Progressive power lenses

Part 2: Evolution and modern designs

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In Progressive power lenses Part 1 (OT 24/03/06) reference was made to certain generic features in relation to avoiding patient non-tolerance. This article considers in detail the way in which progressive power lenses (PPLs) have evolved, and discusses the latest generation designs.

Advances in spectacle lens technology have made it possible for manufacturers to produce the almost perfect single vision lens. Computer generated aspheric surfaces, including those with variable asphericity to account for higher astigmatic corrections, can almost eliminate troublesome oblique astigmatism. Combining this asphericity with high index, low density plastics and the latest anti-reflection (AR) coating technology has removed the issue of heavy and unattractive lenses. Modern day surfacing techniques cosmetically improve lenses further by producing the thinnest possible finished product in respect to the given frame and decentration parameters.

Despite even further technical advancements being employed in the latest generation PPLs, where every point on the complex computer-generated surface can be individually worked to a predetermined power, it will probably never be possible to produce the perfect PPL.

A difficult question for the lens designer is through what part of the lens will the wearer need to look, to focus on any given distance? We know that the best compromise places the distance prescription at the pupil centre and the upper portions of the lens. A narrow descending corridor widens slightly at the end where the reading prescription is located. From the conception of the PPL, the aim of most designers has been to maximise the width of all viewing zones. Taking this to its limit would see a lens resembling an executive multifocal lens with no dividing lines or ridges, and a smooth power progression from top to bottom across the entire width of the lens. This impossible form would seem at first to be the ultimate progressive design, with full fields of view for each focusing distance. However, the limitations would soon manifest themselves as the eyes scan horizontally to view objects at variable distances.

Perhaps it is no surprise, therefore, that when considering certain patient physiological characteristics, at least one manufacturer has developed a progressive design which deliberately concentrates quite considerable surface astigmatism to the lens periphery, in order to maximise the usable width of the progression corridor and reading zone.

Interestingly, and despite some optimistic advertising claims, even designers are aware of these limitations, knowing that their most advanced lenses cannot meet all the needs of every individual. Patients’ varied lifestyles, occupations and interests, as well as their desire to follow the latest fashions, have seen a marked rise in the need for specialist PPLs.

Removing a focusing zone not required by the wearer reduces the rate of prescription change down the lens, and allows the designers to soften the lens to a degree where in some cases, almost all unwanted surface astigmatism is removed.

It has taken nearly 50 years, but we have now most certainly arrived at an age where we can provide the patient with a PPL that is designed not only to complement their physiological characteristics, but also to meet their demanding and varied lifestyles.

Early days

It was as far back as the beginning of the 20th century that the first steps were taken to produce lenses with a continuous gradual change in power from the distance to the reading prescription. One of the first attempts employed a parabolic concave back surface with an increasing radius of curvature from the centre of the lens, creating a corresponding decrease in back surface power and, hence, an increasing total lens power. It meant, therefore, that the central portion was used for distance vision and the periphery for progressively nearer vision. The first surface employing the now familiar umbilical meridian with its progressive corridor was designed very soon after. Difficulties in production, the absence of computers to help generate appropriate surfaces and the presence of unacceptable aberrations, all probably accounted for the lack of any commercial success with these early PPLs.

Most designers since that time have been striving to produce a lens surface in which the radii of curvature between the distance and near portions of the front convex surface could become progressively smaller by equal

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amounts, horizontally and vertically. At the same time, the surface astigmatism at the lens periphery would need to be reduced to a level that could be tolerated by the patient during normal viewing conditions. It should also be remembered that for optimal binocular vision, the images produced by both lenses must be formed on corresponding retinal positions and have similar optical properties. In all directions of gaze, vertical prismatic effect, as well as power and astigmatism, must be approximately equal.

We will see later how some designers have moved away from concentrating on the front surface to produce the progression from distance to near vision.

With the lens needing to be bent and the power change blended to eliminate any jumping of the image as the eyes scan the lens, surface astigmatism will always be a feature of the PPL. The generic progressive power design with the surface astigmatism confined mainly to the lens periphery is shown in Figure 1.

