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A GLIMPS TO THE MODERN OPTICIANRY TECHNIQUES

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Abstract

Millions of people are suffering from eye refractive errors such as myopia, hypermetropia, astigmatism, presbyopia, etc. Every day, modern opticianry techniques were used to diagnose and treat the patients. And they find solutions to such disorders; therefore, touching the lives of millions of people. In the last decades, laser surgery becomes popular. However, it still has the risk to damage the inner structure of eyeballs such as the inner lens, cornea, etc. Laser surgery is costly since it requires high tech equipment and good experience with outstanding surgical skills. At this point, people continue their daily life via their glasses or contact lenses where simple and effective techniques can solve the problem of millions of people who suffer from refractive errors. In this report, we briefly explain the eye refractive errors and lenses used in the treatment of such errors. We discuss lens types and properties, lens prescriptions, lens cut and preparation techniques, frame types, and contact lenses.

Key Words: Refractive errors; Lenses; Myopia; Hyperopia; Astigmatism

MODERN OPTİSYENLİK TEKNİKLERİNE BİR BAKIŞ

Öz

Milyonlarca insan miyopi, hipermetropi, astigmatizm gibi göz kusurlarından muzdariptir. Her gün modern optisyenlik teknikleri kullanılarak milyonlarca insanın muzdarip olduğu bu göz kusurları teşhis ve tedavi edilmektedir. Son yıllarda lazer cerrahisi gibi teknikler göz kusurlarının tedavisinde yaygın olarak kullanılmaktadır. Ancak bahsi geçen tekniklerin göz küresinin içerisinde bulunan kornea, mercek aköz hümor gibi hassas yapılara uygulanması oldukça risklidir. Lazer cerrahisi operasyonlarında yüksek teknoloji içeren ve sınırlı sayıda üretilmiş cihazlar kullanıldığı için bu uygulamalar oldukça pahalıdır. Ayrıca bu operasyonların başarılı bir şekilde uygulanabilmesi için yüksek tecrübeli ve iyi yetişmiş hekimlere ihtiyaç duyulmaktadır. Bu sebepten insanların çoğu günlük hayatına gözlük ya da kontak lensler ile devam etmektedirler ki bu aparatlar basit ve etkili bir şekilde insanların göz kusurlarından doğan sorunları ortadan kaldırmaktadır. Raporumuzda kısaca göz kusurlarını açıklayıp göz kusurları tedavisinde kullanılan lensler tartışılacaktır. Ayrıca cam (lens / mercek) tipleri ve özellikleri, gözlük camı reçeteleri, gözlük camı (lensi) kesim ve hazırlama teknikleri, çerçeve tipleri ve mercekler ile ilgili genel teknik bilgiler verilecektir.

Anahtar Kelimeler: Göz Kusurları; Mercekler; Lensler; Miyopi; Hipermetropi; Astigmatizm

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1. Introduction

Millions of people suffer from refractive errors. Refractive errors are often referred to as a disorder since refractive errors occur as a result of a dysfunctional part of the eye. Myopia, hyperopia (hypermetropia), presbyopia, and astigmatism are prevalent refractive errors. It was estimated that the number of people with refractive errors is between one and two billion. Global burden of diseases report of 2013 claims that almost 10 % of people do not aware of their refractive error and/or are living with not corrected refractive error [1]. Epidemiology of the refractive errors alters depending on the region; it was predicted that almost 25% of Europeans suffer from eye refractive errors while such percentage increases up to 80% in some Asian countries [2]. Myopia is one of the most common disorder which defines nearsightedness [3]. The people suffering from myopia cannot see the objects which are far away from their eye. Another common refractive error is hyperopia or also known as hypermetropia where people suffering from such a disorder are not able to see the object which is close to their eye. Astigmatism is another refractive error where the eye of the patient cannot focus the light properly on the retina due to deformation of the cornea. Since the light comes from different angles the vision of the patient was blurred.

Unfortunately, there is no simple medication or drug-based treatment to overcome such refractive errors[4]. Laser eye surgery, which is also known as LASIK (laser-assisted in situ keratomileusis), is a promising method to correct presbyopia, myopia, hyperopia and astigmatism [5]. In most cases, it corrects the refractive errors. However, it is not suitable for each eye. There are certain criteria to define the suitability of an eye. For example, eye pressure is an important criterion in the assessment where the patients with high intraocular pressure and glaucoma are not suitable for such operation [6], [7]. It was reported that eye surgery often increases intraocular pressure. Therefore, patients with glaucoma and high intraocular pressure have a risk to damage the inner structure of the eye [6]–[8]. The thickness of the cornea is also an important criterion where thin corneas pose a risk [9]. It was reported that corneal thickness decreases after eye surgery [8], [10]. Moreover, corneal infection (keratitis) may be observed after eye surgery which may have a deteriorative effect on eye health [6], [11]. Laser surgery has certain risks for eye health. The procedure is quite complex, and the equipment used in the surgery is sophisticated and costly which uses high tech gears and software. Such a case increases the cost of the operation reduce and affect the patience

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preference [12]. Moreover, the equip take part in the operation should have a vast experience about the process. Hence, training requires a long time, and sophistication in the field is essential to reduce the risks and increase the success rate which also increases the price of the operation [13].
At this point, modern opticianry techniques help patients to solve their refractive error problems. Modern opticianry techniques can easily diagnose and treat refractive errors. The techniques and equipment used in the correction of refractive errors are facile and cheap. The training of an optician is slightly easier than that training of an ophthalmologist. The technique and tools used in the correction of a refractive error are safer than refractive surgery which minimizes the long-term eye health risks. Due to the benefits mentioned above, people chose modern opticianry techniques to correct their refractive errors. Such techniques are simple, fashionable, affordable, reliable, and safer.
In this report, we discuss modern opticianry techniques that are used in the preparation of glasses for people with refractive errors. Hence, we first illustrate the basic anatomy of an eye, refractive errors, lenses, lens types, lens properties, lens cutting techniques, frame types.

