Ophthalmic Lens

P. S. Selva Kumar, Optometrist, Department of Optometry, Aravind Eye Hospital, Madurai

Introduction

Patients normally come to an ophthalmologist to determine their refractive status of their eyes either diagnostic or treatment. So, ophthalmic dispensing is certainly a significant part of ophthalmology.The purpose of this article is to provide a brief resume of the types of spectacle lenses available to the patient for better vision (visual needs). The medical practitioners should know about the ophthalmic lenses to able to manage the patient's requirements.

History

The use of spectacles has its origin in ancient history. Marcopolo noted the first authentic record, when he visited China in 1270. He noted that convex lenses were used by the aged to read the fine print. In Europe, the famous English Franciscan monk Roger Bagon was the first to recognize the value of +lens.

In 1784,Benjamin Franklin invented the first bifocal by dividing his lenses for distance and near. Cemented bifocals, were invented in 1884, the fused bifocals in 1890, and solid (or) one-piece types followed in 1906.

Materials used in spectacle lens

Spectacle lenses are made from three different sources of materials.

In spectacle lens, there are many materials used. Natural media, quartz (or) rock crystal, semi-precious stones (i.e. Topaz, Ruby, etc) were widely used for making lenses.

Glass materials

Now-a-days spectacle lenses are made from either plastic or a high quality glass material. Although many types of glass materials are used in optical industry, crown glass (1.523) material is extensively used for making single vision ophthalmic lenses. It is a soda-lime-silica material that contains about 70% silica, 12% calcium oxide and 15% sodium oxide and some other materials in smaller percentages like potassium, borax, arsenic etc.

Flint glass, material (1.620) is used in the making of bifocal or achromatic lens. It contains 60%, lead oxide, 30% silica, 8% soda and potash and small percentage of arsenic. The lead oxide material increases the refractive index of glass as well as specific gravity and weight. This material is used for making the bifocal segment and also it produced high chromatic aberration. In later days, Flint glass material was replaced by barium crown material, which has no chromatic aberration. It contains 35% Barium Oxide, 30% silica and small percentages of lime, zinc, zincorium, aluminium, boran etc. It increases the refractive index of the glass. Now-a-days almost high quality bifocal lenses are made only from Barium-crown glass material.The high-index glass named Hidex (1.806), which is used for making high refractive power lenses in a remarkably thin form. High-index glass is very suitable with antireflection coating, giving a superior effect to the appearance of crown glass. Such glasses are obviously not suitable in fused bifocal form.

Plastic materials

Plastic lenses are generally made from two different materials. They are:

1. Original plastic lens made of (PMMA) Polymethylmethocrylate
2. Modern hard resin lens from allyl diglycol carbonate (CR 39) which is harder and more resistant to scratches than other plastic lens materials.

Plastic lenses are made from a very high quality material as glass. Plastic lenses are about half the weight of glass and are highly impact-resistant. With a center thickness of 3.0mm without special hardening process. Plastic lenses have a thicker profile than glass, get scratches more easily and do not protect the eye from UV rays unless properly tinted. Glass lenses unlike plastic, must be treated to resist breakage. They can be hardened by chemical or heat processes.

Corrective lens

In optical lab each manufacturer has an individualized series of base curves for toric meniscus lenses. In theory, the inside Base Curve should have the same radius coincides with that of the rotating eye ball, that maintains the proper vertex distance between cornea and the spectacles to avoid distortions. A corrected lens is a compromise designed to avoid or minimize the distortions through the edges of the lens. Corrected lenses are in different designs but mainly in meniscus lens form, which are usually ground on 6.00D Base curve.

A toric lens is curved like a meniscus lens but also contains a cylinder that is ground on a convex surface in single vision lens and on a concave surface in bifocal lens. In plastic lenses the cylinder is ground on concave surface, most modern plastic cylinder lens have the cylinder on concave side and are referred to as "cyl" lens.

Multi focals designs

There are two basic types of multifocal lenses used.

1. In one-piece (or) solid type designs, the same material (glass or plastic) is used throughout the lens and changing the curvature of lens varies the power. (Fig.1)

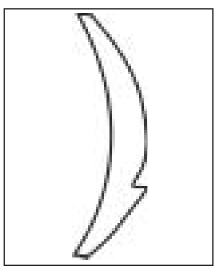


Fig 1a: Solid (or) one piece bifocal

The Executive bifocal (glass or plastic) is a modern version of the original Benjamin Franklin bifocal which has two lenses in each eye of which the lower half is used for closer view and the upper half for distance.