First generation lenses

It was not until 1959 when the French company Essel, now known as Essilor, produced the first commercially available PPL. This was known as the Varilux® 1. The design of the lens was rather basic, having relatively large spherical distance and near zones linked by a narrow progression zone. Little attention was paid to the quality of peripheral vision. This resulted in two main issues, as seen in Figure 2:

• Rapidly increasing surface astigmatism across the temporal and nasal parts of the lens, indicated by the closely positioned iso-cylinder lines
• Issues with the symmetrical optical design, either side of the progression corridor. The problem for the wearer becomes apparent as the eyes move across the lens. Each eye will move laterally by a different amount from a fixed point but as the design is symmetrical about the progression corridor, each eye will encounter different amounts of astigmatism causing poor dynamic binocular vision

The symmetrical design did mean that lenses could be used for either the right or left eye. Although this suited manufacturer’s stock holding requirements, it was not so advantageous for the patient’s visual correction. With a symmetrical design, the lens is required to be ‘swung’ upward nasally in order to try to align the reading zone with the eyes’ near visual point when converging to read. With astigmatic prescriptions, one was faced with the issue of compensating the cylinder axis for this lens rotation.

This lens, and others designed around this time, did not produce a very high adaptation success rate so it was not surprising that dispensing opticians were reluctant to recommend this as an alternative to bifocal or trifocal lenses.
**Asymmetrical design**

The Varilux® 2, introduced in 1972, was an example of a second generation PPL providing relatively wide fields of view for all distances. It introduced a new concept of ‘horizontal optical moderation’ achieved through an asymmetrical design. Figure 3 shows an example of both eyes converging to a near point (1) on the mid-line. As both eyes rotate to fix on point (2), the right eye can be seen to have rotated nasally a lesser amount than the temporal rotation for the left eye.

With the new design incorporating a rate of change of surface astigmatism that was greater in the nasal than the temporal regions of the lens, the example given here shows that both eyes will encounter similar amounts of astigmatism at each corresponding point as they look from side to side.

Binocular vision was now optimised, with each eye now experiencing equal amounts of surface astigmatism. The lenses, not spherical but a descending succession of conic sections of ellipses, circles, parabolas and hyperbolas, were now produced for right and left eyes with the corresponding near zones already inset.

**Hard and soft designs**

Designers began to consider re-distributing the surface astigmatism, concentrated in the lower peripheral regions, into the upper peripheral distance zone of the lens.

The benefits this gave to the patient were a reduction in the rate of change of surface astigmatism, which helped with adaptation and the ‘swim’ effect as well as a lengthening and widening of the progression corridor improving the field of view for intermediate vision. Conversely, the encroachment of the surface astigmatism at the edges of the distance vision zone brought an awareness of image blurring with lateral eye movement to the lens periphery. The area of the true reading prescription was reduced but as the lateral rate of change of surface astigmatism from the reading area was lessened, the effect on patient tolerance was minimal.

This redistribution and, therefore, more gradual change of surface astigmatism brought in the term ‘soft’ to describe PPLs with this design characteristic. The previous designs were still available, so the opposite term ‘hard’ to describe these lenses was brought into the optical vocabulary.

The distribution of iso-cylinder lines shown in Figure 4 demonstrates the differences of rate of change and location of surface astigmatism in the hard and soft designs. Note the greater rate of change on the nasal side in both lenses.

The description of these lenses is somewhat subjective especially the width of the reading zones, which must be viewed in relative terms. When compared to even the smallest round segment bifocal, the reading zone of a hard design PPL would still be described as narrow.

Not only were dispensing opticians now more confident in the success rate from recommending PPLs, but with two distinct lens designs now available, they were able for the first time to offer a product that would go some way to help meet patients’ differing lifestyle requirements.

If intermediate vision was rarely needed, but the patient requirements were for wide distance and near vision, then a hard design would be chosen. Others who fell into this category were those who drove for a living, or required a change from bifocals either for cosmetic reasons or the need for limited intermediate use.

Soft design PPLs would have been recommended to first time presbyopes or those working at a computer or other tasks requiring a wide intermediate zone. The well-known Sola Graduate is typical of the hard design PPL and is still available today. With the aim of most lens designers being to reduce surface astigmatism, technical advances have seen the replacement of all soft lenses from this period, with even softer designs.