2. Essentials Of Optıcıanry

2.1. Eye Anatomy

The eye has a quite complex structure that consists of different segments and parts. The purpose and structure of each part are different from each other. Basic anatomical parts of an eye were presented in Figure 1. Basic anatomical parts were as follows:

Cornea: Cornea stands in the very front part of the eye. It is transparent. Light coming into the eye pass through the cornea. The main refraction occurs in the cornea. The refractive power of the cornea was estimated as 43 dioptres [14]. Such a case means that most of the refraction sustaining the eyesight exist in cornea region.

Iris: Iris is the coloured section in the eye. It stays in the anterior chamber. Iris adjusts the amount of light entering the interior chamber and shedding on the lens. It is colourful since it contains colour pigments in its structure. Iris is often accepted to be a part of the choroid.

Aqueous humour: Aqueous humour is a transparent water like fluid that exists in the anterior chamber between the iris and cornea which feeds and supports cornea and iris by providing sufficient pressure.

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Pupil: Pupil is a black hole in the middle of the iris. The light getting in the eye transfer through the pupil. The pupil arranges the amount of light entering the posterior chamber.

Lens: The lens is the main part of the eye that arrange the amount of refraction that accommodates the eye to see the object which is close or far away from the eye.

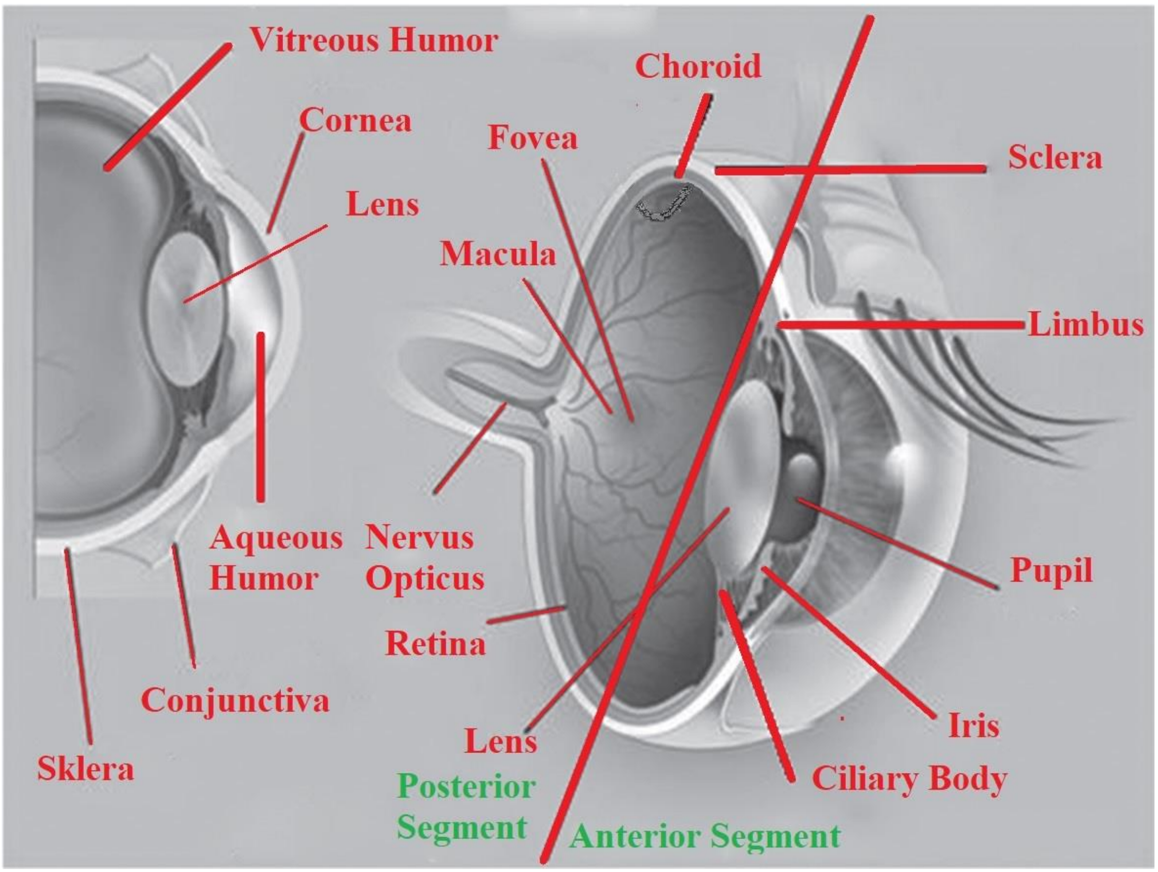

Figure 1. Sketch shows basics of eye anatomy.

Ciliary body: The ciliary body is a part of an eye which is consisting of a special muscle group that surrounds the lens. The muscles adjust the shape of the lens where suitable accommodation and positioning were obtained for the lens for a perfect view.

Sclera: Sclera is a hard and resistant tissue surrounding the eye which is also known as white of the eye. The colour of sclera tissue is white, it helps to protect the inner structure of the eye and contains fibre, and collagen.

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Conjunctiva: The conjunctiva is a vascularized tissue that covers the sclera and position between the eyelid and sclera.

Choroid: The choroid is a vascularised part lying under the sclera. It consists of connective tissues and vessels choroid covers the eye under the sclera which is called the uveal tract. The tract ends in the iris where the iris is also considered anterior uvea.

Retina: Inner wall of the eye was known as the retina. The retina is covered with blood vessels and nerves and photoreceptors. The vision occurs on the retina where the light was converted to electric signals. Macula took part in the eye where the coloured vision occurred.

Macula: Macula is a yellow pigmented area in the retina which has an oval and/or spherical shape.

Fovea: High resolution colour vision was performed in the fovea which is in the middle of the macula where all the colour sensitive photoreceptors exist.