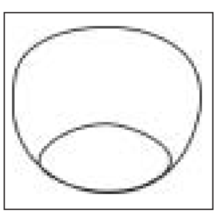


Fig 1b: Ultex A

2. The fused multifocal lenses are made of two or more glass materials with different refractive indexes when the segment with higher indices is fused into the main lens; the surfaces of fused lens have no change of curvature. (Fig. 2)

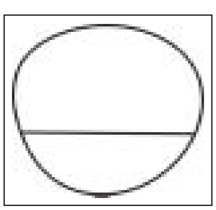
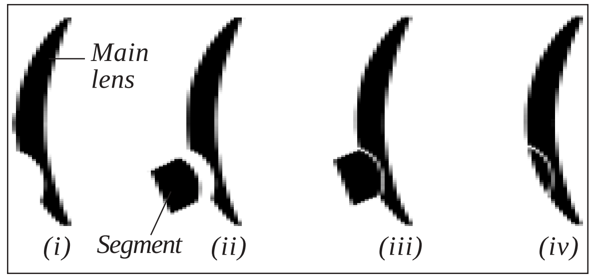


Fig 1c: Executive bifocal

Falling into a category between one piece and fused lenses are cement bifocals. Two lenses of the same type having the same index of refraction are attached together to form a lens with the special features of the one-piece lens. The original cement used was Canada balsam and choser because it has a refractive index close to that of glass. Cemented segments are useful because it can be made of any power ranges and positioned anywhere into the main lens. These types of lenses are particularly helpful for a patient with low visual acuity who needs the high add powers (+20. 0 DS). A high powered lenticular lens can be constructed using the thermally cemented segment process. There are now numerous designs of Multifocals available in market. Bifocals have an inherent disadvantage which is the image jump when there is a change in the direction from distance zone to near zone. Effort is made to minimize the image jumps/ displacements by incorporating additional segments with optical centers designed to produce a compensating prismatic effect.



Fusing methods in bifocals

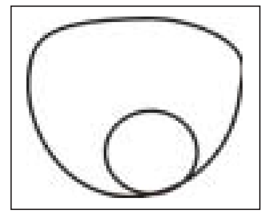


Fig 2b: Round segment (or) Kryptok

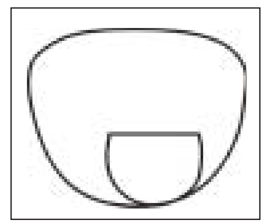


Fig 2a: Flat top 'D'

Progressive addition lens

Among the various types of multifocal designs progressive addition lens has become very popular now-a-days. Over 150 PAL designs have been introduced since 1984 with more than 70 PAL designs currently available in the market.

The progressive addition lenses gradually increases in power as the line of sight comes downwards through the lens. The main difficulty in any lens that gradually increases in power is that vision on either side of a vertical line through the optical centre produces unwanted cylinder causing great distortion, which occurs in the lower part of both sides of the lens. Progressive addition lenses are suitable for the person who need the

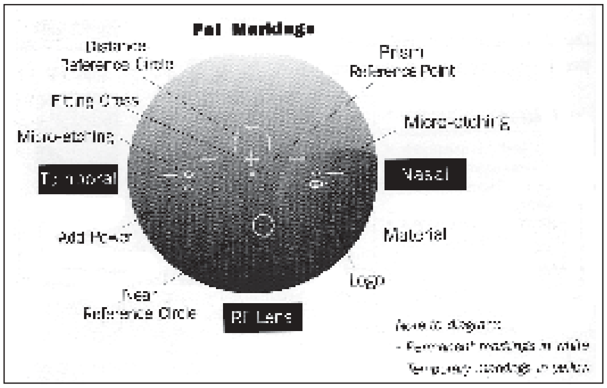


Fig 4: PAL marking

intermediate vision (e.g. computerist) and for the constant bifocal wearers. The progressive additive lens is recommended for the presbyope to provide clear distance, intermediate and near vision without visible separating lines.

High power lenses

In high-powered lenses a strong distortions would occur through the edges of the lens inherently. To avoid these distortions special lens have been designed to minimize the distortion and the weight of these lenses.