**Horizontal symmetry**

We have discussed the limitations of the symmetrical lens design with equal graduation of nasal and temporal astigmatism and no inset of the reading zone. This should not be confused with a concept introduced in the mid 1980s by Carl Zeiss, of horizontal symmetry in its Gradal® HS PPL. The lenses were asymmetrical but designed to give the wearer equal acuities and prismatic effects at all corresponding points of horizontal gaze, in order to achieve excellent binocular vision.

This set even greater standards by guaranteeing identical visual imaging wherever the wearer looked and optimum binocular vision for both eyes. The progressive surface was aspheric in design. The prescription surface, as with Rodenstock’s Multigressiv® PPL, could be atoroidally structured with varying asphericity to account for higher astigmatic corrections. A further additional feature with these lenses was the variable reading inset to account for not only different reading additions, but the induced prismatic effect at the near visual point.

To recap from the previous article, a plus prescription will induce base-out prism when the wearer converges down and in to read. The pull of the eye will be in towards the prism apex, requiring a greater inset to ensure visual alignment. Conversely, a high negative lens will require a lesser inset due to base-in prism.

**Measured powers**

A past issue that often concerned dispensing opticians was that with some PPLs, the powers measured by the practice focimeter frequently did not match those on the order, especially the near prescription. To ensure the correct prescribed power at the eye, some manufacturers modified the lens powers to account for certain mean parameters, such as pupilary distances, working distances and frame fittings. Modified powers on the lens packets were provided so that the lenses could be checked prior to collection. Without this reference, the lens supplier needed to be contacted to verify the lens readings.

We will see later how the latest generation PPL designs have built upon these factors to create lenses which compliment the wearer’s individual parameters.

**Multi design PPLs**

Until the mid 1980s, all PPL types maintained either hard or soft design features throughout their range of reading additions. An early presbyope who may benefit more from a soft lens design, would be required to change lens types if they were to gain the benefits that a harder lens would provide, as their presbyopia progressed. Switching from a soft to hard design can require considerable adaptation and as the change is generally accompanied by an increase in reading addition,
Progression profiles of a multi-design PPL range. Although not produced anymore, its multi-design concept has been retained with later additions to the Essilor range.

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**Further advances**

Computer technology used to create thinner, flatter, aspheric single vision lenses with excellent off-axis performance was extended to the production of PPLs. This resulted in further reduction of surface astigmatism as well as allowing thinner, less bulbous lenses to be produced for the fashionable large frame sizes of that period.

Shorter corridor lengths, normally associated with a hard lens design, were made possible without compromising the lens performance, allowing the wearer to maintain near-natural posture and comfortable eye movements when reading. These ‘firm’ design lenses, with their reading zone positioned high in the lens, enabled the wearer to achieve 85% of their reading add at only 12mm below the fitting cross. Only another 6mm was required to reach the full reading prescription (Figure 6). The Varilux Comfort is one example and its success has meant that it is today still a best selling PPL.

With higher index and photochromic plastics materials becoming readily available, most manufacturers began to produce ‘families’ of lenses incorporating the same progression design. These enabled patients to obtain greater benefits from their spectacles, as well as being able to interchange them to meet specific needs without having to continually adapt to a different design and form of lens.

Combining computer technology to increase useable viewing zone widths and reduce surface astigmatism with the concept of multi-design, meant that non-tolerance to correctly fitted lenses became very much the exception. Dispensing opticians were able to discuss with more confidence the benefits of PPLs with their patients. Decisions such as whether to recommend a hard or soft design lens were being superseded by giving more consideration to patients’ lifestyles, and the lenses needed to fulfil their needs.

**Keeping up with fashion**

The 1990s saw the steady demise of large frames; 60mm eye sizes were becoming a thing of the past and as frames became smaller and shallower, even high ametropes were at last able to wear cosmetically attractive spectacles with thinner and lighter lenses. However, this placed a greater demand upon the dispensing optician to provide these benefits to the presbyopic population.