2.2. Refractive Errors and Corrective Lenses

Different refractive errors were known which were reported as follows:

Astigmatism: The eye with astigmatism cannot totally focus on an object. Most of the time single object was seen as doubled. The reason lying behind the phenomena is an irregular structure of cornea which make the incoming light refracted from a different direction. Therefore, a blurred an/or doubled vision was obtained. Cylindrical lenses were used to correct the refractive error where the angular position of the cylindrical lens is important (see Figure 2).

Myopia: An image in the myopic eye was seen blurred and foggy since the lights coming from the image do not fall on the fovea on the retina where it appears before the macula. Hence, the image was not focused properly on fovea and patient with myopia cannot see the objects which are far away. Concave spherical lenses were used to correct the refractive error. Such lenses disperse the light and help the light focus on the fovea.

Hyperopia: Hyperopia is a refractive error that patients cannot see small objects which are close to their eye. The main reason lying behind this case is the refractive error of the lens where the lens in the eyeball over refracts the lights coming from the objects. Therefore, the vision appears beyond the fovea therefor small objects close to the eye cannot be seen. Convex type spherical lenses were used in the correction of the refractive error where convex lenses collect the dispersed light and help the light focus on the fovea.

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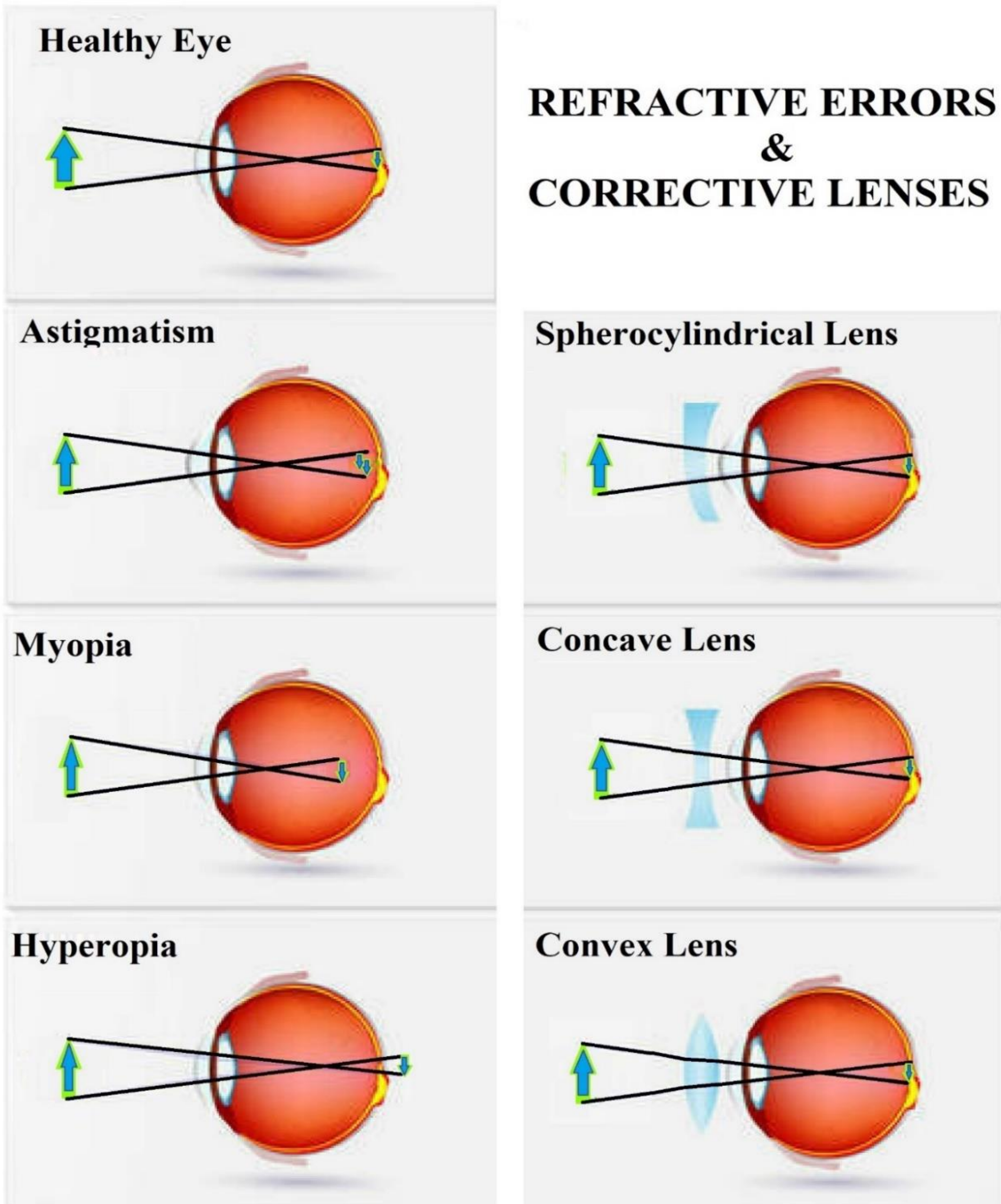

Figure 2. Figure illustrates refractive errors and proper corrective lenses to correct errors.

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2.3. Lens Types

2.3.1. Lens Types by Shape

Three main lens types were used in the corrective of the refractive errors which spherical and cylindrical and spherocylindrical types. Concave and convex type spherical lenses were commonly used in the correction of myopia and hyperopia, respectively. The refractive power of the lenses was measured with dioptre which indicates the refractivity of the lens. Dioptre is often showed as D where

$$D = \frac{1}{f} \qquad \text{(Eq.1)}$$

where D is the power of refractivity, f is the distance between the focal point of the and the centre of the lens. Different D values were known depending on the type of the lens. Spherical and cylindrical lenses were used to correct refractive errors. For example, simple hyperopia was corrected with spherical convex lenses with (+) dioptre value, myopia was corrected with spherical convex lenses with (-) dioptre. Astigmatism was corrected with cylindrical lenses where cylindrical convex (+) and cylindrical concave (-) lenses were used (see Figure 3).

