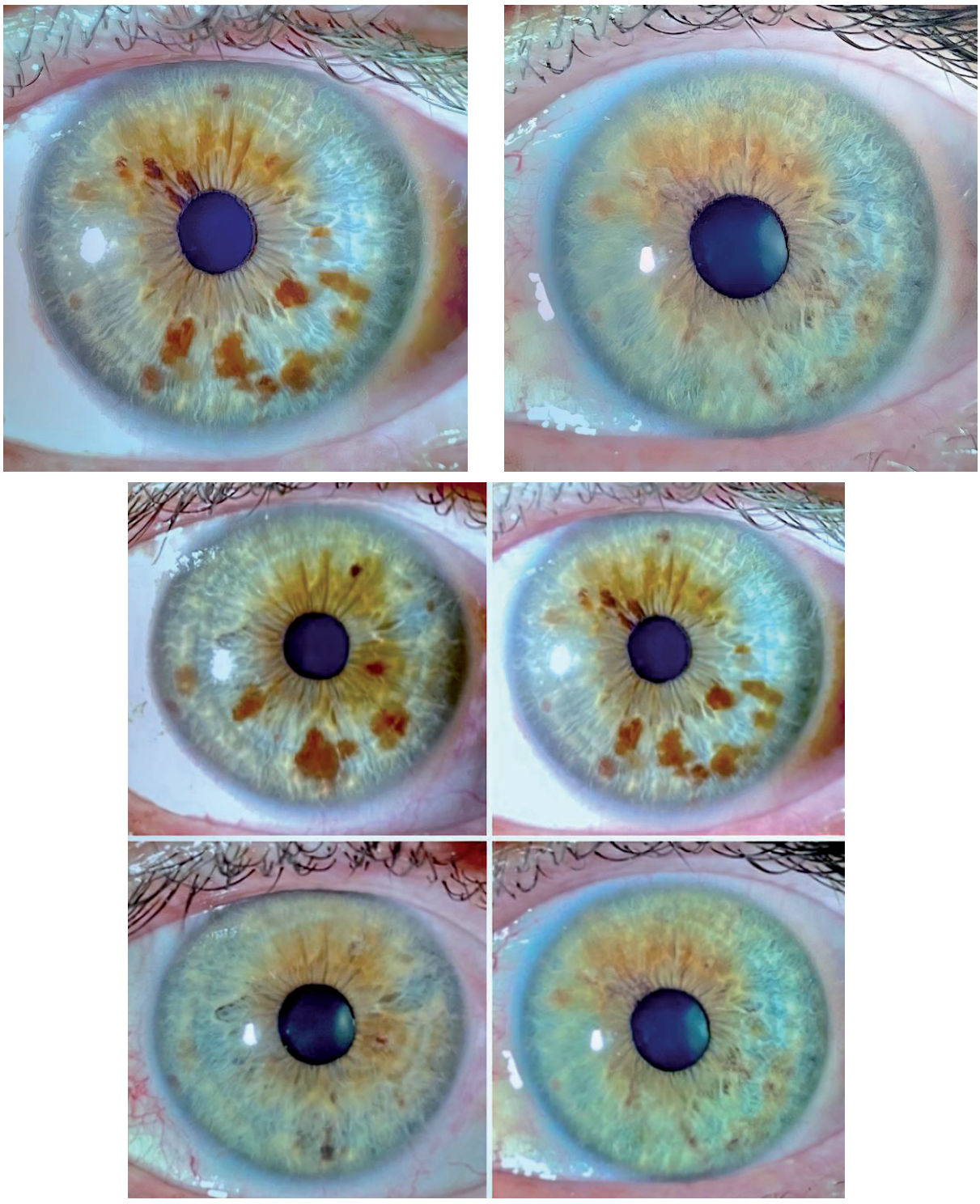
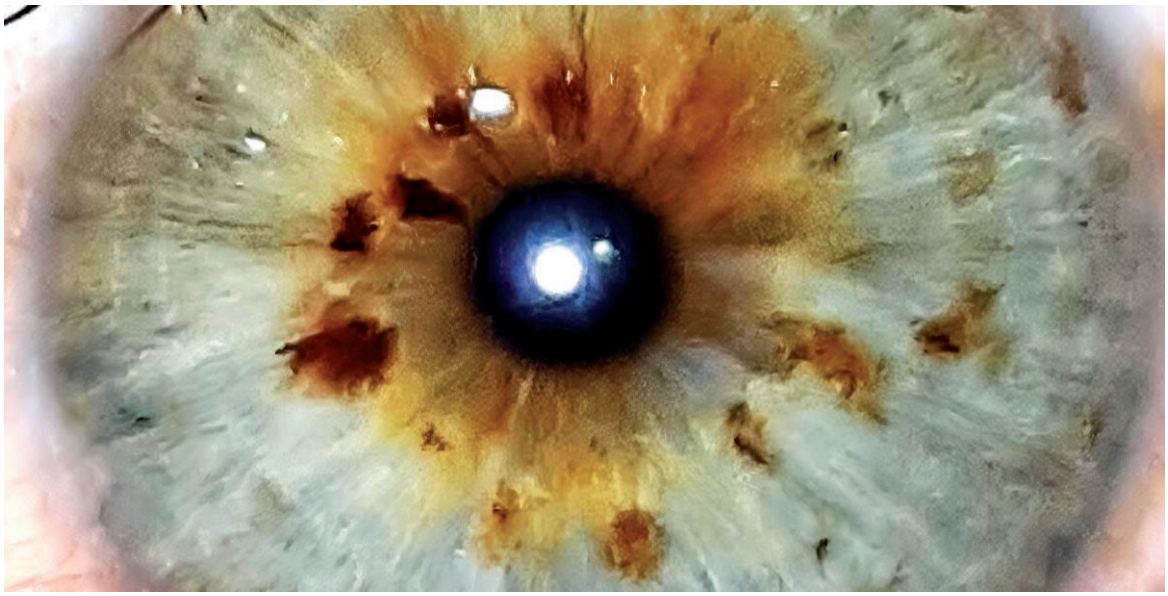
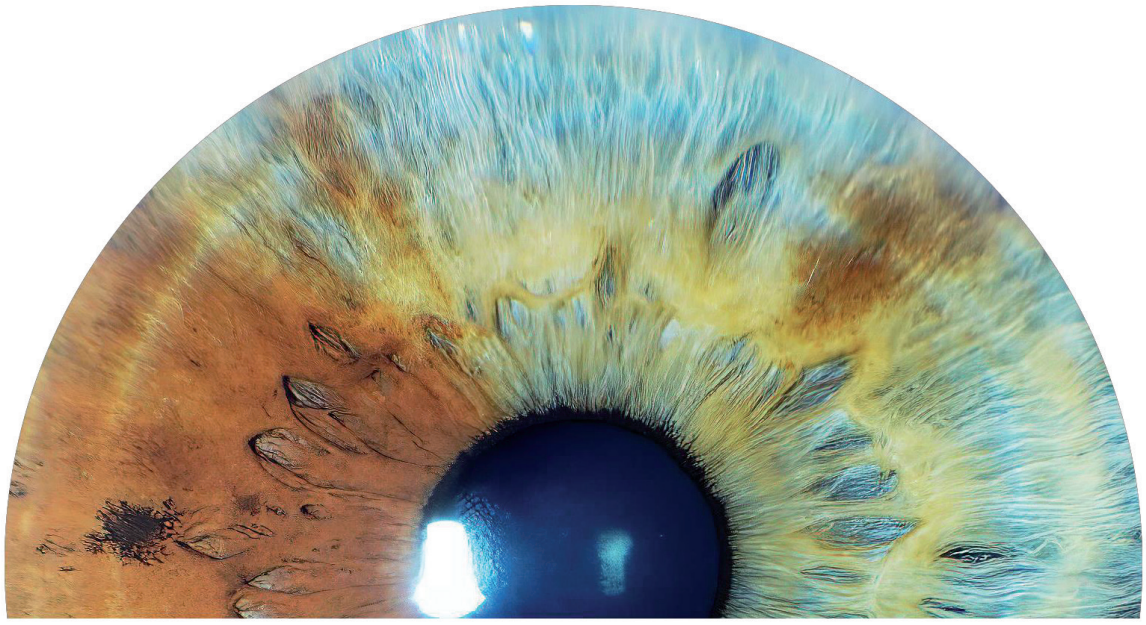


FIGURE 86: Full pigment removal on a typical multinevi case

3 8.2 Nevus





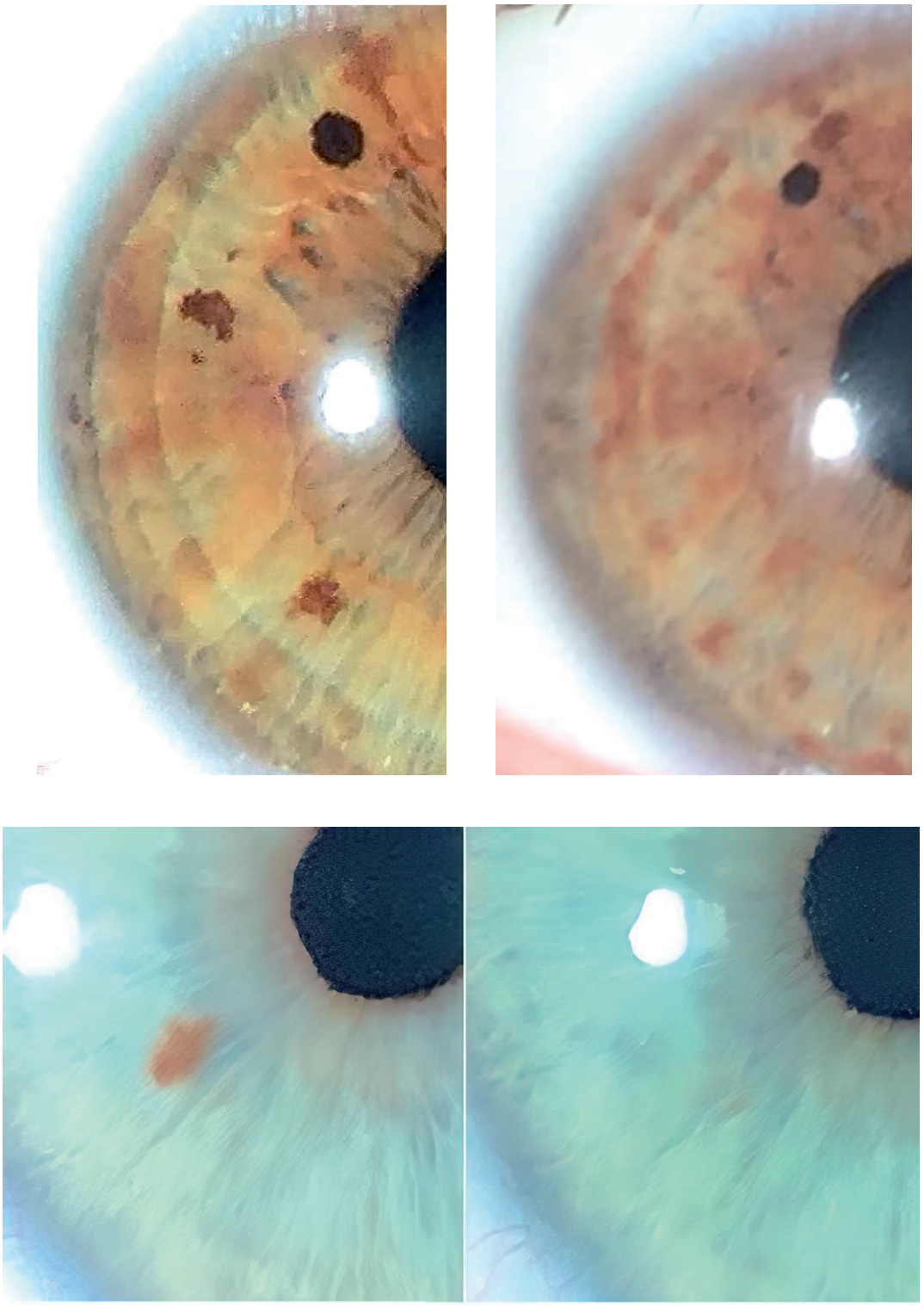
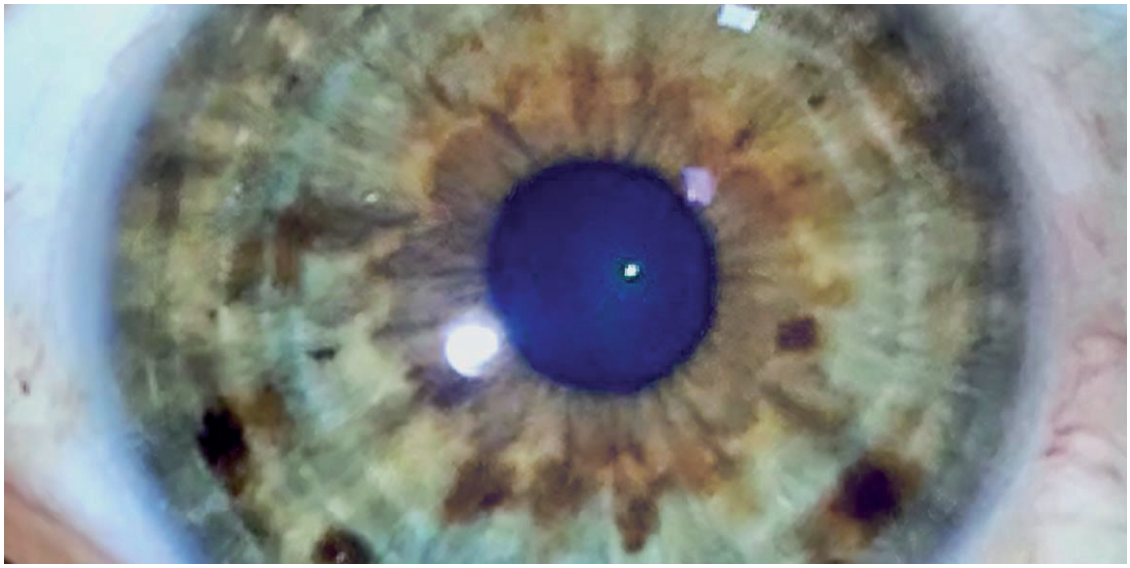
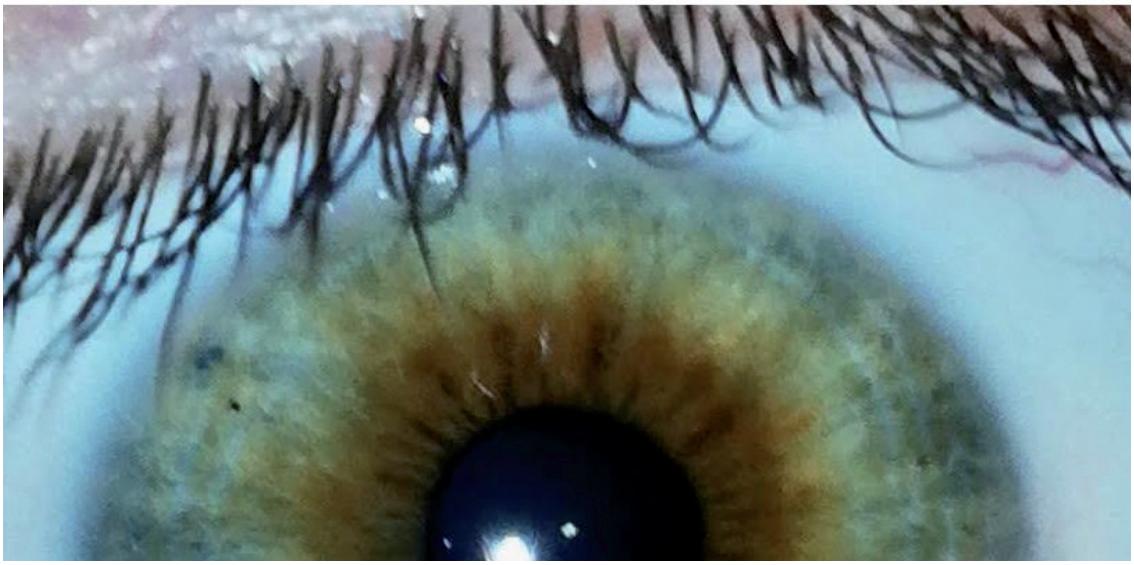


FIGURE 87: Complete removal of small and medium nevus

3 8.2 Nevus





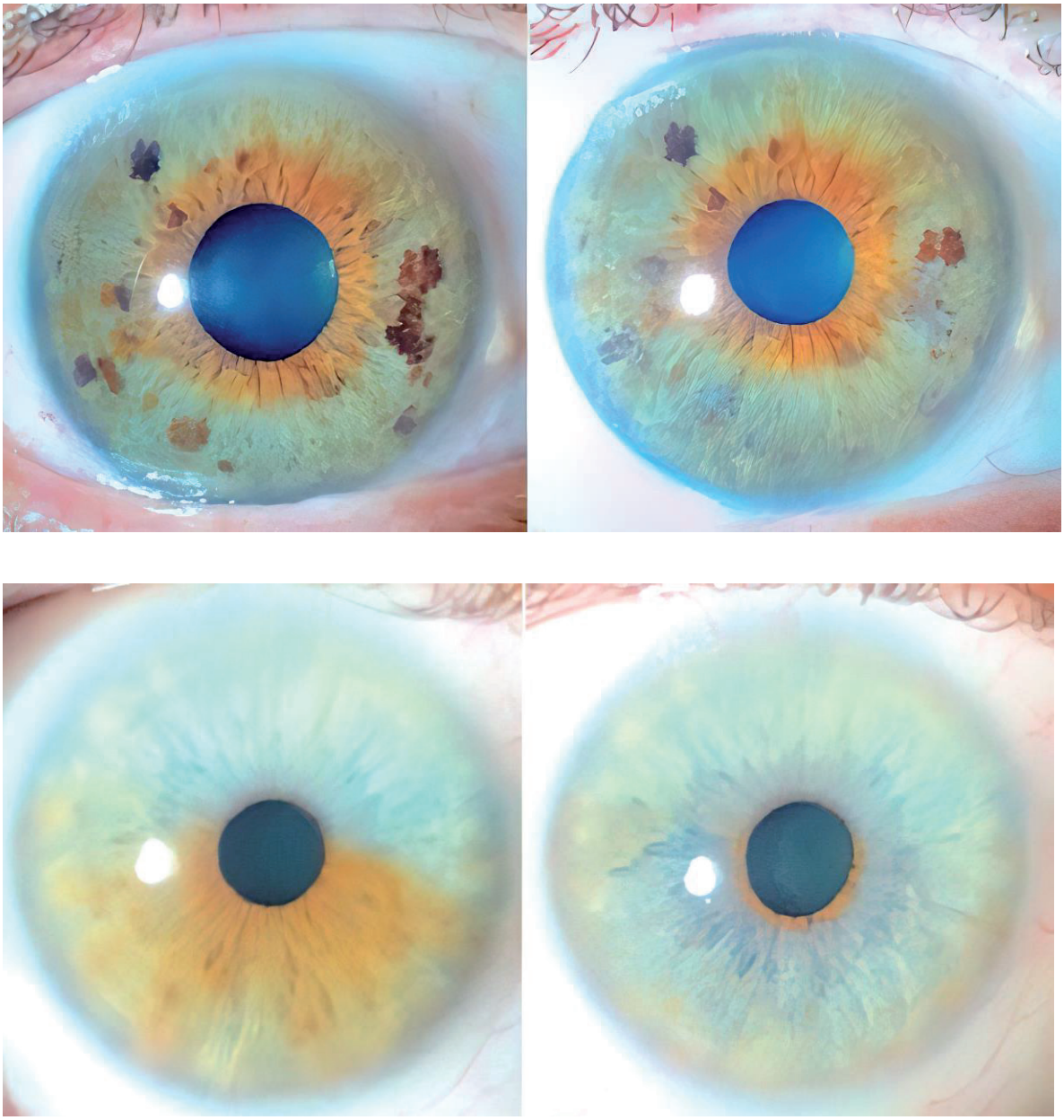
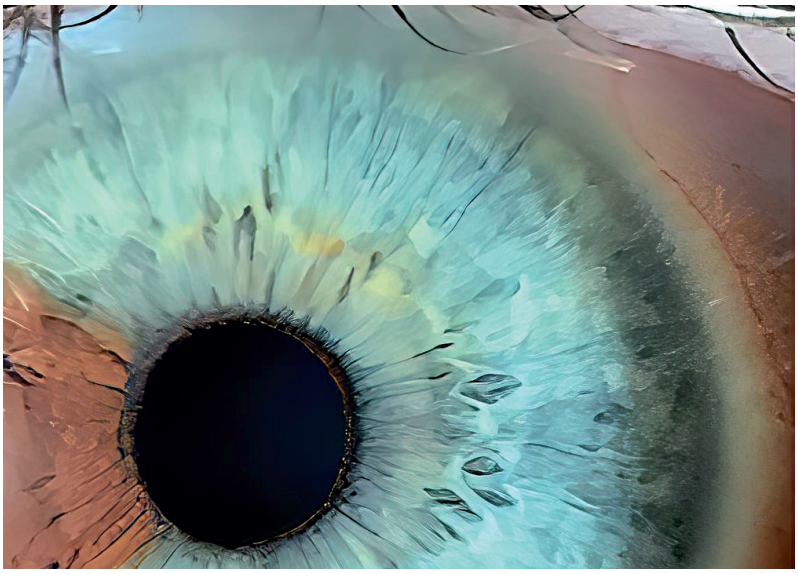
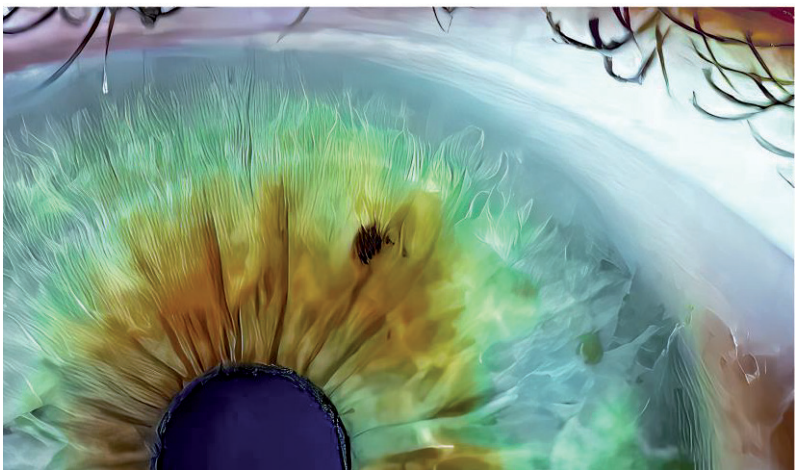


FIGURE 88: Dynamic nevi and partial heterochromy good results

3 8.2 Nevus





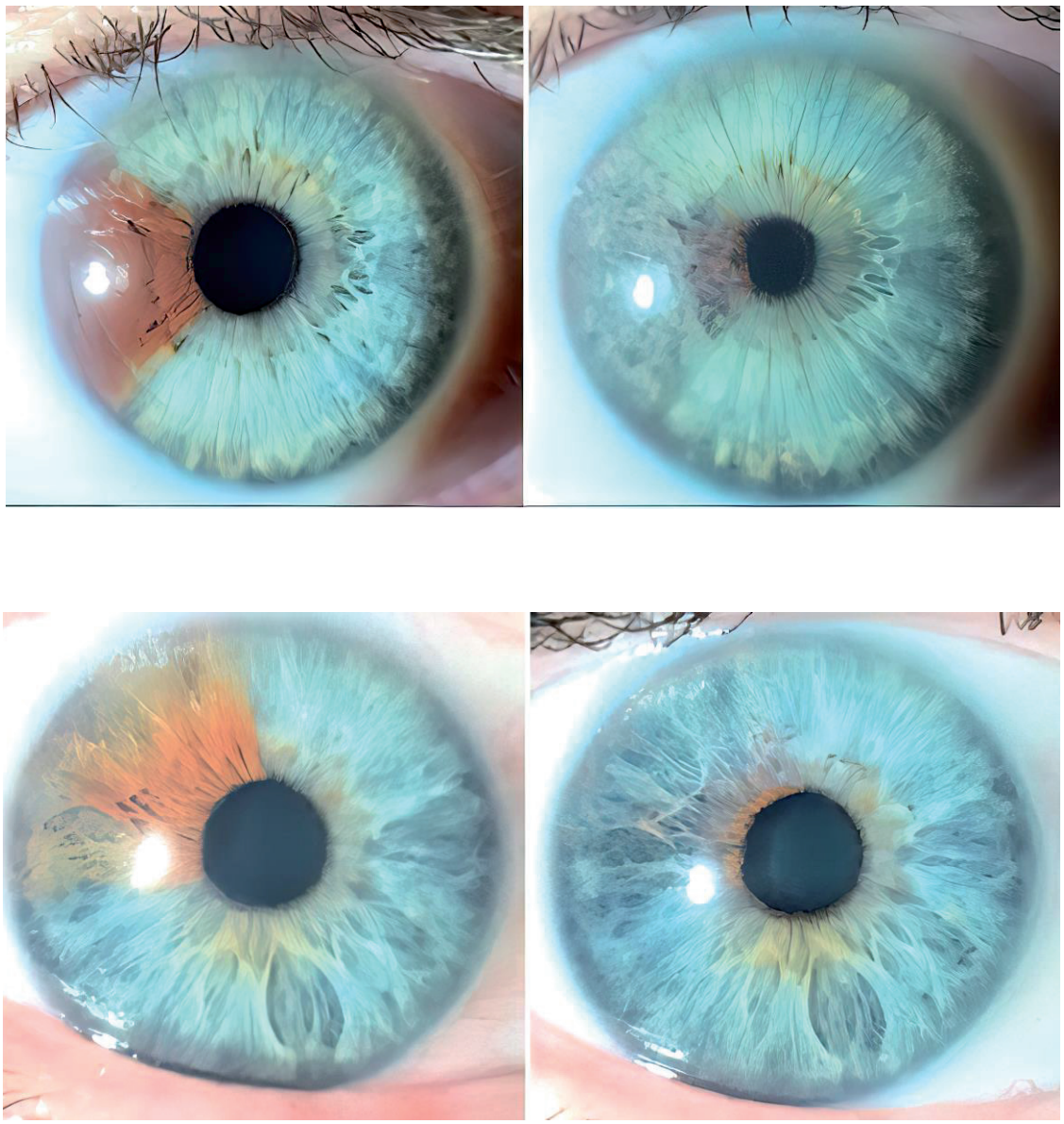
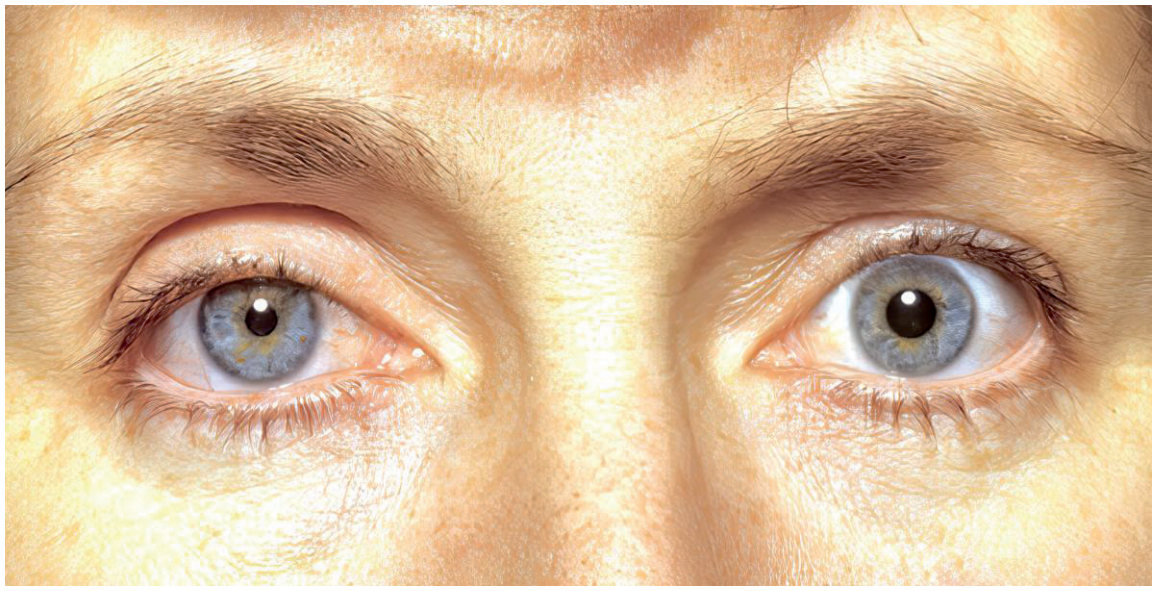
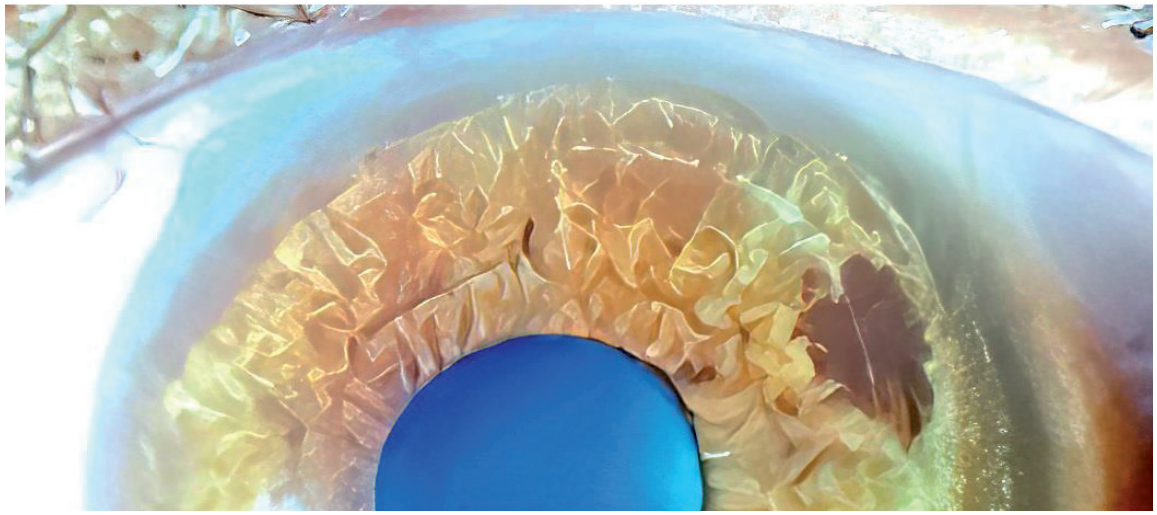
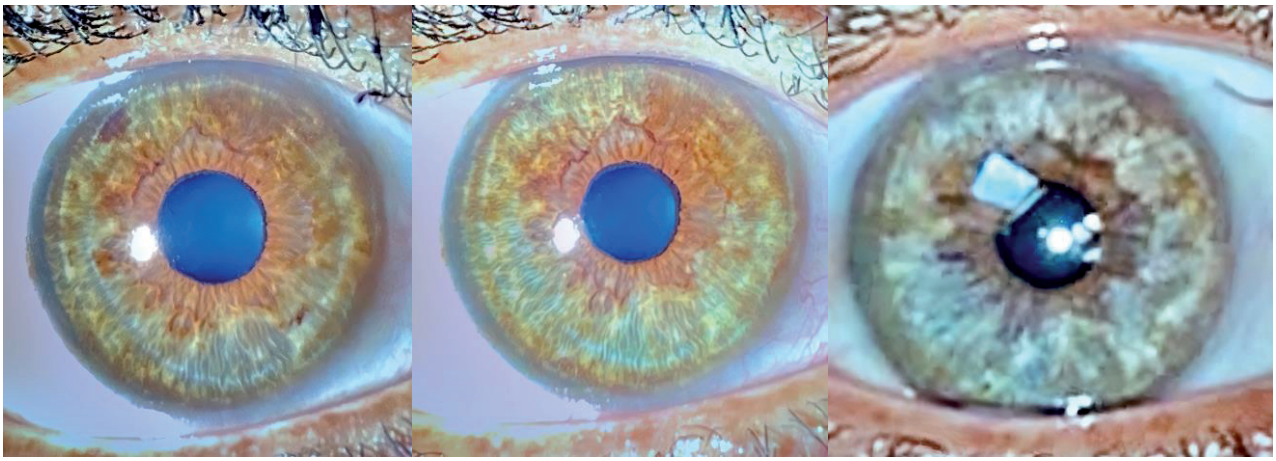


FIGURE 89: Big nevus. Good estethic results with complete cleaning

3 8.3 Syndrome BH







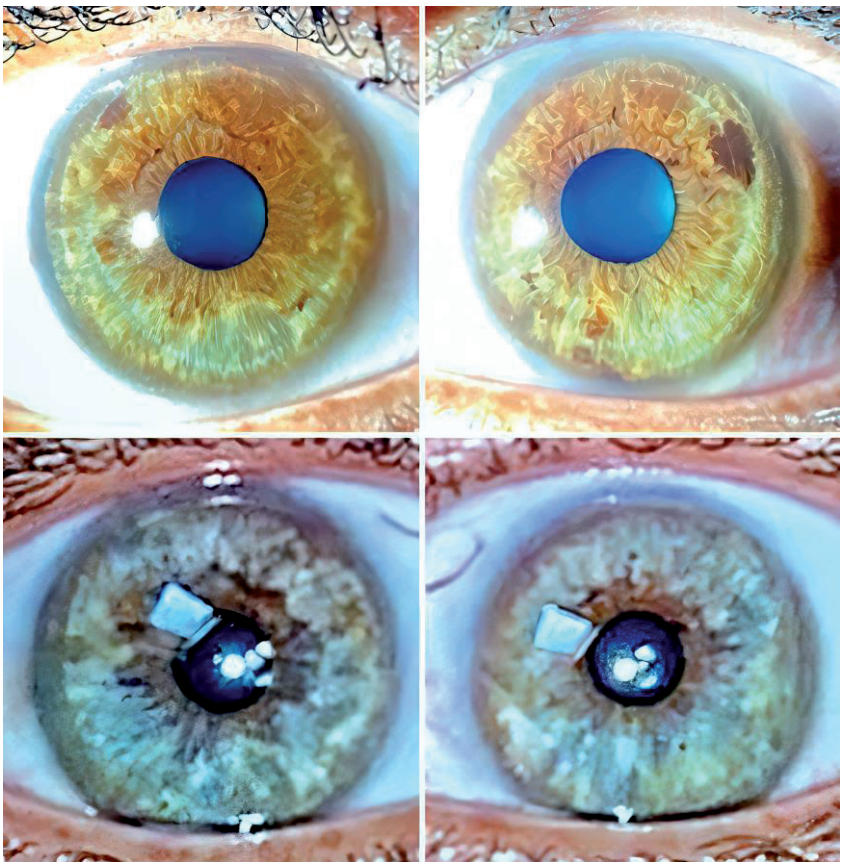
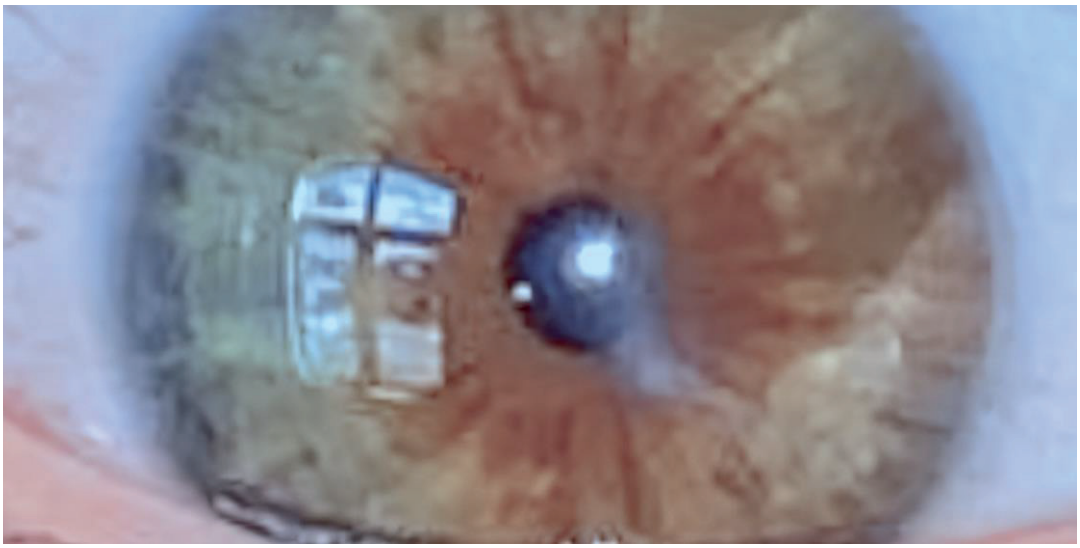
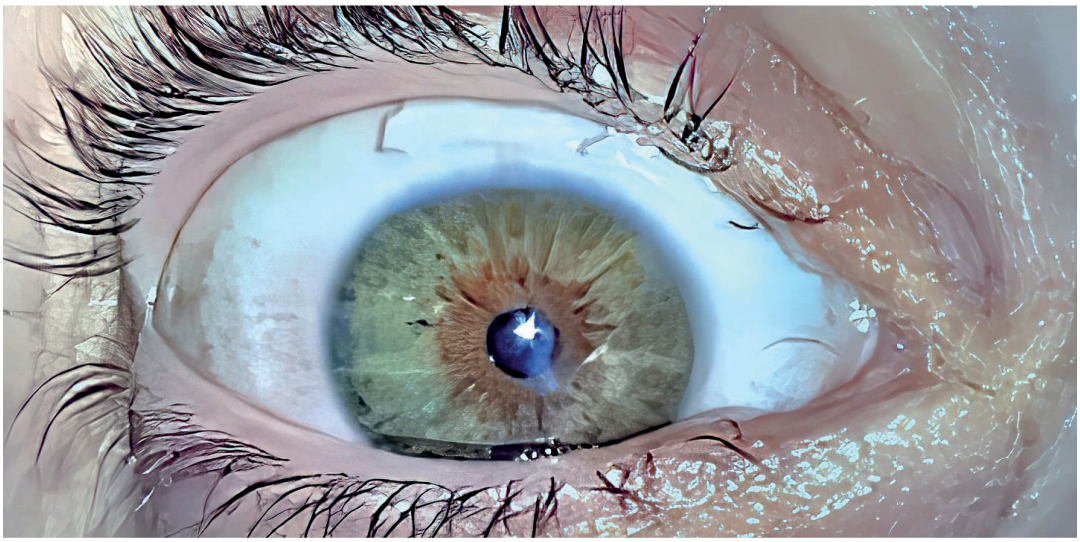


FIGURE 90: Nevus removal on Bernard-Horner syndrome

3 8.4 Trauma





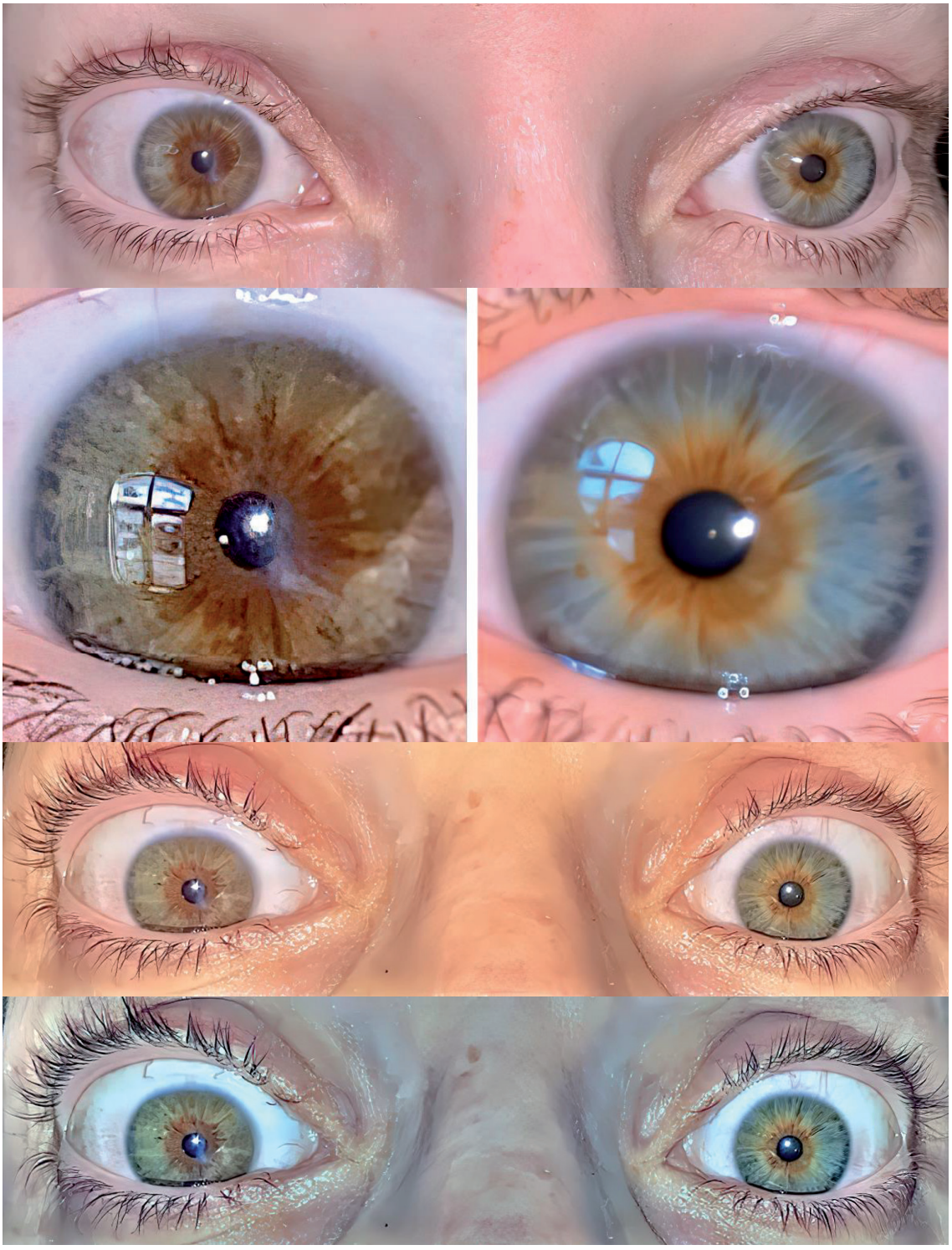
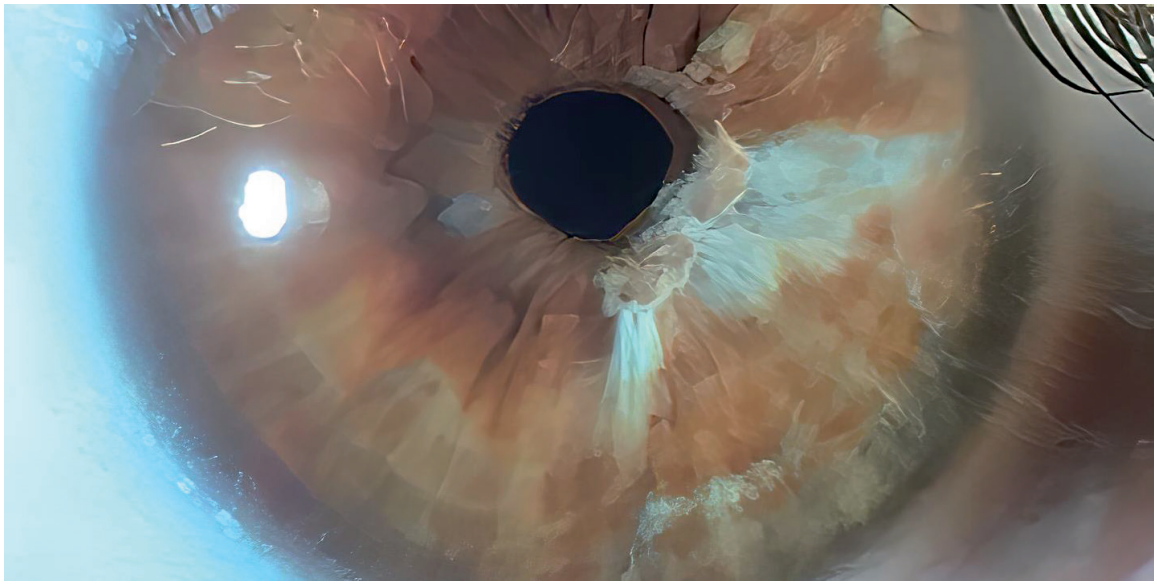
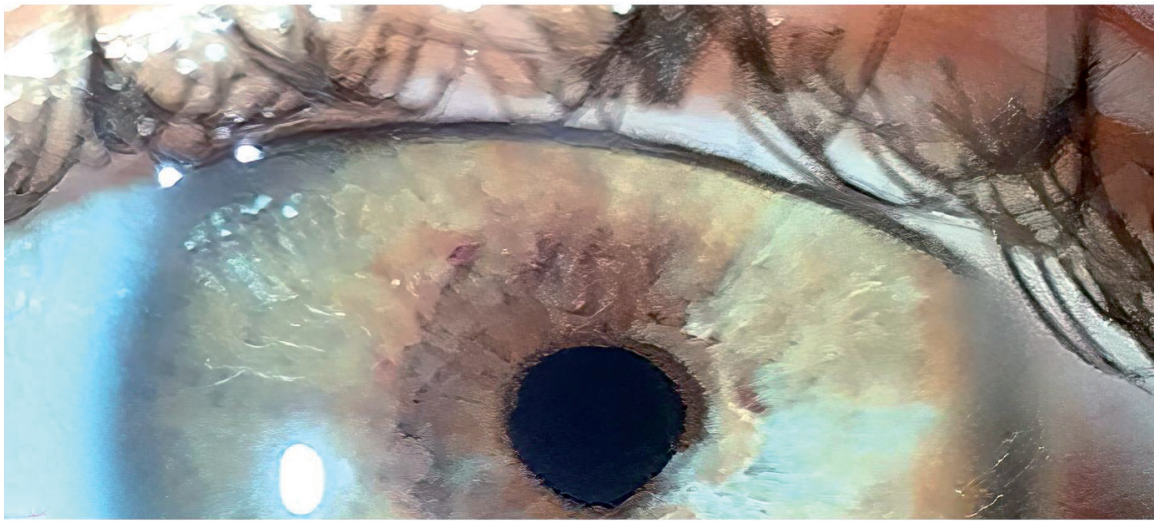


FIGURE 91: Central heterochromy, secondary to corneal trauma

3 8.4 Trauma





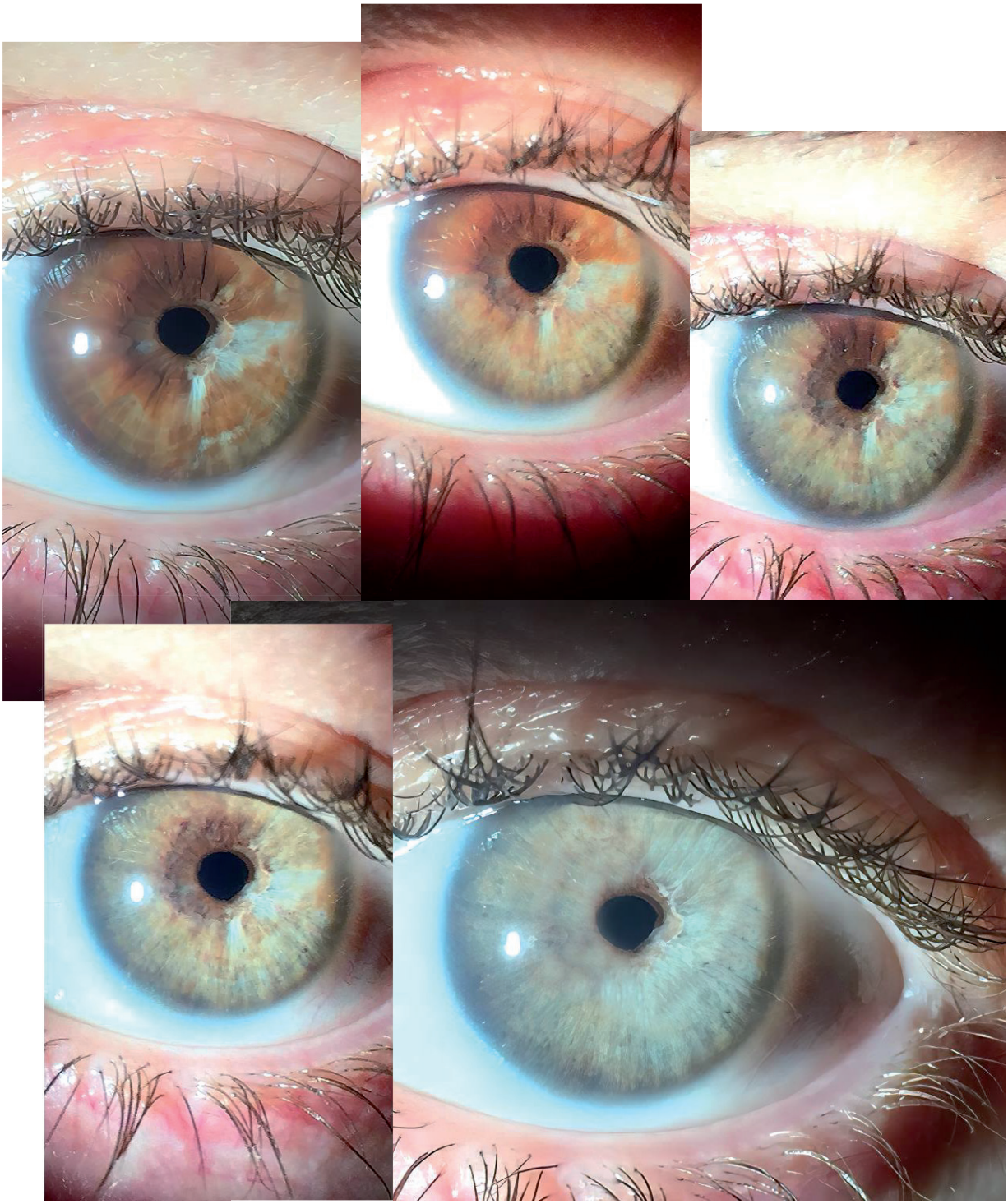
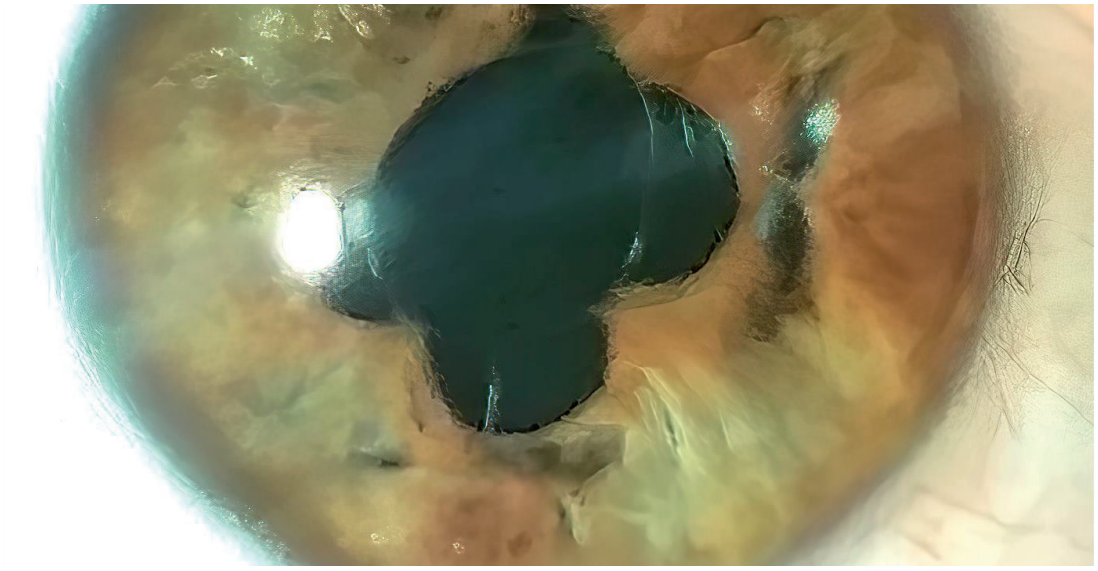
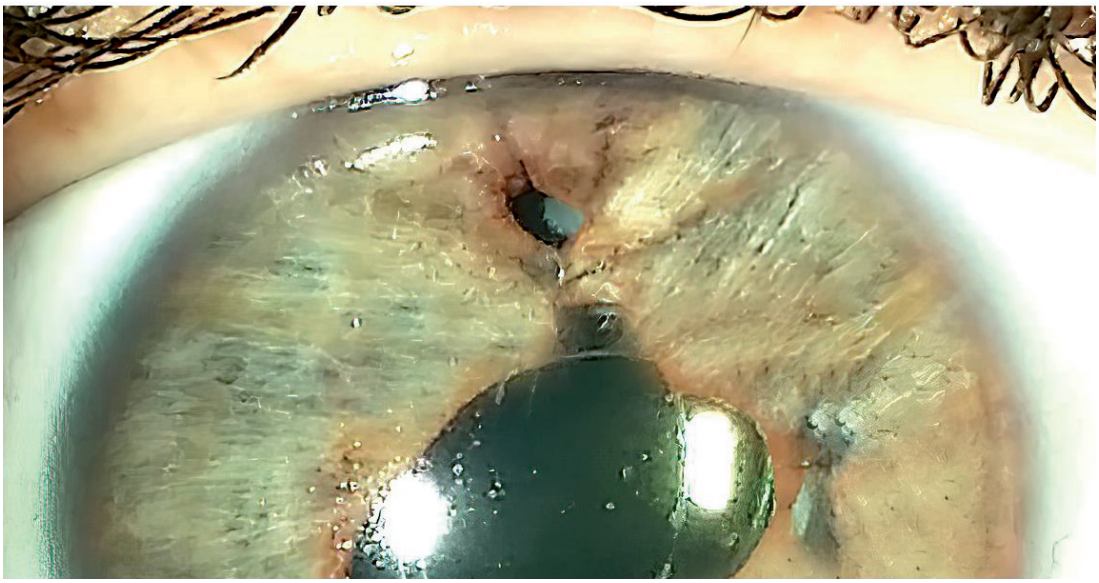


FIGURE 92: Progressive lightening on iris darkening after eye trauma

3 8.4 Trauma





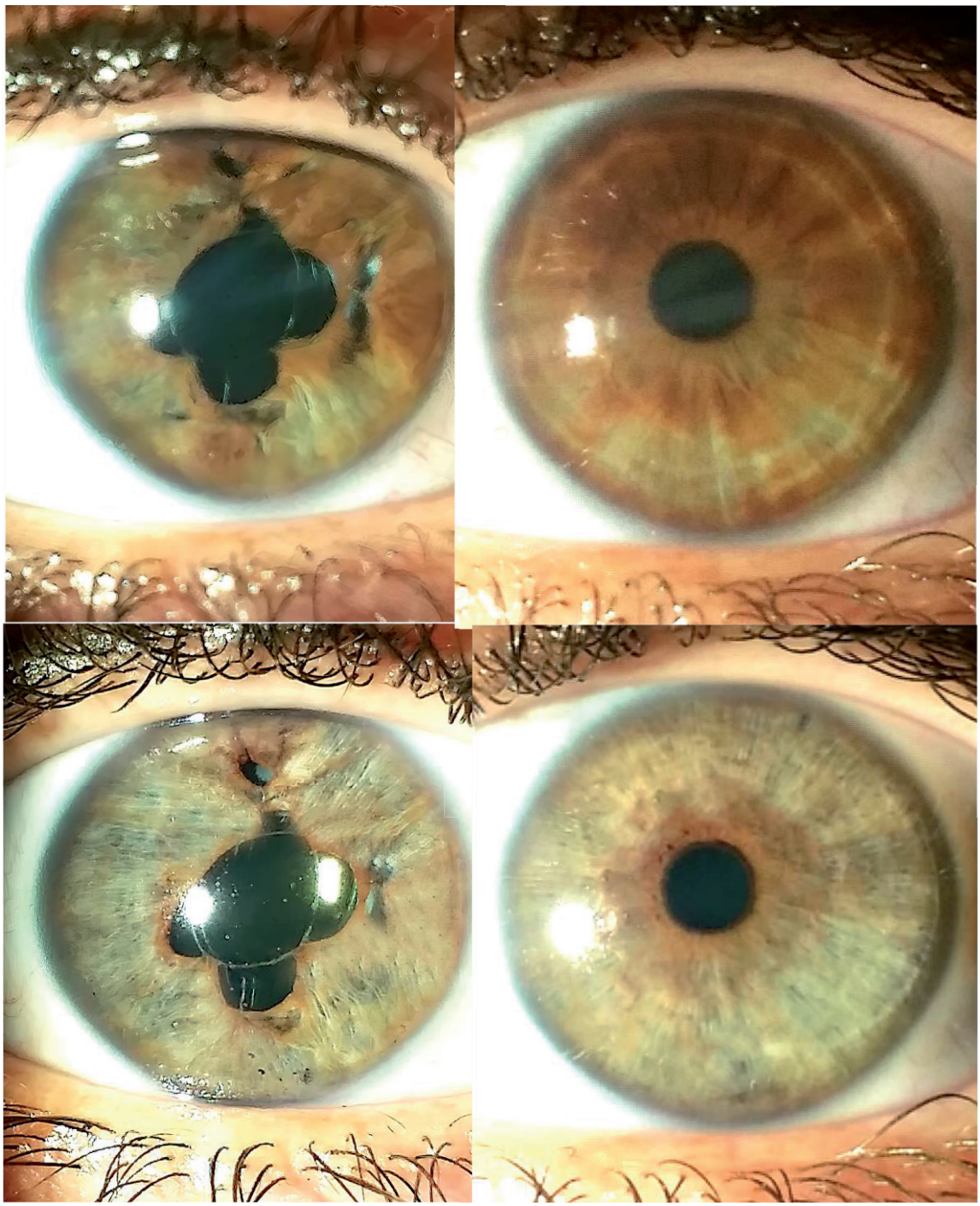
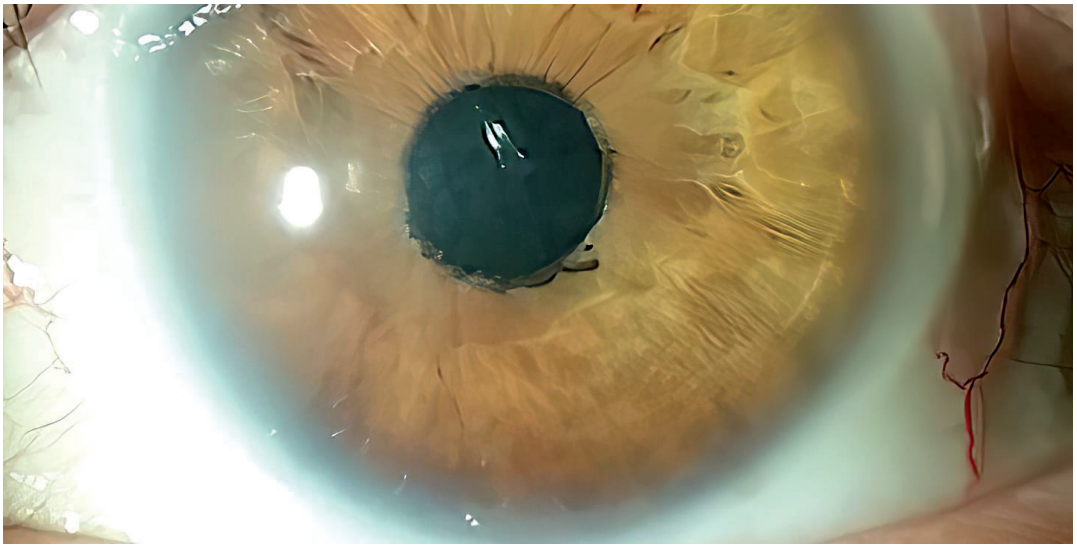
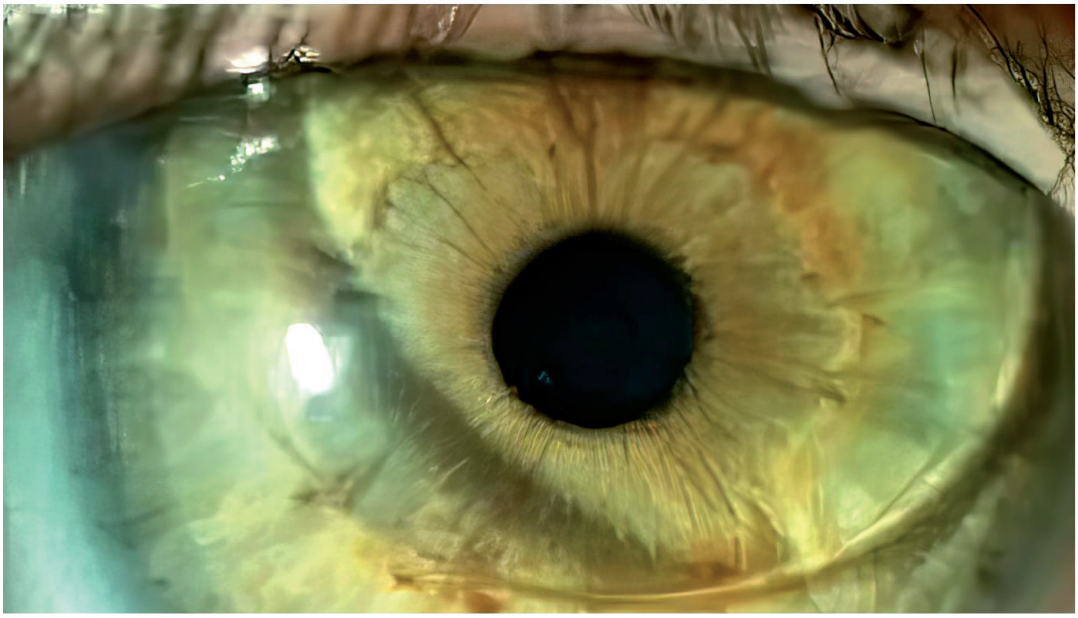


FIGURE 93: Pigment removal after left eye surf devasting trauma

3 8.4 Surgery





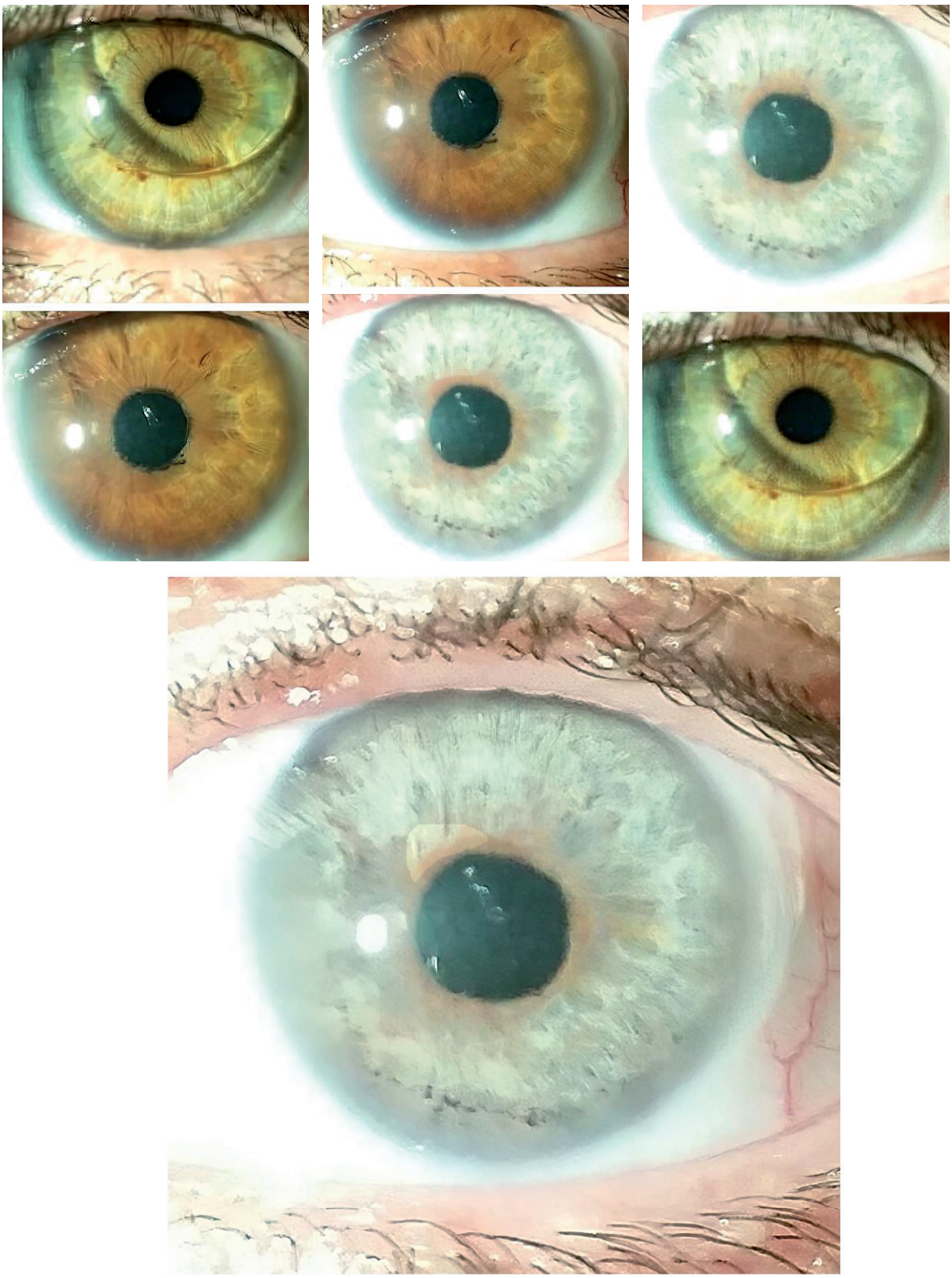
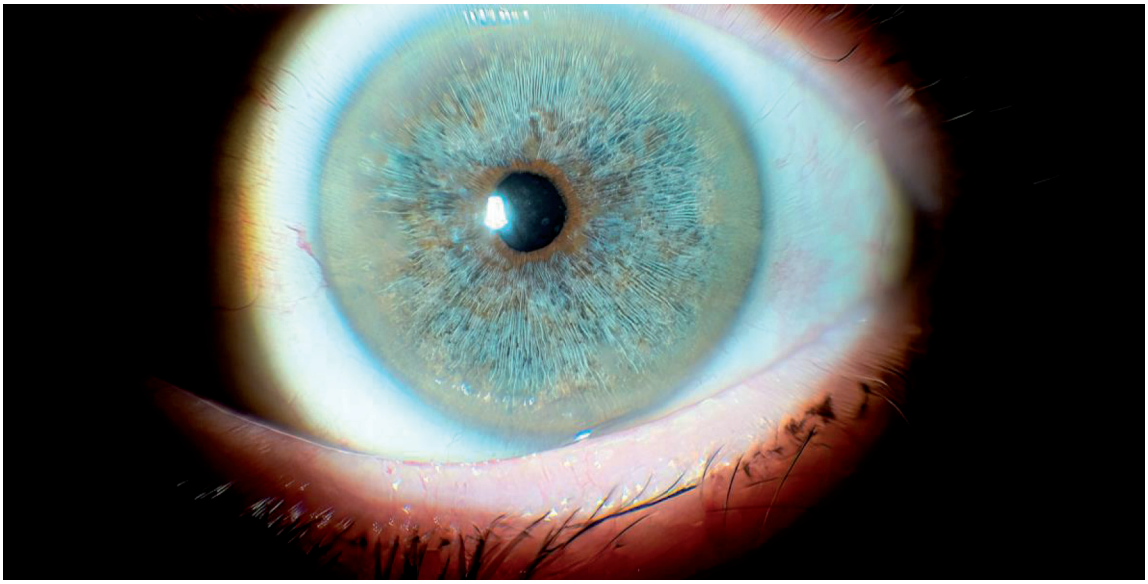
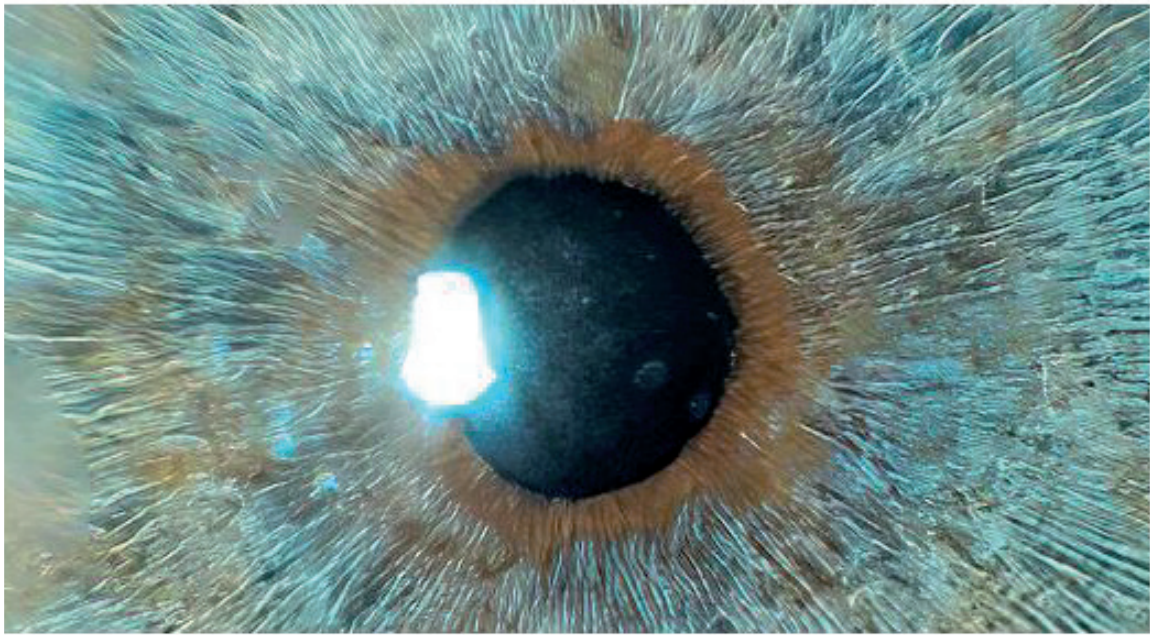


FIGURE 94: Esthetic result after congenital cataract surgery

3 8.4 Surgery





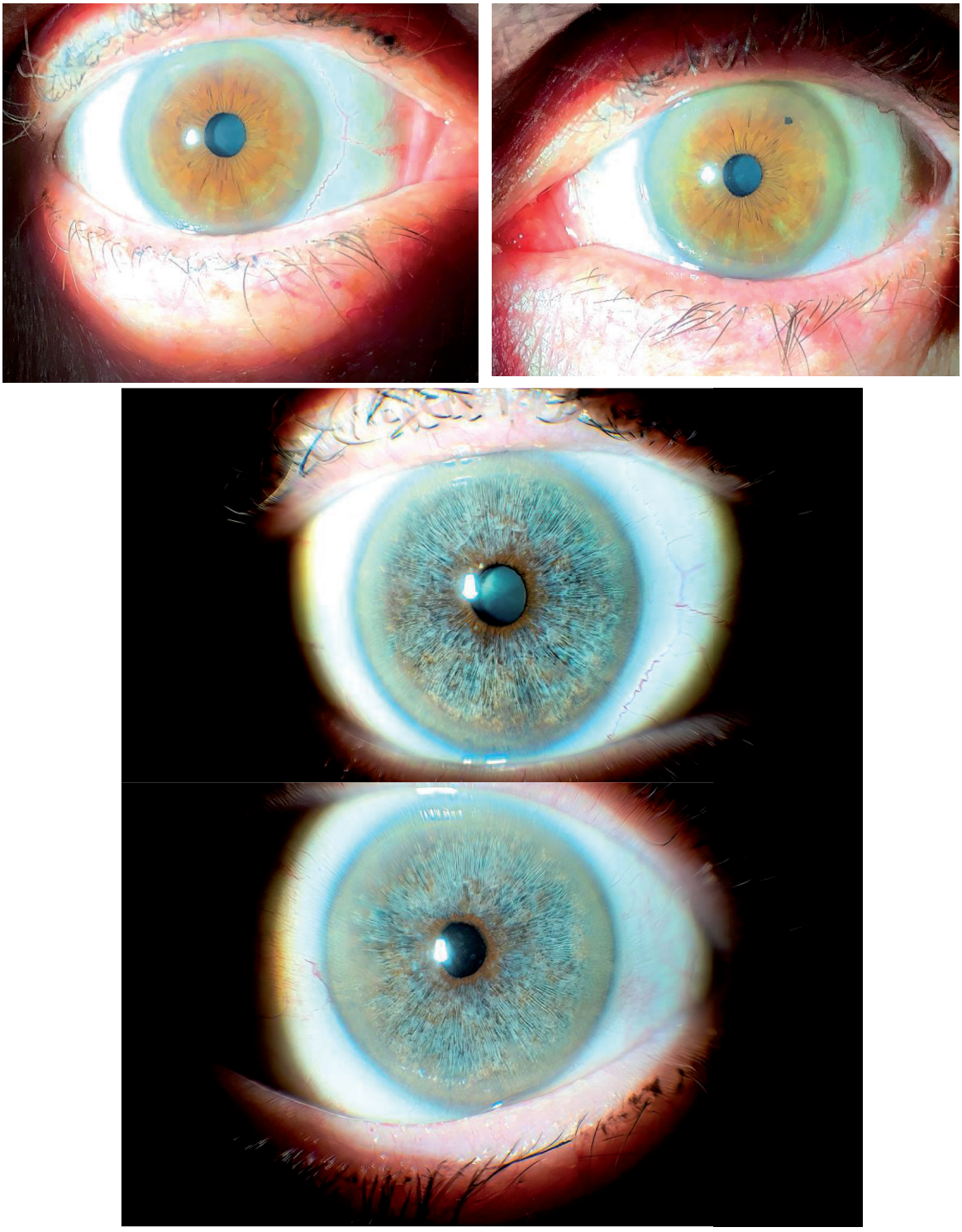
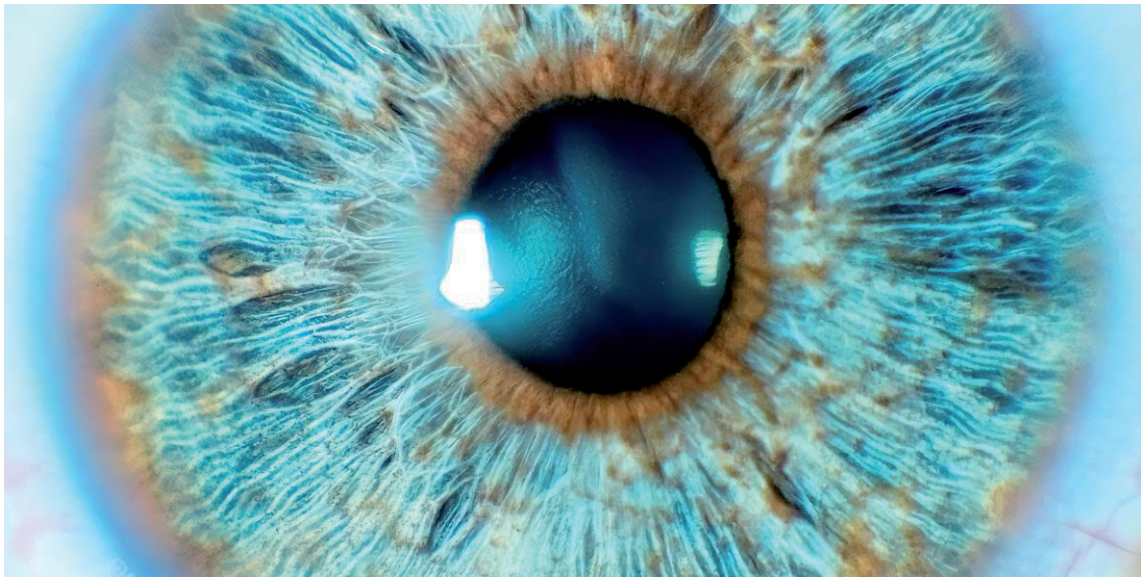
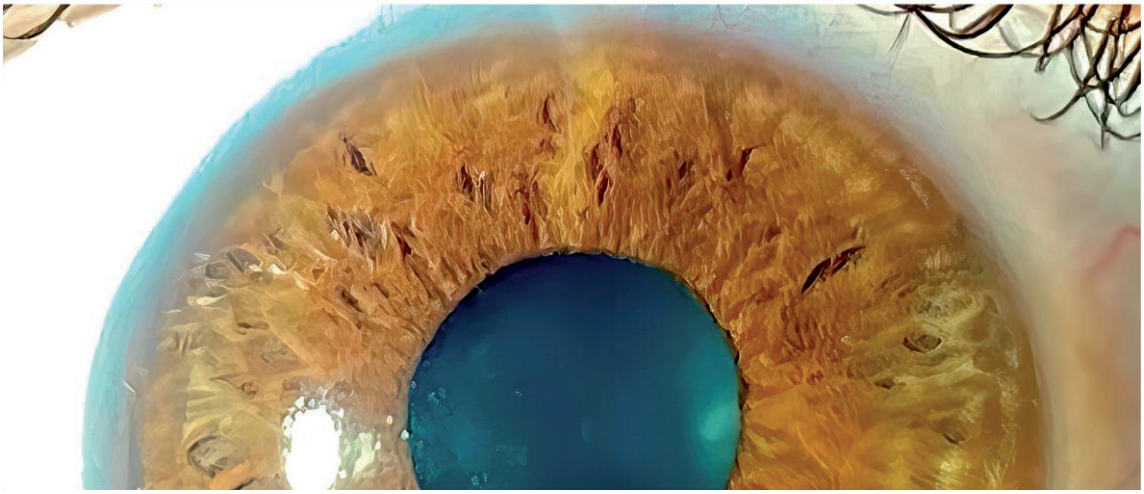


FIGURE 95: Cosmetic result on left eye cataract surgery case

3 8.4 Surgery





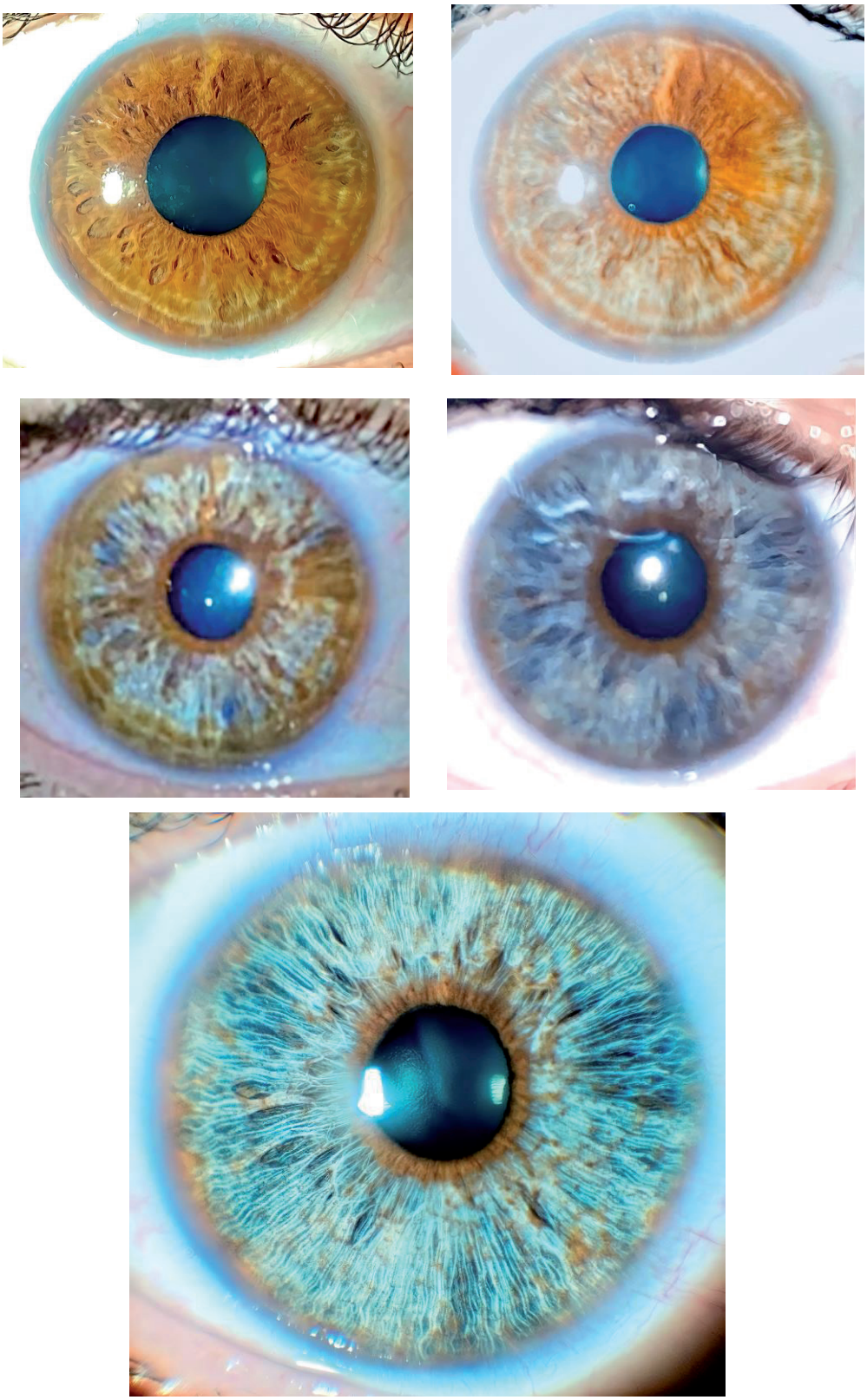
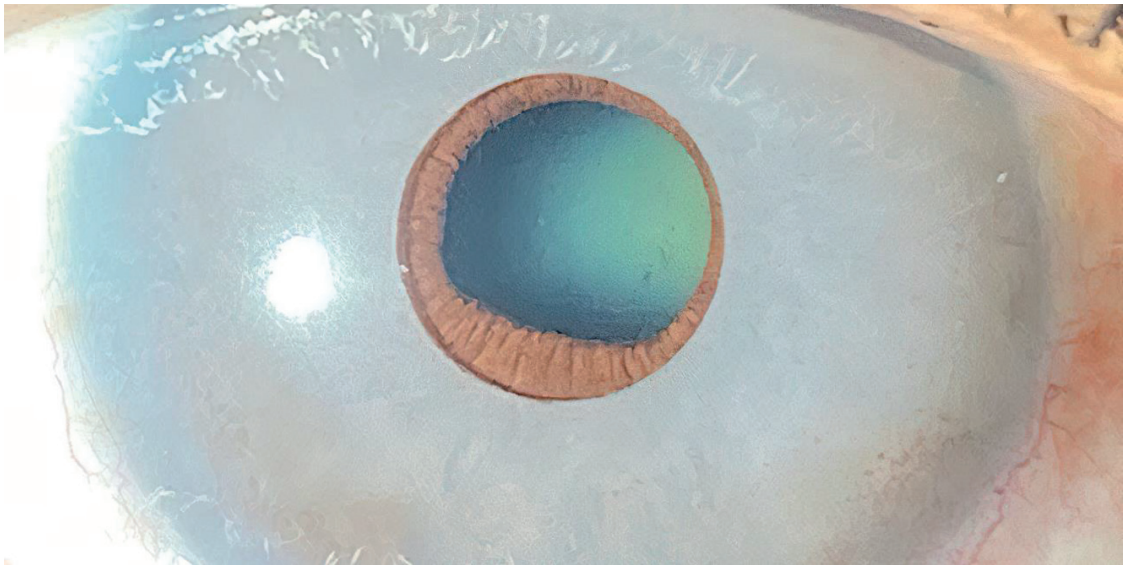
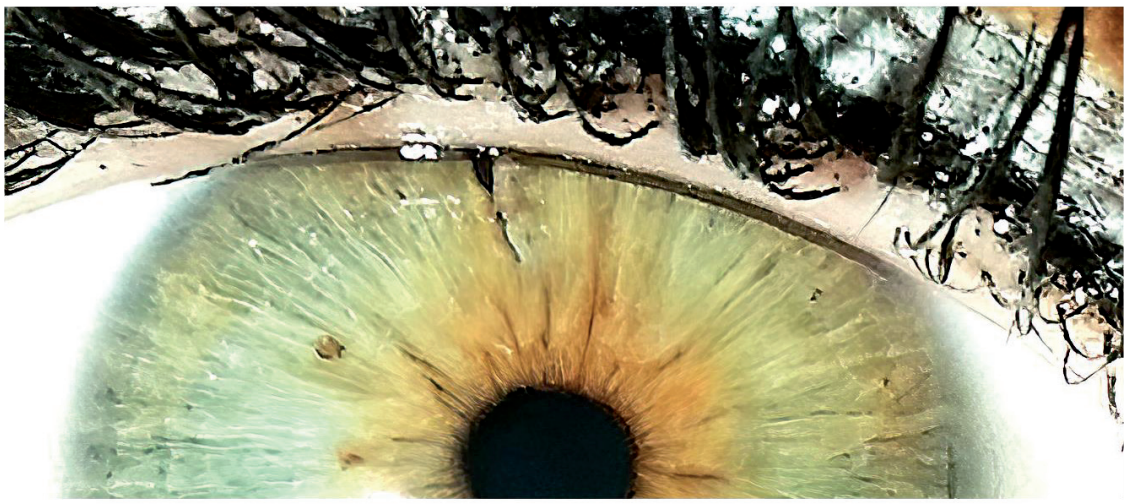


FIGURE 96: Laser Iridoplasty after lasik and failed corneal tattoo

3 8.4 Surgery





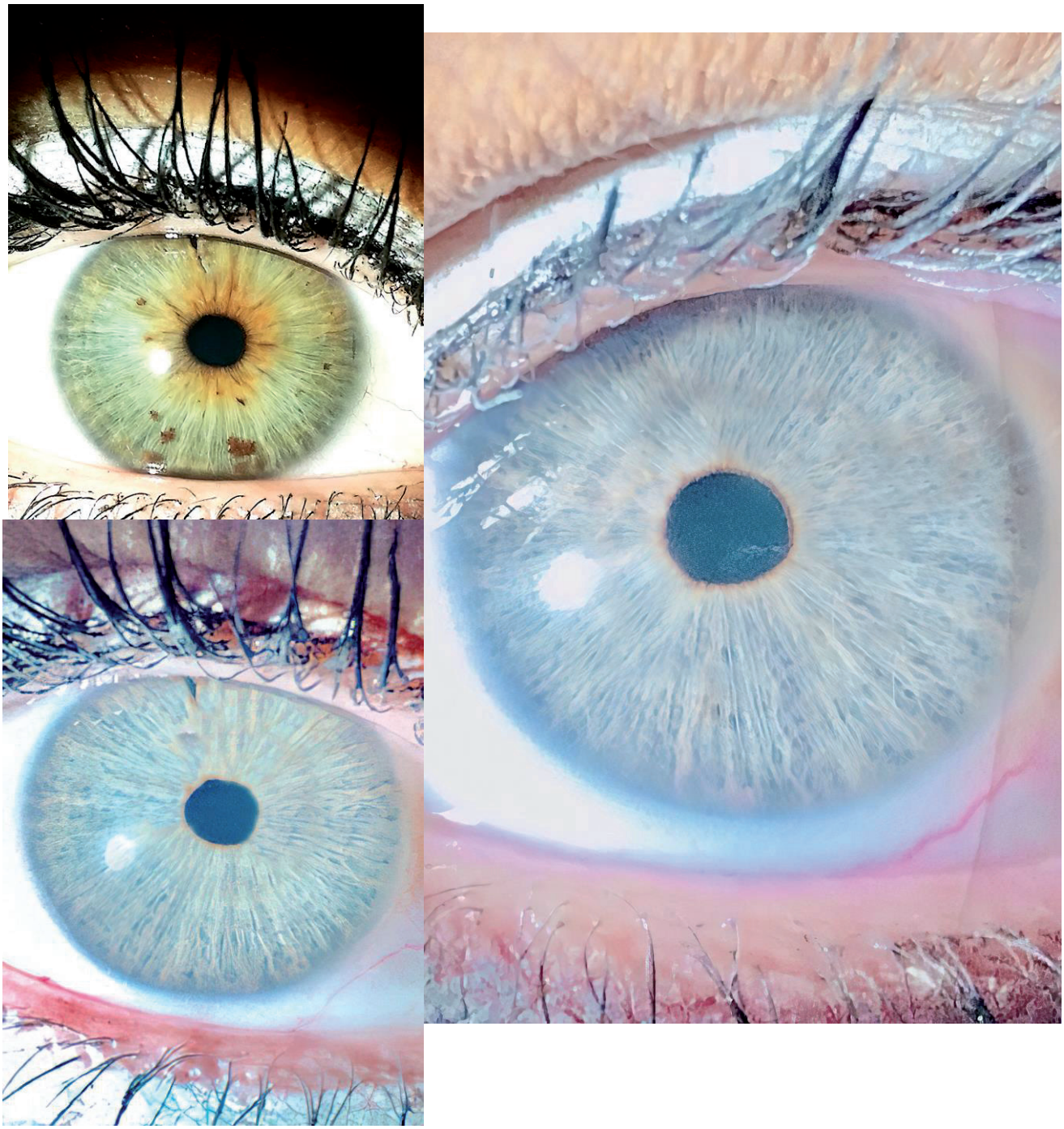
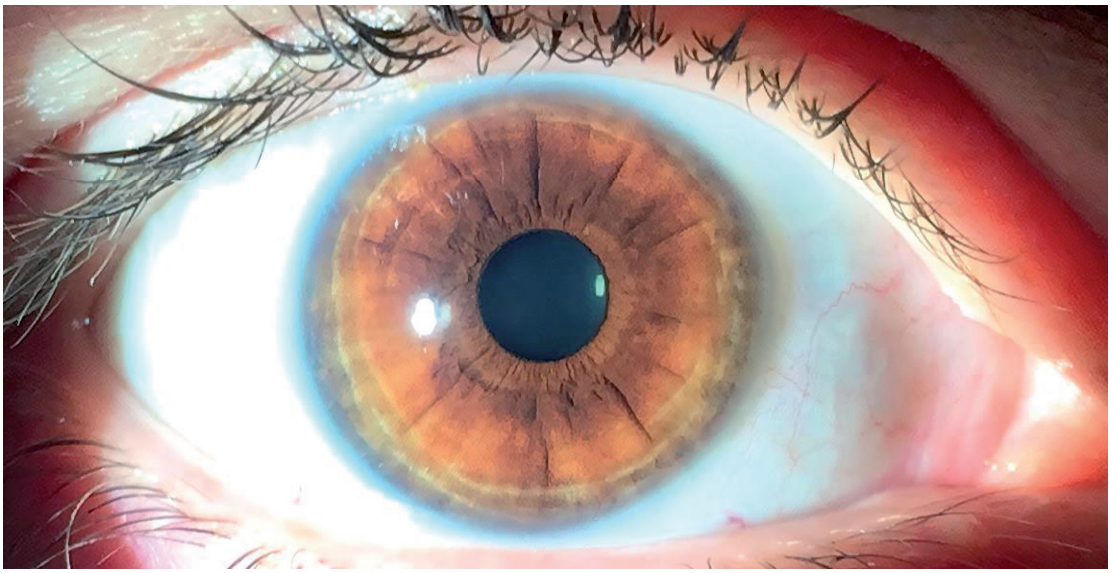
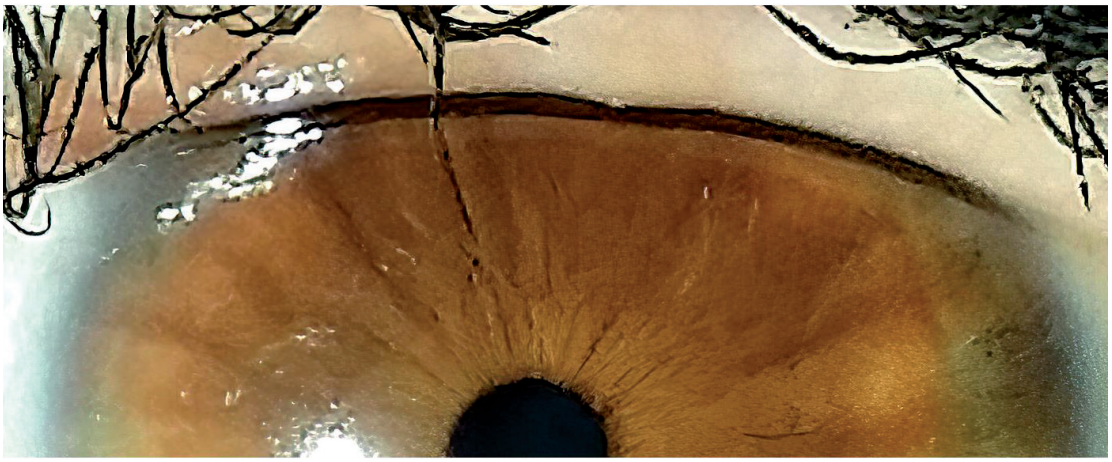


FIGURE 97: Laser Iridoplasty after complicated cosmetic IOL removal

3 8.5 Prostaglandins





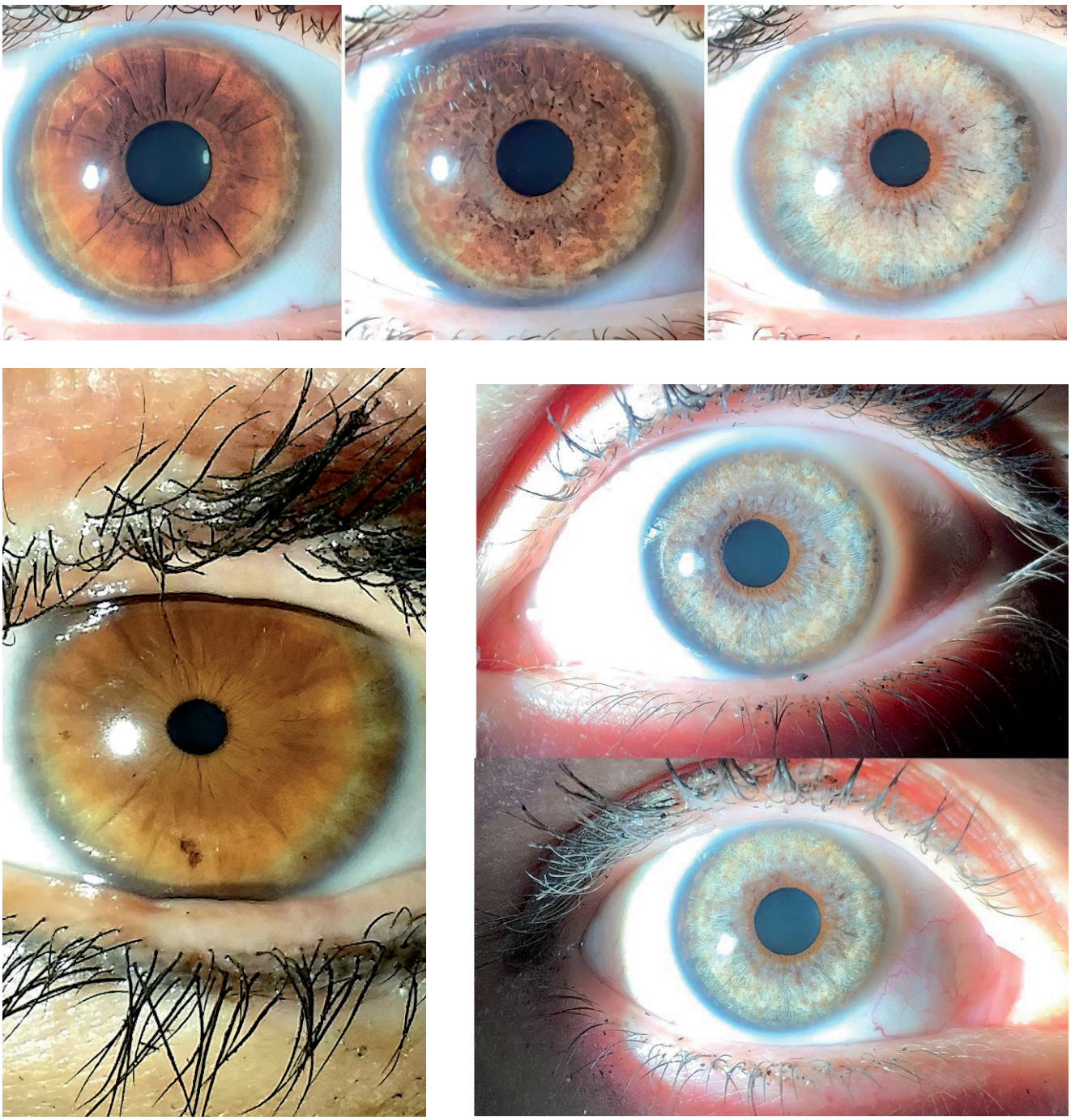
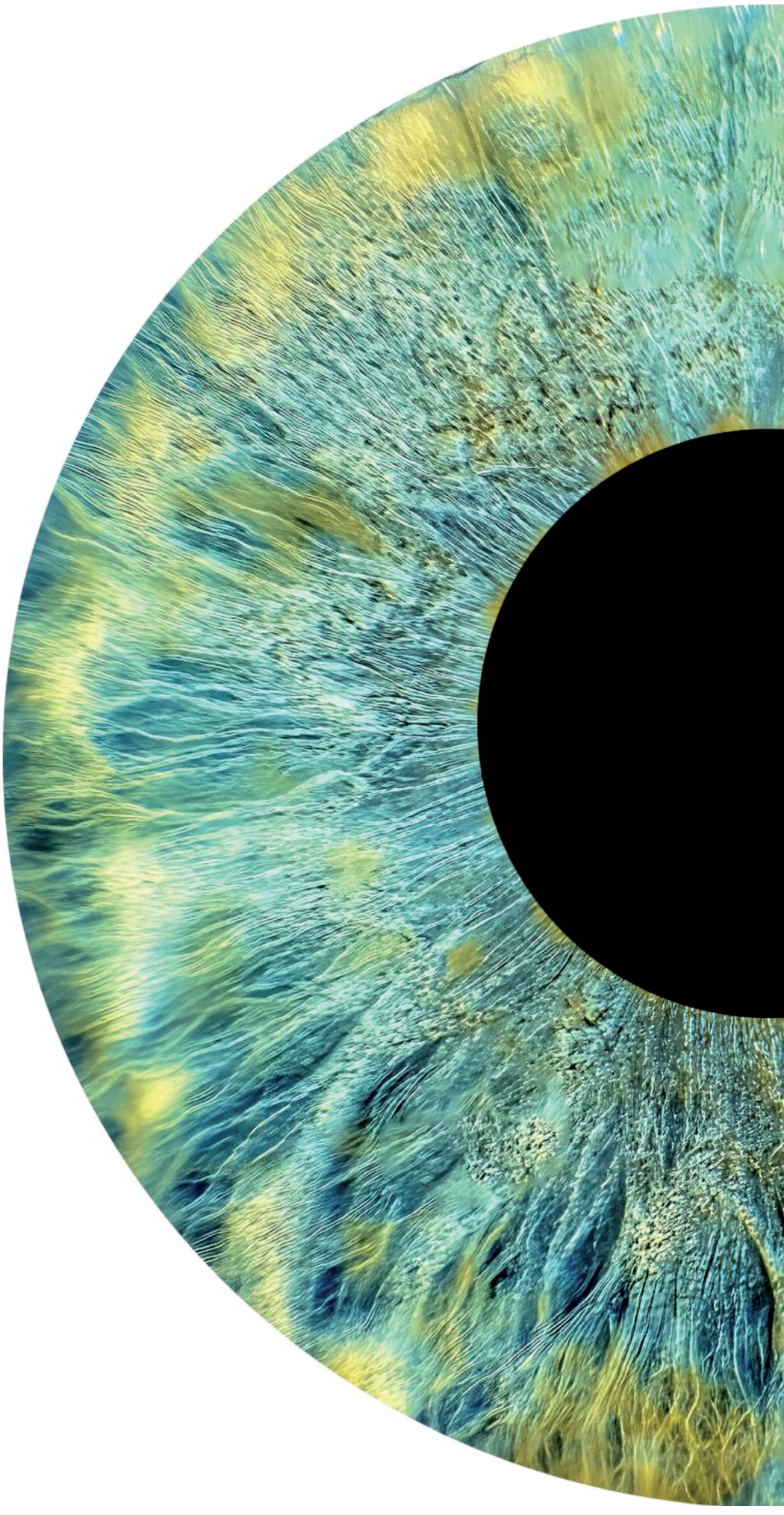
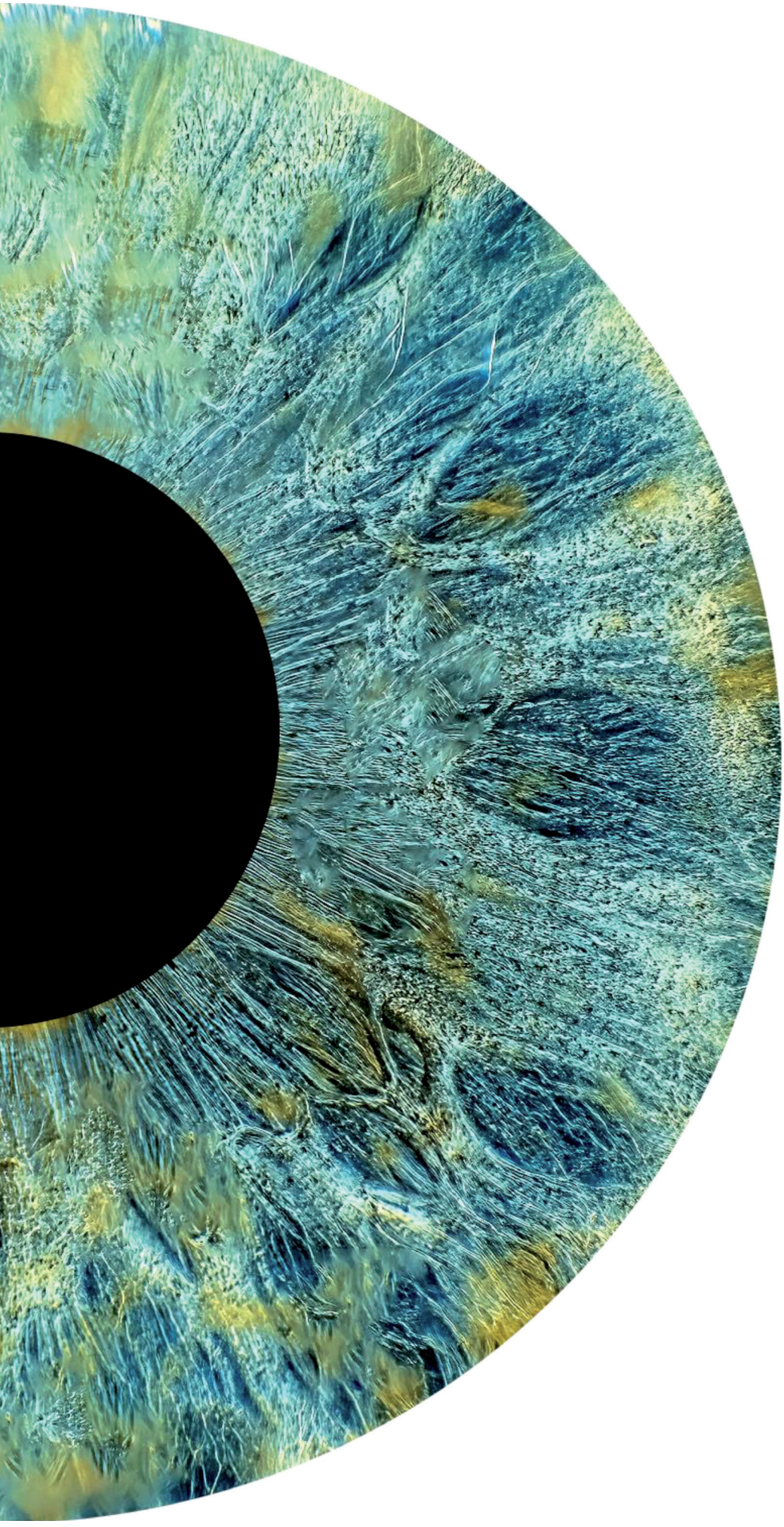
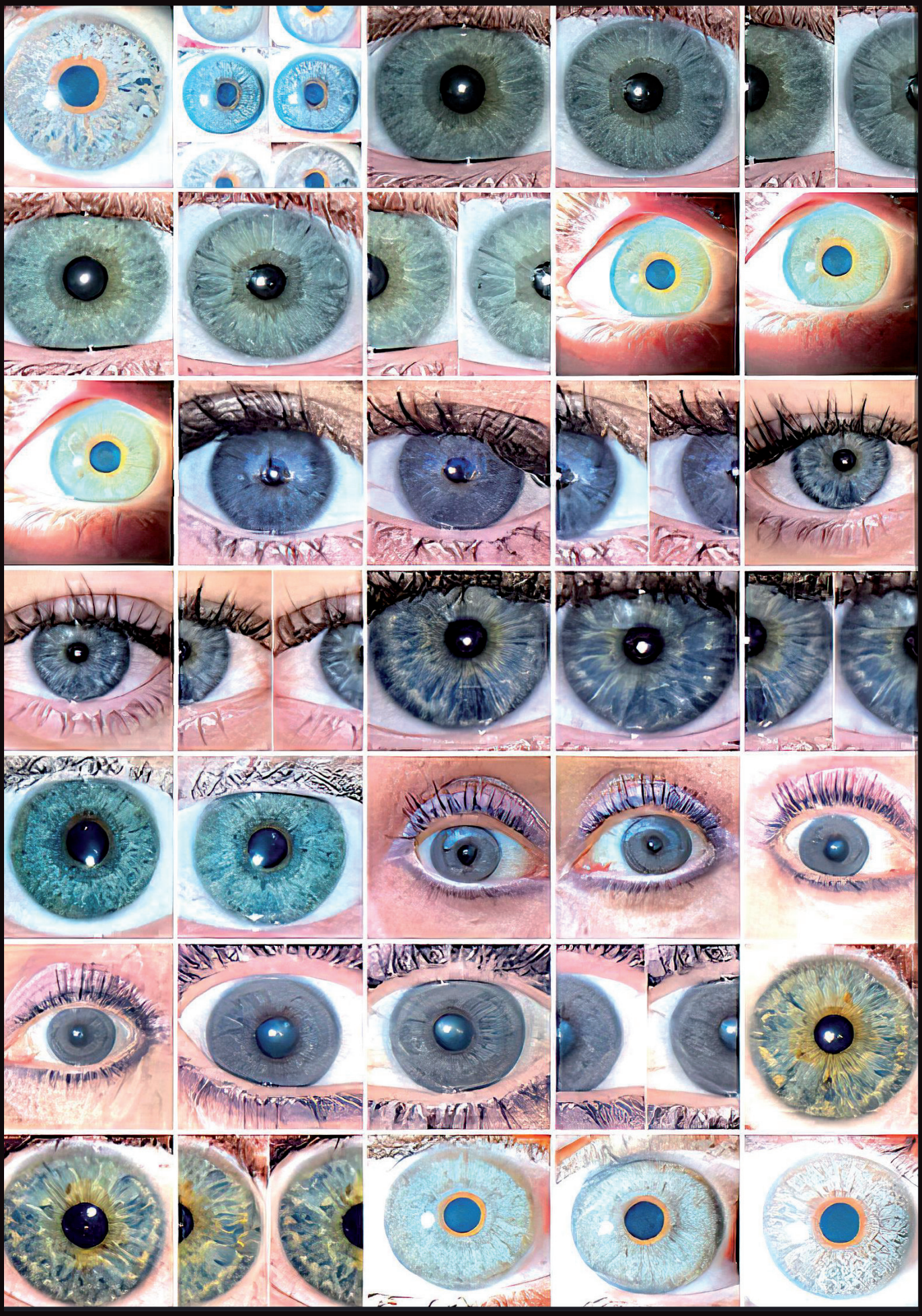