The over-40s, now very aware of image and fashion, were demanding the same small shallow frames as worn by the younger generation. Unless the presbyope had separate distance and near lenses, the new frame designs were unlikely to provide enough depth to accommodate even the shortest corridor of the then current generation of PPLs.

In 1999, American Optical produced the first short corridor PPL, known as the AO Compact™. With its short intermediate zone and the reading area positioned higher, the minimum fitting height could now be reduced by 4mm compared to that required for most conventional lenses of that time. Other companies soon responded to demand and added short corridor lenses to their catalogues. Wearing did, however, find that if the latest fashions were to be followed, then they had to tolerate the relative hardening of the lens resulting from the increase in rate of change of power from the distance to the reading portion that occurred when the progressive corridor was shortened.

**Latest advances**

Up to this point, all PPLs were designed with respect to a determined set of criteria. These would include parameters such as an average pupillary distance, vertex distance, panspheric tilt and near working distance. In addition, the same base curve would be used for a range of prescriptions and additions resulting in possibly just one combina-
tion producing the optimum design. With no account of fitting criteria, as well as other prescription/base curve combinations, within the range, the final lens design could be considered at this stage an acceptable compromise. Obviously, a better solution would be to have the optimum base curve for each prescription, but this would not be economically viable. All companies still offer these lenses which, because of the economics of production, are within the financial reach of most patients.

With the advent of even more advanced design and manufacturing technology, companies looked to produce the ‘made to measure’ PPL for those requiring better visual performance than an ‘off the peg’ product.

For a lens to be specifically made for an individual’s needs, it would have to incorporate more than just the sphere, cylinder and axis and the mean parameters decided by the lens designers. It would need to include details specific to that individual and may not only require other frame and facial measurements, but also lifestyle and physiological details.

Traditional tools have either spherical or cylindrical surfaces, which nowadays are made to only work the back surface of a lens. They cannot create the aspheric or complex progressive designs, which until now have been pre-moulded by manufacturers for the lens front surface.

**Freeform technology**

Using proprietary software and computer numerically controlled (CNC) technology, the required patient specification can be very rapidly interpreted as the design criterion, which is then fed to high speed and precision freeform machinery. This consists of three dimensional diamond cutting spindles, which grind the highly complex lens surfaces to an accuracy of 0.01D. It is possible to grind either or both lens surfaces using this method. With the latest generation of PPLs, some companies have utilised this feature to enable them to dispense with the stocking of semi-finished blanks and to generate both lens surfaces from a plastic blank on receipt of the order details. Others have retained the moulded progressive semi-finished blank and used freeform technology to produce the optimum prescription surface.

The polishing process can cause deviation from the freeform surface design, therefore this is has to be carried out using computer controlled diamond polishers. Theoretically, any curve that is mathematically possible can be generated using freeform surfacing, however, whilst an accurate lens is produced, its performance will only be as good as its design allows. In other words, freeform technology is only valuable when it is paired with excellent lens design.

It is interesting to note that one of the industries using freeform surfacing is car body manufacturing, where areas of panels having different radii of curvature have to be accurately blended with a continuous rate of curvature between the sections, to avoid reflections appearing disconnected. The connections between each computed point for a lens surface (which could be as high as 40,000!) has to be similarly blended.

Although free formable surfaces have previously been created using spline technology, for example with the Zeiss Gradal HS design, it is only with the greater advancement of computer software and precision freeform machining that lens manufacturers have been able to incorporate sufficient detailed patient specification to produce a truly individual and personalised PPL.

**Latest generation lenses**

An issue facing the dispensing optician from a retail point of view is that visually, it is almost impossible to differentiate between the most basic and most advanced PPL designs, especially if they are made with the same material. Secondly, and uniquely with the latest bespoke PPLs, they cannot be demonstrated prior to ordering except possibly in a generic way, which rather misses the point by not showing the patient the added benefits their unique lens will offer. It is left to the dispensing optician, through demonstrating their knowledge of the products, to gain the trust of the patient and dispense the best product to meet their needs.

We will look at how some of the major lens manufacturers have incorporated their own philosophies, beliefs and technical expertise into their latest PPL designs.