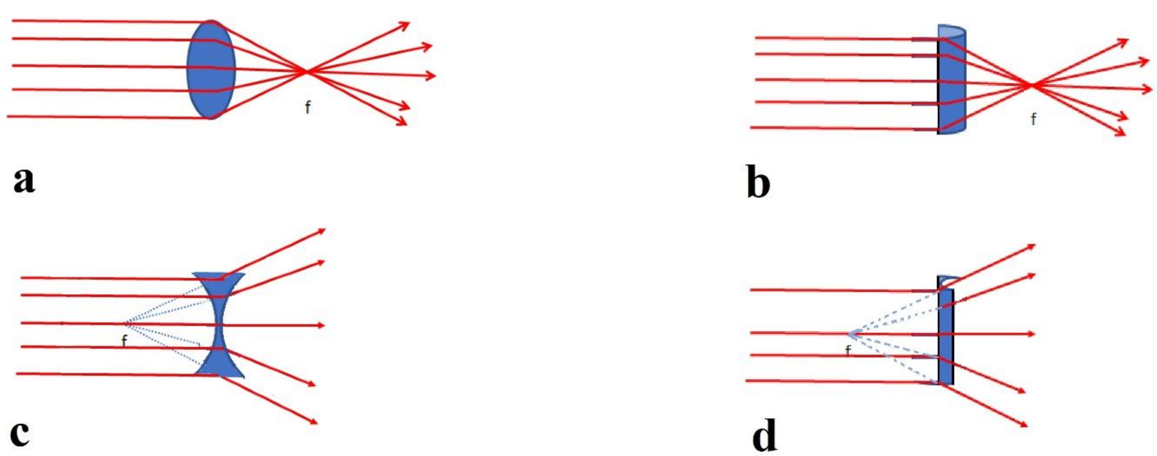

Figure 3. Illustration of spherical convex with (+) dioptre (a), cylindrical convex with (+) dioptre (b), spherical concave with (-) dioptre(c), cylindrical convex with (-) dioptre.

Complex refractive errors require complex lenses for example people may have both astigmatism and myopia, or both astigmatism and hyperopia. At this point mix or spherocylindrical lenses were used. Such lenses are in a complex structure where cylindric lenses were embedded in the spheric lenses. In this case, the embedding angle of the cylindrical lens also affects the correction of astigmatism. Therefore, spherocylindrical lenses were prescribed with embedding angle. If no angle was reported, it should be noted that the embedding angle is 0. If a patient has myopia with astigmatism with (-) dioptres, the patient should have a lens with (-,-) dioptres. In this representation, first - refers to a spheric dioptre value, second – refers to a cylindrical value. Please check Table 1 and Figure 4 for detailed dioptres.

Table 1. Spherocy lindrical lens table.

Lens Marks	Astigmatism with (-) dioptre	Astigmatism with (+) dioptre
Myopia	(-,-)	(-,+)
Hyperopia	(+,-)	(+,-)

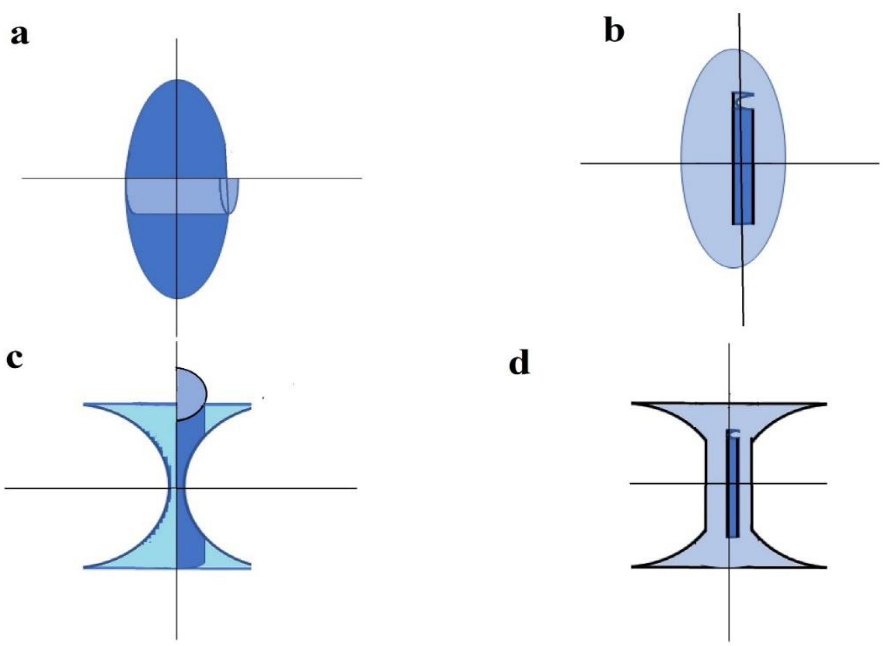

Figure 4. Illustration of spherocylindrical lenses used in the correction of complex refractive errors; lens in a is (+,+), lens in b is (+,-), lens in a is (-,+), lens in a is (-,-).

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Patients may have both myopia, and hyperopia at the same time. In this case, patients shall use two different glasses to overcome such an obstacle. Modern opticianry techniques find a solution for the problem where bifocal and/or progressive lenses were produced.

Bifocal lenses are lenses where convex lenses were embedded in the lower section of the concave lenses. In bifocal lenses, an apparent convex lens can be seen in the lower section of the lens. Progressive lenses have similar characteristics to bifocal lenses. A special region in the lower region of the concave lens act like a convex lens; however, no distinct difference can be seen where the smooth transition between concave and convex sections can be seen (see Figure 5). No apparent difference in the lens surface can be seen with the naked eye. Progressive lenses can be detected and measured with a focometers. Focometer is a special tool that was used to measure the dioptre values and cylindrical angles of lenses.