The types most commonly used are

(i) Lenticular lens

(ii) Aspheric lens

Lenticular lens

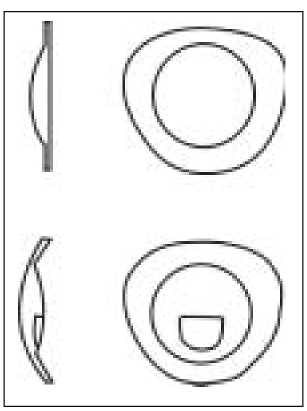


Fig 5: Lenticular lens

The lenticular lens may be described as a small in diameter or circular and mounted on a longer diameter, thin plano-carrier which is edged to fit into the frame. The main disadvantage of lenticular lens is that it gives a bull's eye effect making it more conspicuous than the other lens.

Aspheric lens

An Aspheric lens is particularly designed to eliminate the "pincushion" distortion in the (aphakia) high plus lenses.

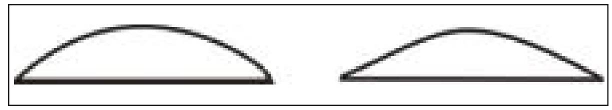


Fig 6: Aspheric lens

A standard "+" lens suitable for a patient who has had a cataract operation may be optically correct through its center but it gives a increased strong effect as the patients vision moves away from the center to the edges of the lens. This increase in '+' power towards the edges resulting from an increase in vertex distance, causes the pincusion distortion as well as blurred vision in these areas.

Fresnel lenses

Fresnel lenses are sheets of Polyvinyl chloride, and it was designed by Augustine Fresnel. The Fresnel lenses are used for various purposes. It is used in ships and lighthouses as a "light-condensing lens". As Fresnel lens is thin and weightless it would make an ideal cataract lens but it shows a pattern of fine concentric circles, which gives poor cosmetic appearance to the wearers.

Safety lens

The risk of damage to the eye from broken glasses is minimized by the use of safety glass. It is however advisable to use it for those who are engaged in industrial works and sports.

Plastic hard-resin lenses

These are safety lenses with no additional treatment, because they will take abuse much greater than that required to shatter a standard glass lens. A shattered hard-resin lens does not have the sharp splinters typical for broken glass. Hard resin lenses are superior to hardened glass for welding for if not metal may splatter on the lens.

Another type of safety lens is the laminated lens in which a sheet of plastic is sandwiched between two pieces of glasses. If the lens is shattered, the glass particles adhere to the plastic.

Polycarbonate lens

First introduced in plano safety goggles in industry, polycarbonate lenses are one the most impact-resistant lenses now available in the market. In this regard they out perform plastic and glass heat-treated or chemically treated and thus easy to scratches. Polycarbonate is now being moulded into ophthalmic Rx lenses that are coated to substantially reduce their tendency to scratch.

Heat-treated impact-resistant lens

The polished lens is heated an oven almost to its melting or softening point, removed and then rapidly cooled by blasts of cold air on both surfaces simultaneously. The surfaces cool and contract quicker than the interior of the lens. Eventually the interior of the lenses cools and contracts and brings the surface of the glass lens into a compression condition. All heat-treated glass lenses may be identified by the fact that they un polarize the polarized light. A popular type of sunglass in the market is the polarized sunglass that are usually made of plastic but sometimes are found in a laminated form in which the polarizing filter is sandwiched between two sheets of glass. Polarized sunglasses are available in prescription form.

Some glasses in the market are named 'toughened lens'. Another type of impact-resistant lens is a chemical treatment lens which is popularly employed and is far superior in impact-resistant, qualities to those produced by the heat-treating method, this type of lens consists of placing the finished glass lens in a hot solutions of potassium salt for about 14 hrs. Meanwhile the sodium ions in the glass are replaced by potassium ions. While cooling the potassium ions place the surface in a state of compression, which give impact resistant properties to the lens.

Unlike the heat-treated lens, polarized lights cannot delete this process. Failing other indications that the lens has been chemically treated.

Safety lenses are recommended mainly for children, with refractive errors and for those who are engaged in sports and industrial works.

Tinted lenses

By using of the appropriate chemicals, white lens may be dyed with colour or mirrored evenly. The popular tints are available as green, neutral gray, pink, brown and transparent one-way mirror surfaces.

Tinted ophthalmic lenses give an even colouring a cross the whole surface of the lens whether it is a strong plus or a strong minus lens. The coating, whether it is anti reflection mirror or not, colour may be removed chemically in about 10 seconds, should this be necessary.