FIGURE 99: Full pigment removal after iris darkening by prostaglandins





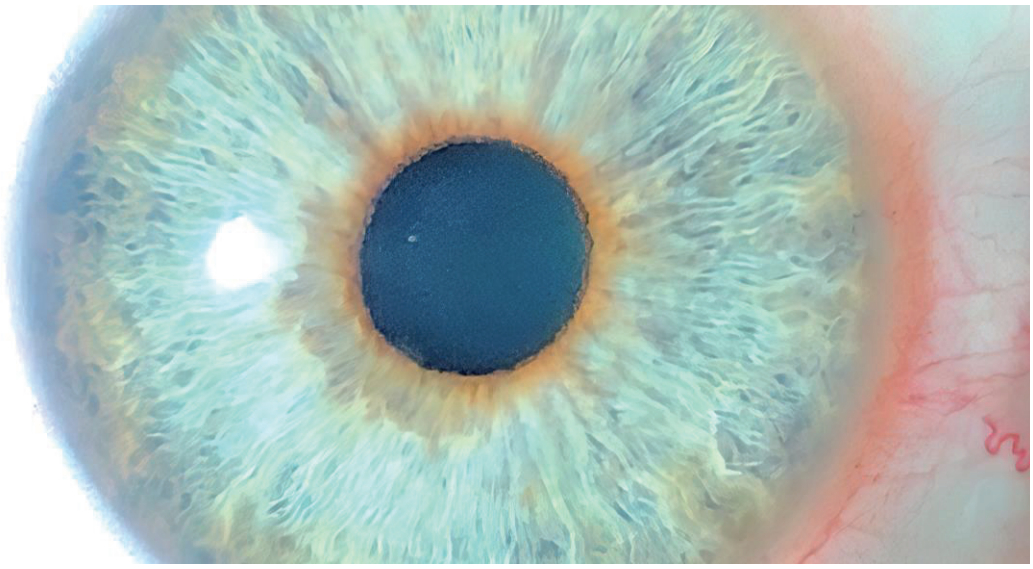


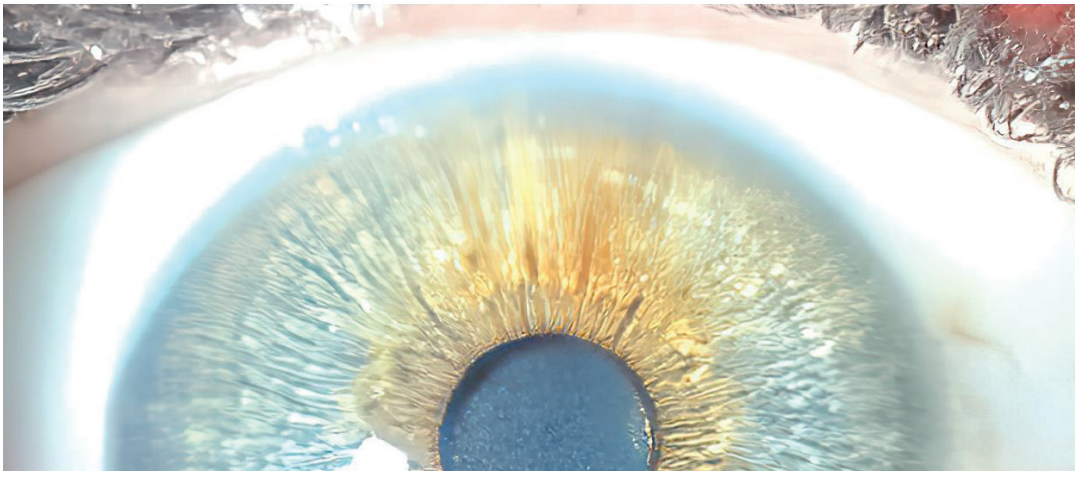
PART 3

COSMETIC RESULTS

CHAPTER 9 ESTHETICS

3 9.1 Levels 1-2





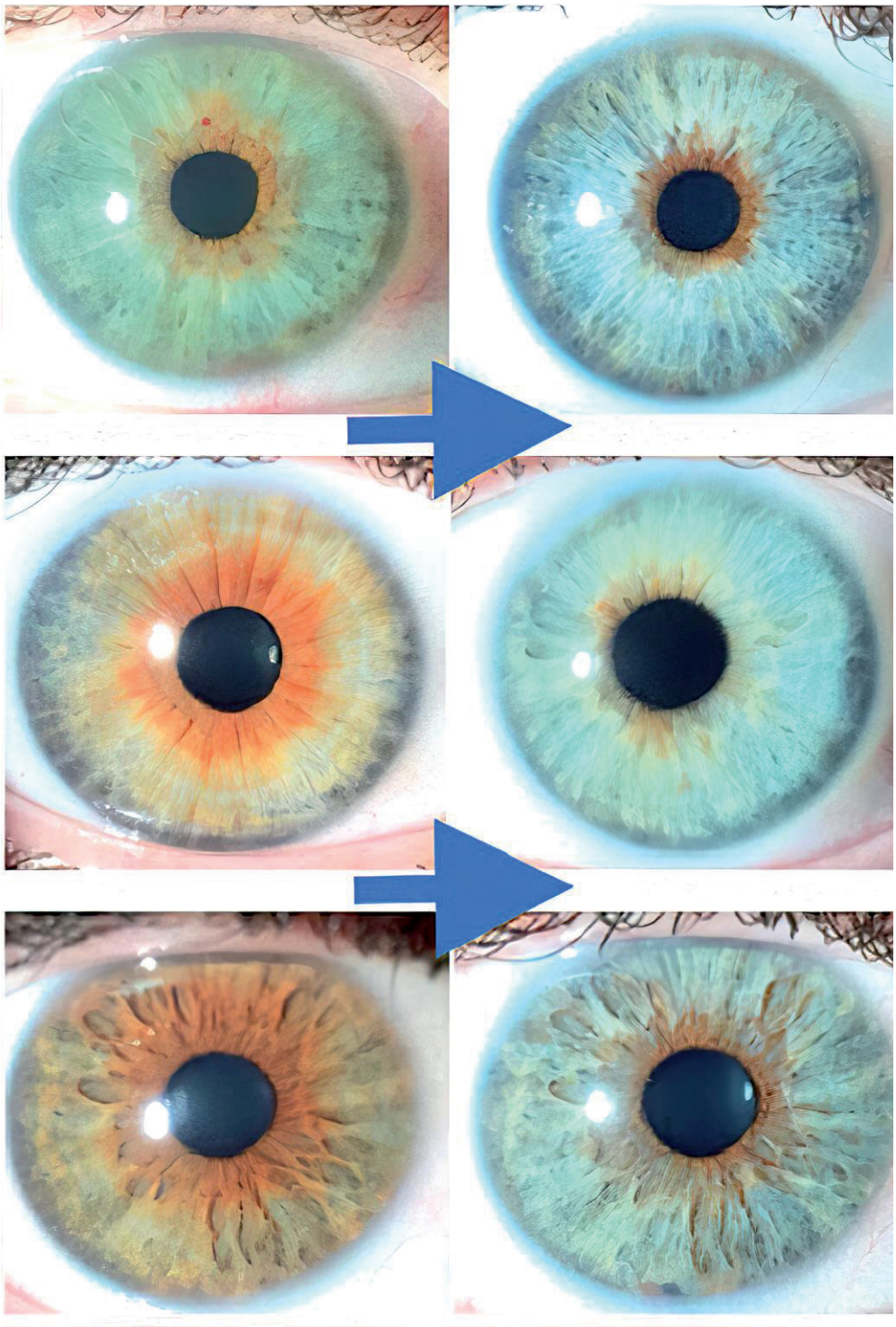
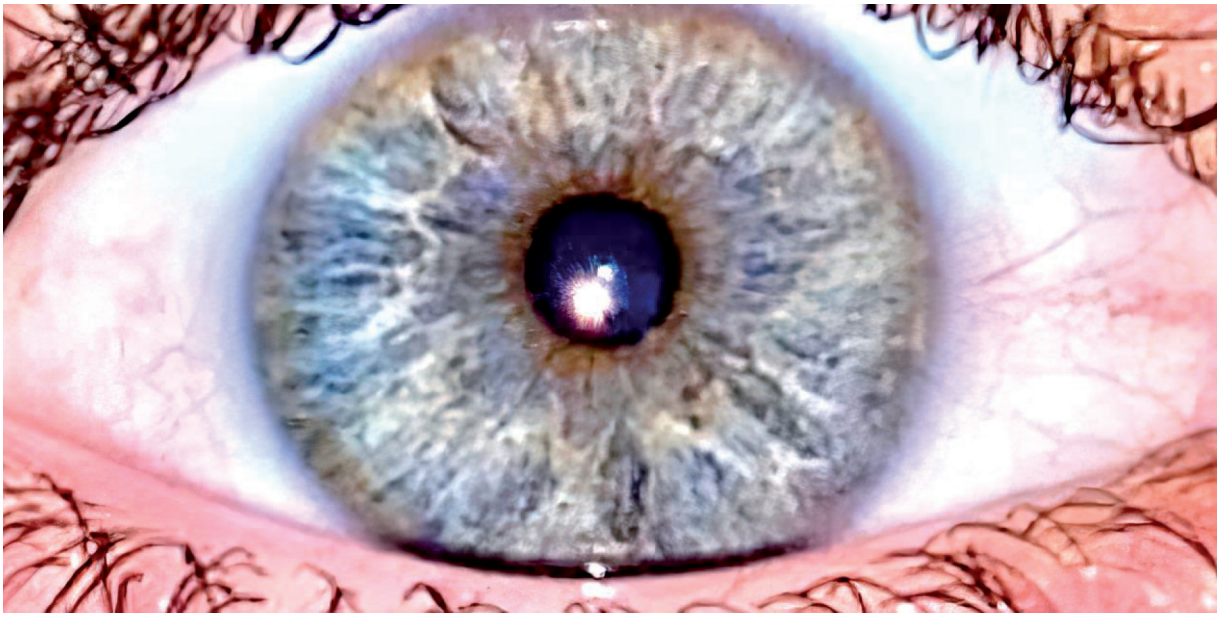


FIGURE 100: Level 1-2 cosmetic results to blue

3 9.1 Levels 1-2



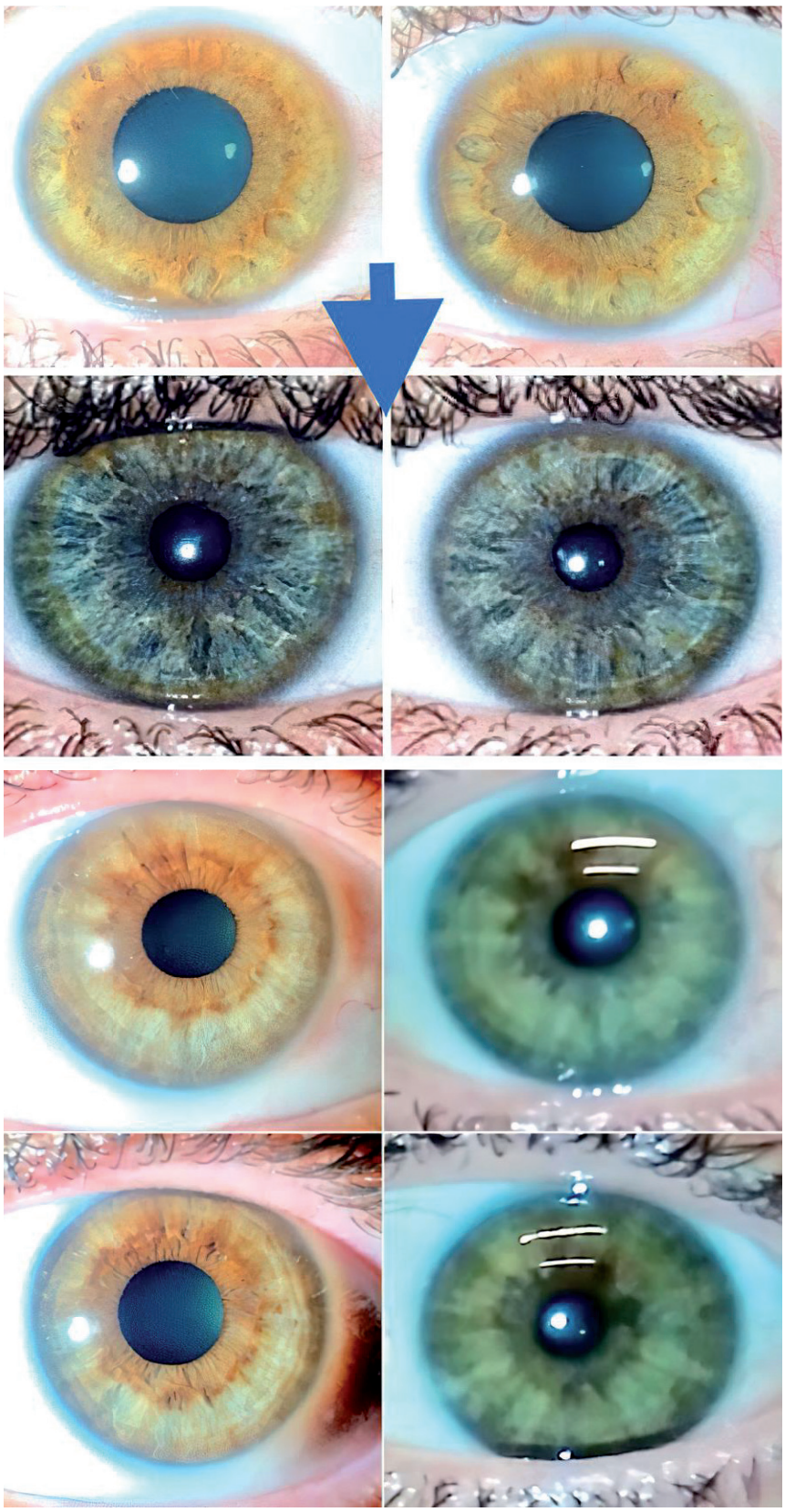
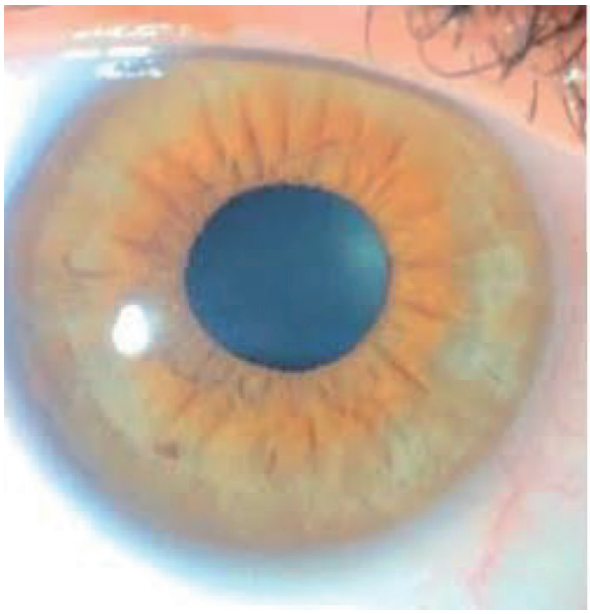
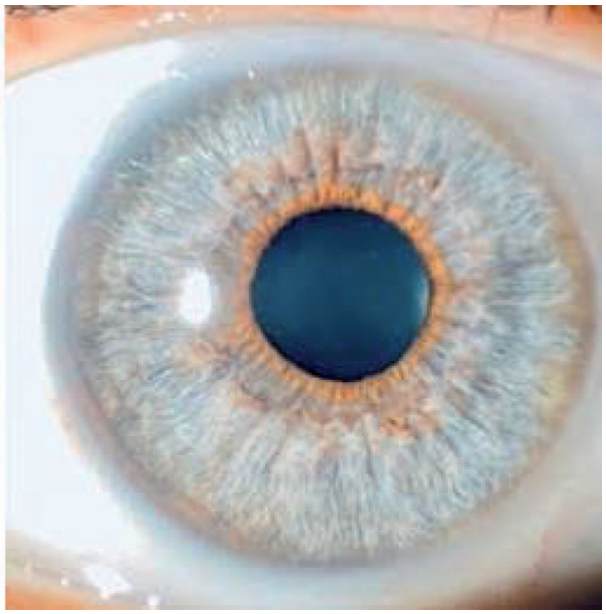
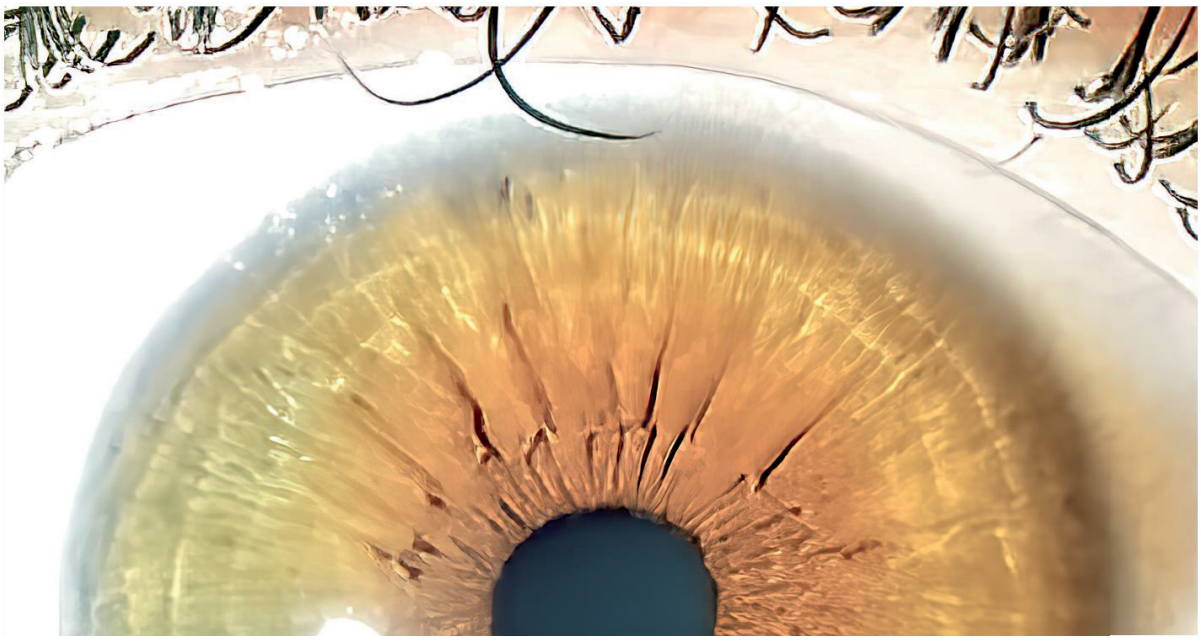


FIGURE 101: Levels 1-2 fine results to mixed turquoise

3 9.1 Levels 1-2







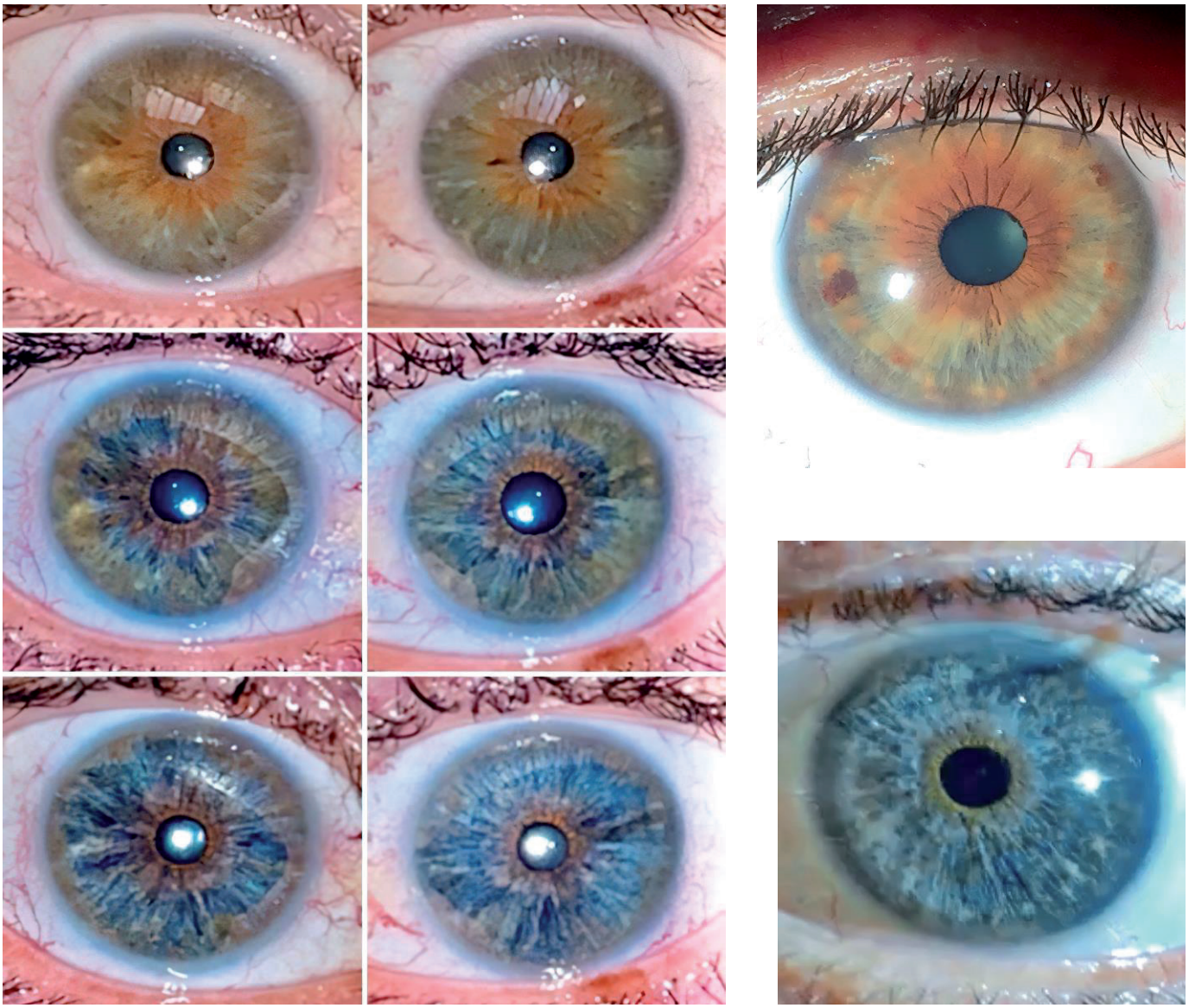
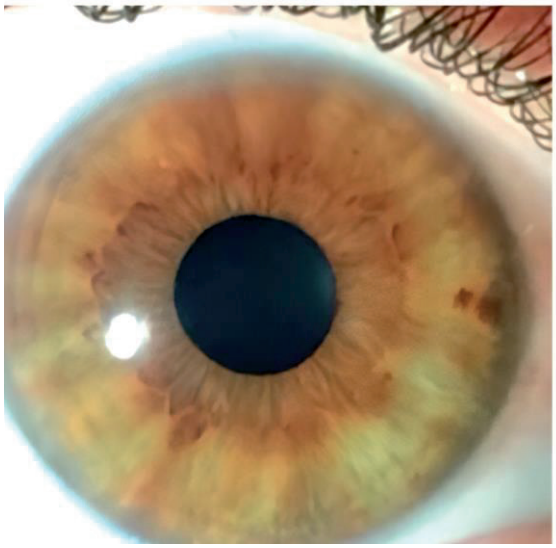
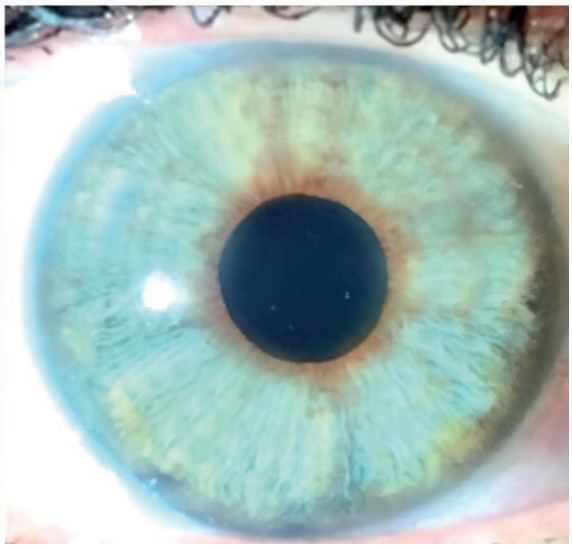
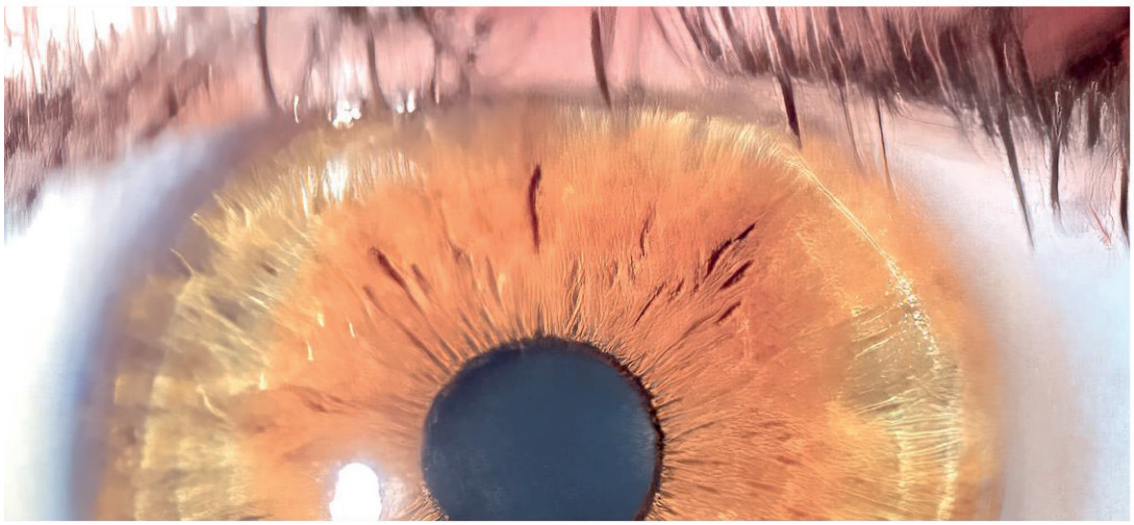


FIGURE 102: Levels 1-2 fine results to dark sea blue

3 9.1 Levels 1-2







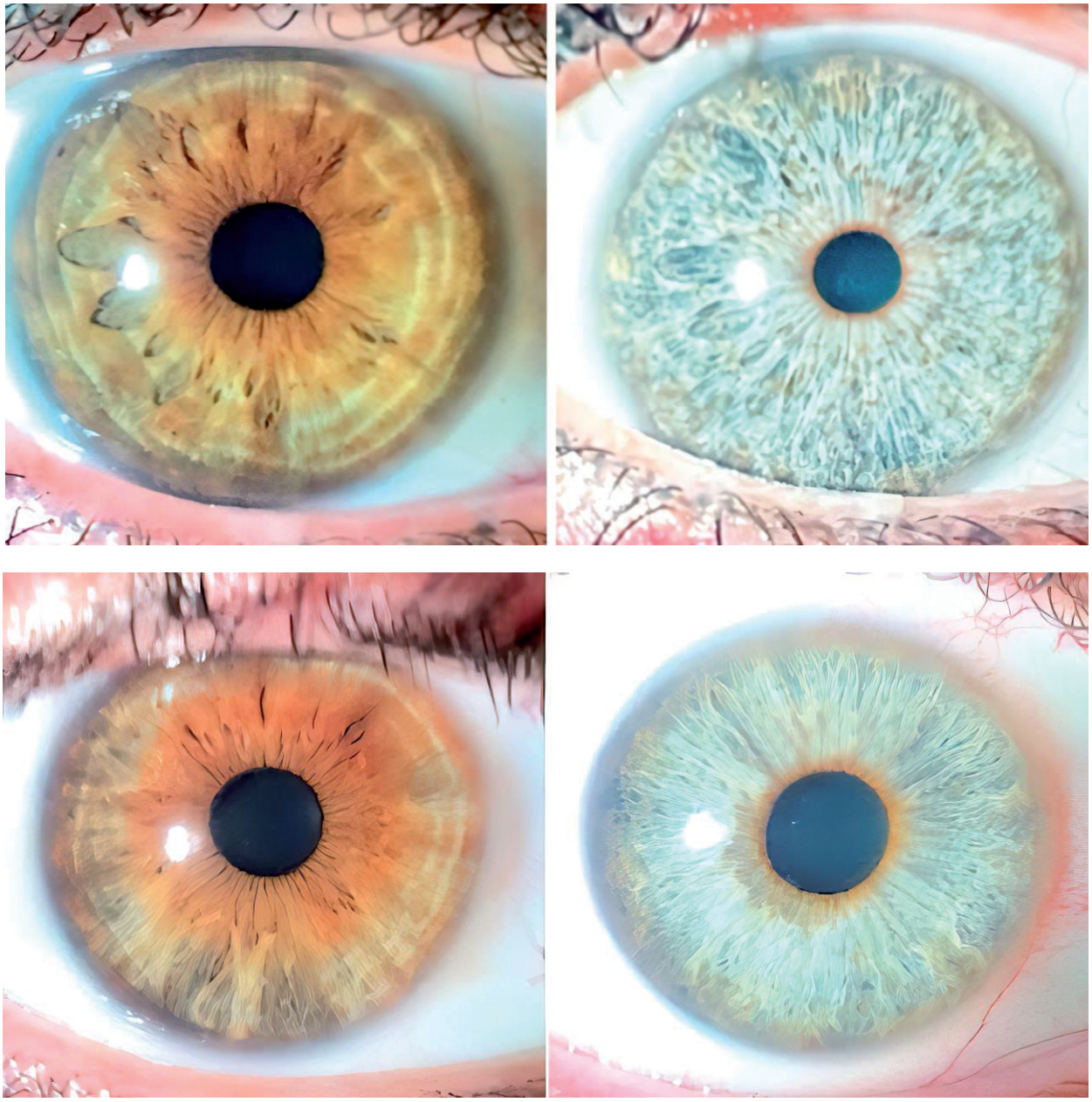
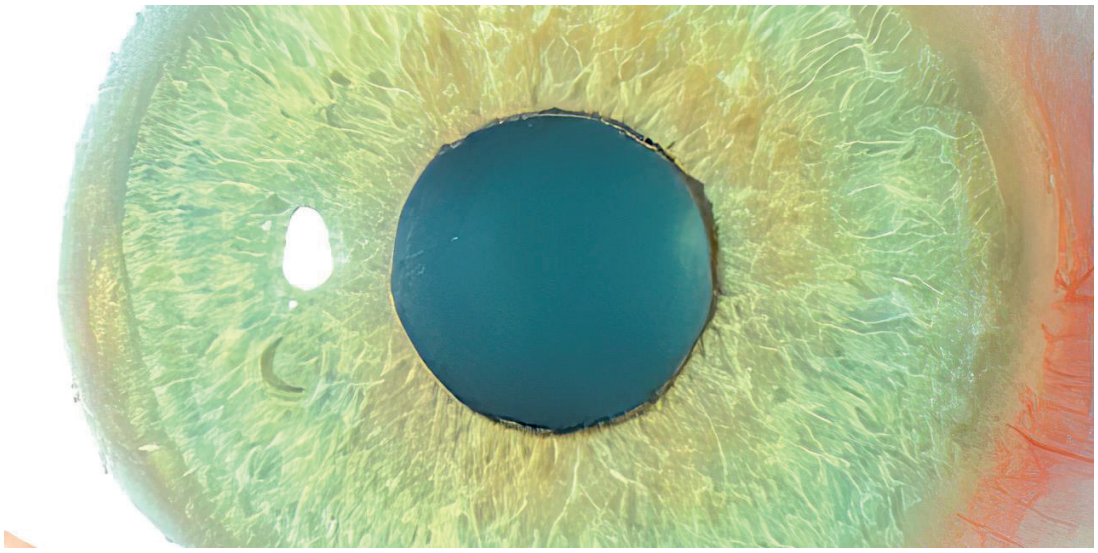
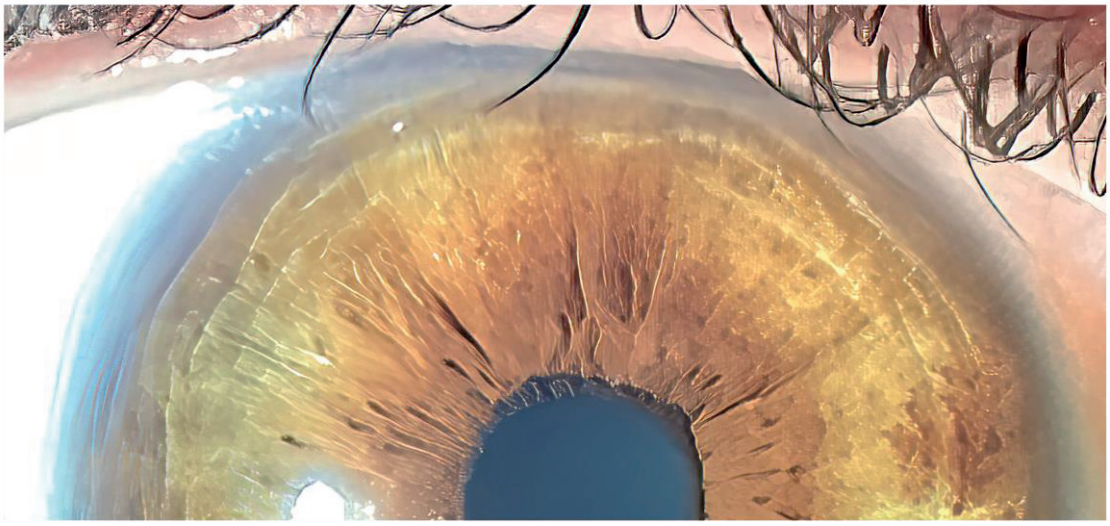


FIGURE 103: Levels 1-2 fine results to light blue

3 9.1 Levels 1-2





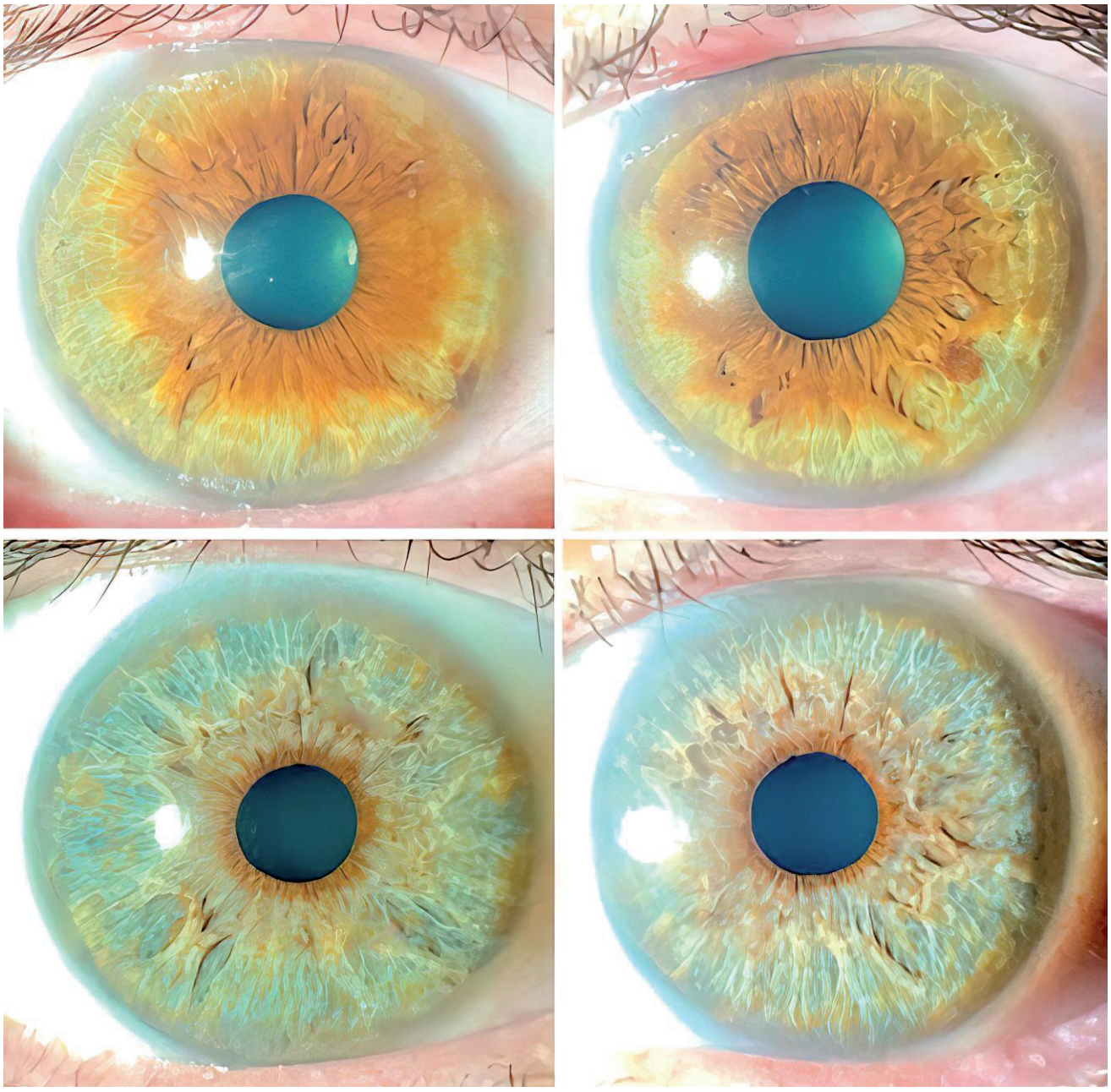
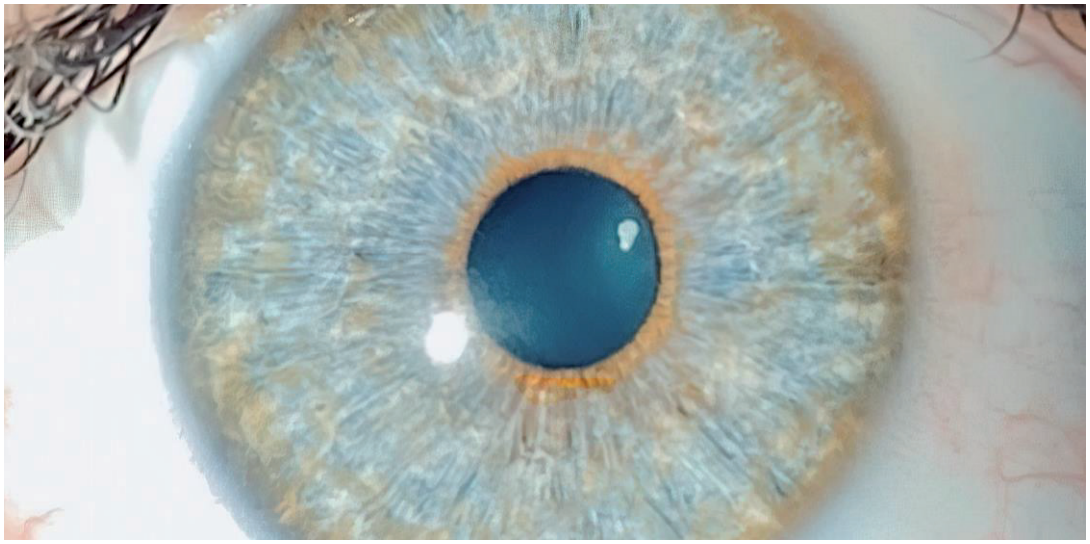
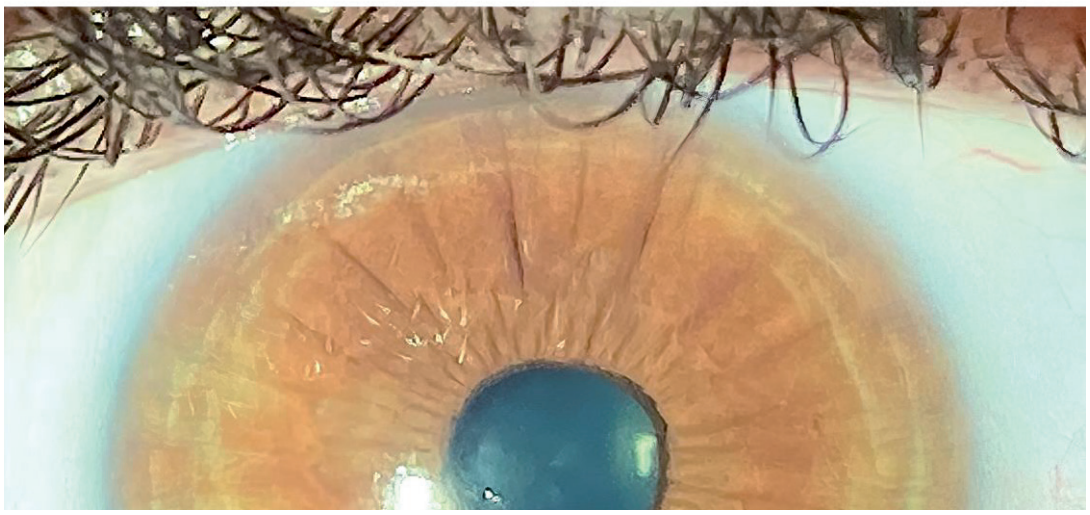


FIGURE 104: Levels 1-2 fine results to greenish turquoise

3 9.2 Level 3





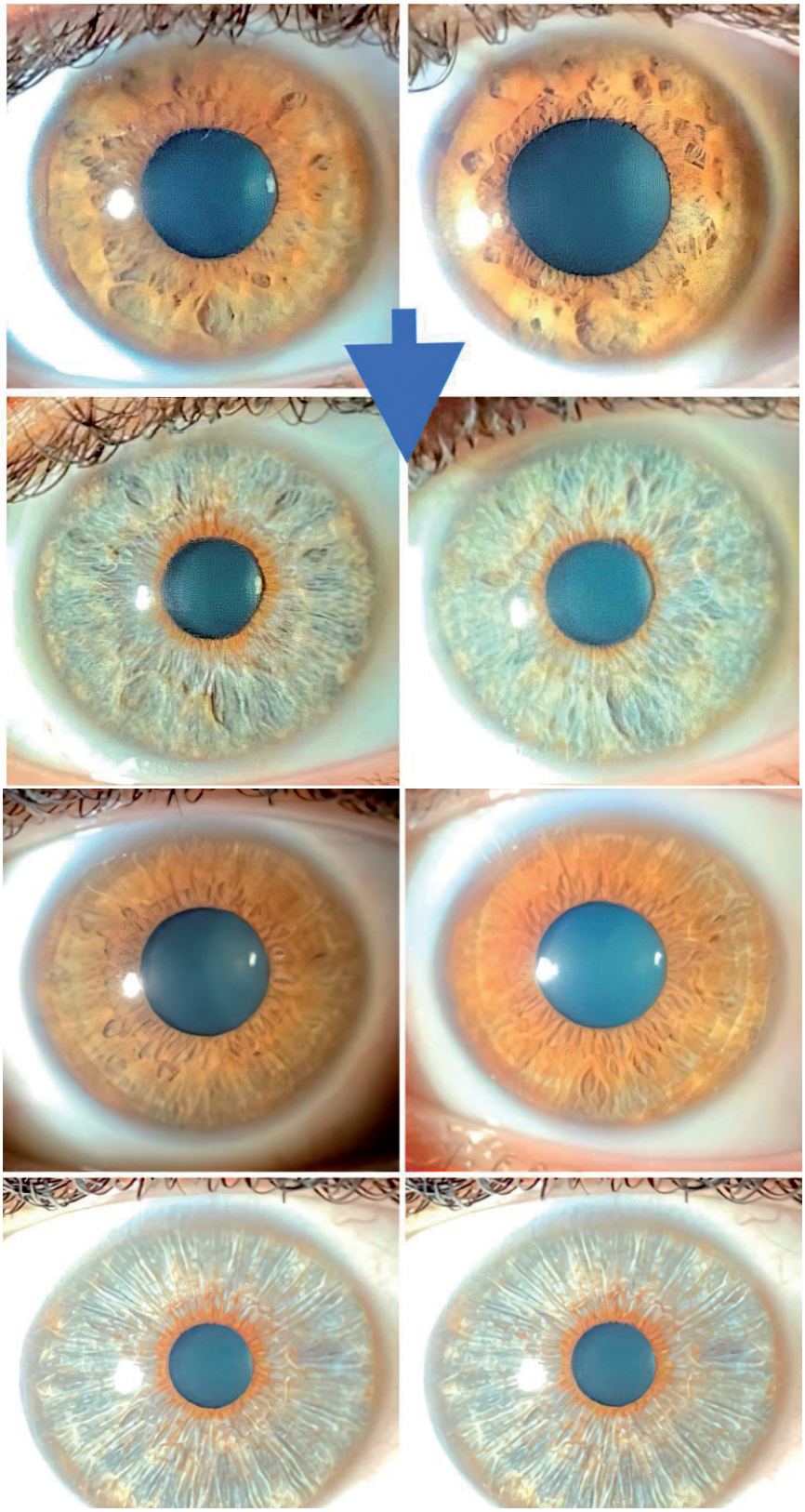
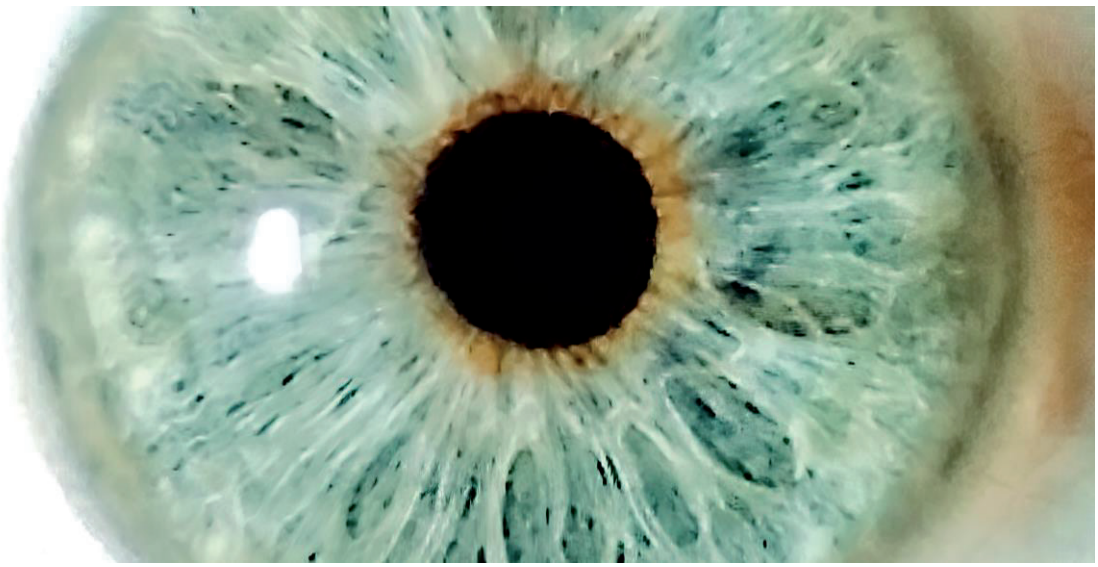
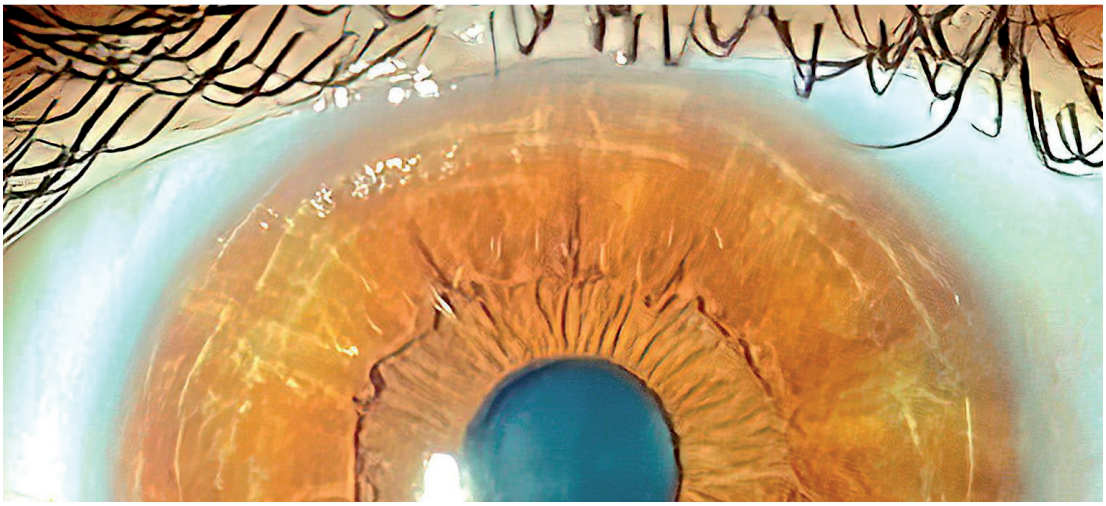


FIGURE 105: Level 3 fine results to bright turqouise

3 9.2 Level 3





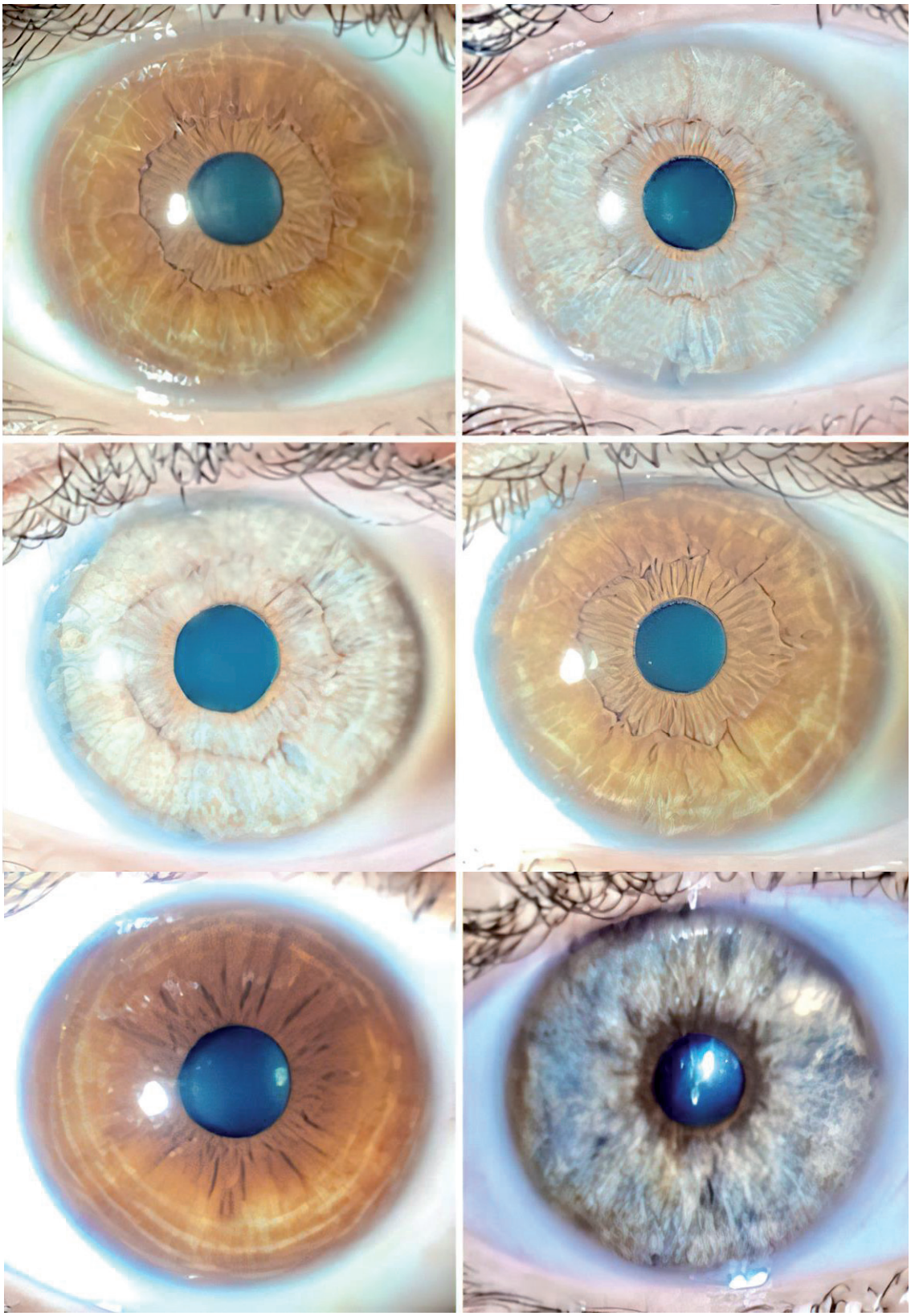
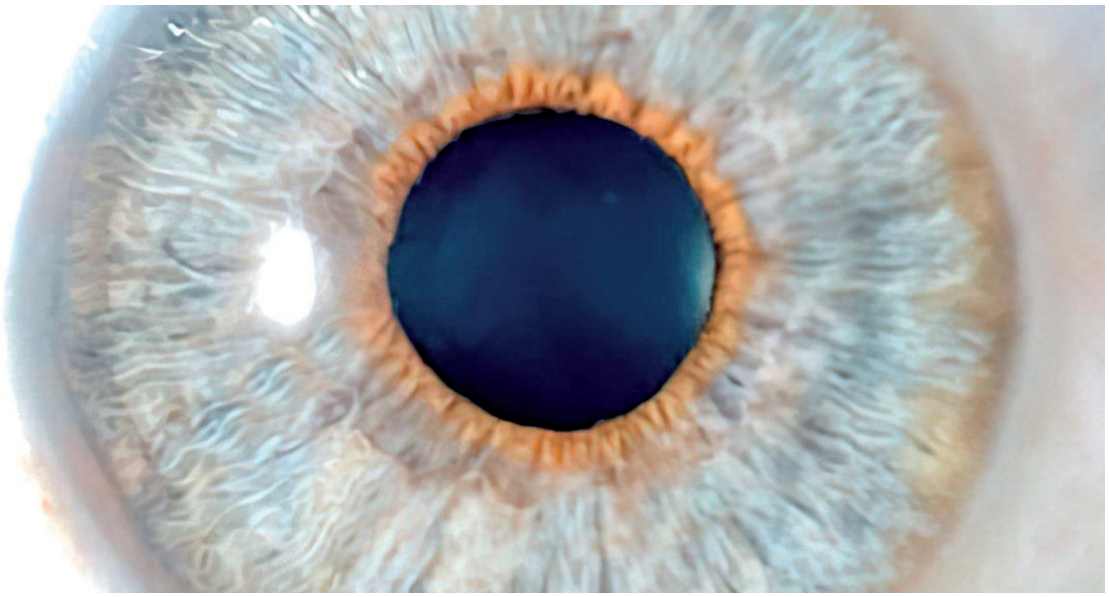
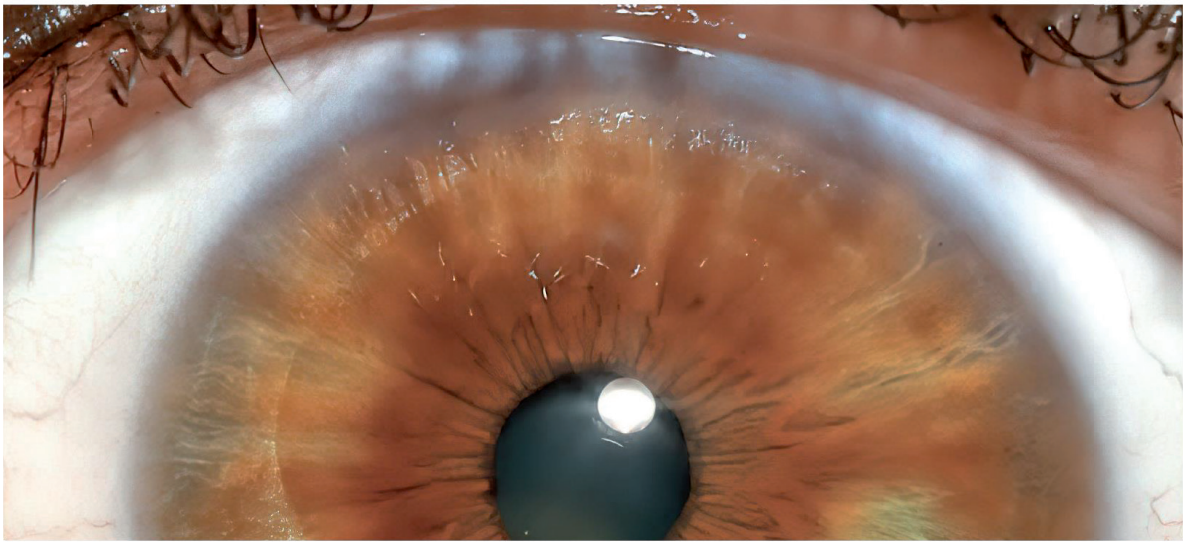


FIGURE 106: Level 3 fine results to very bright blue

3 9.2 Level 3





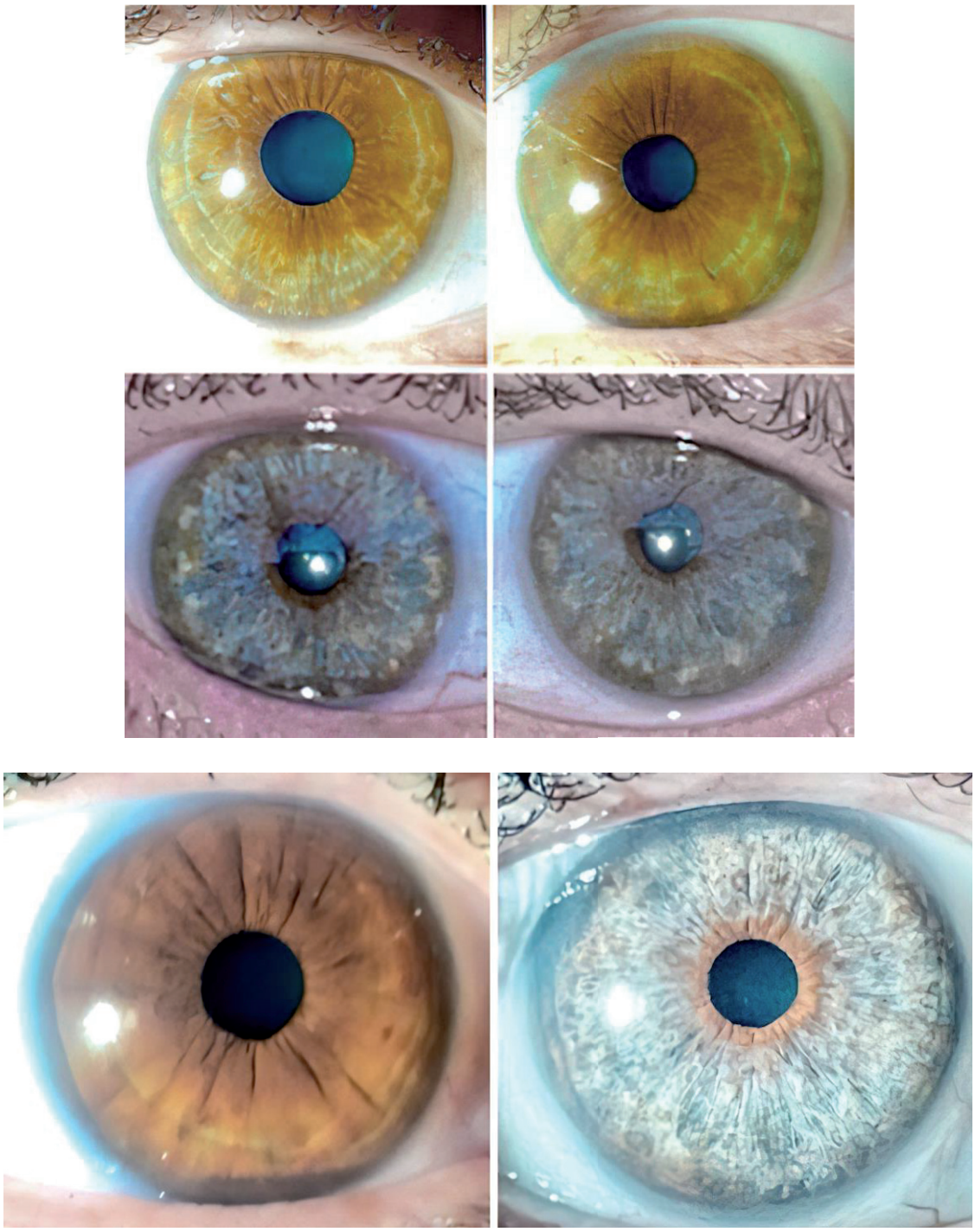
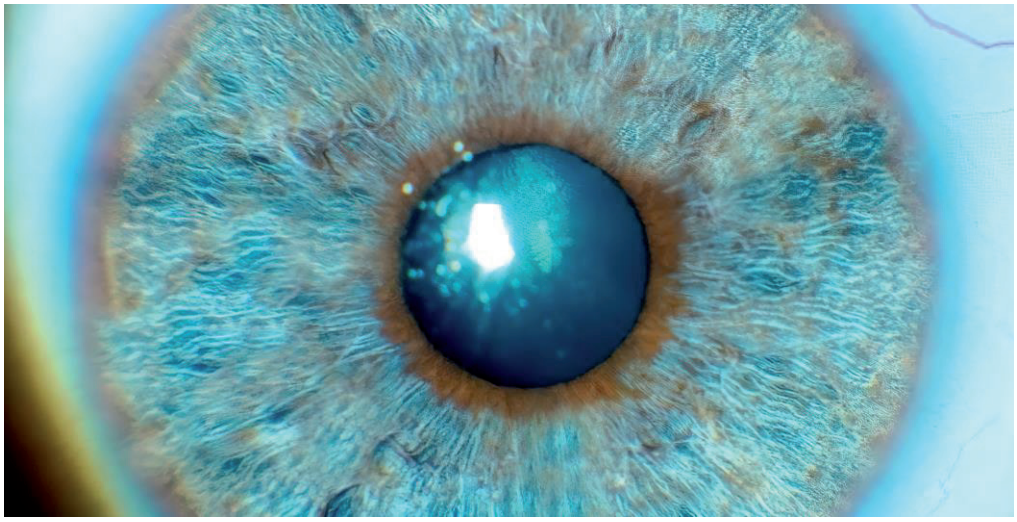
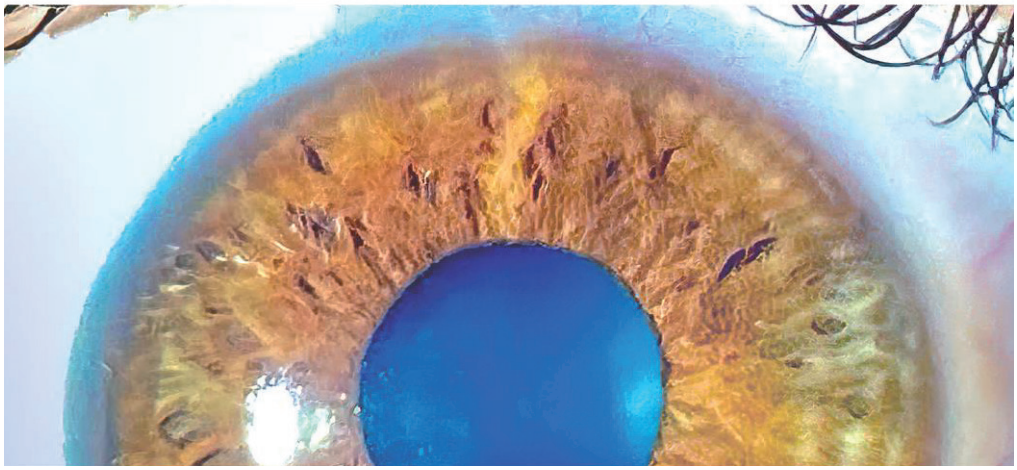


FIGURE 107: Level 3 fine results to light and dark blue

3 9.2 Level 3





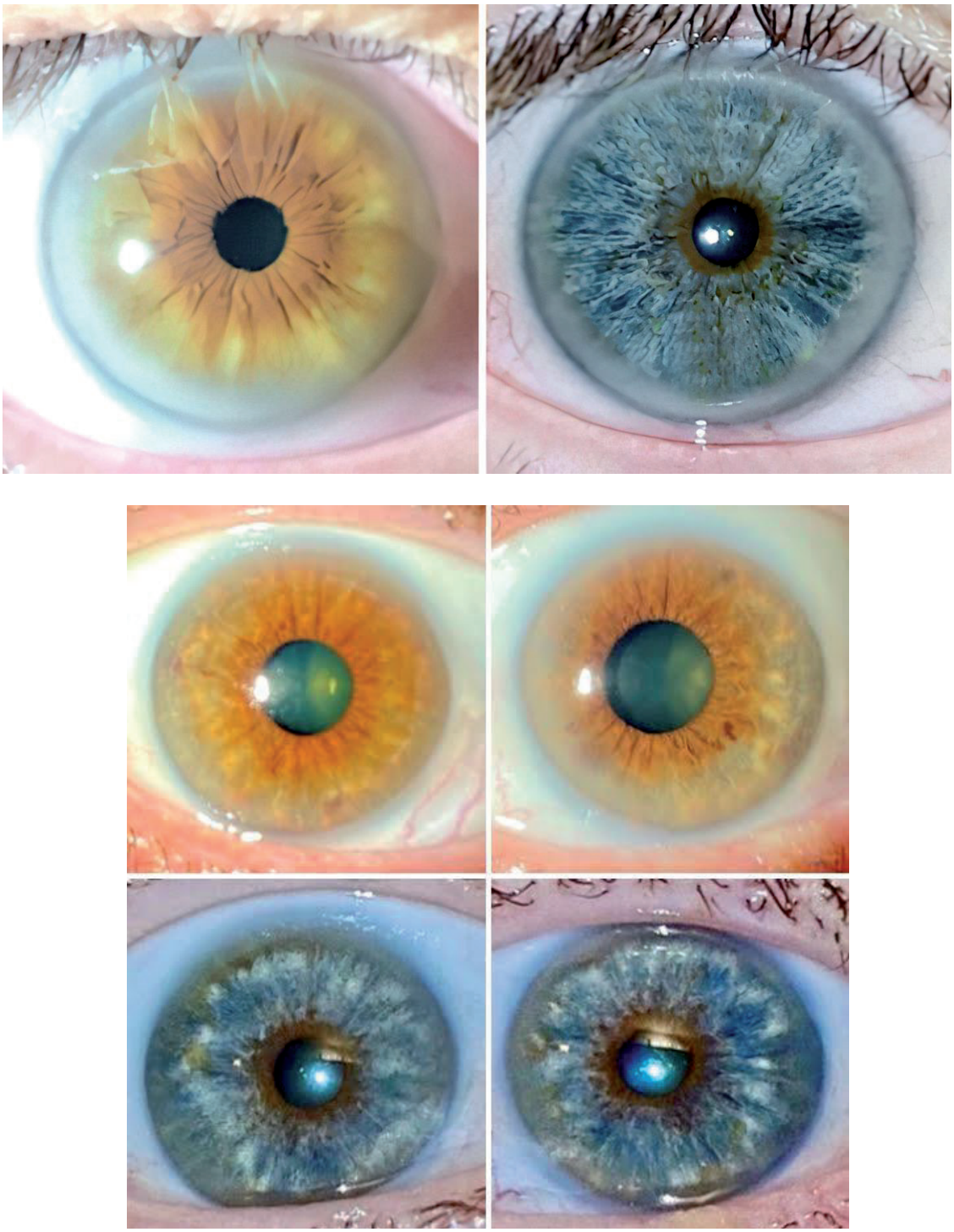
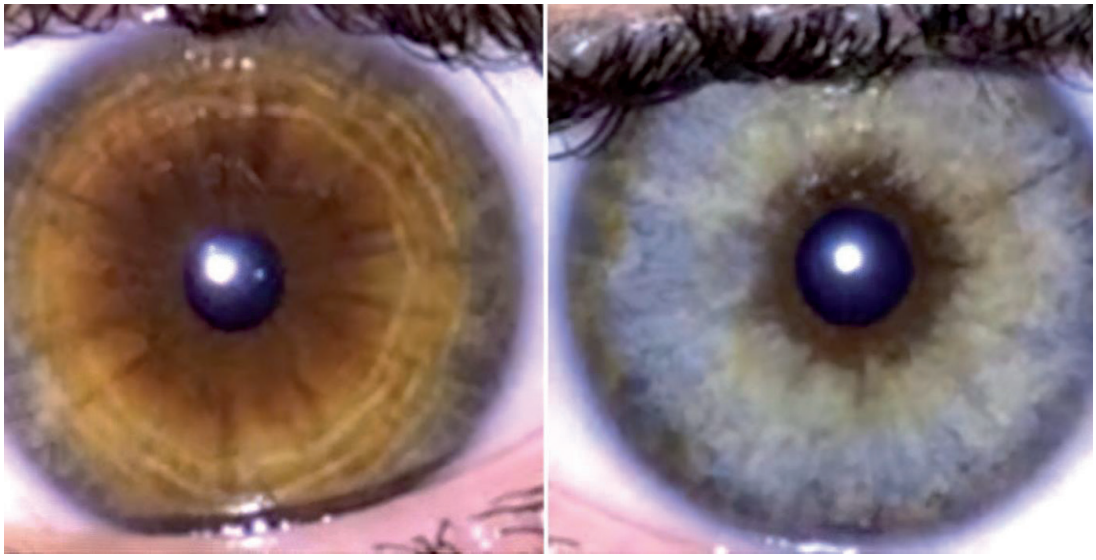
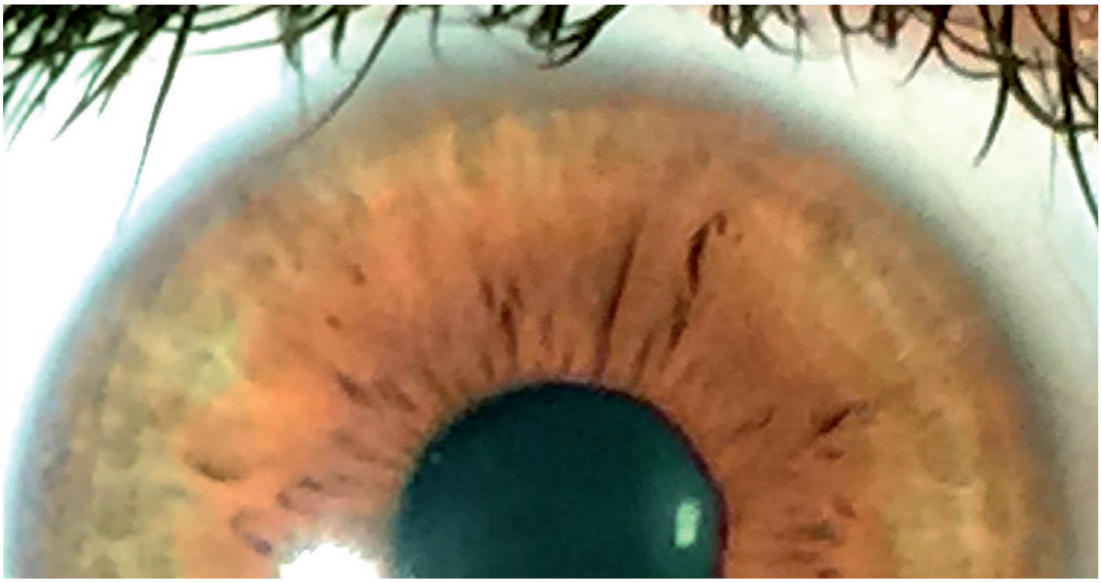


FIGURE 108: Level 3 fine results to dark turqouise

3 9.2 Level 3





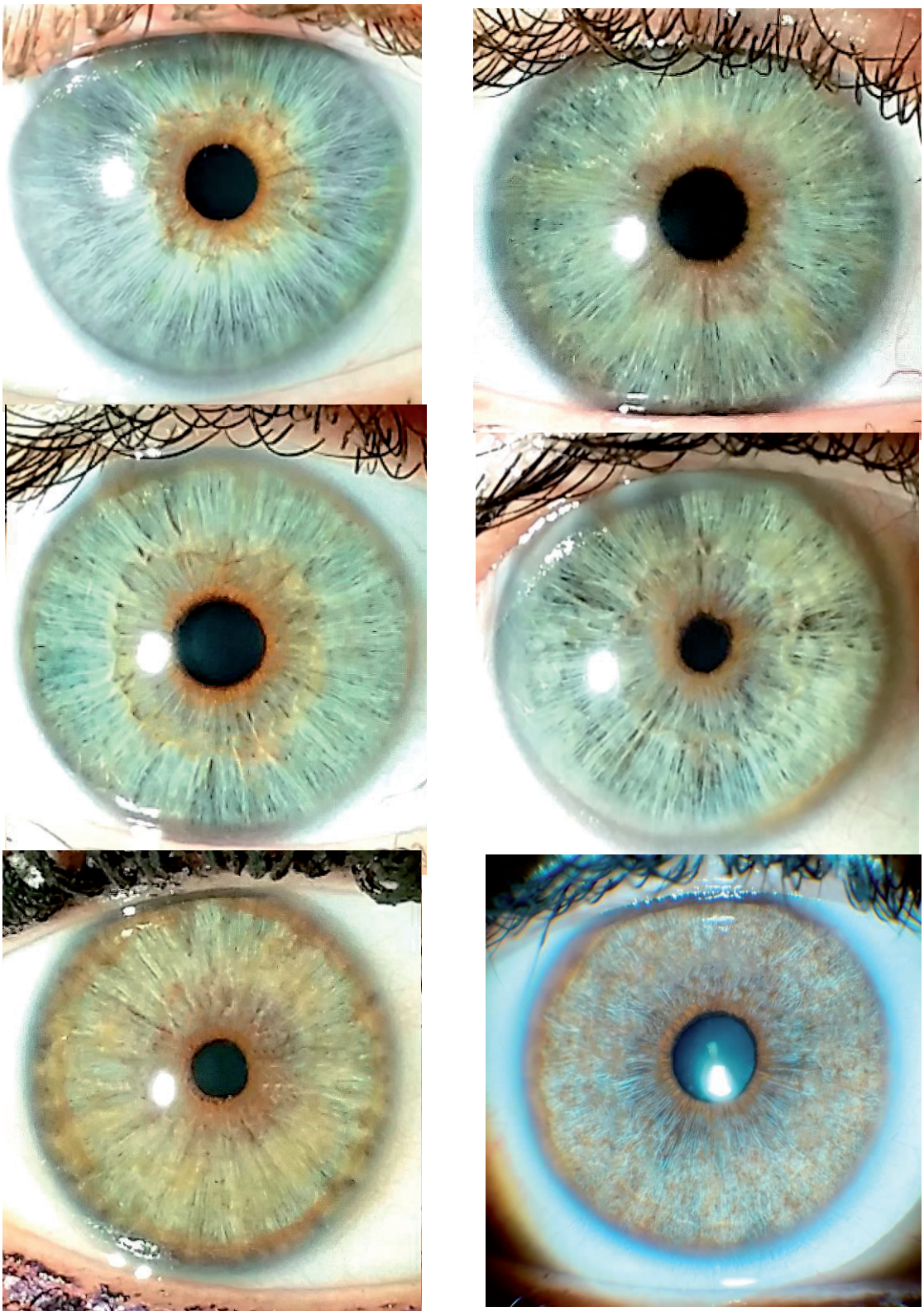
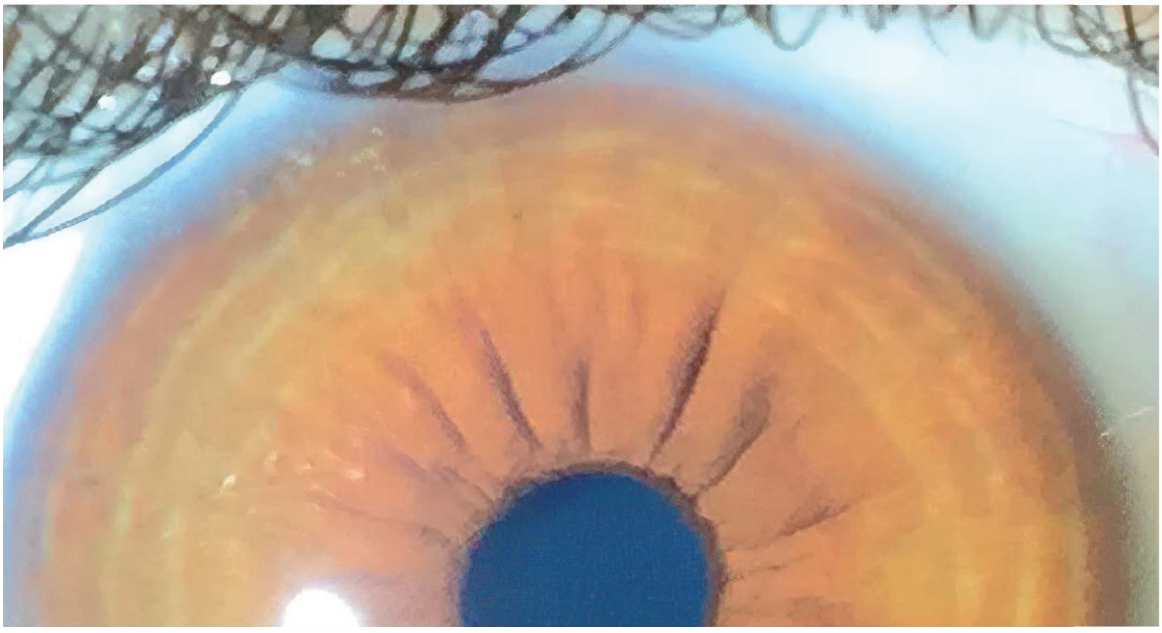


FIGURE 109: Level 3 fine results to blue, greenish and turqouise

3 9.2 Level 3



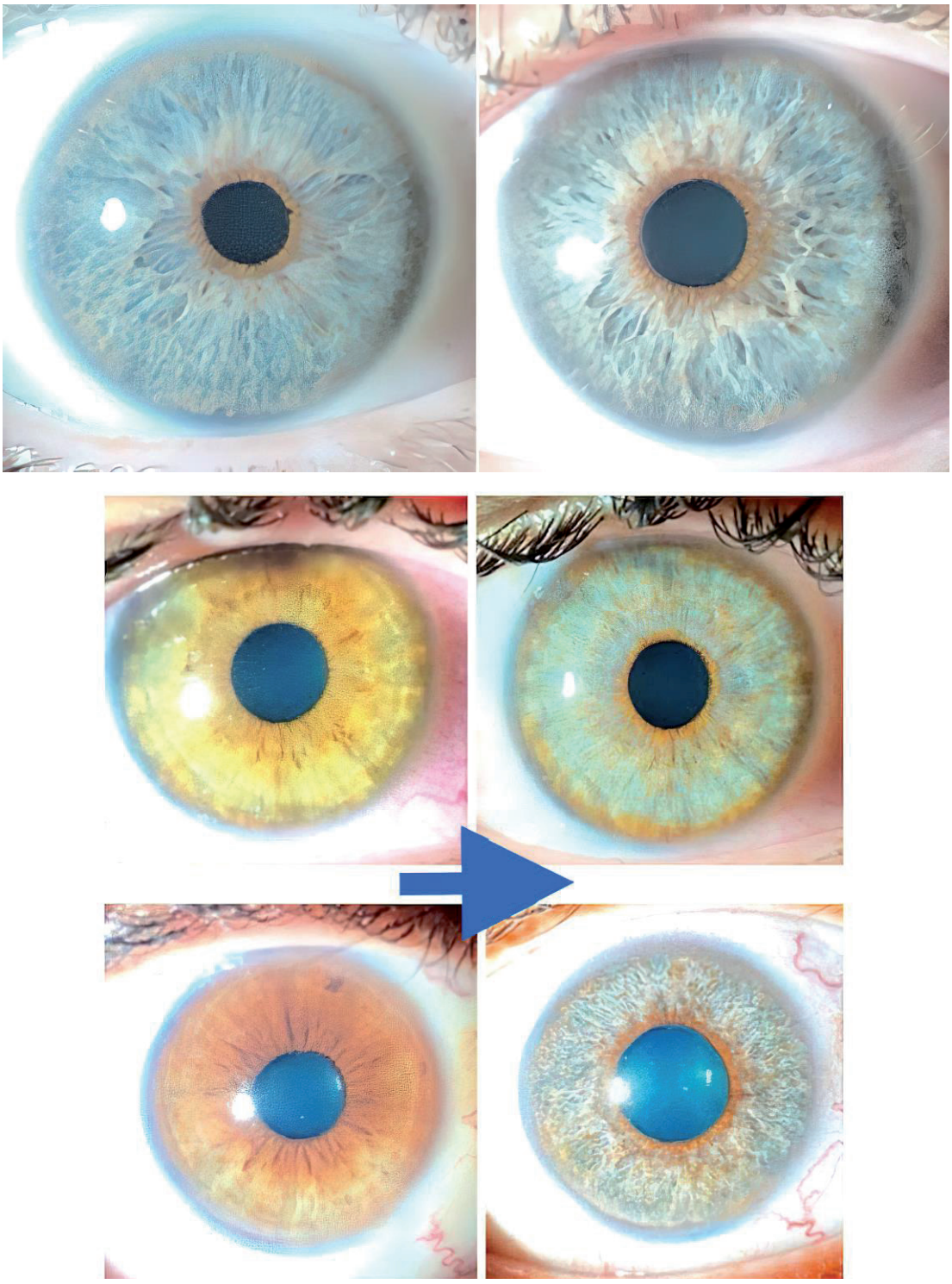
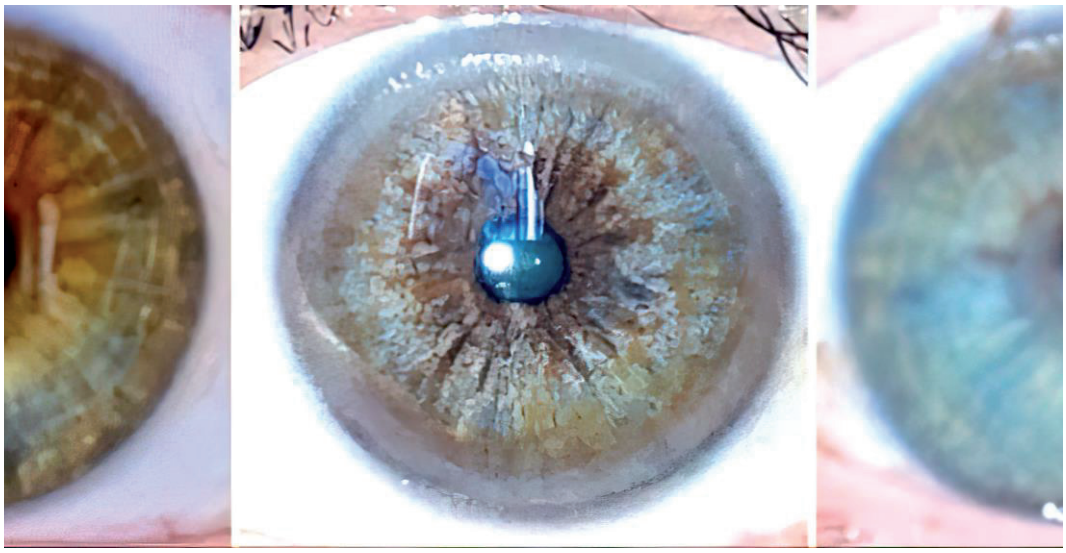
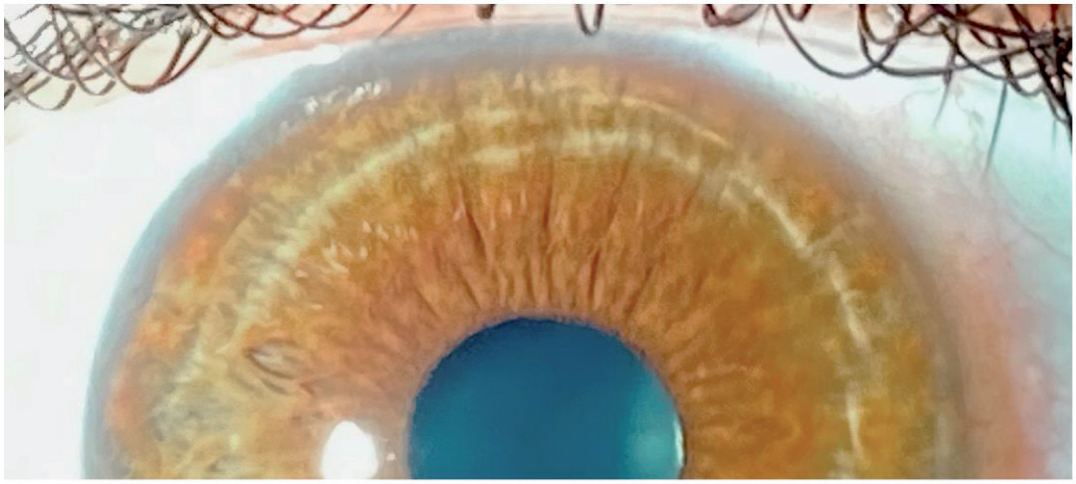


FIGURE 110: Level 3 fine results to light blue turqouise

3 9.2 Level 3





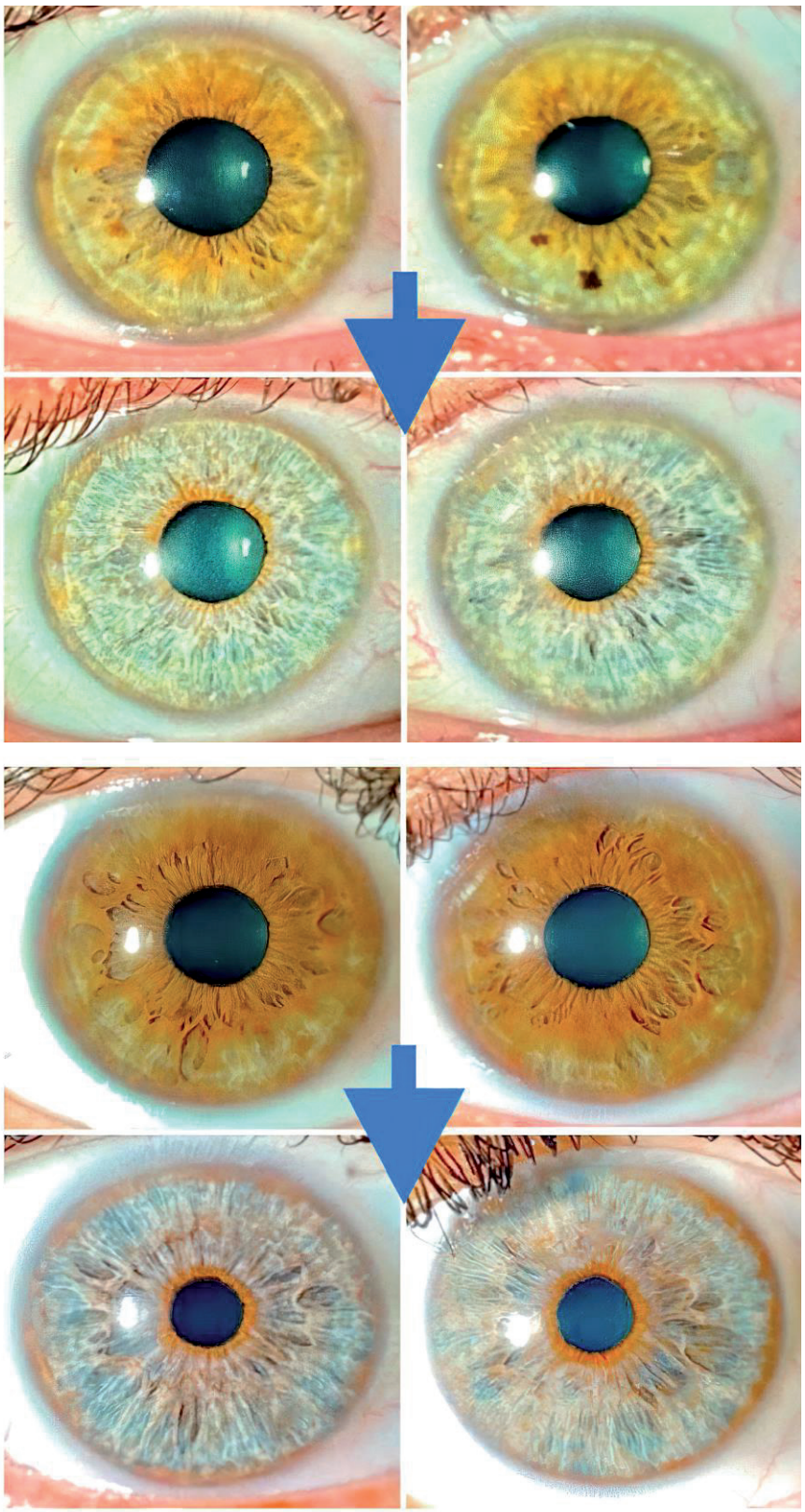
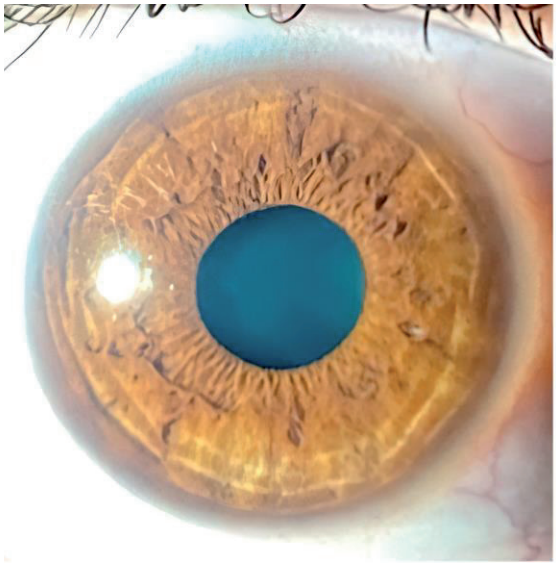
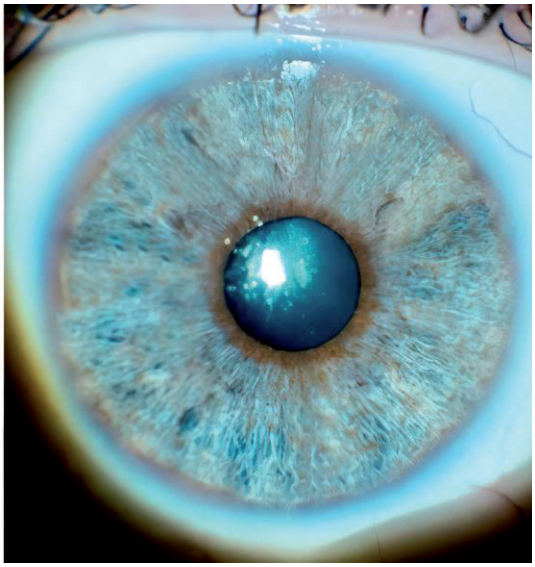
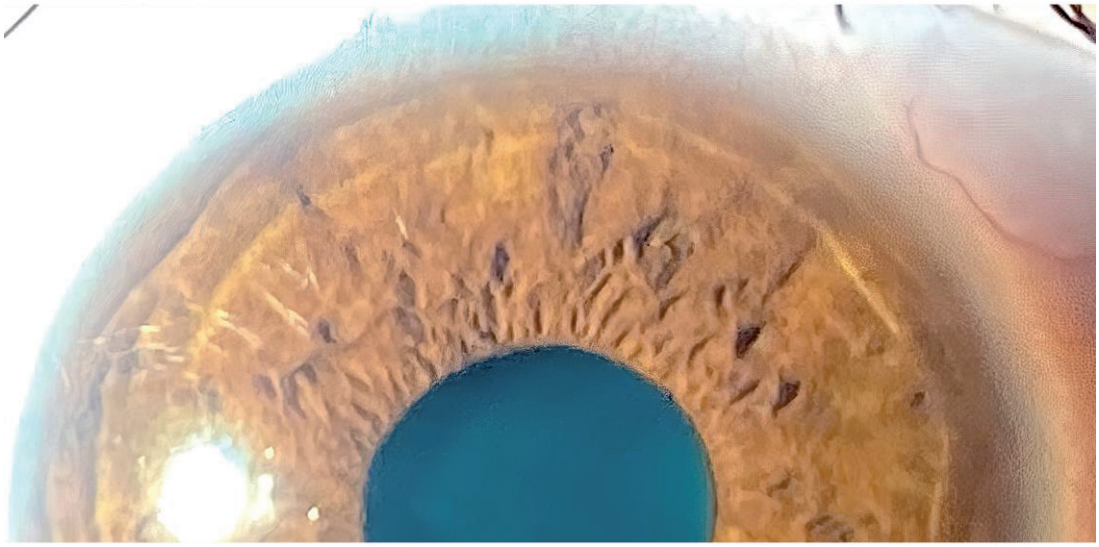