**Rodenstock**

With its Multigressiv lens, Rodenstock was the first company to incorporate the patient’s individual physiological, as well as frame and fitting details, into a PPL design. The subsequent Multigressiv 2 retained these features, but also featured an aspheric progressive front surface and a freeform aspheric/atoric back surface. As mentioned previously, the atoroidal surface was only required to optimise the performance of a lens with an astigmatic prescription.

The major advancement with Rodenstock’s latest design, the Impression (Individual Lens Technology)\(^{17}\) was the progressive power, as well as the cylinder, with astigmatic prescriptions being worked on the back surface of the lens. This allows the progressive surface to be closer to the eye, giving an expansion of the fields of view compared to those with a front progressive surface (Figure 7). Having a spherical front surface, only power changes occur, which reduces skew distortion and hence the feeling of sway.

With a real as opposed to a ‘thin’ lens, its magnification is the product of shape and power factors. Shape factor is dependant upon the power of the front surface and as this remains constant, the magnification difference between visual areas of the lens is kept to a minimum.

Additional parameters to be included with the order are pantoscopic and dihedral (frontal bow) angles of the actual frame as worn by the patient, and the back vertex distance. The front curve can be surfaced to match the bow of the frame. Rodenstock has developed a toolbox to assist with these measurements.

When prisms are prescribed, Rodenstock also requires the sequence of lenses placed in the trial frame. A relationship exists between the amount of convergence and a patient’s interpupillary distance, which is incorporated in the design from the accurate monocular PDs supplied with the order. This is in addition to the calculation of the near inset, after accounting for the influence of the distance prescription.

For high hypermetropes, Rodenstock has included the Hyperopt in its Impression\(^{17}\) range. With the use of the Perfast 1.67 material, the Impression\(^{17}\) technology and centre thickness minimisation as standard, hypermetropes up to +13.00D can expect the optimum optical and cosmetic performance from their lenses.

Both the Impression\(^{17}\) and the Hyperopt are available as the XS short corridor versions, with minimum fitting heights of only 16mm.

**Hoya Lens UK**

Hoya has looked at determining the most effective location of the components of a
PPL. The outcome, with its Hoyalux integrated Design (ID) surface lens, has been to position the vertical progressive components on the front surface, with the concave surface incorporating the horizontal components.

The additional power only increases in the vertical direction, and the proportionate increase in image magnification in this meridian is easily adapted by our visual system. With the vertical progression components on the front surface, there will be less eye rotation to reach the full addition. This can be seen from Figure 8, if we consider the eye rotation to be vertically in the plane of the paper where there is less rotation to scan the same distance (x).

The horizontal progression components that give rise to skew distortion are closer to the eye on the inner lens surface and, hence, there is less image deformation resulting in a wider field of view in the horizontal direction. The two surface structures needed to be balanced, however, to prevent the troublesome skew distortion from affecting the wearer’s visual comfort. Hoya then introduced its Skew Deformation Index (SDI) mapping technology, which was able to simulate actual patient wear to examine and quantify the extent of image deformation at any point of the visual field. The optimisation process was taken further with its Balanced View Control, which evaluated the movement of an object or scene across the retina during PPL wear.

For accurate inset values, Hoya requires with the full prescription, monocular pupil distances and the near working distance for the prescribed Add. The Hoyalux ID is available in 11mm and 14mm corridor lengths.

Seiko Optical
The world’s first inner surface PPL, the P1GR, was launched by Seiko-Epson in 1997. The new design by Seiko, the Super Proceed Internal (Super P-1), uses its new design technology, Variable Aspheric Surface Setting (VASS), which places all the correcting prescription parameters together with the progression on the inner surface. Astigmatic prescriptions are optimised by surfacing curves with variable asphericity, to provide the correct prescription at all angles of gaze. The inset is varied dependant upon the distance prescription, monocular PD and the reading Add. With the Super P-1 available in a 1.74 plastics material, combined with the decreasing minus power or ‘degressive’ back curve, the lens offers excellent benefits of comfort and aesthetics. The lens is available in three lifestyle options, known as type A, B and C for distance, general and indoor priority respectively, and each type has five progressive corridor lengths from 18mm to 10mm.