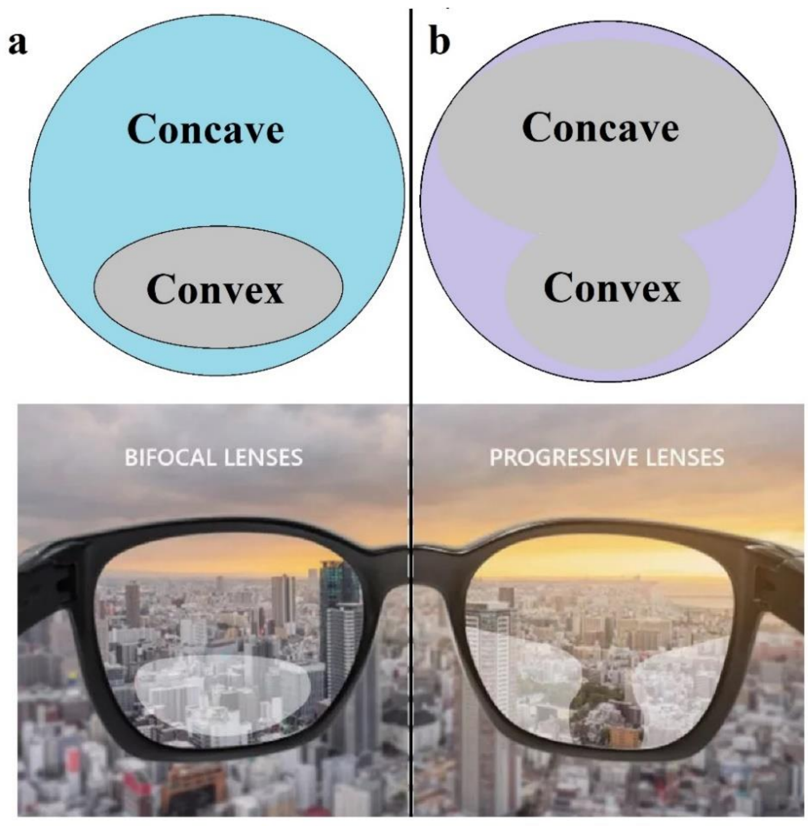

Figure 5. Figure illustrates bifocal (a) and progressive lenses (b).

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2.3.2. Lens Types by Materials

Emerging technological and technical advancements allow manufacturers to produce high quality lenses using different materials. Please see the lenses listed below:

Mineral based Lenses: In the early 20th century, mineral based lenses were used in the glasses that lenses were mostly produced from SiO2, CaO, BaO, Na2O and K2O mixtures. Mixtures were heated till they melt, and the melted mixture was cast in a special mould where mineral based lenses were obtained. The mineral based lenses are hard and scratch resistant. However, they are heavy and fragile. It can easily get broken; it is also uncomfortable since the lens thinning process cannot be applied to such lenses. Therefore, patients have to carry heavy and thick glasses.

Organic Lenses: Organic lenses were made of an organic compound which was a king or agarose solution. Different resin types were tried in the trials. Trial 39, which was also known as Colombian resin, was found to be successful in the material development process. Therefore, the organic resin solution used in the organic lens production was named Colombian resin 39. The capital letters of the "Columbian resin 39" were used to name the lens material also known as CR39. Lenses made of CR39 were known as organic lenses. Such lenses are affordable, soft, and durable; they are light and break resistant. However, they can easily be scratched.

Polycarbonate Lenses: As a material, polycarbonate was developed by the aerospace industry. The lens industry adapted the material and use it in the lens production. Polycarbonate is a kind of plastic based material produced from plastic palettes. It is hard and durable which was also used as safety glass. Therefore, it is break and scratch resistant, and light. It is possible to produce thin lenses since the refractive index of the polycarbonate is suitable to produce thin glasses. However, it is difficult to process the material and it is quite expensive compared to mineral and organic lenses.

Trivex Lenses: Trivex is a special material that was used in bulletproof applications. In the early 2002s the material used in the optic industry to produce durable break free lenses. Polycarbonate lenses were often used in safety glasses applications where Trivex lenses also take part in the production of safety glasses. After safety glasses applications Trivex lenses were used to correct the refractive errors of patience which find an application in the child glasses as well. Trivex lenses are durable for shock resistant, they are thinner than organic lenses since they have a higher refractive index. On the other hand, they are expensive, and it is difficult to process such lenses.

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ColorMatic (Photochromic) Lenses: Photochromic lenses are special lenses the colour of which changes in the exposure to the sunlight. In the colour alteration process transparent lenses become darker and cat as sunglasses, especially in sunny weathers therefore, act as sunglasses during outdoor activities. Such a change occurs due to the intrinsic characteristic of the materials which enhance the vision quality or and help users to adapt to the sun faster. Different materials like glass, polycarbonate and other types of plastics were used in the production. The key factor is adding silver chloride and/or silver halide in photochromic lenses. Additive material interacts with the light and the colour of the lens was seemed darker in the exposure of the sunlight.

2.3.3. Film Coating for Lenses

Various types of coatings were applied to the lenses for various applications. Coatings are kind of thin films which were applied inner and/or outer surface of the lenses. Such coatings give special adaptations for lenses, for example, coatings may protect the lens against scratches or prevent it from dirt. The films were deposited using high tech applications such as thermal evaporations, magnetron sputtering, electrodeposition or deep coating techniques. Film coats and applications are as follows:

Anti-reflection Coat: Having a photo taken by a regular lens cause reflection due to the intrinsic properties of the lens. Therefore, the eyes and part of the face of the patient could not be seen in the photo. To overcome this situation, manufacturers coat the inner and outer surface of the lenses with anti-reflection films which changes the intrinsic characteristics of the lenses. While passing through the lens, a certain amount of light (1% to 10 % depending on the lens material) was lost. Such a case affects the vision quality and the quality of the patient photos. After the application of the anti-reflection coat, the light can pass through the lens and the eye of the patient can be detected in the photos and enhanced vision quality for patients was obtained. Different types of materials can be applied as anti-reflection coat. MgF2 and SiO2 based coatings were applied in single layer anti-reflection coats. TiO2, ZrO2,TaO5 were mostly used multi-layer coatings.