Almost all sunglasses are white lenses coated with colour. However, coloured-glass lenses are still available that are perfectly satisfactory for plane and weak power prescriptions.

In high-powered lenses, such tinted lenses are not suitable for perfect vision. The tinted lens usually reduce the actual illumination level so that such lenses are not suitable for high power lens as well as Bifocals.

Neutral gray tint has been the most popular tint for sunglasses. Because of its neutral absorption of all colours of the visible spectrum, light intensity is reduced without colour distortion or imbalance- a very important factor when proper colour perception is concerned. Such a gray lens can be recommended for one who wants perfection from "intensive light" or glare without loss of colour patterns.

A green tint lens will absorb most of UV & IR light and transmission peaks roughly at the same point as the luminous curve of the eye.

Green lenses are recommended for situations with high amount of reflected (UV) light. In industry green lenses of various densities are used for welding and other high light and heat situations. They also have the psychologics effect of "coolness" during hot weather and thus provide comfort to the wearer.

For many years, brown tints were very popular. Brown lenses will absorb almost all of the UV light and have a very even progressive curve throughout the visible spectrum. This type lenses are most useful made moderate-to-cold-climate radiations with the added benefit of creating a "warm" visual environment.

Yellow tint lenses are good absorbers of UV, violet, and blue suppressing this area of the spectrum will enhance contrast in the rest of the visible spectrum. A yellow lens therefore is preferred to increase contrast in marginal light conditions, such as twilight and foggy condition, but should not be worn to protect against excessive light.

Other tints, such as pink, purple and mauve are deviants of the aforementioned tints and are used mainly as fashion accents. Cheap sunglasses are made from flat, coloured glass sheets of low quality.

Photochromic lens

Photochromic lenses have the chamelon-like ability to change from light to dark and back again. The silver halide microcrystals in the glass, which gives this changeability never wear out. The halide becomes darken when exposed to UV light or blue end of the spectrum.

The cycling of the modern photochromic lens requires 60 seconds to become darken. The range of dark to light is greater in cold weather than in hot. The clear photo-chronic lens darkens only to the point where 15% of the light is filtered out and is not really dark enough when compared with standard sunglasses. It is available in three different colours; grey, pink and brown.

In dispensing tinted lenses it is important to know about light conditions and environment the lenses are going to be used in. In dark areas, tinted lens will dilate the pupil and reduces the visual acuity. Providing a medium tint with a gradient mirror will help the patient to select the density according to the common light conditions.

Ultraviolet and blue-blocking lenses

Through-and-through tinted lenses that filter out over 98% of blue and UV light were developed. The latter is made in CR-39 plastic which is in colours that range from amber to red. For the normal individual these lenses provide comfort from glare, reduce haziness and create sharper vision; such light-colour lenses may help persons with developing cataracts and the darker red lenses may improve the functional visual acuity for such conditions like Retinitis Pigmentosa albinism, aniridia and intense photophobia.

Mirrored sunglasses

In mirrored sunglasses a one-way mirror surface is placed on a white or coloured lens to convert it in to a sunglass for special purpose.

There are situations in which patients do not wish to trouble their eyes (perhaps because of disfigurement). Mirrored sunglass give a cosmetic protection and the patients has no trouble seeing through the mirrored lenses.

Anti-reflection coating

Artificial powerful lights (i.e.) halogen lights in cars and trucks, and computer monitors can cause reflections in untreated glass and produce ghost images. It occurs mainly in high index glasses.

When light passes through spectacles some light rays are reflected by front and back surface of the lens. Streetlights in the driver's field of view may be duplicated or triplicated. AR coated lens prevent these images and only one image is seen.

Magnesium fluoride a material 1/4th of wavelength of yellow-green light, which is heated and fumed on the lens surfaces. The coating material is very tough and usually lasts througout the life of the lens. It will be seen on the surface of the lens. All camera lens and ophthalmic instrument lenses are coated to filter out internal reflections and permit greater light transmission. Almost all lens coatings are not multicoatings. These coatings, which are almost invisible, eliminate the red and blue end of the spectrum. Such multi coated lens should be cleaned with proper special cleaning solutions. AR coated lenses are readily available in market and it can be coated separately too.

Reference

1. *The ophthalmic Assistant, "A guide for ophthalmic medical personnel"*
2. *Lecture notes on visual sciences*