Pentax
Pentax, a division of Seiko Optical, uses its Retinal Forward Design in the form of computerised modelling of the human eye, together with analysis of 5,000 points on each lens, to optimise the surface powers for different positions of wear. The mathematical smoothing between these points creates power changes, giving the minimum distortion. The Super Atoric ‘F’ is available in 1.67 plastics and four progression lengths, from 16mm to 10mm, to accommodate the requirements of the patient.

Essilor
An entirely new concept in PPL design was seen in the UK in October 2004, when Essilor launched its Varilux® Ipseo® lens. The design is based on measurements carried out in practice of the patient’s combination of head and eye movements. When considering the requirements of their design crite-
ria, the company looked at good foveal vision when viewing through the peripheral areas of the lens, low perceived levels of distortion and good binocular symmetry for the merging of right and left images. Based on these observations, the concept of the Ipseo lens is simply:

- For those who look at objects by moving their eyes across the lens, a wide clear visual field is required. The surface astigmatism is concentrated in the periphery of the lens, allowing much larger areas of clear central foveal vision for all viewing distances.
- For those who predominantly move their head or ‘point their nose’, a softer design is required to prevent the swaying effect caused as the lens moves with the head. Essilor has slightly reduced the central area of the lens which is of lesser importance to the head mover, who always looks centrally through these areas.
- For all intermediate behavioural patterns, a compromise design is needed.

Other PPLs within the Essilor group are based on the Dioptoric Loop design, which involves analysis of wearer tests to create the best lens for all patients. Because the production technique involves moulded progressive surfaces for a range of prescriptions, certain compromises must result. With the Ipseo lens, each patient’s individual physiological and prescription details can be fed directly into advanced freeform surfacing equipment. The Loop approach is no longer required, as the resultant lens is individual to that patient.

The head/eye measurements can only be performed using a specially developed instrument called the VisionPrint™ system. The patient sits 40cm away from the unit and observes for two minutes, random stimuli generated by one central and two peripheral bulbs. The instrument displays a head/eye ratio and a stability coefficient. The latter reading indicates the consistency of head rotation during the measurement, which is compensated for in the final lens design.

It is interesting that at first glance, we could be looking again at the difference between a ‘hard’ and ‘soft’ lens design. Of course, there can be no real comparison between this lens and the older designs, especially with the wide viewing areas for the eye mover and the huge technological advances in production. However, it does raise the question of whether, in the past, a certain lens type was tolerated depending on the patient’s preference for head or eye movements.

The Ipseo now has three fitting heights of 14mm, 16mm and 18mm measured directly from the fitting cross to the lowest point of the inside rim of the frame, and is now available in Stylix 1.67 and Transitions® V with ESP Brown and Grey.

Essilor recently announced a new PPL design with the launch of Varilux Physio™. This lens uses a Wavefront Management System in order to apply wavefront technology to a PPL design for the first time. In doing so, the higher order aberration coma has been controlled in the distance zone of the lens, thereby offering wearers superior sharpness of vision through improved acuity and contrast sensitivity. Other benefits include widening of the intermediate zone through vertical orientation of the unwanted surface astigmatism in the margins of this part of the lens. Finally, the near zone has been extended vertically to improve postural comfort.

Sola Optical

Sola describes its SOLAOne™ as “a truly all purpose PPL”. It qualifies this by saying it delivers superior optical performance across the range of visual tasks that wearers perform every day. The lens design is the culmination of a 10-year research programme, which included analysis of over 10,000 presbyopic subjects using proprietary head-tracking technology.

The SOLAOne lens has acceptable surface astigmatism distributed in the distance periphery, which has allowed the company to concentrate on optimising the balance among all viewing zones, giving excellent distance, intermediate and near vision. Benefiting from its High Definition (HD) technology linked to freeform surfaces, the lens is optimised for an ‘as worn’ position to account for the prescription and Add, as well as individual frame fitting and facial dimensions. The near zone of this inner surface progressive is wide and positioned relatively high in the lens, and the soft distance periphery gives excellent dynamic and peripheral mid range vision.