Benefits of anti-reflection coat:

-Better and shaper vision can be obtained

-Contrast enhancement can be obtained especially for the displays

-Increase the vision quality of the drivers

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-Over refraction and reflection for high indexed glasses can be limited.

-Better and more aesthetic products can be produced.

Hard Coat: It was reported that organic lenses (CR 39 lenses) are quite soft due to the material they produced which was a resin based material. Therefore, organic lenses were found to be fragile against scratches. Such a characteristic is an essential drawback of the organic lenses since mineral, Trivex, and polycarbonate lenses were found to be hard and scratch resistant. To enhance the durability of the lens special coats were applied which are harder than CR39 material. Coating the CR39 material with a thin film with a thickness of two microns enhances the hardness of the CR39 lenses by 6 folds. The coat also protects the lens against scratches. It should be noted that the exposition of the lenses to excessive heat or light may cause degeneration of the hard coat.

Clean Coat: Clean coats aims to keep the surface of the lens clean. Different external factors like dust, dirt, rain, etc, accumulates on the surface of the lens. The main objective of the clean coat is to keep the dust and water away from the lens. To overcome this objective, the coat uses two different adaptation electrostatic forces and hydrophilicity. Hydrophobic is a word defining a material characteristic where the material repels the water and water based molecules from its surface. Such repulsion keeps the water away from the surface of the material where the surface was kept clean since water can keep and dissolve different small molecules which can attach or stick to the surface. Another adaptation of the clean coat is repelling the dust like molecules from the surface by using electrostatic forces. The clean coat was mostly applied as the top layer which was coated as the last layer of the lens since it has direct contact with dust and hydrogen. Hydrophobic characteristics keep the water away from the surface which helps the lens to stay clean. The last clean coat should be quite flat which also prevents dust and water to attach to the surface.

Anti-fog Coat: Especially in cold weather, the lens surface gets cold. When the lens user gets in a hotter place or room, the humid in the rom condenses on the lens where foggy vision was obtained. Such a case is annoying and dangerous for the lens used since most of the time vision of the lens user decreases dramatically which may pose a risk for the lens user. Therefore, anti-fog coatings were applied to the lenses. Anti-fog coatings are quite similar to clean coats. However, the main purpose of an anti-fog coat is not to keep the surface of the lens clean, it is to keep the surface of the lens dry. Therefore, it has very strong hydrophobic characteristics. Special sprays can work as

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an anti-fog coat or anti-fog film as well. The spray with good hydrophobic characteristics can be applied on the surface of the lens where a thin layer of films can be formed. Hence, the surface becomes hydrophobic where anti-fog characteristics were obtained. Polyvinyl alcohol (PVA) and Polyethylene maleic anhydrite (PEMA) were used as hydrophobic materials for anti-fog sprays.
Aesthetic Coats (Mirror coat, colour coat, etc): Aesthetic coats were mostly preferred by sunglasses lenses since such coats change the outer look of the lens. Aesthetic coats give different colours to the lenses. For example, mirror like coats or coloured polished coats in different colours were vastly applied to the sunglass lenses. Such coats can also provide UV protection where UV-A, UV-B and UV-C rays can be blocked. As it was previously discussed, the CR39 material was found to be soft and lenses produced of CR39 material are not scratch protected. Aesthetic coats may give different colours to lenses while they increase the scratch resistant properties of the lenses.

2.4. Lens Prescriptions

A typical lens prescription should give details about the lenses which can correct the refractive error of the patients. The refractive error can be simple or complex where the required lens to correct the error can be changed. For example, patients can have single refractive errors such as myopia and/or hyperopia. In this case, the prescription should include details about the dioptre values of spheric lenses for each eye (see Table 2). The patient may have astigmatism. In this case, the prescription should include dioptre values of cylindrical lenses for each eye. In the case of astigmatism, the prescription should also include an angular value that identifies the angular position of cylindrical lenses (see Table 2). Patients with complex refractive errors where patients can have myopia and astigmatism or hyperopia and astigmatism should have spherical lens dioptre, cylindrical lens dioptre, and angle value for each eye (see Table 2). In de prescriptions of patients, who have myopia and hyperopia simultaneously, dioptre values were written separately.

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Table 2. Examples of prescriptions for patients with myopia (a), hyperopia (b), astigmatism (c), myopia and astigmatism combination (d), and hyperopia and astigmatism combination (e). S:Spheric, C:Cylindric, A:Angle; R:Right Eye, L: Left Eye.

Eye	S	C	A	Code
R	-2.00			a
L	-2.25			a
R	+1.00			b
L	+1.50			b
R		-2.00	40	c
L		+2.5	75	c
R	-1.75	-2.25	50	d
L	-2.25	-3.00	70	d
R	+2.50	-1.00	30	e
L	+2.00	-1.00	50	e

2.5. Frames

Various types of frames can be found in the market. One of the motivations of manufacturers to produce different types of frames is fashion trends. Such trends direct producers to alternative models and types. Shape and production material was used to categorize the eyeglasses frames.

2.5.1. Frames by Shape

Essentially rimmed, semi-rimmed and rimless glasses were general categories.

Rimmed Frames: Rimmed or full rimmed frames were frames where glass edges were fully covered with a rim. Different materials can be used in rimmed frames. In ancient models, animal horns were used as rim material. Therefore, models made of hard plastic were also known as horn rimmed glasses. Nowadays, animal originated products were now preferred due to regulations. Instead, hard plastics were used. But such modes were still known as horn rimmed frames. Besides hard plastic, soft thermoplastic models were also used in full rimmed models. Metal is another important material used in full rimmed frames. Metal is abundant and well known material. Therefore, it was vastly used as frame material (see Figure 6).

Semi Rimmed Frames: Semi-rimmed frames are special kinds of frames where the lens was stabilized to the half of the frame. Such lenses were also known as nylor frames (see figure 6).

Most of the time, semi-rimmed frames consist of the upper part, lower part consists of a string that supports the lens. String size is important to balance the lens, longer string may result in lose lens which can be dropped.