FIGURE 111: Level 3 fine results to greenish and bluish turqouise

3 9.2 Level 3







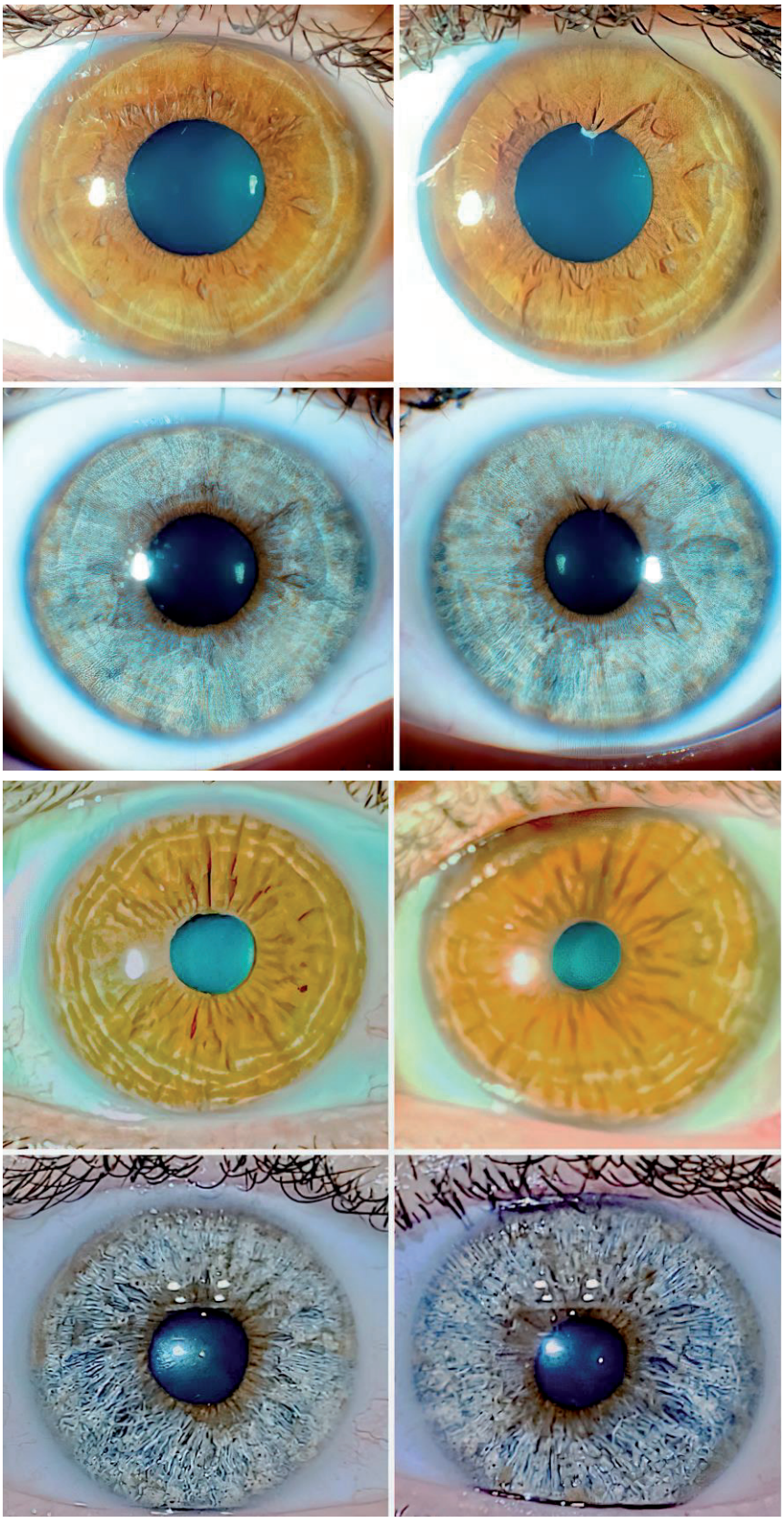
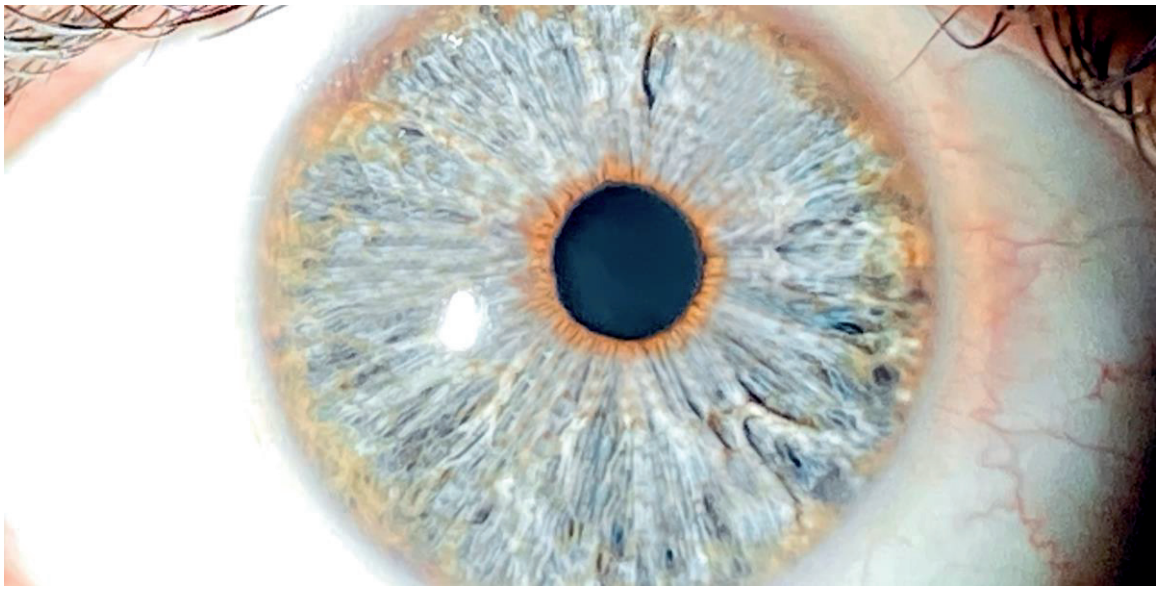
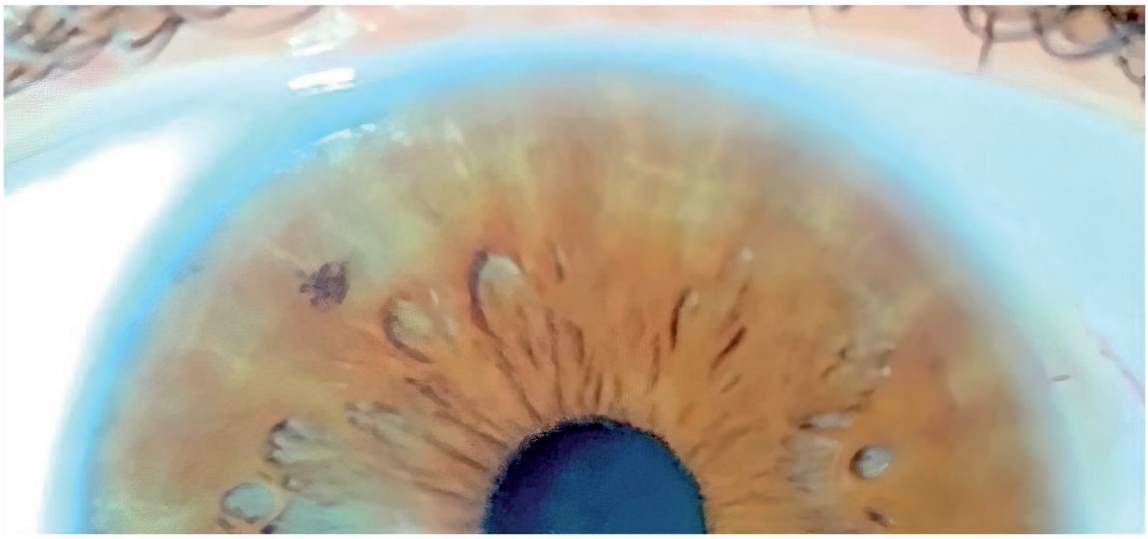


FIGURE 112: Level 3 fine results to turqouise

3 9.2 Level 3





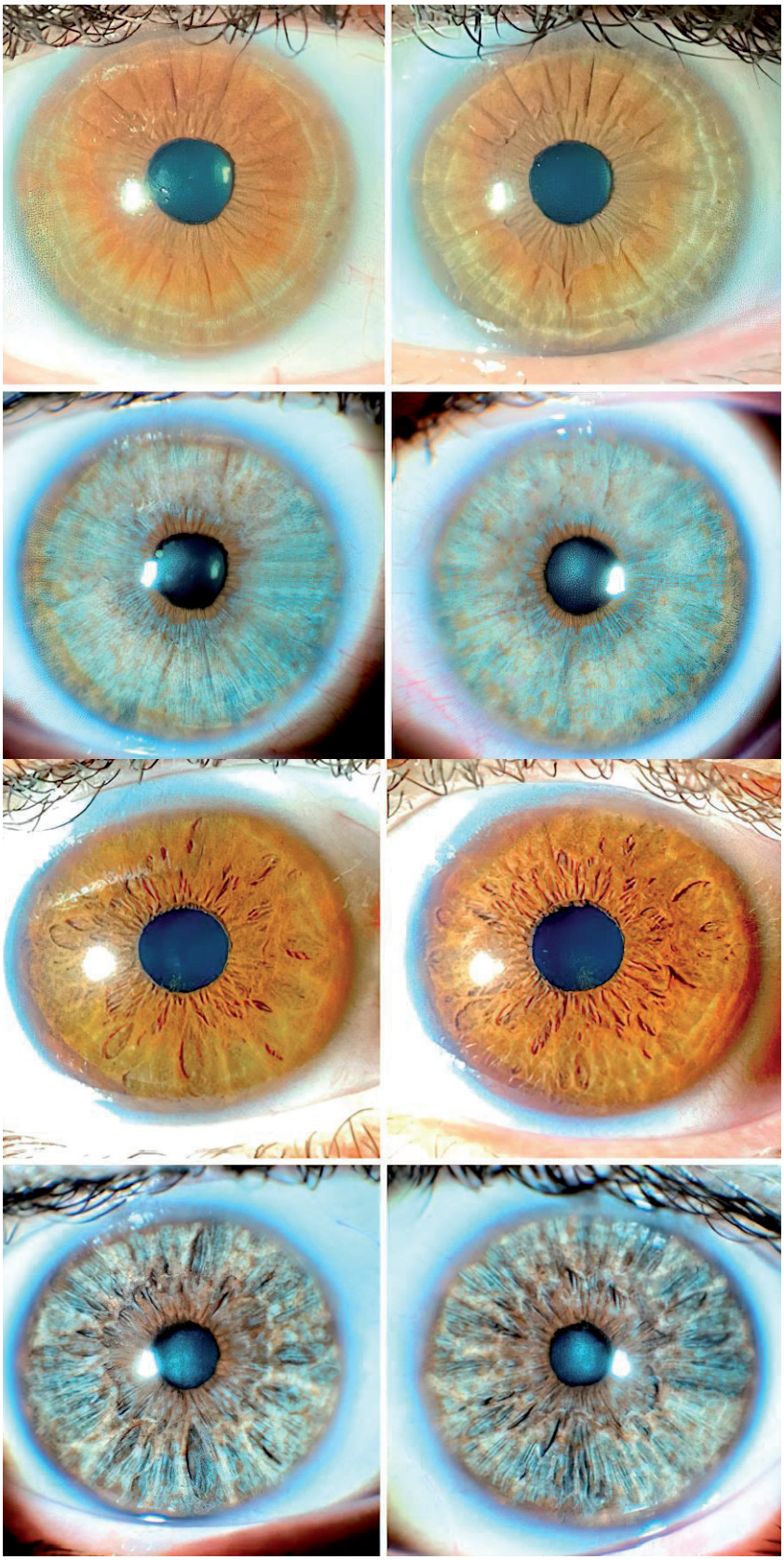
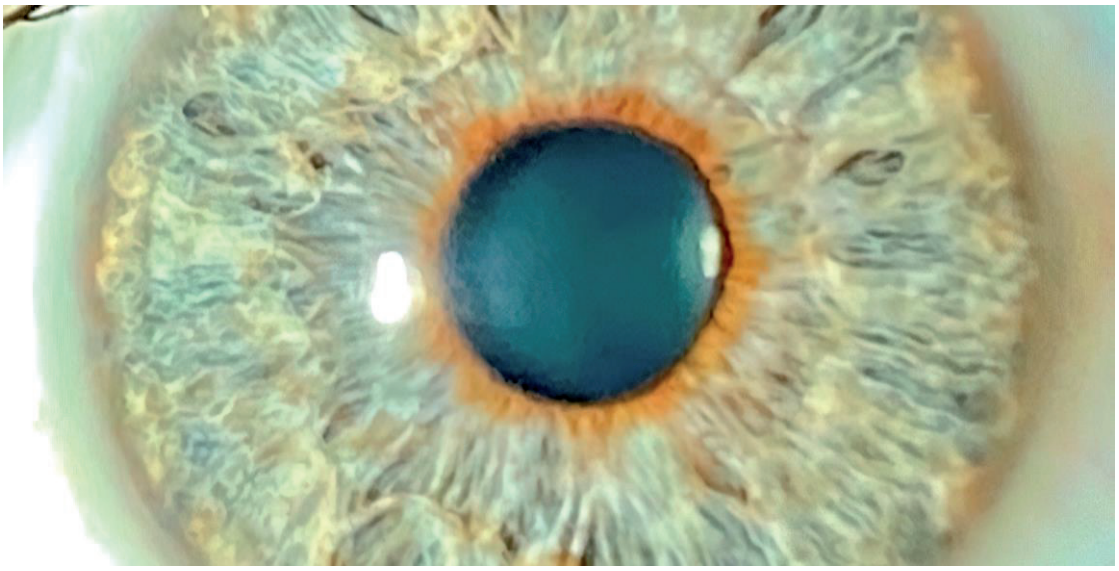
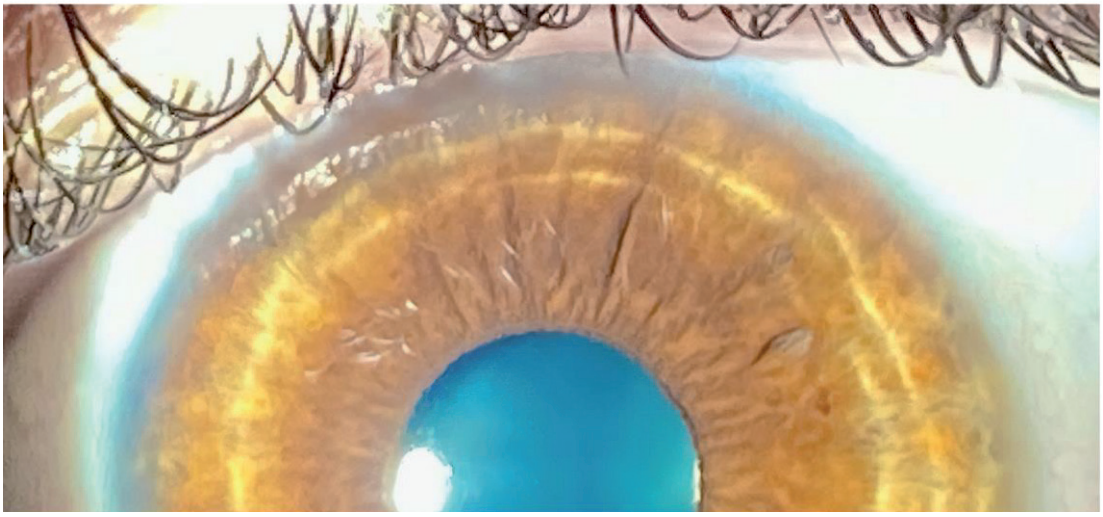


FIGURE 113: Level 3 fine results: limbal ring and irregular iris

3 9.2 Level 3





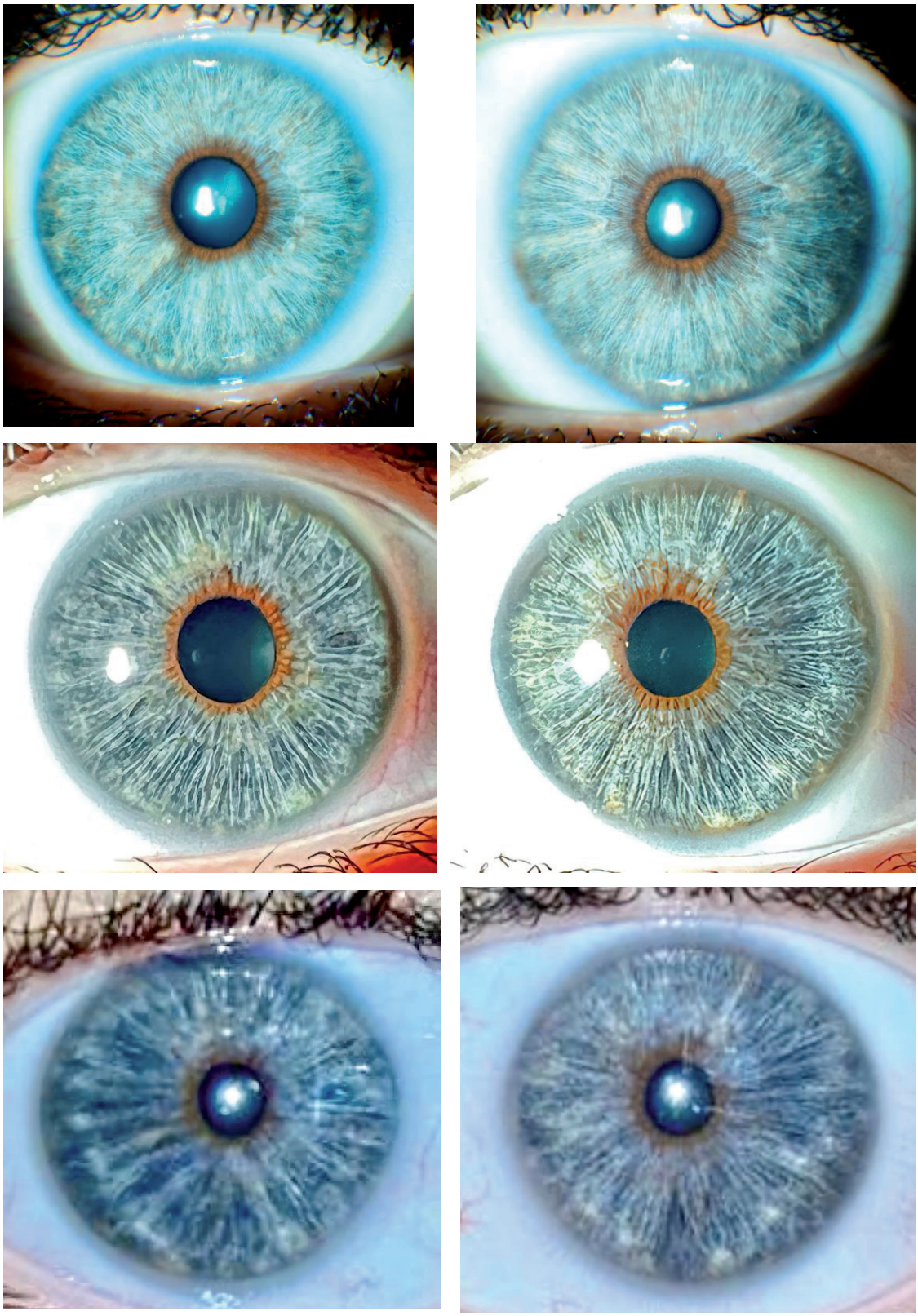
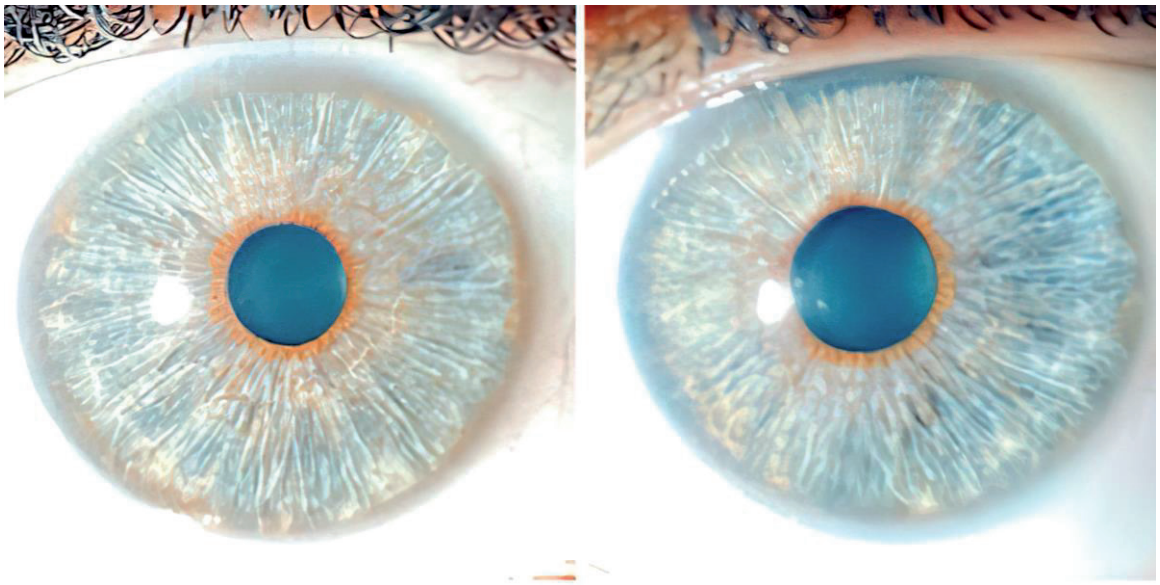
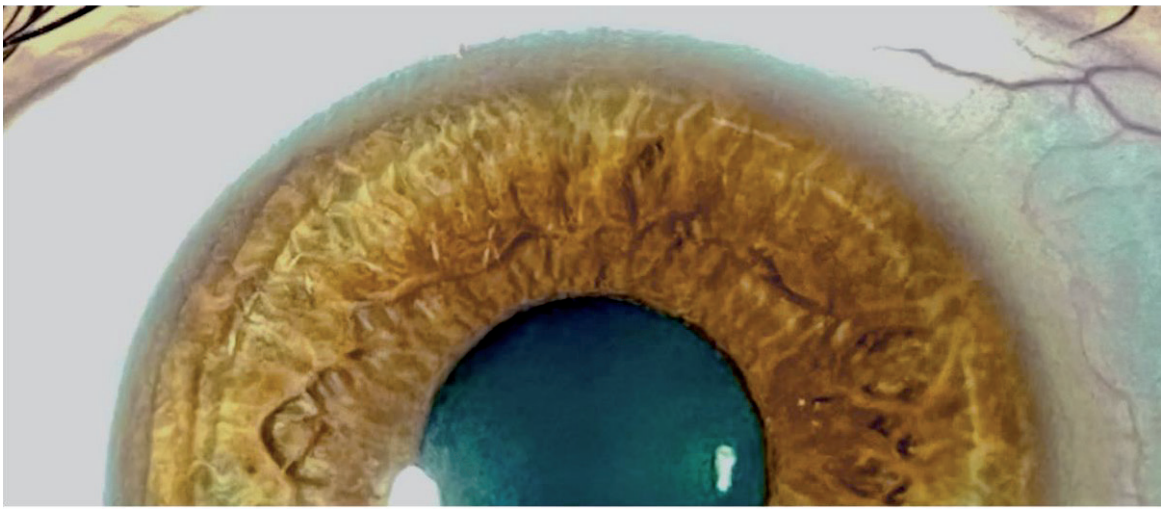


FIGURE 114: Level 3 fine results to medium blue turqouise

3 9.2 Level 3





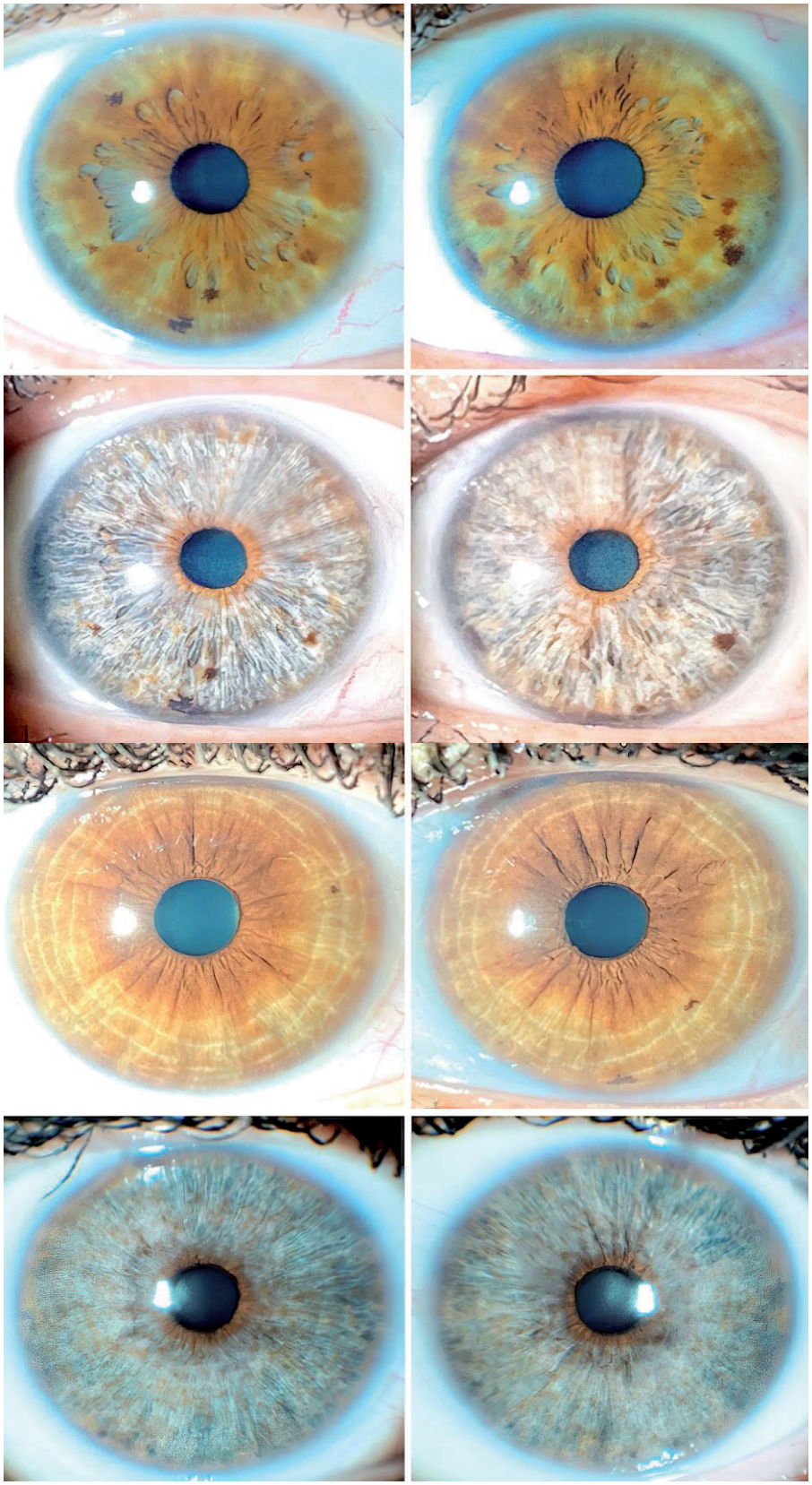
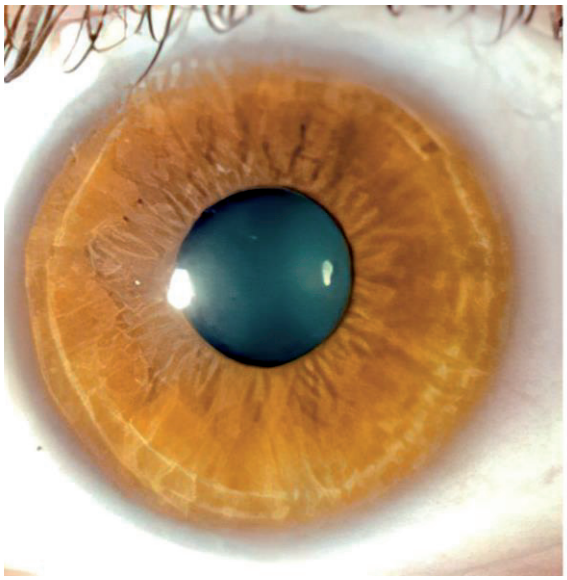
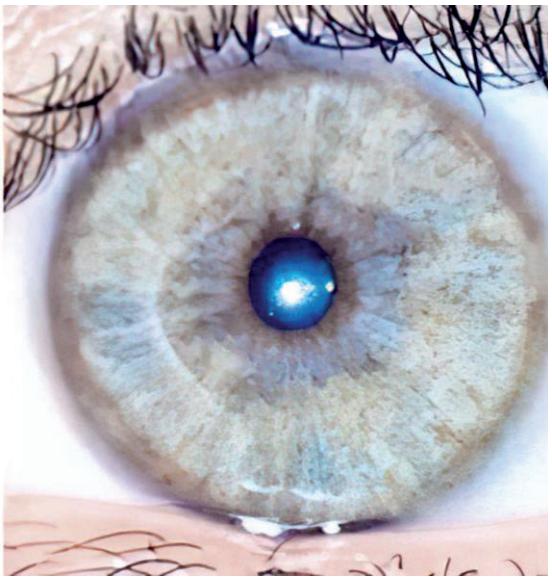
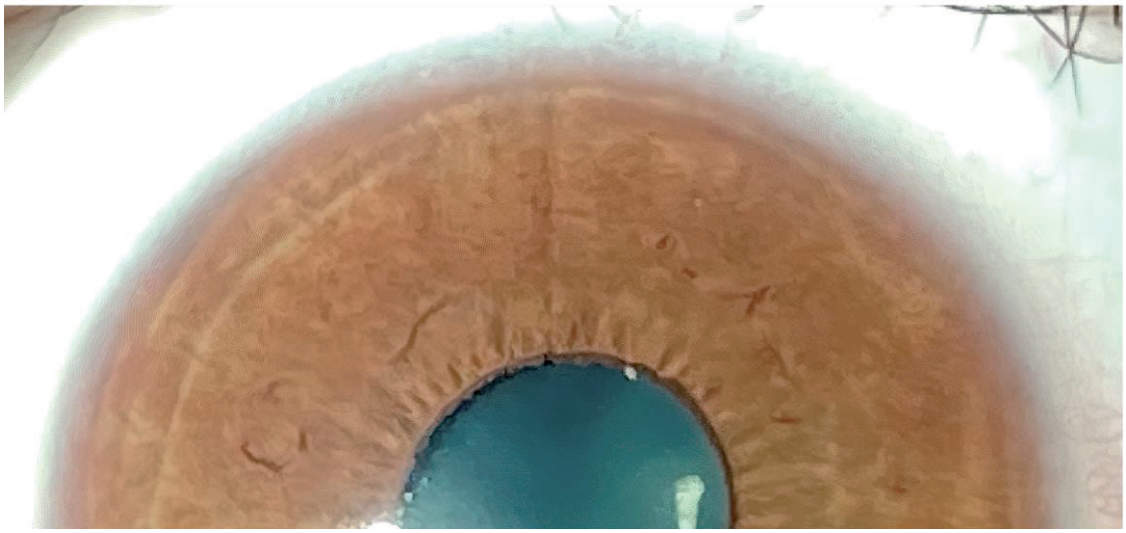


FIGURE 115: Level 3 fine results to bright and medium turqouise

3 9.2 Level 3







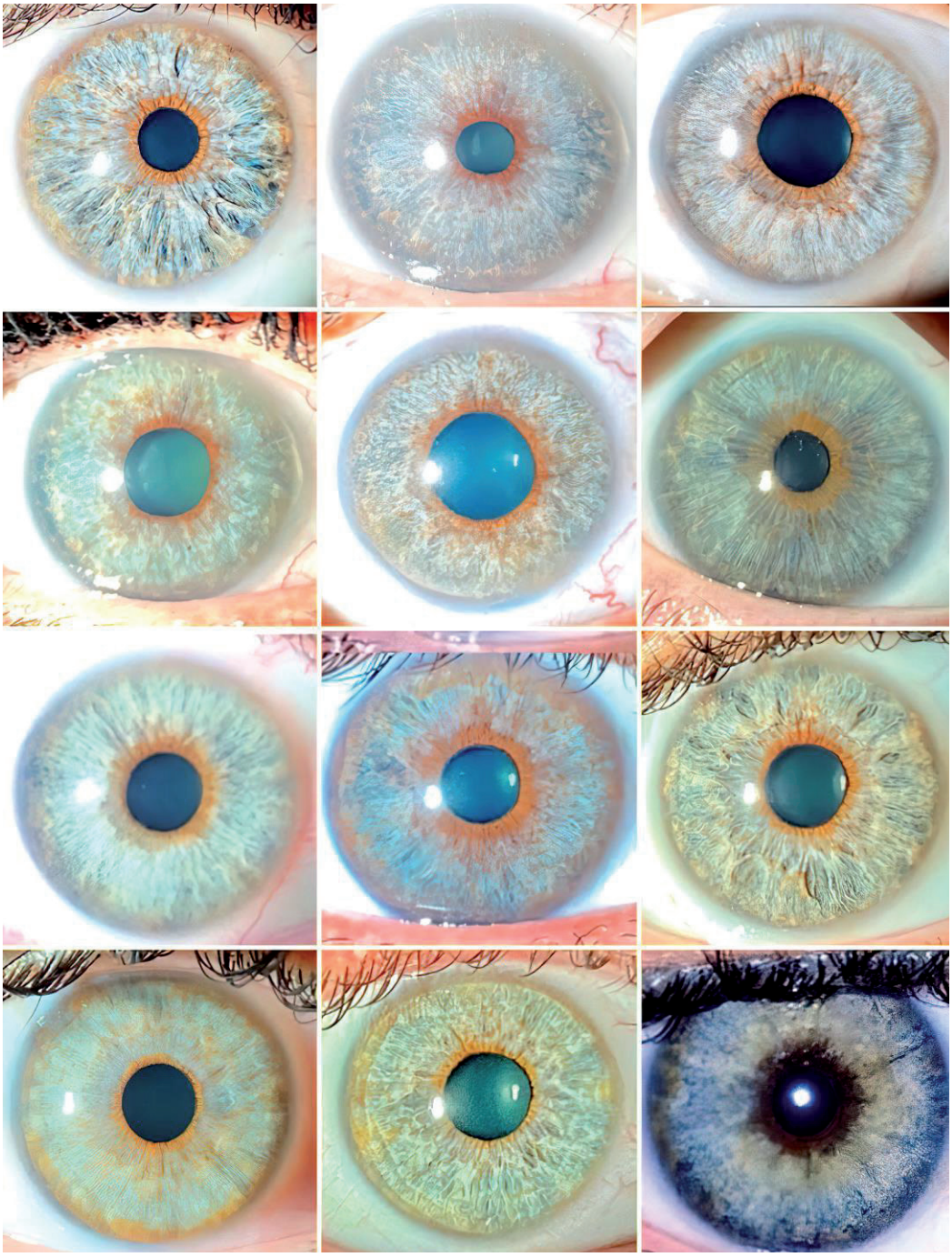
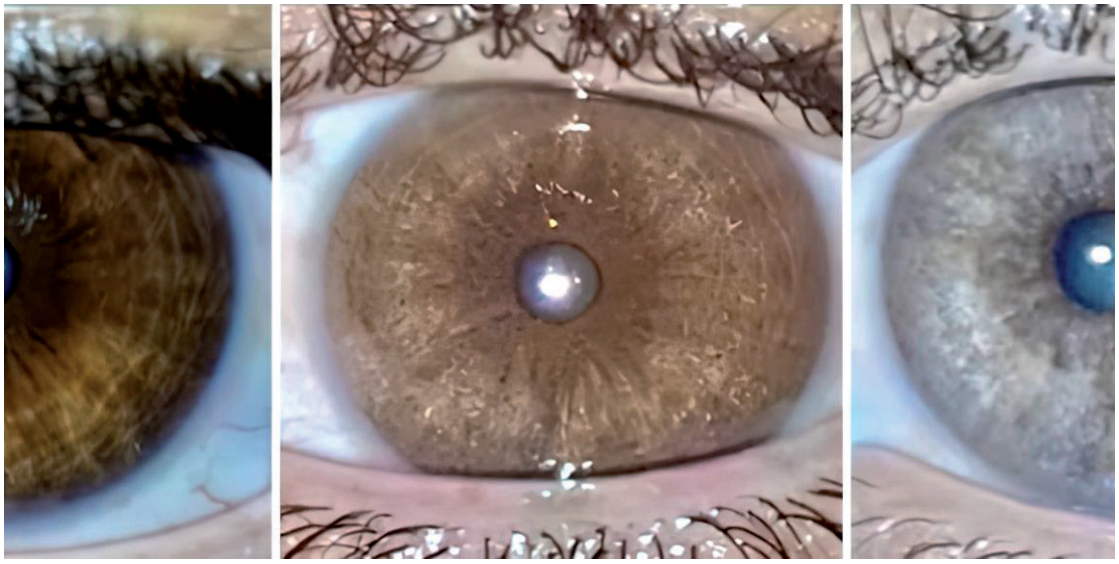
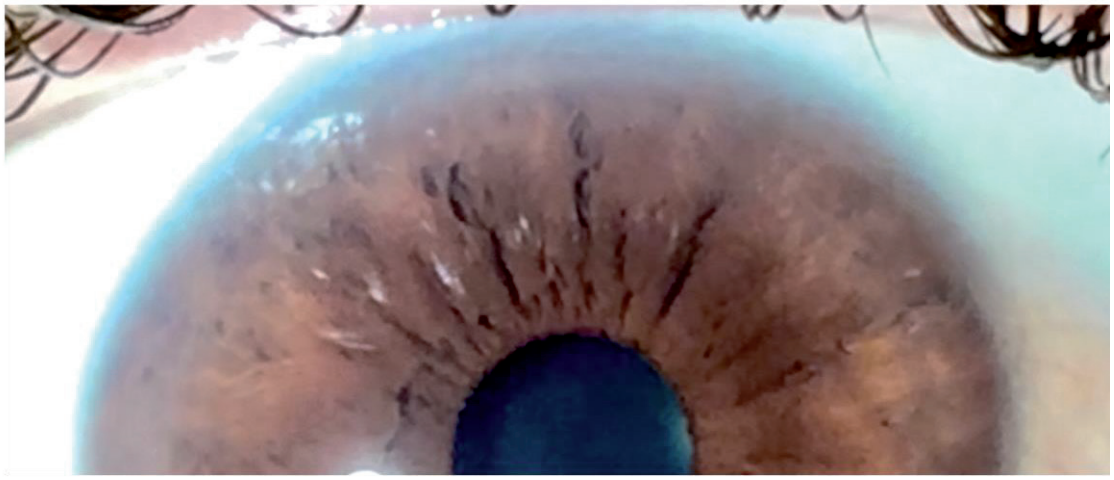


FIGURE 116: Level 3 fine results from very light to dark blue

3 9.2 Levels 4-5





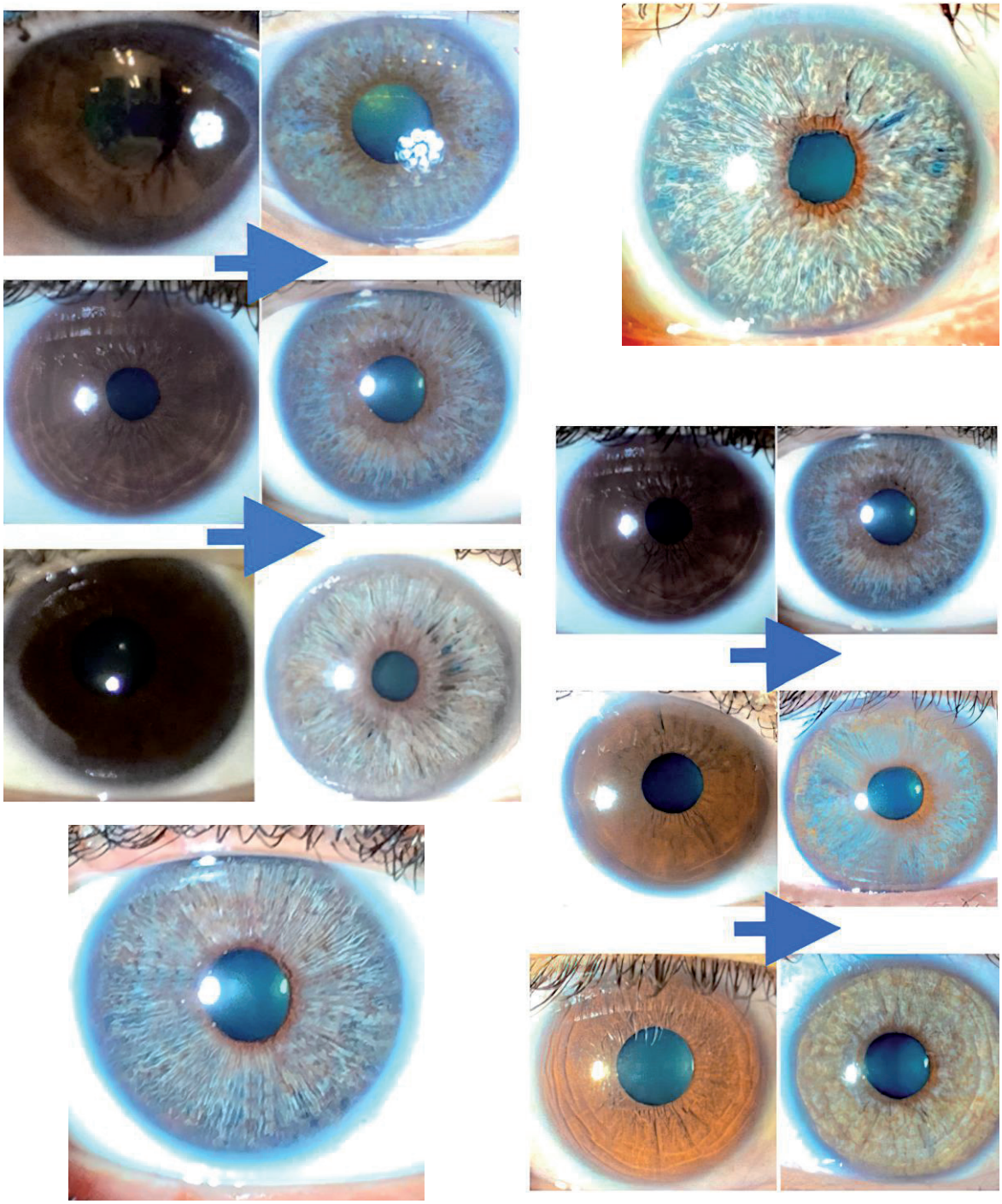
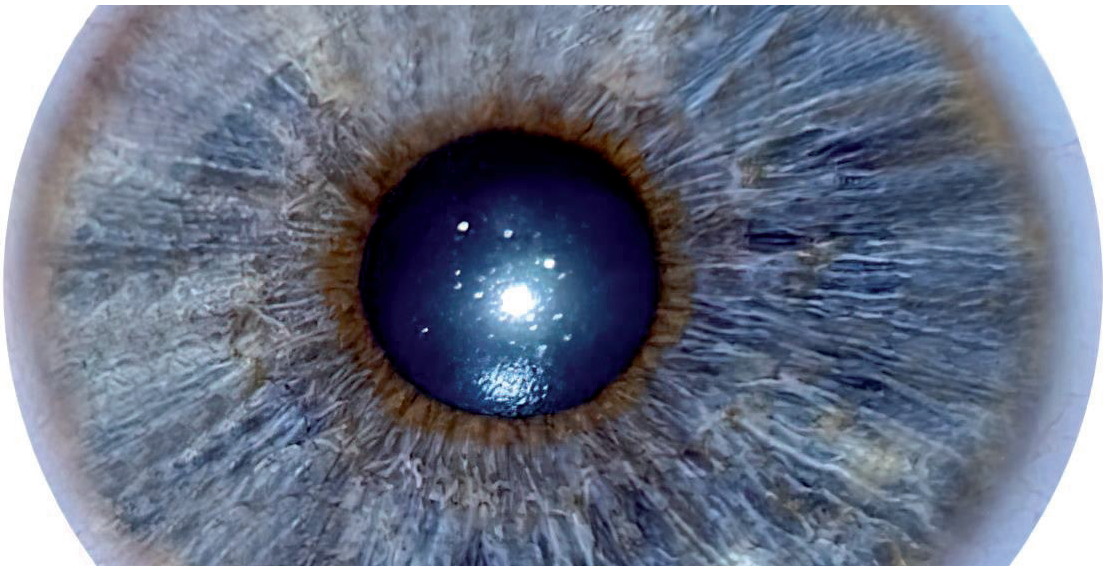
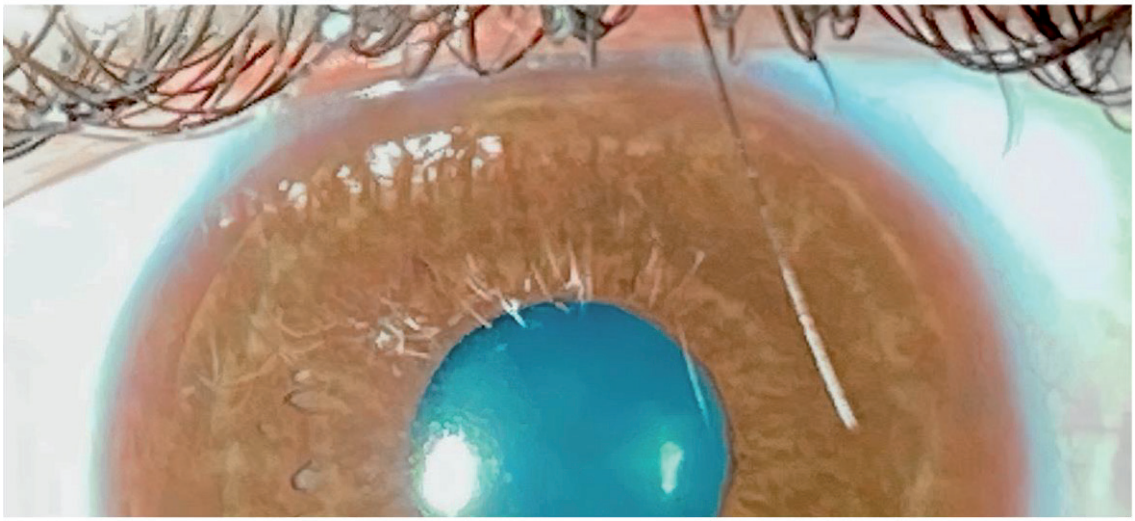


FIGURE 117: Level 4-5 fine results from light to dark grey

3 9.2 Levels 4-5





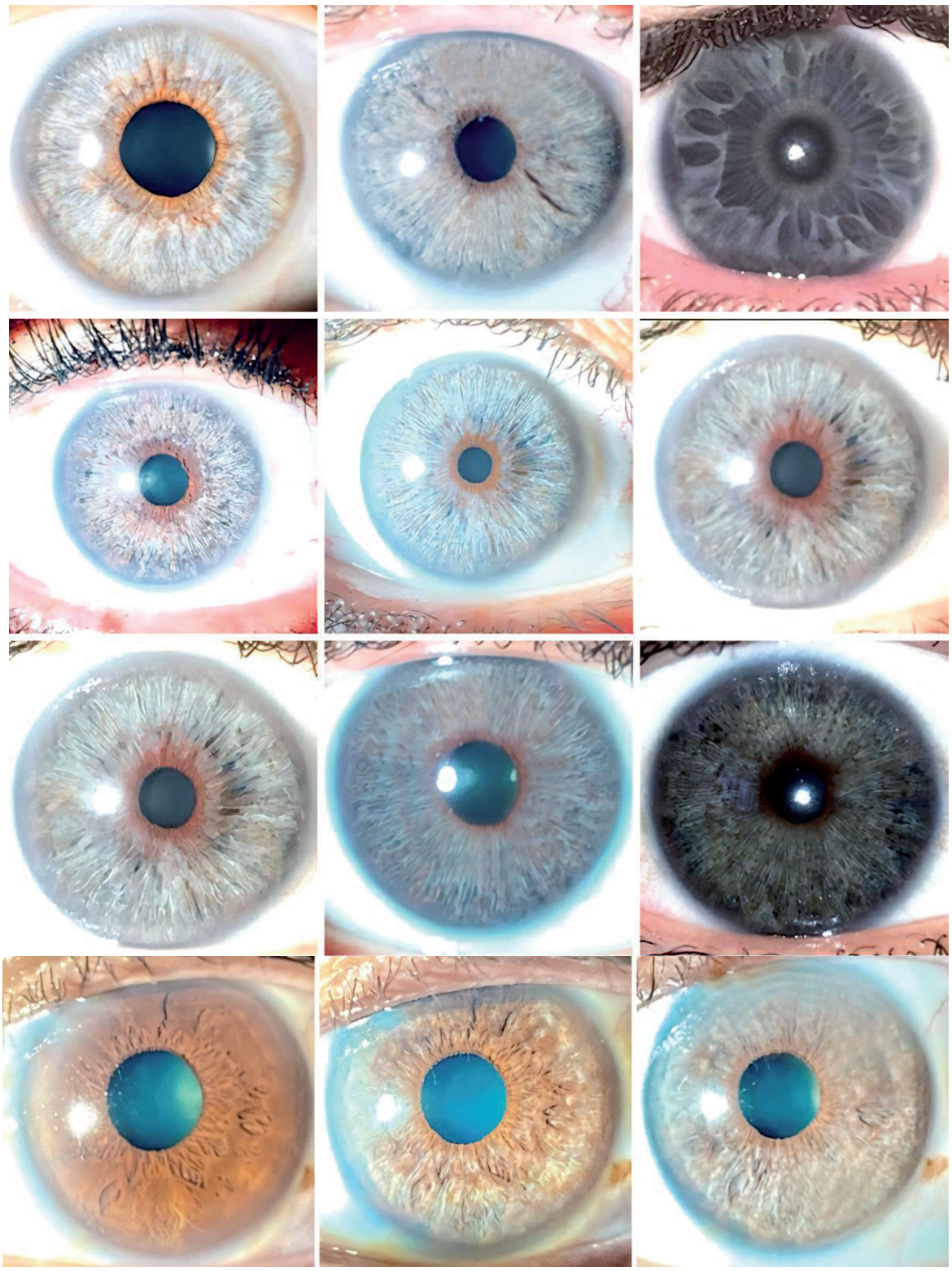
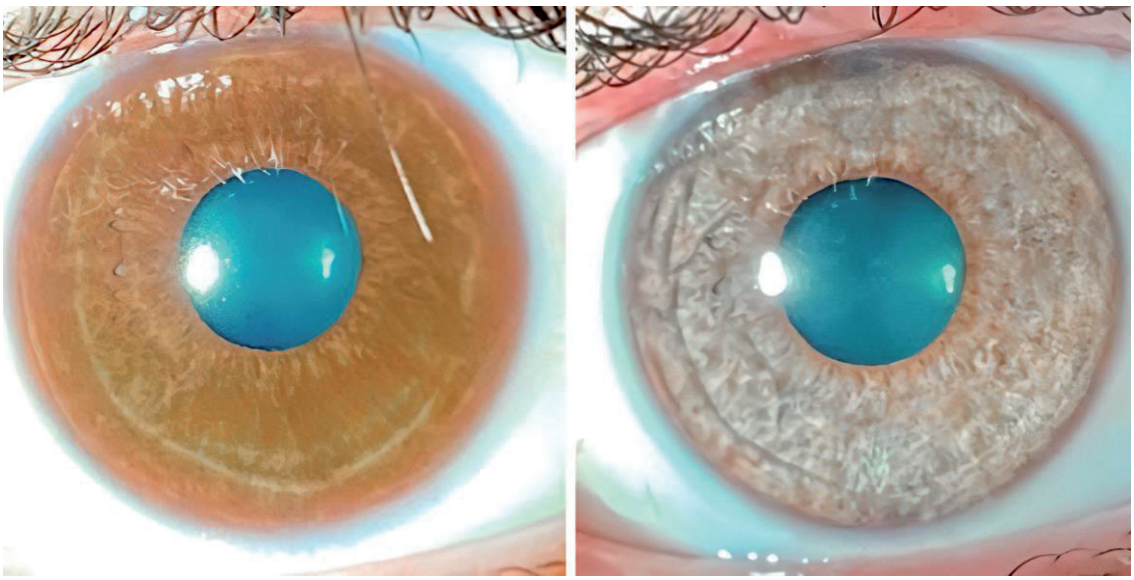
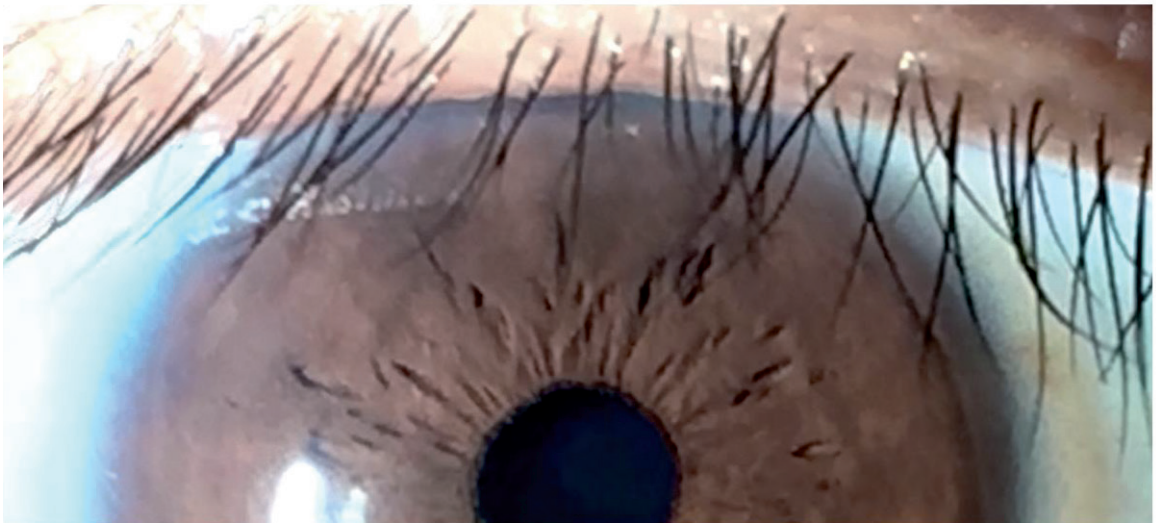


FIGURE 118: Level 4-5 fine results from light to dark blue

3 9.2 Levels 4-5





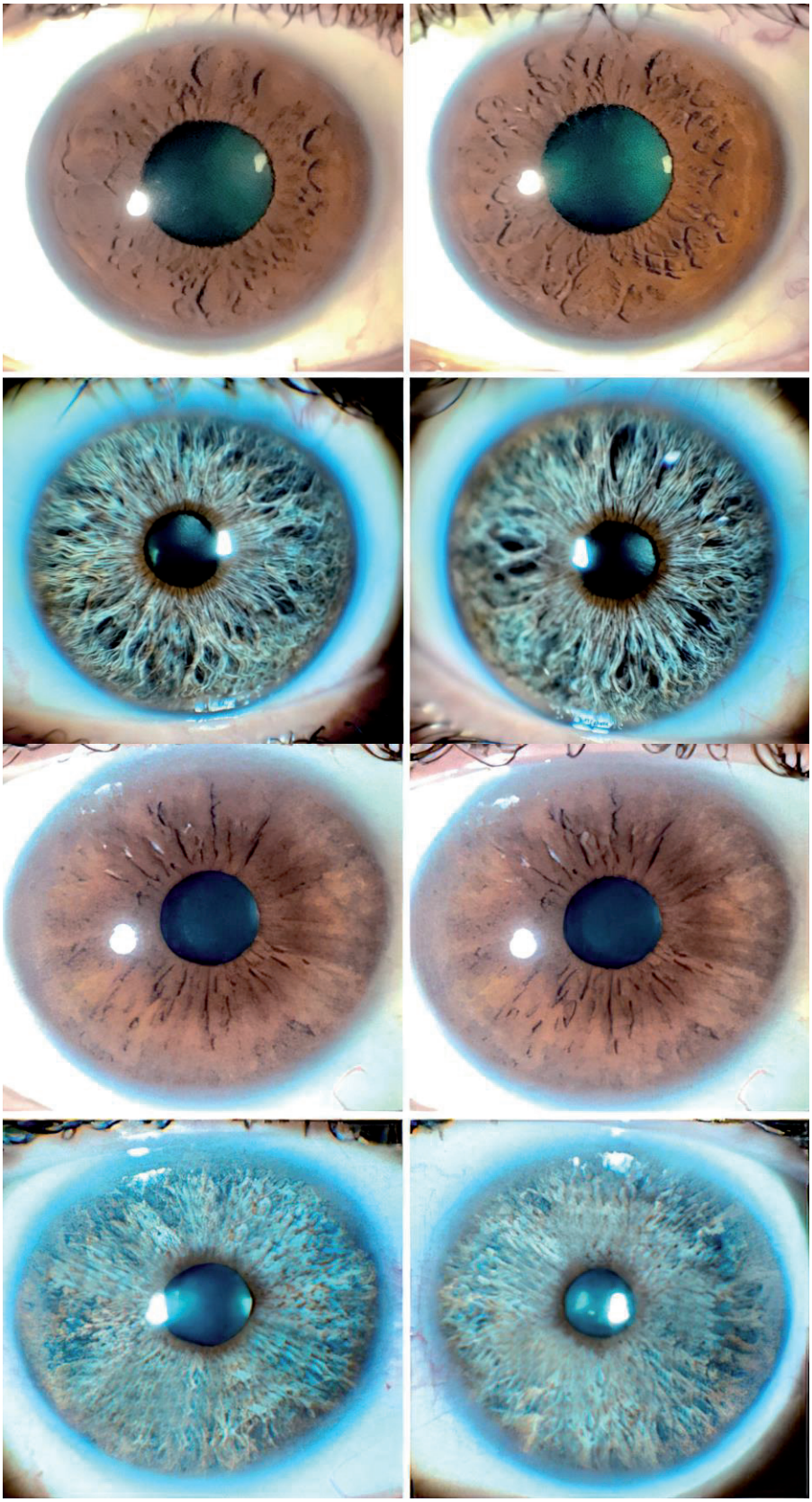
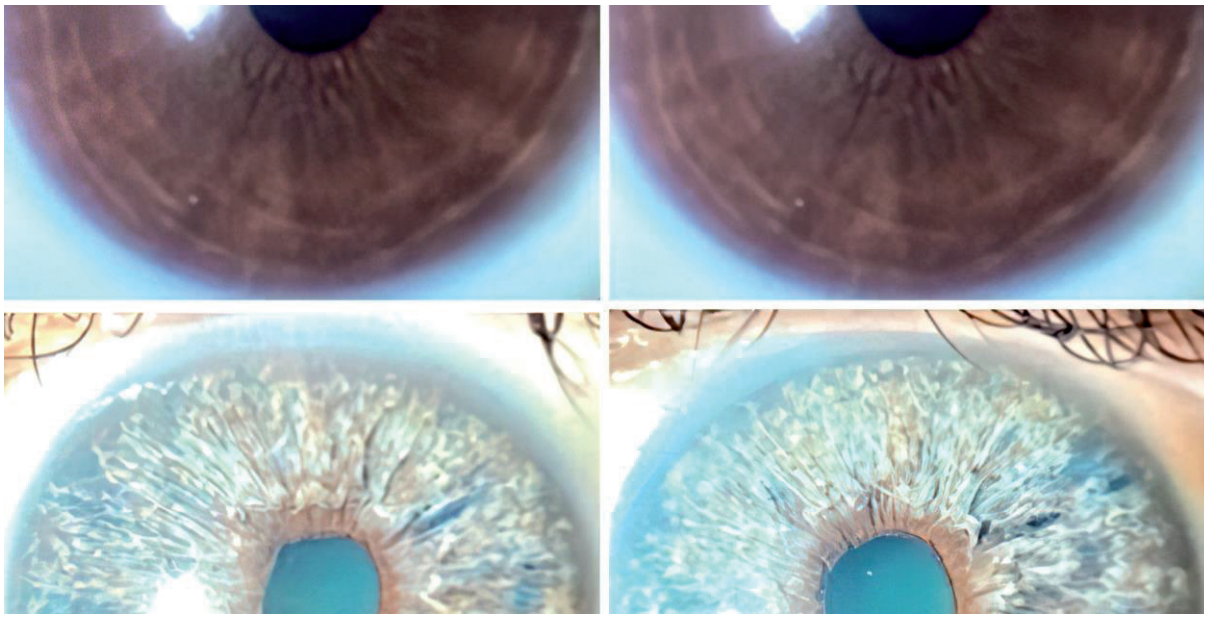


FIGURE 119: Level 4-5 fine results to dark grey turqouise

3 9.2 Levels 4-5



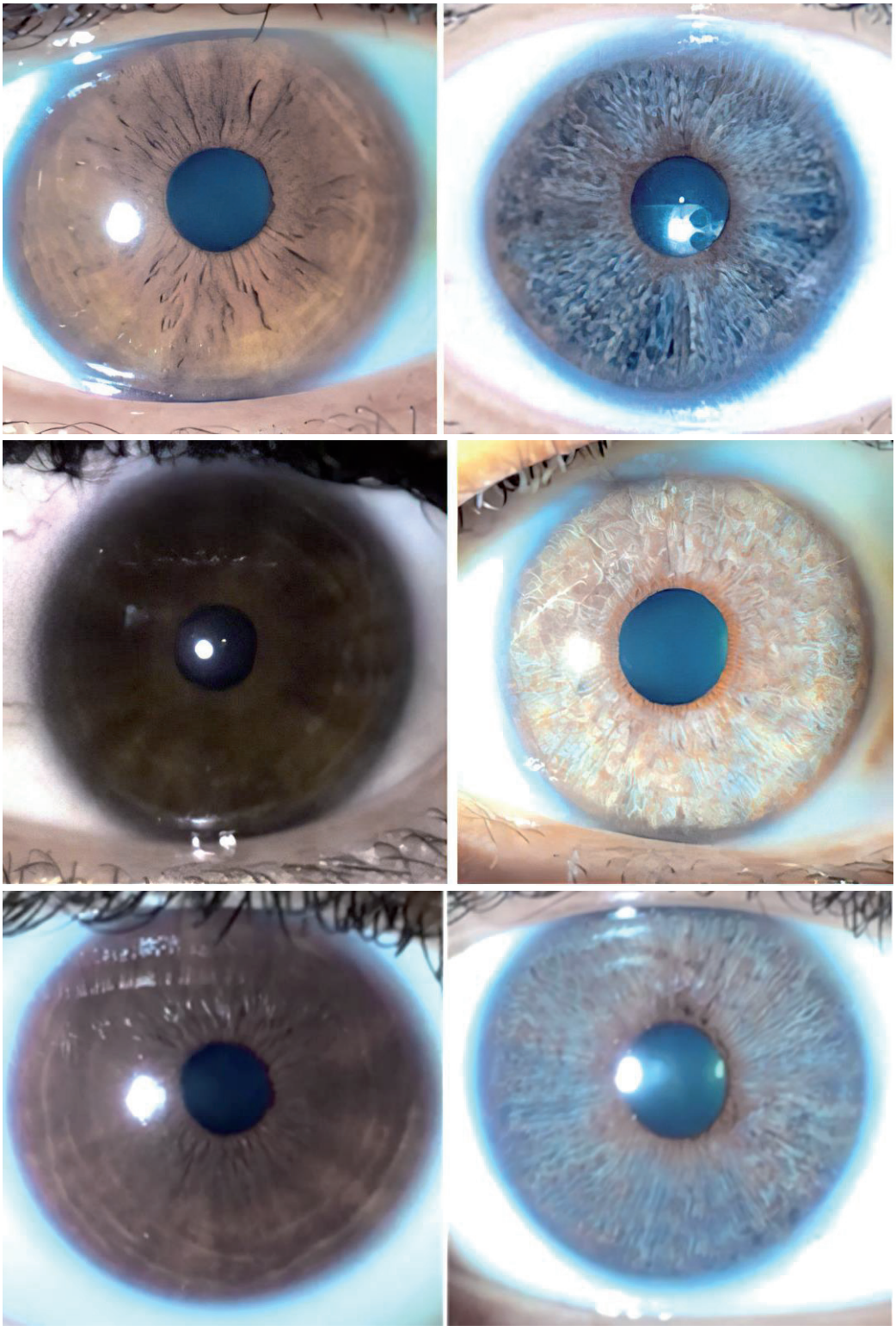
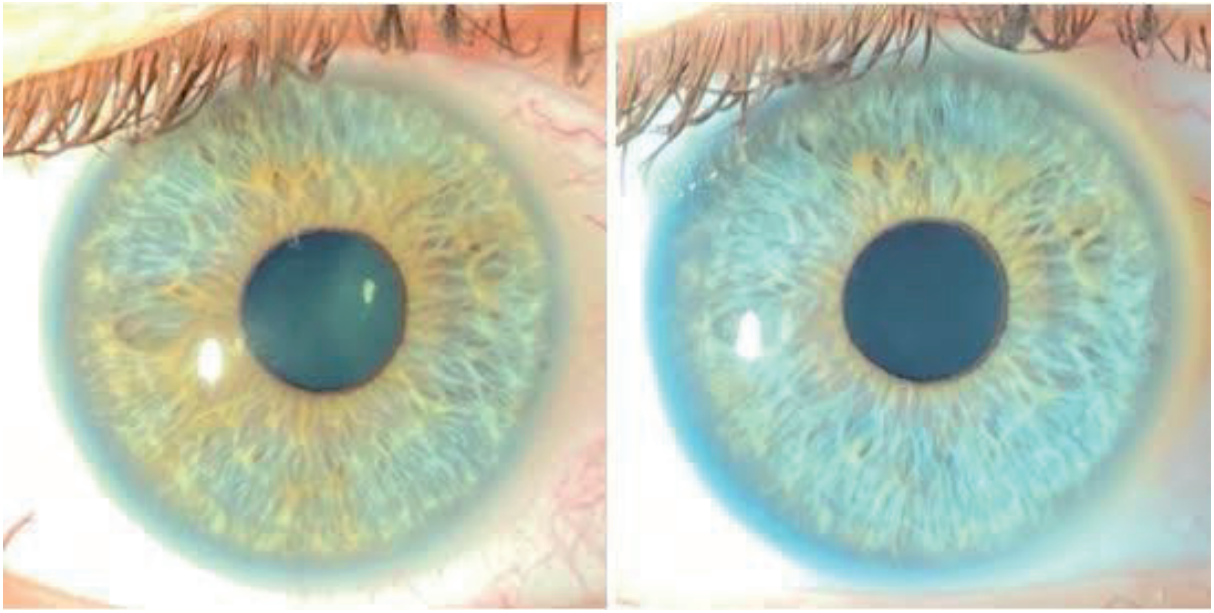
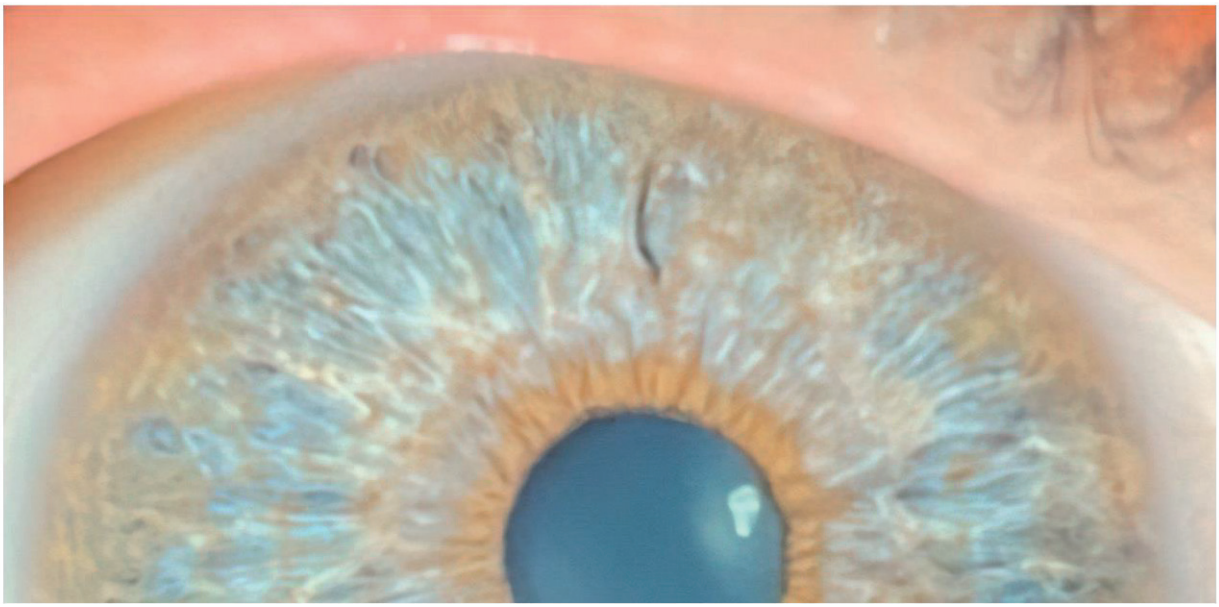


FIGURE 120: Level 4-5 fine results to light and dark grey

3 9.4 Phase 1- L2





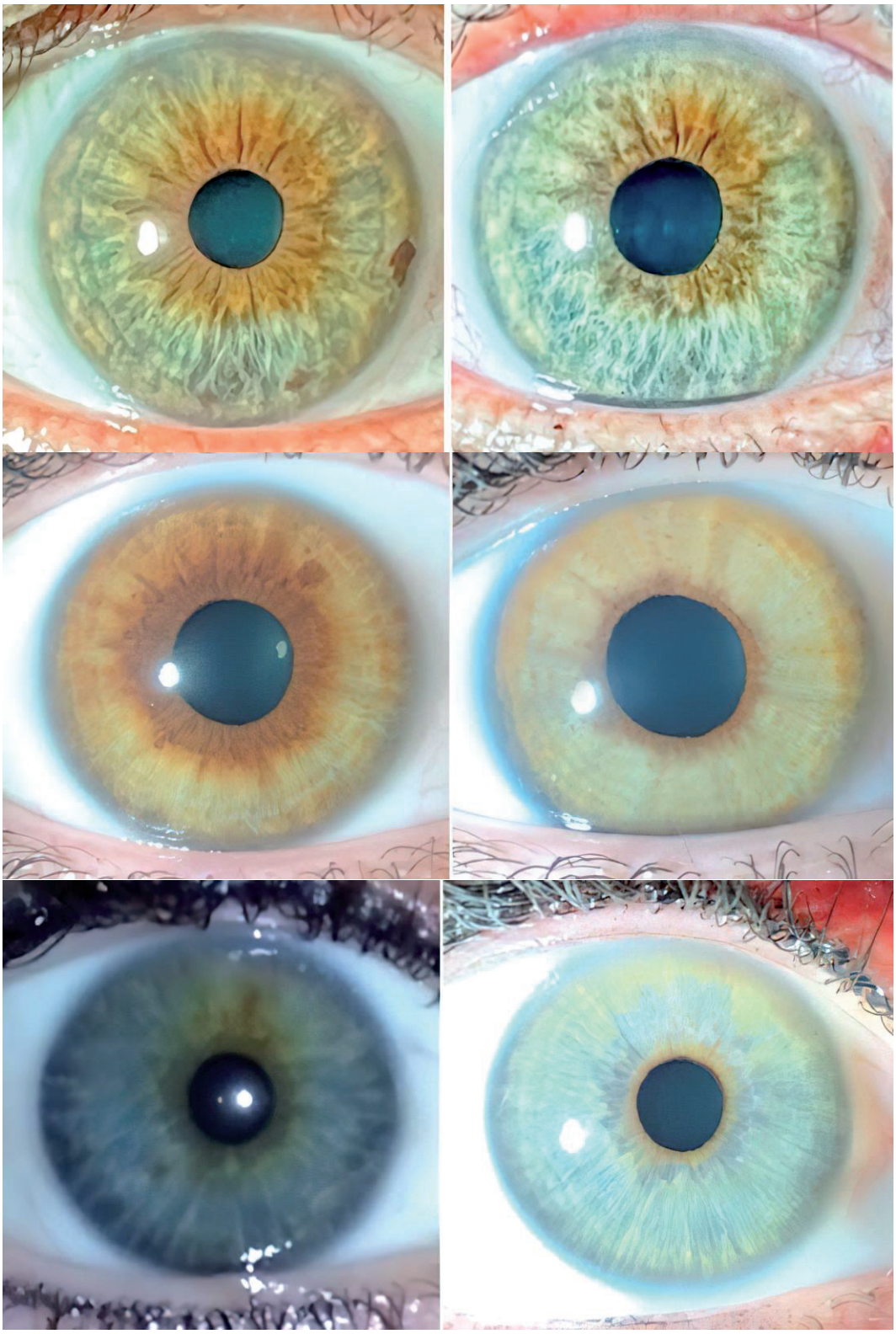
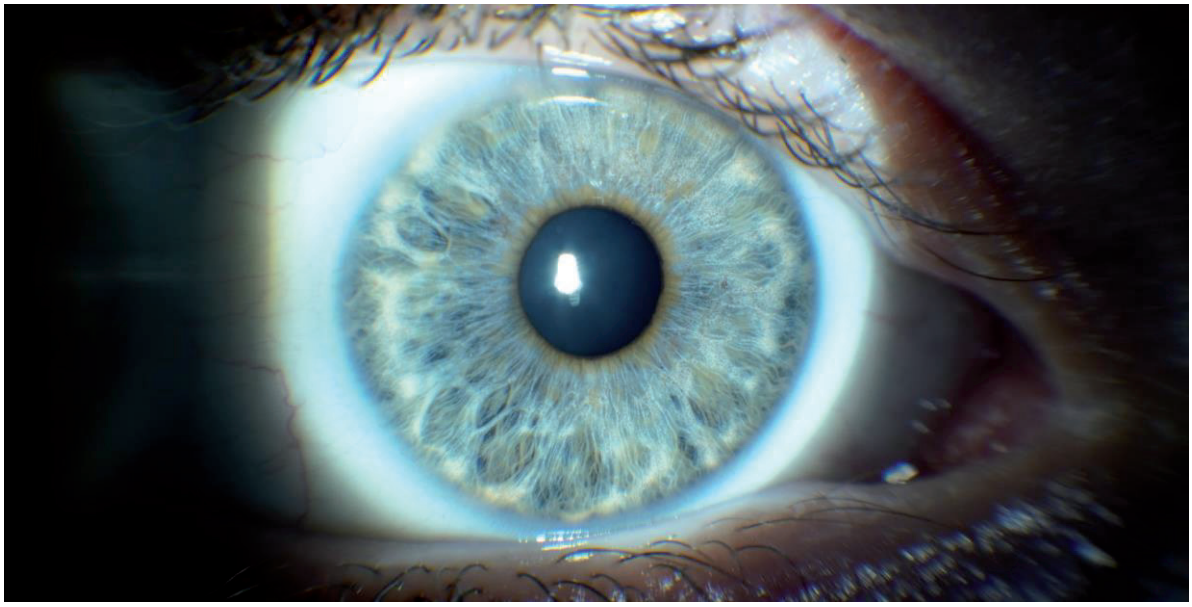
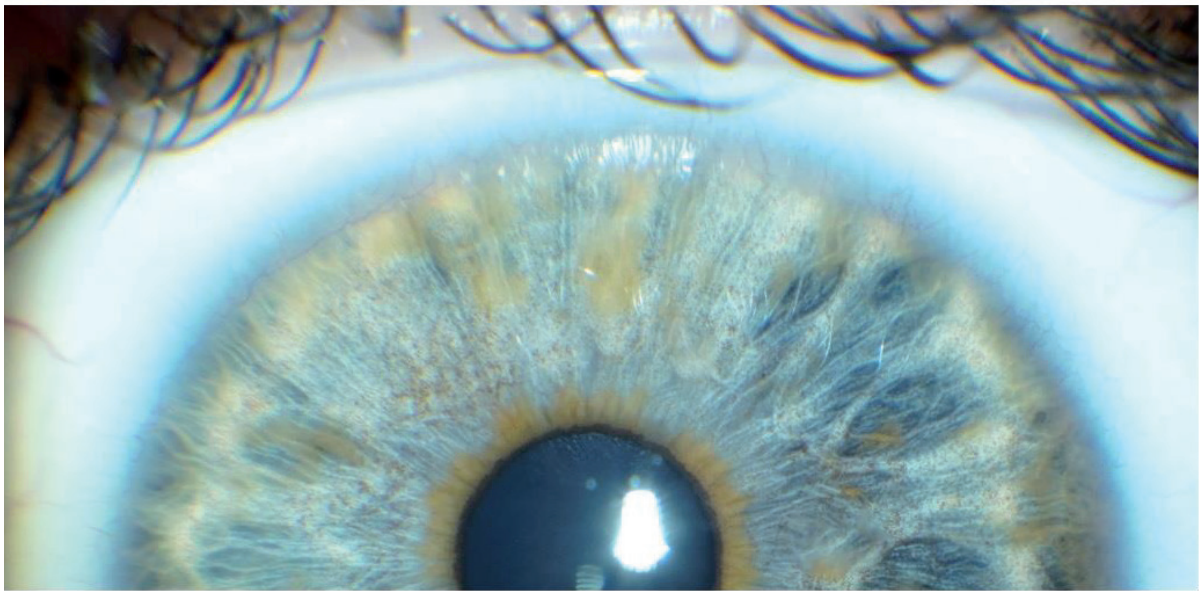


FIGURE 121: Partial fine results after phase 1 on levels 2 eyes

3 9.4 Phase 1- L2





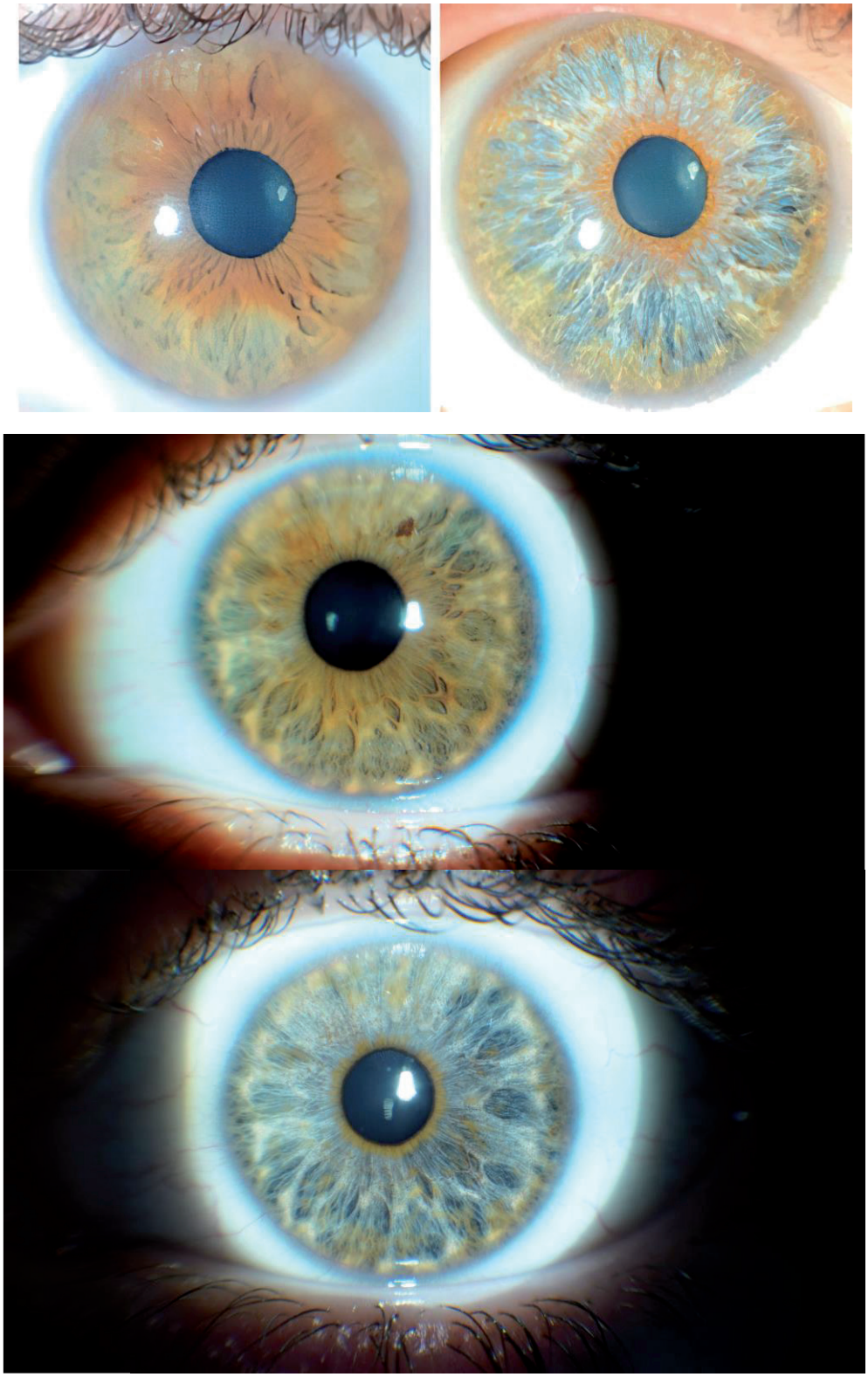
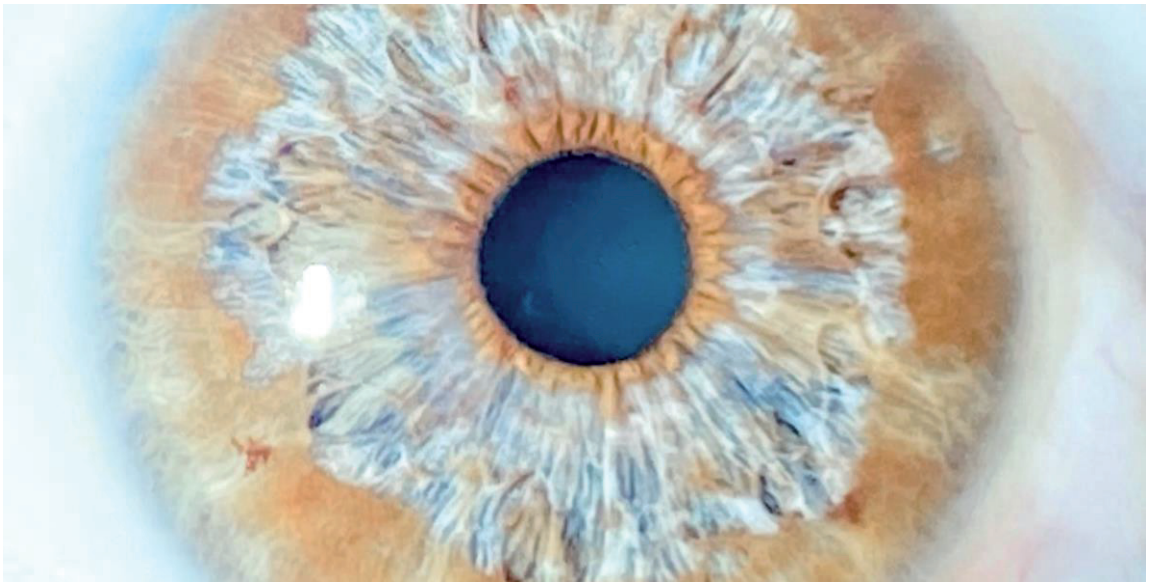
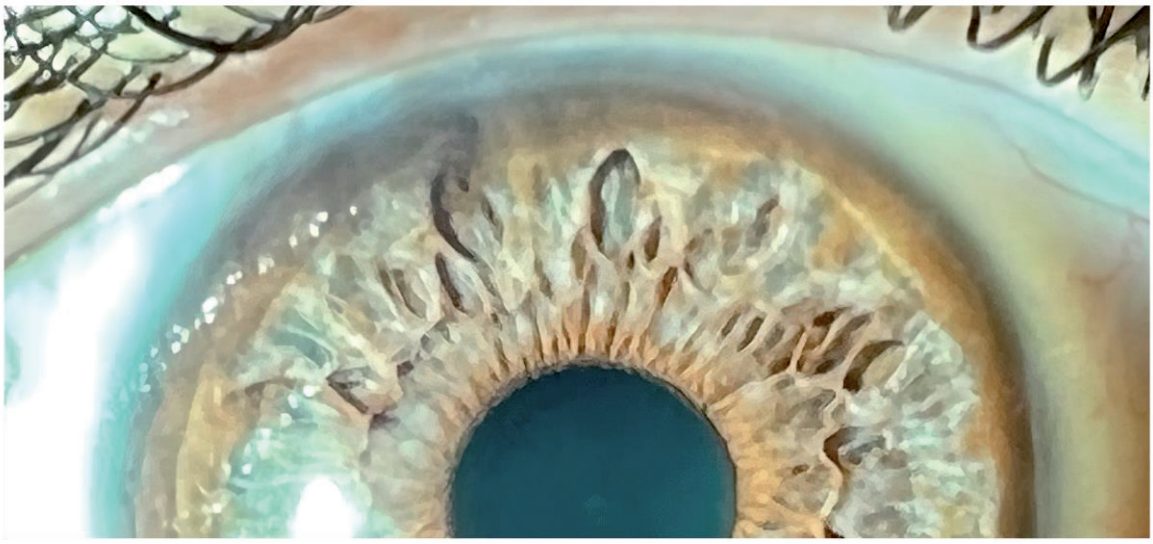


FIGURE 122: Partial fine results after phase 1 on levels 2 eyes

3 9.4 Phase 1- L3





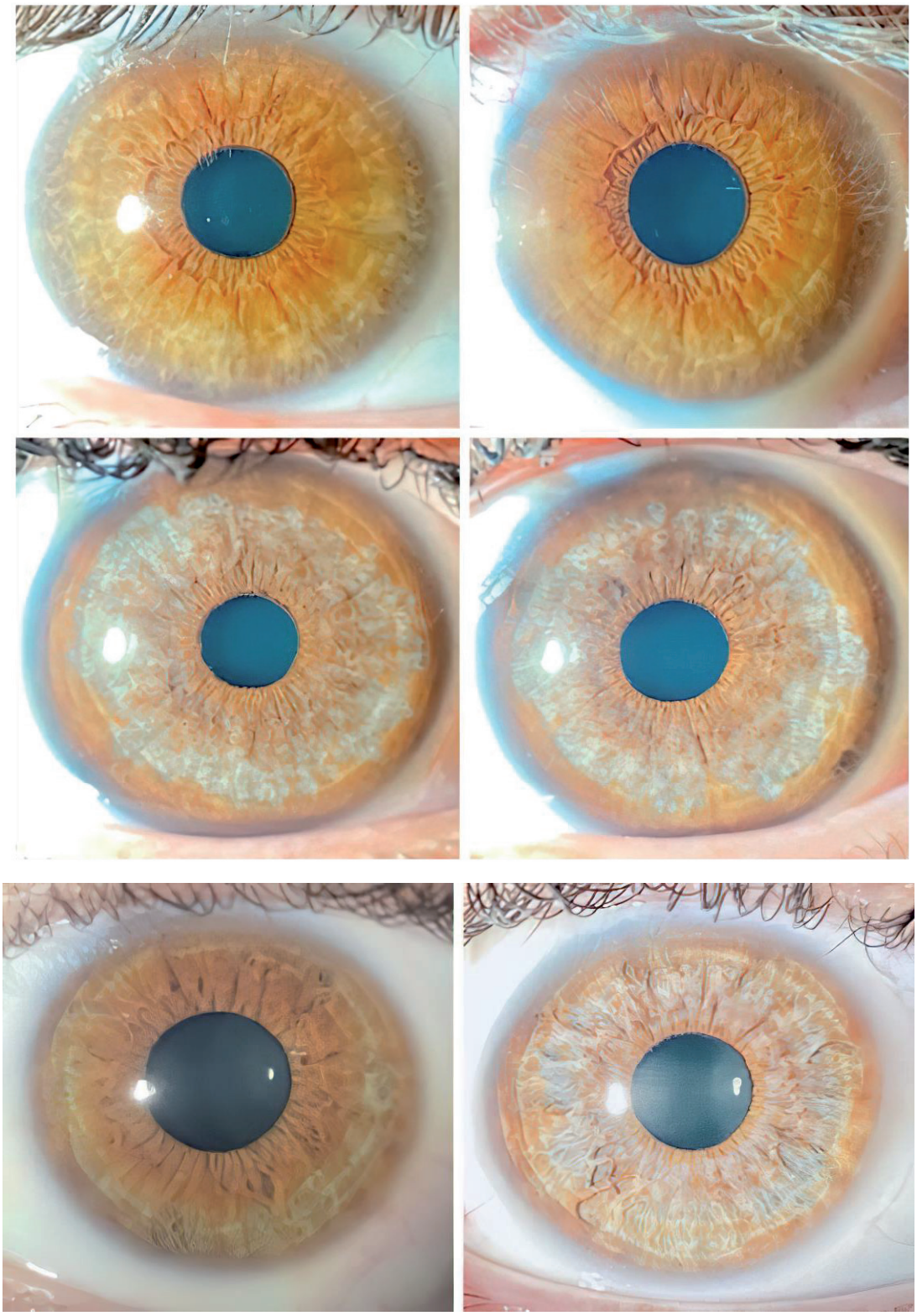
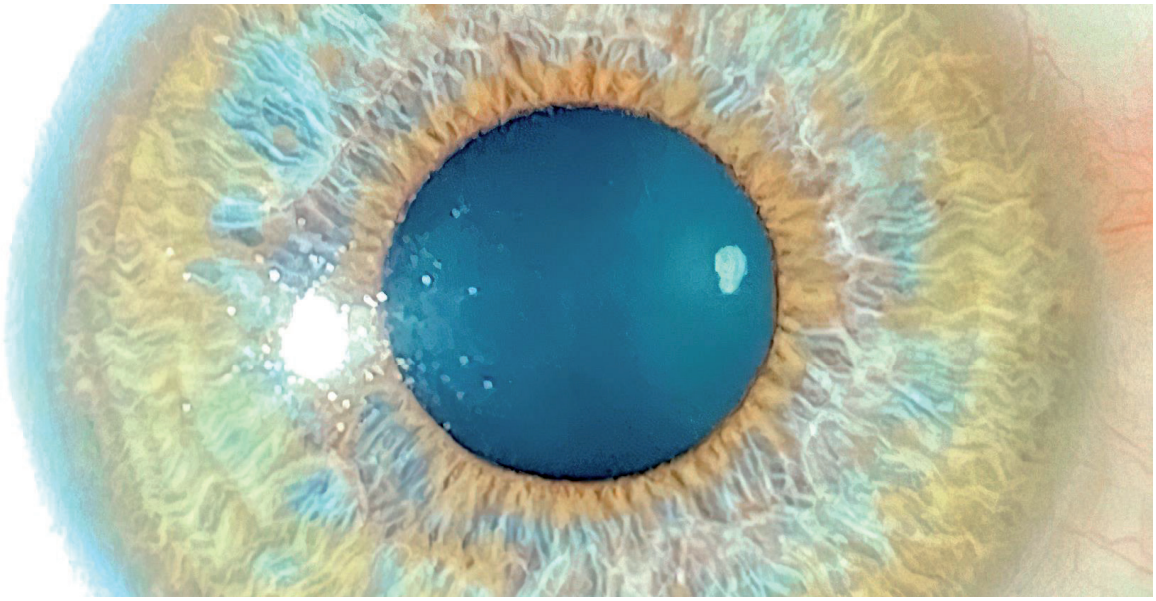
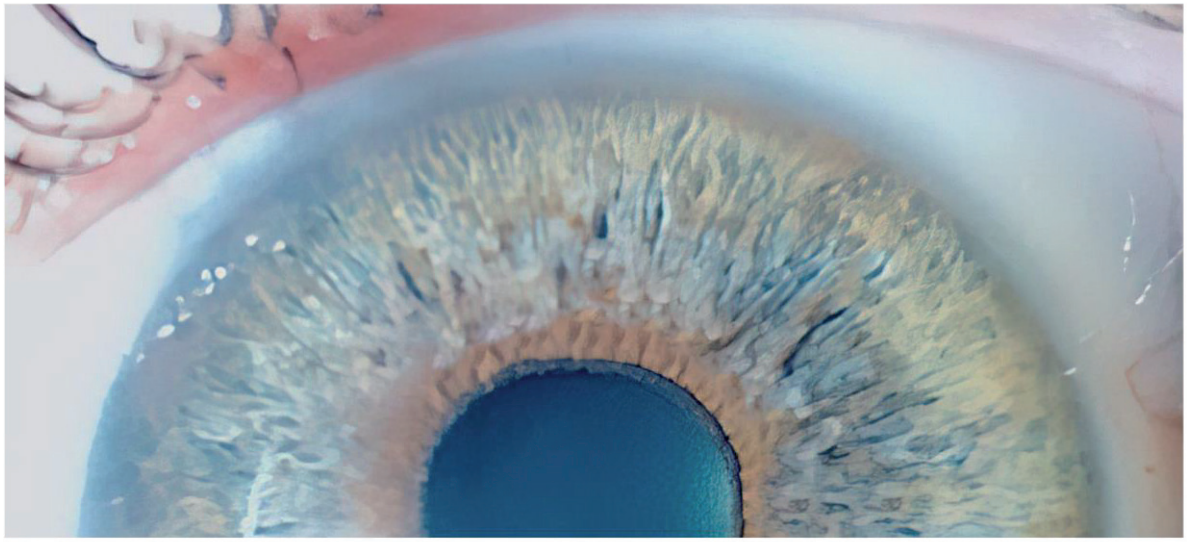


FIGURE 123: Partial fine results after phase 1 on levels 3 eyes

3 9.4 Phase 1- L3





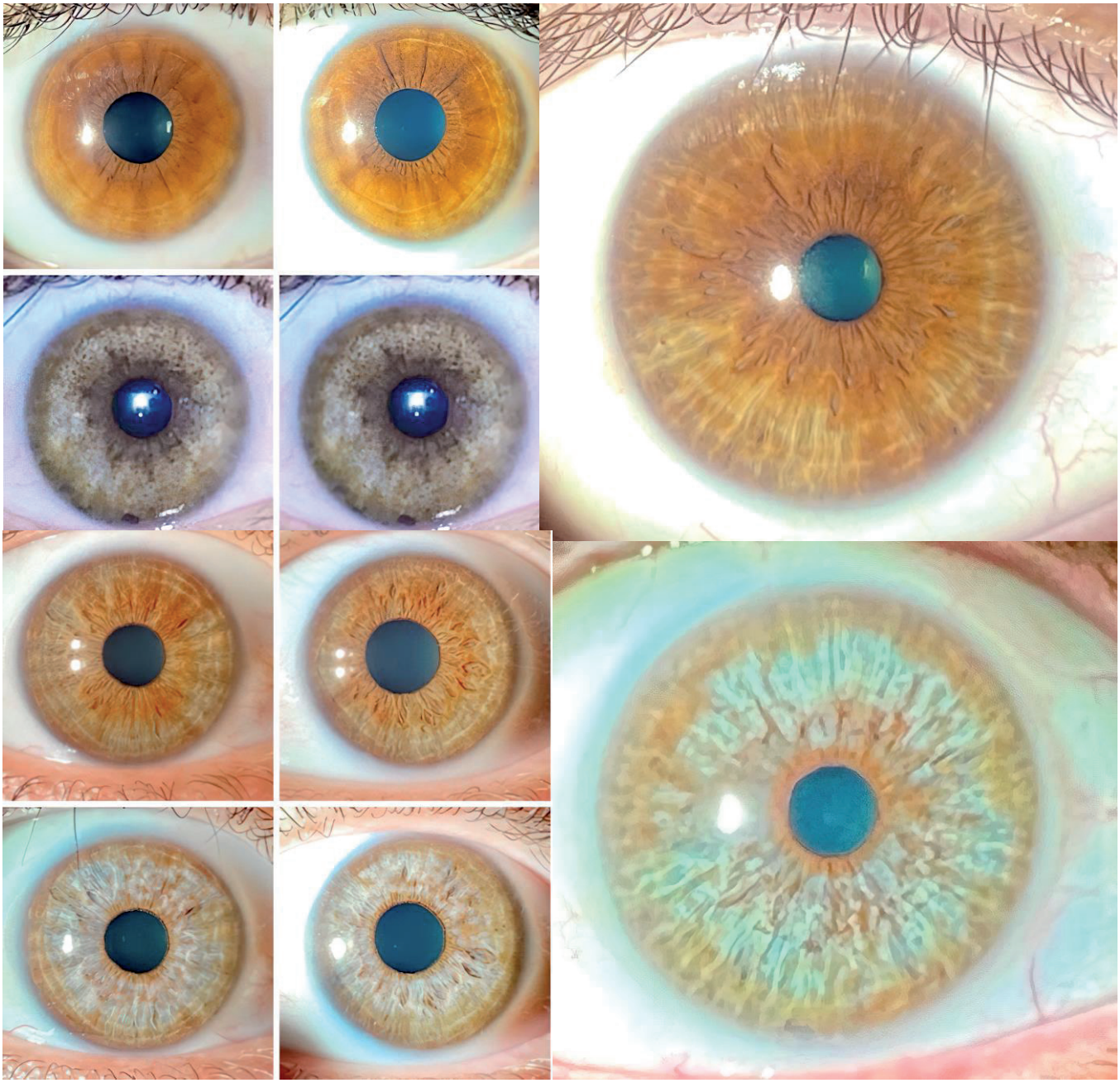
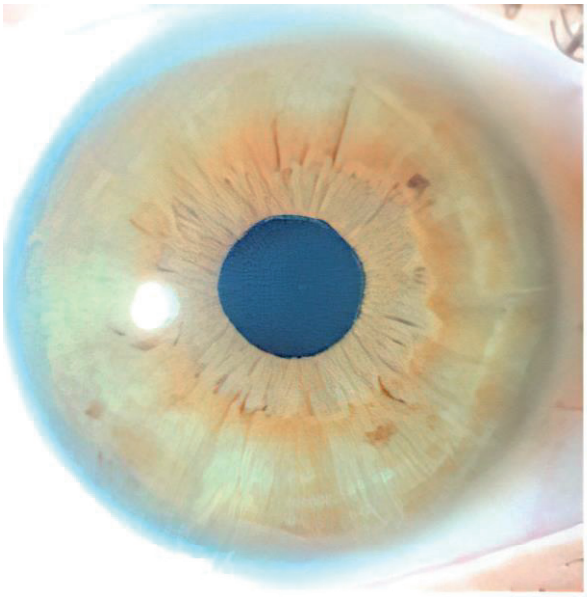
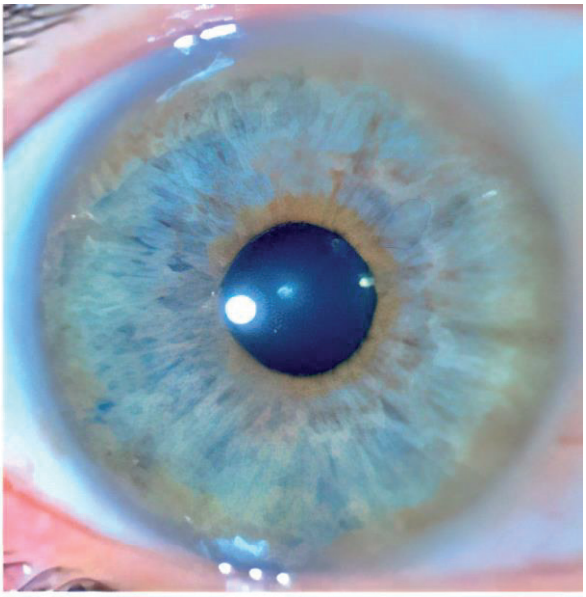
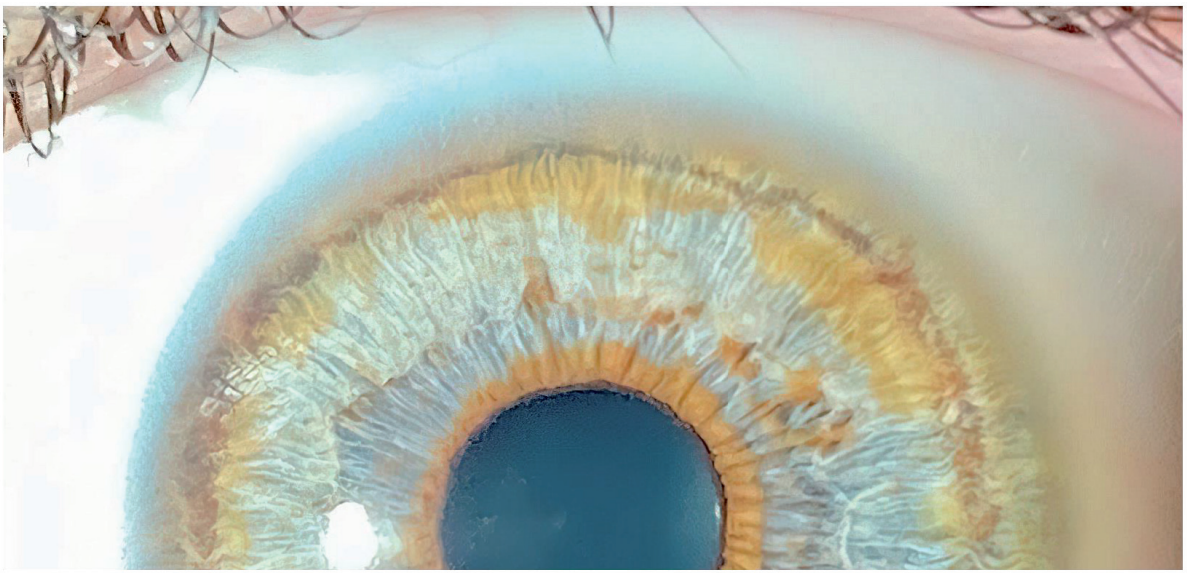