By using a system of binocular analysis and optimisation with computer ray tracing, any binocular difference in power, prism and magnification is virtually eliminated. A design-by-prescription concept ensures each individual PPL is optimised for the same prescription and reading addition (by courtesy of Carl Zeiss). Each wearer. One feature of this concept is that the size of the near zone increases with the base curve, resulting in hypermetropes enjoying the same near field of view as myopes.

The HD technology is employed with Sola’s latest SOLAOne™ Ego, described as a ‘lifestyle customised’ PPL. A computer-based dispensing system, called the iPilot, is used by the dispensing optician to gather the relevant lifestyle information required by the company. A customisation code is created which when combined with the HD design calculations, produces an individual PPL based on the wearer’s vision and lifestyle demands. Both SOLAOne and SOLAOne Ego are available in 1.67 plastics and have a minimum fitting height of 18mm.

Carl Zeiss

We have already discussed some aspects of Carl Zeiss’ Gradal HS progressive design. These have been developed and combined with the company’s latest computer and surfacing technology to produce both the Gradal® Top and Gradal® Individual. The former, a front surface PPL, is designed using statistically determined average parameters, with the production range divided into base curve groups. The Clarlet 1.67® Gradal Top encompasses nine base curves between +1.00D to -10.00D, each with 12 additions resulting in 108 optimised progressive surfaces. To provide the optimised semi-finished lens for every prescription and addition would be economically unviable.

With the Gradal Individual, freeform surfaces can be created to provide the optimum finished lens for each patient incorporating in the design, parameters specific to the wearer’s facial measurements as well as frame fitting and near working distance details. Figure 9 demonstrates the improvement resulting from the individual optimisation process. The new process also means that even if the parameters differ greatly from the mean values, it is possible to create the ideal progressive design for the
patient.

To demonstrate how technology has advanced, at the beginning of the 1980s, Zeiss computers could calculate a progressive surface in about three hours. Today, computing time per surface is about 10 seconds.

The Gradal® Individual Short for shallow eye shapes has a minimum fitting height of 16mm – 4mm less than the Individual. A recent addition to the Zeiss range is the Individual Frame Shape. Progression zone lengths of between 10mm and 16mm can be ordered to adapt to the patient’s frame and needs, whilst ensuring the reading zone stays fully usable. A frame fit value is assigned to each progression zone, meaning that the frame fit stays fully usable. A frame fit value must be included with the order, or a frame fit value is engraved on the lens for reference. A further additional order requirement for this lens is the bow angle of the frame front, as shown in Figure 10. On request, an additional personalised engraving (up to five digits) can be applied to the lens, identifying the wearer or their practitioner, documenting that the individualised lens was fitted at that practice.

## Table 1

| Individual FrameFit™ values (by courtesy of Carl Zeiss) |
|---------------------------------|----------------|
| **FrameFit™ value** | **Length of progression zone** | **Minimum fitting height** |
| 0.0 | 10.0 | 14.0 |
| 0.1 | 10.1 | 14.1 |
| 4.0 | 14.0 | 18.0 |
| 5.9 | 15.9 | 19.9 |
| 6.0 | 16.0 | 20.0 |

Nikon Optical

Producing a thinner, flatter and lighter lens is often to the detriment of the quality of vision for the wearer. The Presio W PPL from Nikon, now produced in the highest available index of 1.74 (as well as 1.67 and 1.60), is claimed to offer almost natural vision. This is achieved through a combination of a new double surface design created through the latest computer technology linked to freeform surfacing. The back surface is described by Nikon as an Aberration Filter Surface (AFS), and is formed not only to complete the prescription but to minimise the aberrations created after refraction in all meridians by the front progressive surface. Figure 11 show the impact of the AFS on the performance of the lens.

Signet Armorlite Europe

Signet Armorlite Europe adopted a new approach with its Kodak Precise™ PPL. The optical qualities for superb vision were defined, and the required power to provide this was specified at virtually every point on the lens. The calculations to create the desired vision and lens powers were translated into the progressive surface design. A computerised modelling technique traces light rays from the lens to the eye, to evaluate and verify the image at every point of gaze across the lens. Individual designs are used for each base curve and Add.