Rimless Frames: Such kinds of frames do not have a rim around lenses. The lens was stabilized with two temples and a bridge. Temples were directly attached to the lens. To attach the temples and bridges lens was drilled and tiny holes was produced. Temples and bridges were attached to the holds using tiny nuts or plugs. Rimless frames do not have an outer frame around lenses therefore, they look more aesthetic (see Figure 6d).

Figure 6. Rimmed frames (horn frame a, metal frame b), semi rimmed frame (nylor frame c), and rimless frame (d).

2.6. Lens Cutting

Lens cutting includes various stages. Each stage has a special purpose to obtain lenses for glasses. Following states have followed in the lens cutting and grinding process:

-Marking

-Tracing

-Blocking

-Grinding

-Smoothing

-Polishing

-Edge Cleaning

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2.6.1. Marking

The centre of the lens should be positioned at the point where the pupil stays parallel on the frame. To adjust such position the centre of the lens should be adjusted. For spherocylindrical and/or cylindrical lenses cylindric angle is also important. The angle of the cylindricity should also be adjusted in accordance with lens prescription. Digital focometers were used in the adjustment of angle and lens centring. After the adjustment, the lens is marked using marker tips of the focometer (see Figure 7).

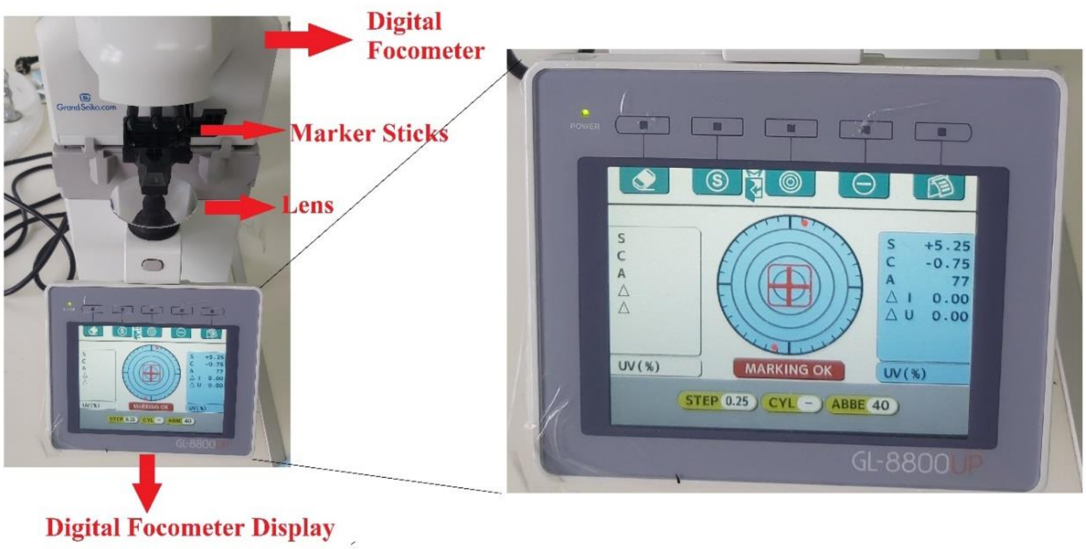

Figure 7. Digital focometer and marking procedure were illustrated in the figure. The display illustrates the data for a spherocylindrical lens with an angular value of 77 degrees.

2.6.2. Tracing

Tracing is a method where the size and shape of the eyeglasses frame are obtained using digital tracers. Depending on the frame and/or tracer type different tracing methods can be followed. Digital lens edgers have different combinations. Some edgers have separate (external) tracers and blockers, some other lens edgers have internal tracers and blockers where tracers and blockers are embedded in the edger system (See Figure 8).

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Figure 8. Figure illustrates edgers with internal tracer and blocker (a) and edger with external tracer and blocker (b).

Therefore, different tracers may require different tracing methods. For example, edgers with separate external tracer can trace the lens shape using the frame for full rimmed frames such as horn frames and metal frames (Figure 9a and 9b). However, to trace the lens of semi rimmed or rimless frames the lens itself was used (Figure 9c). On the other hand, combined edgers, where internal tracer and blockers used, can only trace the lens shape using the lens which was taken from the frame (Figure 9d).

2.6.3. Blocking

Blocking is an important part especially for the cylindric or spherocylindrical lens preparations. Since the angle of the lens is important to achieve a high quality vision. In the marking section, the centre of the lens was marked with marker sticks on the focometer. In the marking section, the angle written in the prescription for the cylindrical and/or spheroscylindrical lenses should be adjusted. Marker dots should be scribed on the lens using marker sticks where the cylindricity angle was set. In the blocking section, the marked lens was centred, and the centre of the suction cups was adjusted to place on the centre of the lenses. Blocking lens with the suction cup helps the lens to attach a stabilized surface where the lens can be placed in the edger. External blockers and internal blockers can be seen depending on the edger type (See Figure 10).

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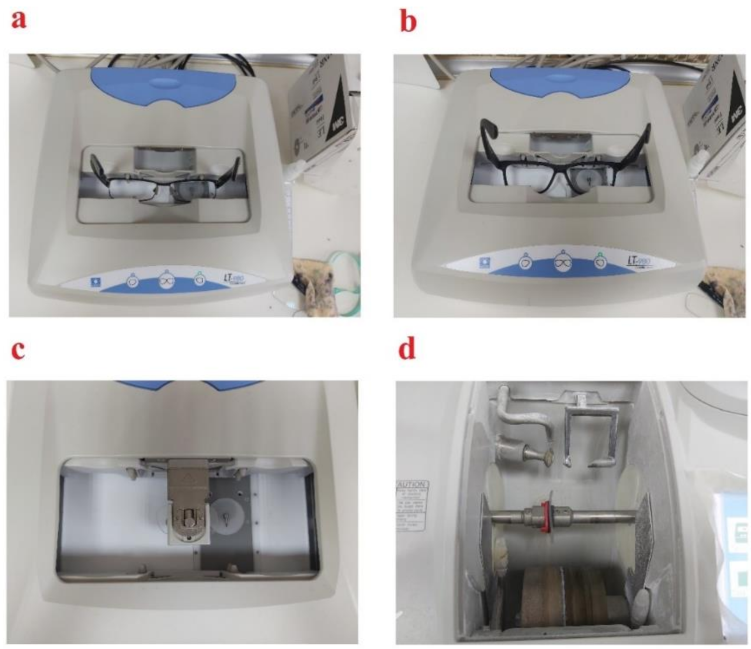

Figure 9. Illustration shows lens the tracing with external tracers (a, b, c) and internal tracers (d).