FIGURE 124: Partial fine results after phase 1 on levels 3 eyes

3 9.4 Phase 1- L3







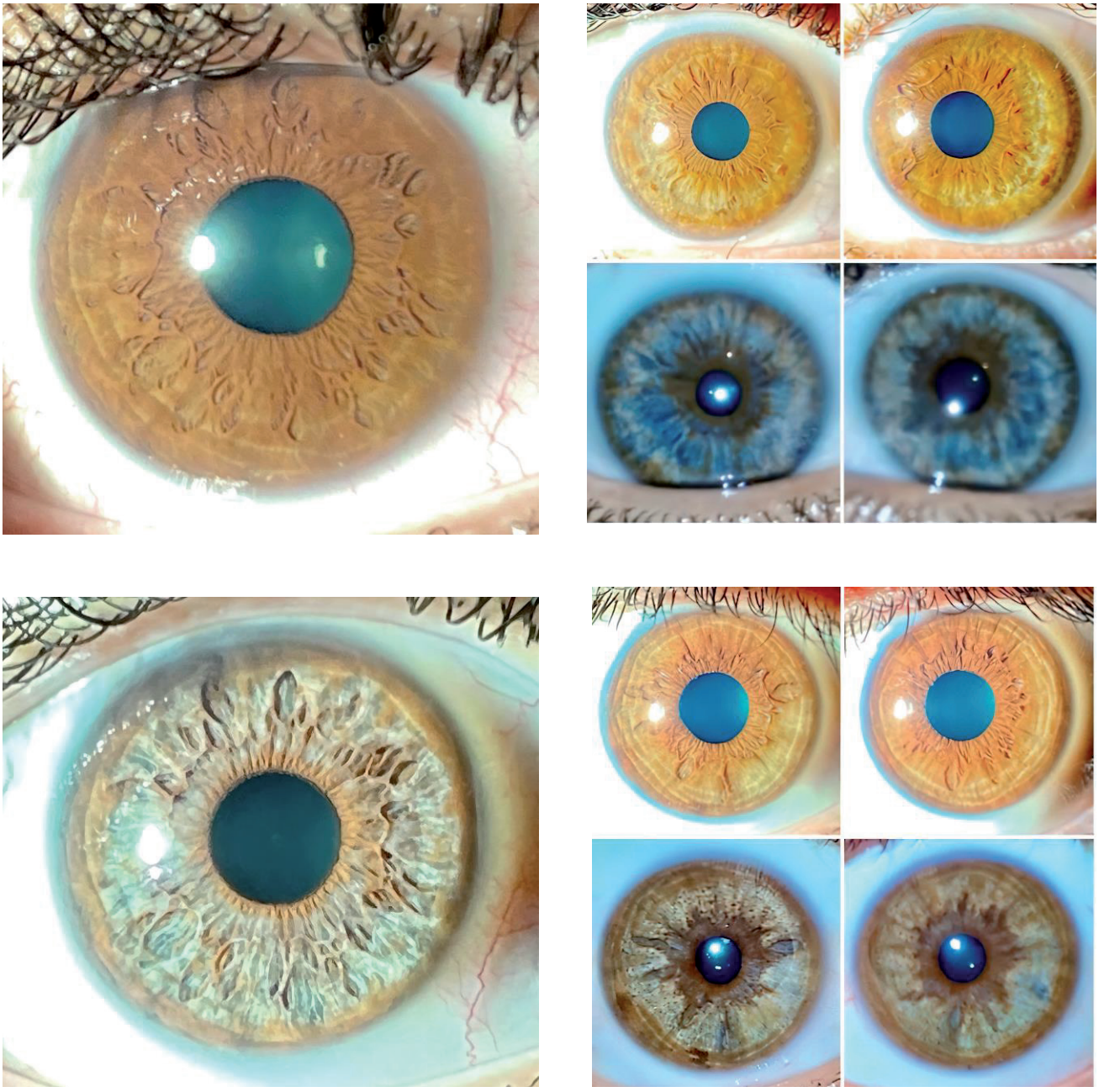
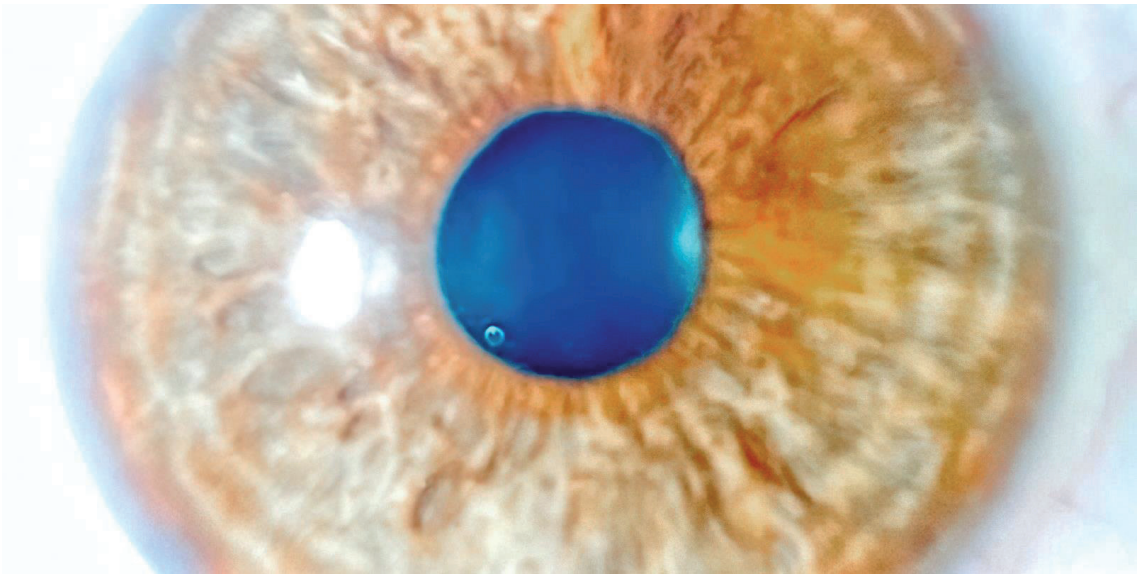
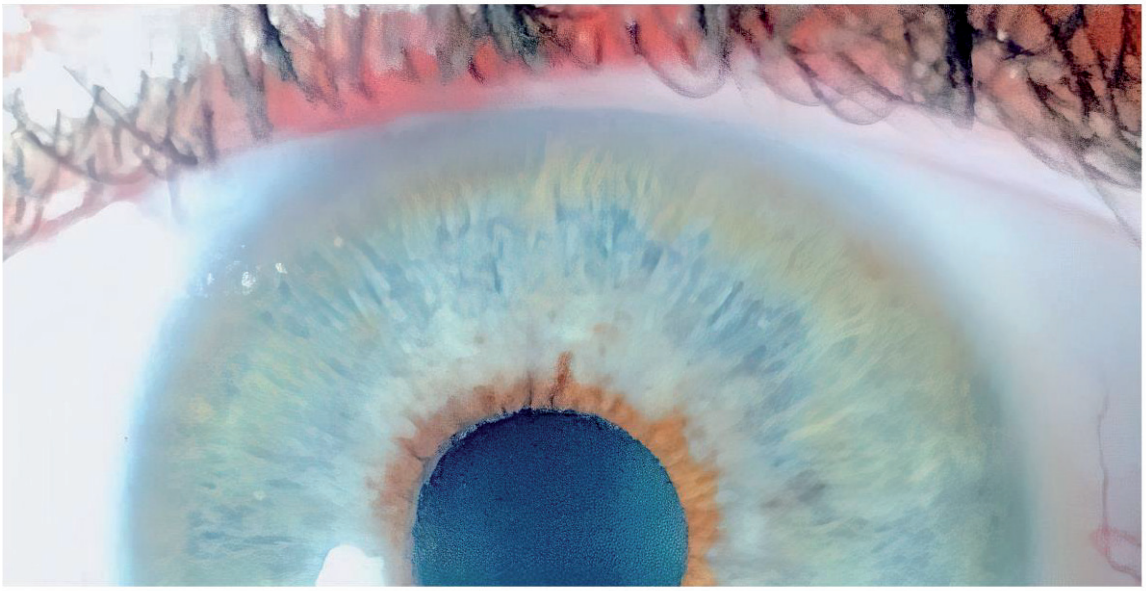


FIGURE 125: Partial fine results after phase 1 on levels 3 eyes

3 9.4 Phase 1- L3





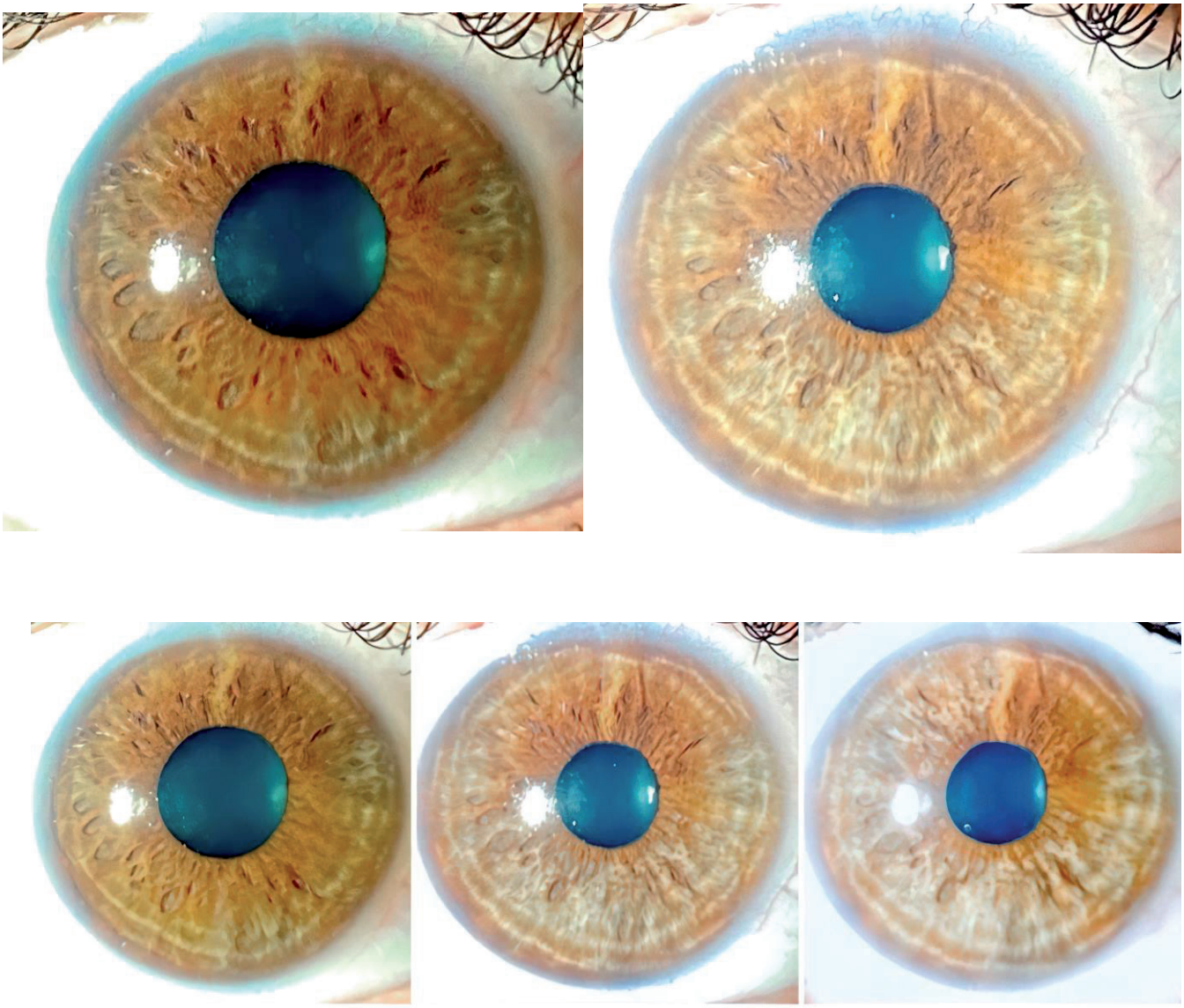
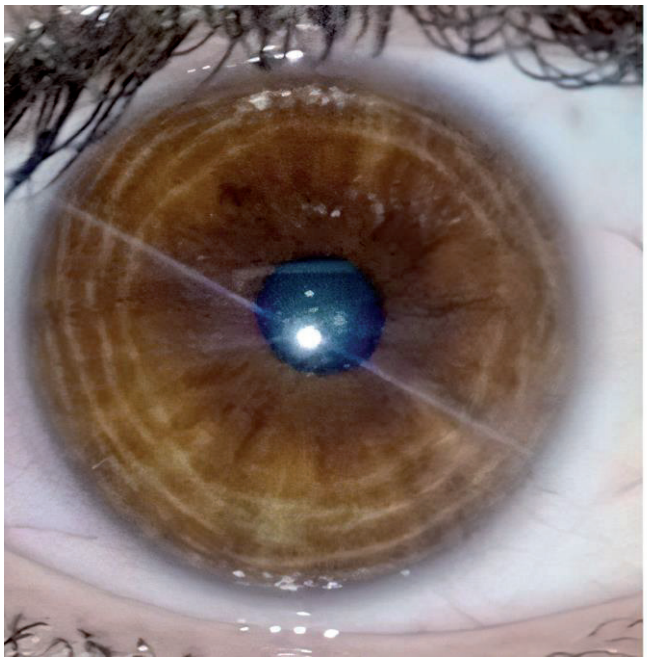
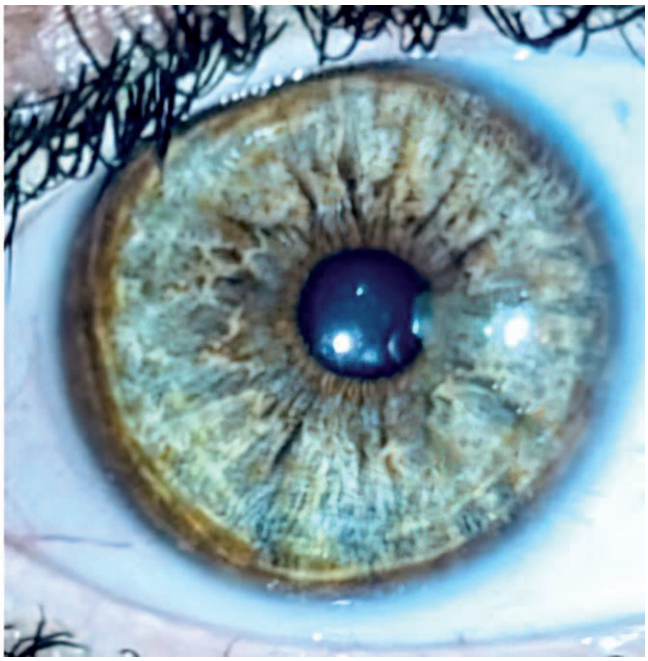
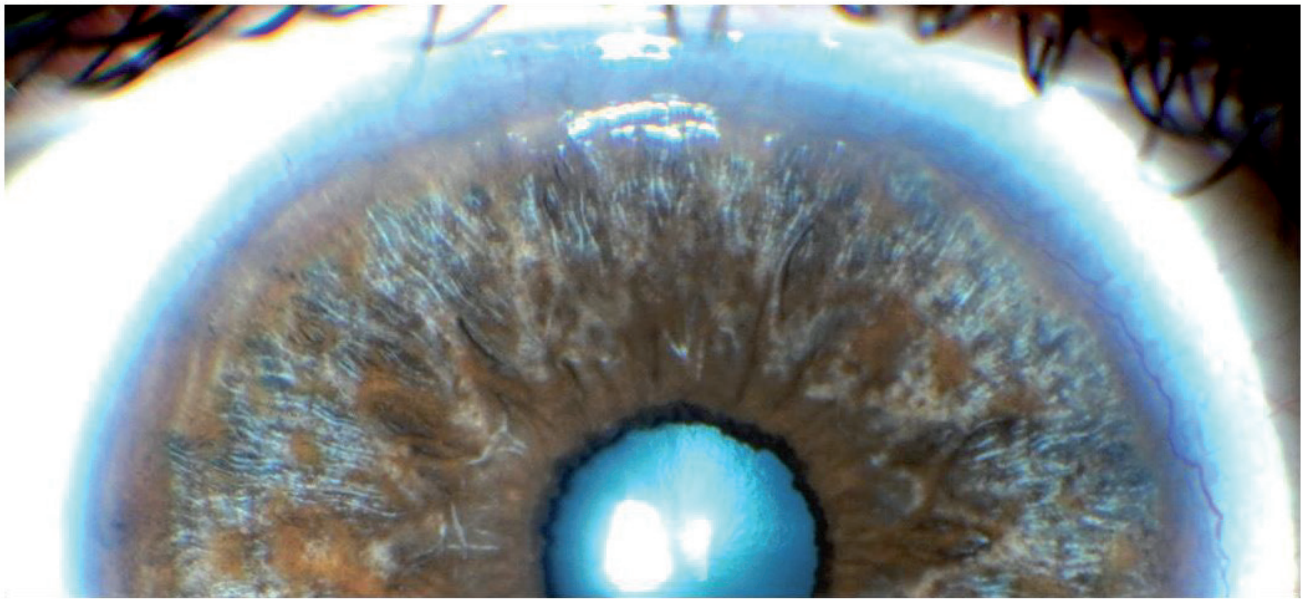


FIGURE 126: Partial fine results after phase 1 on levels 3 eyes

3 9.4 Phase 1- L4-5







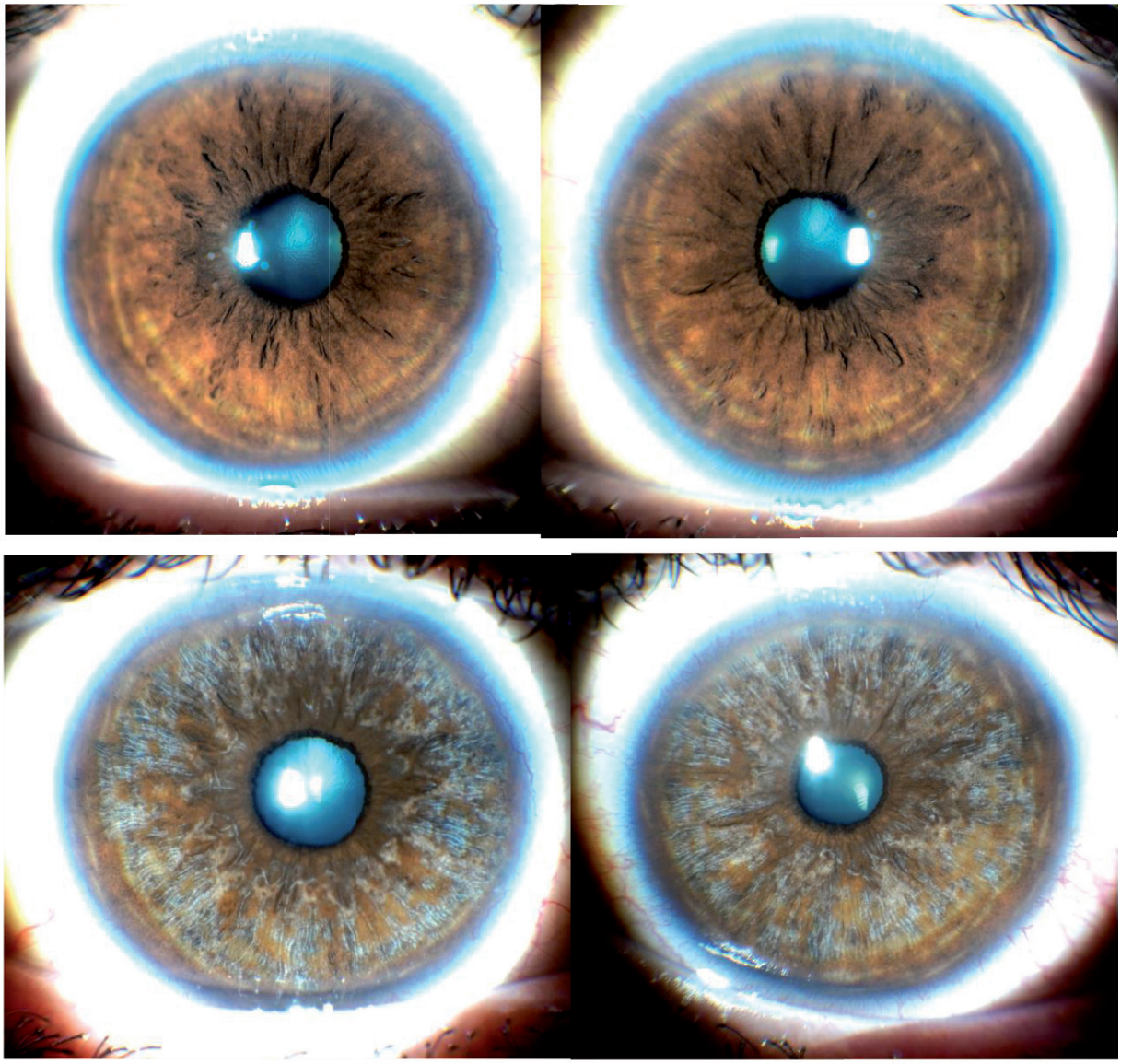
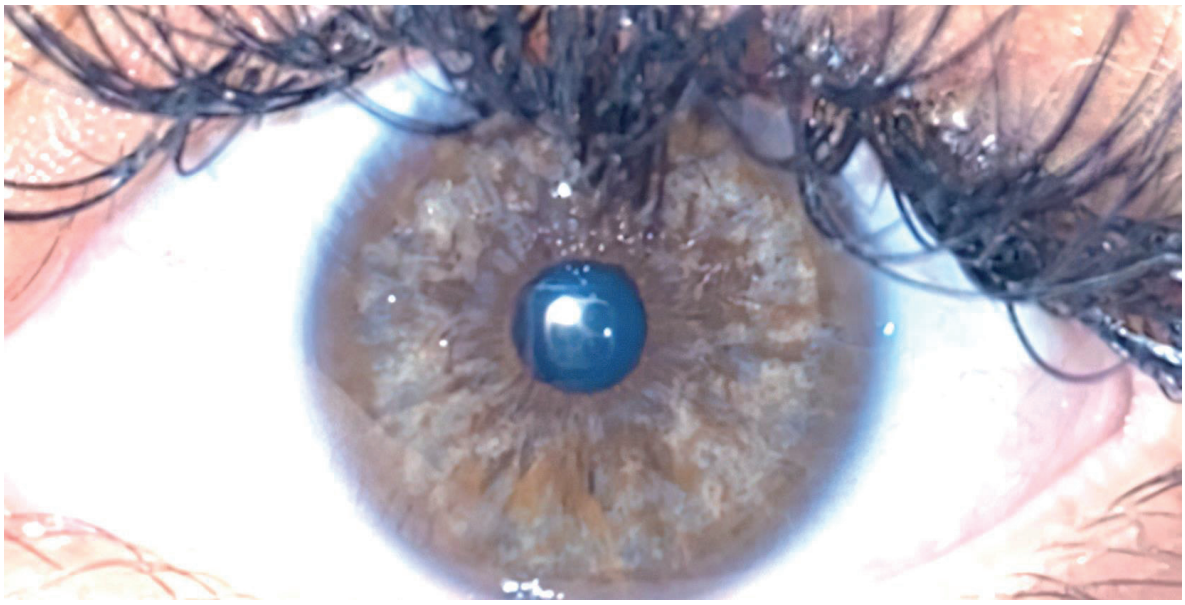
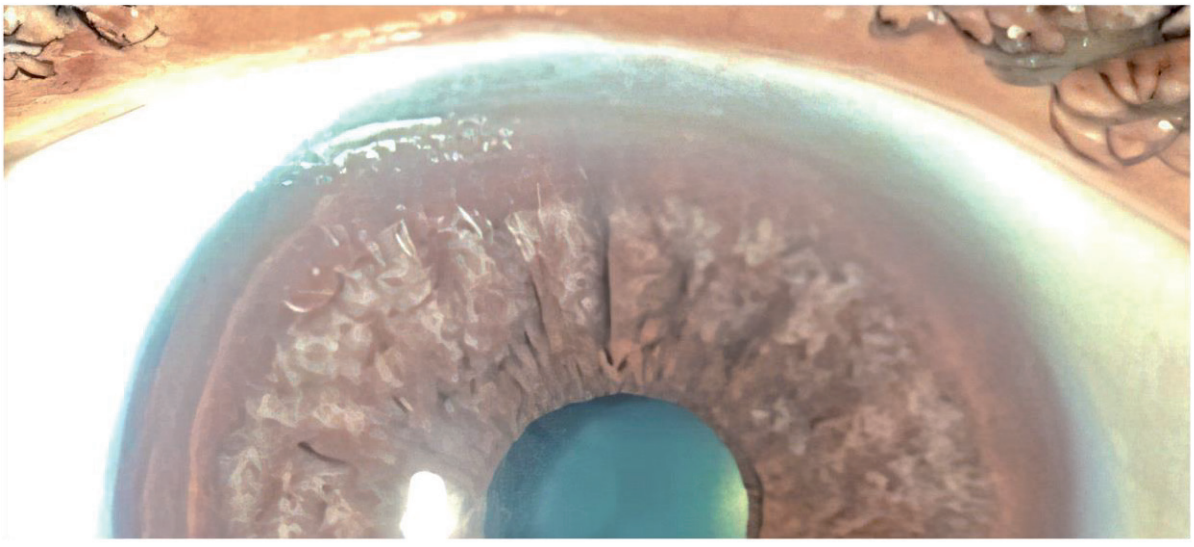


FIGURE 127: Partial fine results after phase 1 on levels 4-5 eyes

3 9.4 Phase 1- L4-5





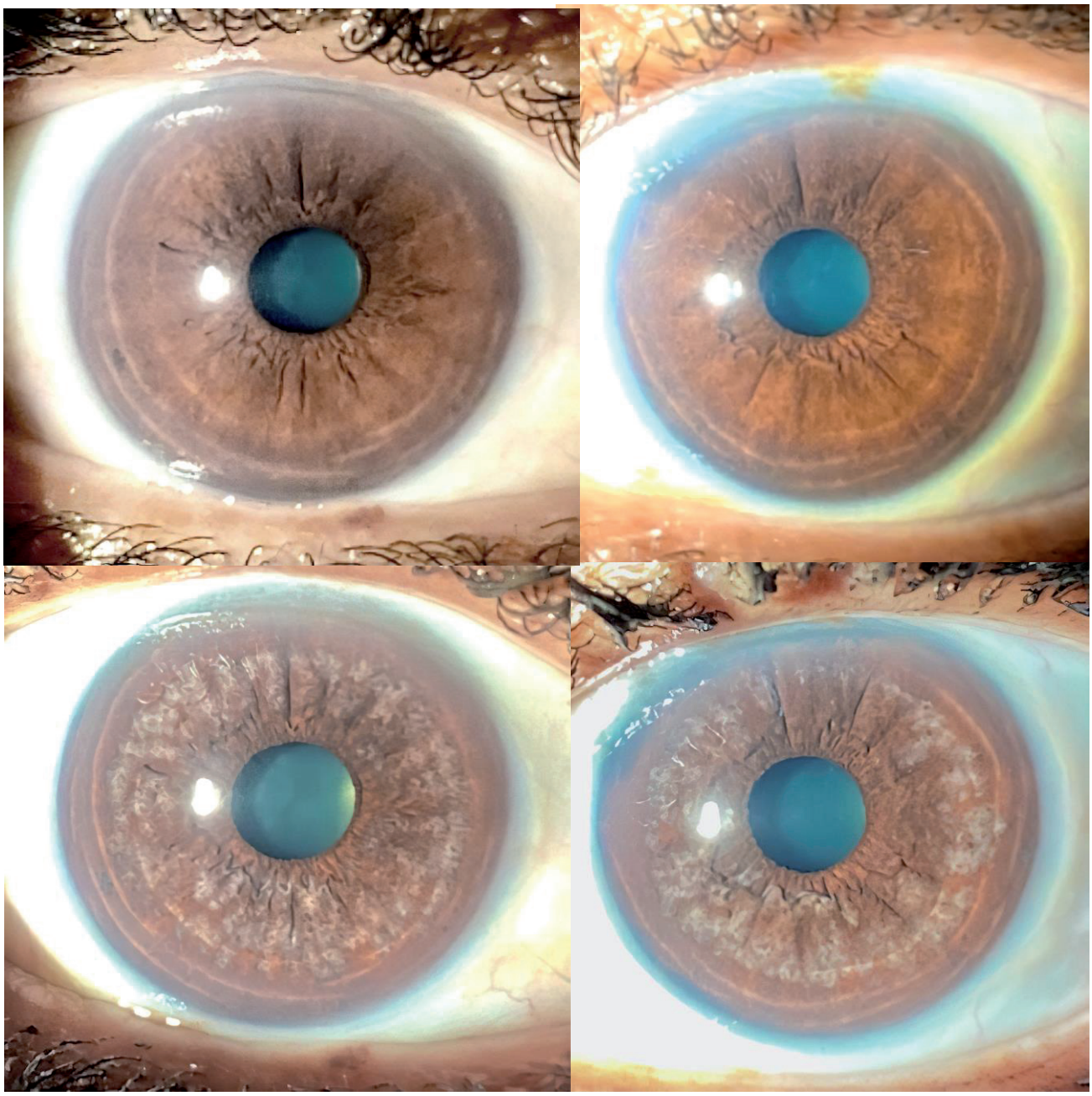
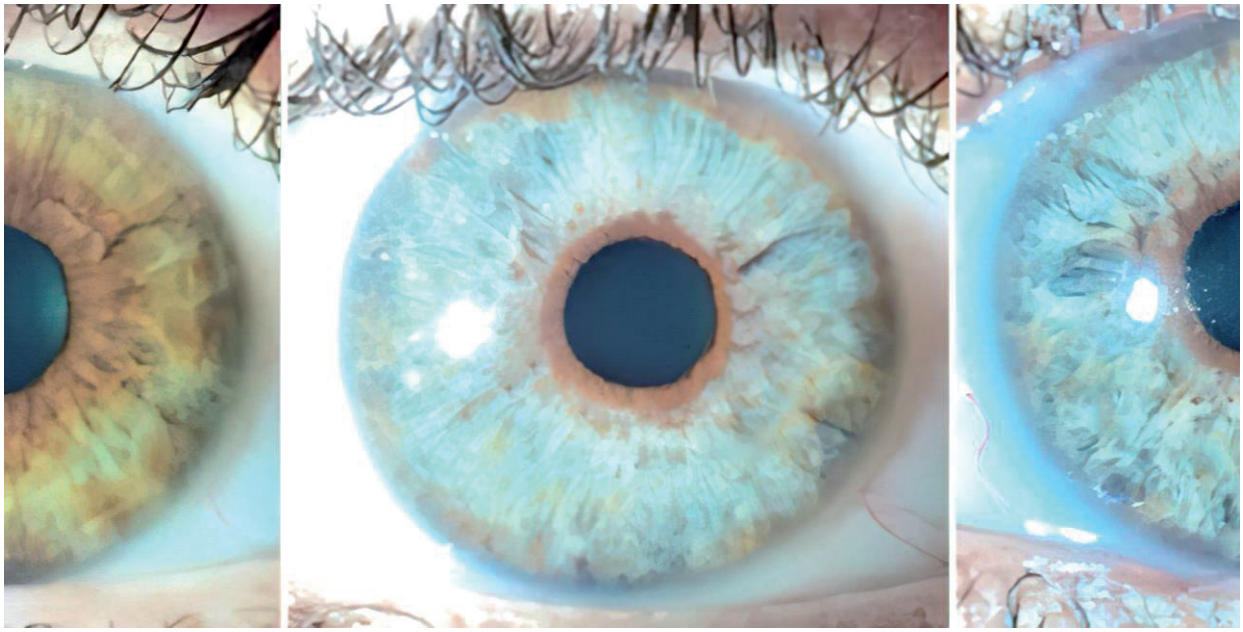
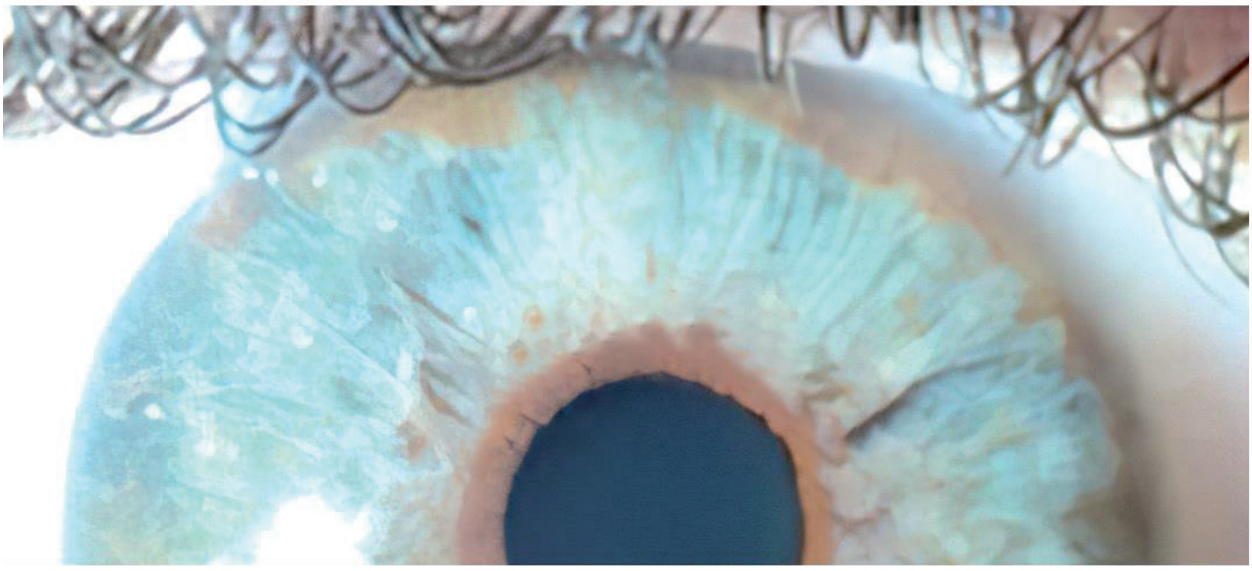


FIGURE 128: Partial fine results after phase 1 on levels 4-5 eyes

3 9.5 Phase 2- L2





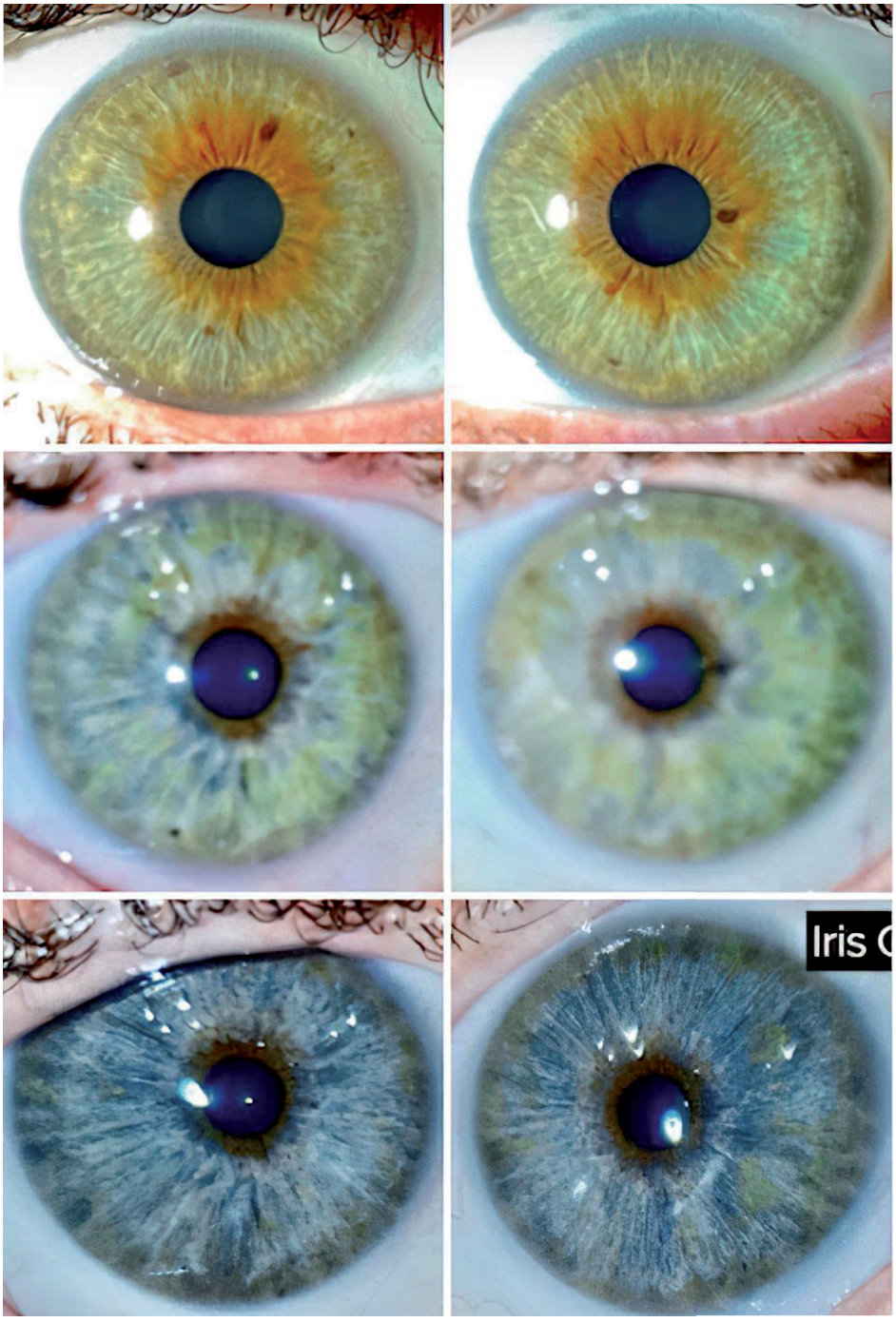
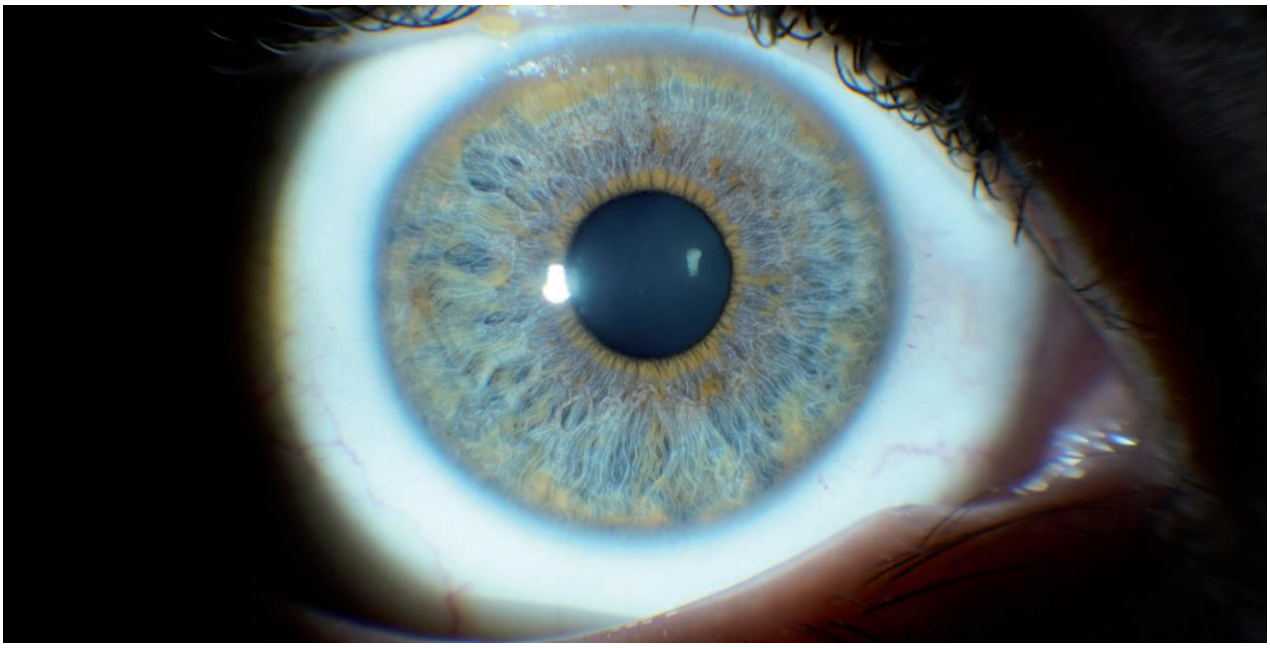
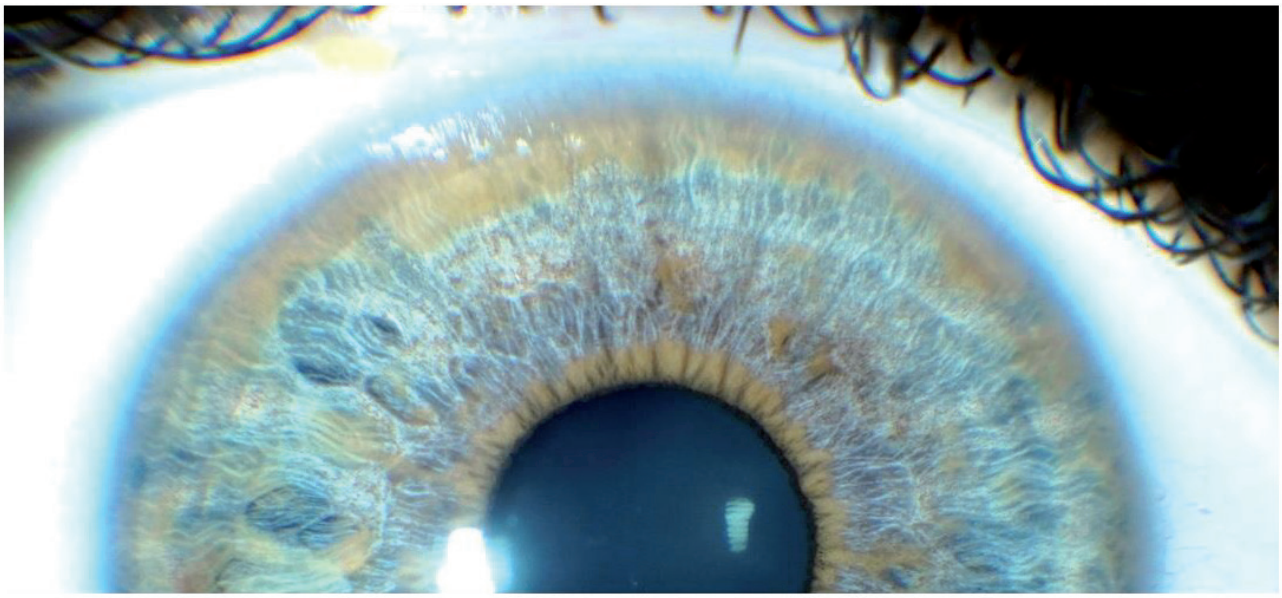


FIGURE 129: Advanced fine results after phase 2 on levels 2 eyes

3 9.5 Phase 2- L2





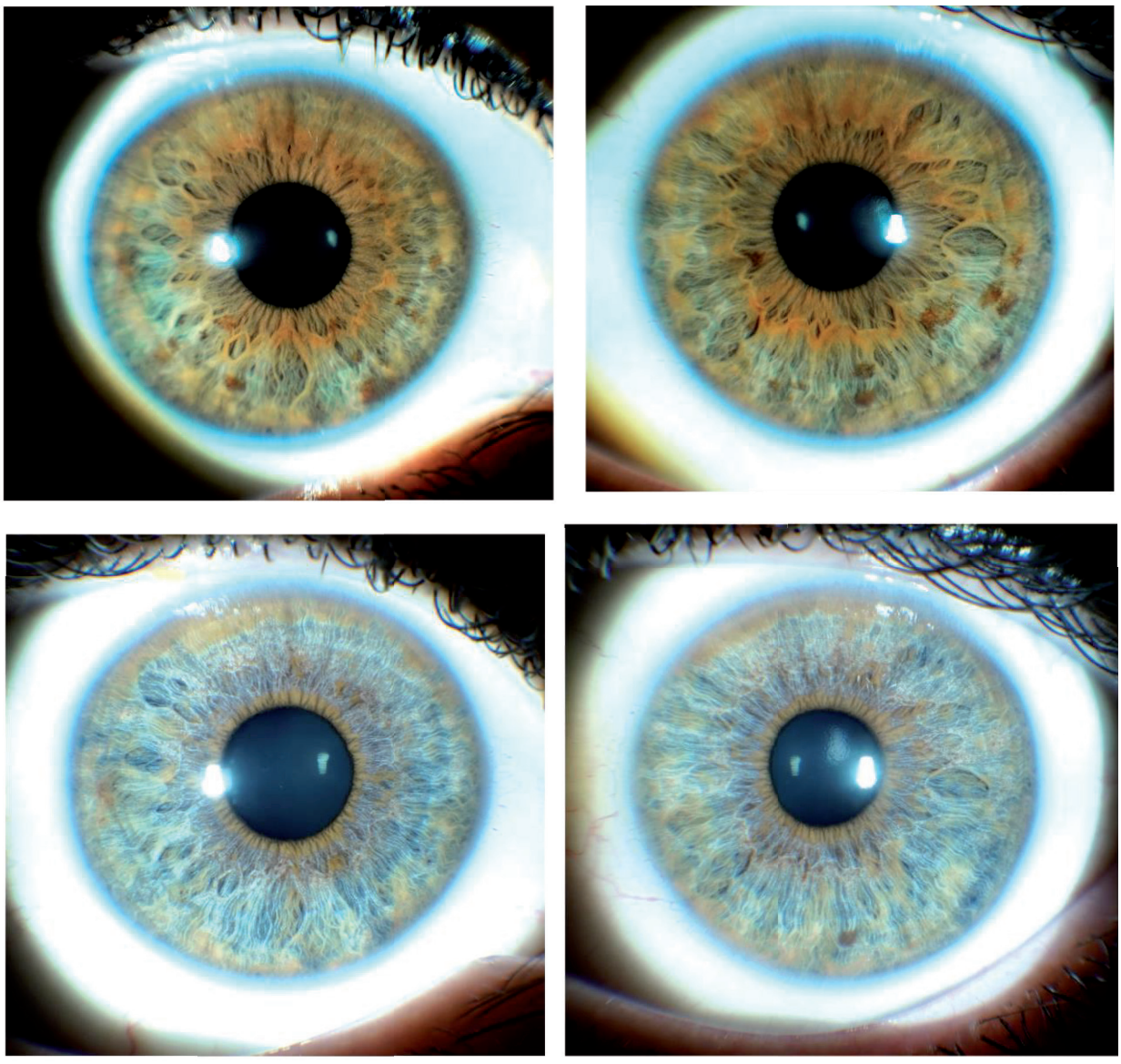
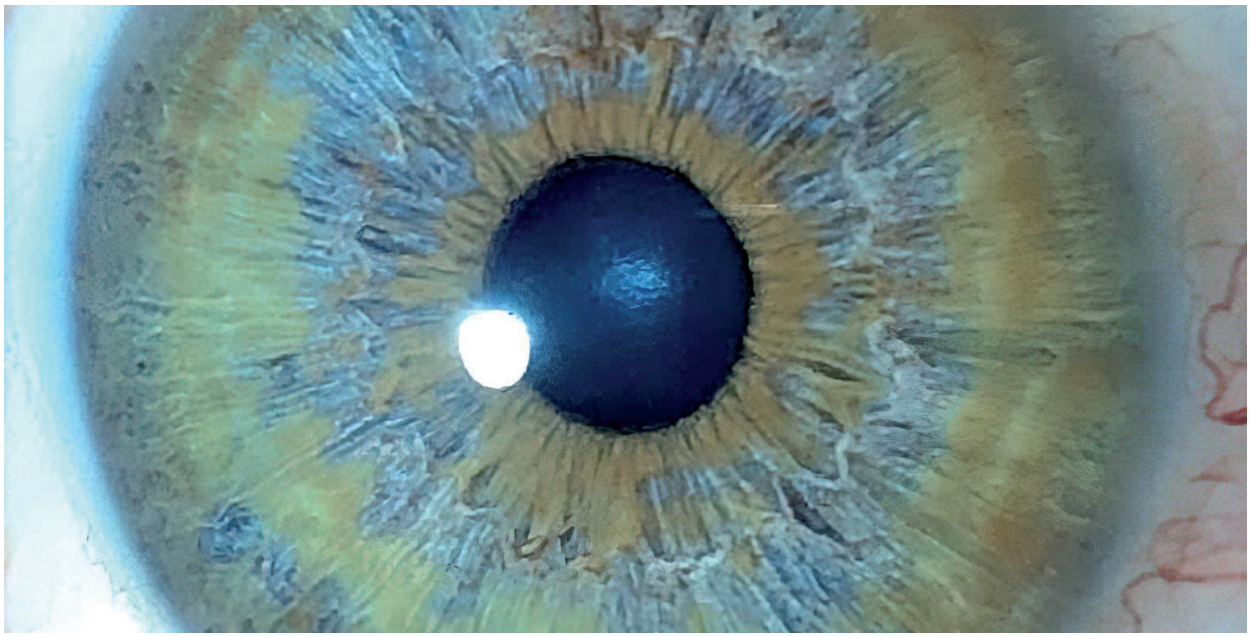
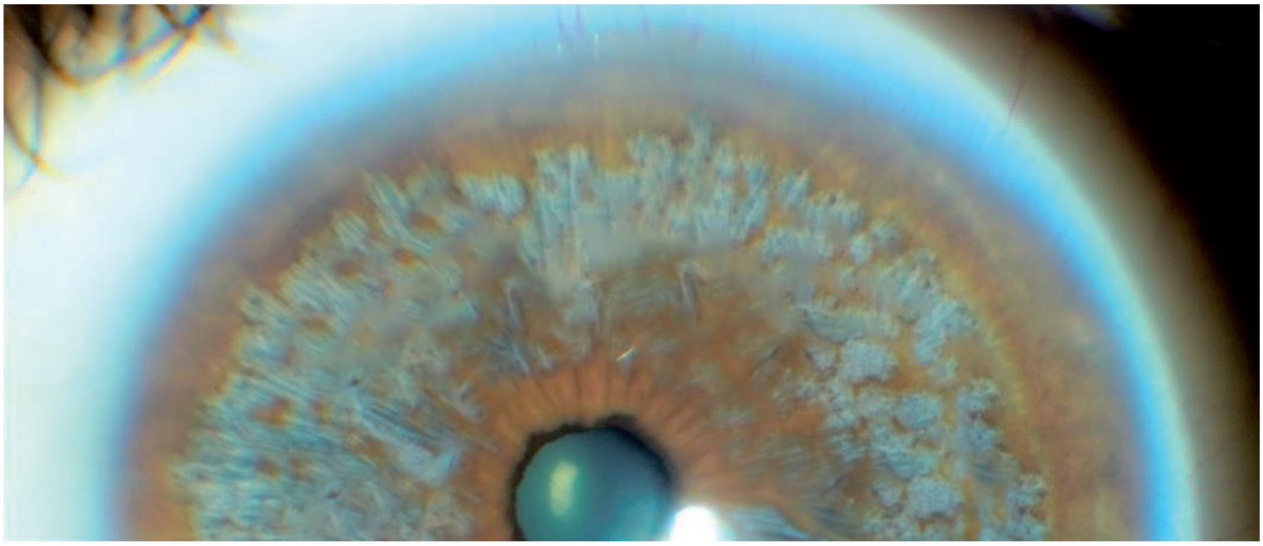


FIGURE 130: Advanced fine results after phase 2 on levels 2 eyes

3 9.5 Phase 2- L3





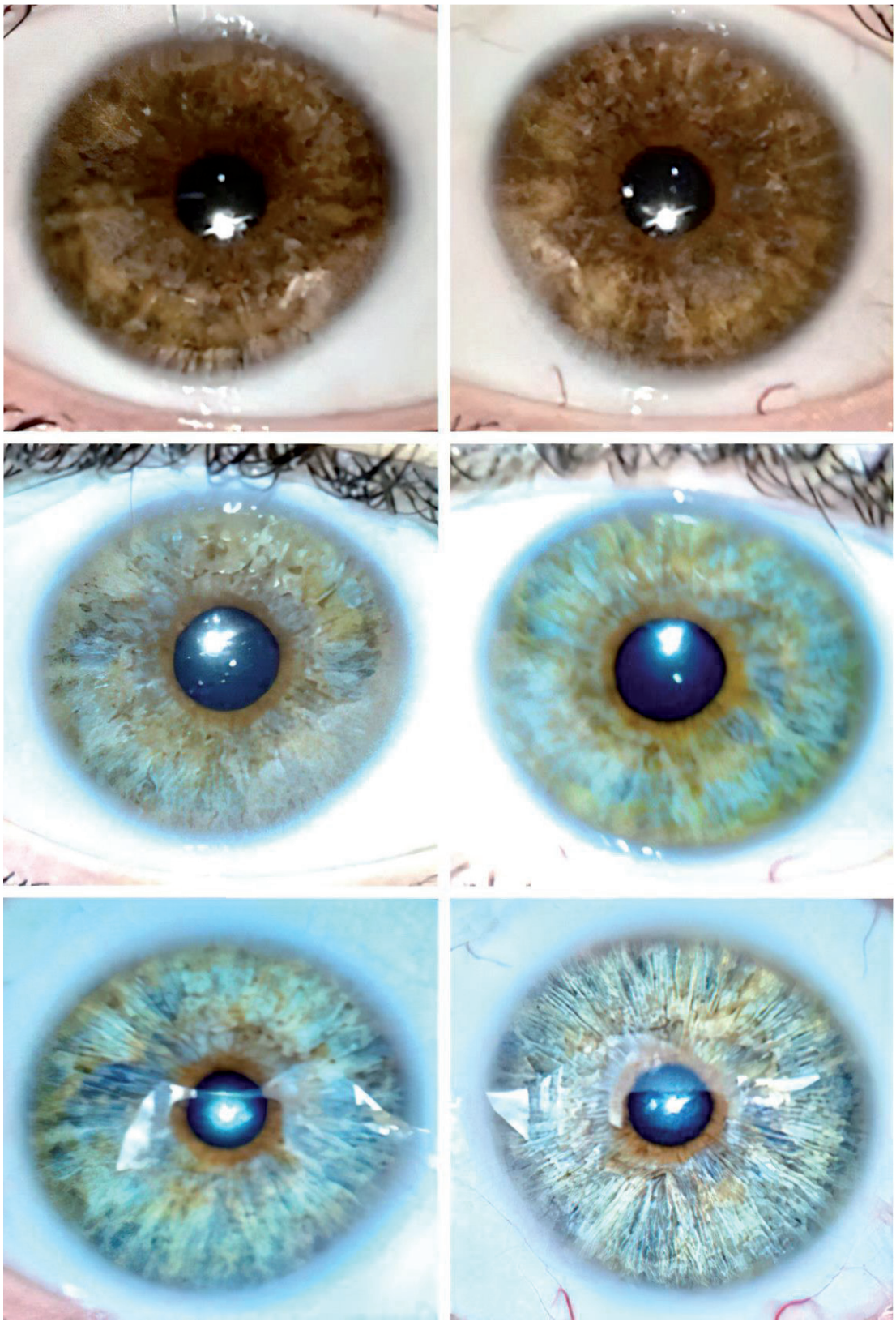
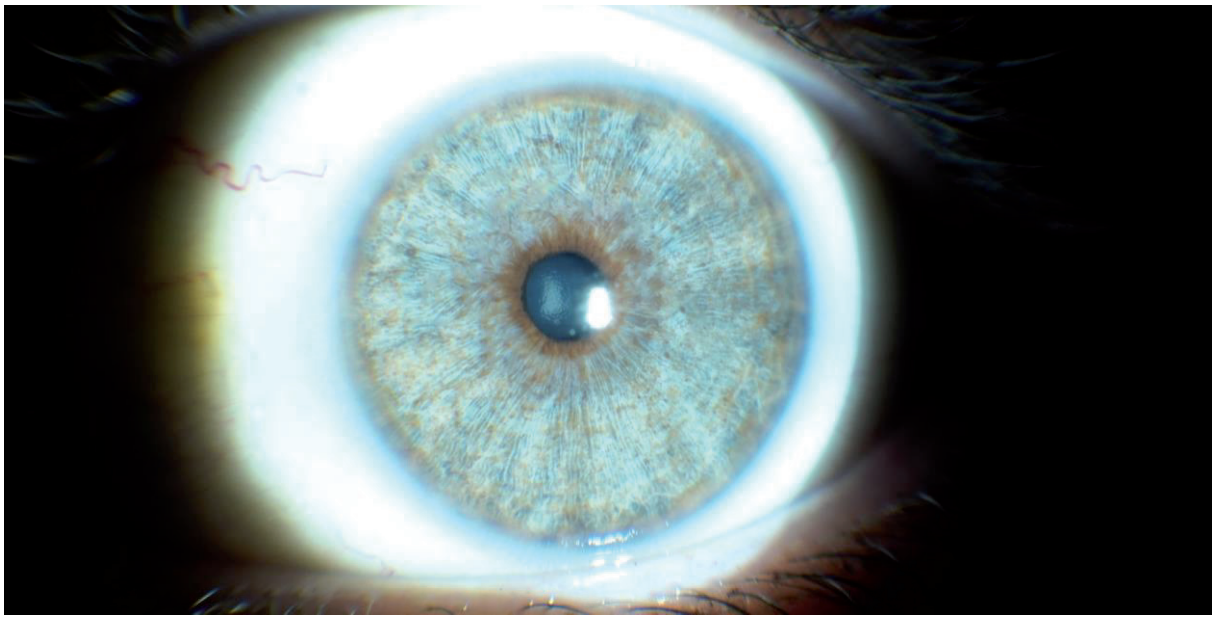
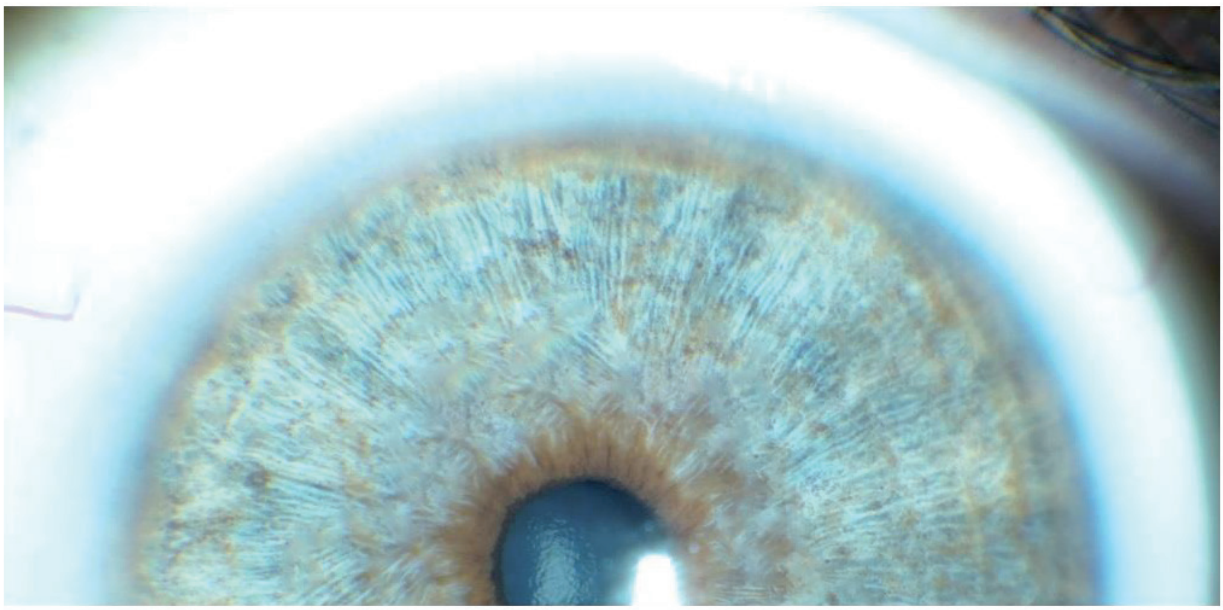


FIGURE 131: Advanced fine results after phase 2 on levels 3 eyes

3 9.5 Phase 2- L3





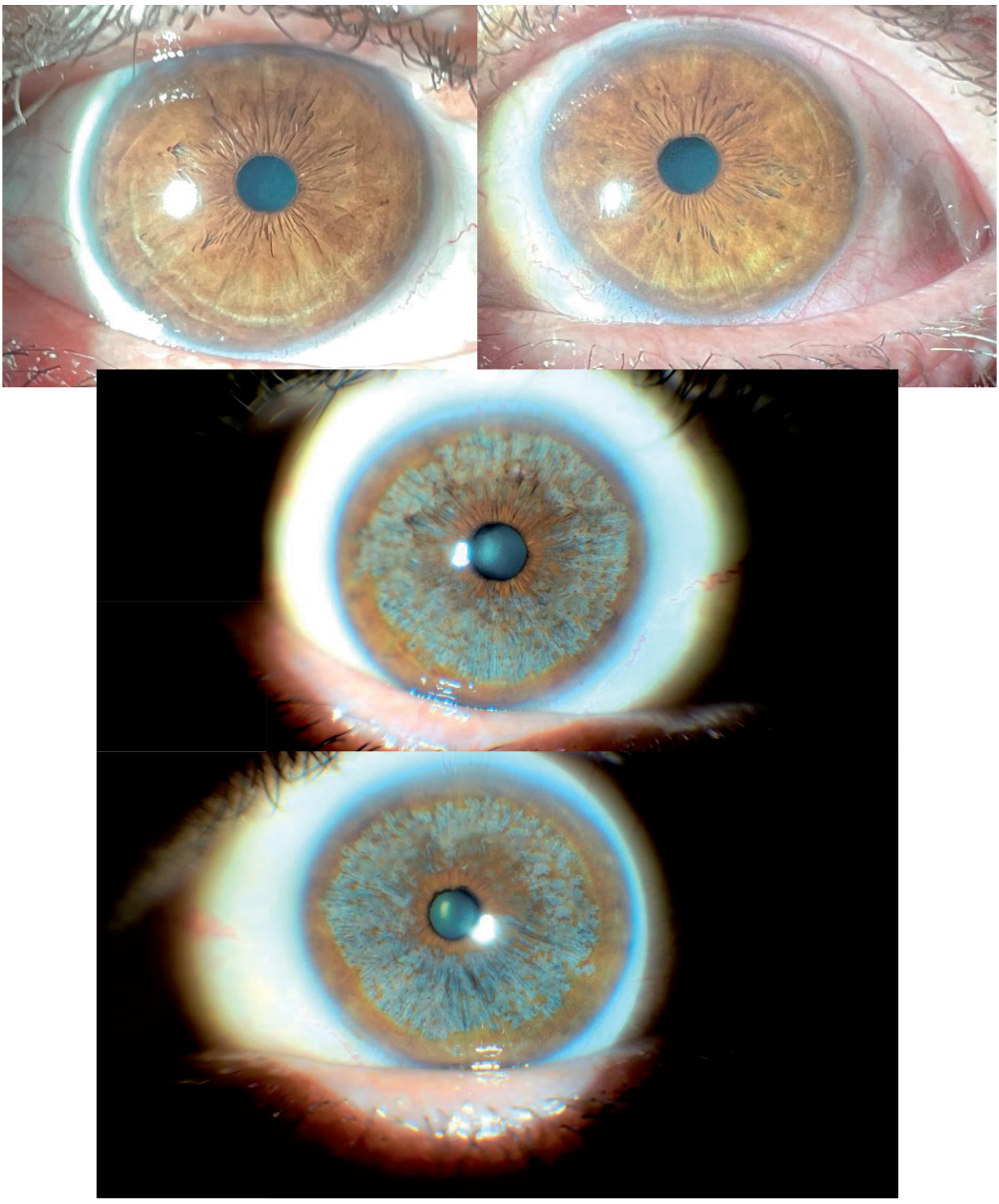
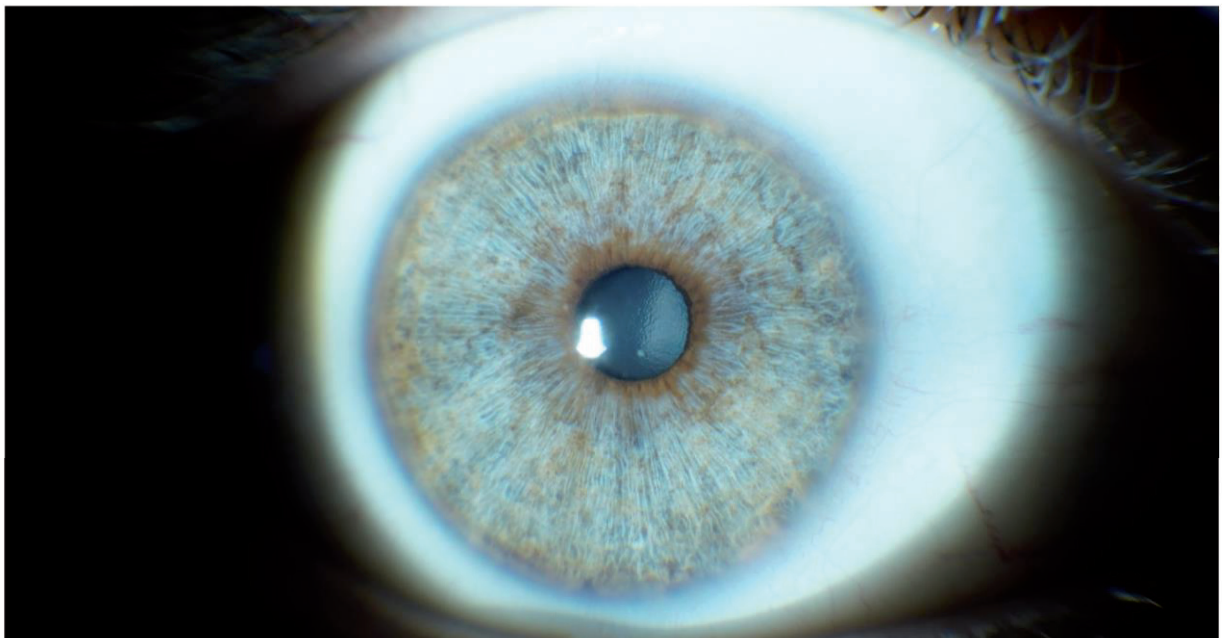
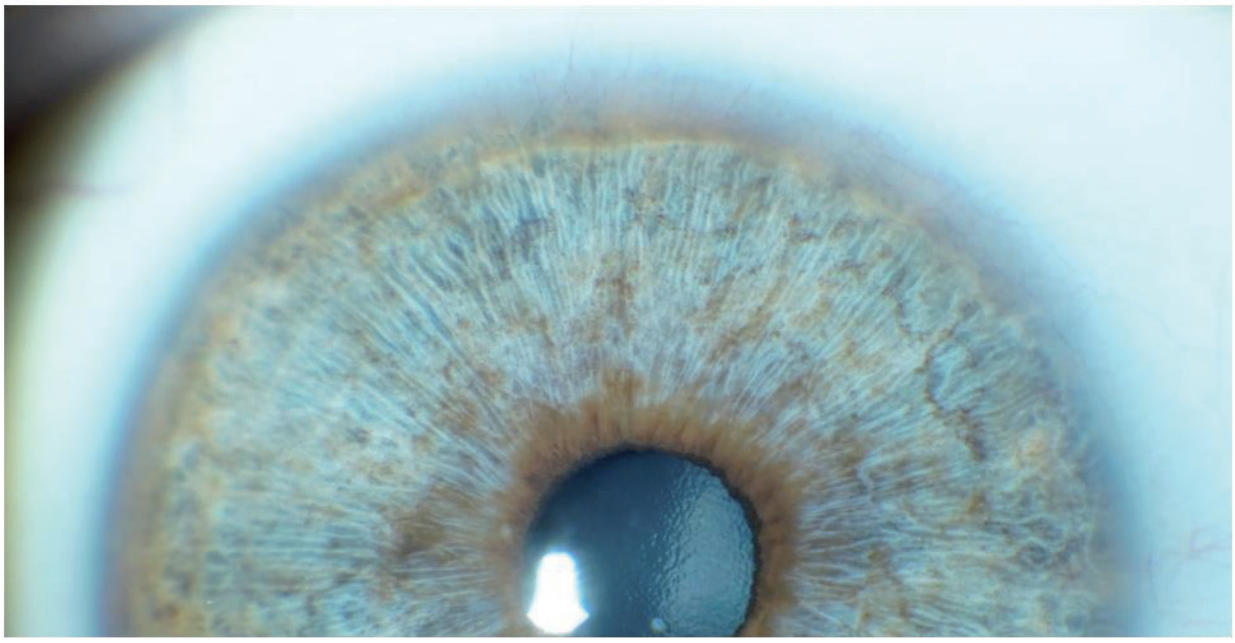


FIGURE 132: Advanced fine results after phase 2 on levels 3 eyes

3 9.5 Phase 2- L3





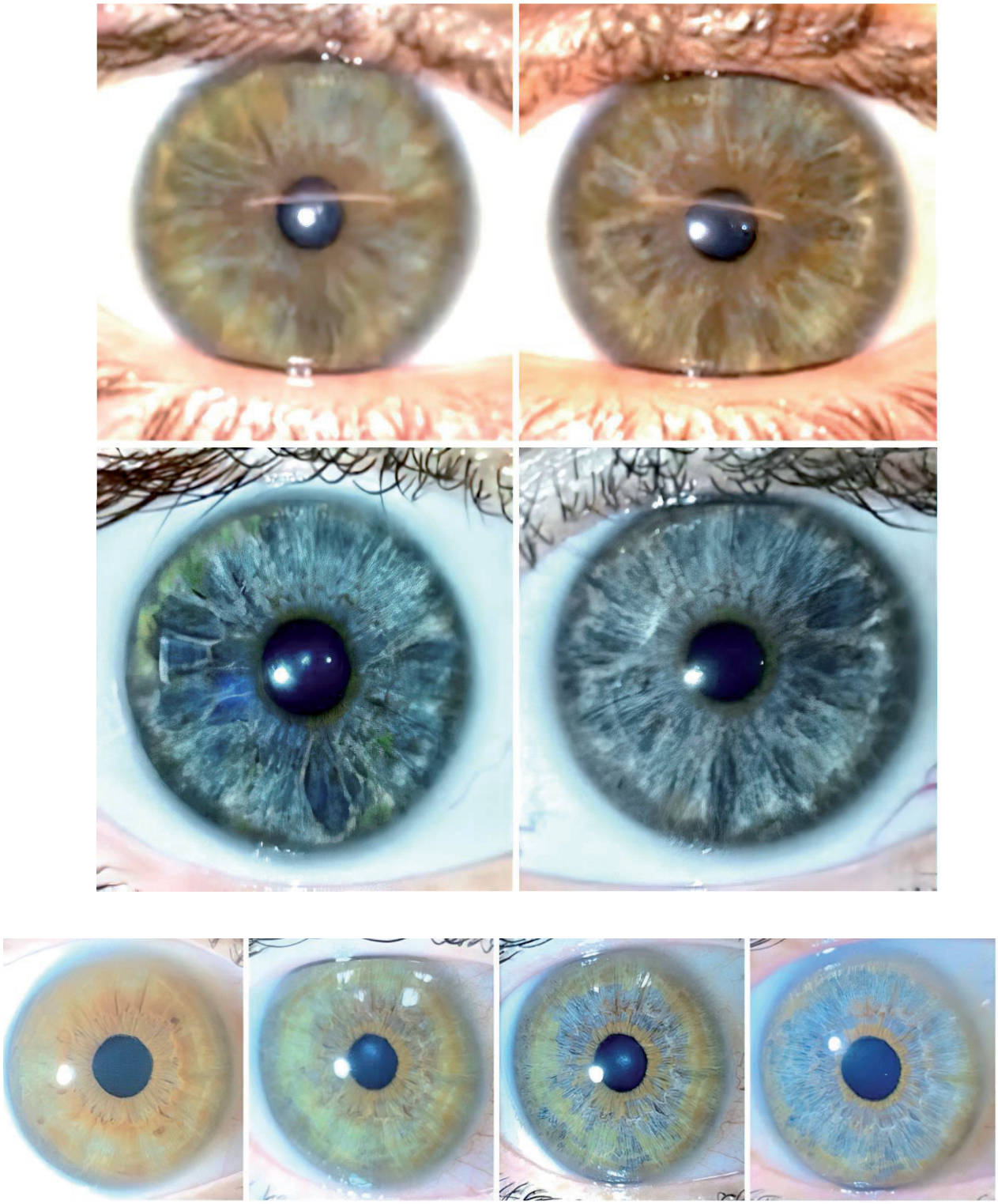
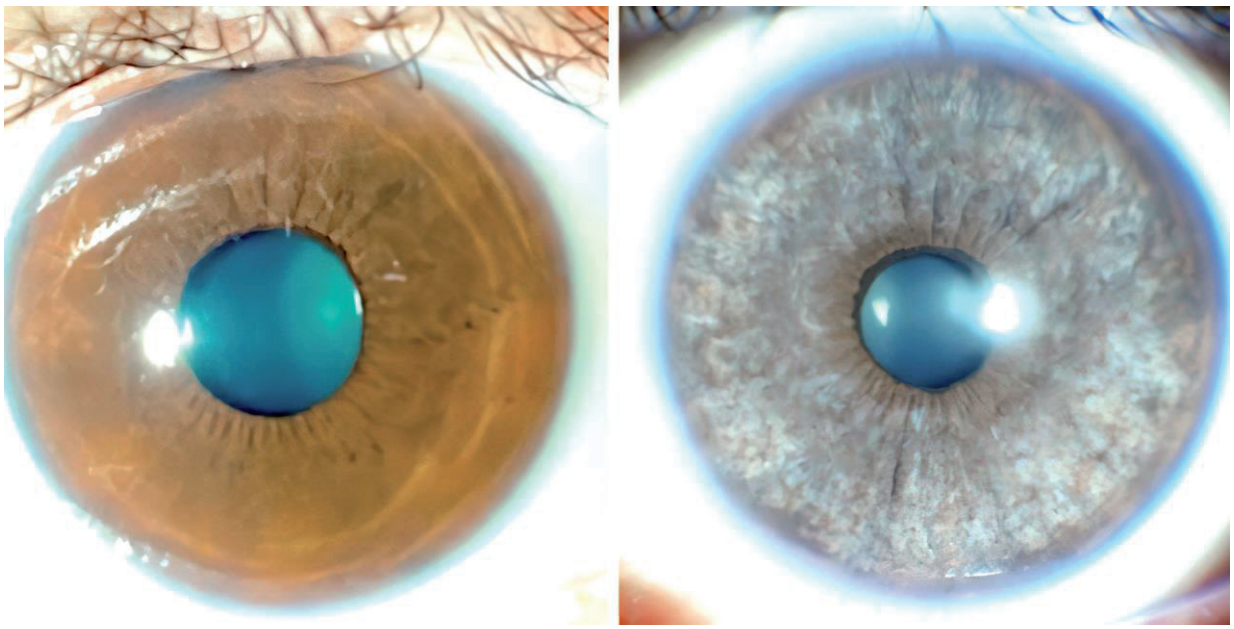
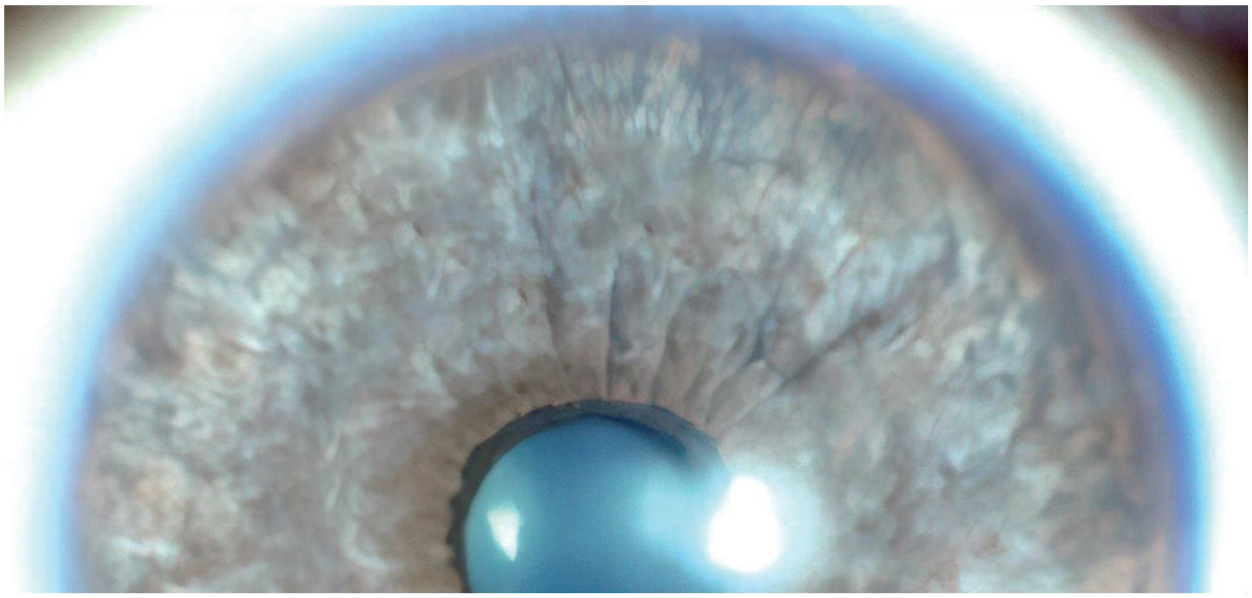


FIGURE 133: Advanced fine results after phase 2 on levels 3 eyes

3 9.5 Phase 2- L4-5





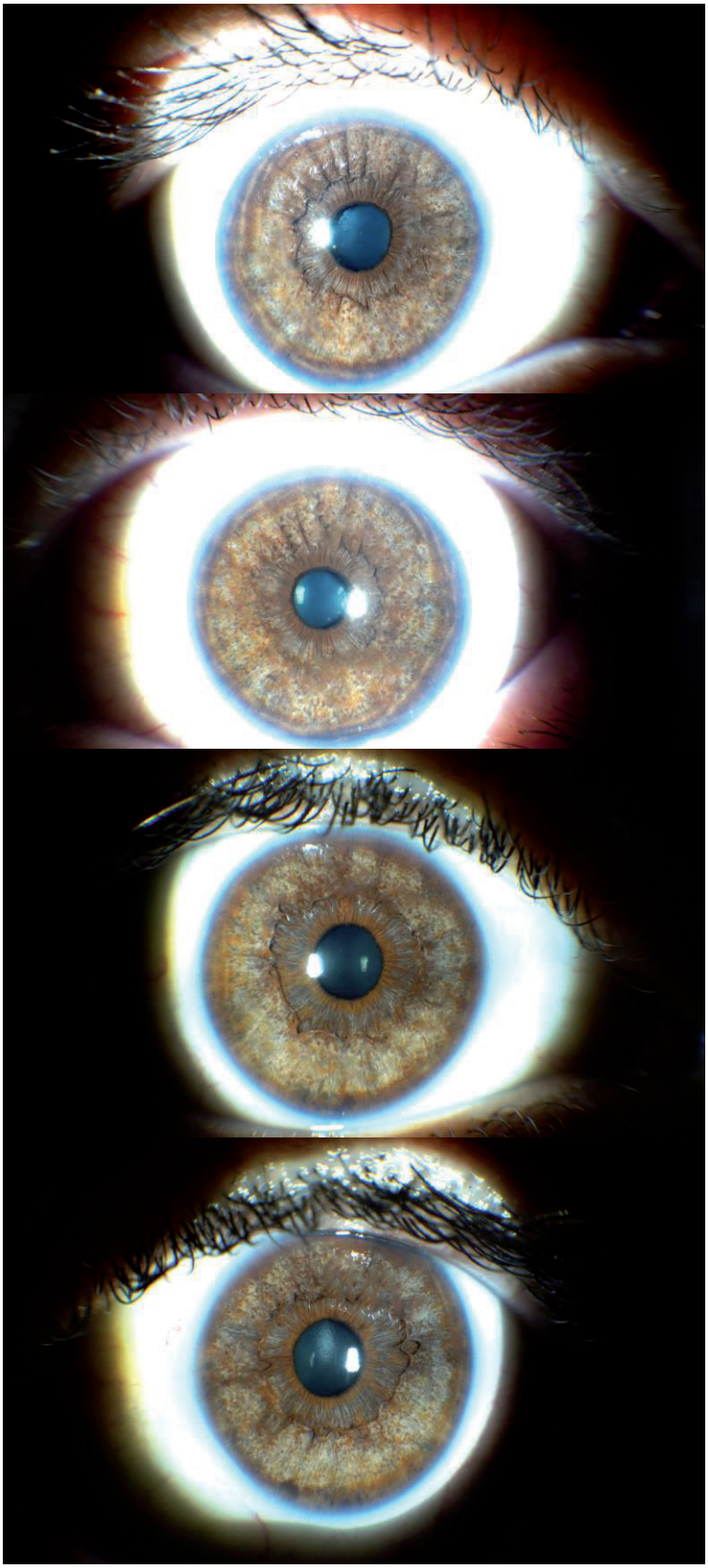
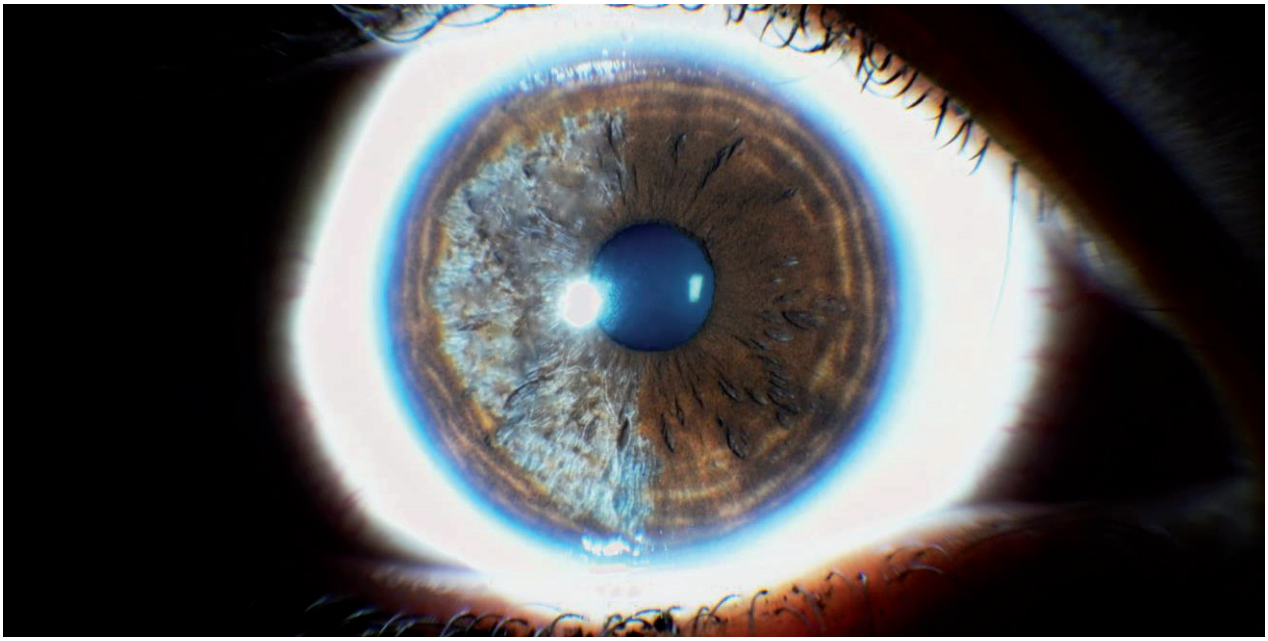
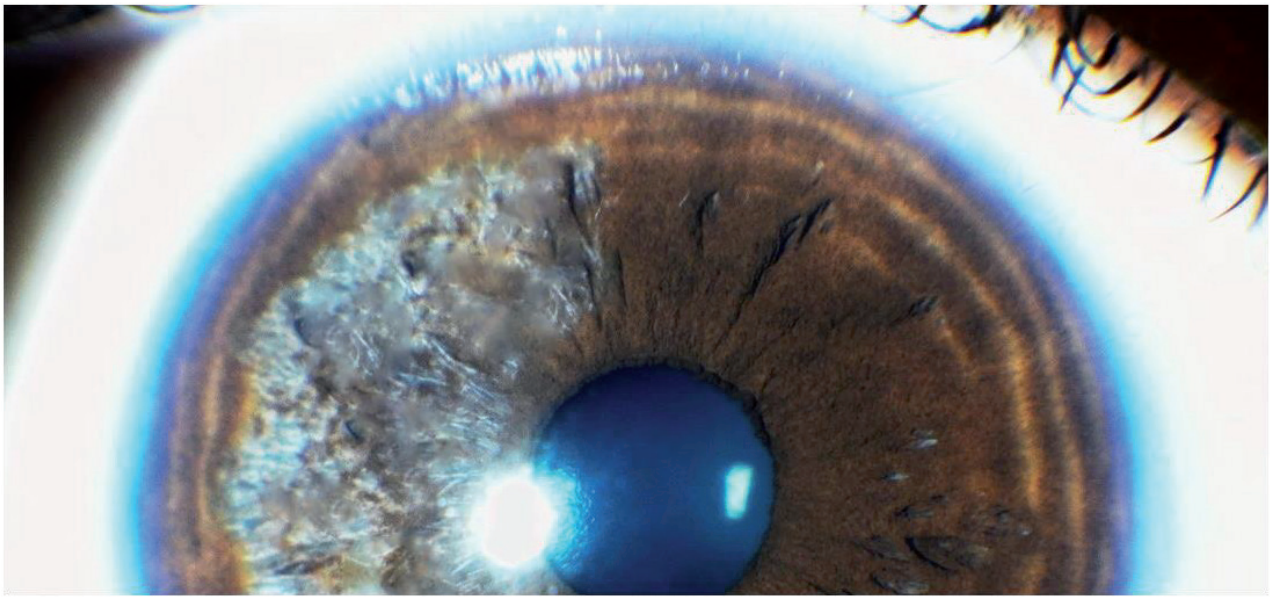


FIGURE 134: Advanced fine results after phase 2 on levels 4-5 eyes

3 9.5 Phase 2- L4-5





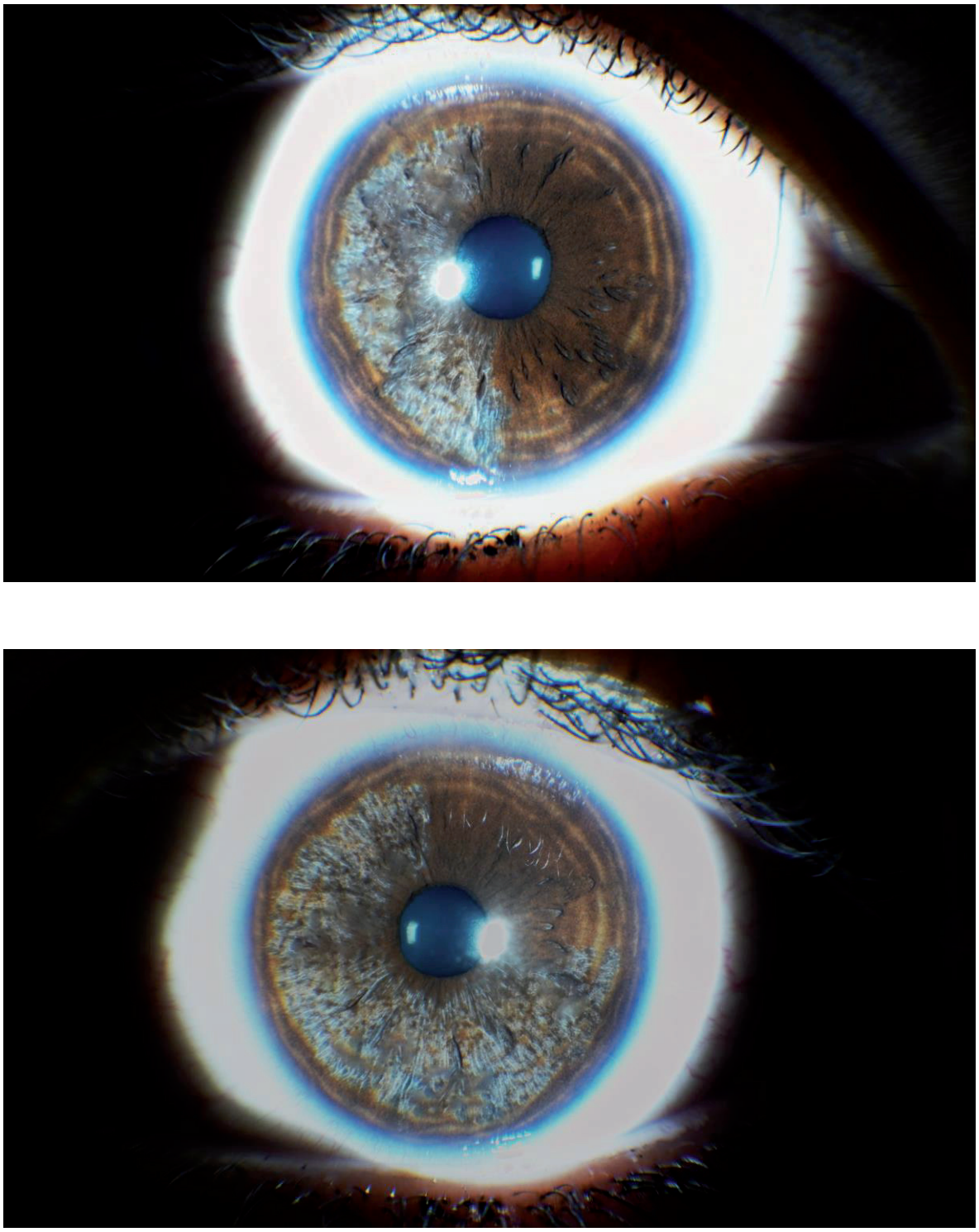
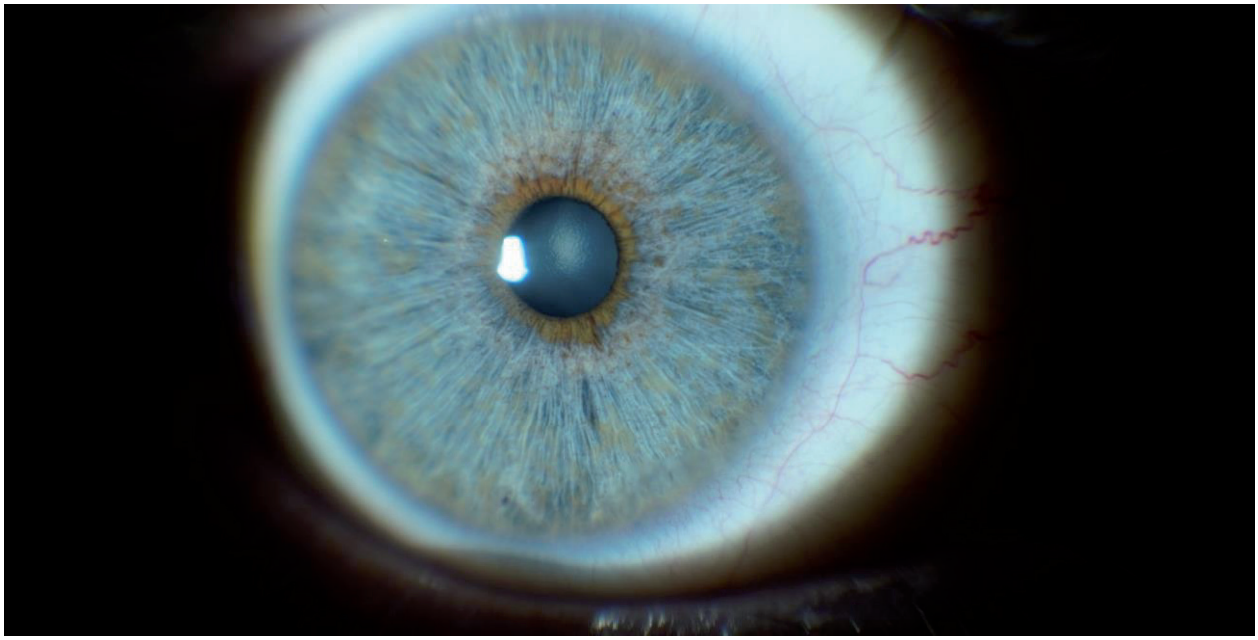
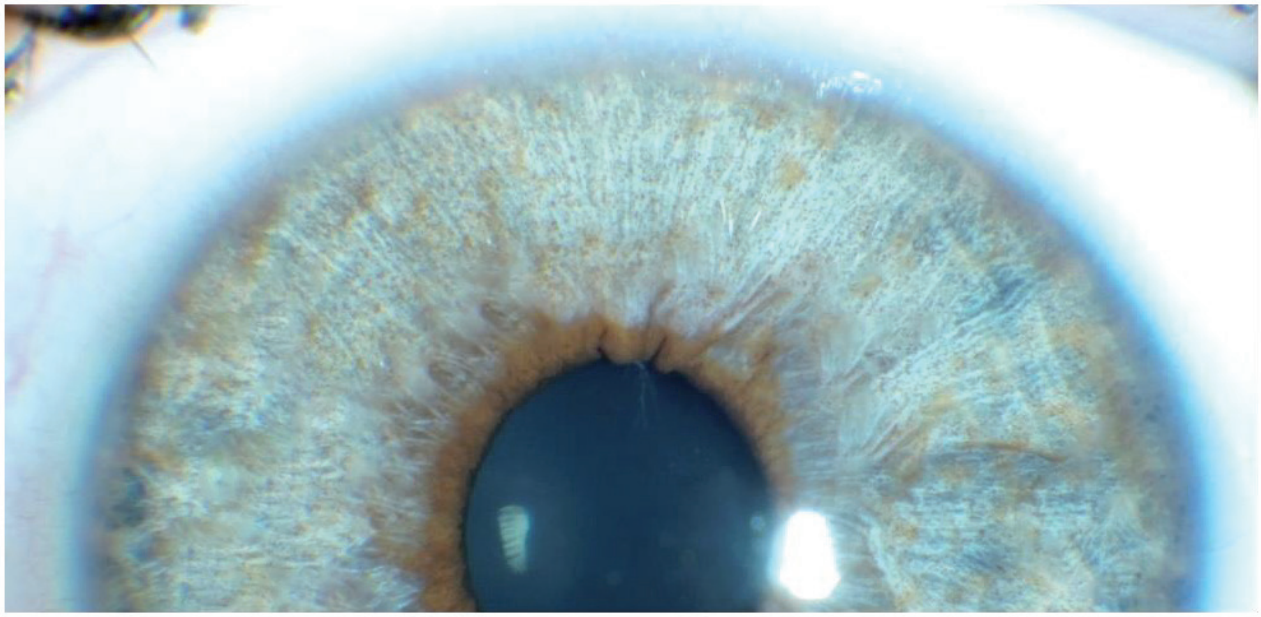


FIGURE 135: Partial fine results after phase 2 on levels 4-5 eyes

3 9.6 Phase 3-4- L2





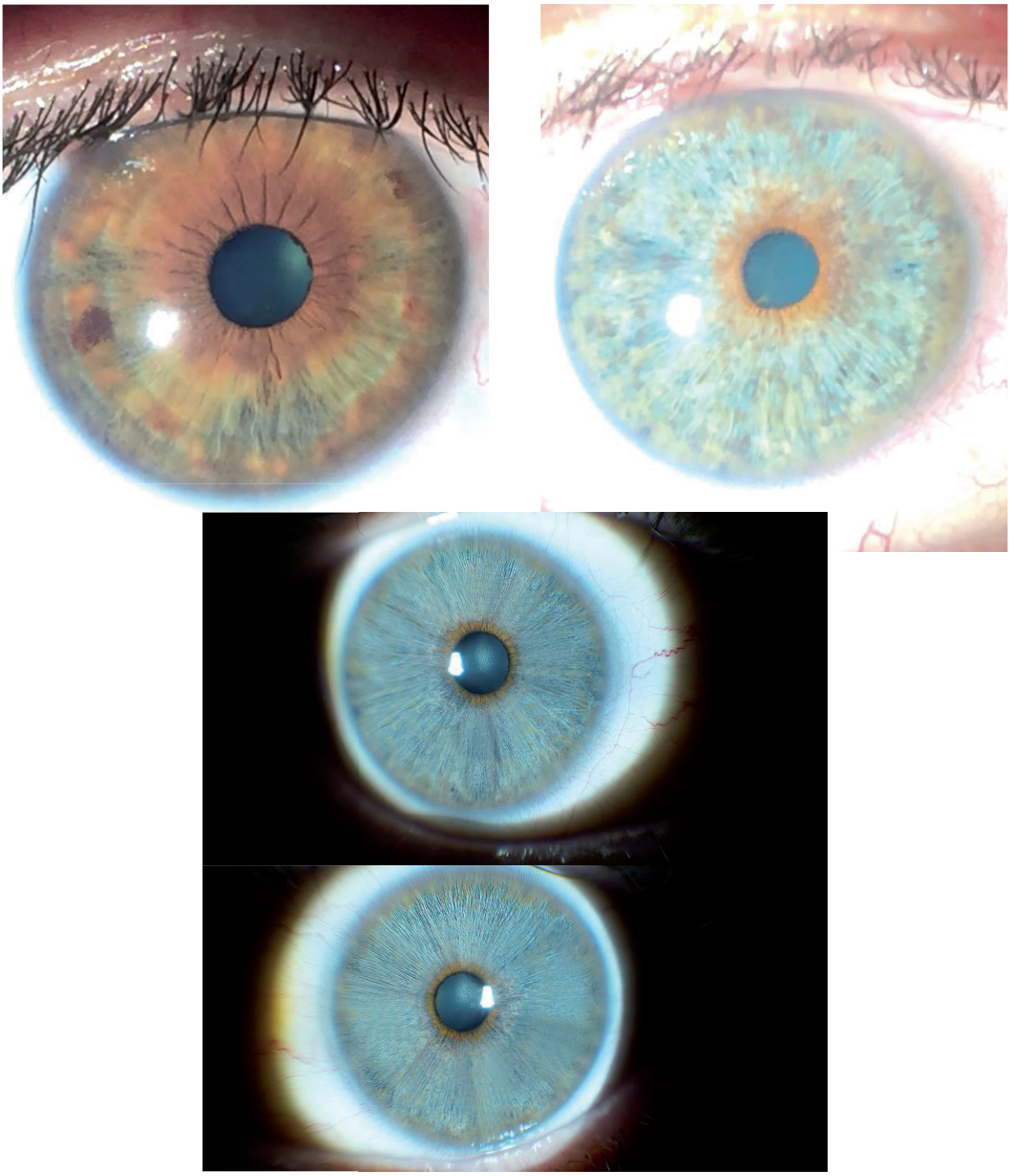
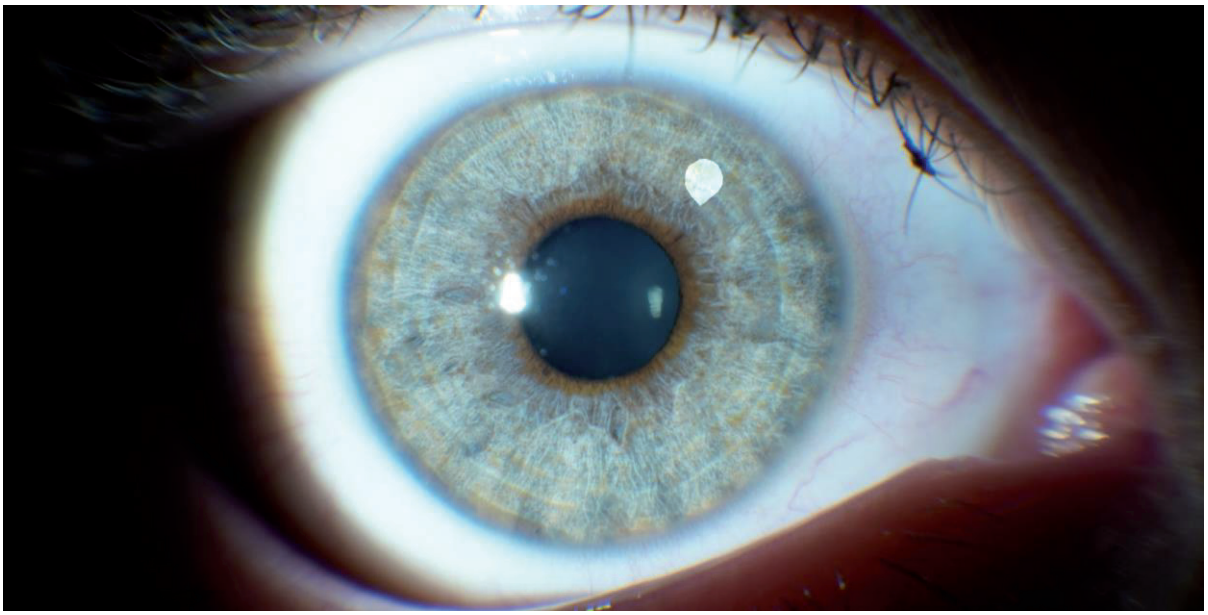
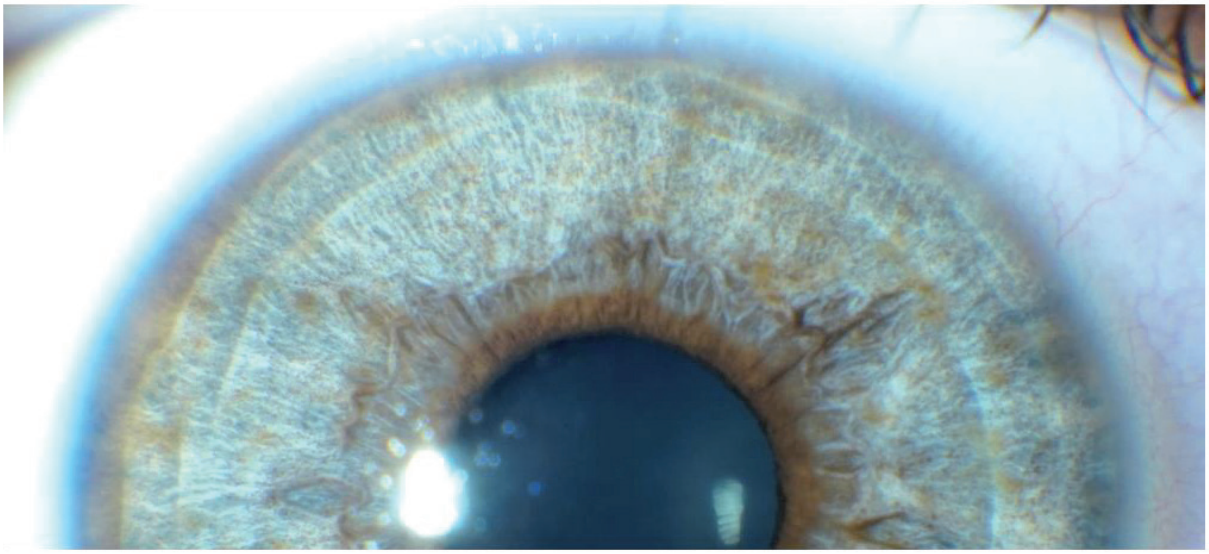


