# Progressive lens

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Progressive spectacle lenses, also called progressive addition lenses (PAL), progressive power lenses, graduated prescription lenses, and varifocal or multifocal lenses, are corrective lenses used in eyeglasses to correct presbyopia and other disorders of accommodation. They are characterised by a gradient of increasing lens power, added to the wearer's correction for the other refractive errors. The gradient starts at the wearer's distance prescription, at the top of the lens and reaches a maximum addition power, or the full reading addition, at the bottom of the lens. The length of the progressive power gradient on the lens surface depends on the refractive index of the lens, with a final addition power between 0.75 to 3.50 dioptres for most wearers. The addition value prescribed depends on the level of presbyopia of the patient and is closely related to age and to a lesser extent, existing prescription.

History

The first patent for a PAL was British Patent 15,735, granted to Owen Aves with a 1907 priority date. Aves' patent included the progressive lens design and the manufacturing process. However this was unlike modern PALs. It consisted of a conical back surface and a cylindrical front with opposing axes in order to create a power progression. This design was never commercialized.

While there were several intermediate steps (H. Newbold appears to have designed a similar lens to Aves around 1913), there is evidence to suggest that Duke Elder in 1922 developed the worlds first commercially available PAL (Ultrifo) sold by "Gowlland of Montreal". This was based on an arrangement of aspherical surfaces.

The Varilux lens was the first PAL of modern design. It was developed by Bernard Maitenaz, patented in 1953, and introduced by the SociÃ©tÃ© des Lunetiers (which later became part of Essilor) in 1959.

Early progressive lenses were relatively crude designs but modern sophisticated progressive lenses have gained greater patient acceptance and include special designs to cater to many separate types of wearer application: for example progressive addition lenses may be designed with distance to intermediate or intermediate to near prescriptions specifically for use as an occupational lens, or to offer enlarged near and intermediate view areas. Since the 1980s, manufacturers have been able to minimize unwanted aberrations by:

Improvements in mathematical modeling of surfaces, allowing greater design control

Extensive wearer trials

Improved manufacturing and lens metrologic technology

Today the complex surfaces of a progressive lens can be cut and polished on computer-controlled machines, allowing 'freeform surfacing', as opposed to the earlier casting process.

Advantages and use

Wearers can adjust the additional lens power required for clear vision at different viewing distances

by tilting their head to sight through the appropriate part of the vertical progression;

The lens location of the correct addition power for the viewing distance usually only requires small adjustments to head position, since near vision tasks such as reading are usually low in the visual field and distant objects higher in the visual field.

Progressive addition lenses avoid the discontinuities (image-jumps) in the visual field created by the majority of bifocal and trifocal lenses and are more cosmetically attractive. Since bifocal and related designs are associated with 'old age', proponents have suggested the lack of segments on the lens surface of a progressive lens appears more 'youthful' since the single vision lenses associated with younger wearers are free of segments or lines on the surface.

Progressive lenses can use the optimization principle, which is based on linearization and represents the lens surface using special spline functions. The lensâ€™ power progressively increases between the high-power and low-power region of the lens. This specialized lens surface provides an accurate power distribution for both near and distant vision and reduces the number of optical aberrations.

Disadvantages

Distortion: Progressive lenses suffer the disadvantage of the power progression creating regions of aberration away from the optic axis, yielding poor visual resolution (blur), which varies in relation to the quality of the lens. As the lenses combine a range of powers in a single surface there are also geometric distortions to the visual field, which increase with the addition power. Some wearers find the visual discomfort caused by these distortions outweigh the benefits of wearing PALs, this is known as progressive non-tolerance. However, manufacturers claim acceptance rates of 90%â€“98%. Clinicians generally agree that in order to avoid adaptation problems it is best to start wearing progressive lenses early in the development of presbyopia (around 40 years of age for most people) while the prescribed addition powers are low. The wearer can then adapt to the increases in a series of steps in addition power over a number of years as their presbyopia progresses.

Peripheral Vision Distortion: Because of the compromise in vertical range of undistorted vision, there is an inherent impact on peripheral vision with progressive lenses which is more obvious than that which is found in single vision lenses. This can affect the intermediate portion of the vision more so than the distance, and wearers who use computers regularly and for prolonged periods of time may benefit from an occupational progressive lens, commonly referred to as an office or extended reading lens.

Fitting: Progressive lenses require careful placement relative to the wearer's pupil centre for a distance-viewing reference position. Incorrect specification of the fitting location can cause problems for the wearer including (depending on the design of the lens) narrow fields of view, clear vision in one eye only, on-axis blur, and the need to alter the natural head position in order to see clearly.

Cost: Progressive lenses are generally dispensed at a higher price than bifocal and single-vision reading spectacles due to the increased manufacture and professional service costs.

When selecting a progressive lens design, an eyecare practitioner will usually ask some lifestyle questions, which coupled with prescription restrictions or recommendations and cost can effectively establish suitability for various models of progressive lens. Different lenses have different glazing restrictions, lens material availabilities, maximum and minimum fitting heights, prescription ranges and as such the variation in quality between higher and lower end varifocal lenses is considerable.

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