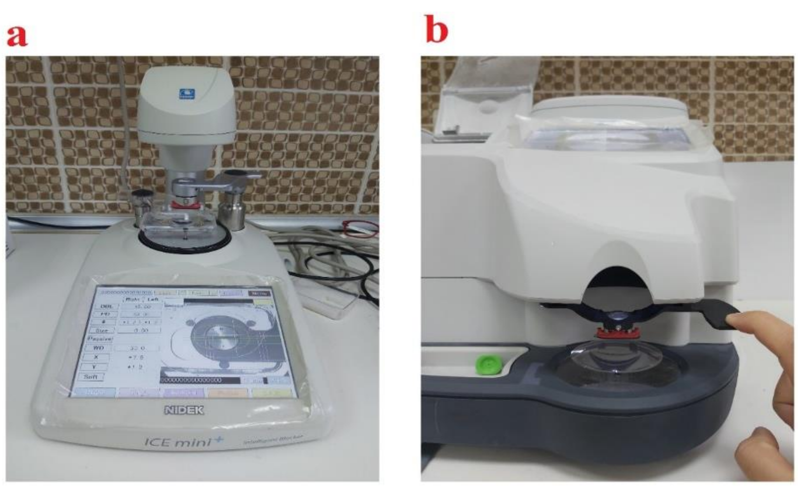

Figure 10. Figure illustrates external and internal tracers.

2.6.4. Grinding, Smoothing, Polishing, and Edge Cleaning

Before the grinding process blocked lens was placed in an edger machine (see Figure 11). Required adjustments for the traced lens were set in edger and the cutting process was started. In the lens cutting process, the initial step is grinding. In this step, the lens was ground by mills where the main shape of the lens was given. After the main shape was obtained the lens was ground by a

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smoothing mill. This mill is finer than the grinding mill. In the smoothing section, the smoothing mill gives the real and exact shape of the lens in exact sizes. The lens is then transferred to the polishing step. In this step, the circumference of the lens was polished by a special tool which is the finest mill of the edger. The mill polishes the lens circumference where shiny circumference surface and edges were obtained. Lastly, the edges of the lenses were cleaned with a special apparatus. Such a process helps to clean residual debris on the lens periphery. When all those stages are completed, the lens is ready to be mounted to the frame.

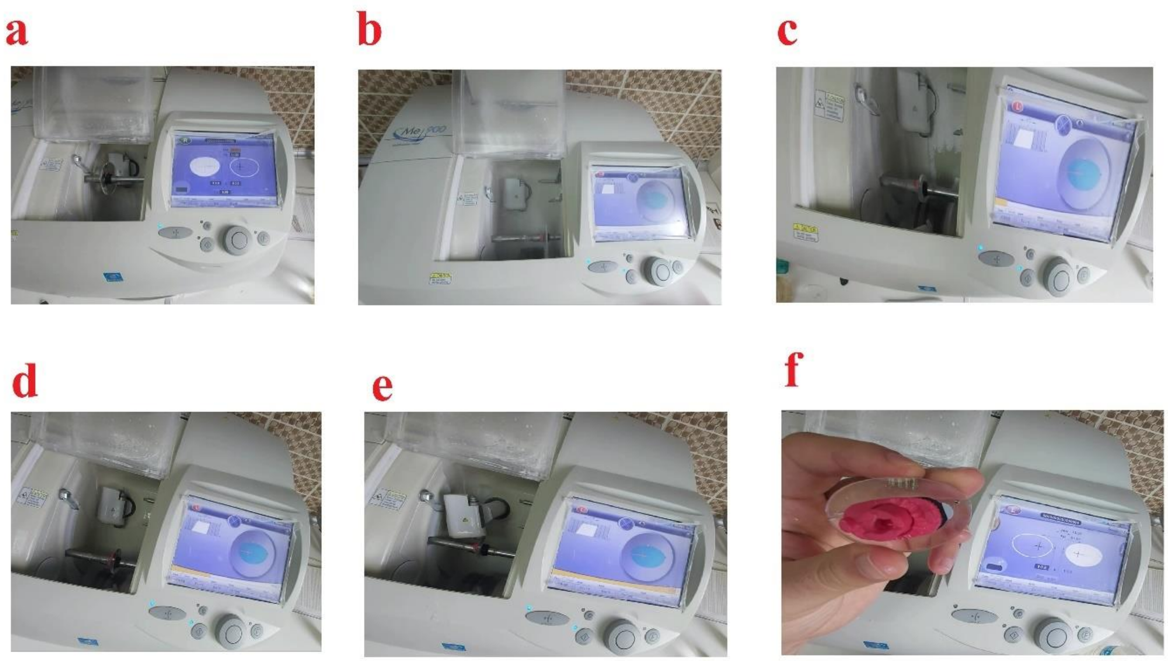

Figure 11. Figure illustrates lens placement (a), grinding (b), smoothing (c), polishing (d), edge cleaning (e) processes and the final product (f).

3. Conclusion

Millions of people suffering from refractive errors. Modern opticianry techniques help people to overcome their problem and to provide a better and healthier vision. In this report, a brief introduction to eye anatomy and refractive errors was given. Then, lens types and corrective lenses were discussed. Finally, frame and lens types and lens cutting techniques were explained. We believe this report is important to give basic technical skills to the people in opticianry industry.

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