FIGURE 136: Final fine results after phases 3-4 on levels 2 eyeseyes

3 9.6 Phase 3-4- L3





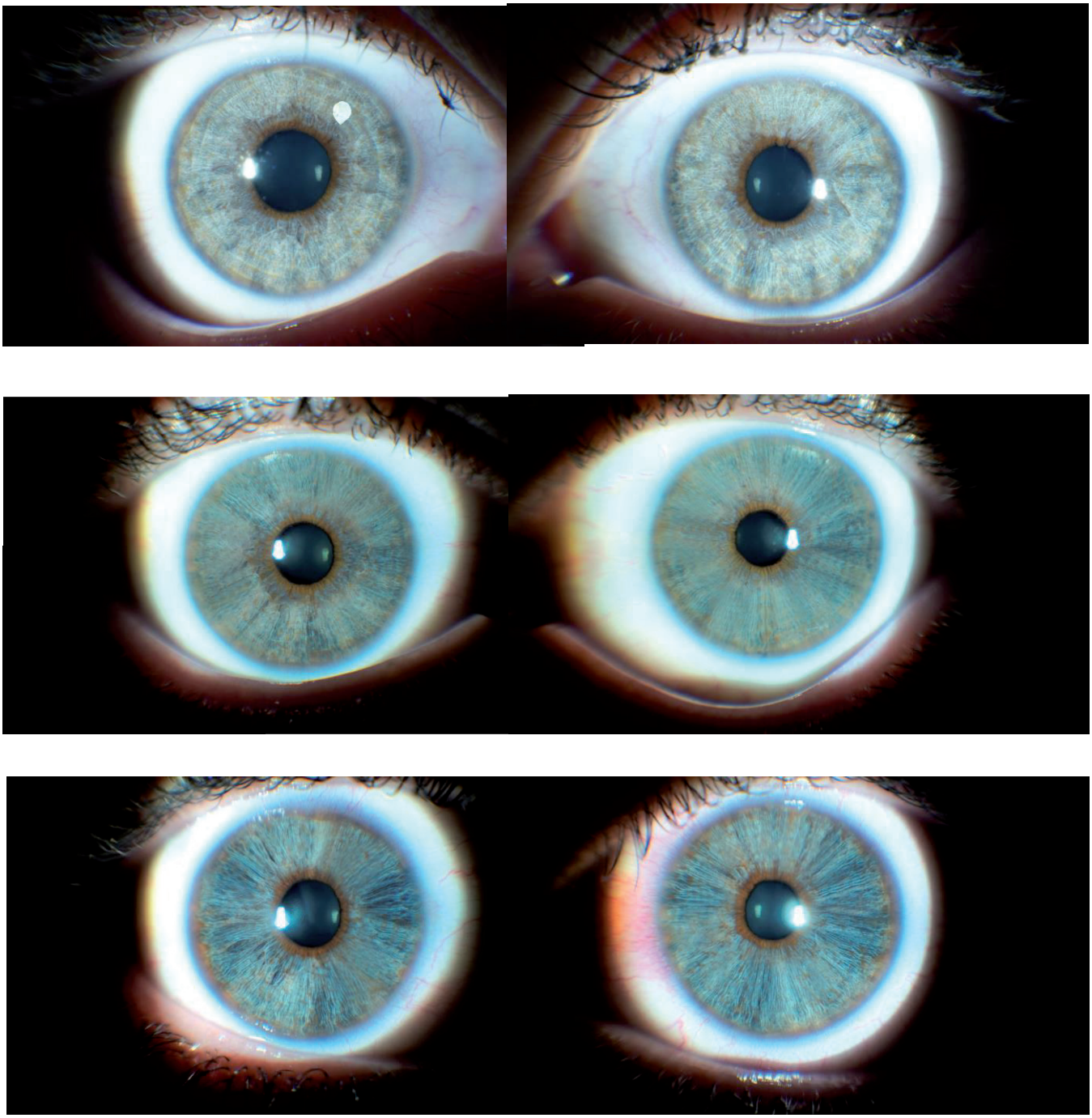
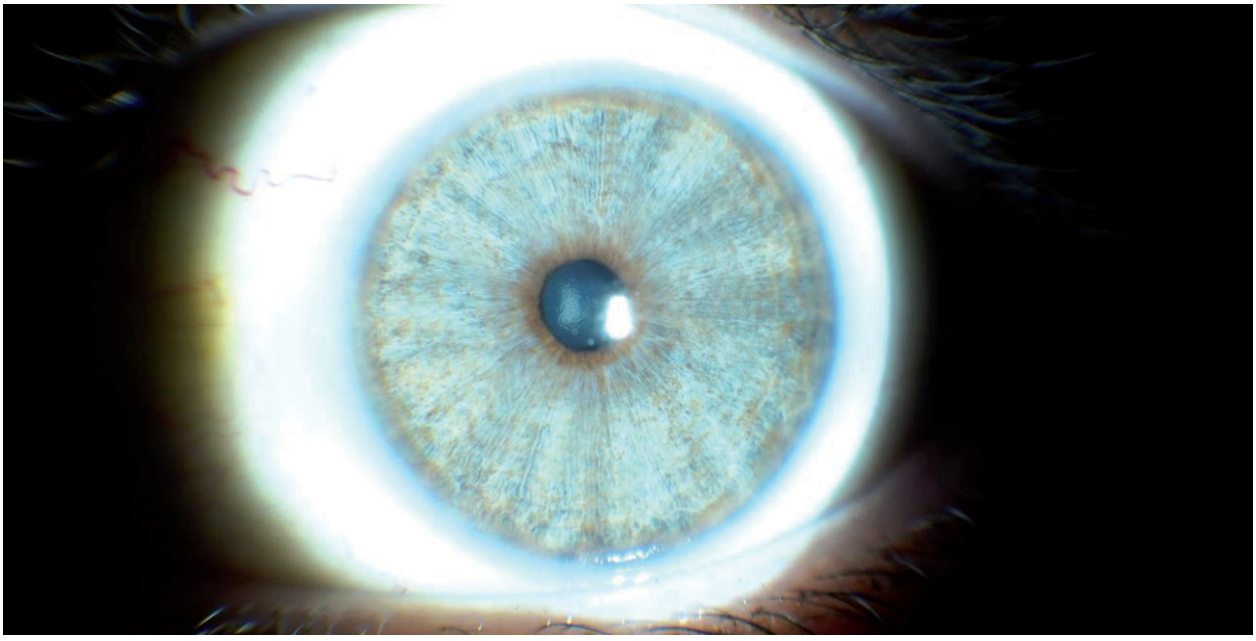
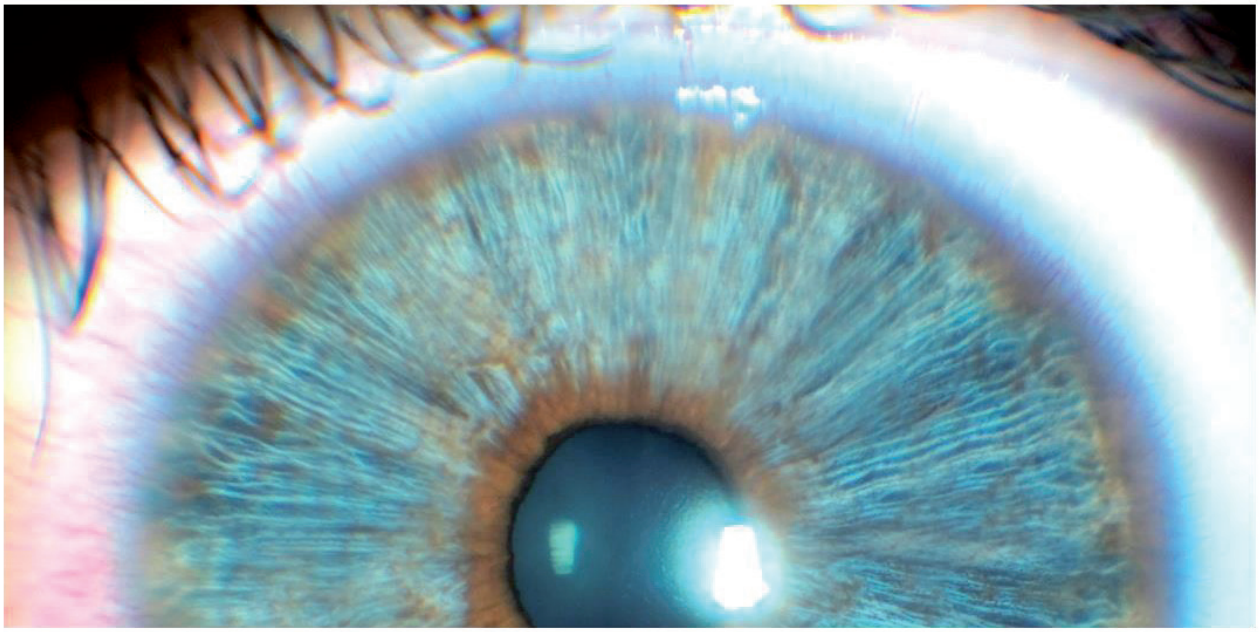


FIGURE 137: Final fine results after phases 3-4 on levels 3 eyes

3 9.6 Phase 3-4- L3





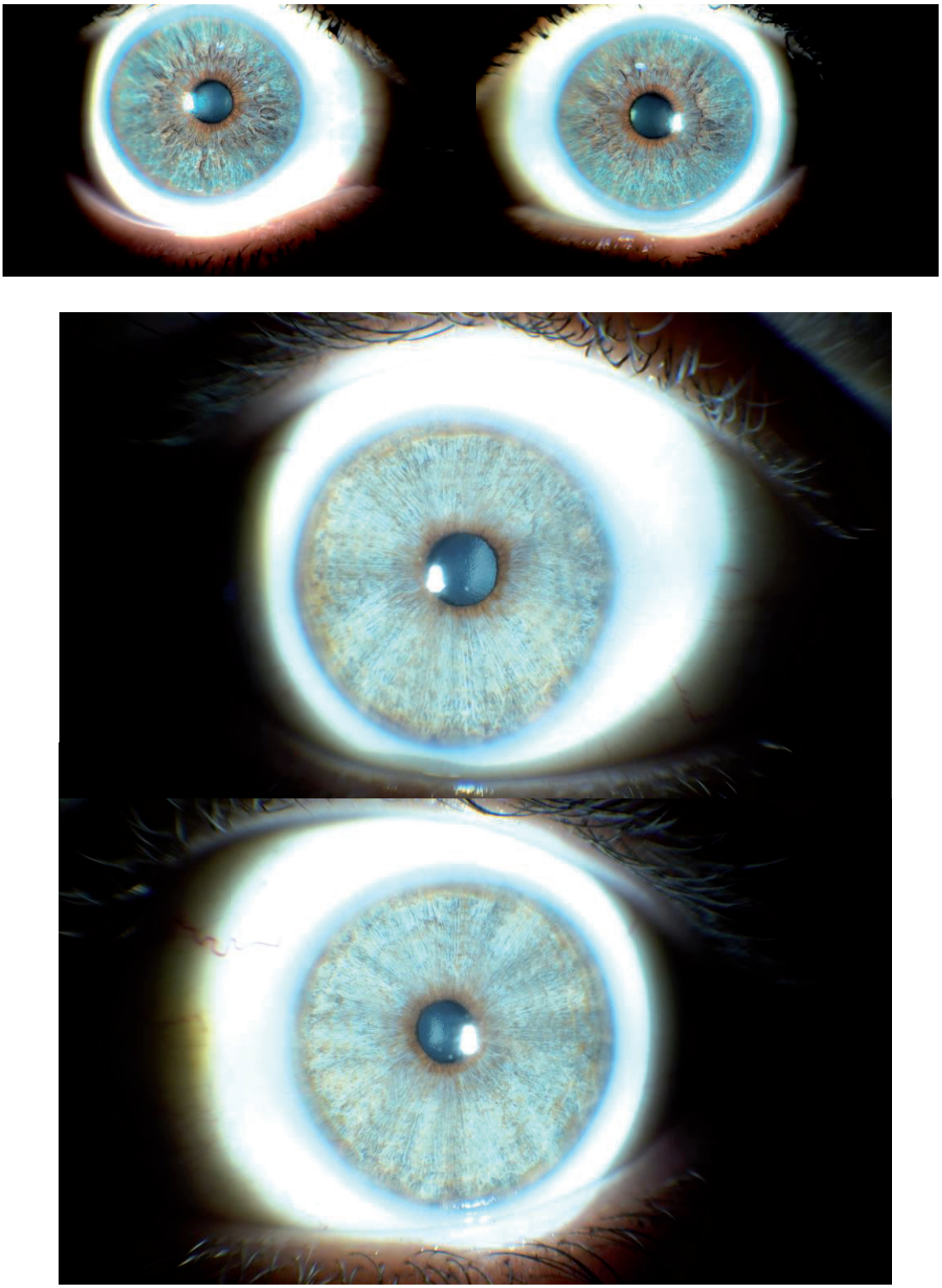
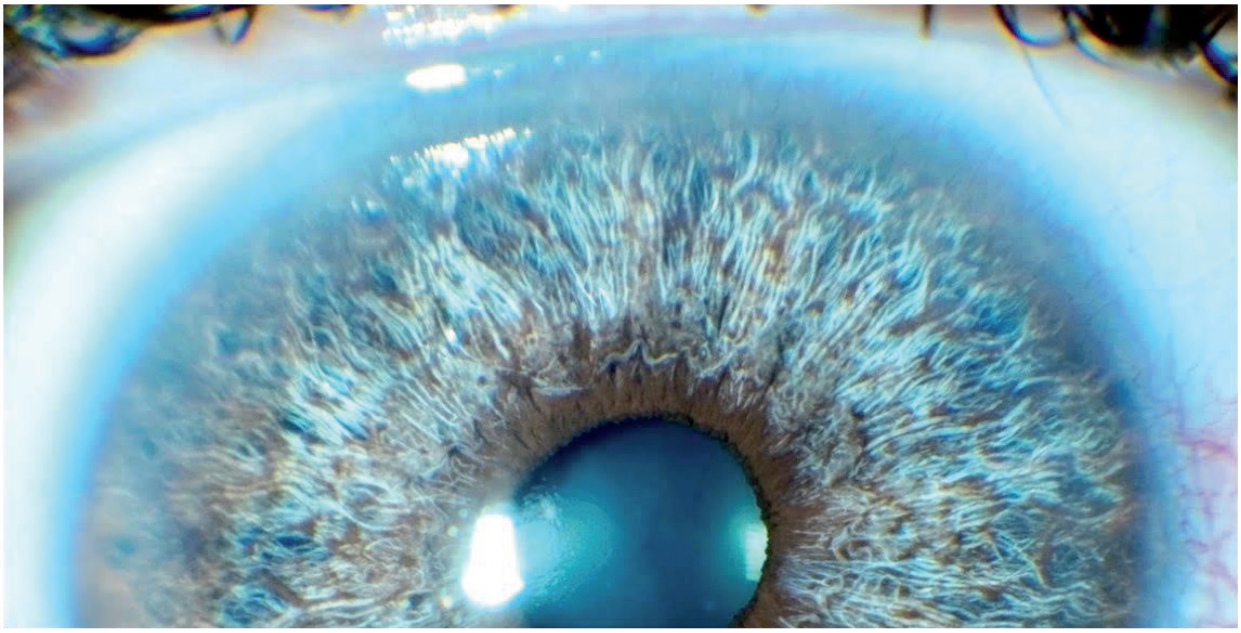
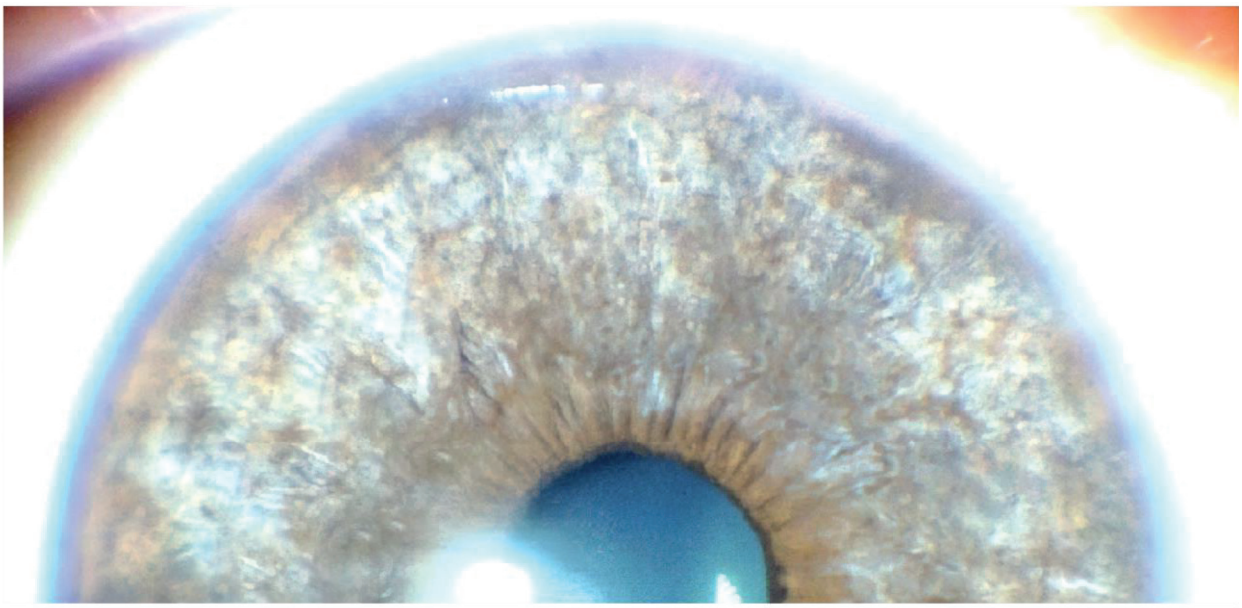


FIGURE 138: Final fine results after phases 3-4 on levels 3 eyes

3 9.6 Phase 3-4- L4-5





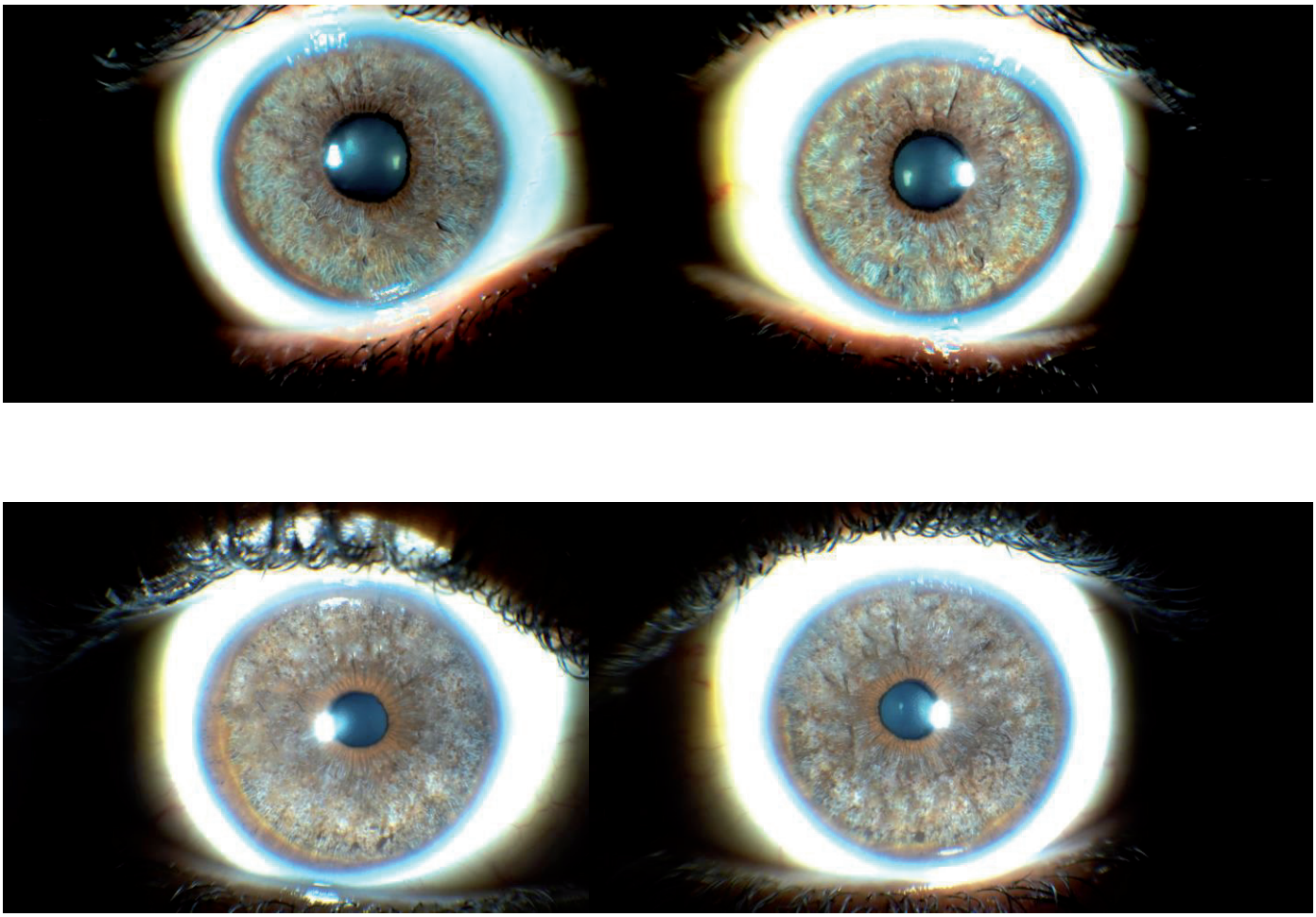
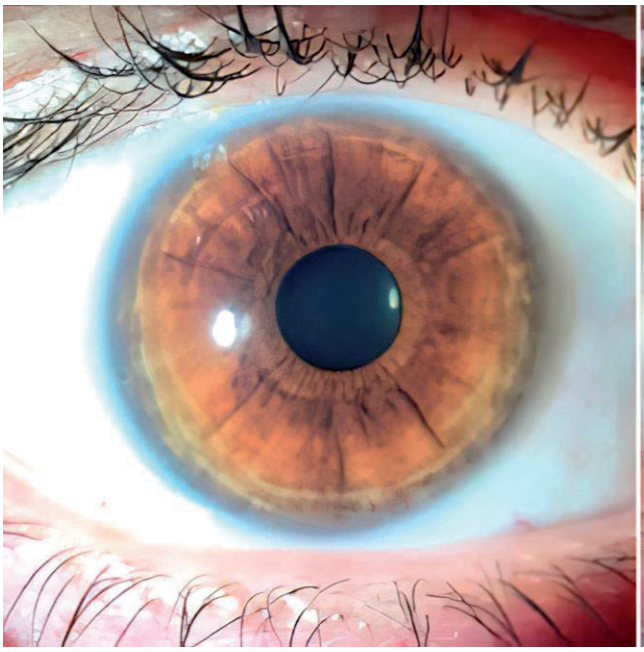
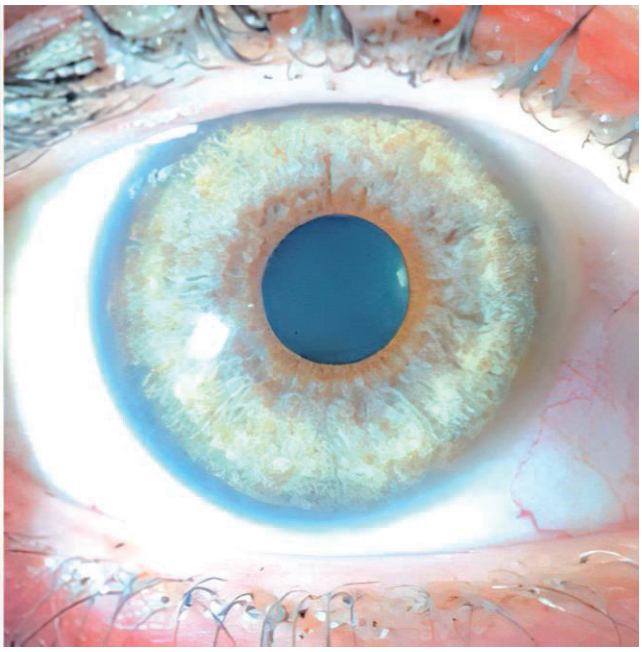
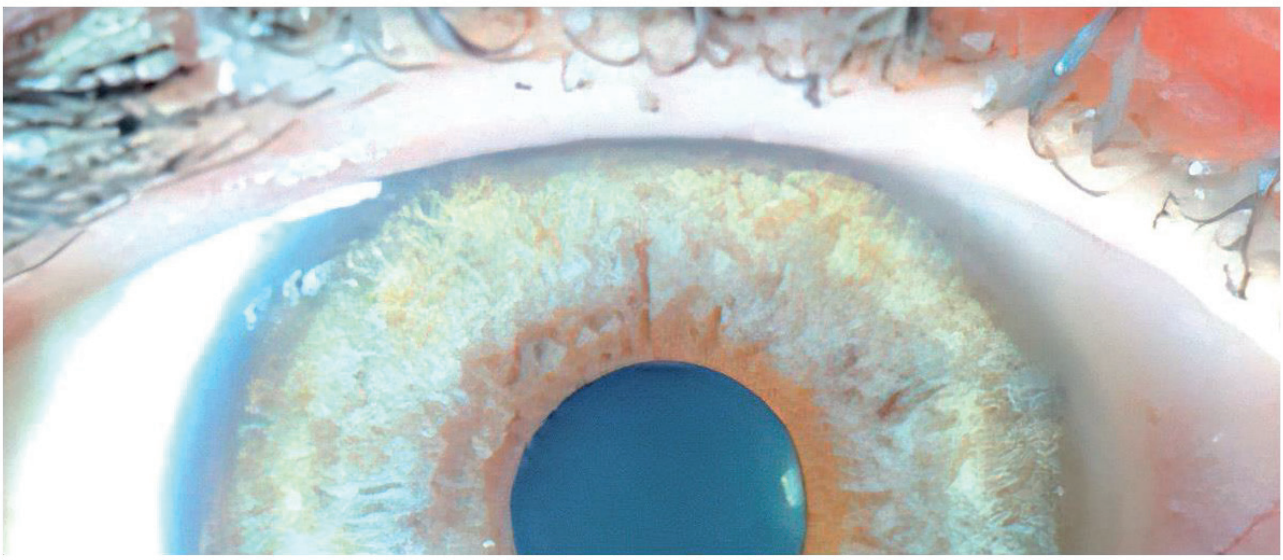


FIGURE 139: Final fine results after phases 3-4 on levels 4-5 eyes

3 9.7 Lasers 532/577







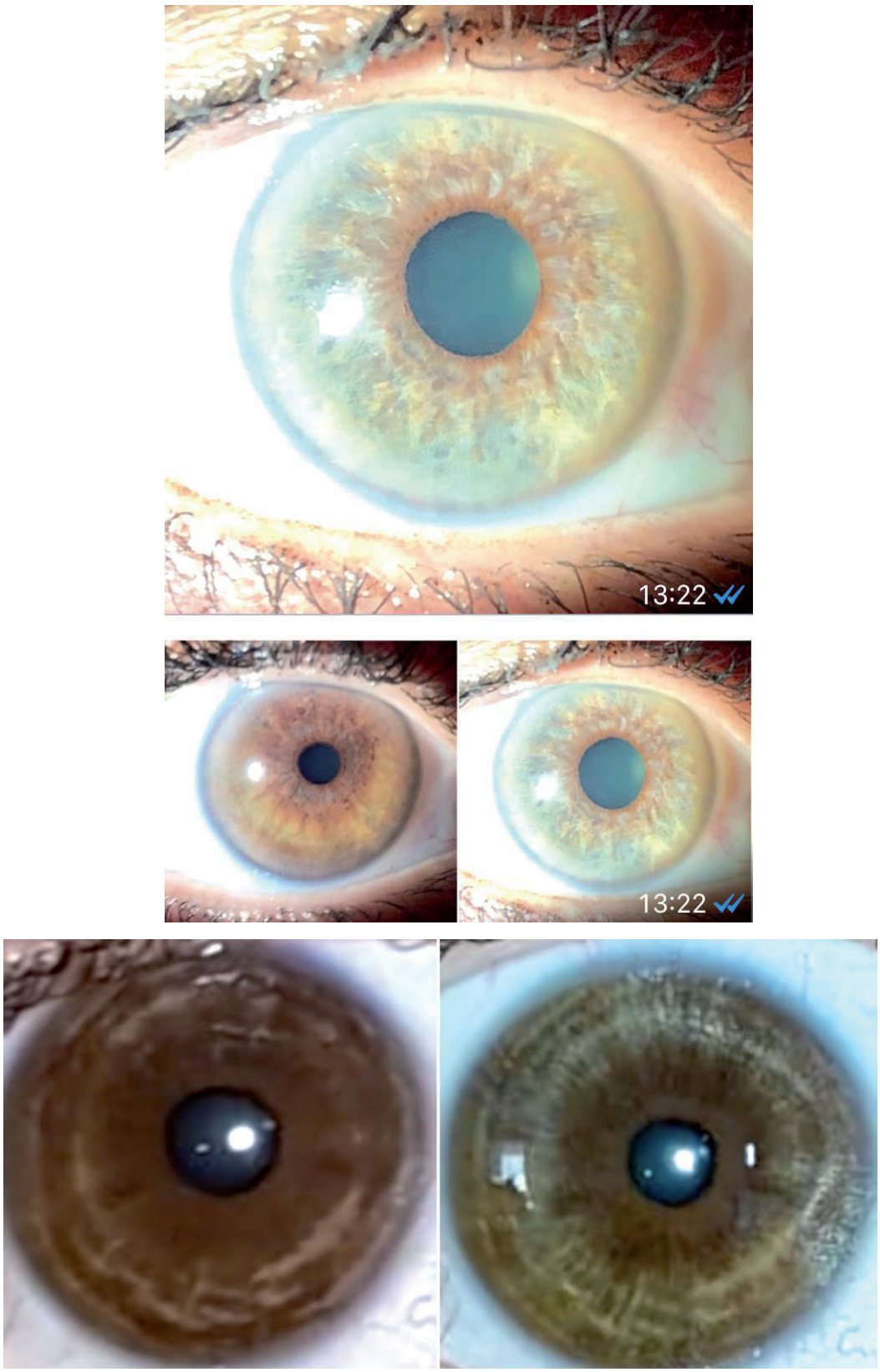
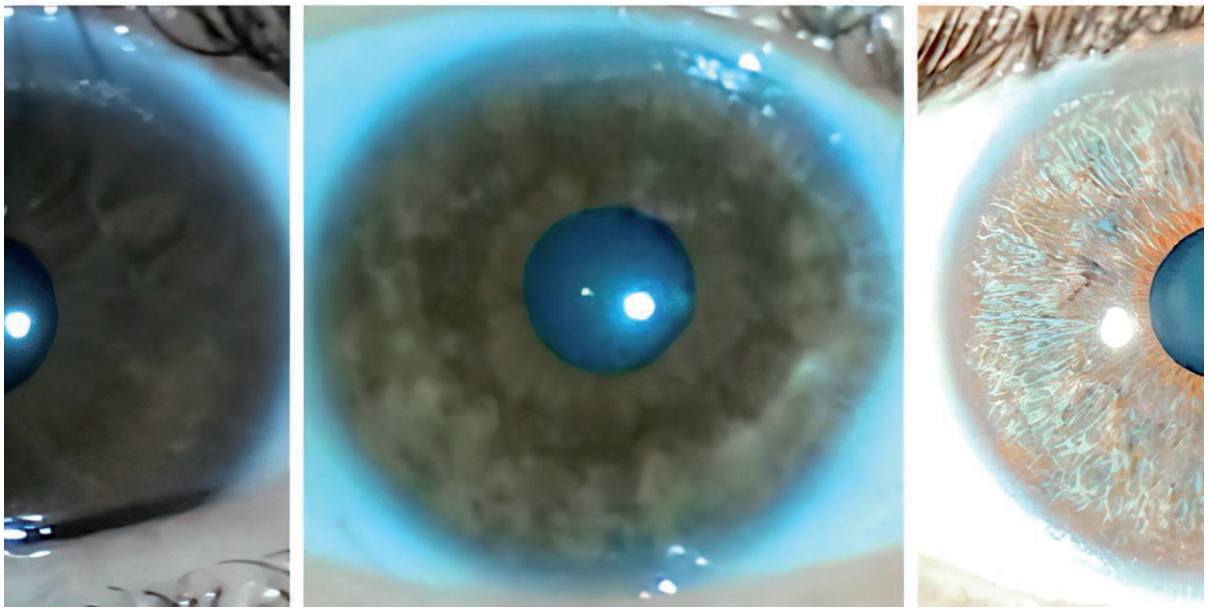
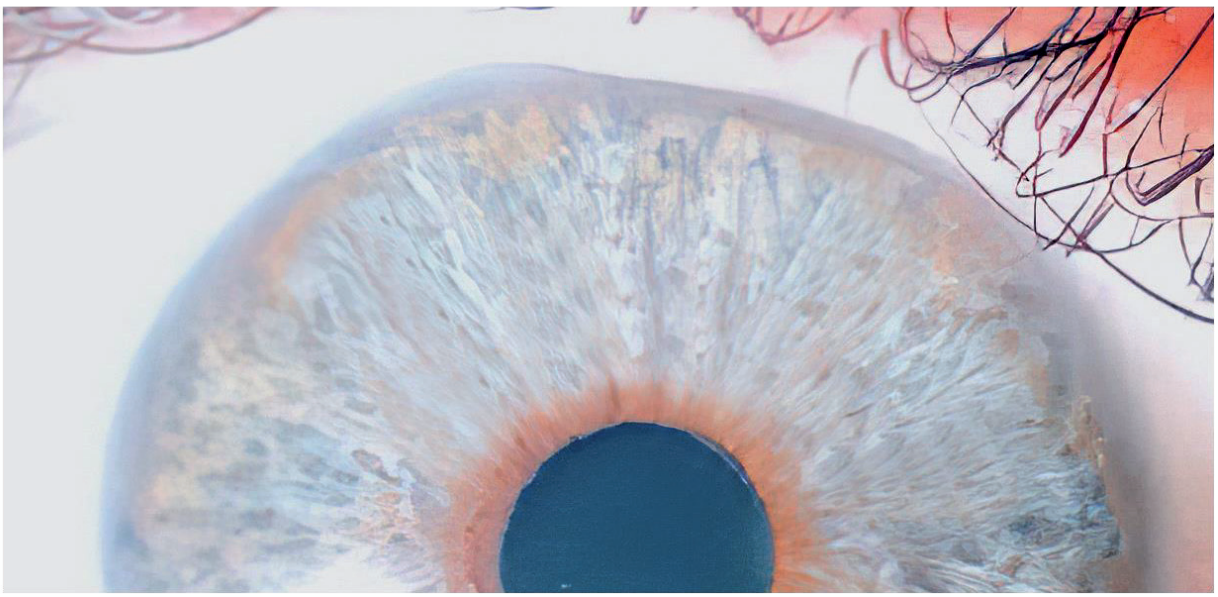


FIGURE 140: Final fine resuls after 532/577 lasers treatment

3 9.7 Lasers 532/577





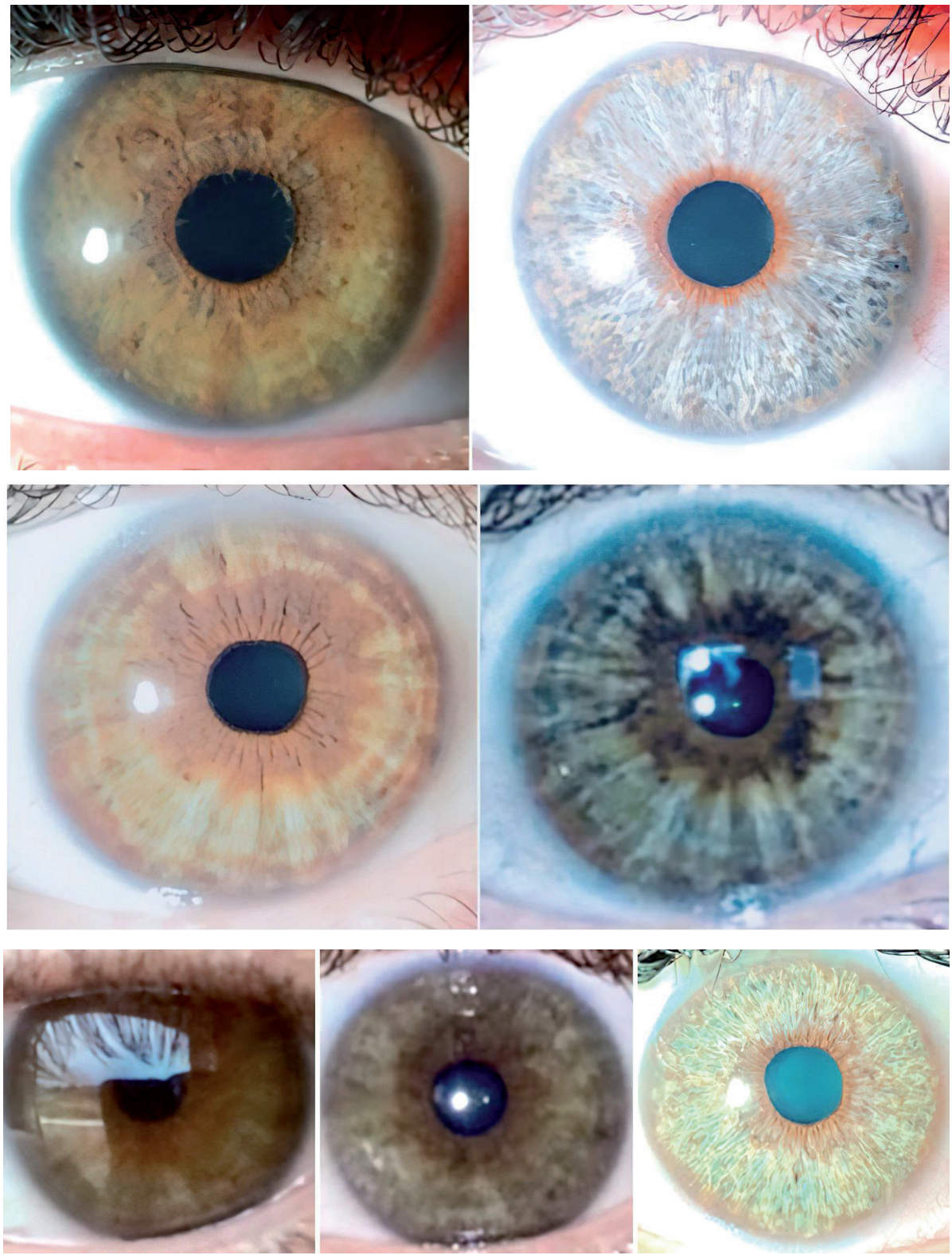
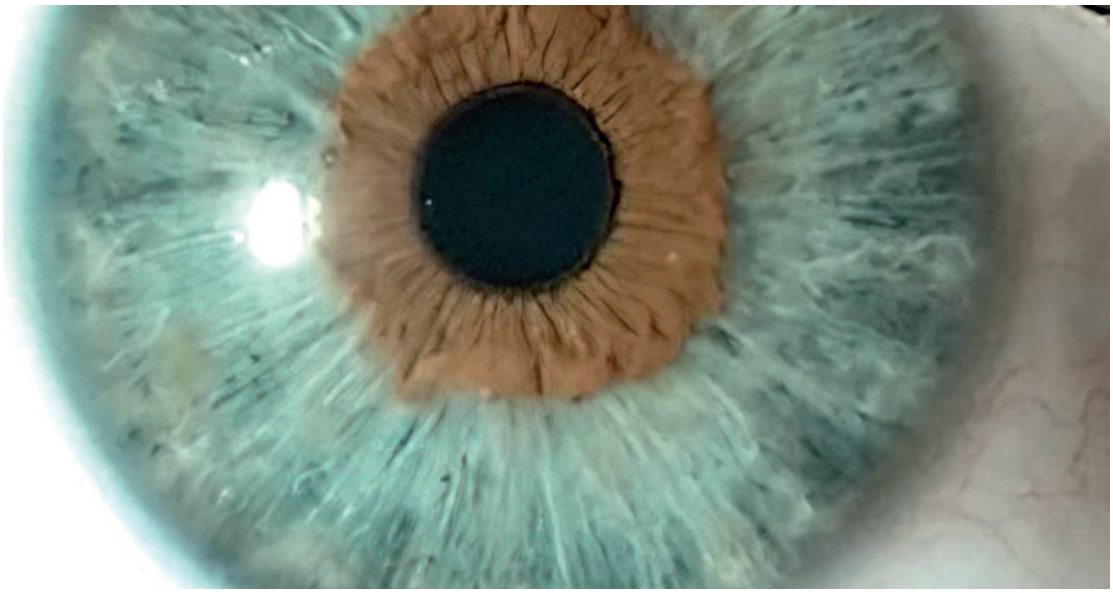
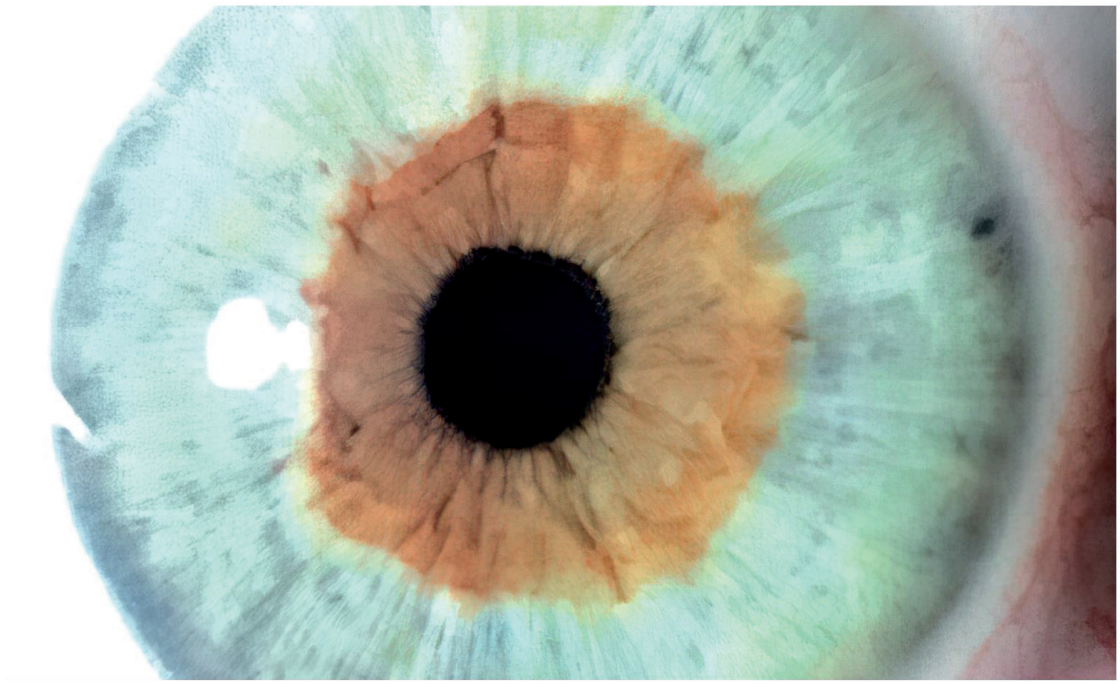


FIGURE 141: Final fine resuls after 532/577 lasers treatmenttreatment

3 9.8 Custom/Tattoo





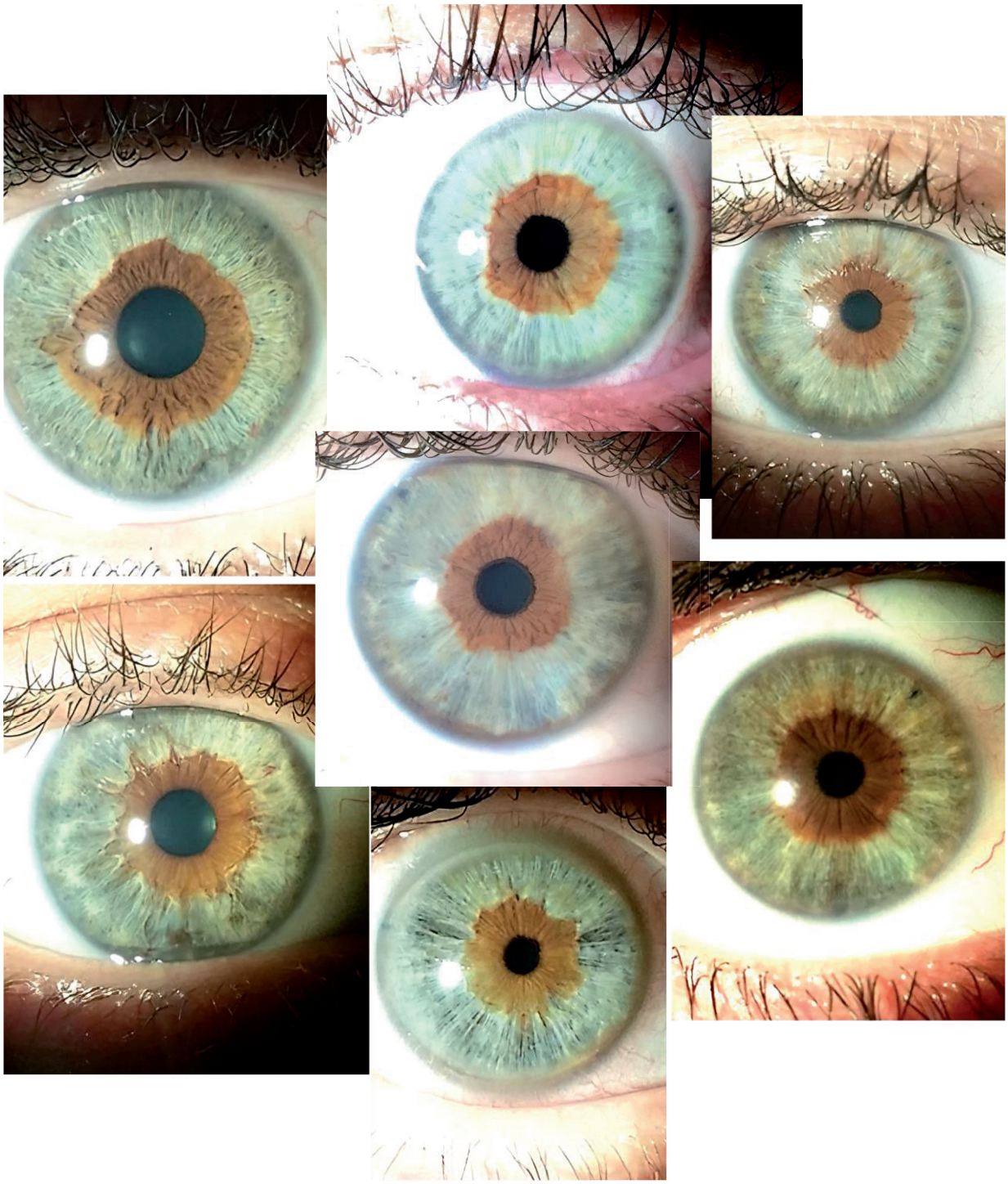
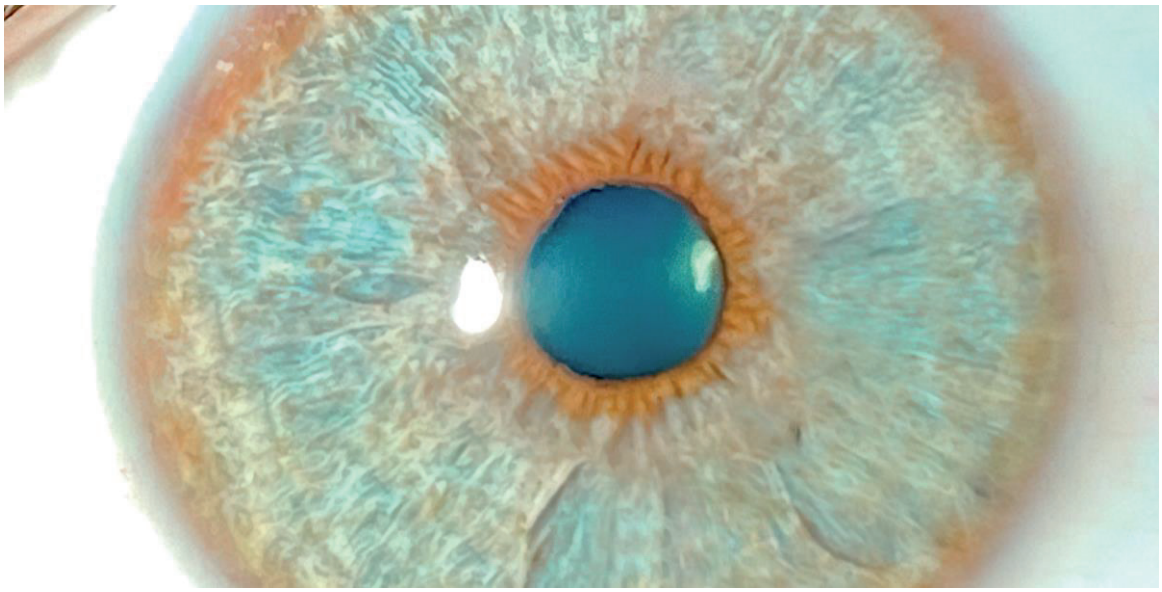
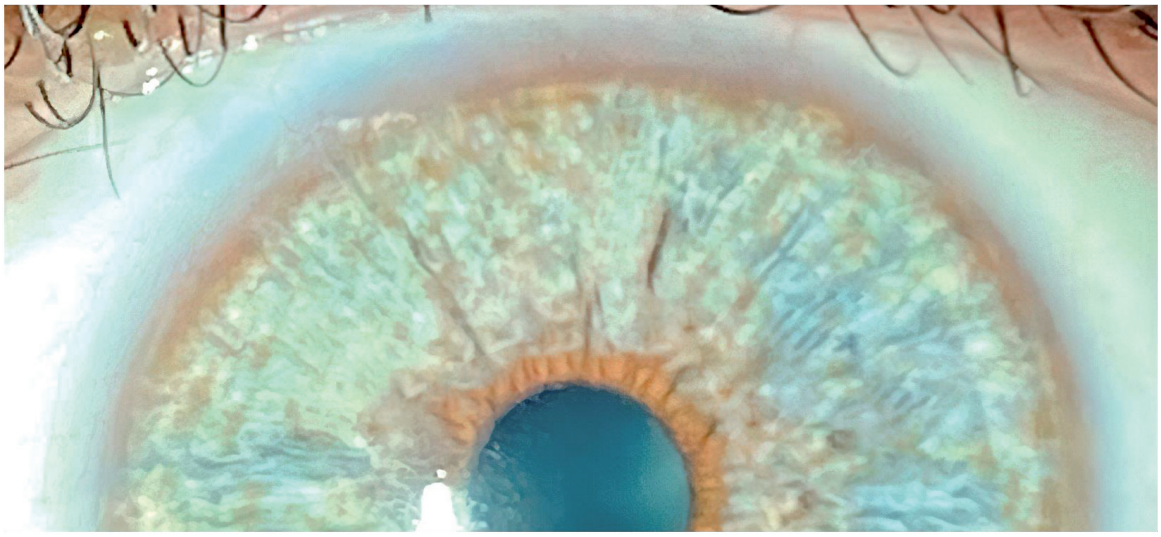


FIGURE 142: Peripheral pigment removal, leaving central area pigment

3 9.8 Custom/Tattoo





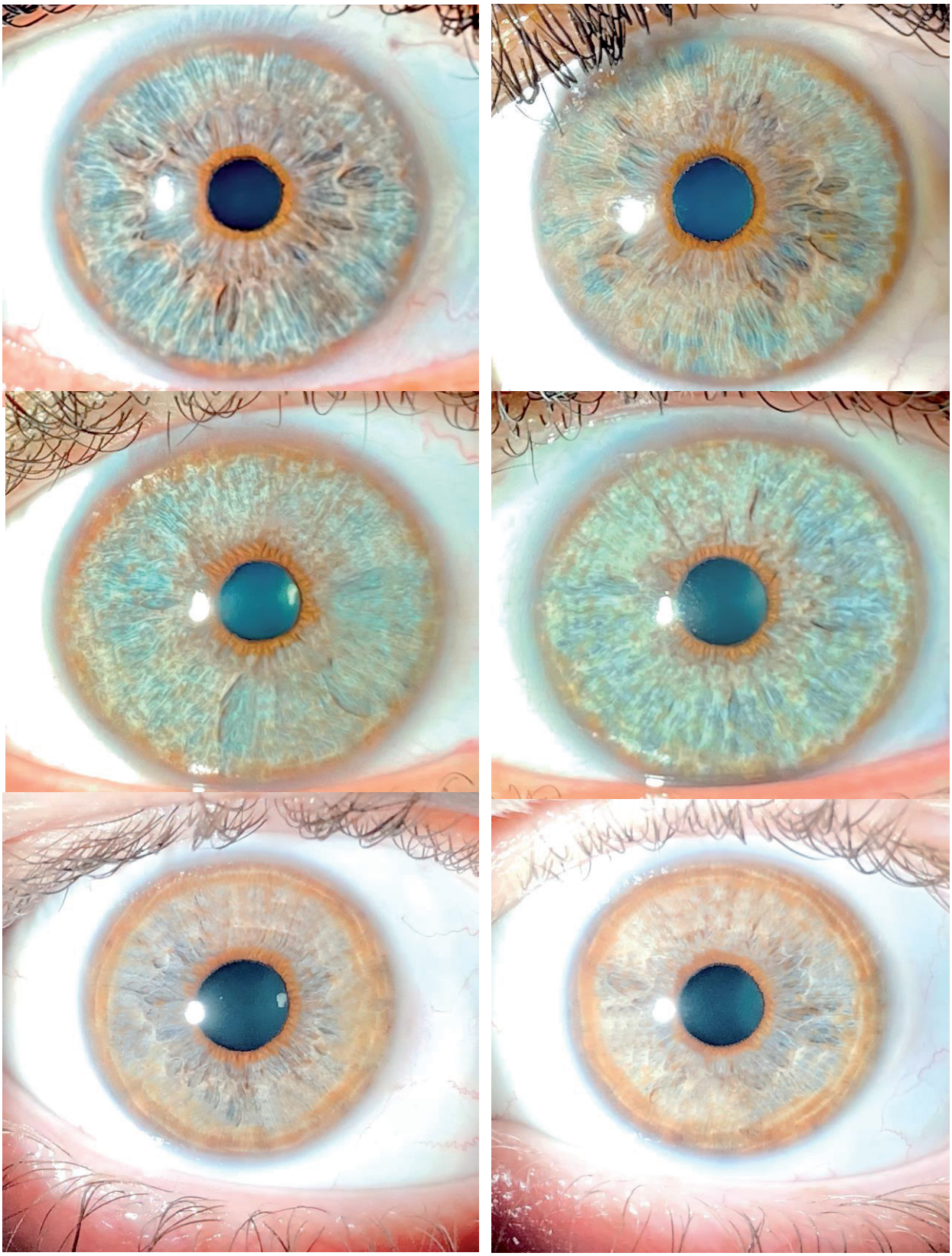
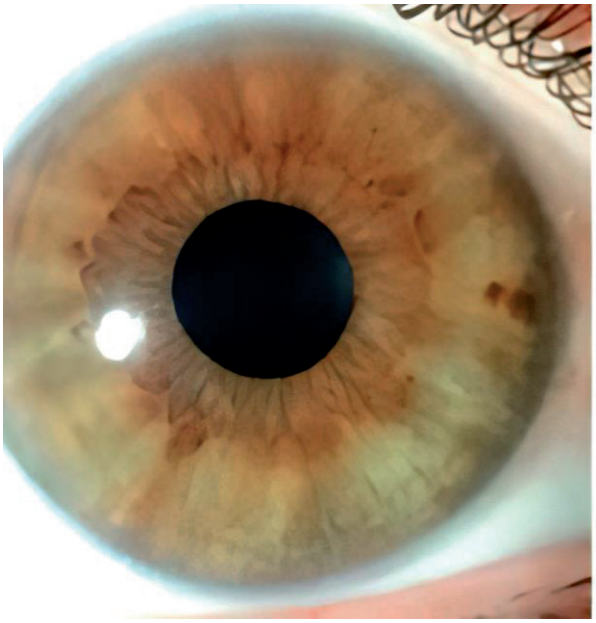
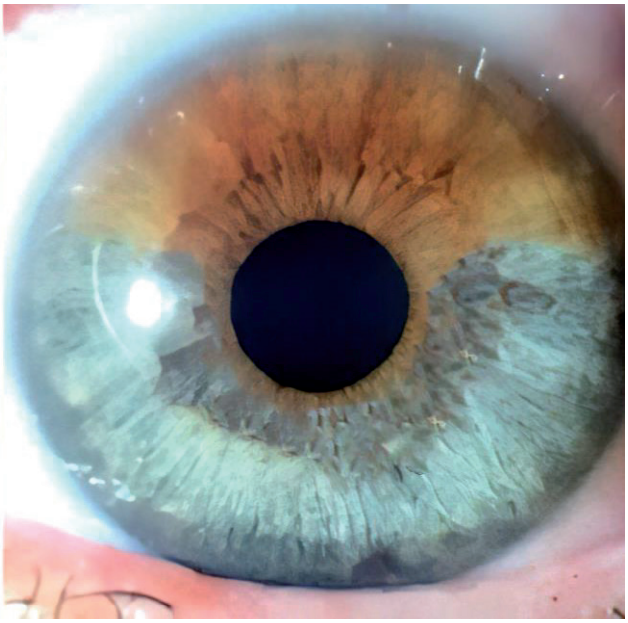
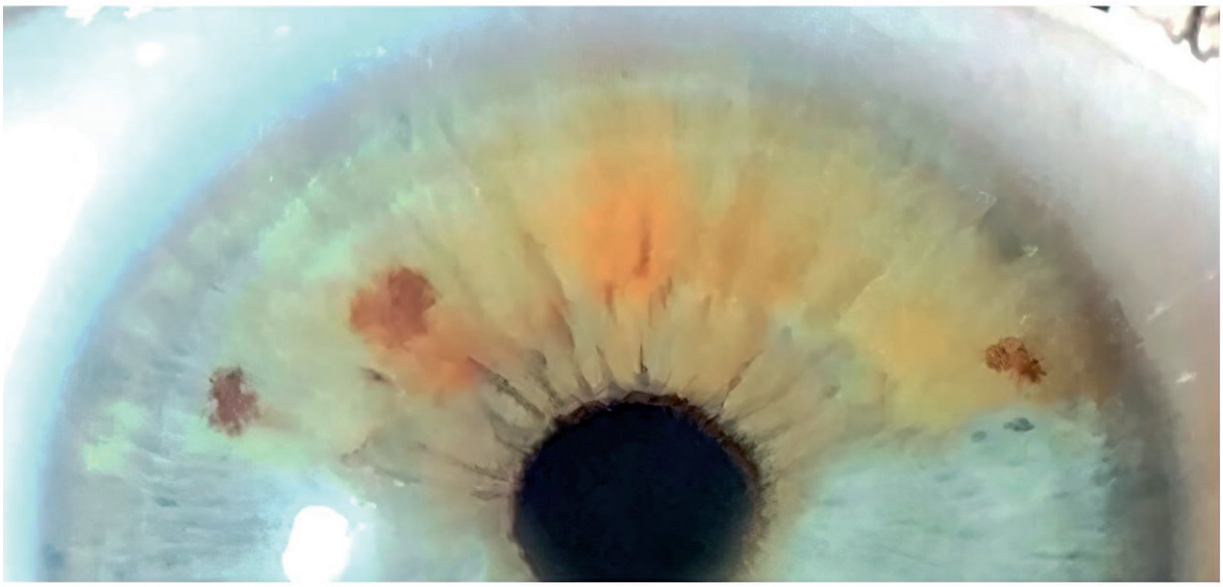


FIGURE 143: Final fine resuls after customized limbal ring treatment

3 9.8 Custom/Tattoo







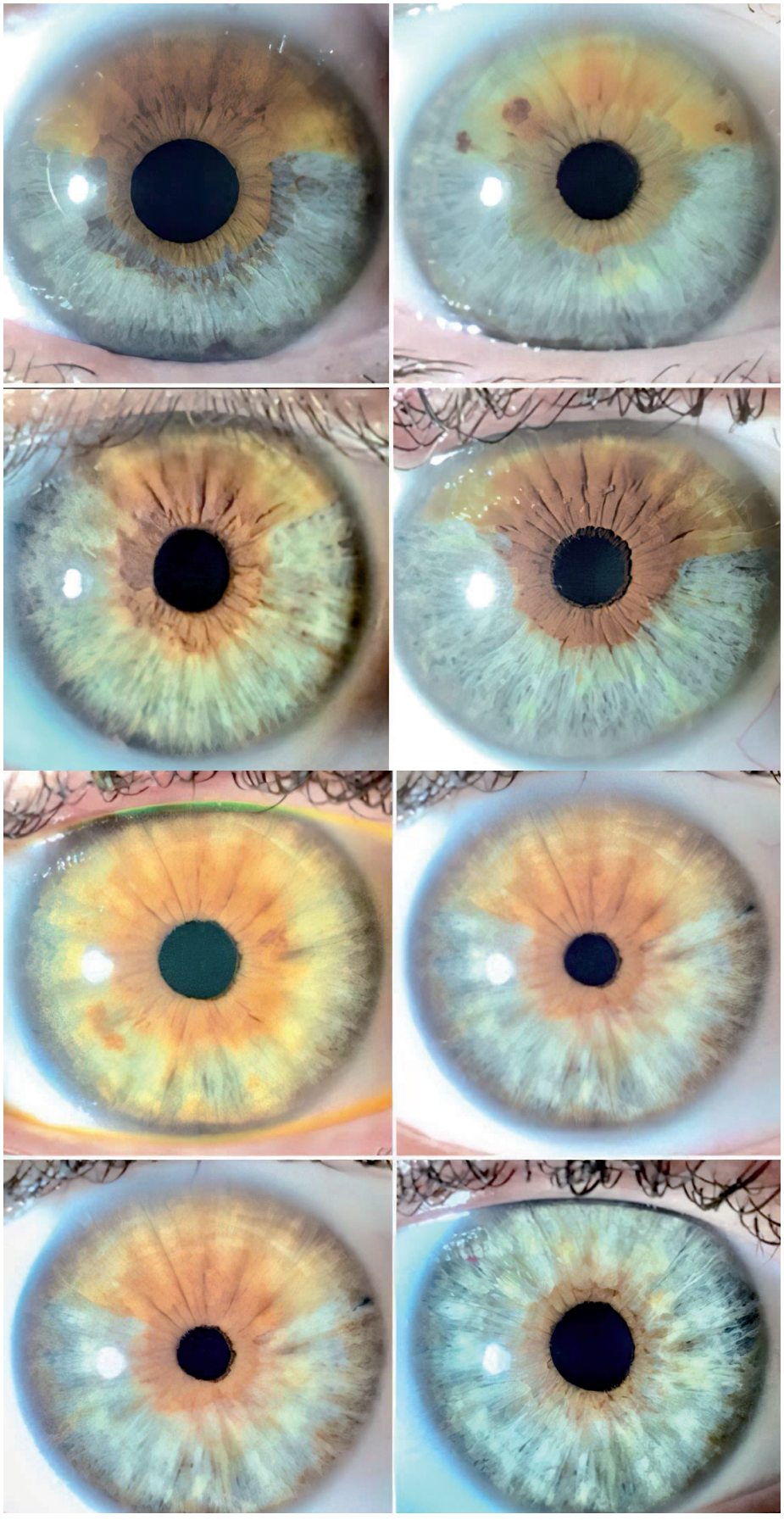
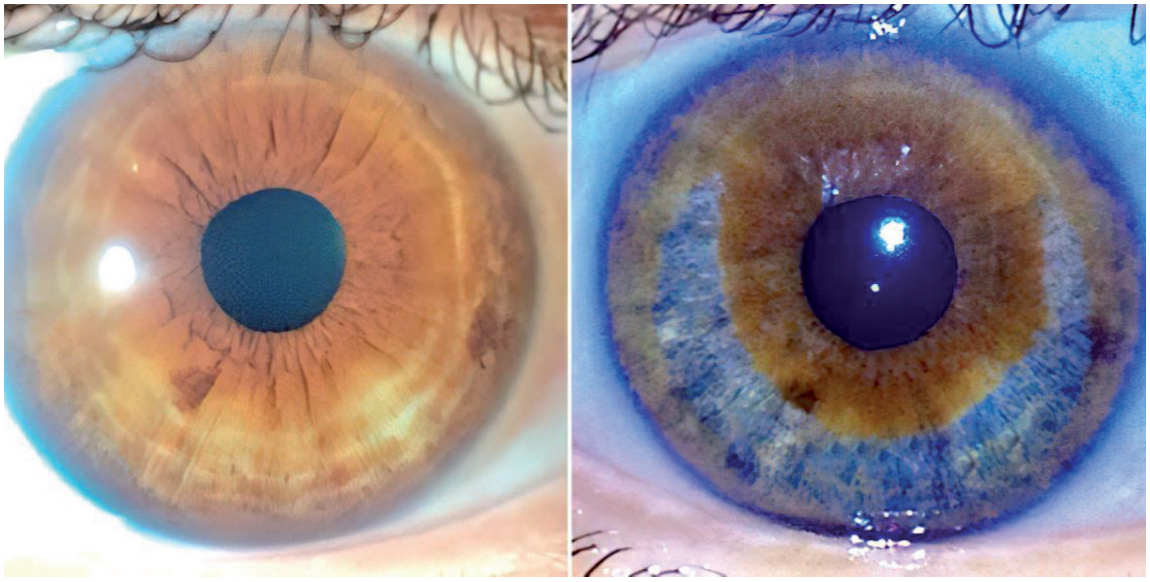
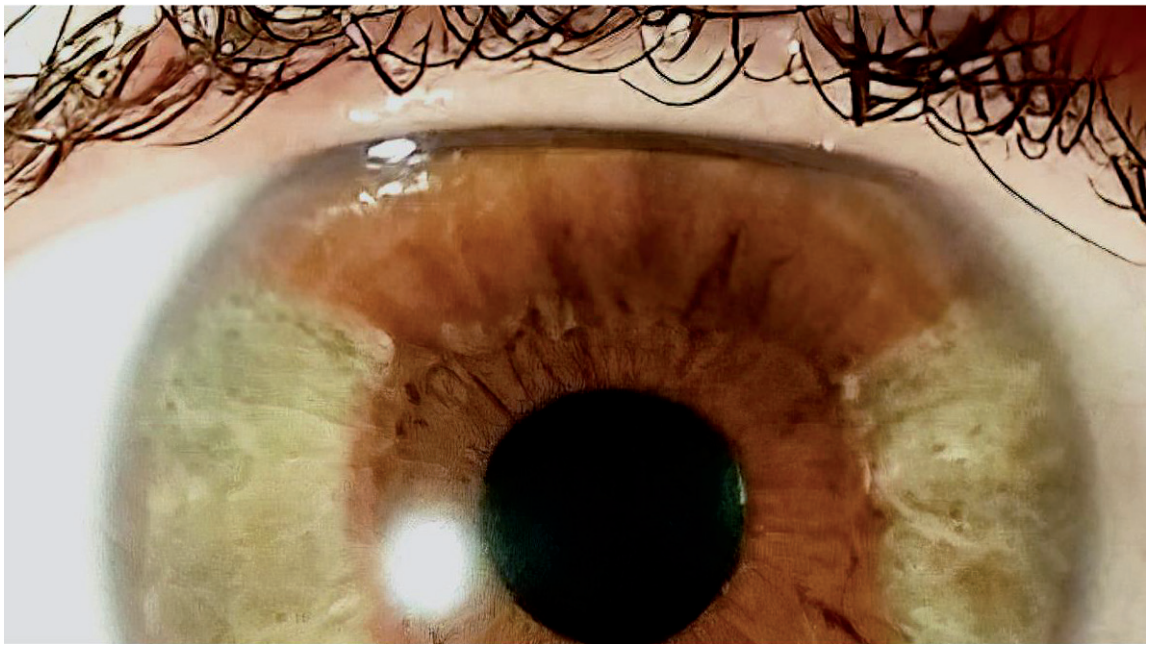


FIGURE 144:Customized fine resuls after half iris treatment

3 9.8 Custom/Tattoo





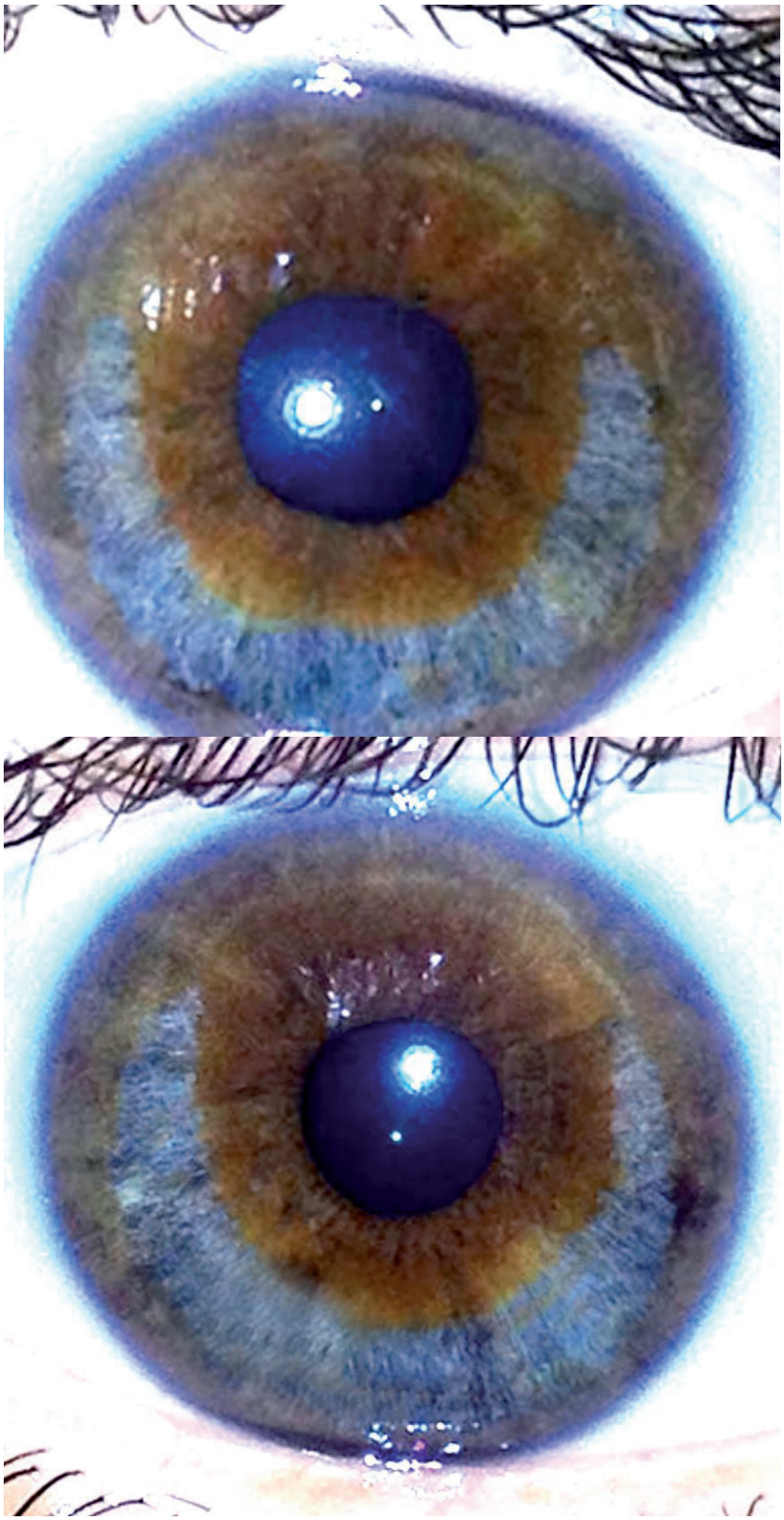
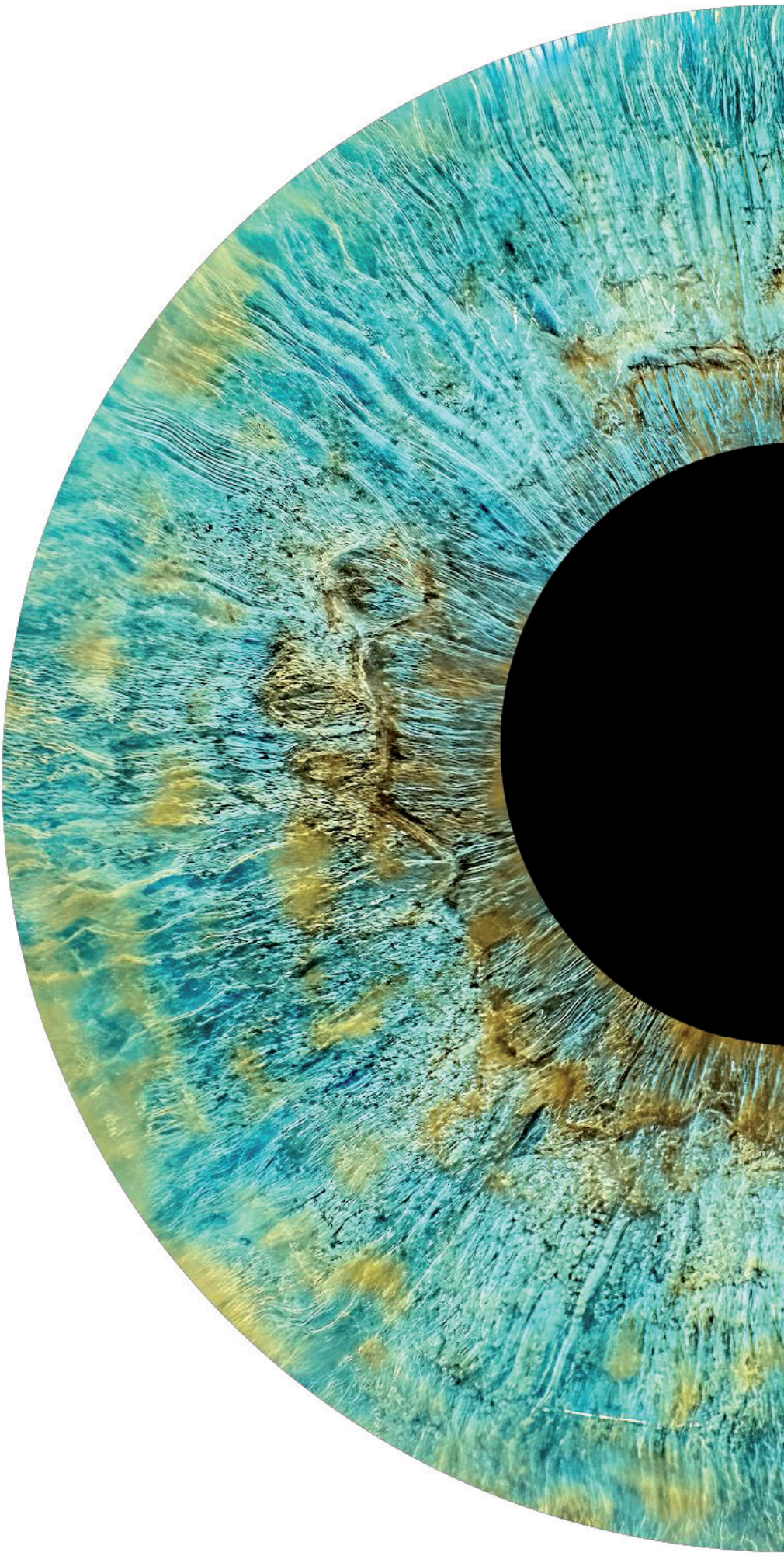
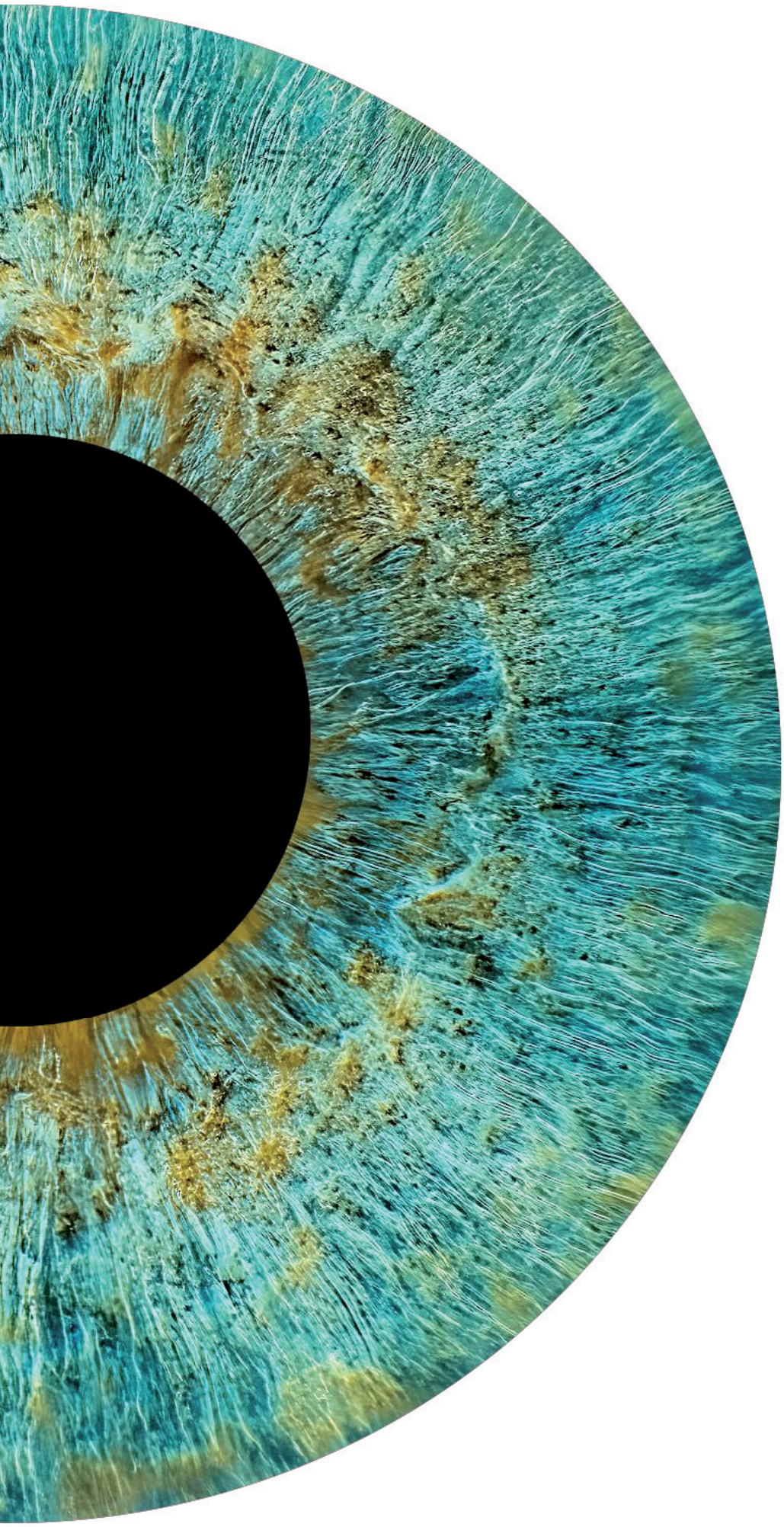
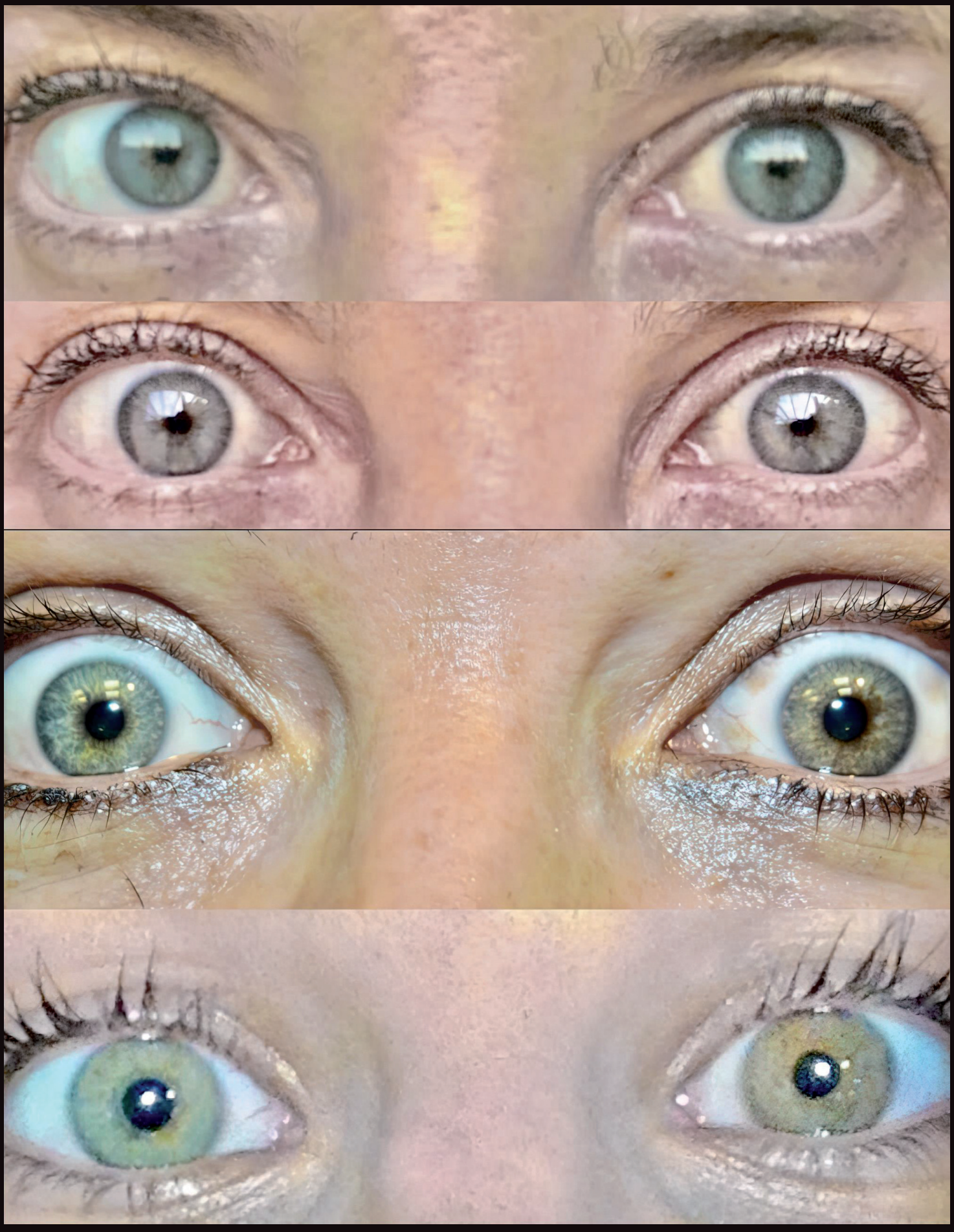


FIGURE 145: Customized fine resuls after smile tatto treatment



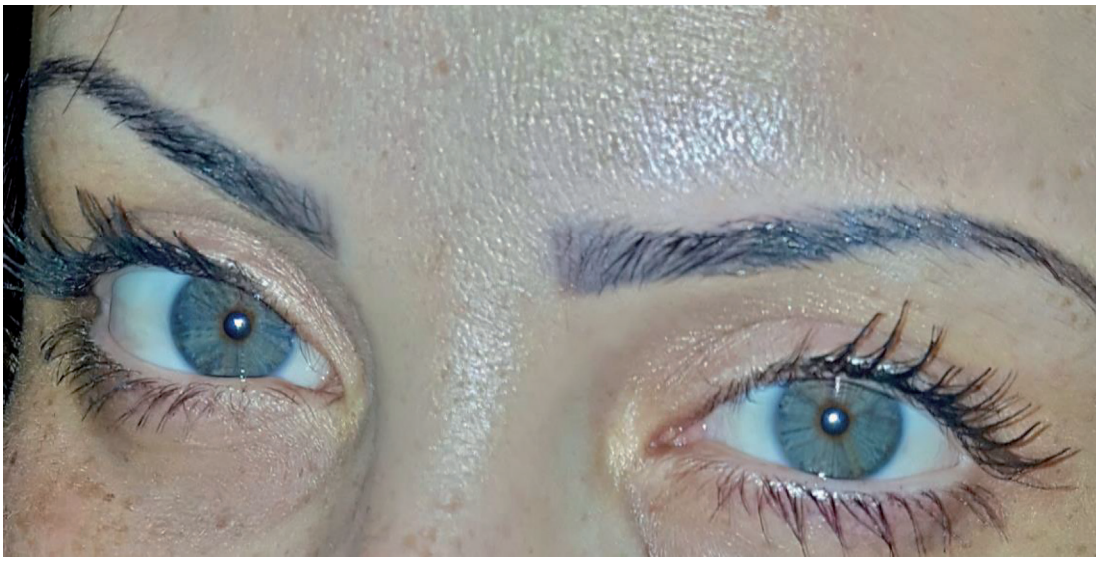




PART 3

COSMETIC RESULTS

3 10 Looks



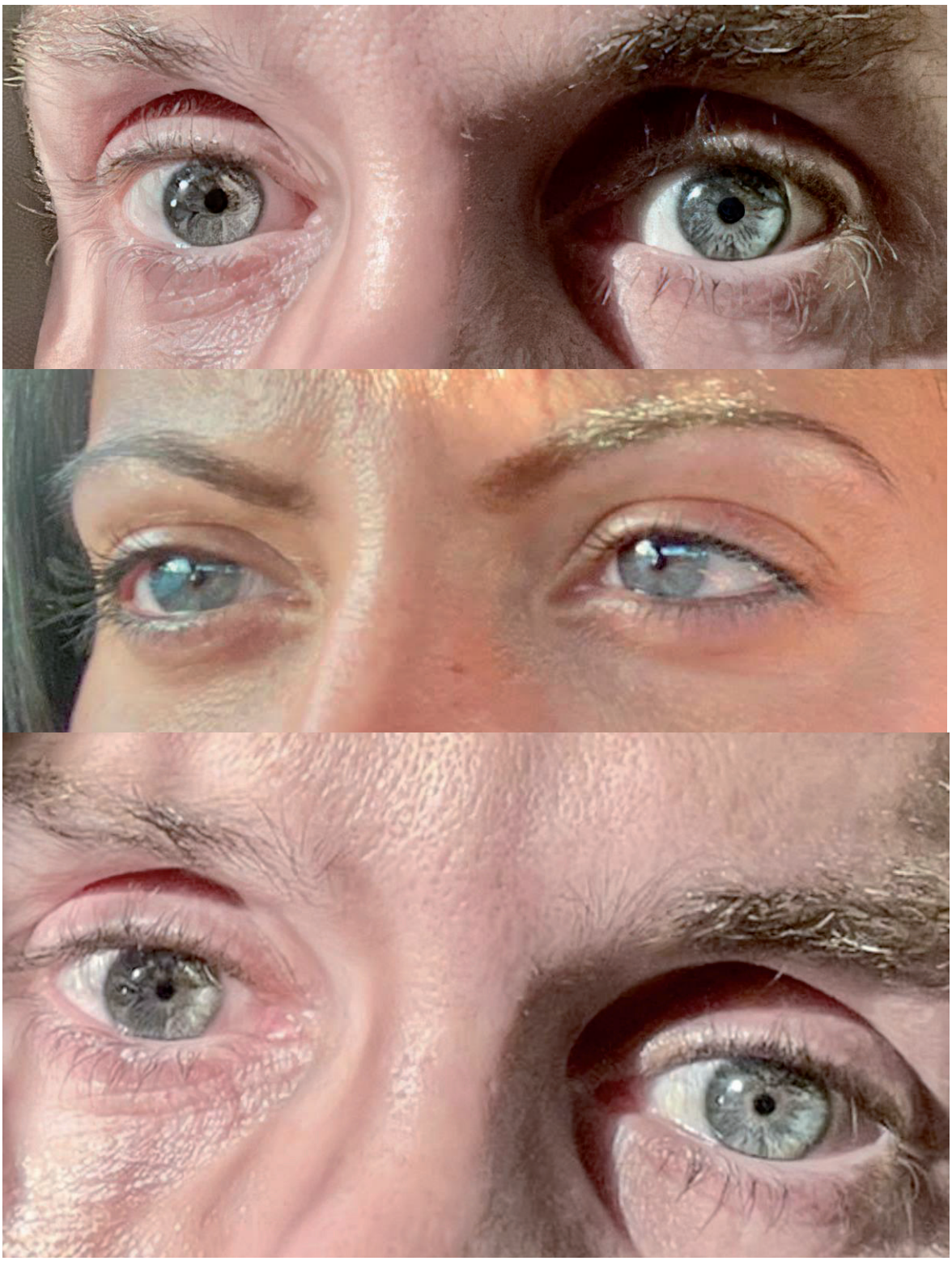
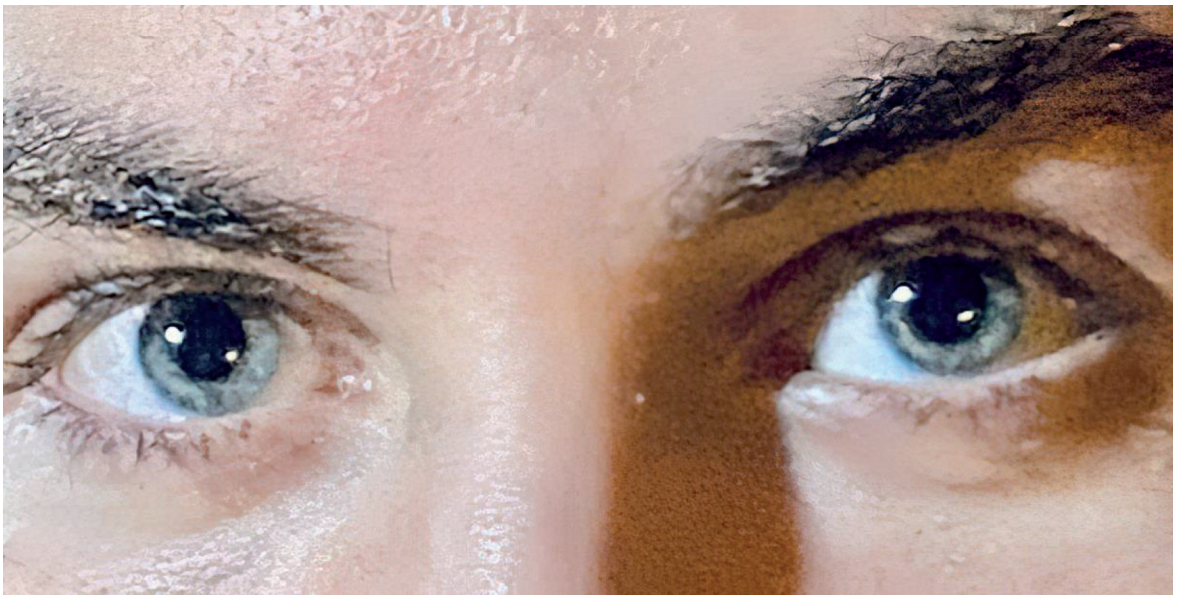
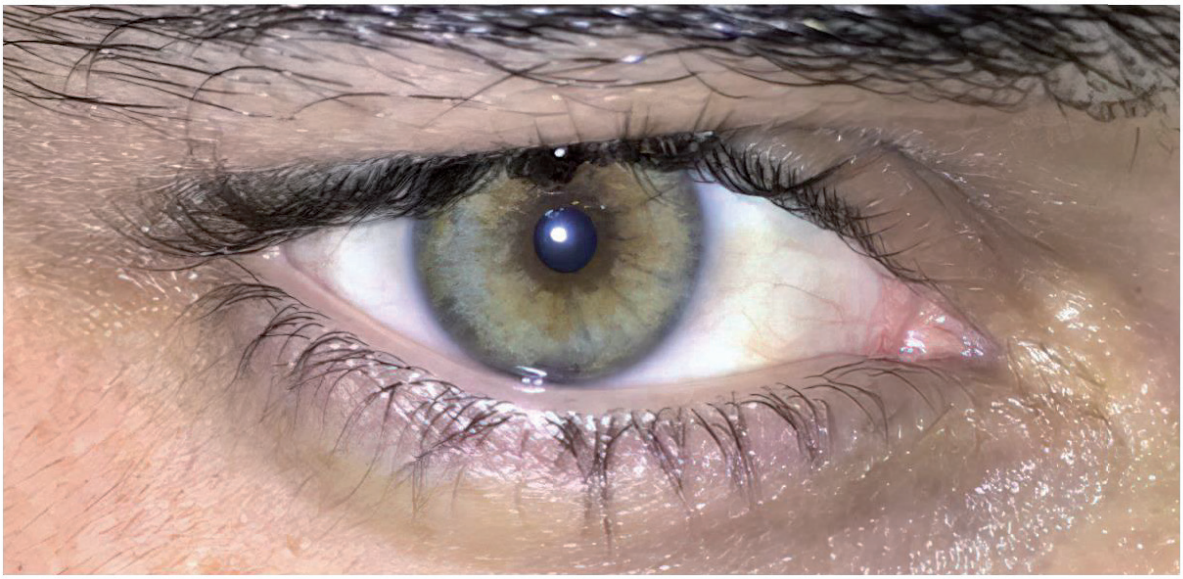


FIGURE 146: Light blue eye looks

3 10 Looks





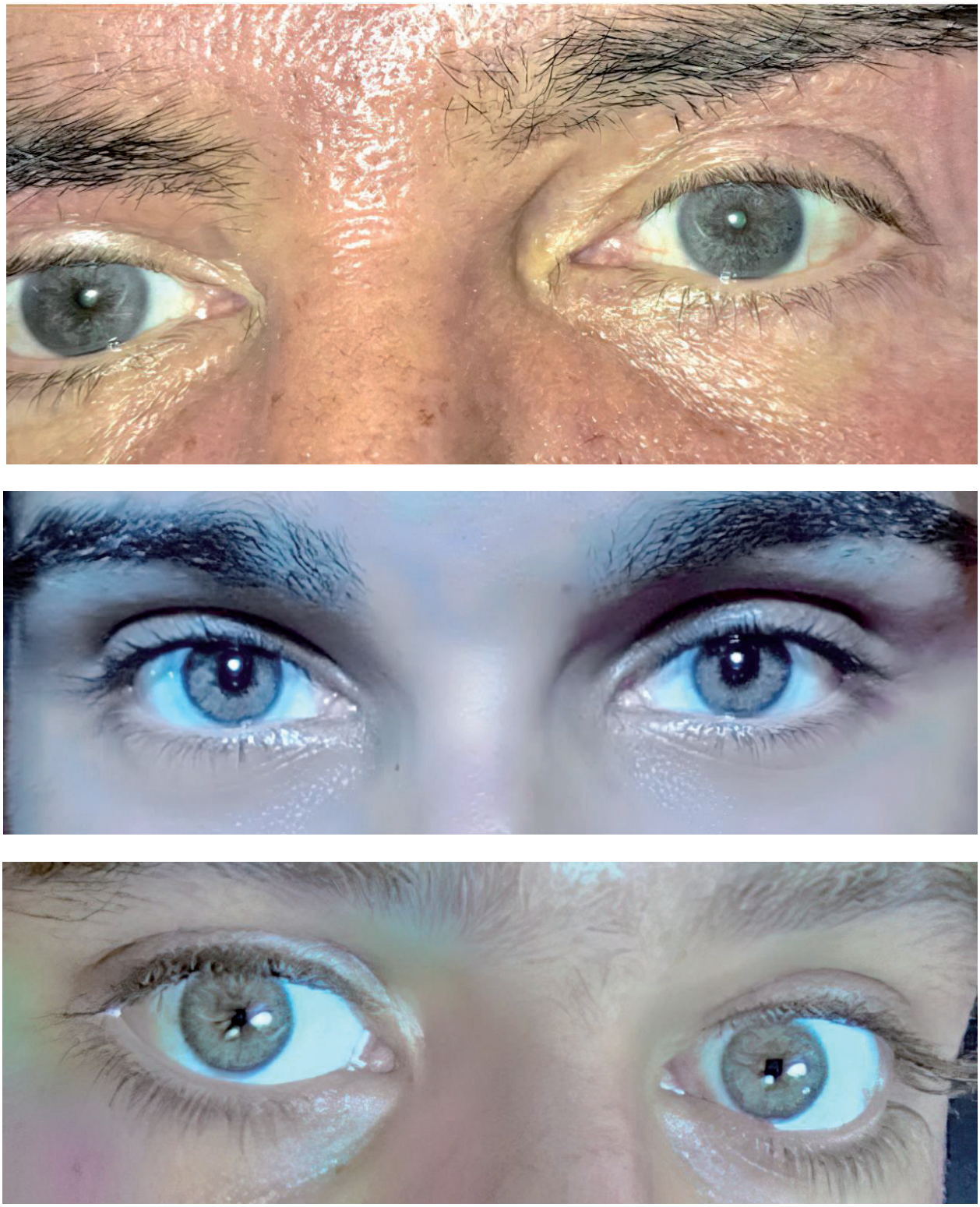
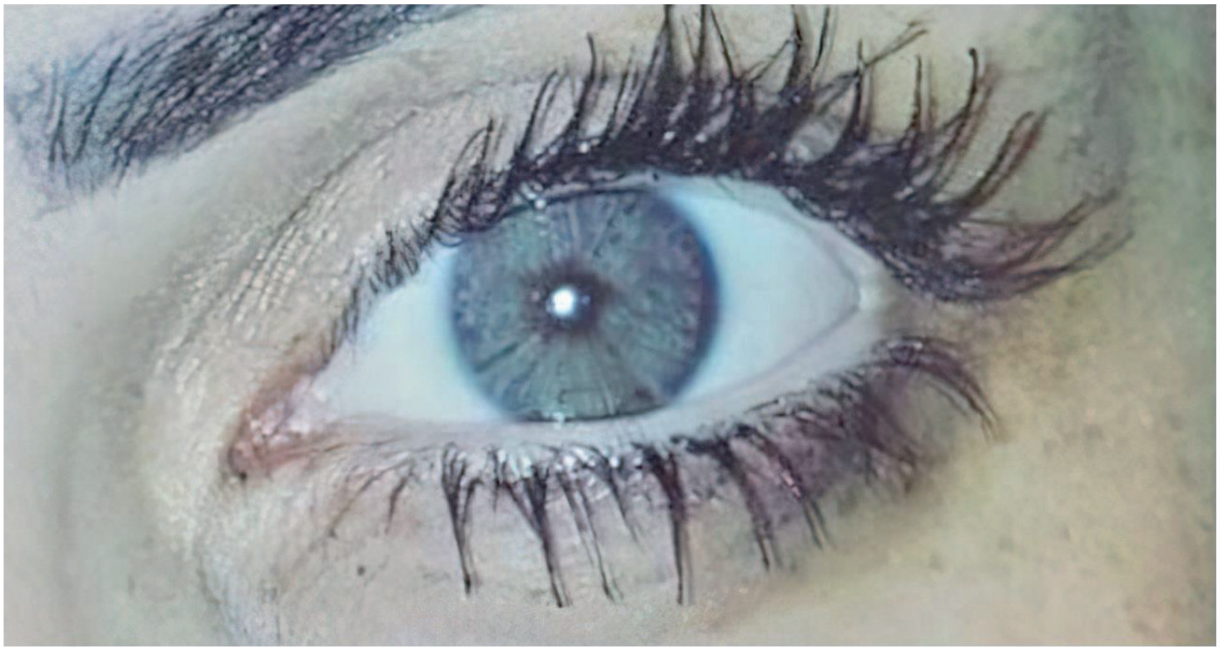


FIGURE 147: Medium greeenish and blue turqouise eye looks

3 10 Looks



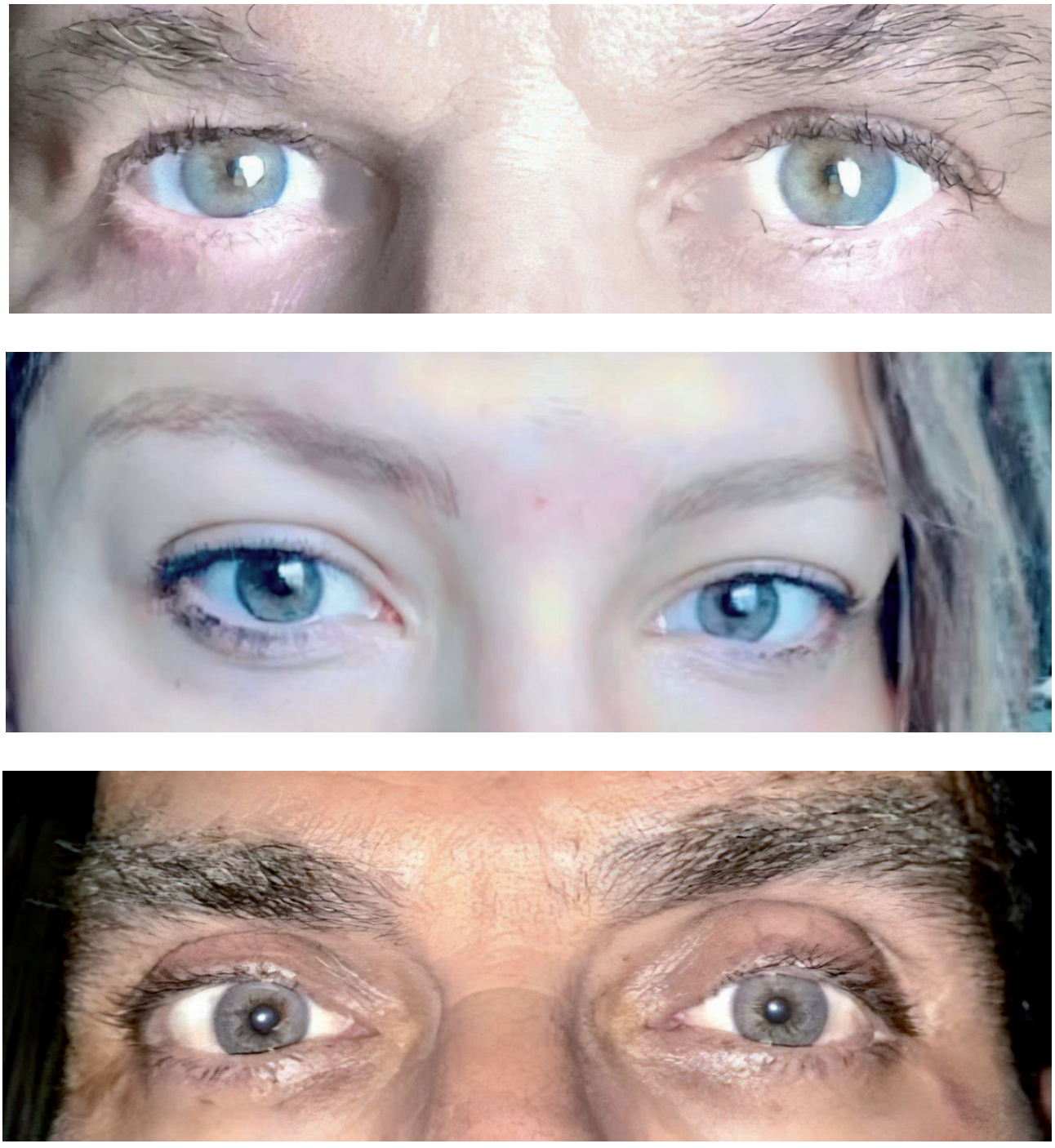
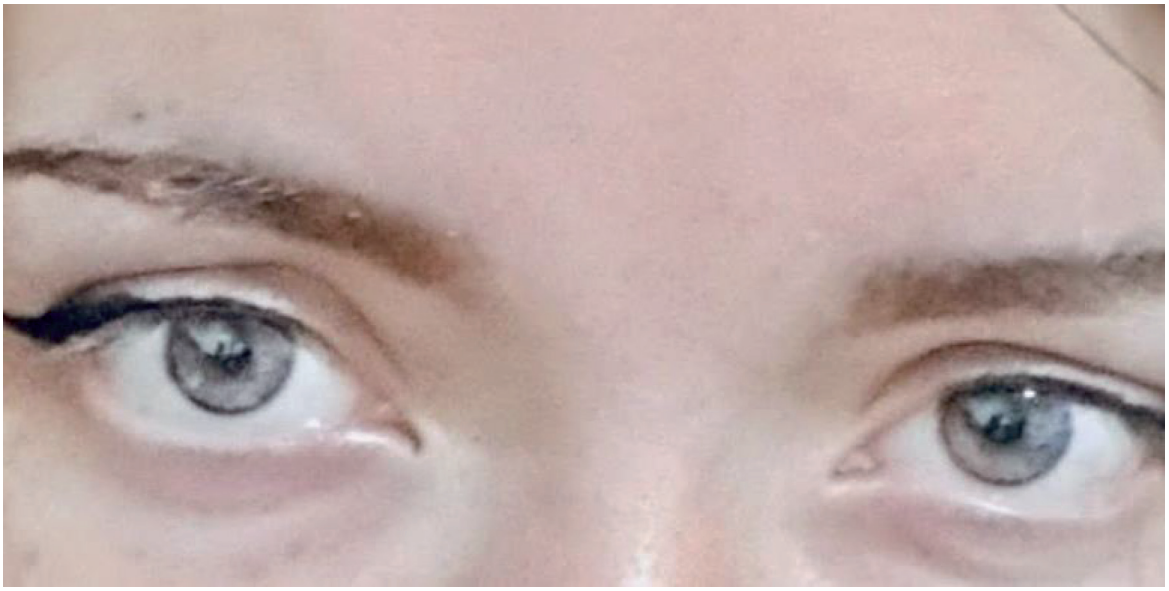
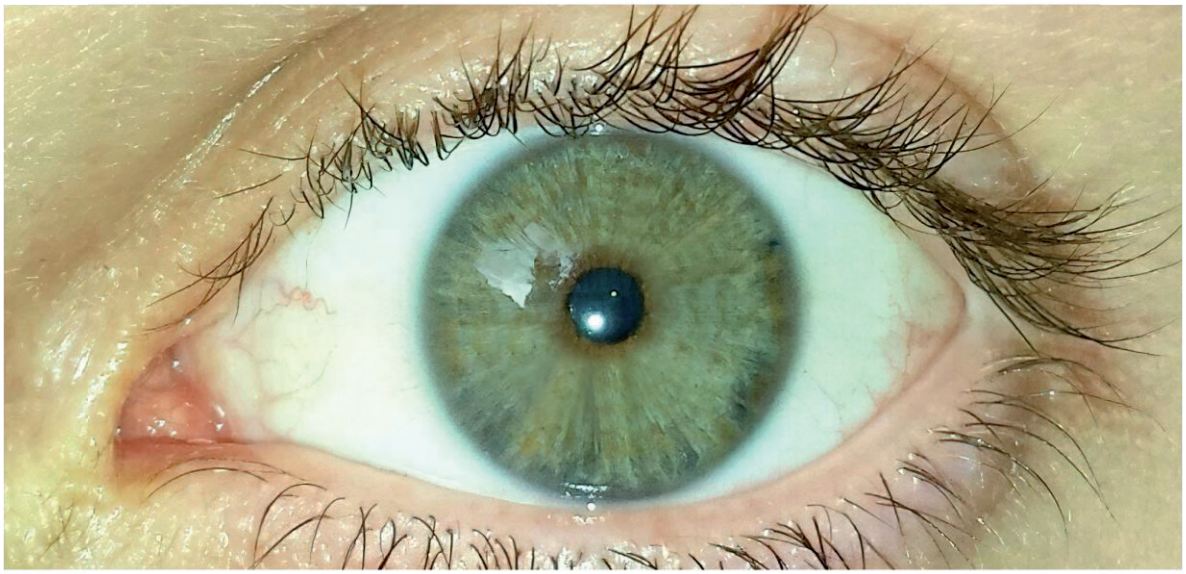


FIGURE 148: Very light blue, green and turqouise eye looks

3 10 Looks





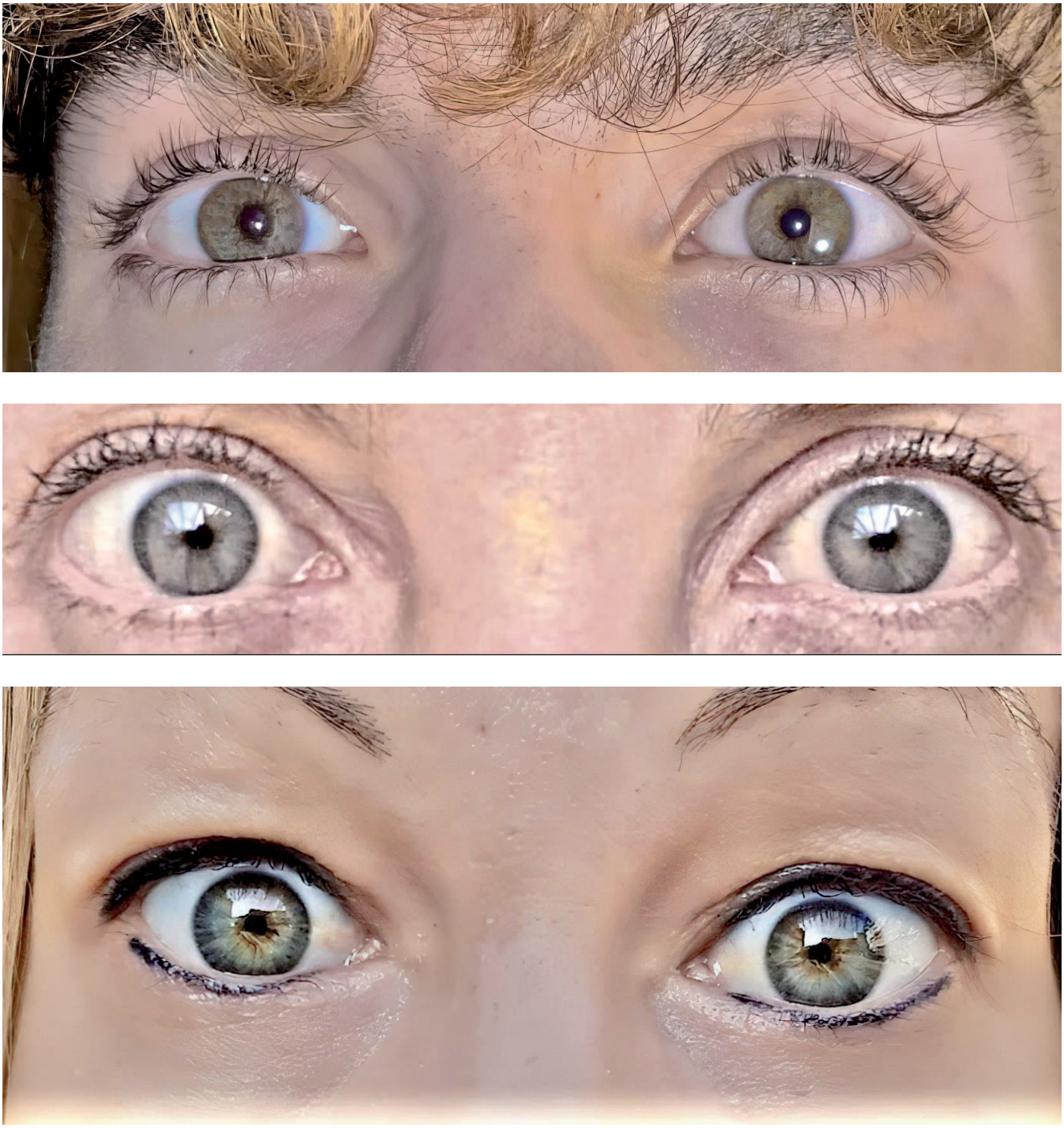


FIGURE 149: Greenish eye looks

3 10 Looks

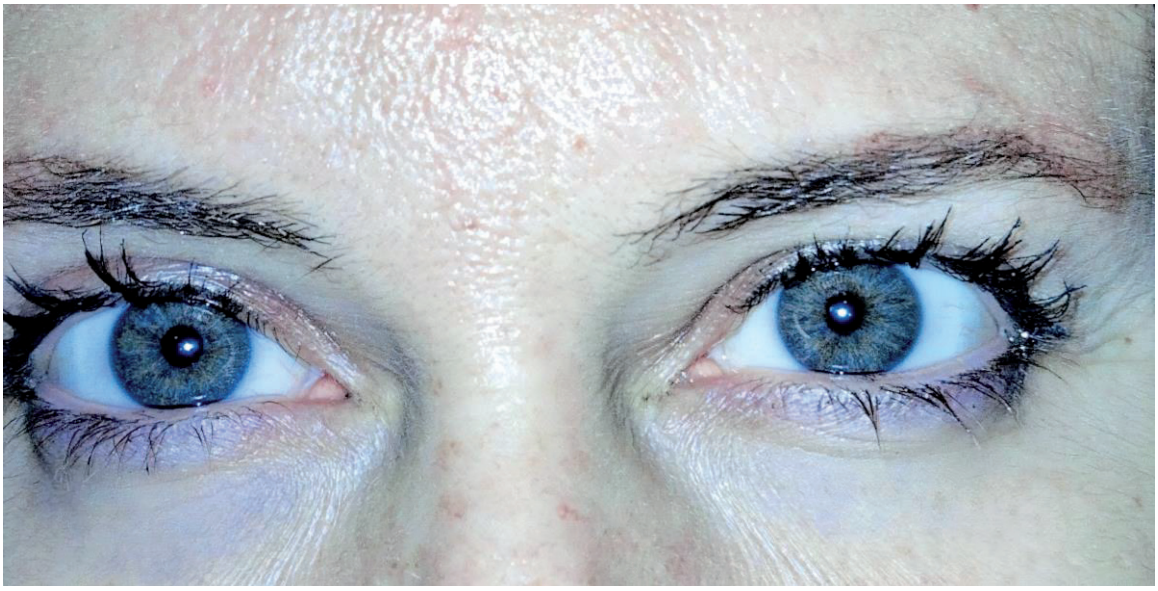
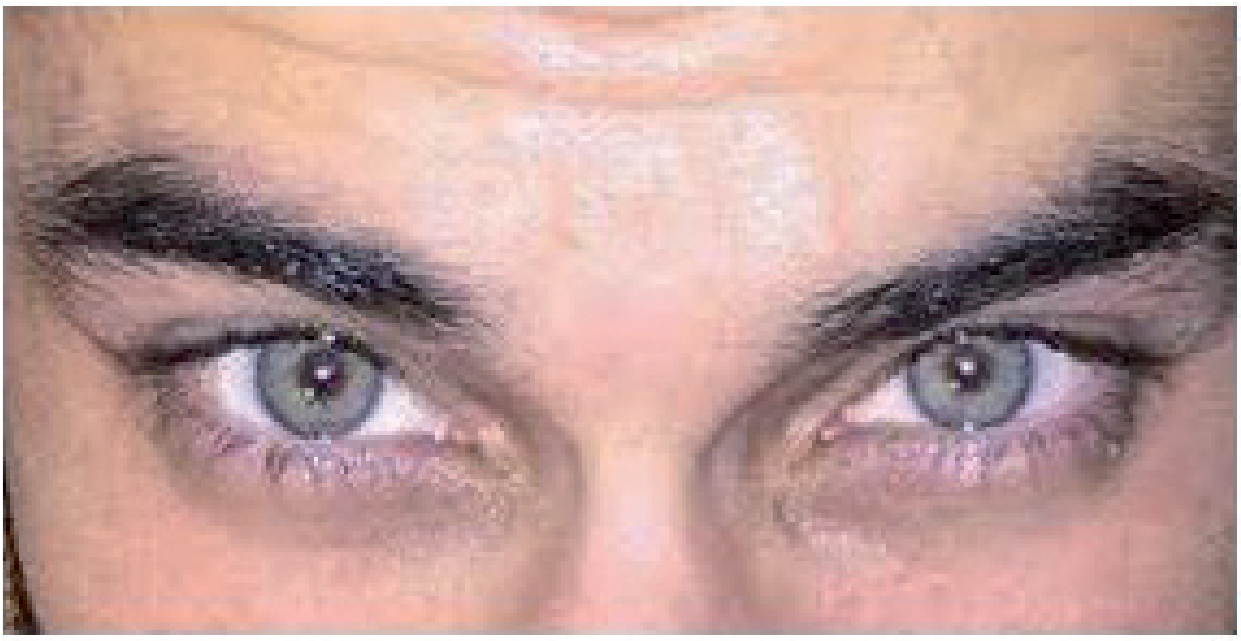


FIGURE 150: Very light blue and greenish eye looks

3 10 Looks



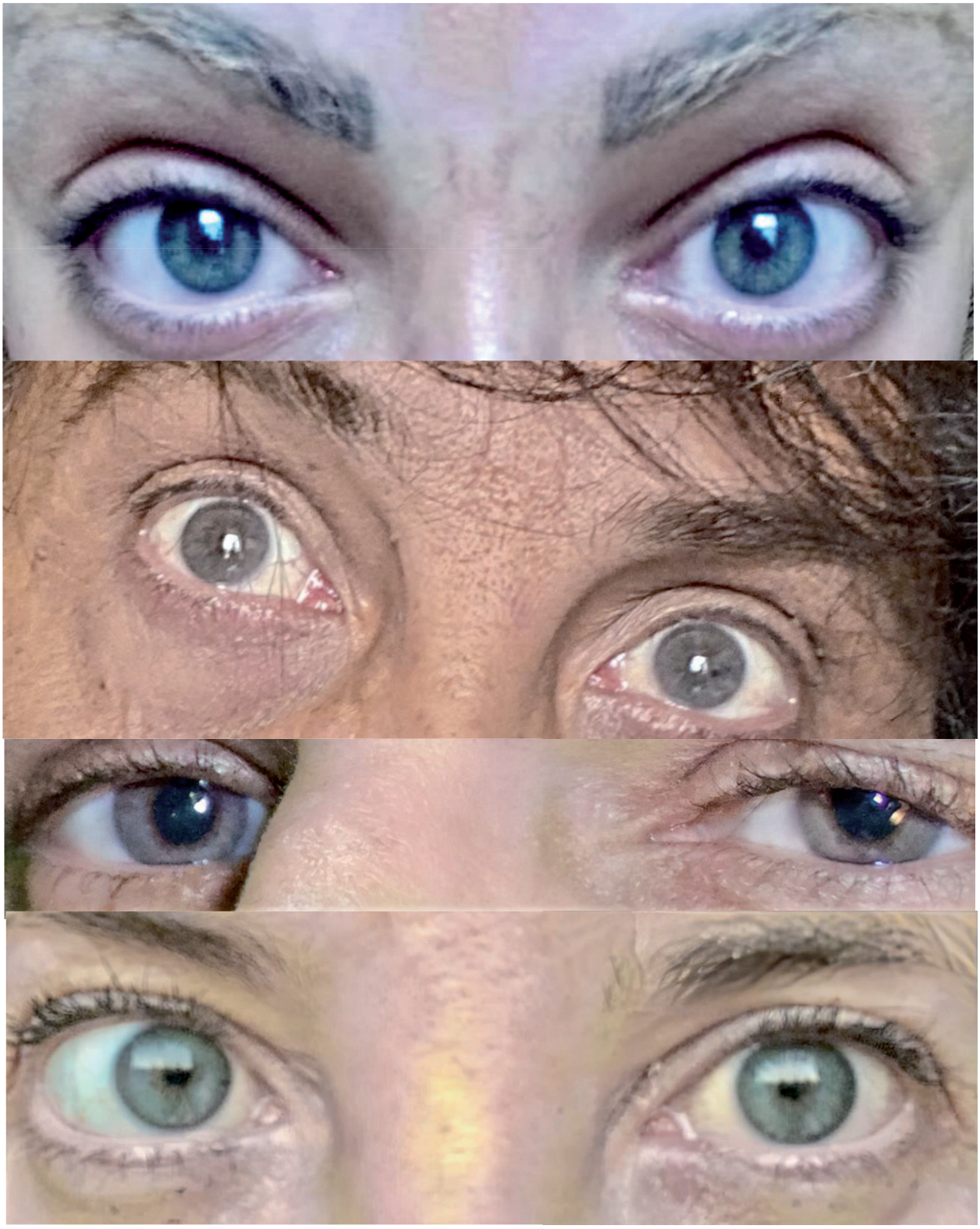
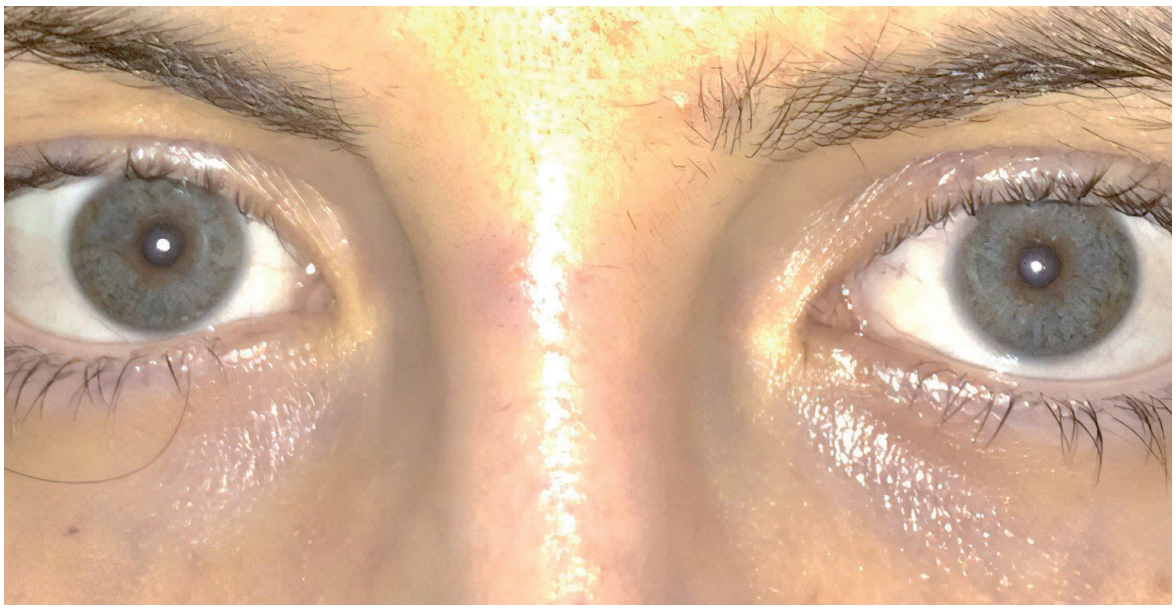
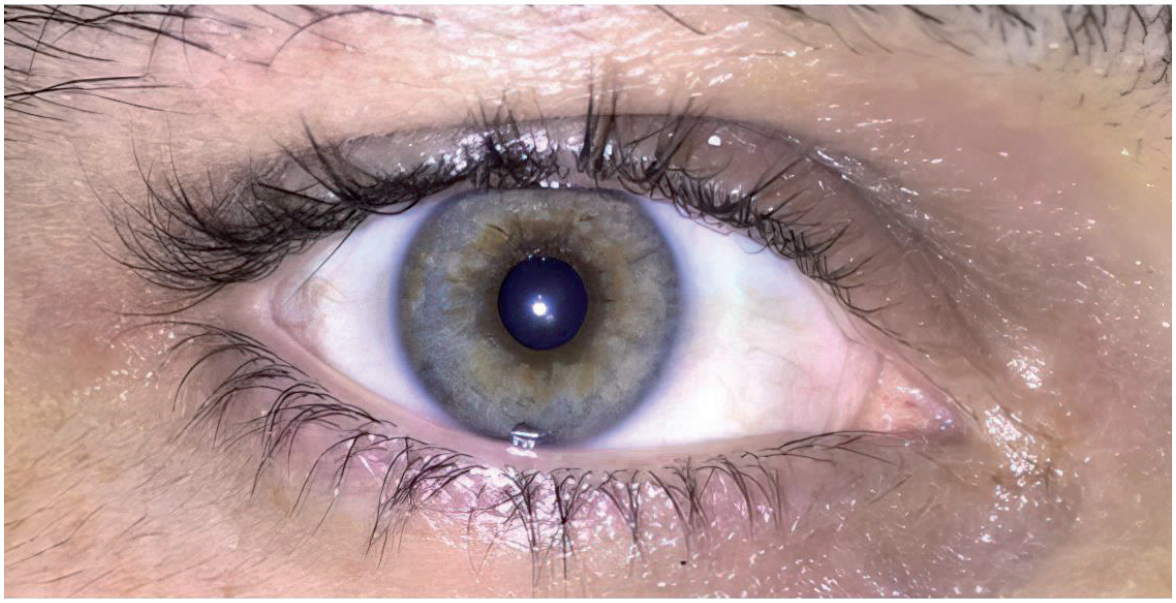


FIGURE 151: Blue turqouise and greenish eye looks

3 10 Looks





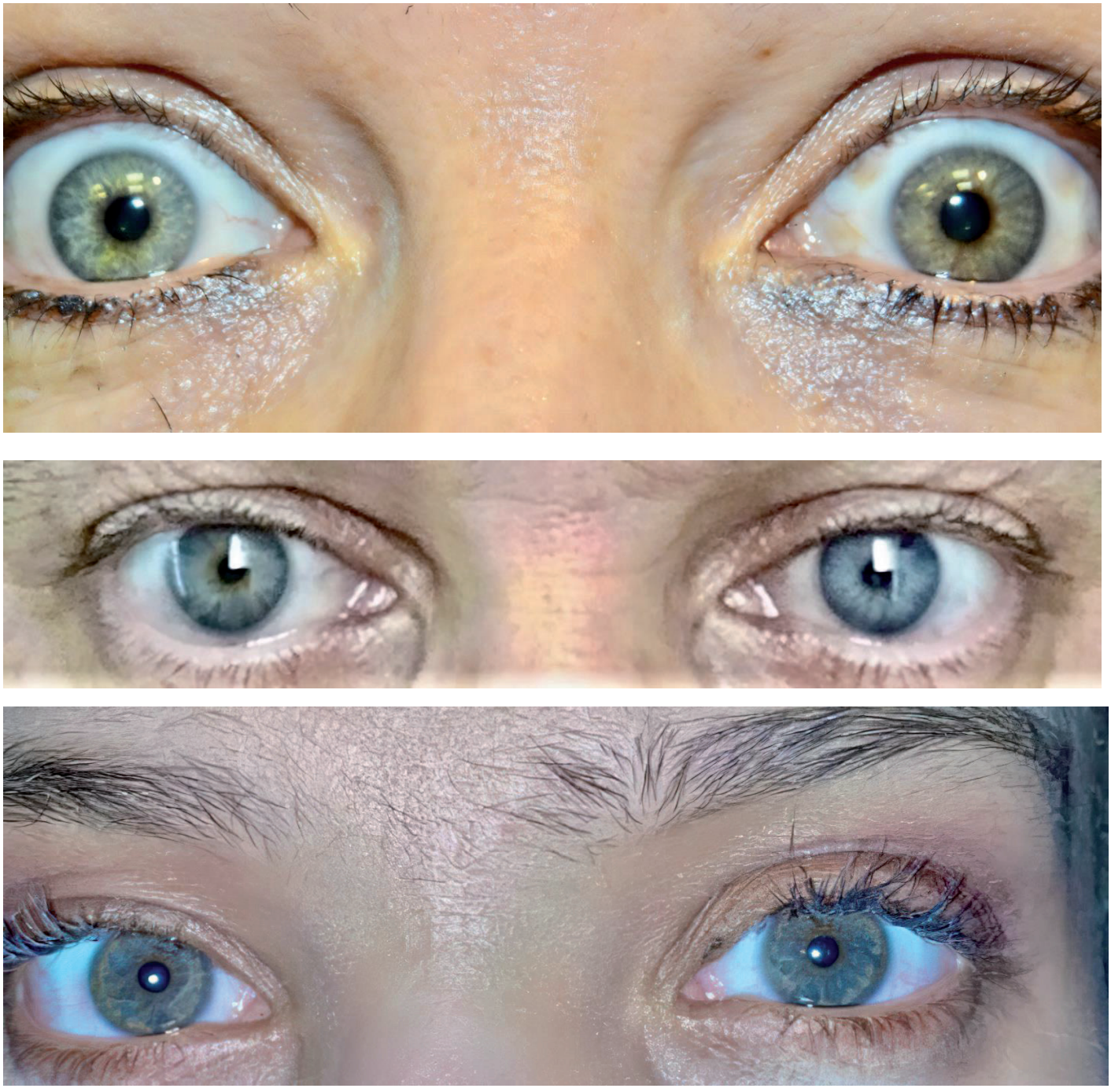
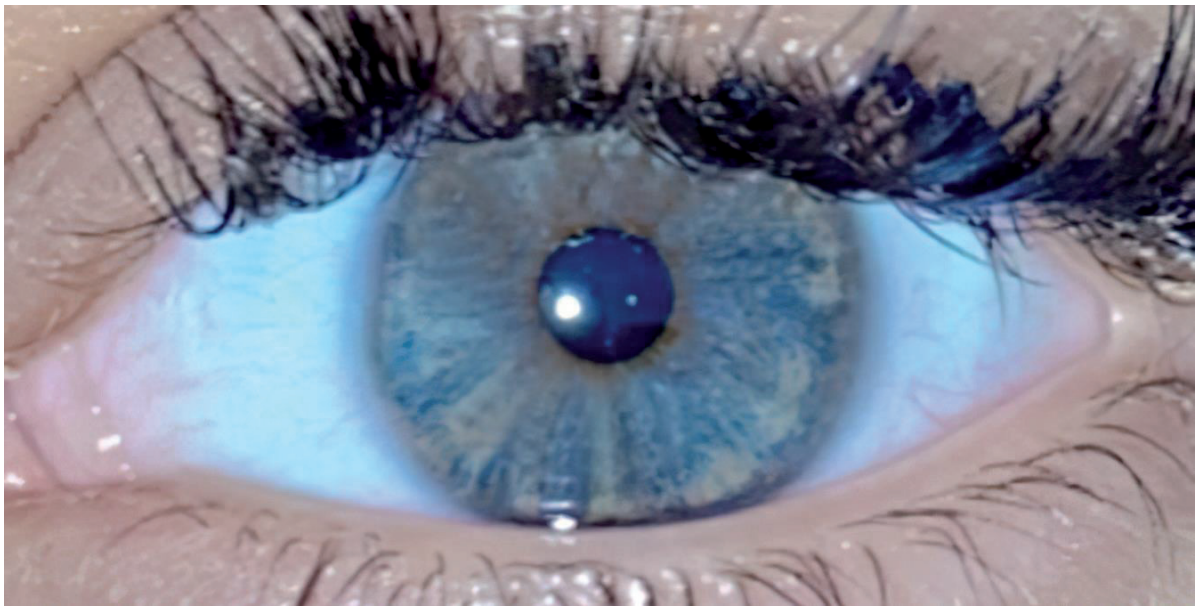
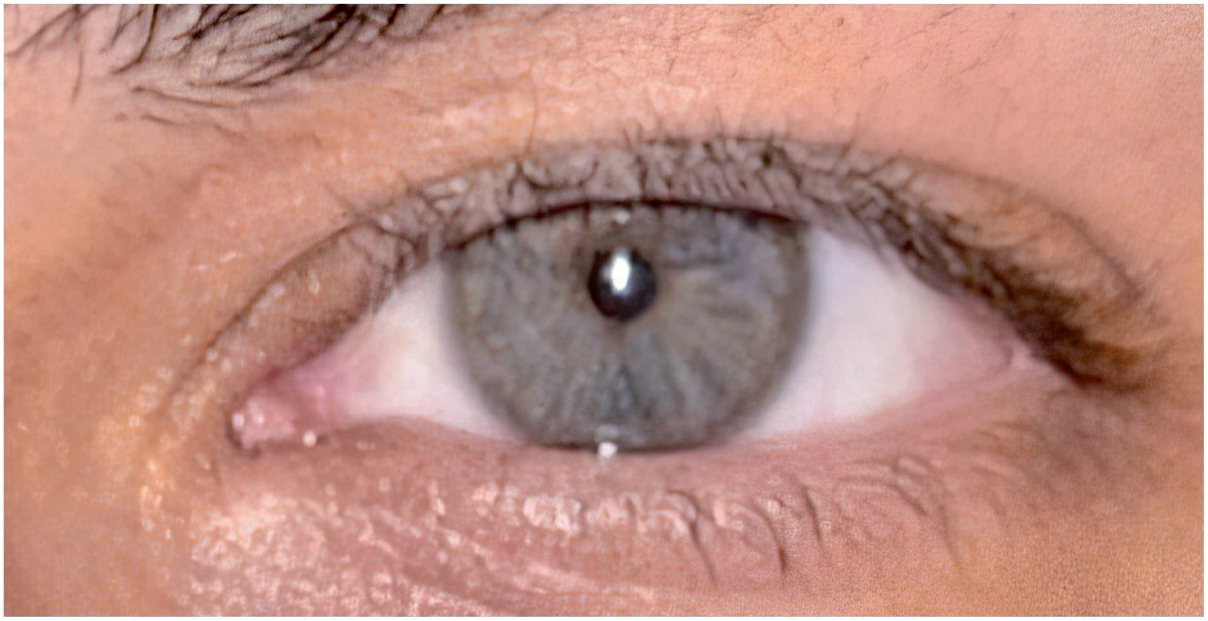


FIGURE 152: Very light and dark blue and greenish eye looks

3 10 Looks





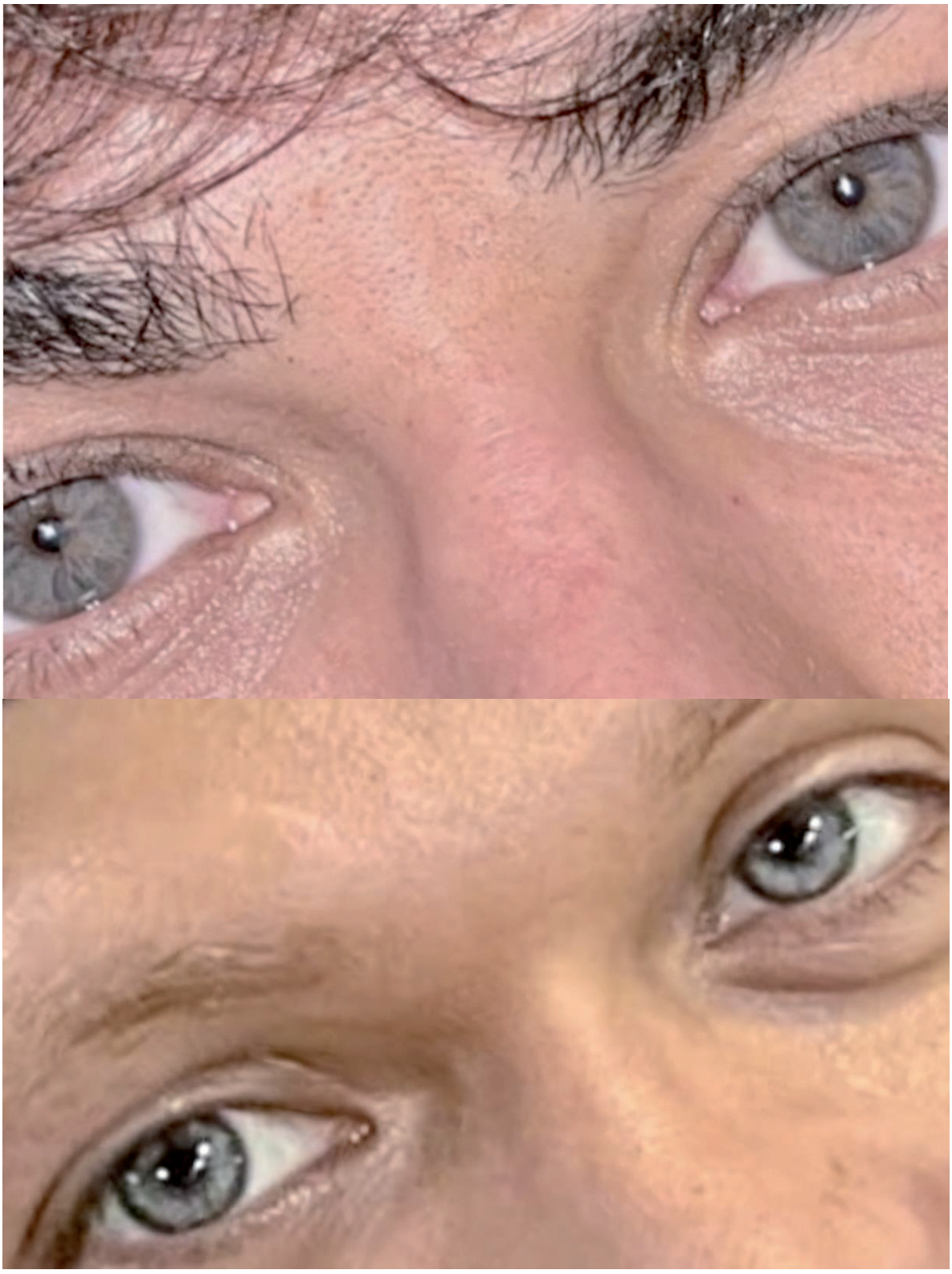
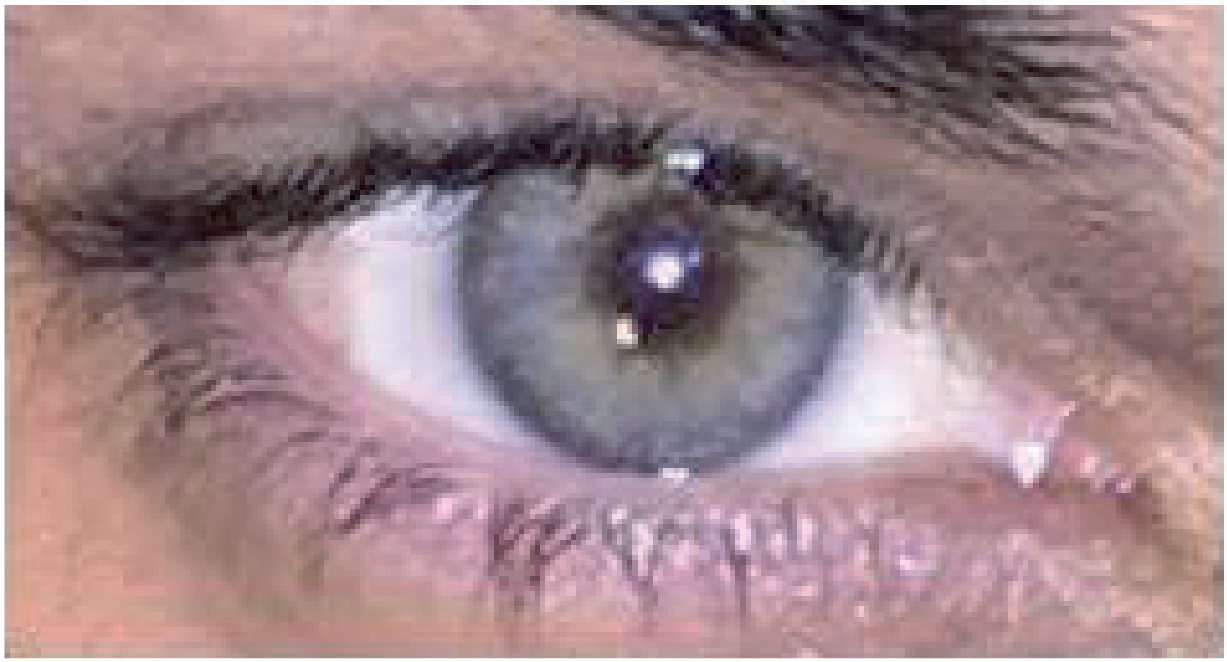


FIGURE 153: Very light and medium turqouise eye looks

3 10 Looks



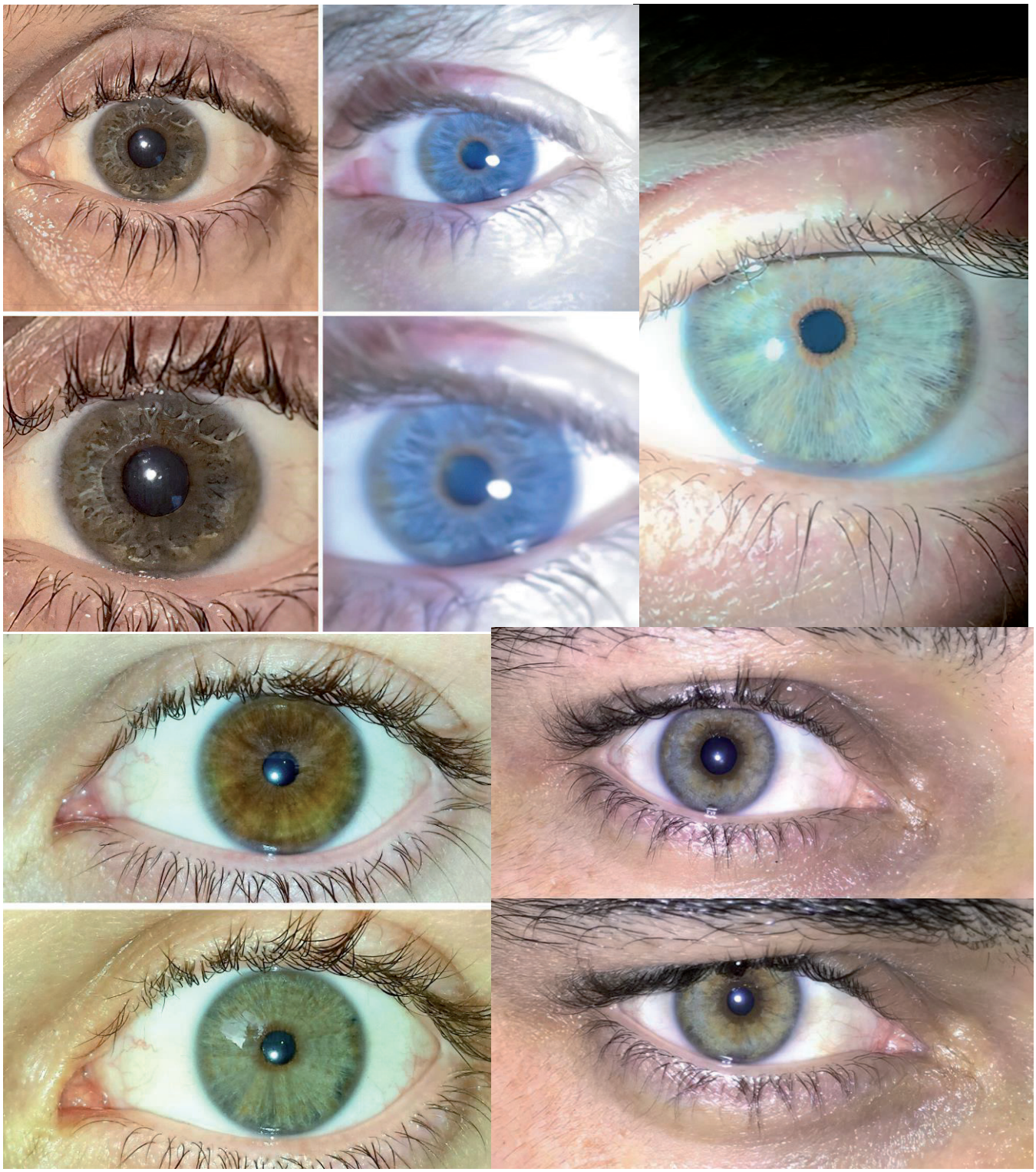
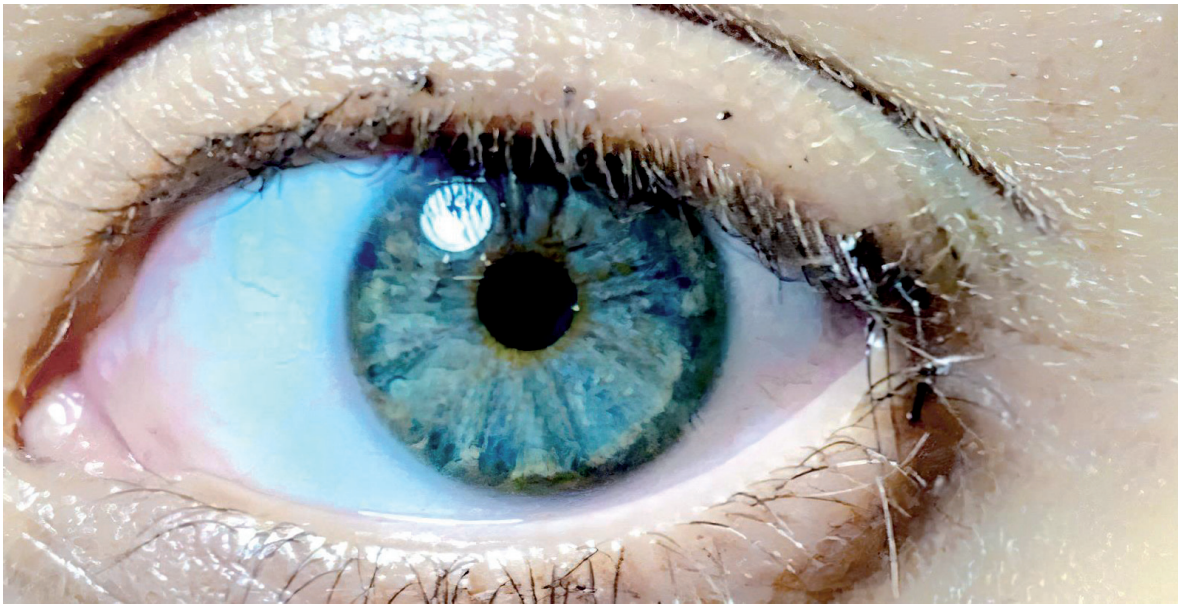
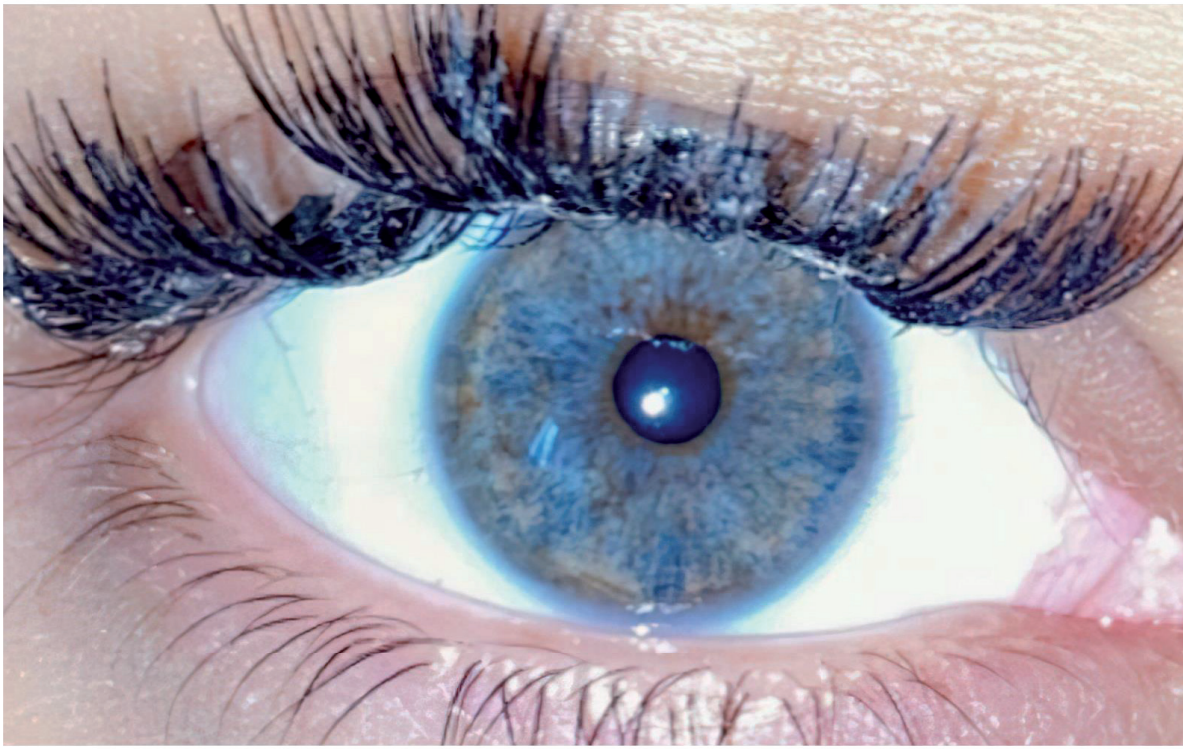


FIGURE 154: Very light blue and greenish eye looks

3 10 Looks





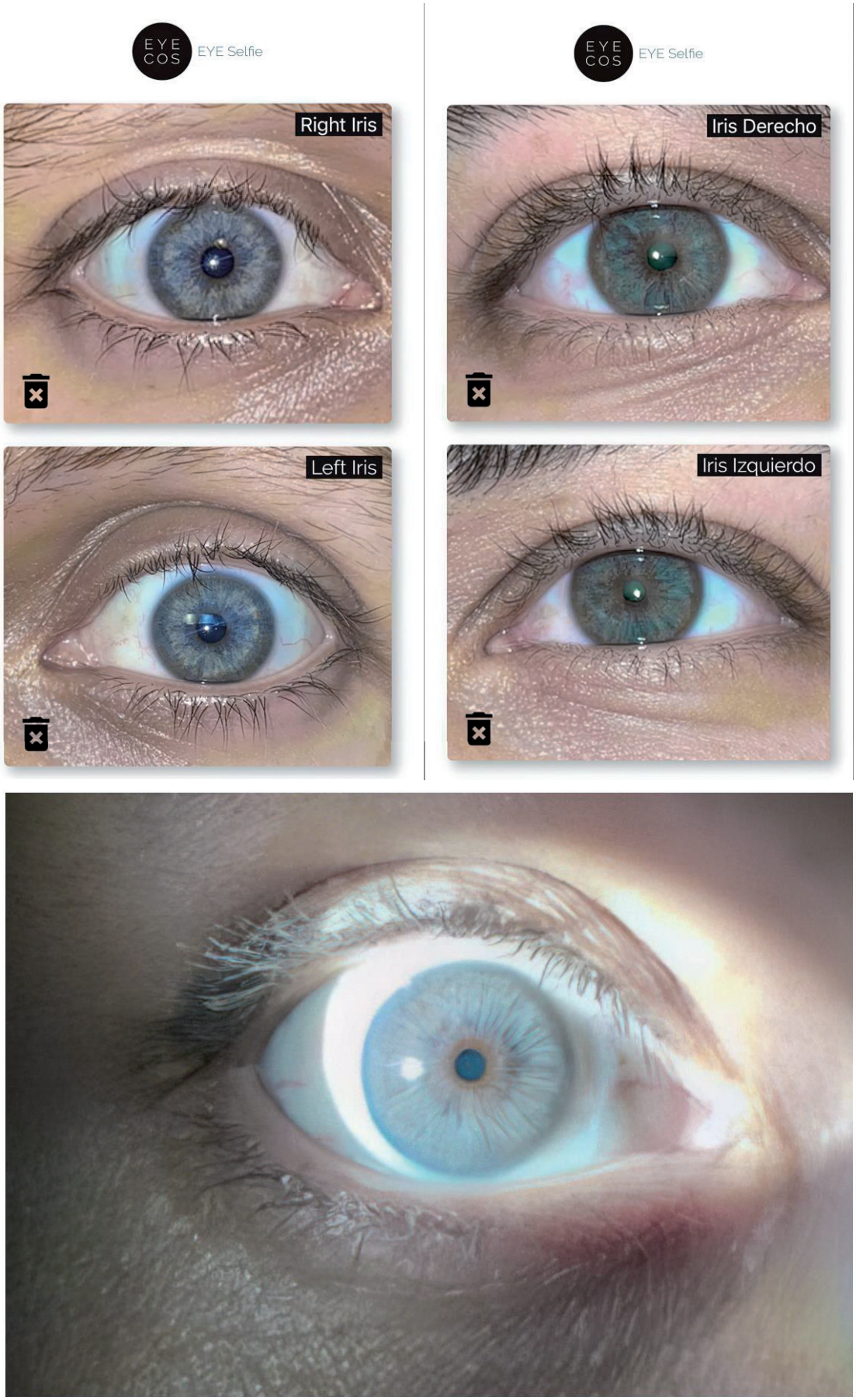
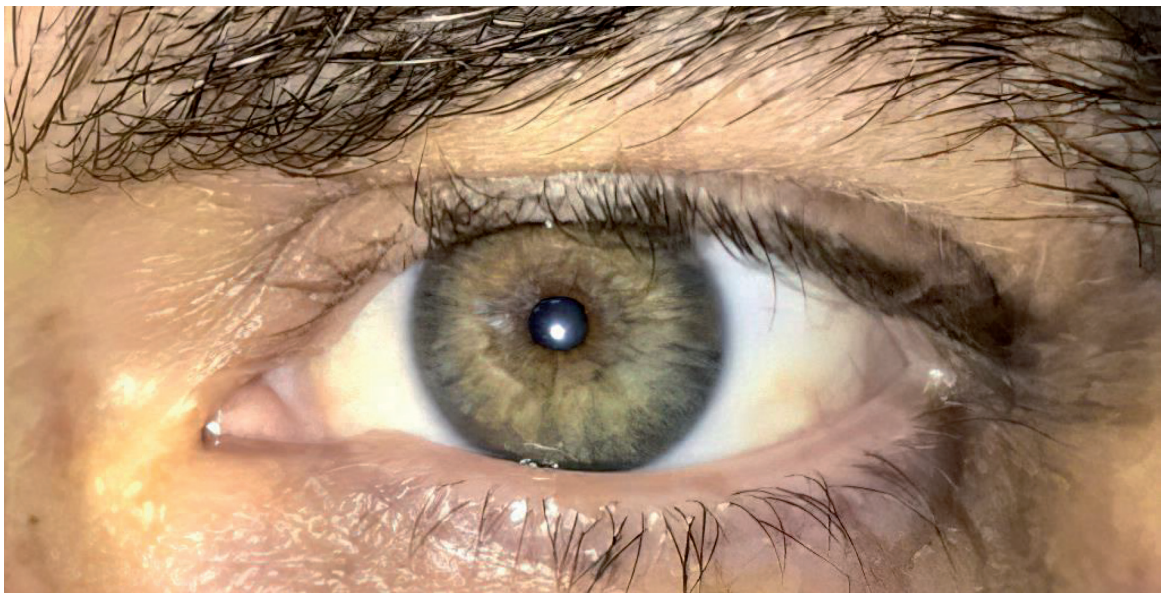


FIGURE 155: Medium turqouise and silver grey eye looks

3 10 Looks



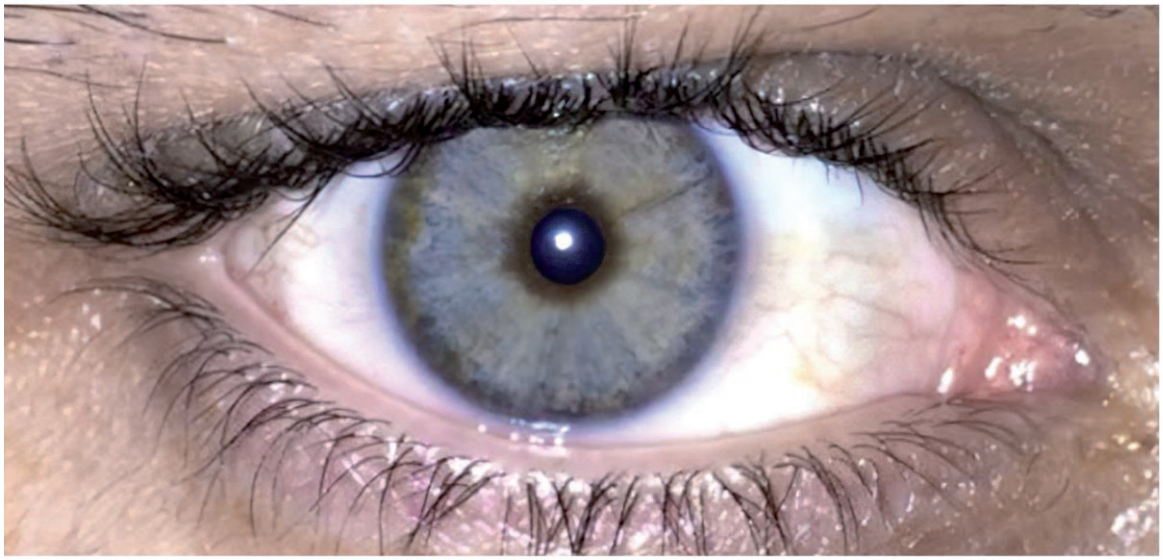
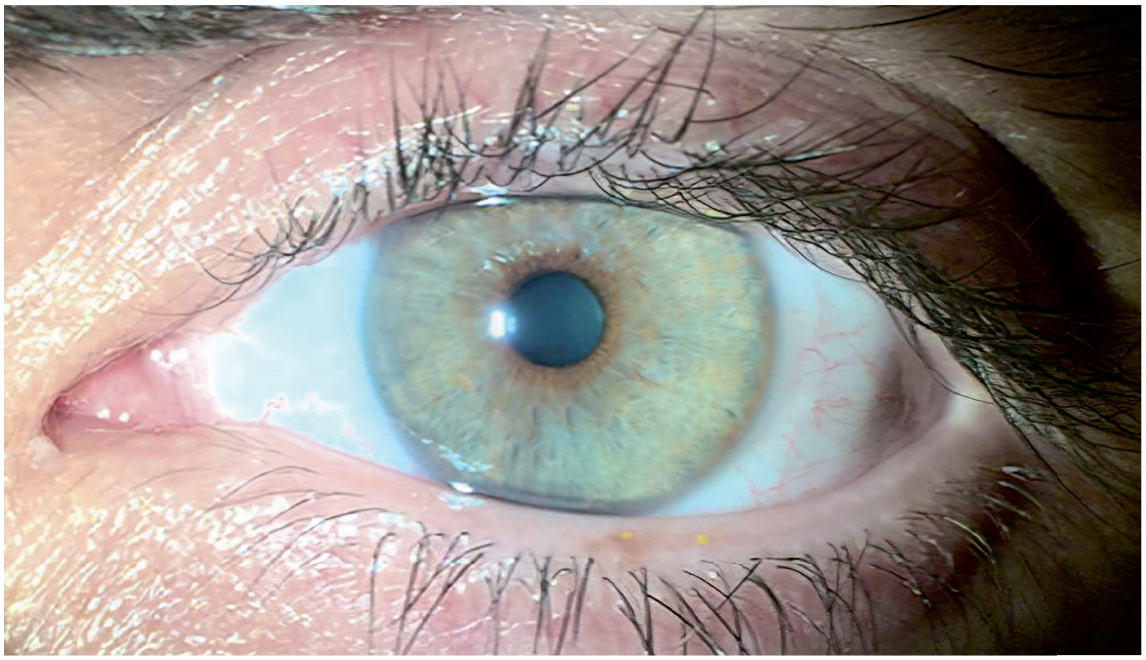


FIGURE 156: Medium blue and grey bluish eye looks

3 10 Looks



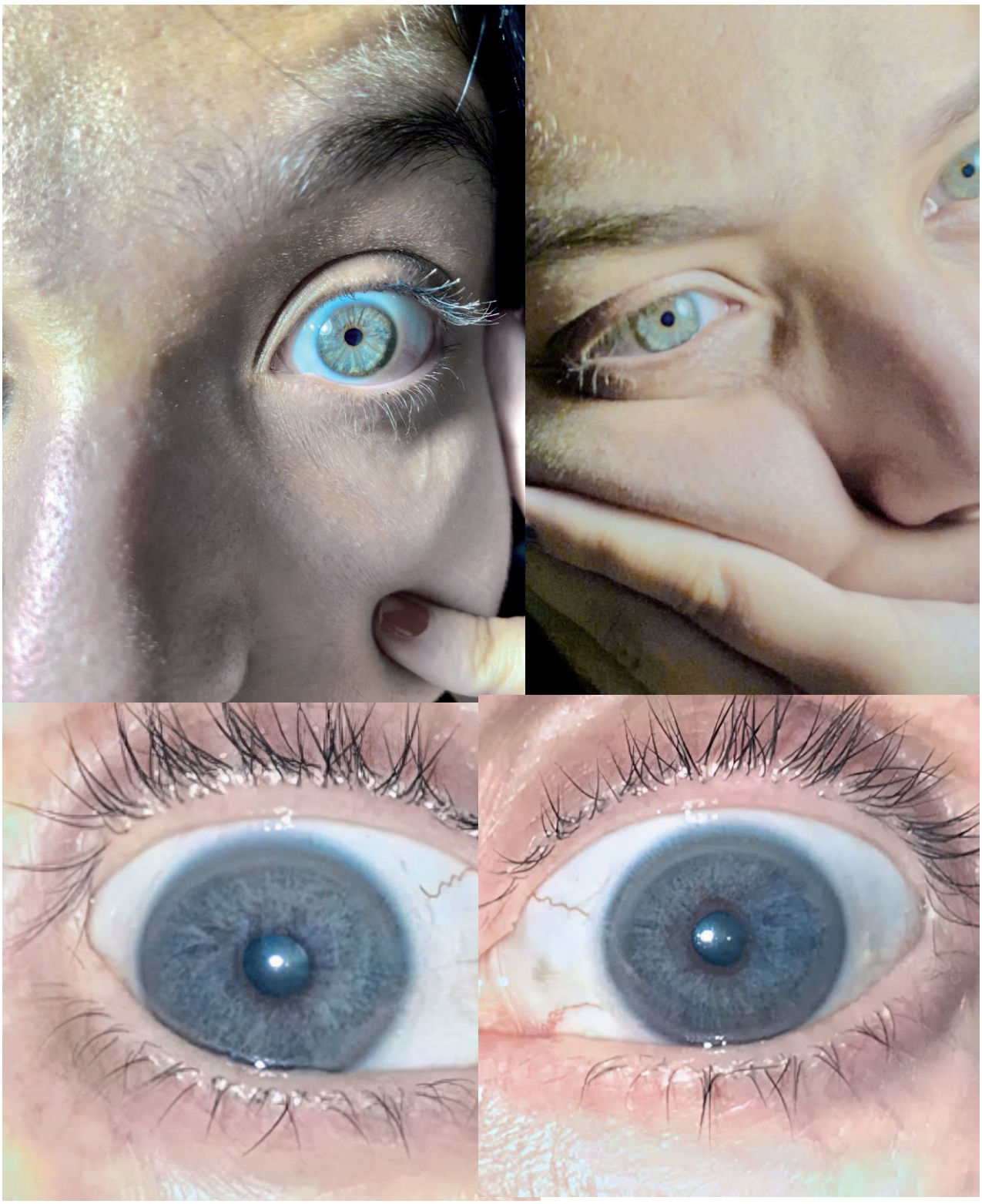
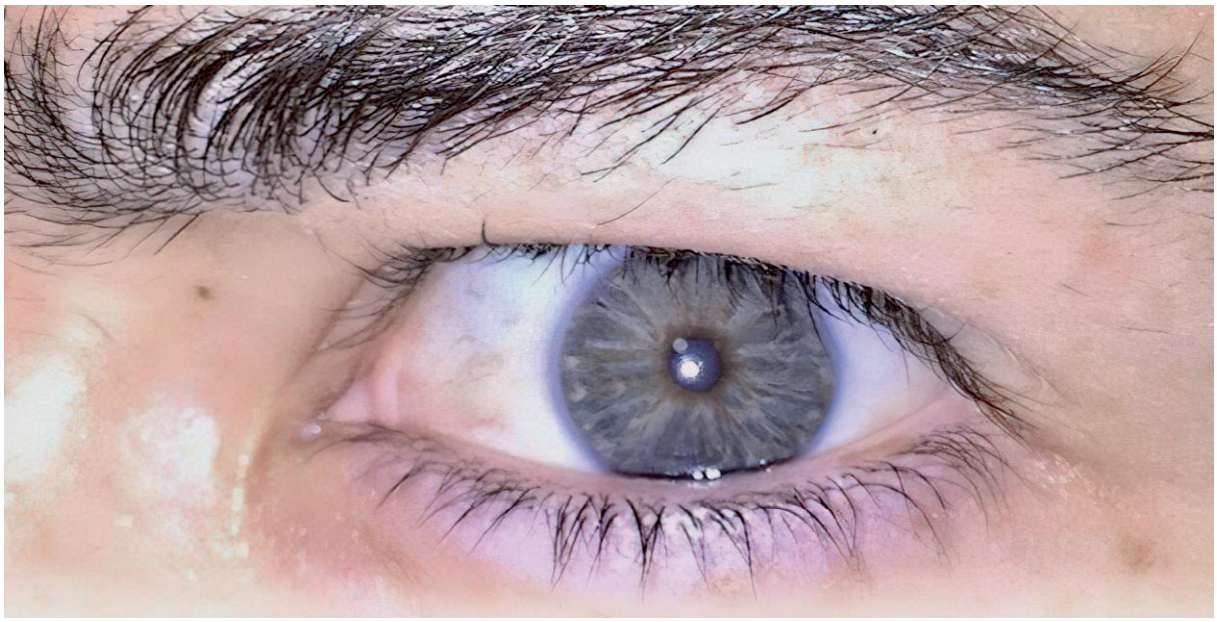
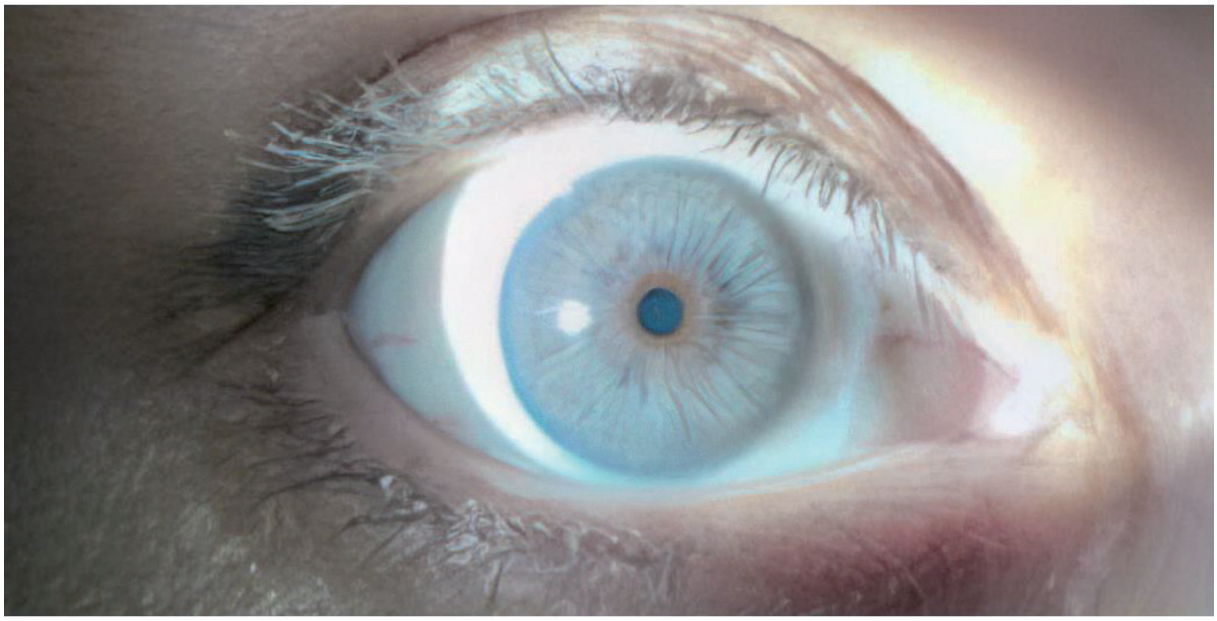


FIGURE 157: greenish and light and dark turqouise eye looks

3 10 Looks





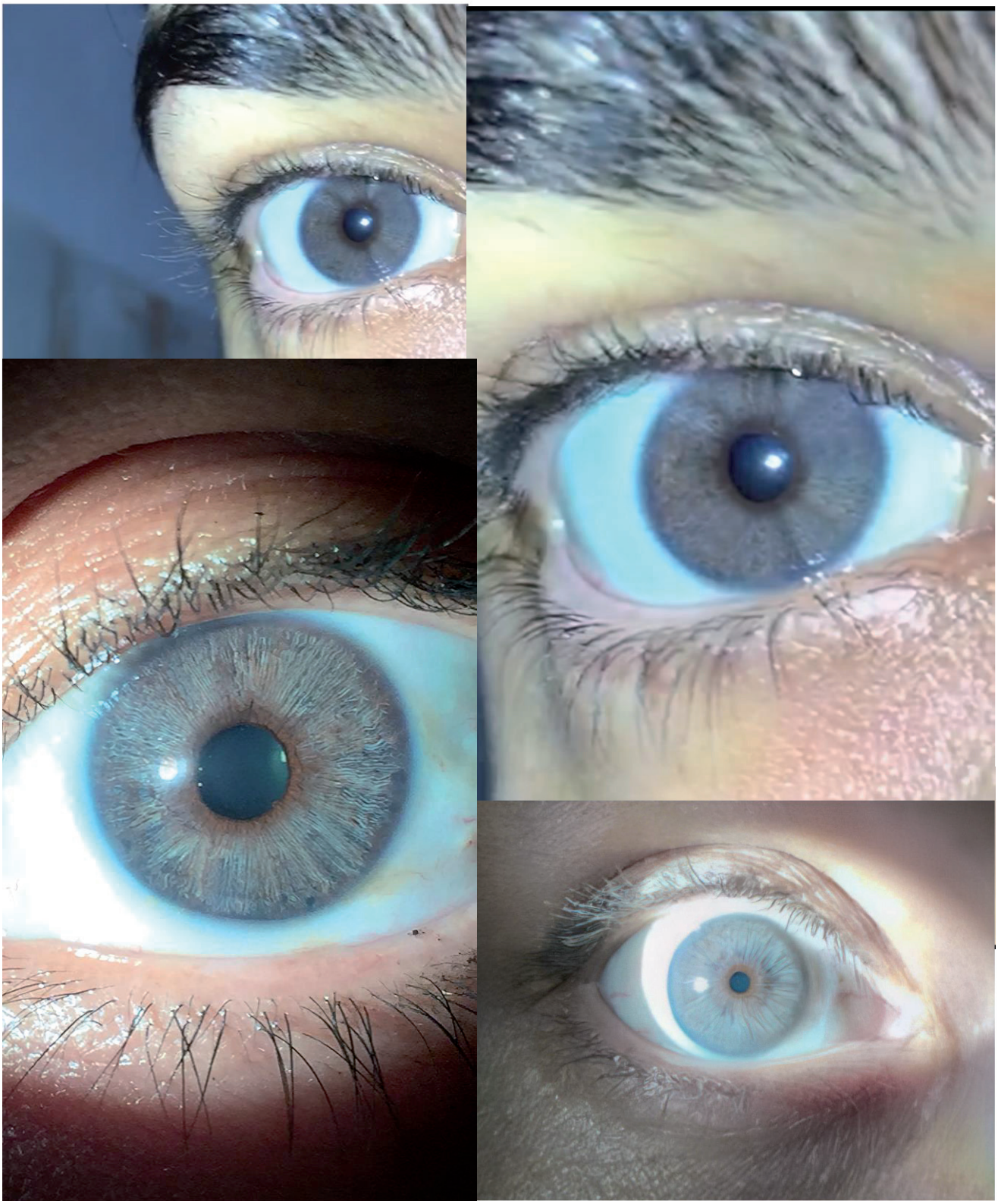
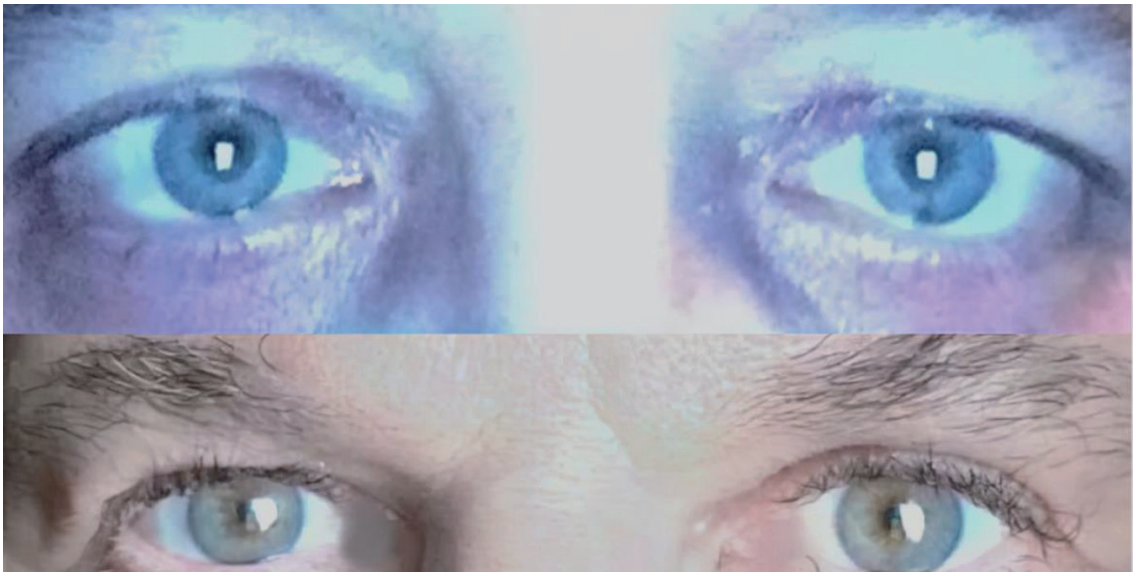
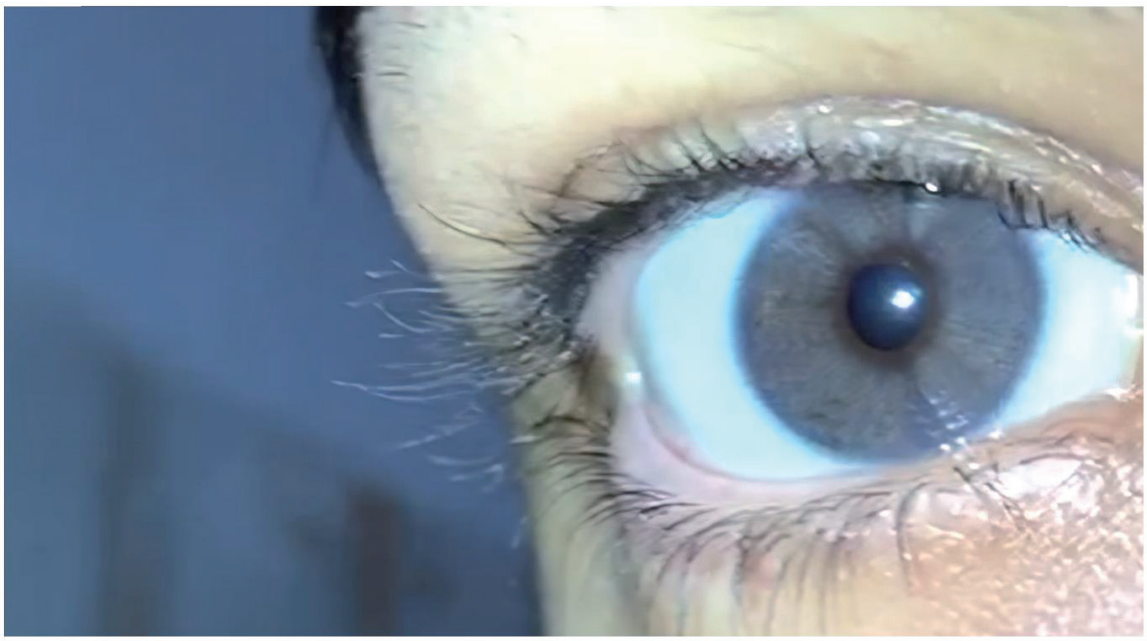


FIGURE 158: Silver, light and dark grey eye looks

3 10 Looks





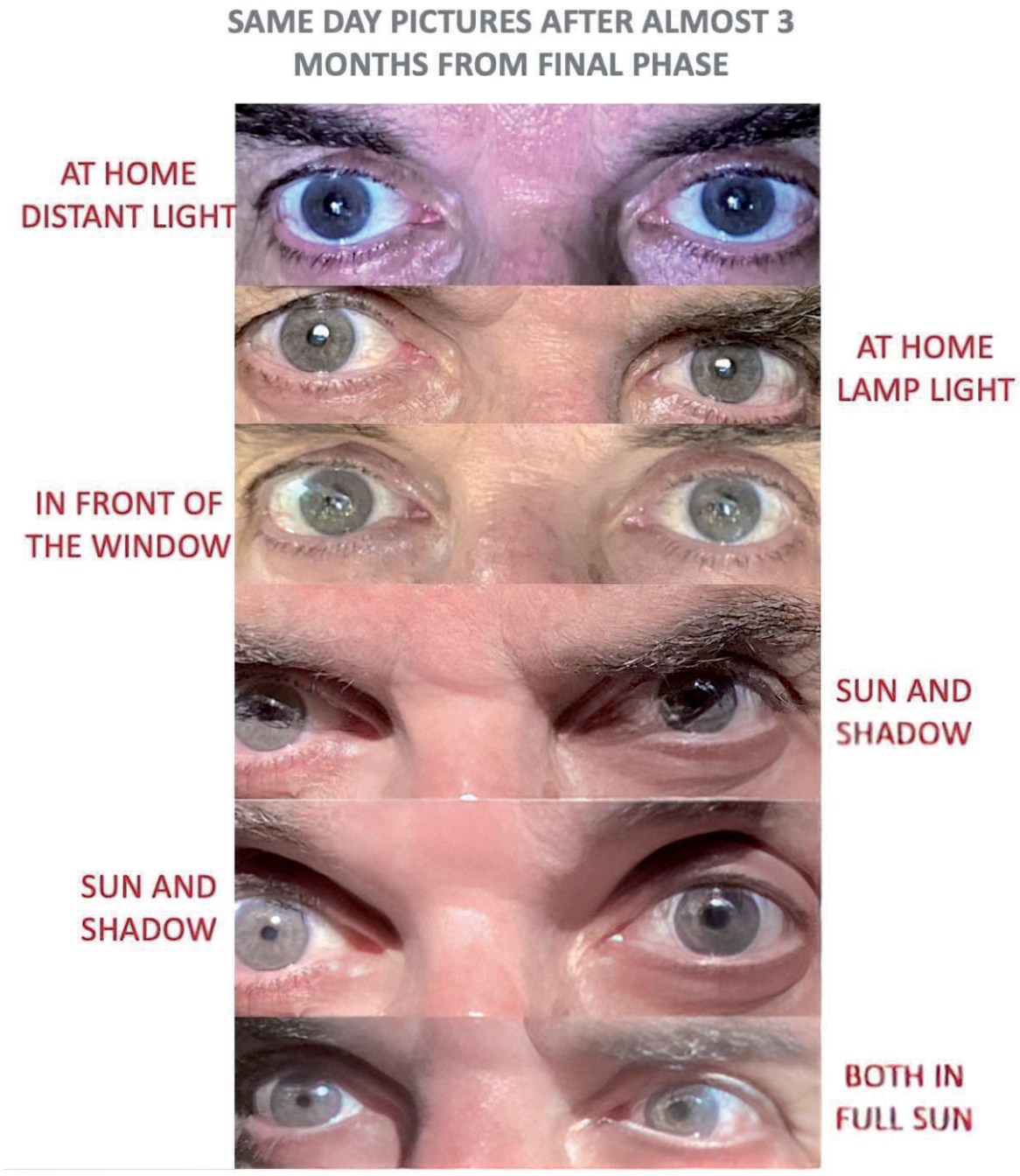
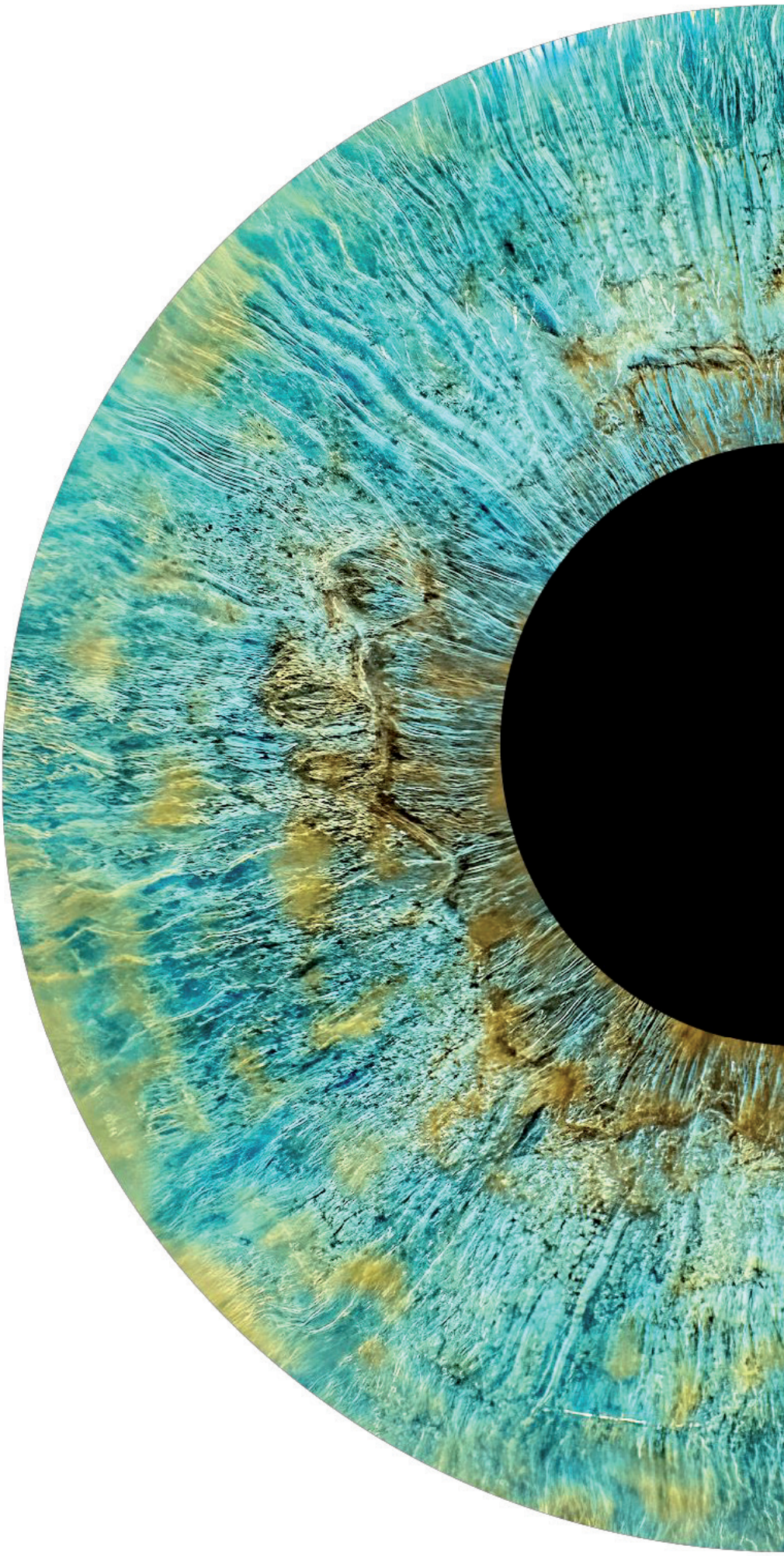
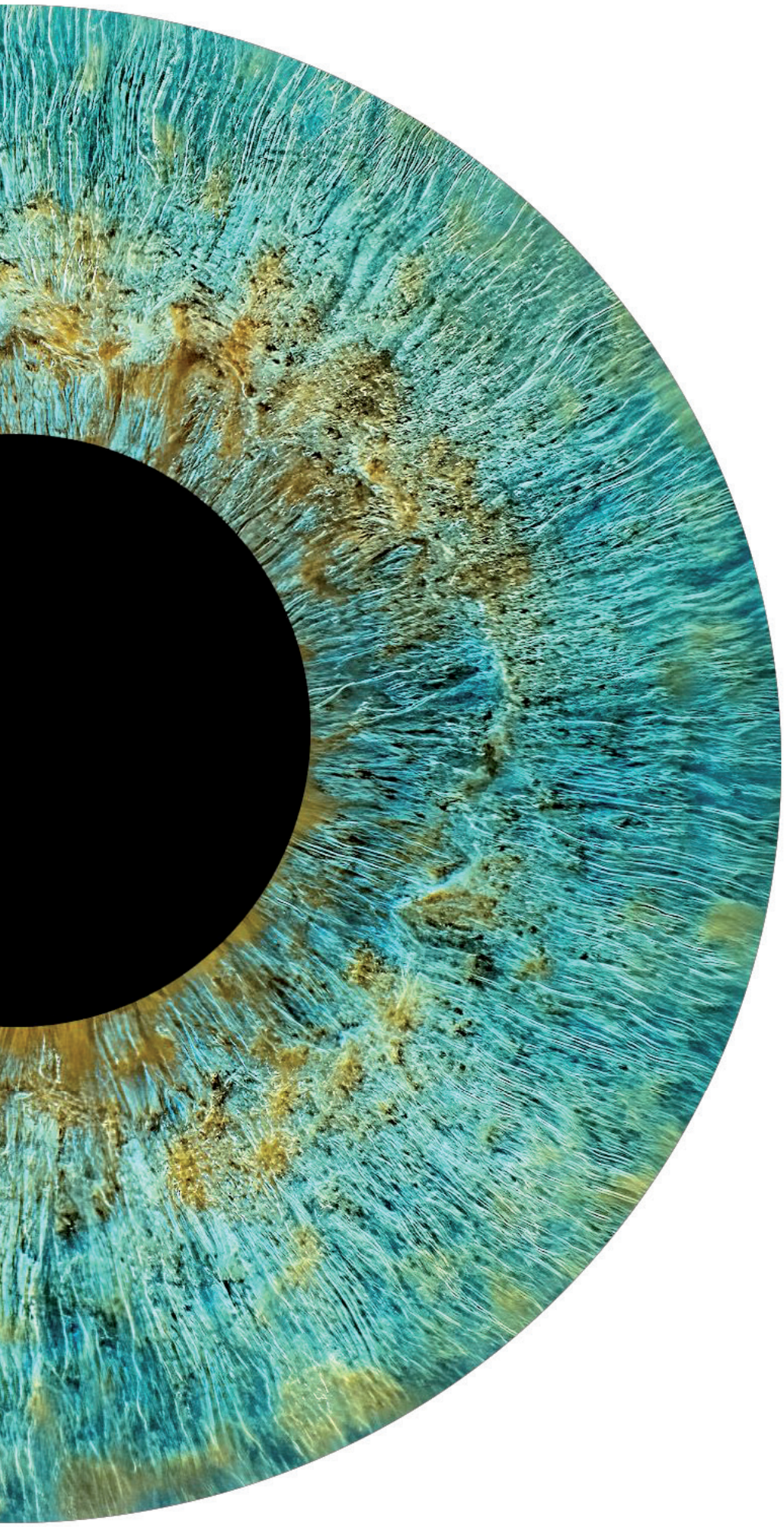
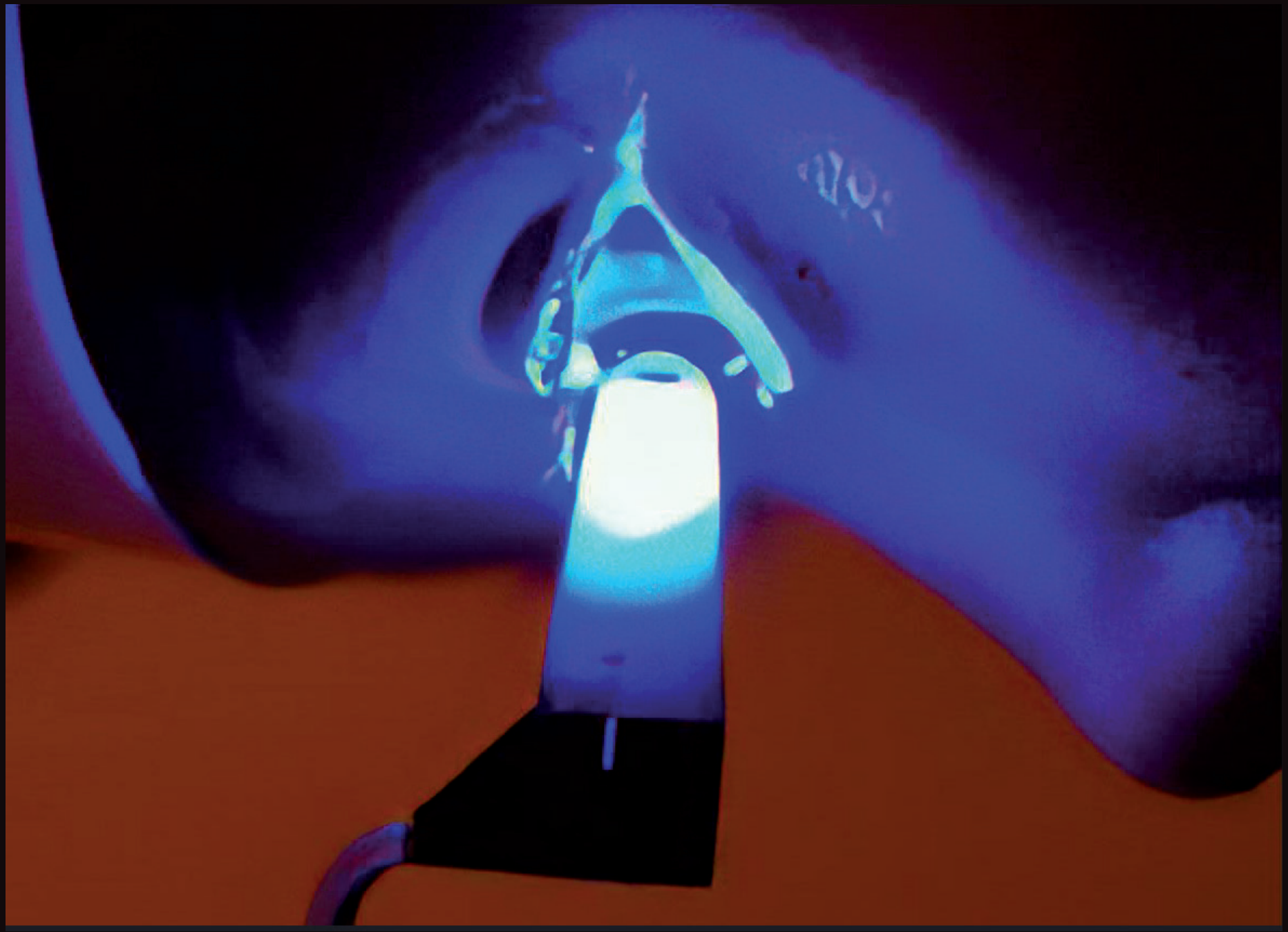


FIGURE 159: Multiple eye color looks as light enviroment





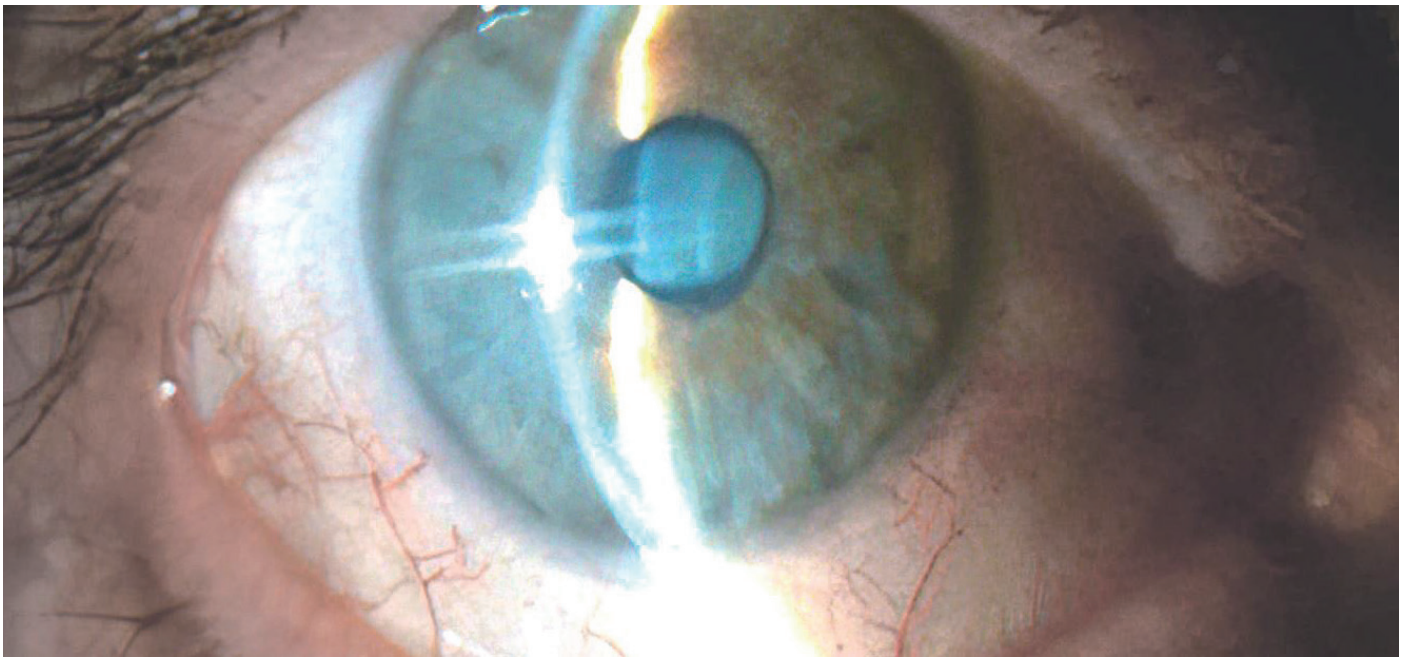


PART 4

COMPLICATIONS

CHAPTER 11 SIDE EFFECTS

4 11.1 Acute high IOP



Acute angle-closure glaucoma is a serious eye condition that occurs when the fluid pressure inside your eye rises quickly. The usual symptoms are sudden, severe eye pain, a red eye and reduced or blurred vision. You may feel sick or be sick (vomit). Immediate treatment is needed to relieve symptoms and to prevent permanent loss of vision (severe sight impairment). In acute glaucoma there is a sudden blockage of drainage of aqueous humour fluid out of your eye. As more fluid continues to be made, the pressure inside your eye rises quickly. This can start to damage the optic nerve at the back of the eye and vision can be affected.

Secondary glaucoma is caused by an underlying medical issue that increases the eye's intraocular pressure (IOP). The most common types of glaucoma stem from problems with the drainage angle.

The different types of secondary glaucoma involved with cosmetic Iridoplasy are steroid-induced, uveitic, exfoliative and pigmentary.

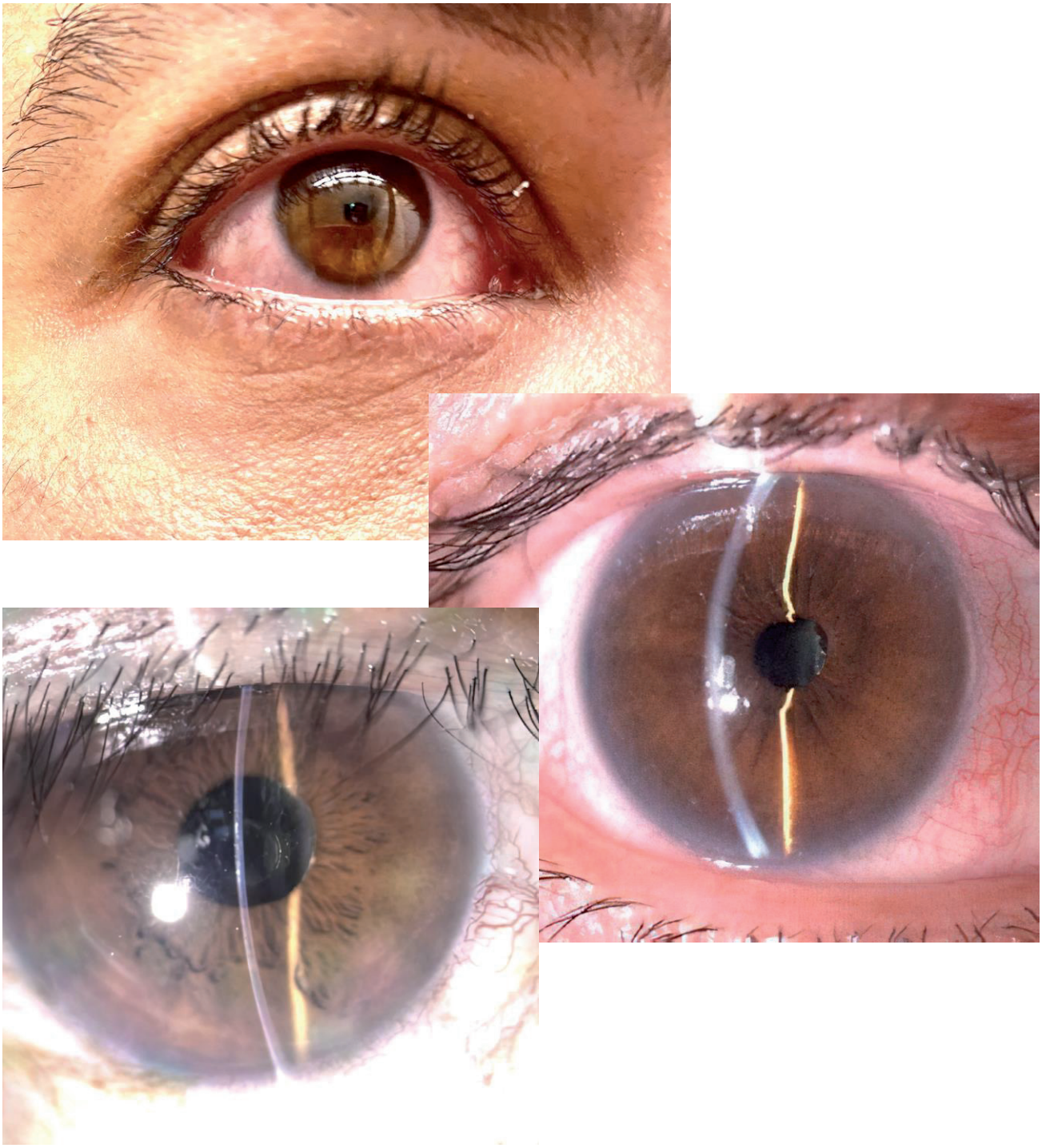
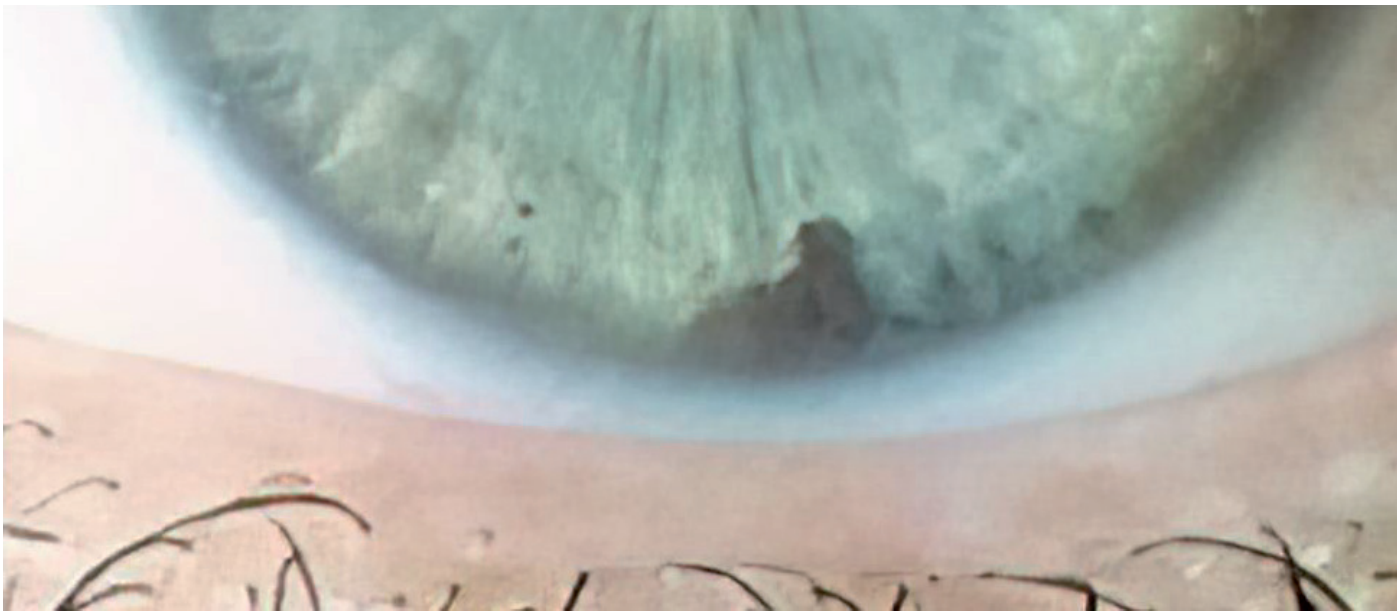


FIGURE 160: Ciliar injection, redness, edema and cloudy anterior chamber

4 11.1 Acute depot



Lower pigment deposition ("6h goop"). Disappears over time, or a minimum rest remains attached to the lower iris.

This type of melanin depot at bottom was more frequent when were used photodisruptive lasers (Yag), but most of cases disappeared in a few days or weeks.

Best way to accelerate its dissolution is with sodium heparin eye drops or with Yag laser application directly on the depot. The natural processes of healing and homeostasis facilitate the total dissolution of the pigment.

Since 2017, by using photoablative lasers (SLT) the lower melanin depots are seen very unfrequently.

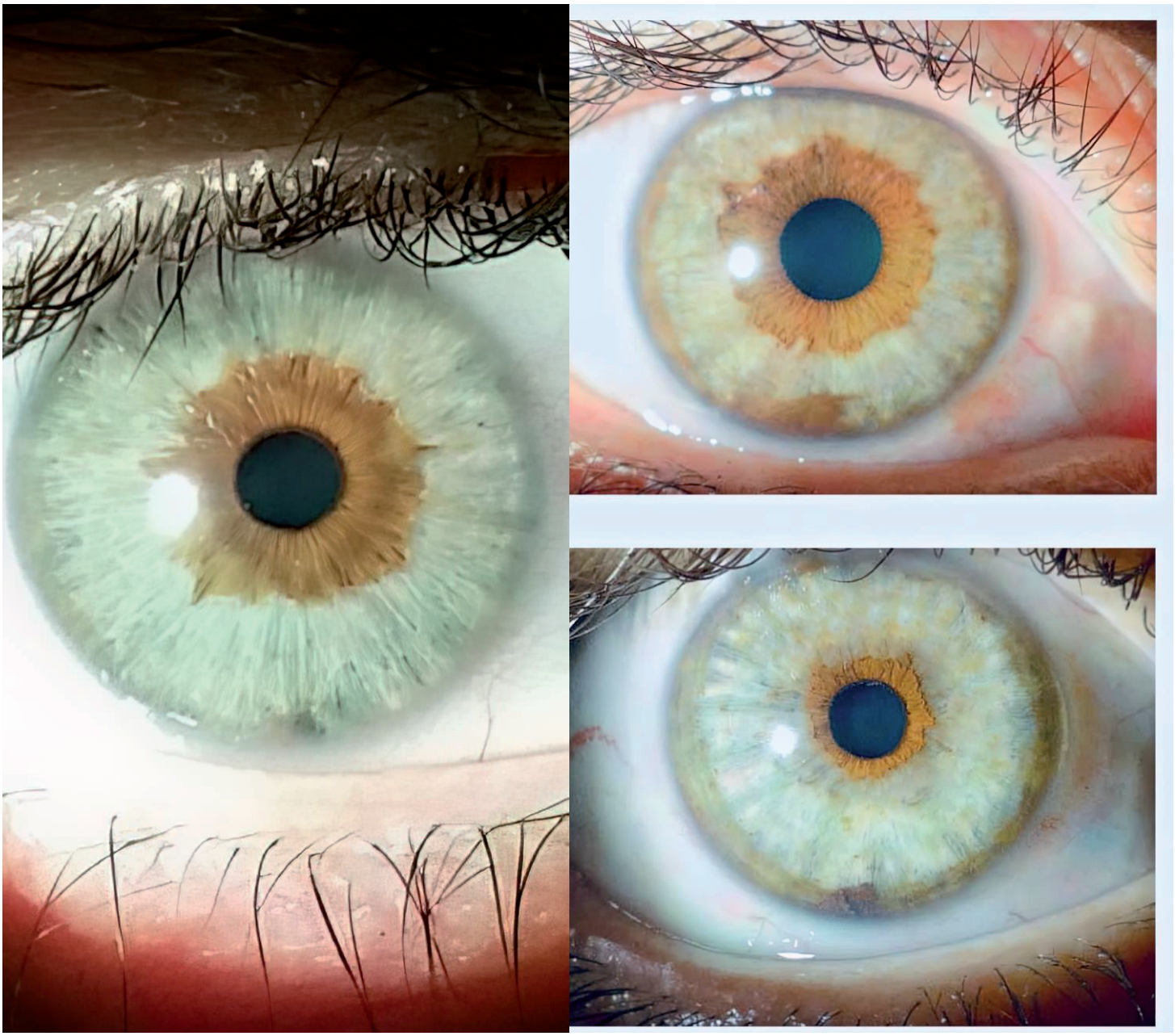
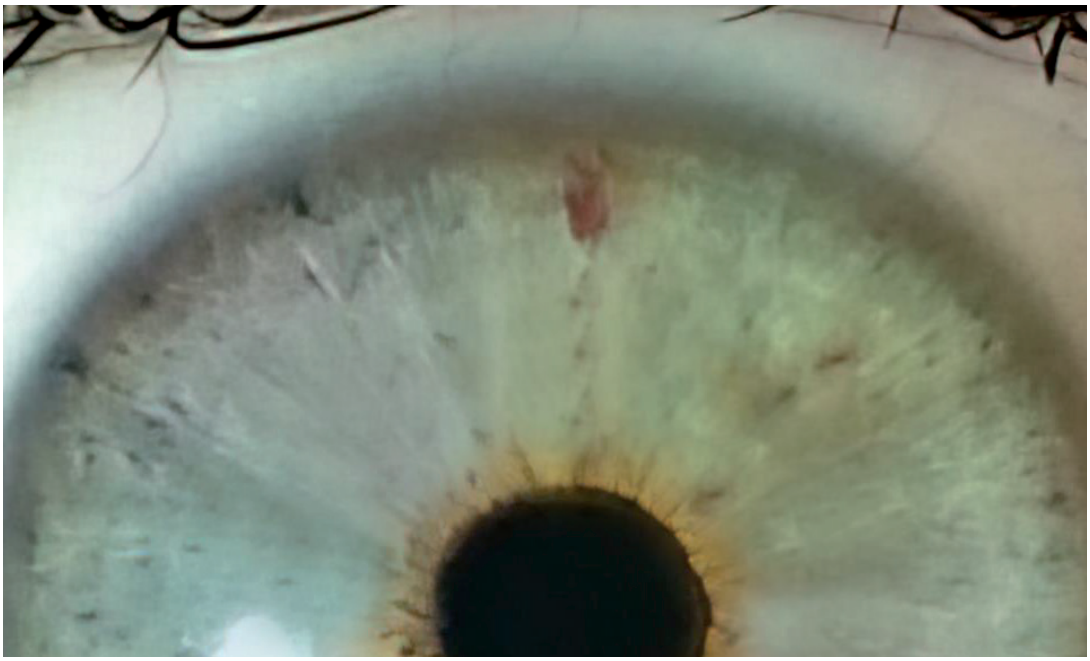


FIGURE 161: Typical early and delayed bottom pigment depot at 6 hours

4 11.1 Microhemorrhage



Stromal micro bleedings. They auto resolve within a few seconds with the help of ocular pressure.

They were more frequent when photodisruptive lasers (Yag) were used regularly, but since 2017, by using photoablative lasers (SLT), are seen very unfrequently.

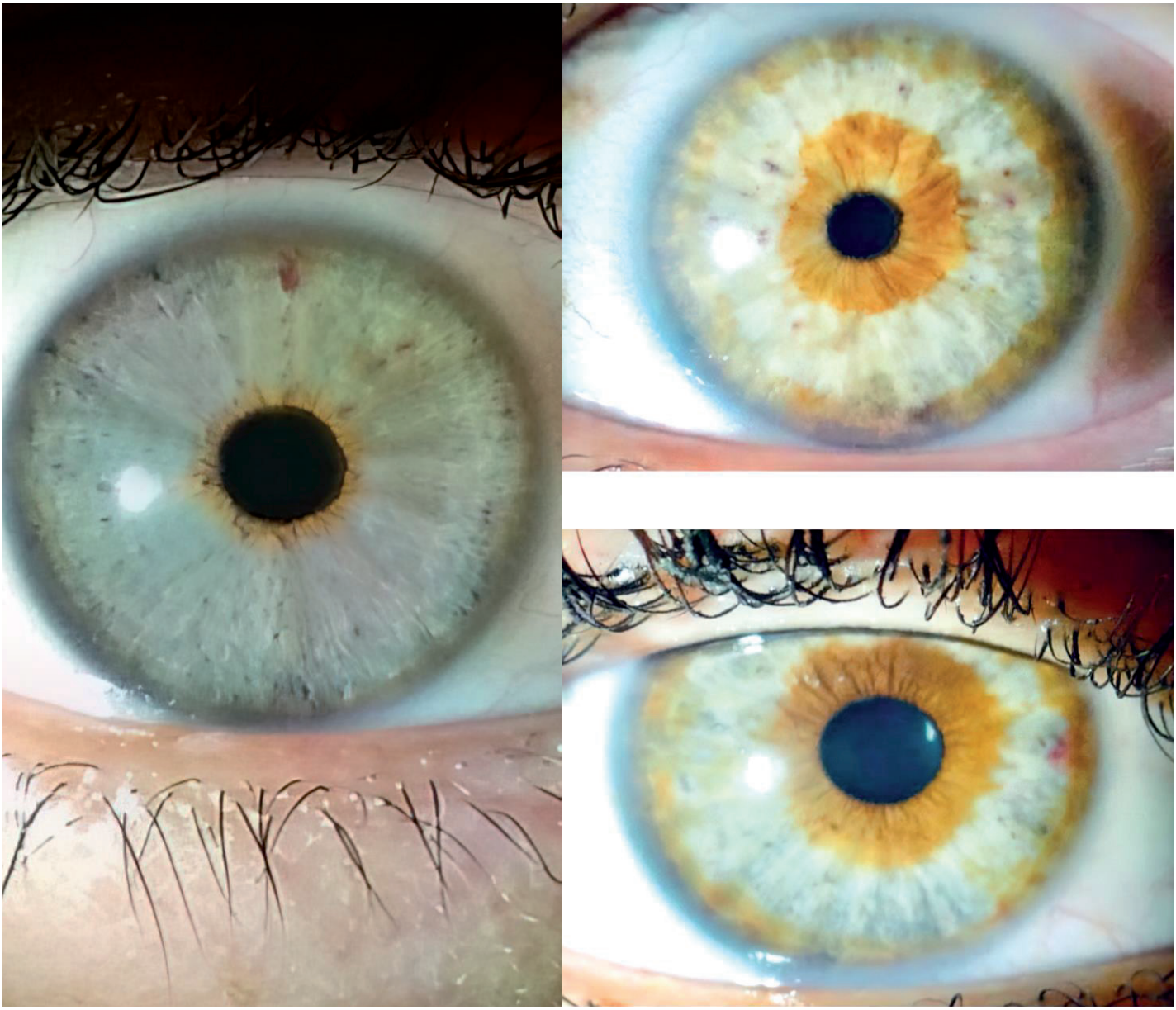
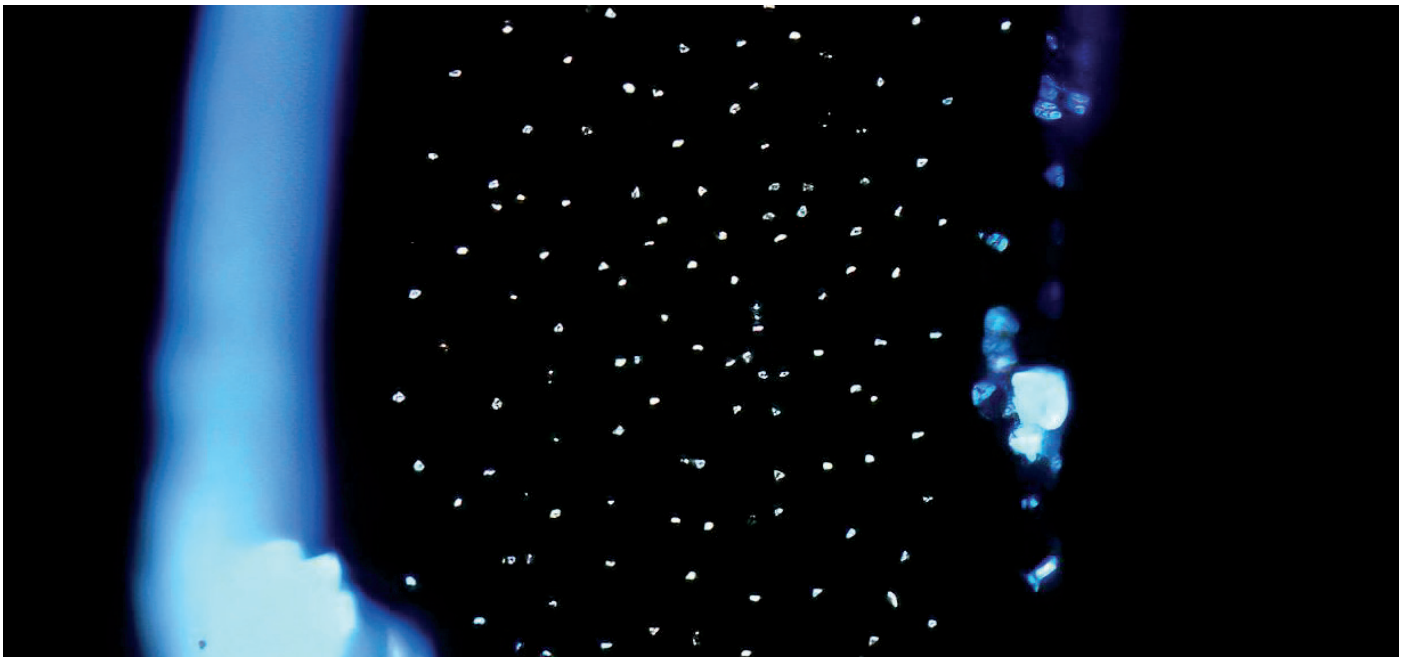


FIGURE 162: Typical small hemorrhage after iris laser application

4 11.1 Acute iritis



Is inflammation of the anterior portion of the uvea. The term anterior uveitis encompasses both iritis (inflammation of the iris) and iridocyclitis (inflammation of the iris and ciliary body). Iritis can occur in one or both eyes. It usually develops suddenl.

Signs and symptoms of iritis includes: Eye redness, discomfort or achiness in the affected eye, sensitivity to light and decreased vision.

Iritis that develops suddenly, over hours or days, is known as acute iritis. Treatment is easy and very effective in one or two days: mydriatic eye drops, steroid drops and antiinflammatory pills. Also,
sunglasses help to reduce light sensitivity.

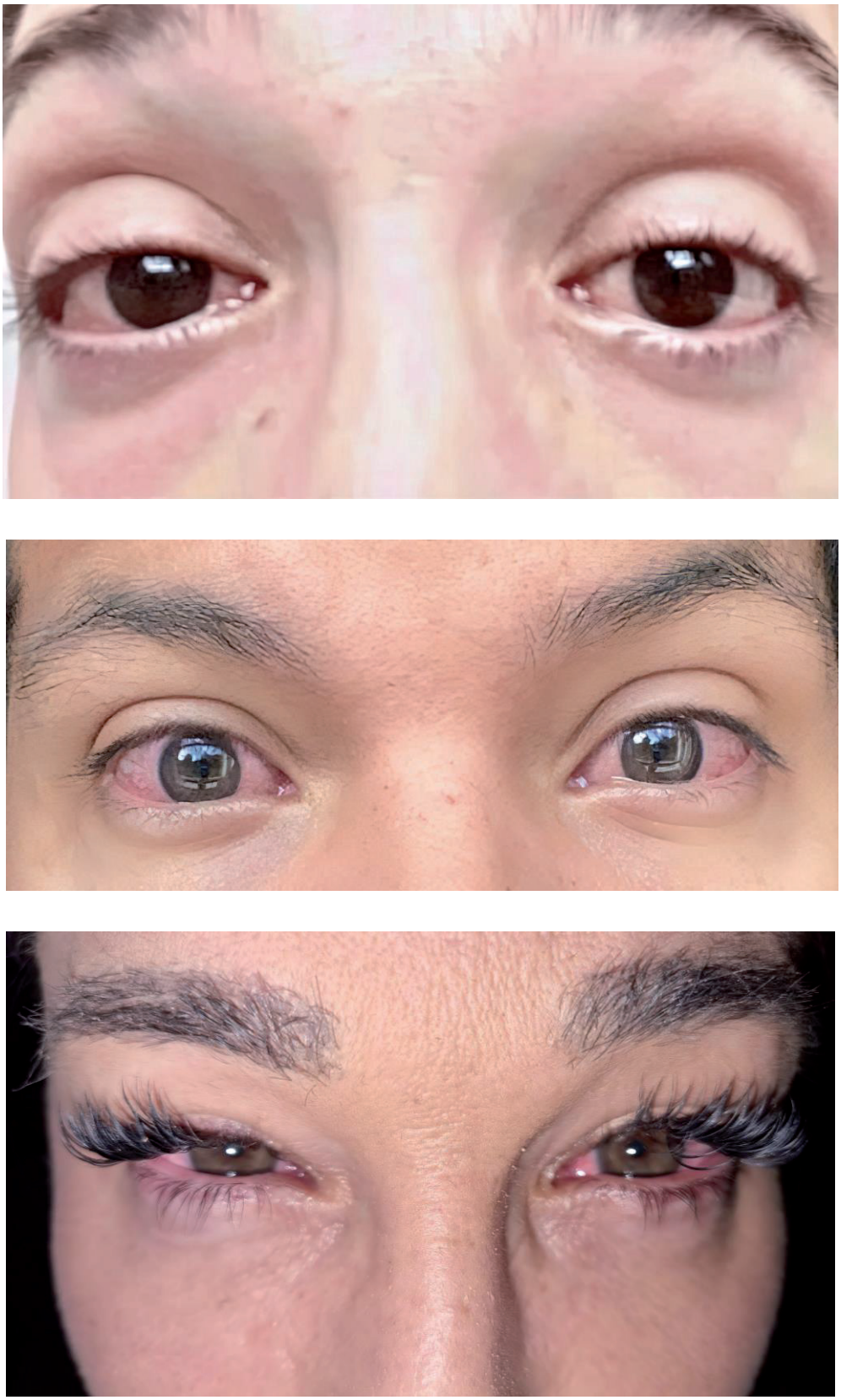
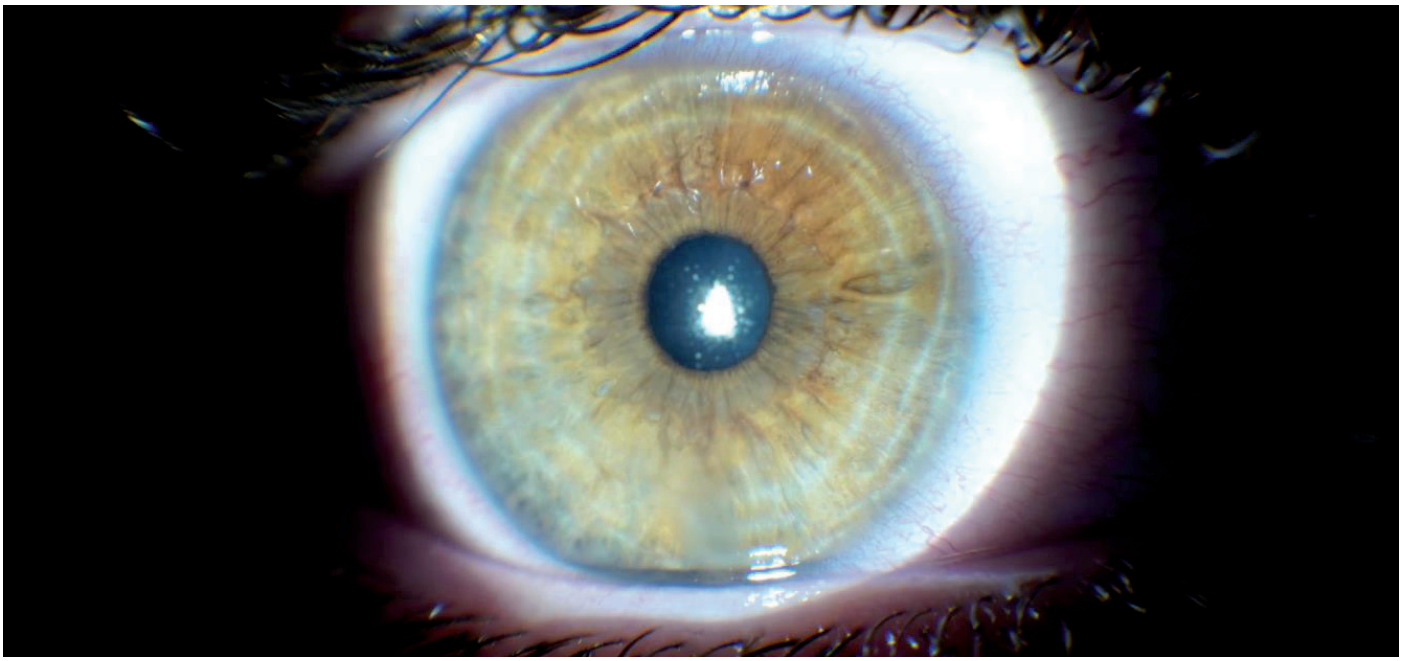


FIGURE 163: Redness, edema and painful light sensitivity

4 11.1 Corneal edema/DLK



The endothelium cells of the cornea pump out fluid to keep vision clear.
When these cells stop working, it creates water retention, which leads to swelling in the cornea. This condition is also known as corneal edema. Corneal edema is caused by disease of the inner cell layer, trauma to the eye, surgical trauma, or certain types of glaucoma.

There are two types of corneal edema related to Cosmetic Iridoplasty by laser, 1-Due to traumatic contact of released pigment into anterior chamber on endothelium (mainly in cases with previous low endothelial cellular density) and 2-Difusse lamellar keratoplasy (DLK) by immunological causes in patients that underwent lasik procedures
before Iridoplasty.

Treatment is easy and very effective in few days: hypertonic sodium chloride eye drops, steroid drops, beta blockers drops and acetazolamide (drops or pills).
Complete resolution is seen quickly.

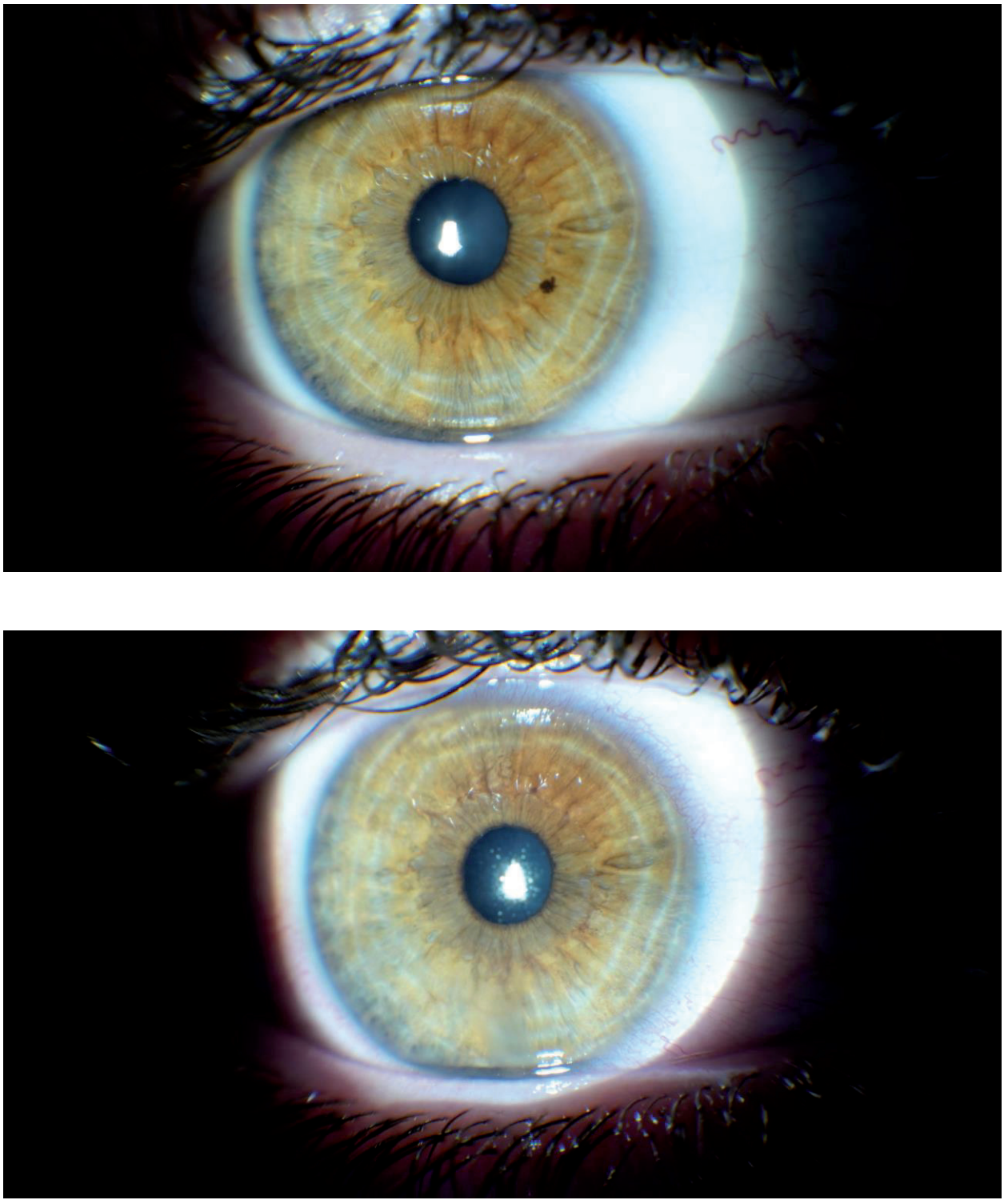
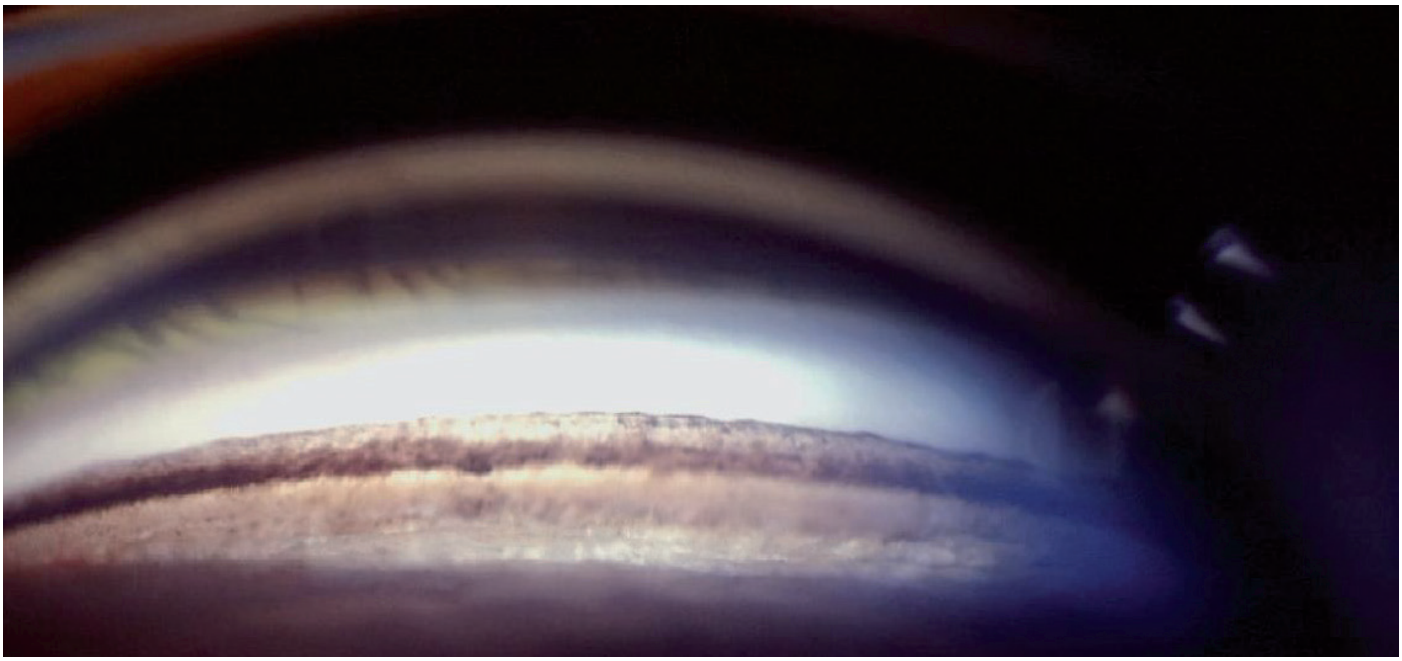


FIGURE 164: Slight bottom corneal edema after Laser Iridoplasty

4 11.2 Chronic high IOP



Secondary glaucoma is one that occurs as a consequence of other pathologies, both ocular and systemic. Pigmentary glaucoma is a secondary glaucoma caused by pigment dispersal syndrome. This disease is characterized by detachment of posterior iris pigments (melanin), which are trapped in the aqueous humor drainage system, causing its obstruction. When melanin becomes trapped in the trabecular meshwork or in any other structure of the drainage system, it prevents aqueous humor from flowing or being absorbed correctly and a significant increase in intraocular pressure occurs.
The elevated IOP levels constant or fluctuating damage the optic nerve causing irreversible damage.

After Cosmetic Laser Iridoplasty, melanin pigment is released into anterior chamber from iris surface, but the typical gonioscopic pattern is just a lower trabecular meshwork pigmentation, only about 70 degrees, remaining free the 290 upper degrees.

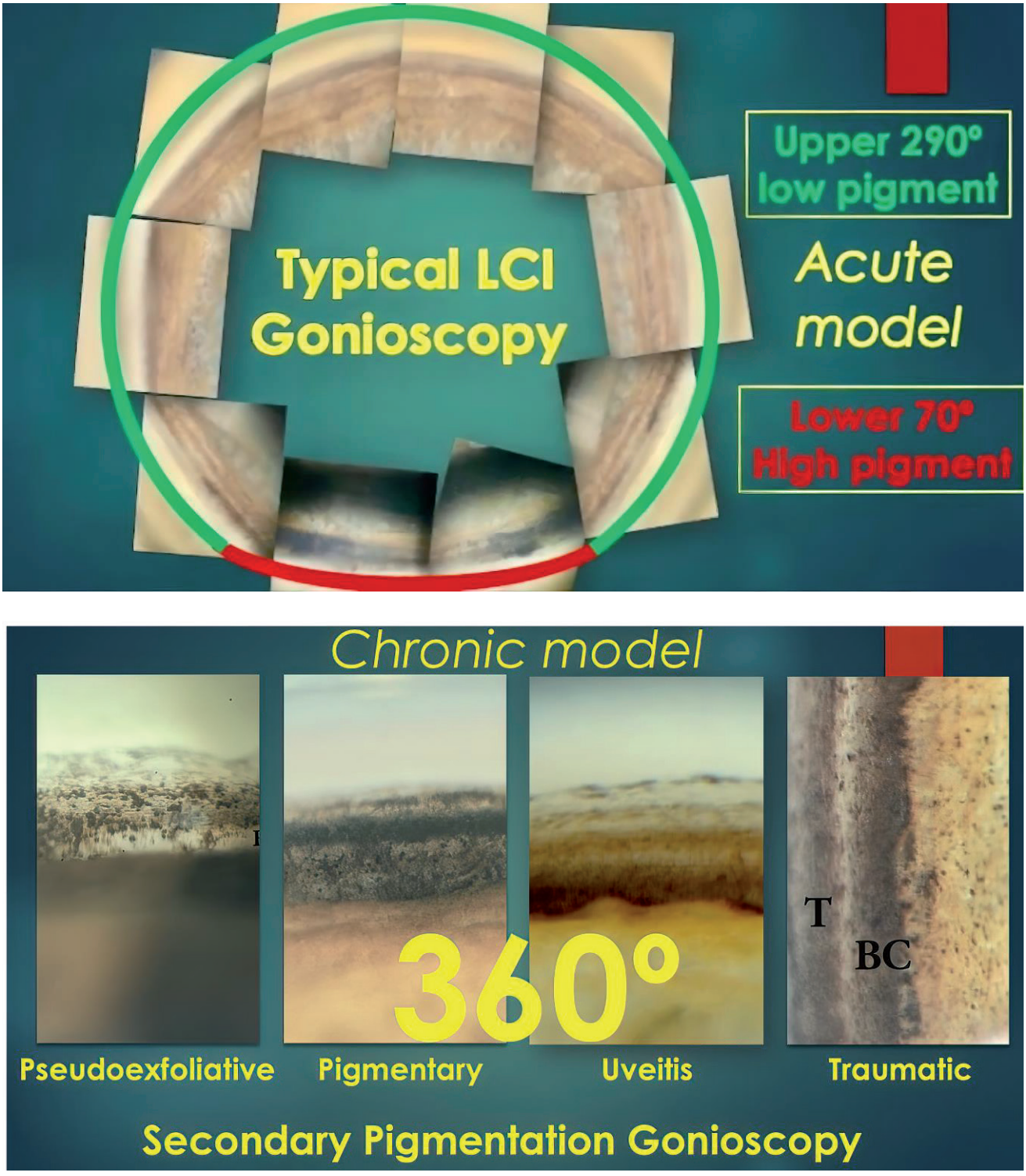


FIGURE 165: Chronical high eye pressure due to trabelular blockage

4 11.2 Anisocoria

Anisocoria is the medical term for asymmetric (different sized) pupils. Anisocoria can be caused by lots of conditions. Some are temporary, but some can be lifethreatening.

Horner's syndrome is a rare genetic condition that affects the tissue around your eyes. It can cause a drooping eyelid (ptosis), irregular pupils and a lack of sweating on half your face.

Mechanical anisocoria is an acquired defect that results from damage to the iris or its supporting structures.

Causes include physical injury from ocular trauma or surgery, inflammatory conditions such as iritis or uveitis, angle closure glaucoma leading to iris occlusion of the trabecular meshwork, or intraocular tumors causing physical distortion of the iris.

Cosmetic Laser Iridoplasty can produce, by traumatic reasons on iris (sphinter muscle and nerves), a transient and slight anisocoria, usually solved fully before one month. Two treatments are used: Vitamin B complex and Pilocarpìne eye drops.

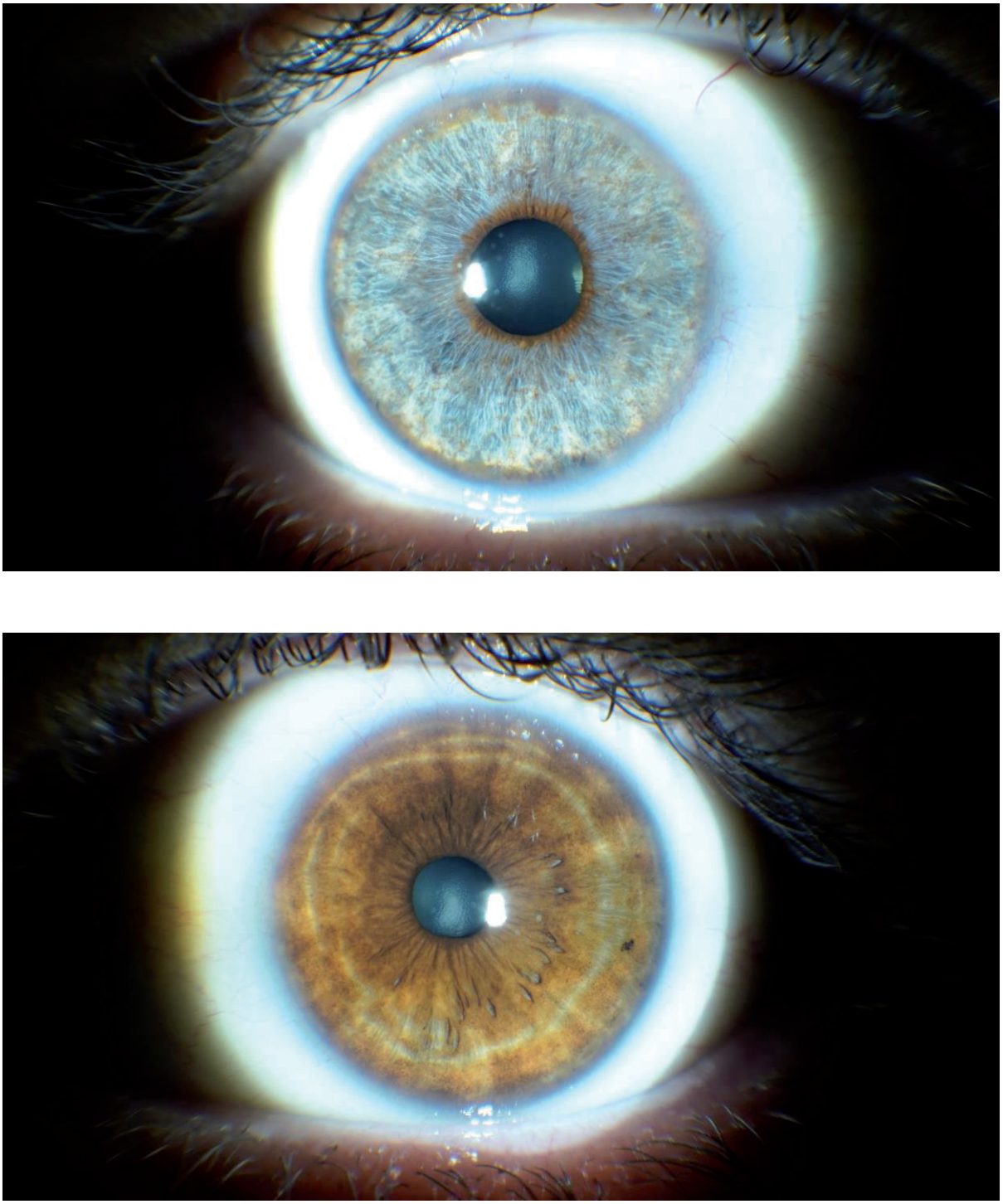
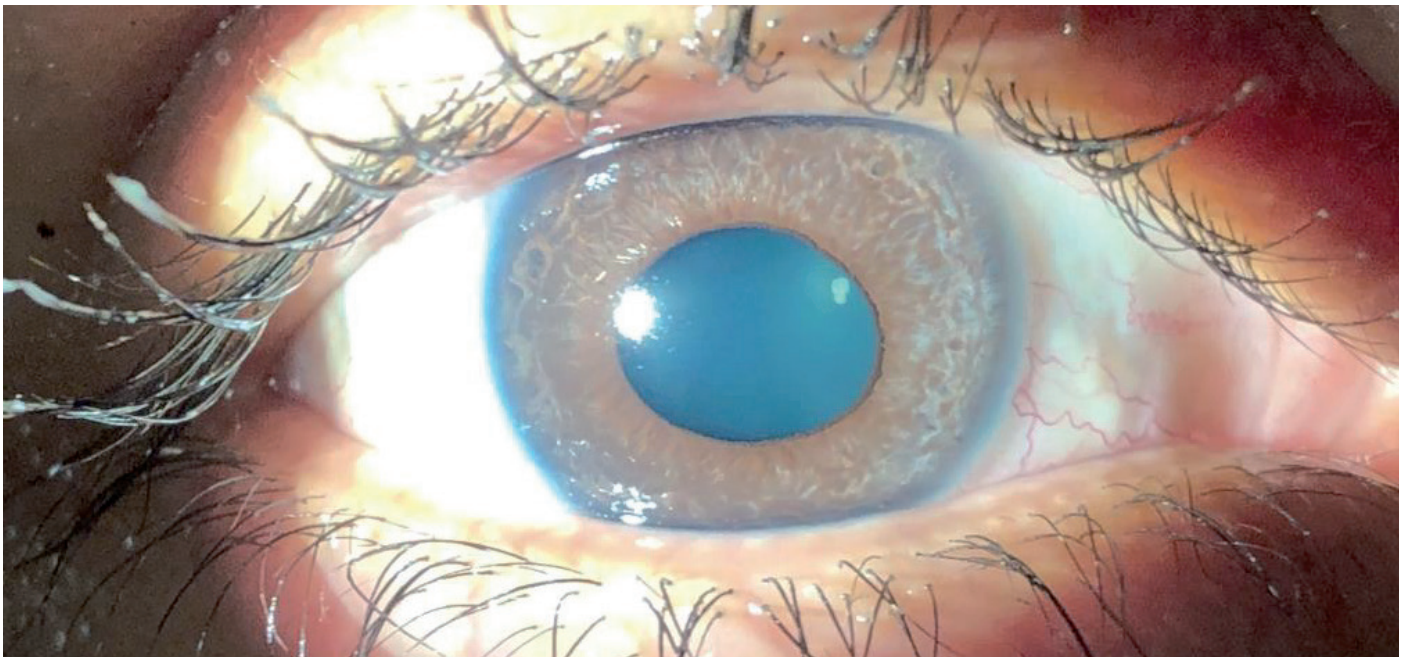


FIGURE 166: Slight increase on pupil size after Laser Iridoplasty

4 11.3 Bad laser practice



Althogh cosmetic Laser Iridoplasty is a safe technique if candidate selection, a good diagnosis and treatment protocols are respected, it can also cause a number of complications that can lead to serious consequences, such as vision loss and chronic pain.

Regarding the most frequent and serious side effects, we can mention: acute glaucoma, intense iritis, sensitivity to light, paralytic mydriasis, pigment dispersion syndrome, iris atrophy (increased transillumination), Urrets-Zavalía syndrome, etc.

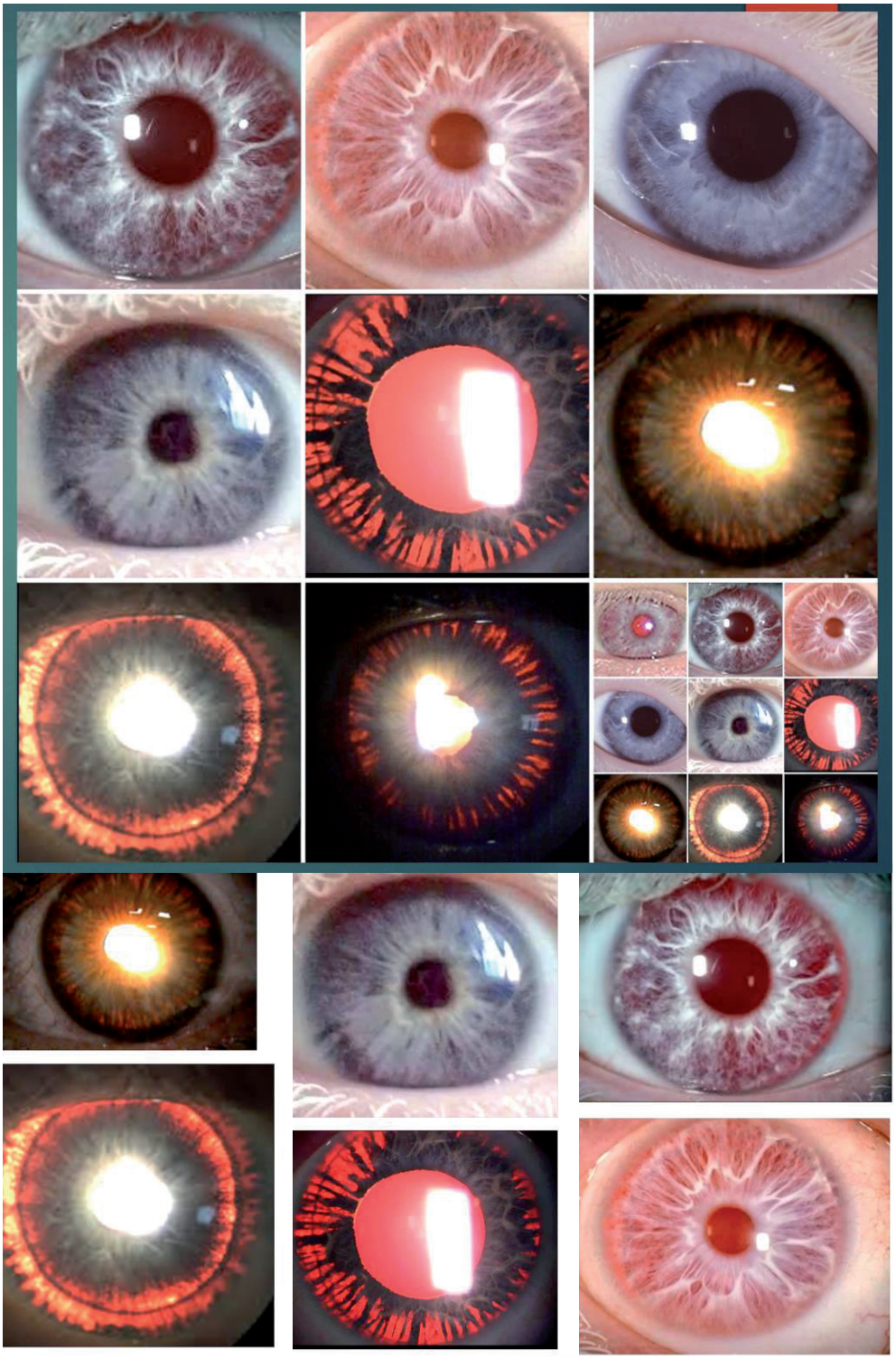
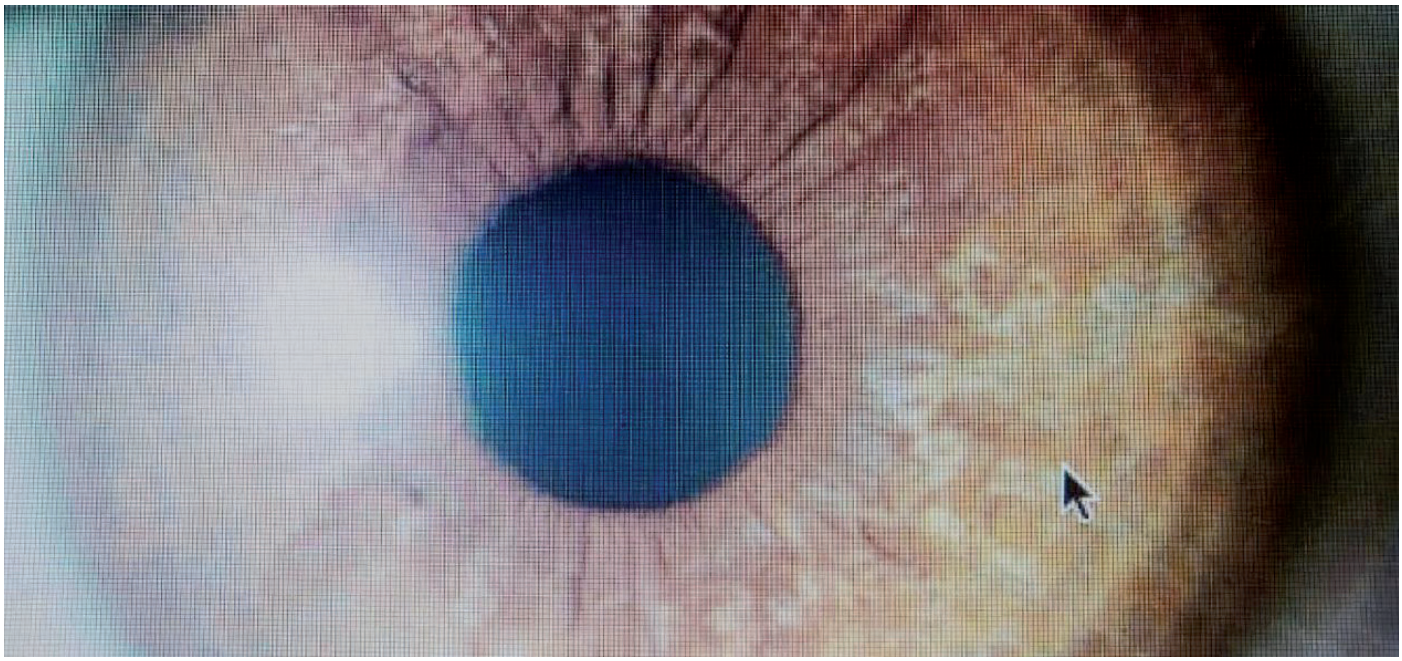


FIGURE 167: Pigment dispersion sindrome and iris atrophy

4 11.3 Bad laser practice



Poorly performed Cosmetic Laser Iridoplasty can cause very dissapointing and sometimes irreversible esthetic results, such as: permanente darkening of the iris due to stromal tattoo effect, caused by the use of inappropiate lasers at too high energies, appearance of irregular pigment spots, due to lack of correct treatment protocols, anterior iridocorneal and iridocrystalline synechiae, deformation of the pupils and anisocoria, areflexic miotic or mydriatic pupils, etc

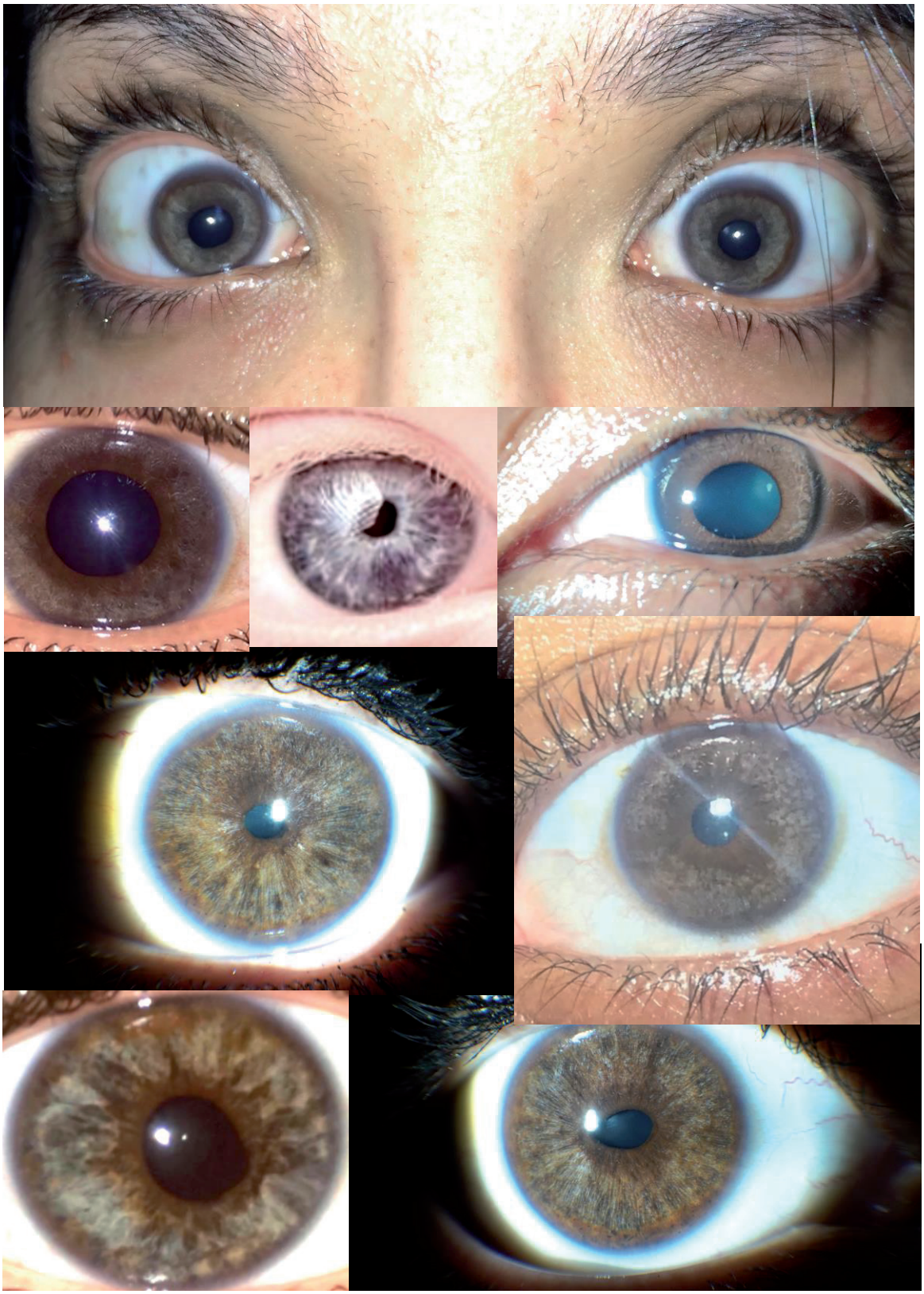
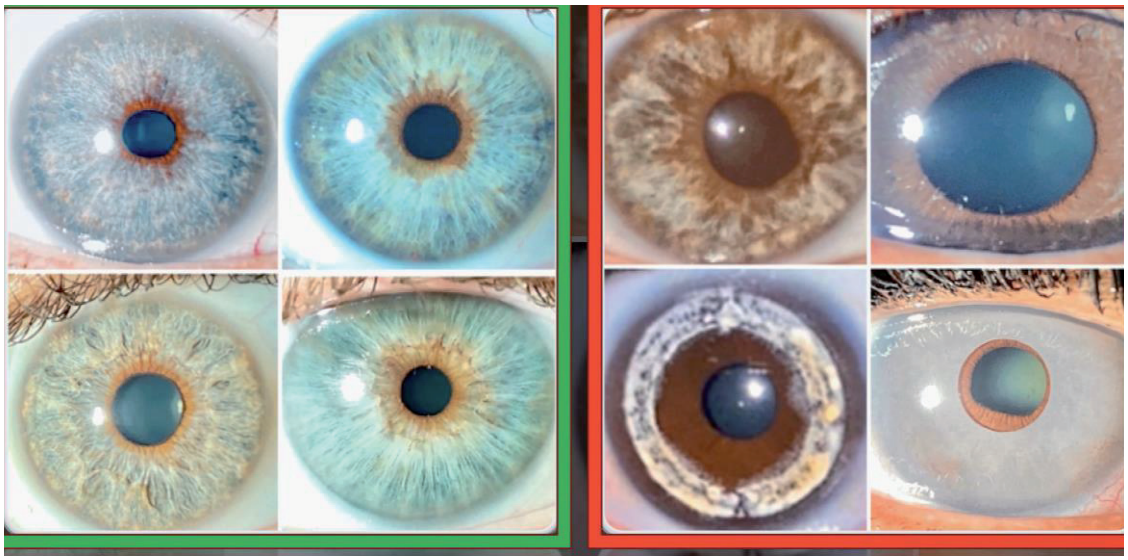
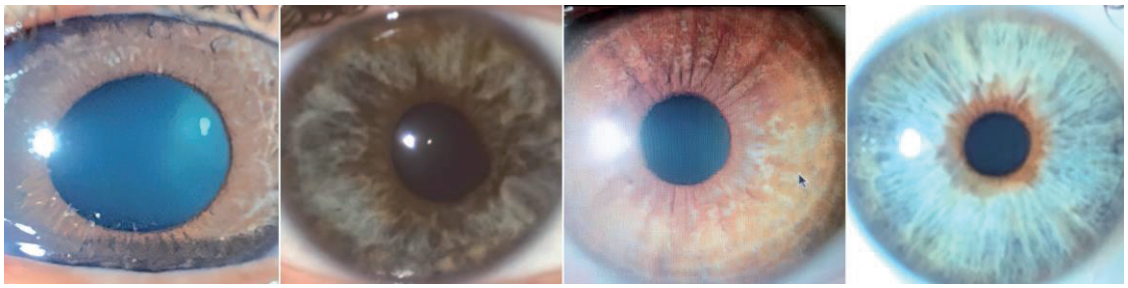


FIGURE 168: Fixed, big and distorted pupils, ugly estethic looks

4 11.3 Comparative





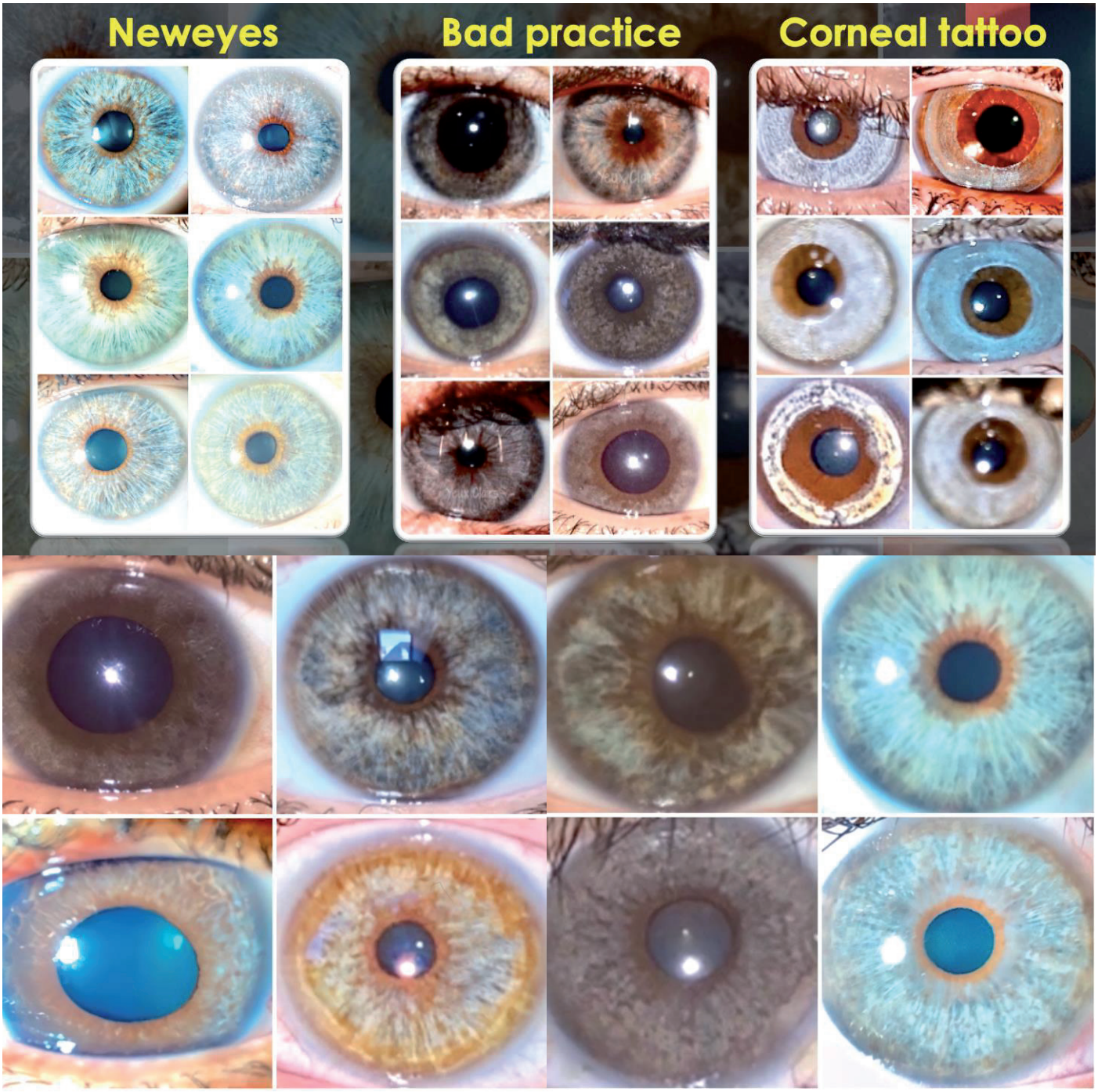
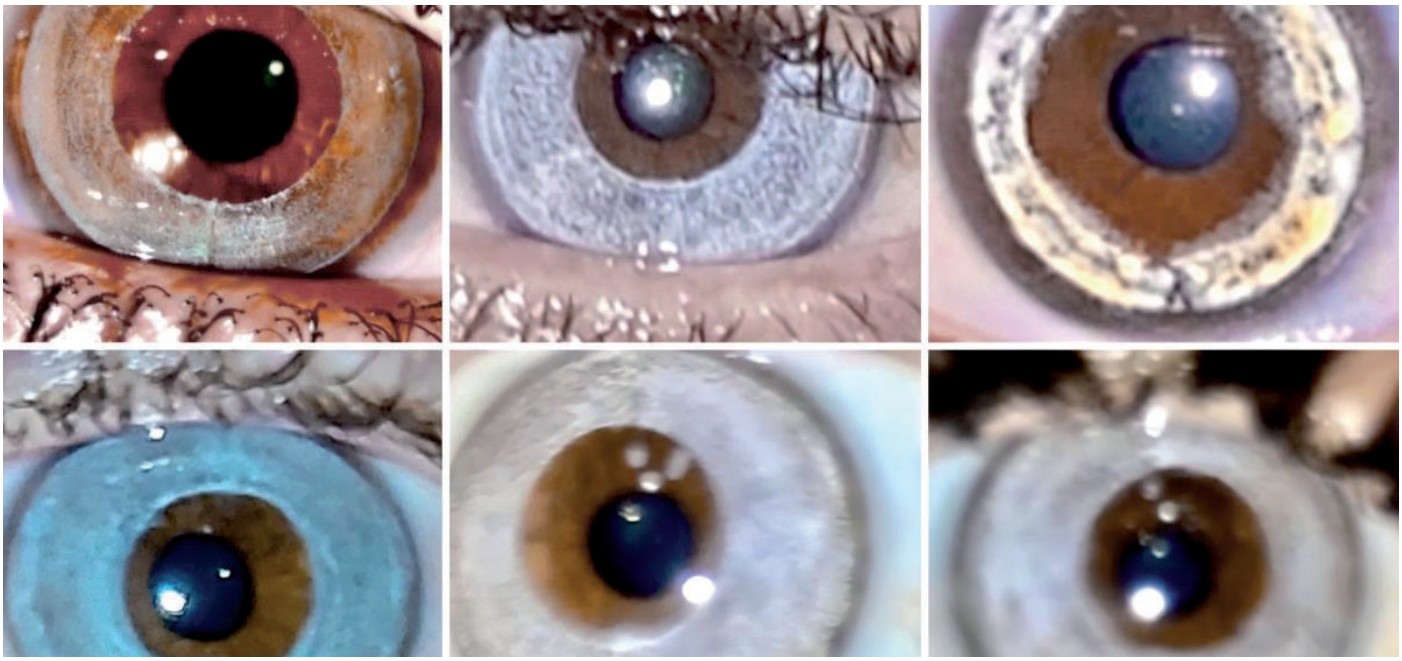


FIGURE 169: Comparative eye looks: Eyecos, bad practice laser and tattoo

4 11.4 Corneal tattoo



Basically, Keratopigmentation also known as corneal tattooing, has been used for cosmetic corneal opacities for many years. In other words, keratopigmentation laser surgery is the process of injecting color into the cornea to change the eye color of a person. The area where the surgery is performed is the cornea.

Potential surgery complications: Infection, off center tattoos (strabismus), bad healing, chemical dye allergy, dry eyes, chronic keratitis.

Potential visual side effects: Vision loss, glare and halos, night blindness, field los, driving discomfort.

Cosmetic outcome: Robot eye appearance, brown pupil at center, Artificial color outside, Color effect loss, Contact lens look.

Future disadvantages: Contact lens intolerance, consecutive surgeries, refractive laser not posible, cataract surgery difficulties, retinal check up limited, corneal graft posible.

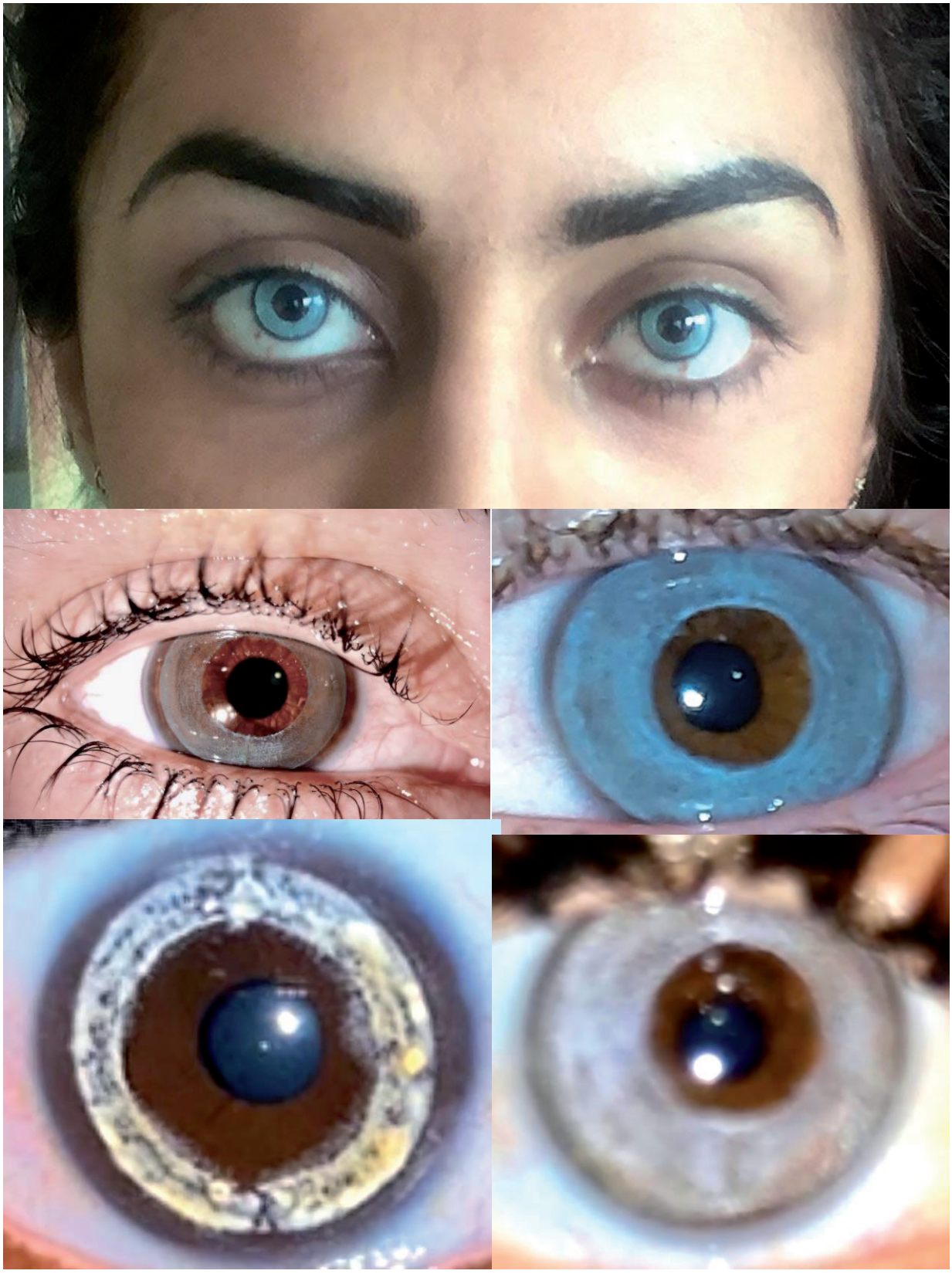
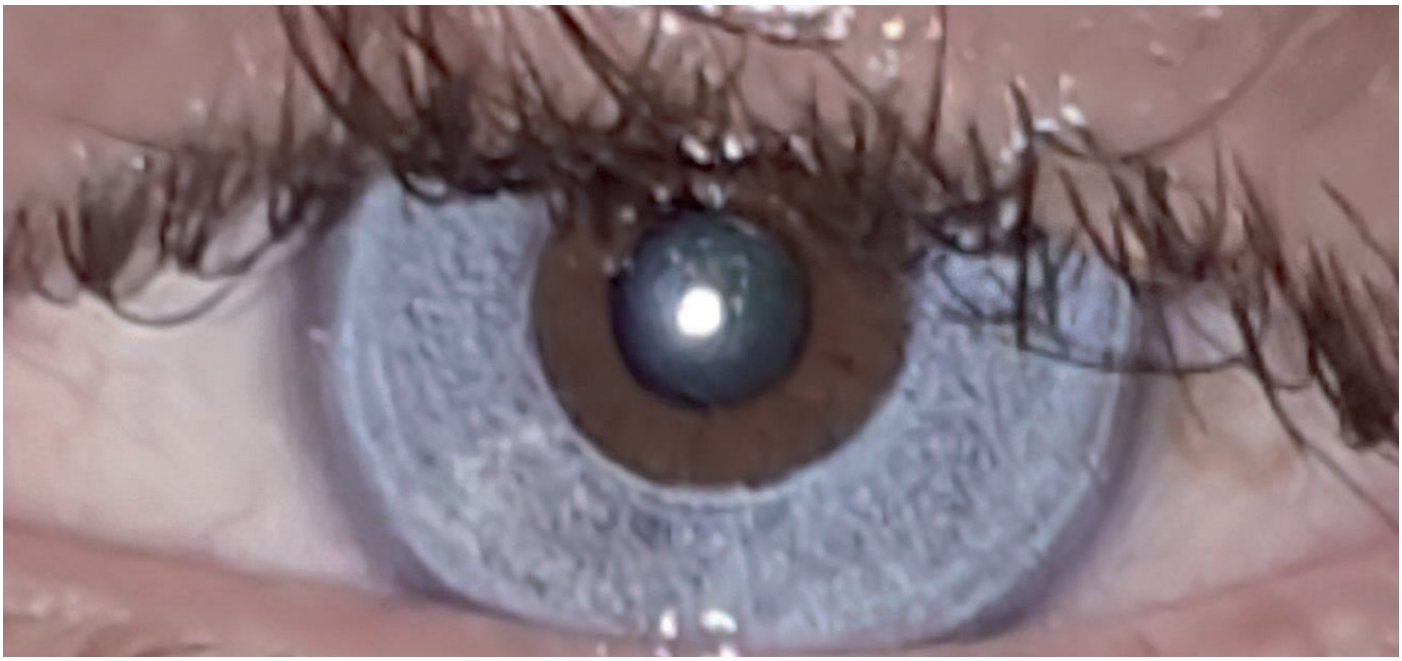


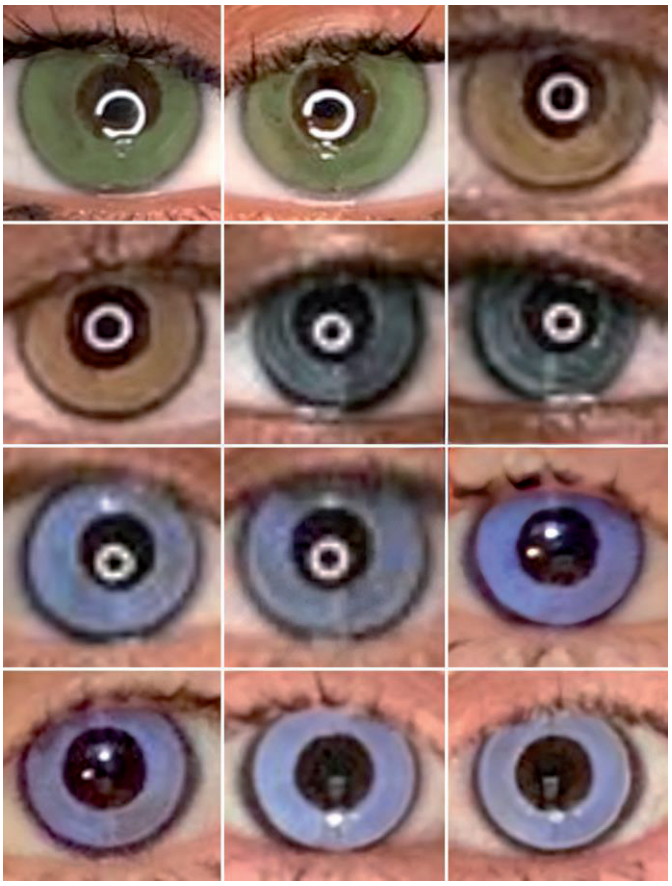
FIGURE 170: Disapointing look after tattoo due to artificial color

4 11.4 Corneal tattoo



The esthetic results of corneal tattooing is always artificial for two main reasons: the pupil is mydriatic and fixed (it does not react to light), also inside it you can see the brown melanin that persits around the pupils (very unpleasant effect), and in addition, the color of the biological dye introduced into the cornea is wierd and artificial.
Originally, keratopigmentation was only indicated to treat corneal scars, but currently is used to change eye color by esthetic reasons.

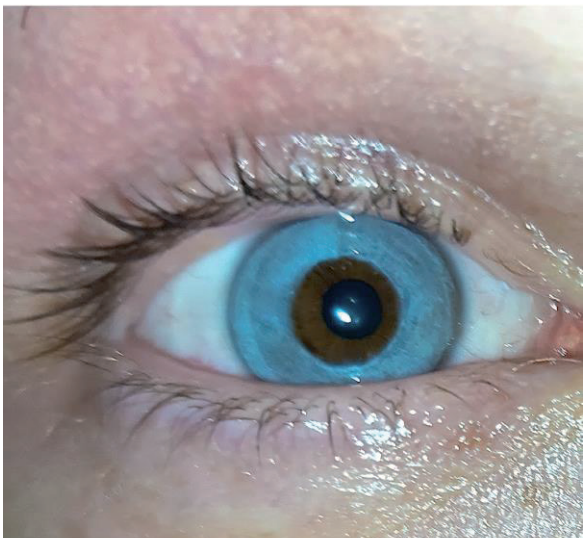
Unfortunally, the results are always similar, and even worse, to cosmetic contact color lenses, but, however, a lot of severe complications, maybe permanent, are associated.



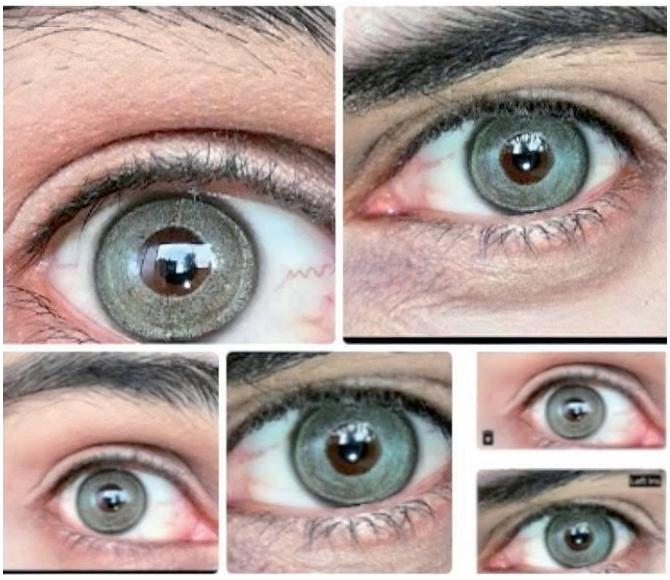
Observaciones

my hole for my pupil is 5 mm . i don't like the brown around my pupil.

Iris Derecho



Iris Izquierdo



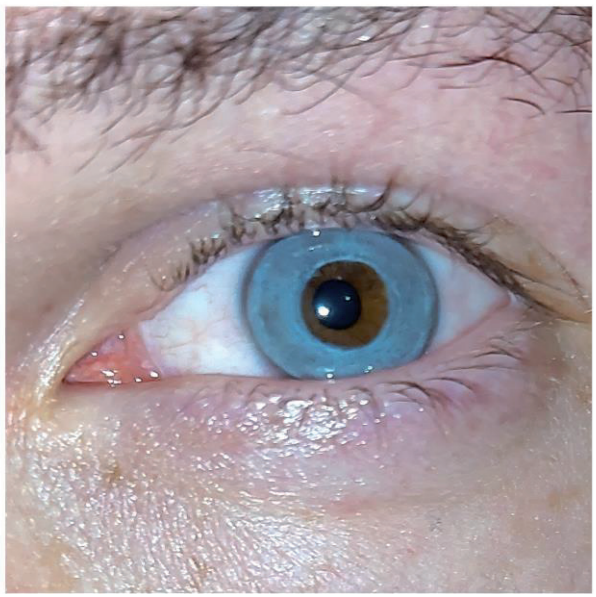
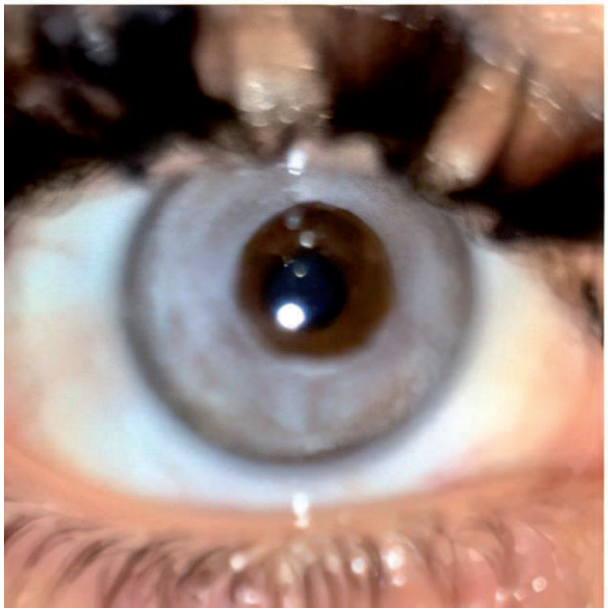
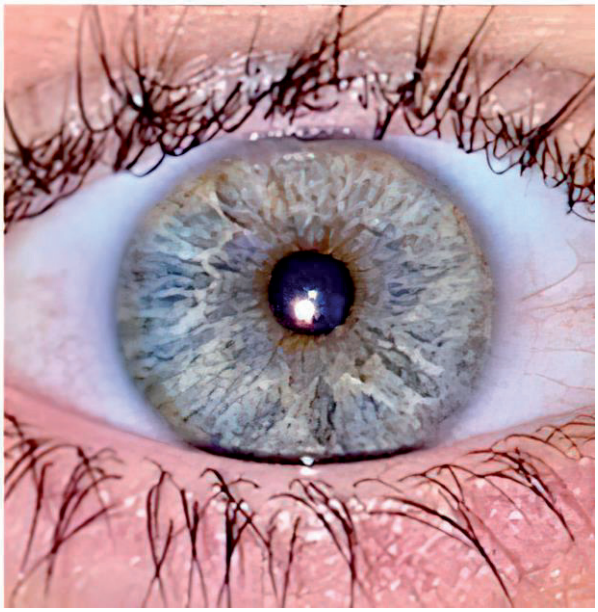
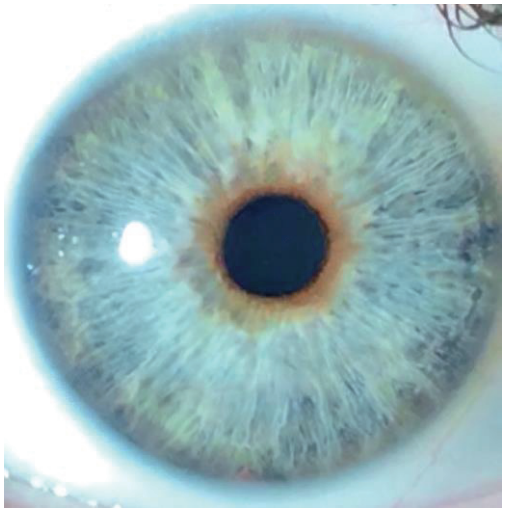


FIGURE 171: Tattoo disadvantage: Brown melanin through central area

4 11.4 Comparative







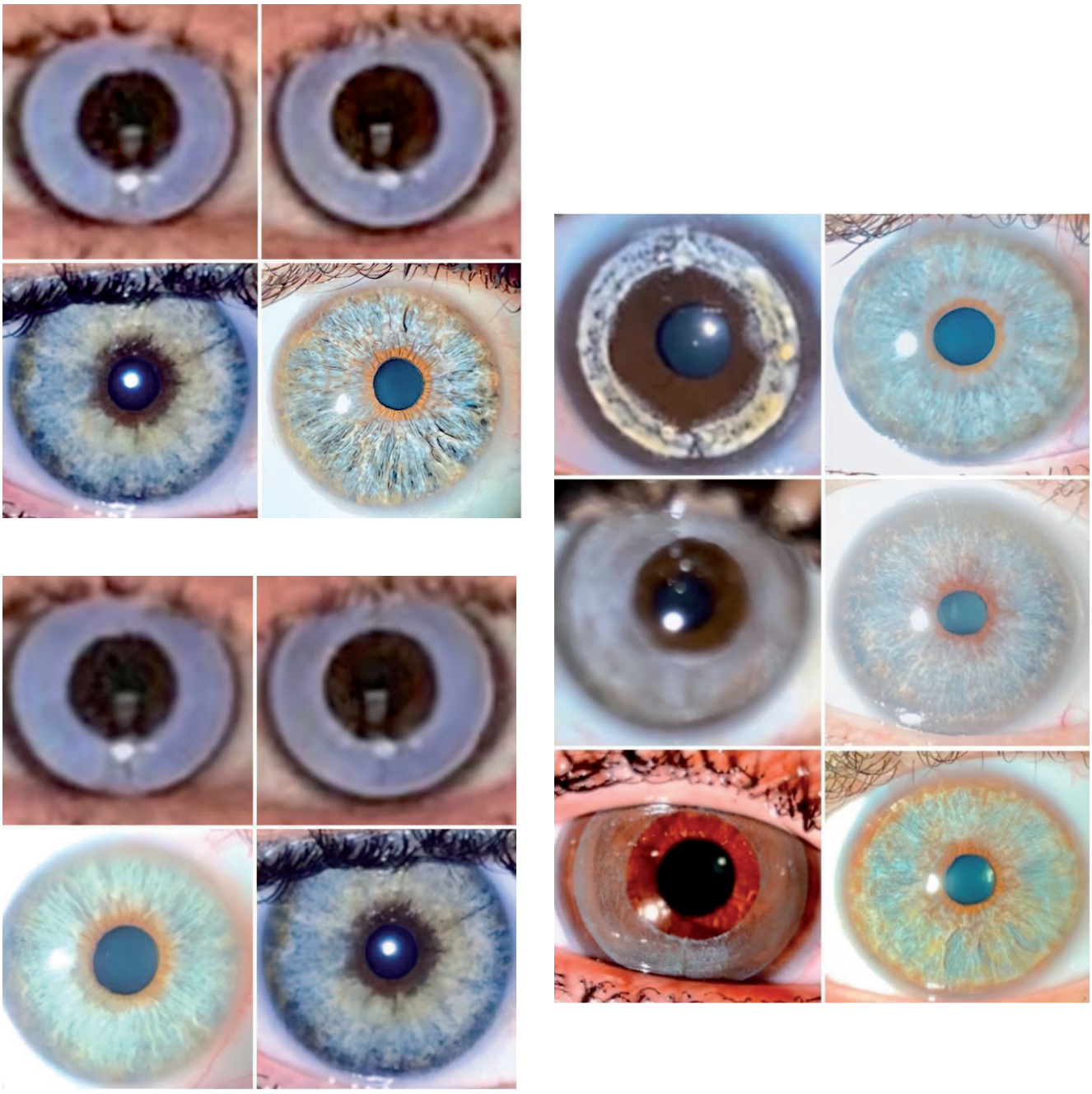


FIGURE 172: Comparative look between Eyecos and corneal tattoo

4 11.5 Cosmetic IOL

Cosmetic intraocular lenses to change the color of the eyes began to be implanted years ago in Panama and lately has been marketed a new model of lens,
which is still used in Turkey, Mexico, Brazil, Tunisia, etc.

From the outset the observed complications have been of extreme gravity forcing the removal of the lens before 6 months to prevent blindness.

On the other hand, the aesthetic result is artificial (robot eye) for several reasons: plastic color of the implant, fixed pupil diameter (the Brown of the iris that is behind is visible with light), and also the field of vision is seriously limited and mostly night vision is reduced , with remarkable constraints to walking in dark places or night driving.

For these reasons, the use of cosmetic intraocular lenses is a completely contraindicated surgery to change the color of the eyes.

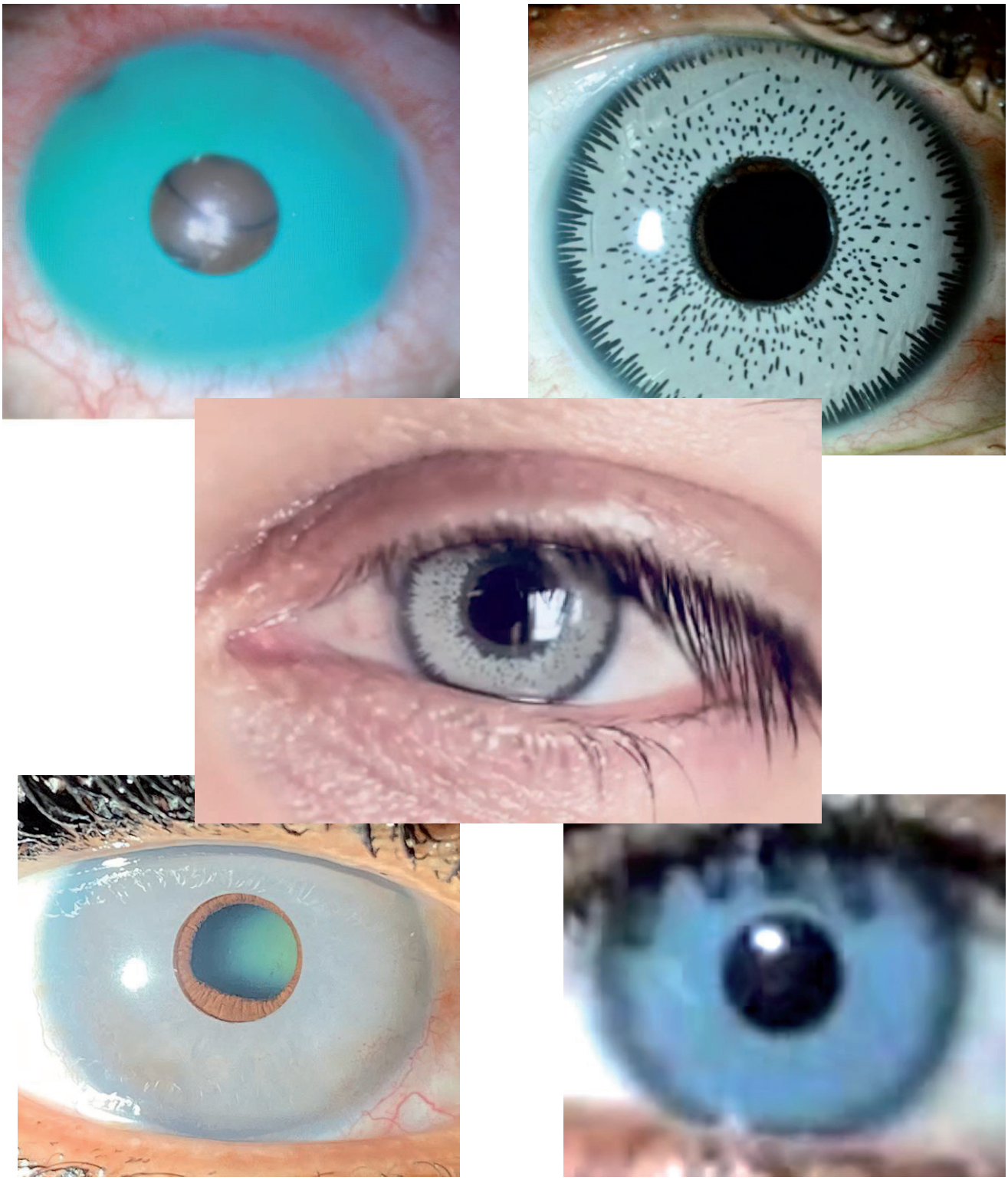
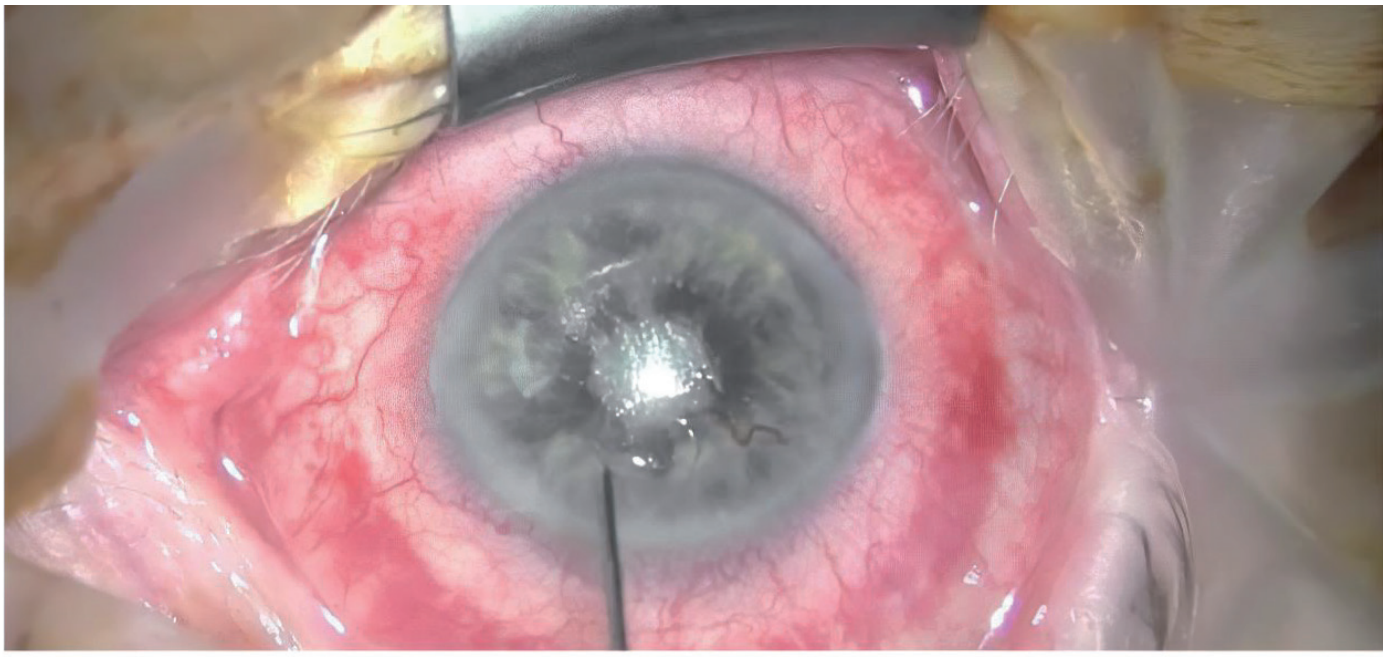


FIGURE 173: Robot eyes after intraocular cosmetic surgery

4 11.5 Cosmetic IOL



Artificial iris anterior chamber implants were originally developed for therapeutic purposes but have been used recently for the cosmetic alteration of eye color. There is a growing body of evidence surrounding their associated risks. These implants are associated with sight-threatening complications that can present years after their implantation.

Cosmetic artificial iris implantation is associated with the development of serious complications such as glaucoma, corneal decompensation, uveitis, native iris damage, and cataract.

Despite cosmetic artificial iris removal, permanent visual loss from residual ocular damage was present in a significant proportion of patients at the last follow-up examination. These findings highlight the role of the ophthalmologist in counseling patients away from cosmetic artificial iris implantation.

Although we do not have data to support it, there is likely a benefit to early removal in limiting late complications. Lastly, promoting public education regarding the potential hazards of cosmetic iris implantation may reduce the burden of complications on society at large.

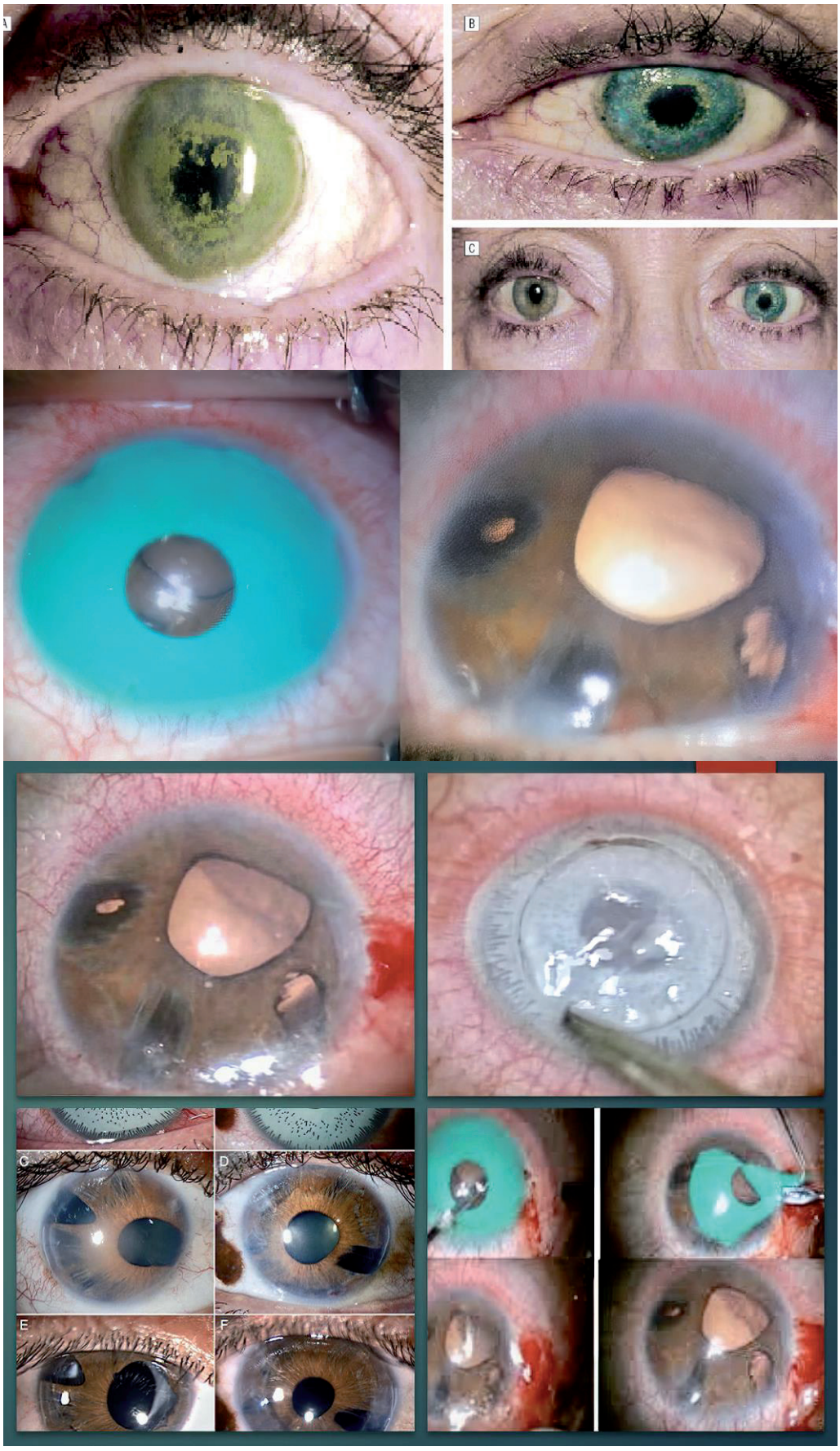
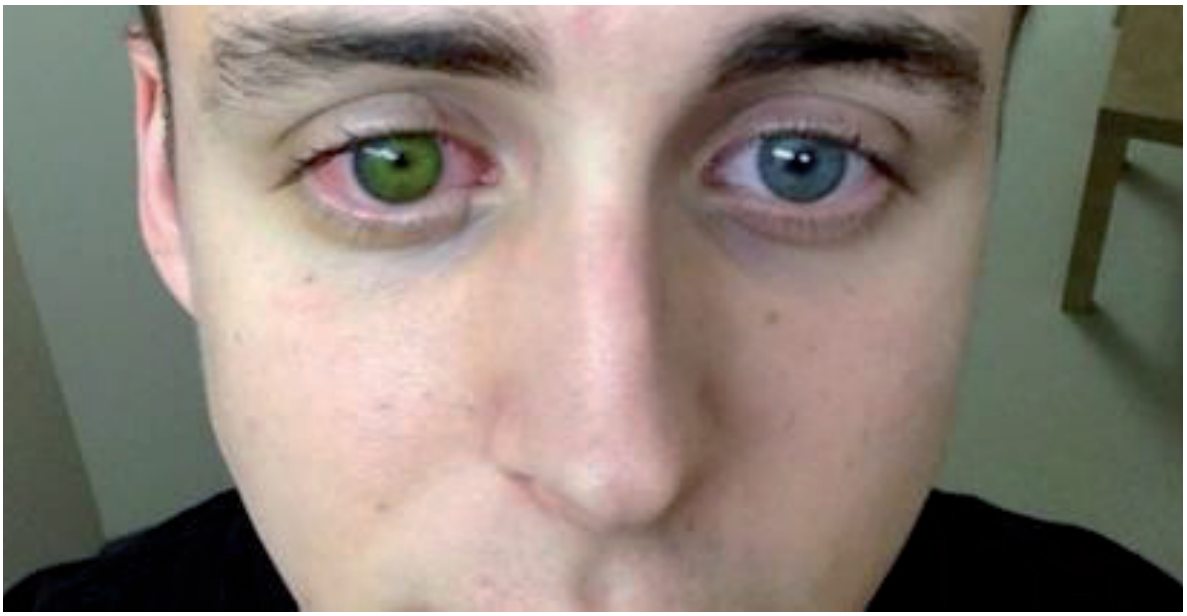
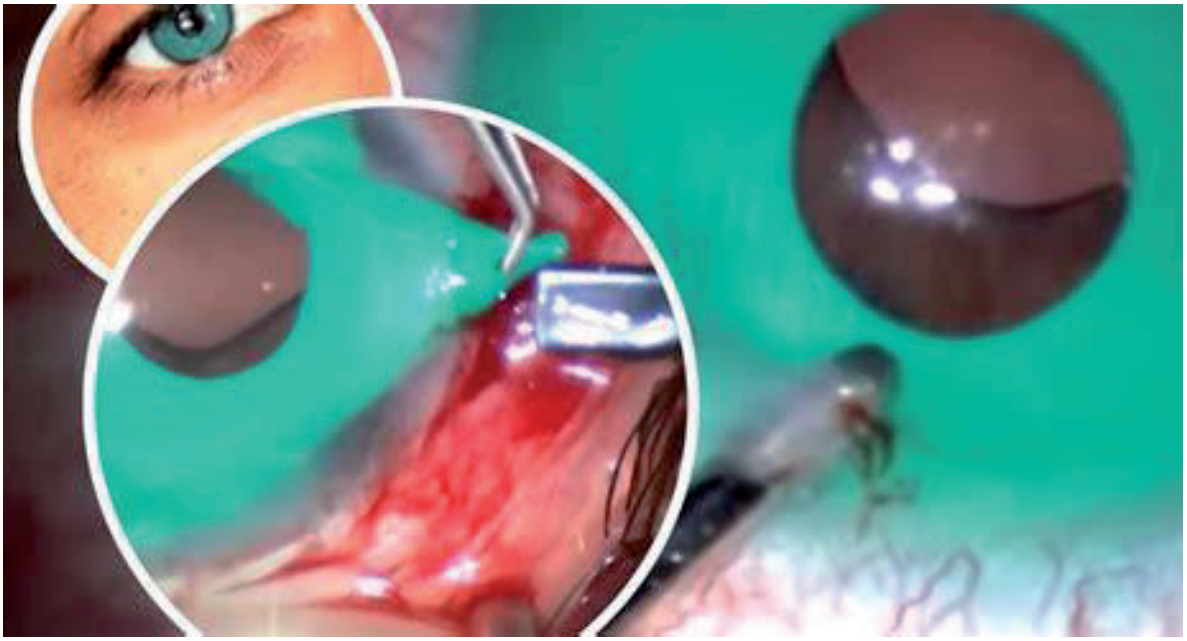


FIGURE 174: Cosmetic IOL removal due to severe complications

4 11.5 Cosmetic IOL





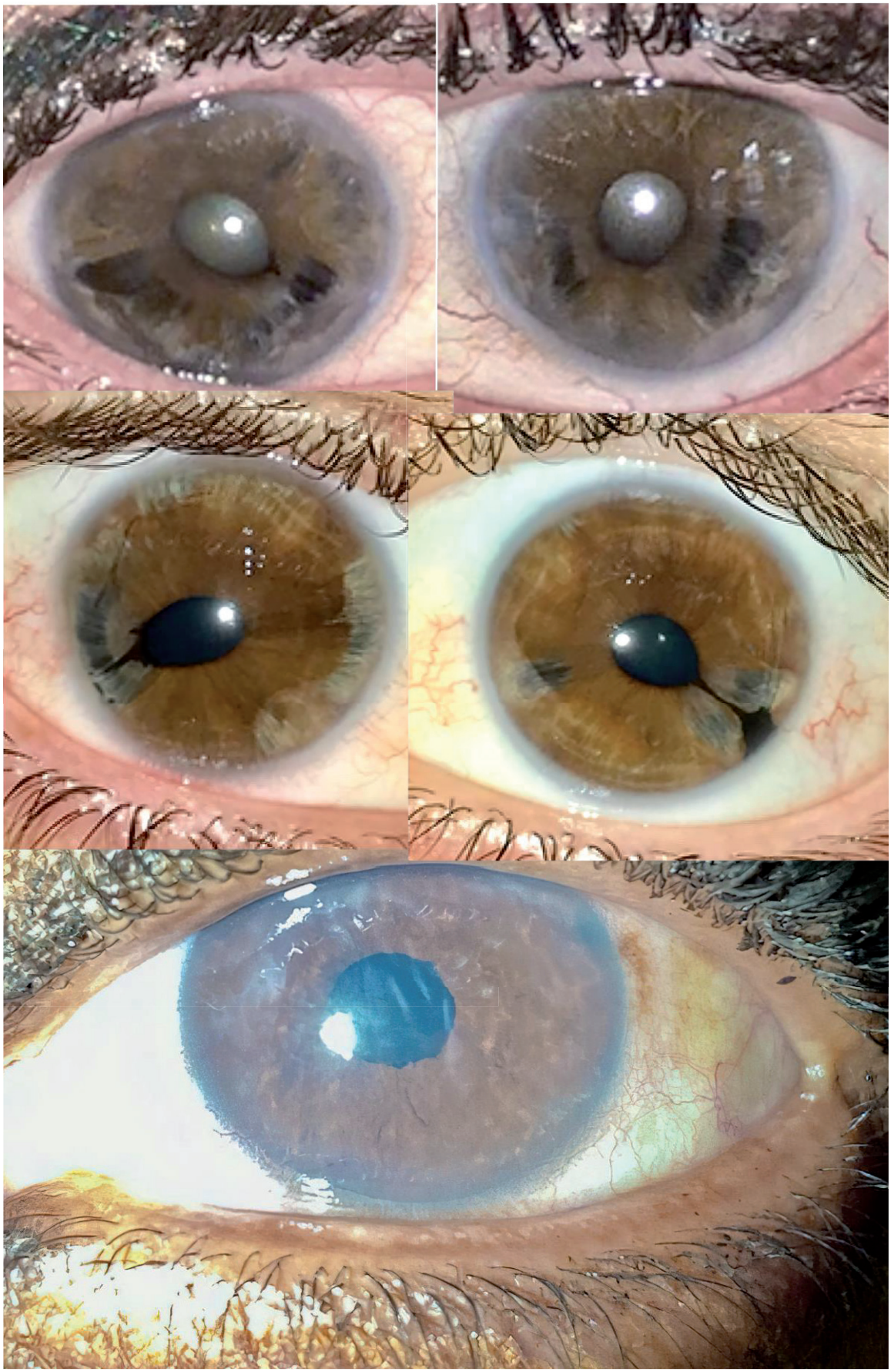
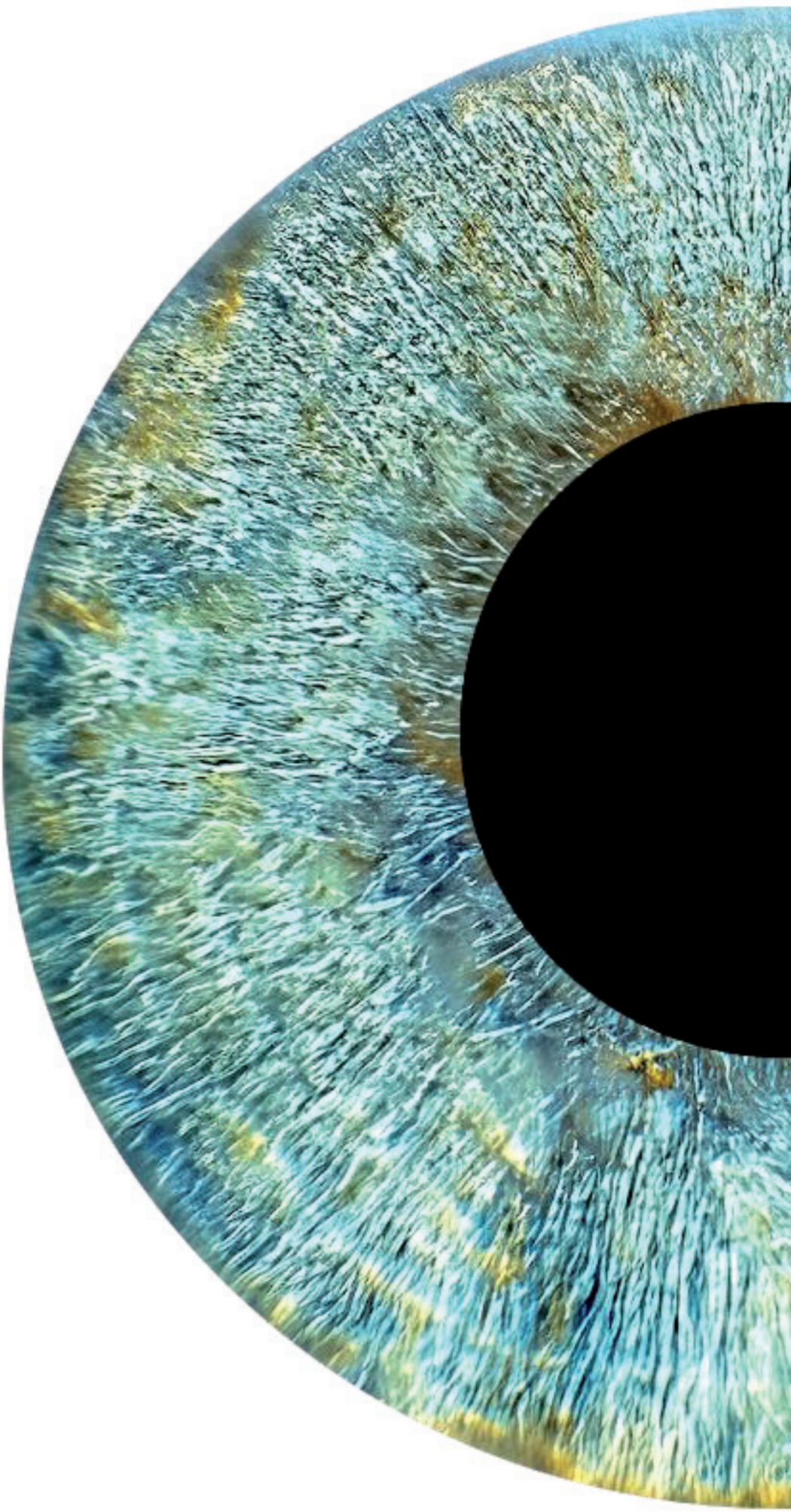
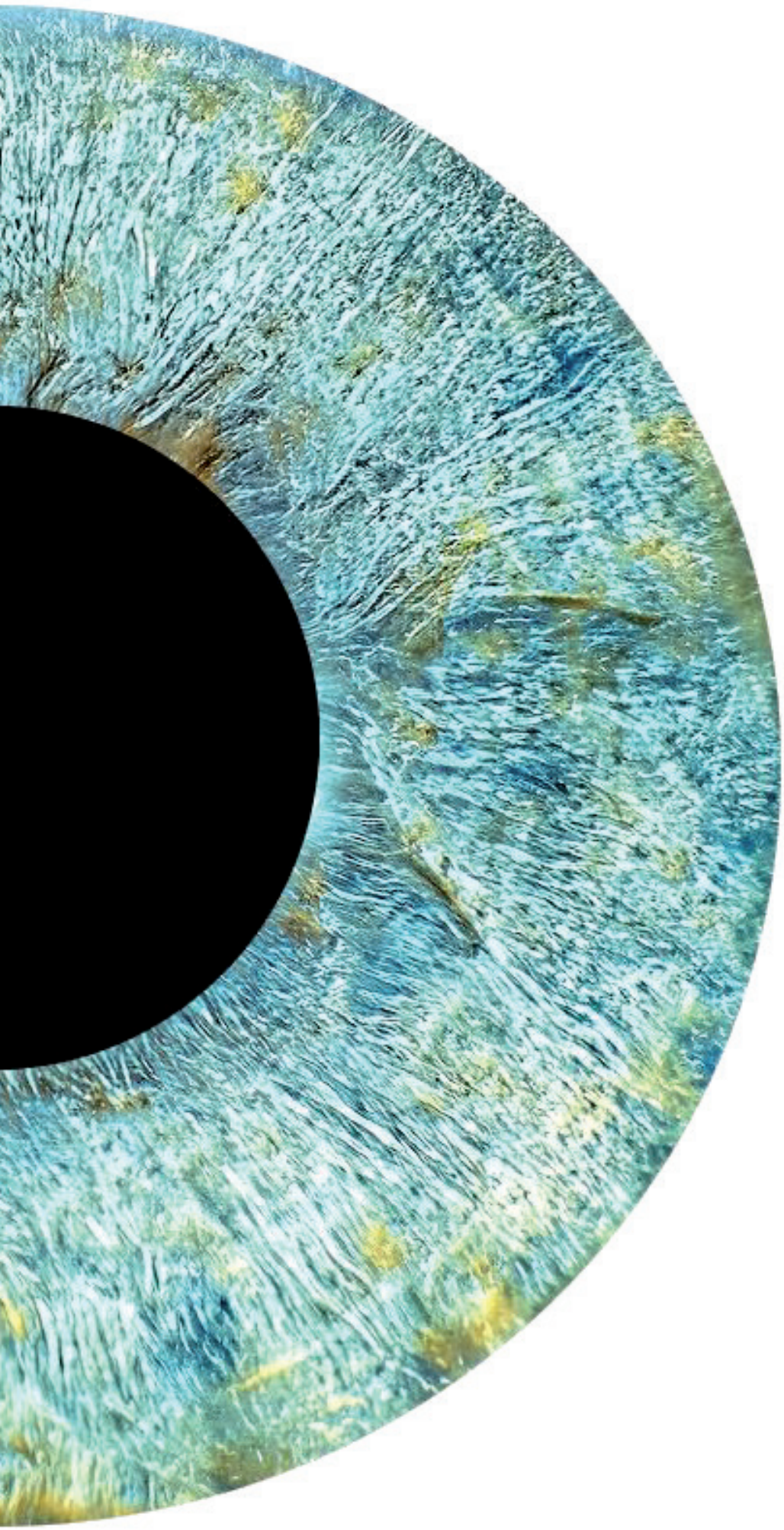


FIGURE 175: Chronical severe complications after cosmetic IOLs



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PART 4

COMPLICATIONS

CHAPTER 12 TREATMENT

4 12.1 Medical

The best way to avoid complications derived from laser Iridoplasty is a good selection of candidates, ruling out contraindications, and preventing problems in each patient according to their medical history. Undoubtedly, the main complication is elevated pressure, so we must carry out a physiodynamic check-up taking into account the volume of the anterior chamber, the chamber angle, the type and volume of melanin pigment to be treated, and the ability to evacuation of the trabeculum. Through the Analyzer software we can predict the risk and plan the treatment phases.

If, despite this, we observe an acute rise in ocular pressure, we must apply the usual treatment, which consists of the administration of hypertonic serum, acetazolamide, beta-blocker and miotic eye drops (or mydriatics in the case of hypertensive miosis). For cases of iritis, the treatment will be the usual one with topical steroids and mydriatics. In cases of persistent medial dilatation, we can use Pilocarpine eye drops to favor its closure.

FIGURE 176: Regular medical treatment in acute glaucoma cases

4 12.2 Laser teraphy

As for laser treatment, we have two types that we can use: YAG and green. YAG is indicated for performing iridotomies in cases of narrow angle, and for the disintegration of pigment deposits that are not spontaneously reabsorbed over time. YAG can also be used to section small inferior anterior synechiae between the base of the iris and the corneal endothelium. The green laser is useful for us to perform gonioplasty at narrow angles and also for the compaction of nonreabsorbed melanin residues.
These remains can first be
constricted with a green laser, and then disintegrated with YAG.

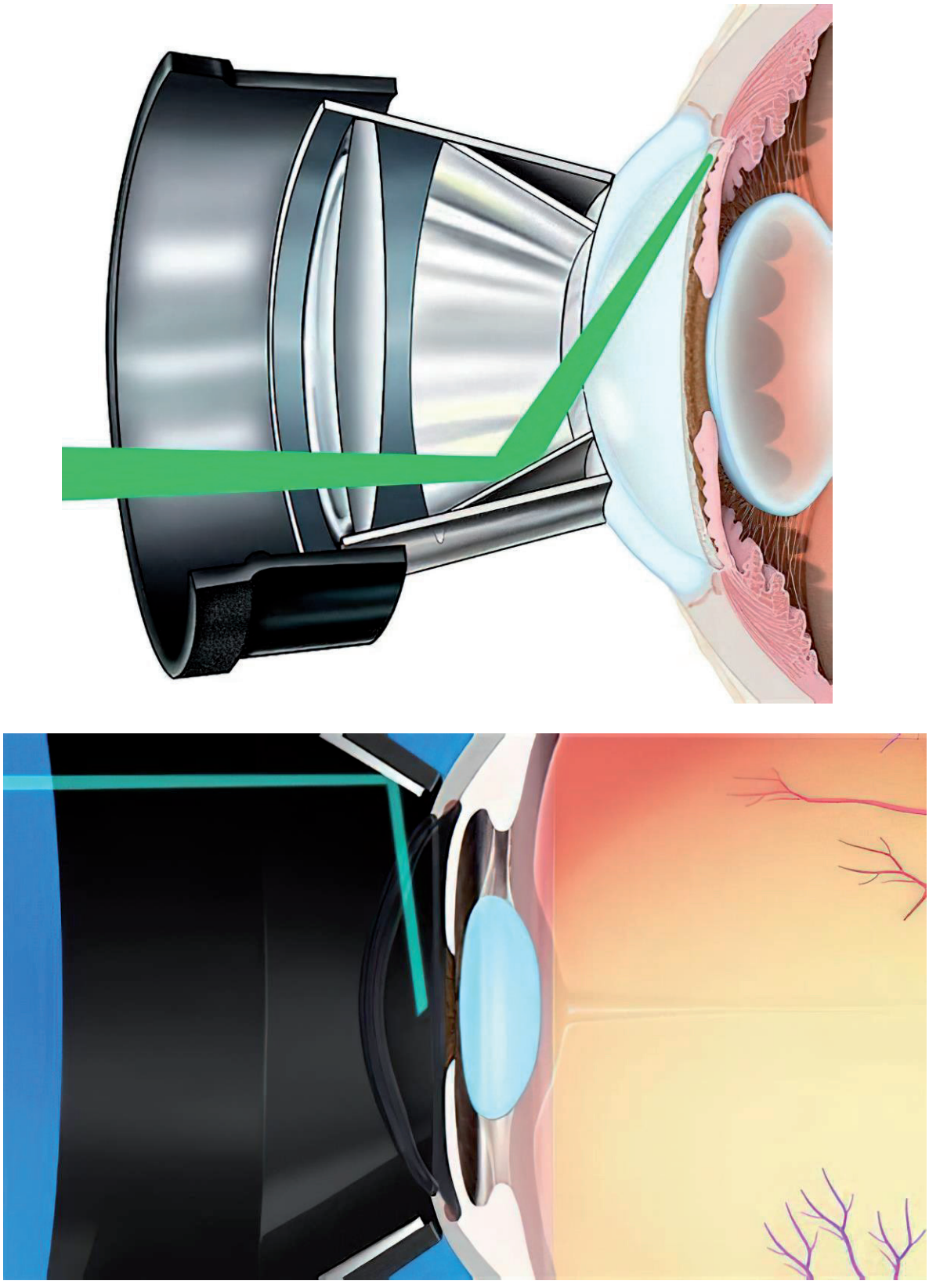
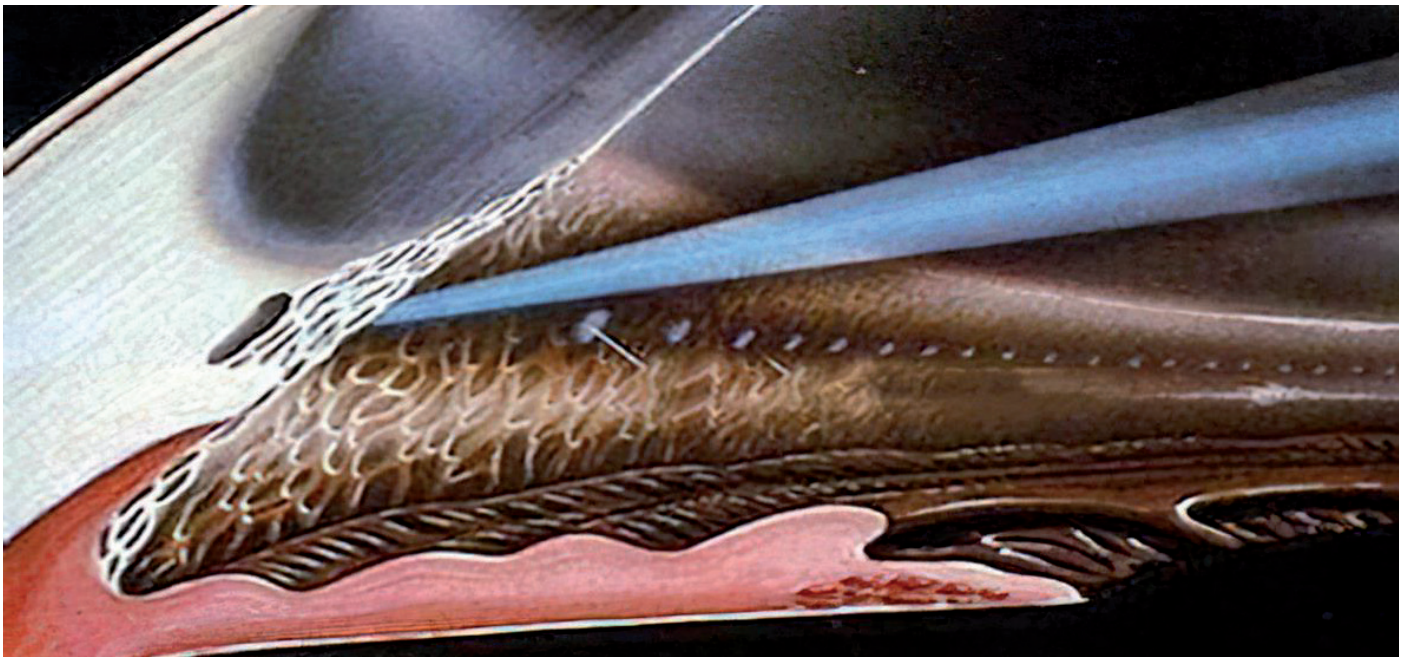


FIGURE 177: Yag and Green lasers are used for AC complications

4 12.3 Trabeculoplasty



Laser trabeculoplasty is a surgical procedure that treats open-angle glaucoma by lowering intraocular pressure. Op nangle glaucoma, the most common type of glaucoma, occurs when the eye's drainage angle is clogged. This results in a backup of aqueous humor (the clear fluid that gives eyes shape and nutrients) and causes increased eye pressure and damage to the optic nerve over time. Laser trabeculoplasty uses a laser to target the trabecular meshwork, which is a structure in the drainage angle. This allows eye fluid to flow at a normal rate and reduces intraocular pressure.

There are three types of laser trabeculoplasty:

1.Selective laser trabeculoplasty (SLT). Also called a cold laser, this device uses minimal heat compared to other lasers.

2.Argon laser trabeculoplasty (ALT). Uses a thermal heat laser to target the tissue.

3.Micropulse laser trabeculoplasty (MLT). Uses pulsing energy to target the tissue.

Selective laser trabeculoplasty is the most popular form of laser trabeculoplasty due to less scarring. It can also be repeated as needed. Laser trabeculoplasty is recommended when glaucoma medications alone do not lower intraocular pressure. Selective laser trabeculoplasty may also be recommended as a first-line treatment for people who can't tolerate or afford daily medicated glaucoma eye drops to reduce eye pressure. Laser trabeculoplasty is an outpatient procedure performed in an ophthalmologist's office. The procedure takes 10 to 15 minutes and is painless. Selective laser trabeculoplasty uses laser energy to target the trabecular meshwork (drainage tissue).

This action opens up the trabecular meshwork while allowing better fluid drainage and lowering eye pressure.

FIGURE 178: Laser Trabeculoplasty SLT or ALT to clean trabeculum

4 12.3 Trabeculoplasty

Laser Iridoplasty has shown a very high level of safety during 10 years of follow-up, thanks to a good selection of candidates and following strict medication protocols, the use of adequate lasers and planning in phases of the complete procedure. In our casuistry, we have only evaluated the performance of Laser Trabeculoplasty in two patients with high hypertension (25 to 30 mmHg) that required the use of beta blockers. Finally, only one of them underwent trabeculoplasty, with a totally satisfactory result. Regarding the three types of laser trabeculoplasty, in cases of Iridoplasty the most indicated in SLT due to the mechanism of action, but ALT could also be useful for cases of angular remnants that want to be reduced in size and then disintegrated.

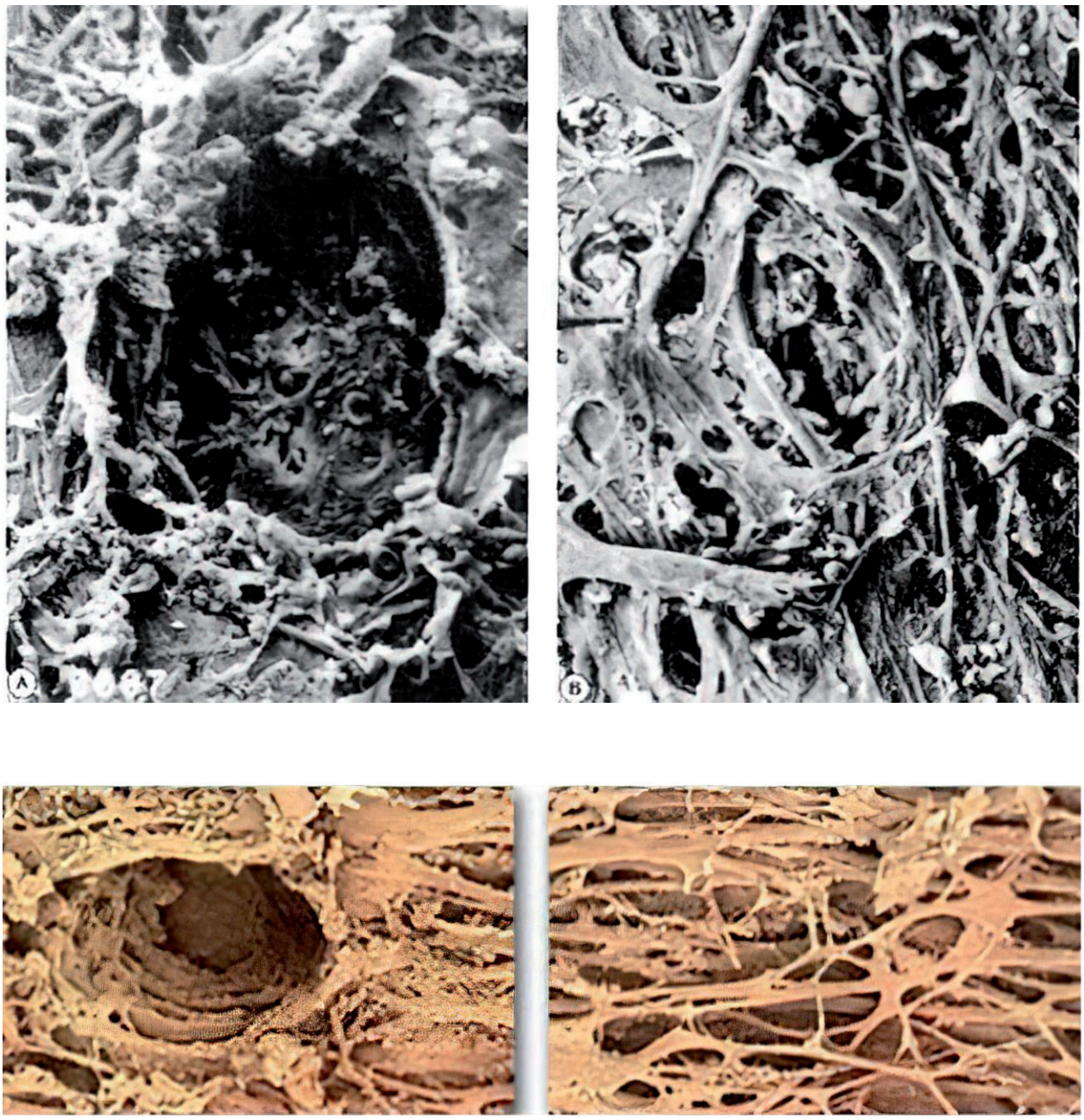
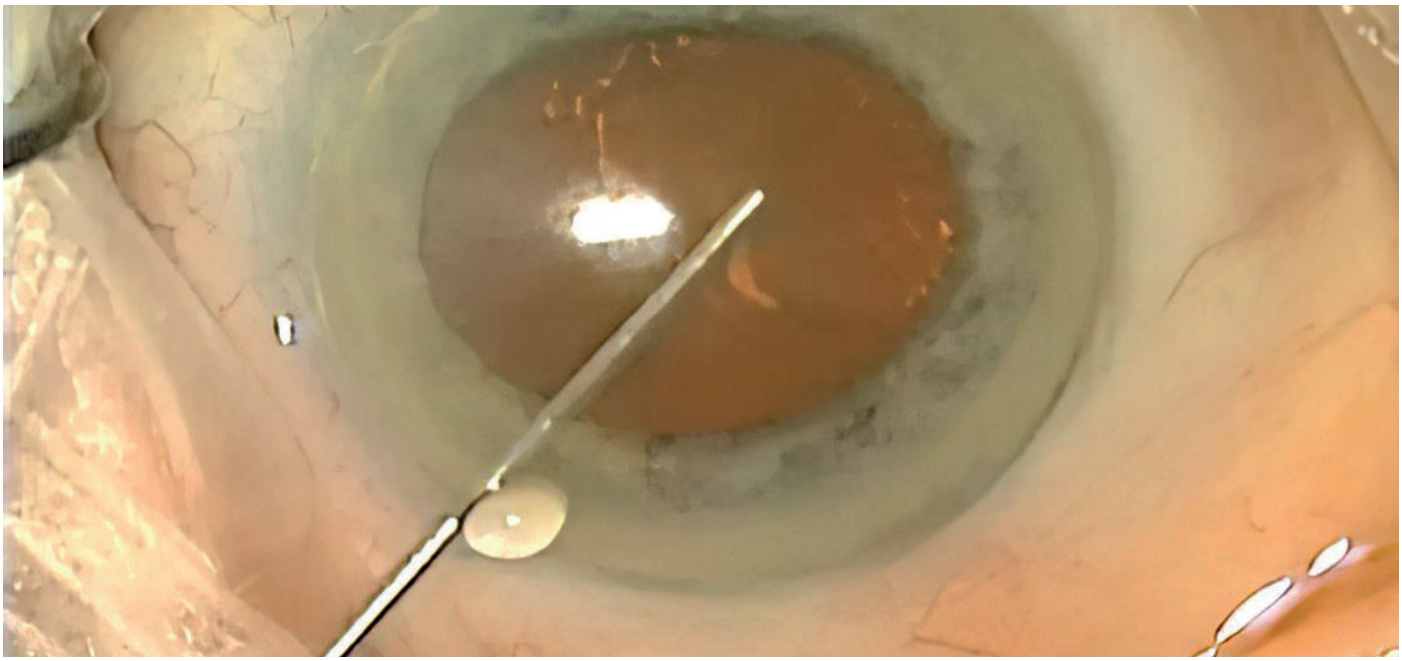


FIGURE 179: Different tissue damage between ALT, SLT and MLT

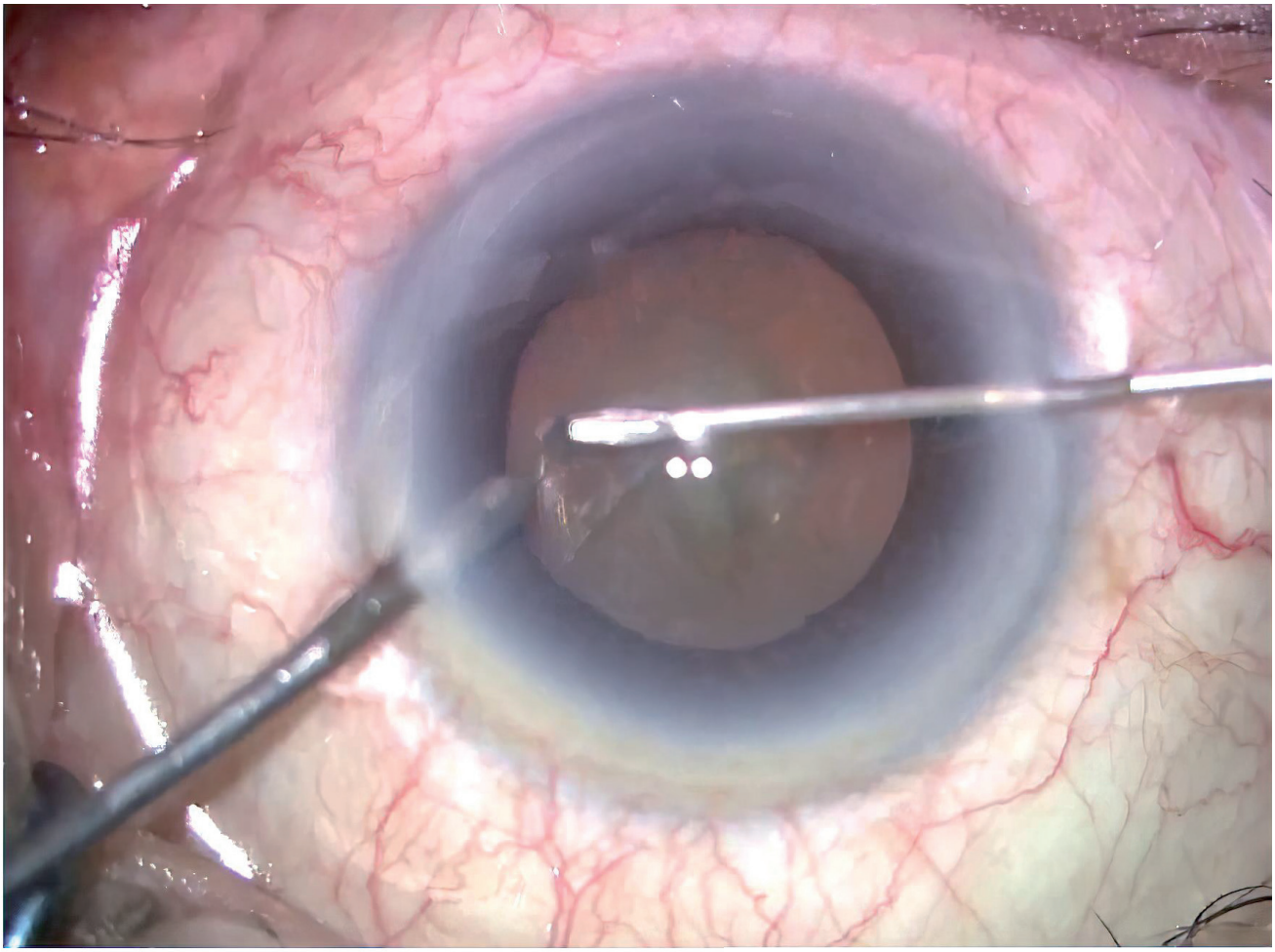
4 12.4 AC Washout

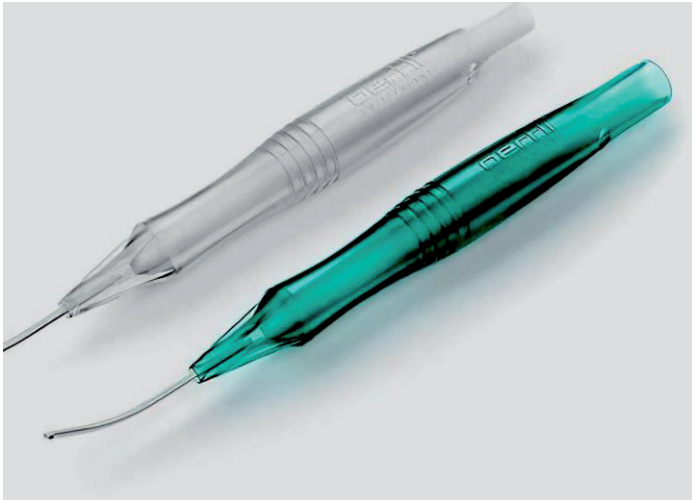


Anterior chamber washout for traumatic hyphema. Sustained elevation of IOP despite medical therapy is a definite indication for surgical intervention. Most commonly IOP is elevated due to outflow obstruction of the trabecular meshwork. Current microsurgical instruments and techniques may offer better results with earlier intervention if absolutely needed. An IOP of 25 mmHg or more for 5 days with a total hyphema or an IOP of 60 mmHg or more for 2 days are indications for surgery, the former to prevent corneal blood staining. A simple two-port anterior chamber washout with nasal and temporal iris-plane clear corneal incisions has excellent success with limited manipulation of the intraocular structures. Balanced salt solution is irrigated through one corneal incision while the posterior portion of the other incision is depressed to evacuate blood. If an inadequate amount of blood is removed, a handheld irrigation/aspiration unit (eg, Simcoe) may be inserted into one corneal wound for gentle clot removal. Complete extraction is not necessary and attempts to do so may harm intraocular structures. Care should be taken to maintain a formed anterior chamber. A single port with an irrigation/aspiration/cutting probe or a two-port method, with one irrigation

probe and the other an aspiration/ cutting probe, can be used to clear an anterior chamber clot.

In cases of persistence of pigment remains in the anterior chamber with elevated ocular pressure, the indicated surgical technique is lavage of the anterior chamber, as in cases of traumatic hyphema due to ocular accidents.





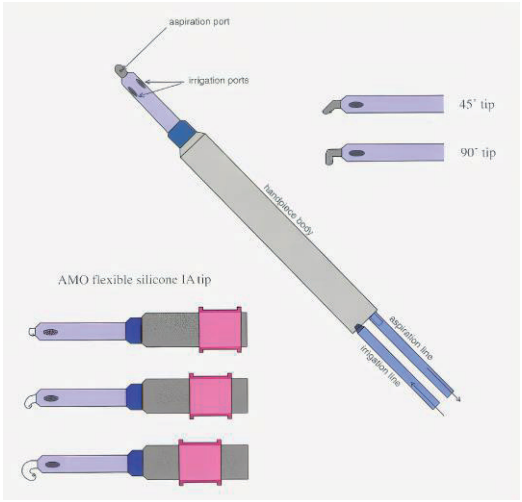
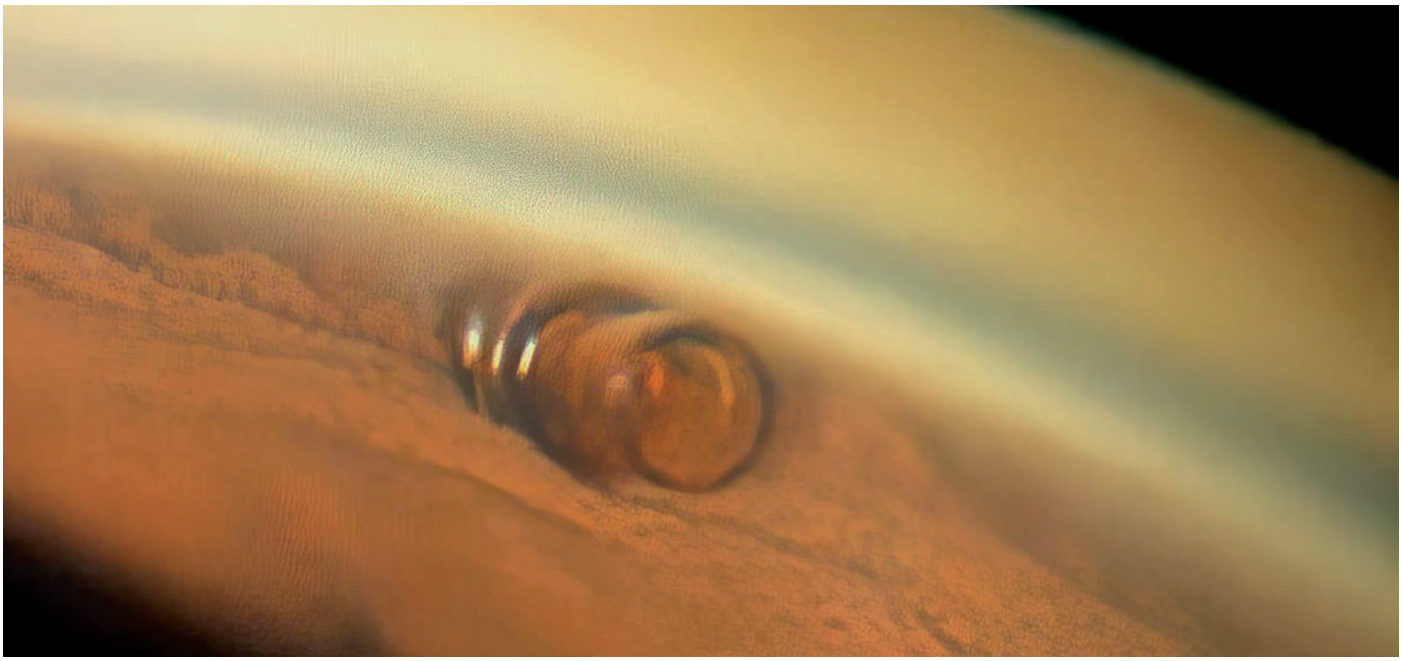


FIGURE 180: Surgical washout for anterior chamber debris

4 12.4 Shunt Surgeries

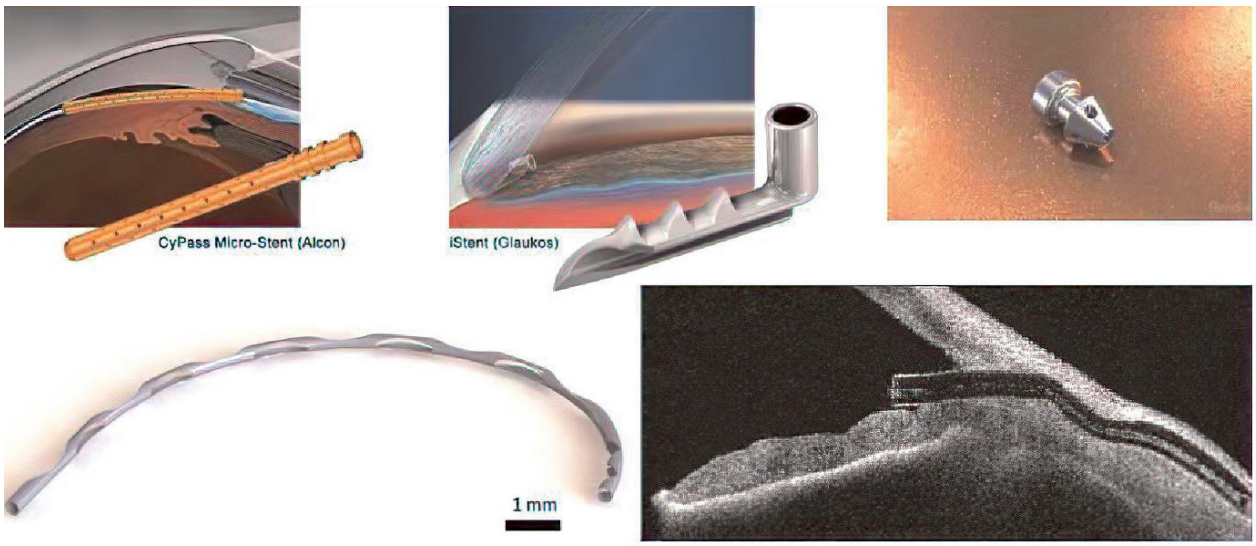


For patients in advanced stages of glaucoma who need low intraocular pressure (IOP), trabeculectomy and tubeshunt surgery remain the mainstay therapies. Both are associated with similar reductions overall in IOP, and both necessitate about the same amount of reliance on supplemental medical therapy after surgery. Traditionally, trabeculectomy has been considered the gold standard glaucoma procedure—the first choice for management of glaucoma patients who need surgery. In contrast, tube-shunt surgery generally has been used as a primary approach only for more complex cases, such as neovascular glaucoma.

Recent results from the Tube Versus Trabeculectomy (TVT) Study, a multicenter randomized clinical trial that compared tube-shunt surgery with trabeculectomy for glaucoma in patients who had undergone cataract surgery or failed trabeculectomy, show that tube shunts are a powerful tool in the fight against glaucoma—with a higher su gical success rate, lower complication rate, and fewer repeat surgeries five years after the procedure compared with trabeculectomy.

Tube-shunt surgery (seton glaucoma surgery) involves placing a flexible

plastic tube with an attached silicone drainage pouch in the eye to help drain fluid (aqueous humor) from the eye. In recent years, some surgeons are using tube shunts or glaucoma drainage devices as first-line surgery and forgoing standard trabeculectomy as the first surgery.



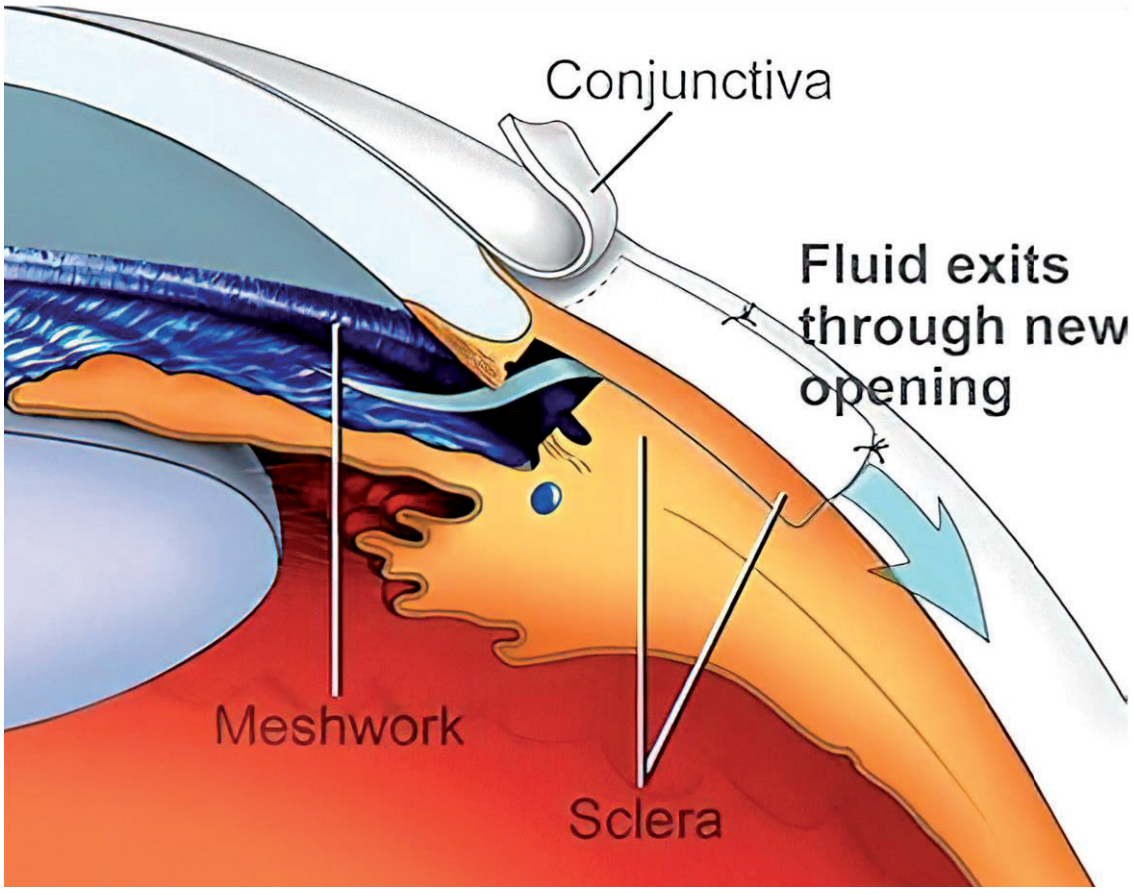
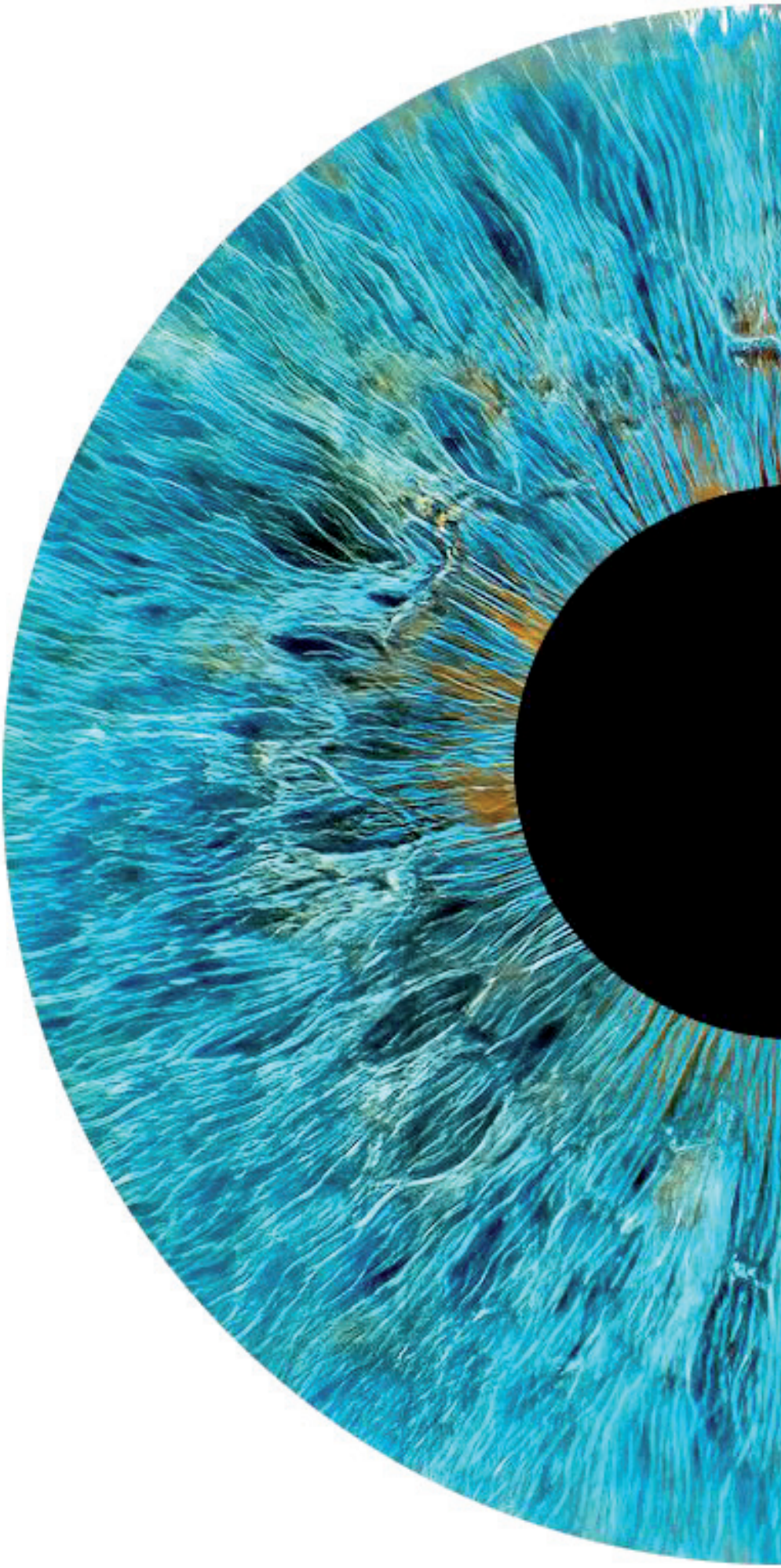
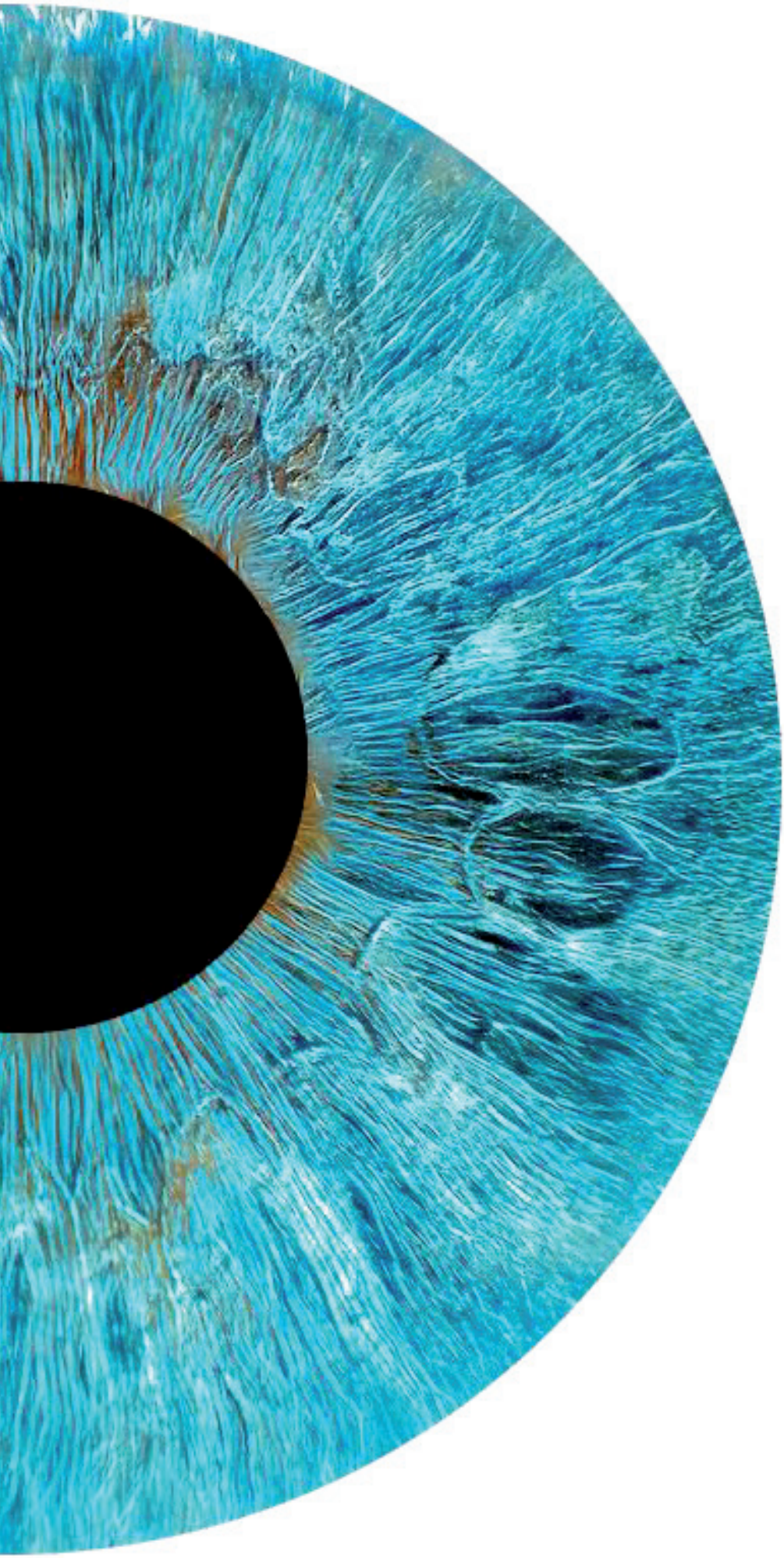


FIGURE 181: Trabeculectomy and Shunt surgeries as final step



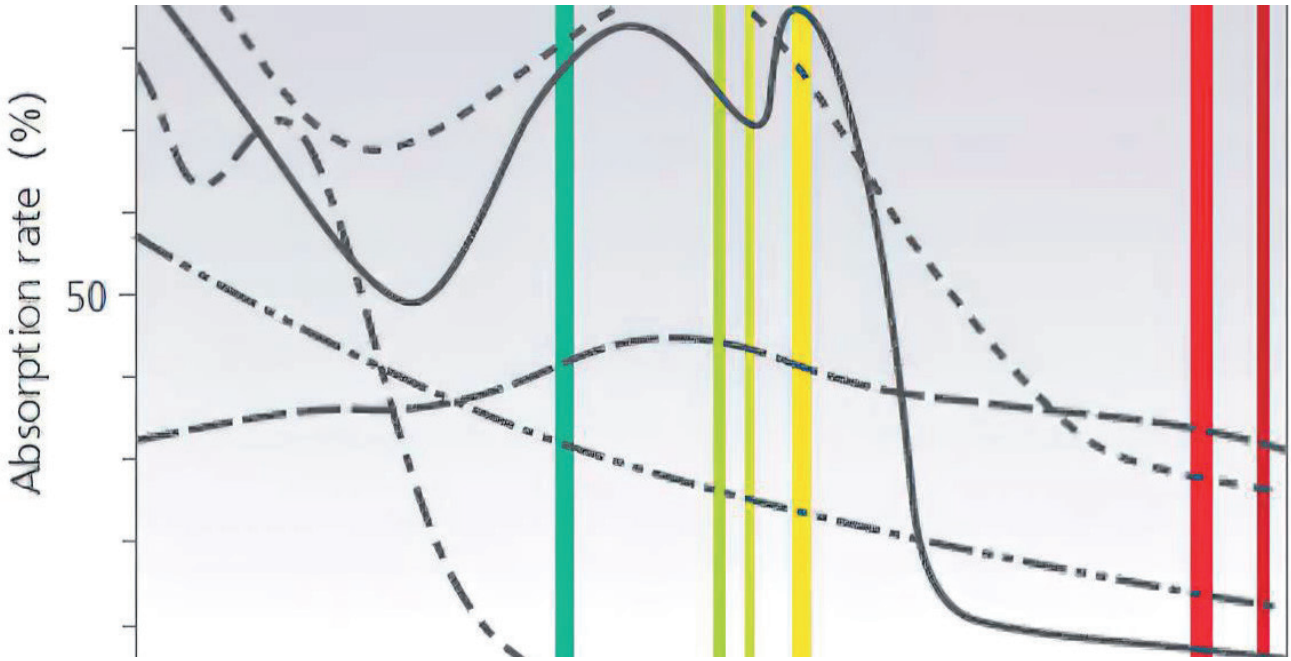


PART 5

DATA ANALYSIS

CHAPTER 13 STATISTICS

5 13.1 Wavelength results



In 2012, we decided to perform a comparative study of four types of equipment: Crystal Q-switched Nd: Yag (1.064 nm), Crystal Q-switched Nd: Yag at double frequency (532 nm), semiconductor optical pump laser (577 nm) and the Crystal Qswitched Nd: Yag at double frequency (532 nm) with 3–4 ns pulses. The 1.064-nm Nd: Yag laser with a photo-disruptive mechanism showed a very high immediate efficacy (90%), and spectacular cosmetic results. However, the safety at 24 h was fairly low (40%), as it produced pressure spikes, blurry vision, and frequent discomfort. Furthermore, the longterm predictability was imprecise due to delayed scarring phenomena (75%). The initial efficacy of the two lasers with a 123 1382 Int Ophthalmol (2021) 41:1381–1393 photo-thermal mechanism, 532 nm and 577 nm, was low and enough (40% and 80% respectively), and although the safety was very high ([90%), they lacked predictability (30% and 70% respectively). The 532-nm Crystal Q-switched Nd: Yag laser with 3–4 ns pulses showed the best levels in efficacy, which was almost immediate (90%), safety (90%), with minimal secondary effects, and short-, mid-, and longterm high predictability: 90–95.5%

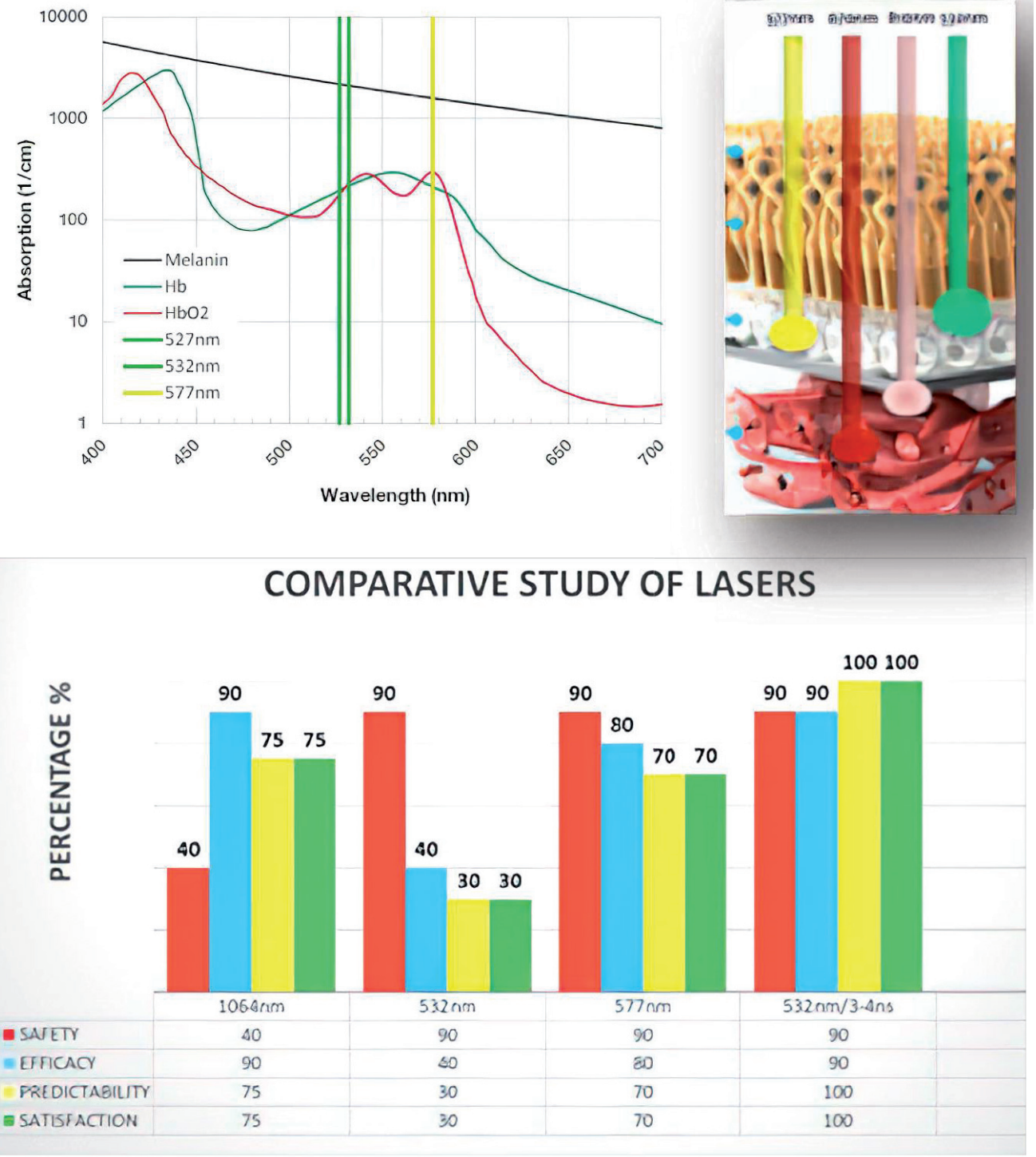
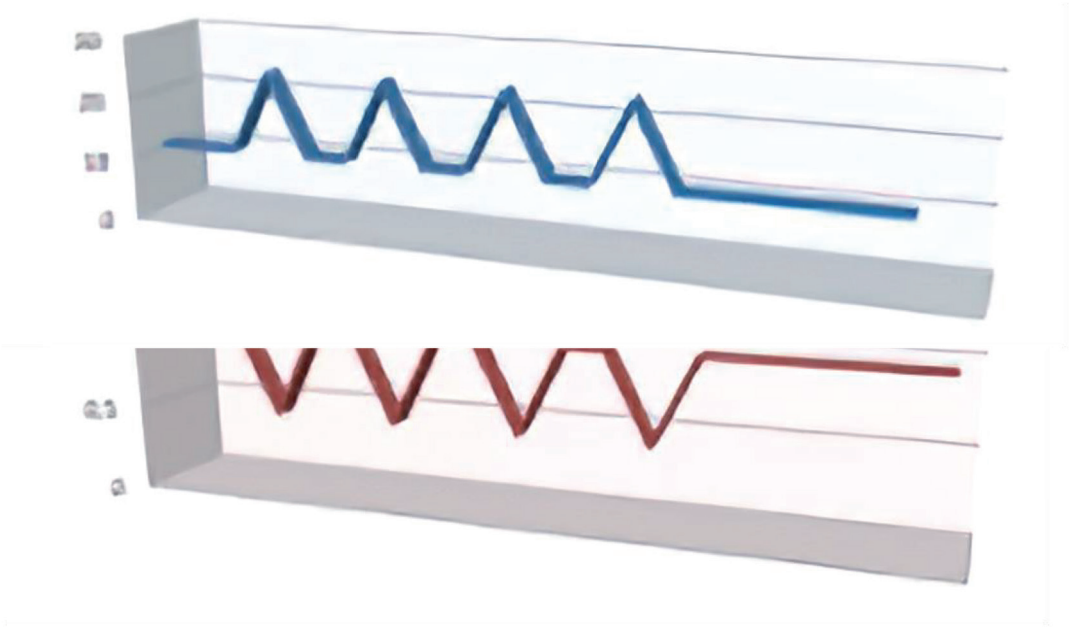


FIGURE 182: Different tissue effects and results as laser wavelength

5 13.2 Vision & IOP



The series studied was highly safe, since it is planned as a sequential procedure in various phases, spaced out over 4-6 months, with adequate medication before and after each session. Prior to the treatment, visual acuity of 0.9-1.0 with best correction was 89%, which did not change after the treatment (p = 0.99999) (Fig. 4). The best corrected vision has shown slight differences in the annual controls, but this has been due to hyperopic shift secondary to the laser and the failure to update glasses and contact lenses, due to small differences in prescription. The mean ocular pressure prior to PCI, using a Goldman tonometer, was 10.6 mmHg, and was 10.8 mmHg following the procedure (p =0.63204). We have found that the long-term trend of eye pressure without any type of treatment has been slightly downward, never upward. We believe it is due to the increase in intraocular volume and chamber angle after removal of the superficial layer of melanin from the iris.

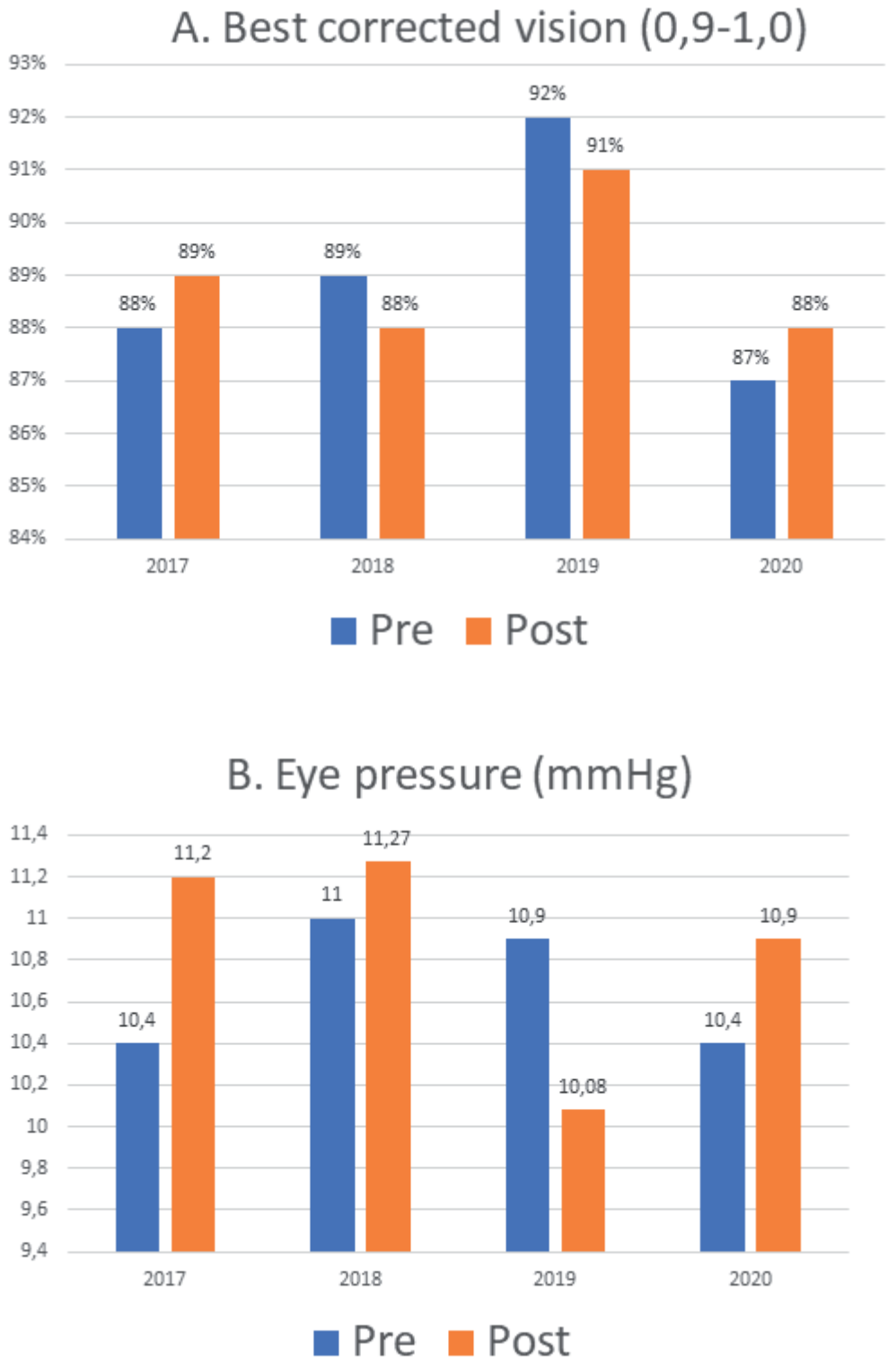
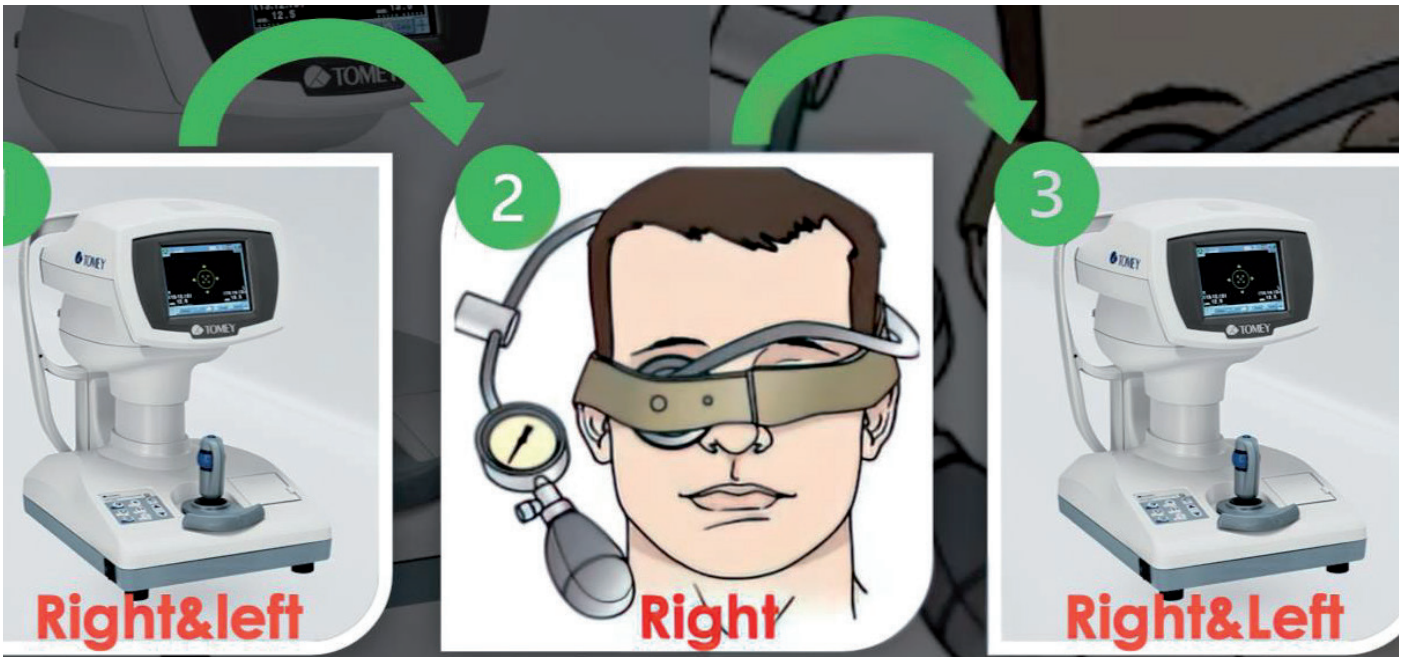


FIGURE 183: Vision and eye pressure levels didn´t impare after laser

5 13.3 Glaucoma risk



Obtaining the intraocular pressure (IOP) before a cosmetic laser Iridoplasty is important to avoid the danger of an immediate increase in IOP. We performed a test on 293 patients with an average age of 35 years. First, we measured the intraocular pressure, then we applied the Honan balloon at 40 mmHg for two minutes. The pressure was measured again no more than 5 minutes after the removal of the Honan.

This procedure resulted in a significant reduction in IOP in most of the patients. The cases where the IOP is maintained or even increased could indicate us a blockage of the trabecular angle. We contrasted the average of IOP decrease between the right eye (after applying Honan balloon) and the left eye (no pressure applied). This resulted in a statistically significant difference (pvalue < 2.2e-16). We also compared the average of IOP decrease between patients in different stages of treatment (p-value = 0.5564) and with different pigment grades (p-value = 0.1662). As shown, in both cases was no statistically significant difference, this indicate us that these parameters are independent with respect to the percentage of IOP decrease.

These results indicate that Laser Iridoplasty doesn´t impare outflow capability through trabecular meshwork in long term, whatever the level of iris pigment or treatment phase. In conclusion, there´s no chronicle glaucoma risk overtime, secondary to Laser Iridoplasty.

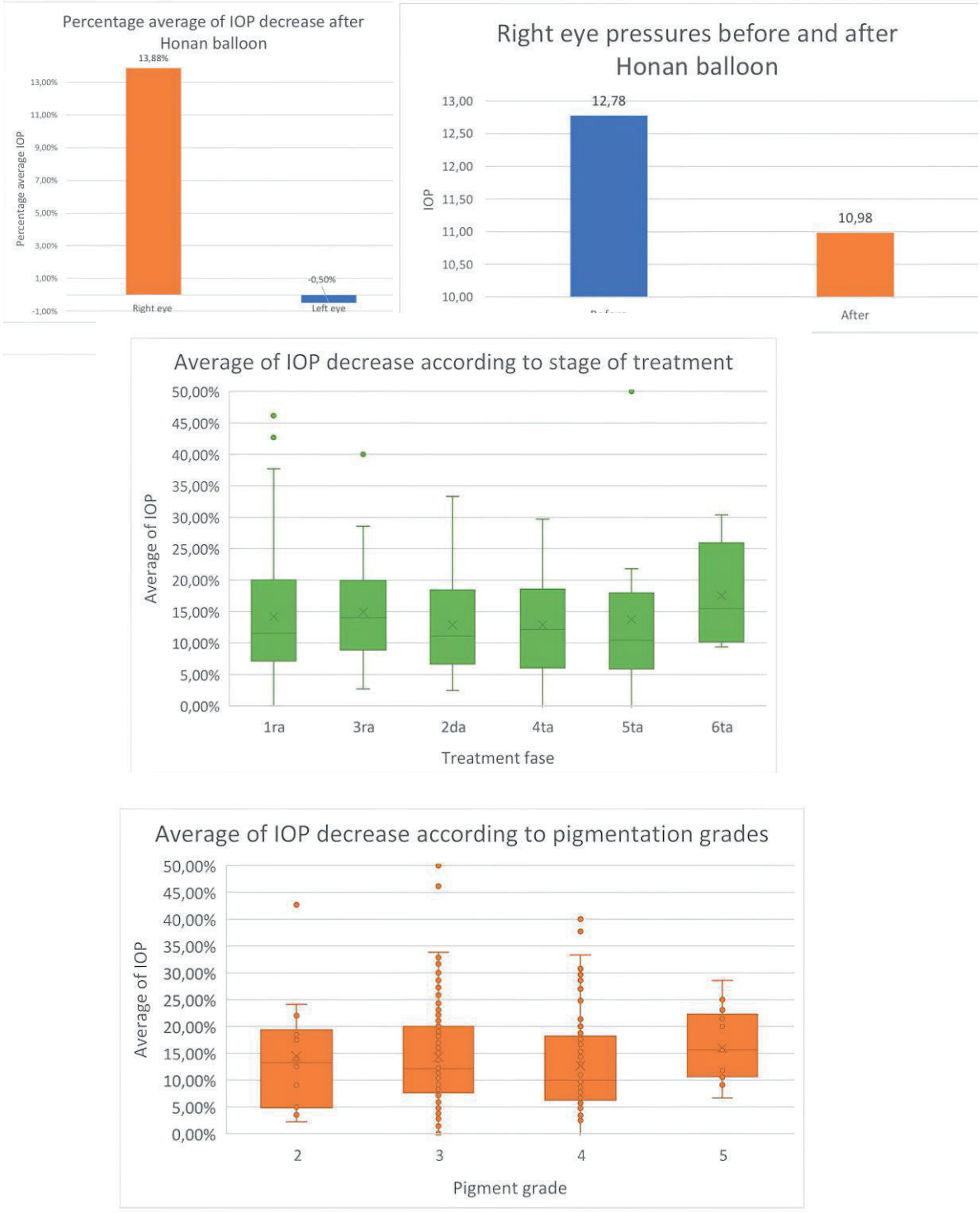
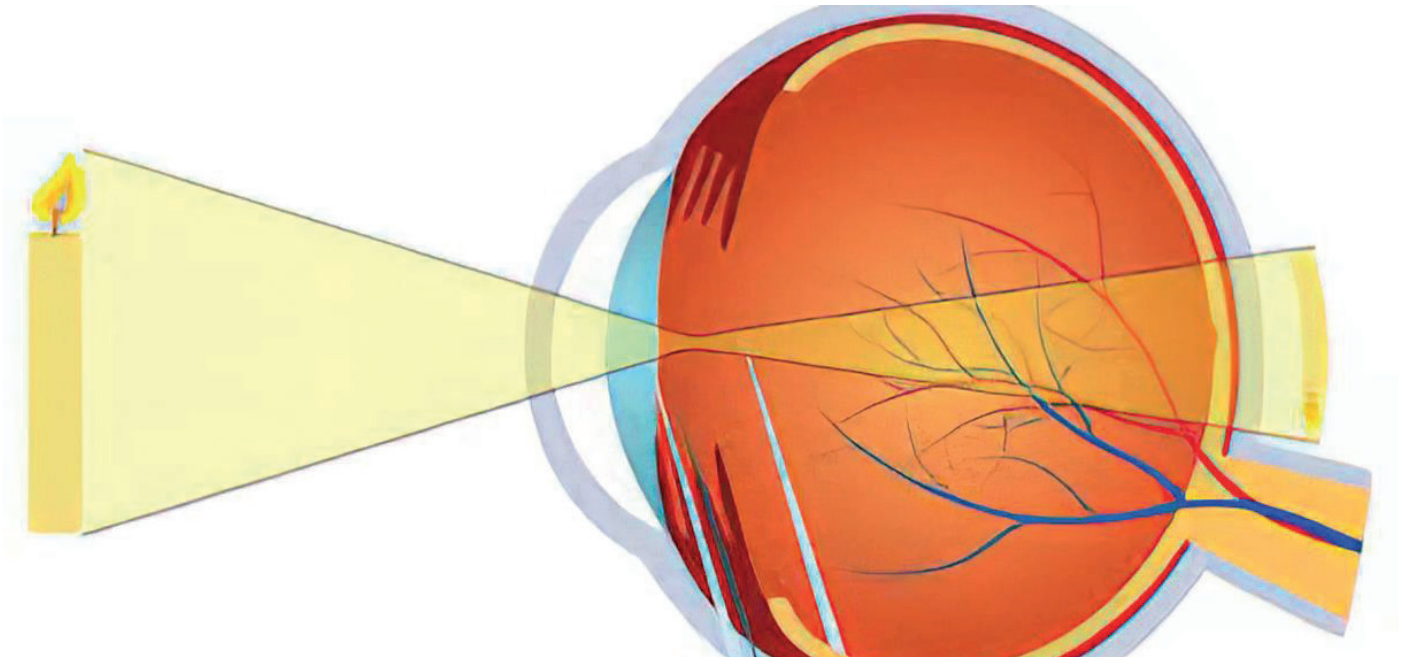


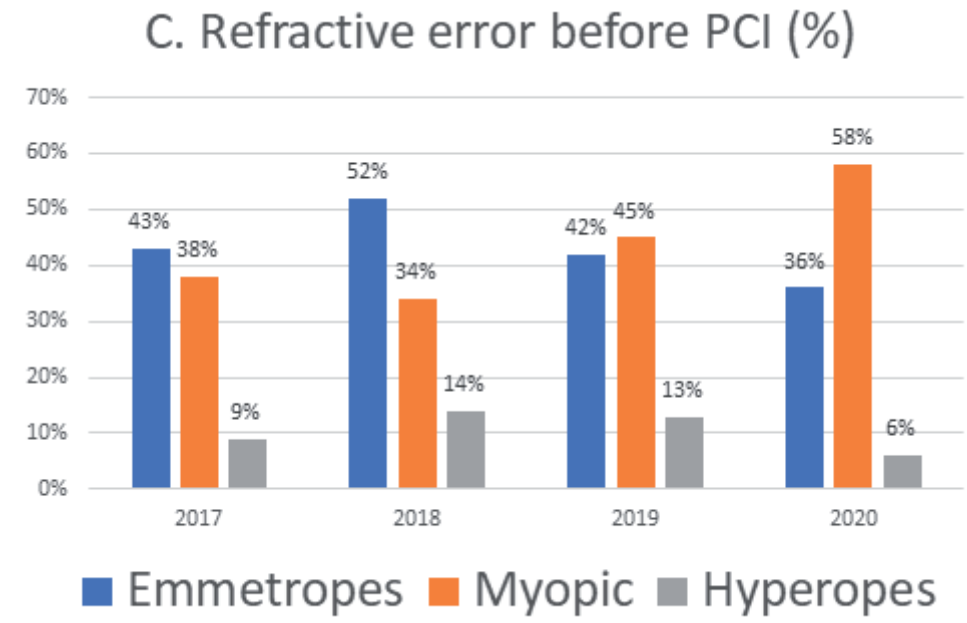
FIGURE 184: Long term glaucoma risk has been rule out by tonography

5 13.4 Hyperopic Shift



The refractive defects prior to PCI were: 43.25% emmetropia, 43.75% myopia, 13% hypermetropia.

Following PCI, the percentages were 43.70% emmetropia, 38.5% myopia and 17% hypermetropia (Fig. 4). After 4-year follow-up, no significant differences were found on emmetropia p = 0.99999; significant differences were found on myopia p = 0.00023; but not significant differences were found on hyperopia p = 0.99999. The refractive errors show a slight hyperopic shift, of ? 0.50/? 0.75 diopters. This phenomenon implied a slight decrease in the number of myopic patients, with or without astigmatism, no change in the percentage of emmetropic patients, and a small increase in hyperopic patients. Some myopic patients became emmetropic and, proportionally, several emmetropes became slightly hyperopic and presbyopic. For practical purposes, this change in refractive errors meant many patients with slight accommodative myopia no longer needed glasses or contact lenses, since their distance vision was ostensibly improved. But, on the contrary, hypermetropia and presbyopia increased in those over 40–45 years old, who began to need reading glasses or an increased prescription.



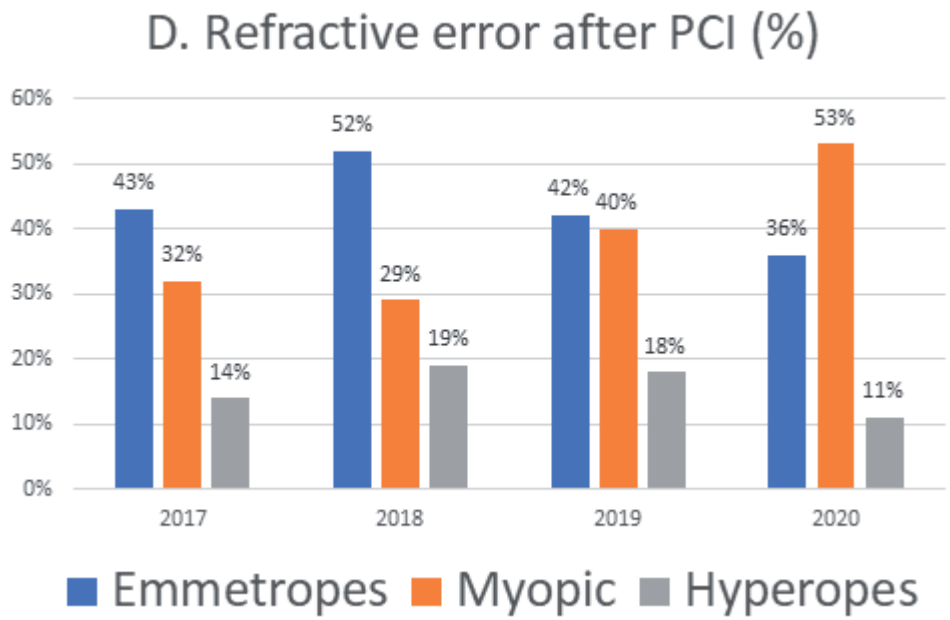


FIGURE 185: Young myopic patients improve a lot after Laser Iridoplasty

5 13.5 Satisfaction

Paradoxically, the patients' subjective satisfaction level does not follow the same pattern as the efficacy and predictability, even though the final result was well predicted at the beginning.

Since the treatment is performed in phases, the brightened area is small in the beginning, and other areas have brown or yellowish melanin in the iris. Therefore, the light that hits the eyes mostly reflects the tones of pigmentation, but not the blue ones. The subjective satisfaction level doesn't depend so much on the patient's own opinion, but rather on comments from their family or friends, and the effect is not maximized until the treatment is complete. Therefore, the satisfaction curve is

ascending, low in the beginning and very high at the end (95%).

Significant difference was found between efficacy and satisfaction $p = 0.09247$; but lower between predictability and satisfaction $p = 0.15403$ (Fig. 5). Fortunately, the latest laser version has allowed us to accelerate the aesthetic effect, and then patient satisfaction curve reaches very high levels just after the first laser phase, in 3 or 4 weeks.

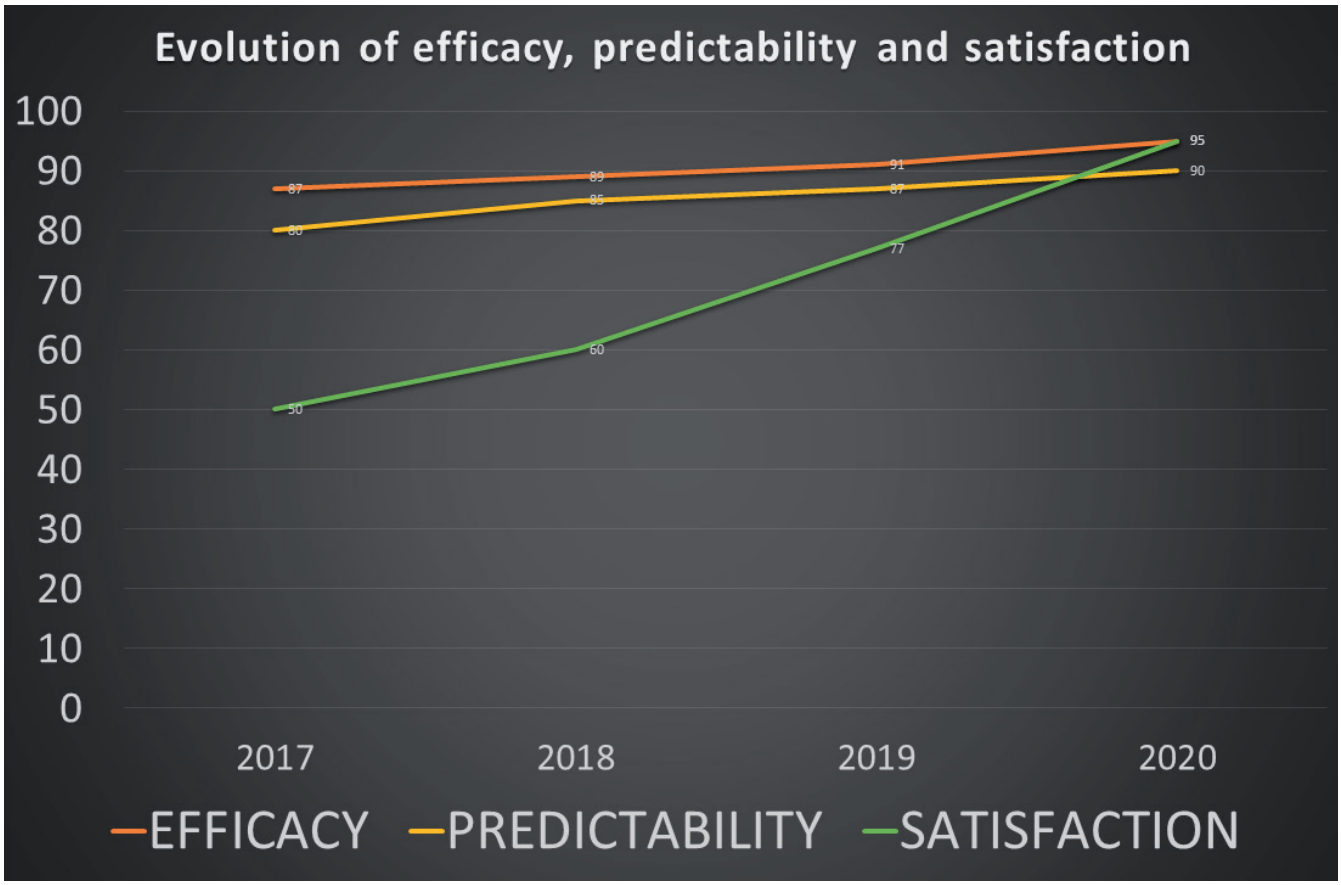
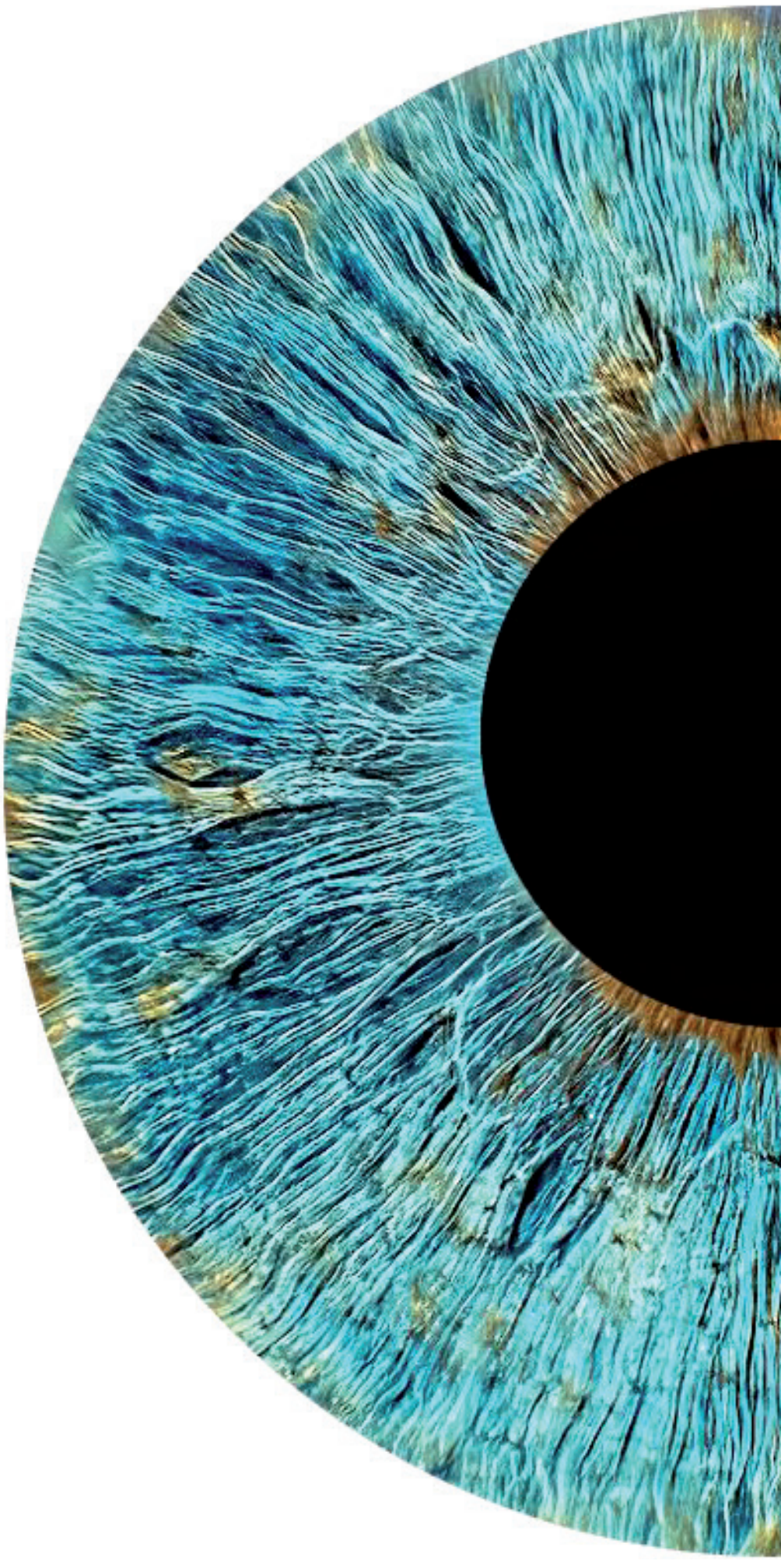
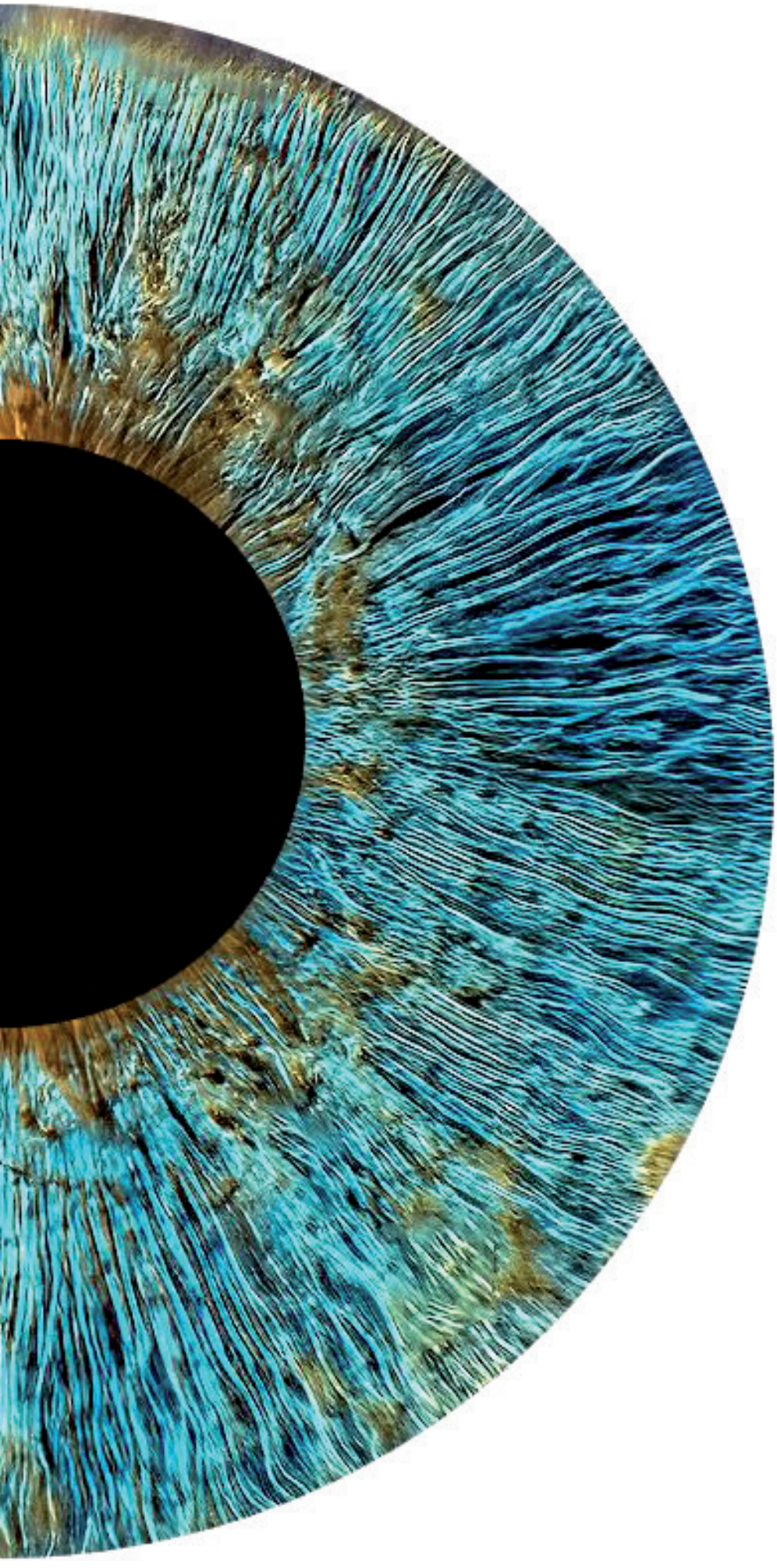


FIGURE 186: Progressive improving satistaction feeling





Int Ophthalmol (2021) 41:1381–1393
https://doi.org/10.1007/s10792-021-01693-5

ORIGINAL PAPER

Photoablative cosmetic iridoplasty: effective, safe, and predictable—eye color change in 1176 eyes

Pedro Grimaldos Ruiz

Received: 7 May 2020 / Accepted: 8 January 2021 / Published online: 23 January 2021

Abstract

Purpose To evaluate photoablative cosmetic iridoplasty (PCI), and its efficacy, safety, predictability, and satisfaction with the 532 nm Crystal Q-switched Nd: Yag laser, with 3–4 ns pulses, for depigmentation of the anterior epithelium of the iris in cases of heterochromia, nevus, or cosmetic indications (eye color change).

Design Prospective clinical study on efficacy, safety, predictability, and satisfaction.

Method The selection of patients was carried out in healthy individuals, over 18 years of age, with iris heterochromia (congenital-7% or acquired, secondary to topical medication-1%, trauma-0.5% or surgery-0.25%), nevus-0.25% and cosmetic cases-91%. Data were collected independently by assistant optometrists and classified in database. Excel statistical program was used to perform a general descriptive study, calculation of correlation factors, and statistical significance analysis between quantitative variables (Student *T* Test). PCI was performed in 1176 eyes of 588 patients. The procedures were planned in 2–3 phases of 4 consecutive sessions spaced 4–6 months apart. The IRÎZ® (Eyecos®) scanner was used to evaluate the cases, with photography, optical coherence tomography, and pneumotonography modules, along with the following software programs: Predictor®, Simulator® 3D, Analyzer® and Planner® (Eyecos®).

Results This study began in 2012, so far 9 years of follow-up, to compare and choose the most suitable among 4 types of lasers to perform cosmetic iridoplasty. Finally, after 5 years, the Crystal Q-switched Nd: Yag at double frequency (532 nm) with 3–4 ns pulses demonstrated the highest efficacy, safety and predictability, so since early 2017 only this equipment has been used. Significant differences were found after 5-year follow-up between 1064, 532, 577 and 532/3–4 ns $p = 0.09172$, 0.06377 and 0.10183. From 9 January 2017 to 28 February 2020, 1176 eyes have been treated in 588 patients, with a mean age of 33.7 years (SD = 9.68 years, range = 18–70 years). 46.2% were male, and 53.7% were female. The efficacy, as quantified with the Analyzer® comparison software, was nearly 87–95%. There were no significant differences in corrected vision (9 years total follow-up $p = 0.78235$; last 4 years FU $p = 0.99999$) and ocular pressure (9 years total FU $p = 0.68251$; last 4 years FU $p = 0.63204$) before and after the procedure. The only notable complications (25%) were delayed and brief iritis, which were self-limited with routine topical treatment. The predictability was 80–90%. In the lightest-colored eyes, turquoise blue colors were obtained as a rule, in varying brightness; and in the darkest ones, gray blue tones of varying lightness. The patients' subjective satisfaction at the end of treatment was 95%.

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PART 6

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Eye Surgeon and Innovator

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- Bachelor of Medicine and Surgery. University of Valencia. Faculty of Medicine 1979-1985
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- Specialist in Ophthalmology. Clinical Hospital of the University of Valencia 1985-1990
- Doctoral Thesis Cum Laude
- Stay at Bascom Palmer Eye Institute of the University of Florida 1992
- Stay at the Doheny Eye Institute of the University of Southern California 1994
- Organization of numerous Congresses of Eye Surgery
- Presentation of numerous clinical research studies
- Invention of Presbilaser to correct Presbyopia with laser (2000)
- Invention of Cosmetic Laser Iridoplasty – Laser NewEyes (2012)
- Extensive research on laser and diagnostic equipment, applications and ophthalmic software
- Development of the NewEyes Laser Workstation with Apps, Scanner, Analyzer, Planner and 7G Laser
- Currently developing numerous R&D projects