The Kodak Precise lens is available in a range of plastics, from 1.49 to 1.67 indices all with a minimum fitting height of 18mm. The 14mm shorter corridor Kodak Concise™ lens is available in the same materials, with a minimum fitting height of 15mm.

Norville Optical

The recently introduced Norlrite Ultor from Norville is another addition to the range of inner surface progressives, giving the usual inherent benefits to the wearer that this type of design provides. At present, the Ultor is available in four plastics materials from 1.56 to 1.67 indices. This May, the range will be extended to include the 1.74 index material with an increased prescription range from +10.00D to -12.00D. Norville’s computer selection system will determine the most suitable progression corridor length, depending upon the specified fitting height.

BBGR

Even though the Evolis PPL from BBGR is personalised, it requires no extra measurements beyond those required for any PPL order. Instead, the company has invested its technological expertise in designing three surfaces, corresponding to the specific needs of either myopic, low ametropic or hypermetropic patients. Each design has a different power profile and progression length, with the design for myopes having a minimum fitting height of 16mm and 14mm for the hypermetropic patient. As seen with other designs, the
Reading inset increases from minus to plus prescriptions.

The Ysis PPL by Rupp + Hubrich, which is distributed in the UK by BBGR, is designed to complement individual lifestyles where the area of lens most used is maximised. Measurements, including the patient’s head inclination for near vision and frame positioning, are incorporated into the final design of each lens.

Conclusion

After 50 years, has the progressive power lens now reached the end of its evolutionary road, or will further technological strides enable that small piece of plastic to take a further step towards becoming the perfect lens? We will have to wait and see.

Acknowledgement

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References


Module questions

Please note, there is only one correct answer. Enter online or by using the form provided

1. Which of the following is not a feature of a hard design PPL?
   a. A relatively narrow distance zone
   b. A relatively narrow intermediate zone
   c. A relatively wide reading zone
   d. A rapid rate of change of near peripheral surface astigmatism

2. Which one of the following is a hard design lens?
   a. Gradal HS
   b. Varilux Comfort
   c. Rodenstock Multigressiv 2
   d. Sola Graduate

3. Which of the following is not a feature of a first generation Varilux 1 lens?
   a. It is optically symmetrical about the progression corridor
   b. It can be used as either a right or left lens
   c. When glazed, it has to be rotated to align the near vision zone
   d. It has a descending succession of different conic sections

4. Which of the following is not true of the first asymmetrical design PPL?
   a. The rate of change of surface astigmatism is greater in the nasal than the temporal periphery
   b. The inset will vary depending upon the distance prescription
   c. The reading zones are inset
   d. It is produced separately for right and left eyes

5. How far below the fitting cross is the full reading addition reached with the Varilux Comfort lens?
   a. 12mm
   b. 16mm

6. Which statement regarding the ‘multi-design’ concept is not true?
   a. The reading area becomes significantly smaller with increasing Adds
   b. The same lens type becomes ‘harder’ as the Add increases
   c. Low reading Adds are associated with a ‘soft’ design
   d. The progression profile of the same lens type varies with different adds

7. Which of the following statements regarding freeformsurfacing is not true?
   a. It may enable companies to avoid the need for stocking semi-finished blanks
   b. Lens polishing can alter the precision freeform surface
   c. It can produce progressive and single vision surfaces on either side of the lens
   d. It enables a less sophisticated lens design to perform to the same standard as a more advanced design

8. Which statement regarding the Rodenstock Impression lens is not true?
   a. The progressive surface is worked on the back surface of the lens
   b. Any cylinder is incorporated on the front surface of the lens
   c. The front curve can be worked to match the bow of the frame
   d. The inset is varied according to interpupillary distance and the distance prescription

9. Which statement is not true in relation to the design concept of the Hoyalux iD lens?
   a. Horizontal progression components on the inner surface can give greater image distortion
   b. Additional power only increases in the vertical direction
   c. The eye rotates less when scanning the same distance across the front surface compared to the back
   d. The front and back surfaces are balanced to reduce skew distortion

10. Which statement is incorrect regarding the Varilux Ipseo lens?
    a. It is available in three fitting heights – 14mm, 16mm and 18mm
    b. ‘Stability coefficient’ is a measure of the patient’s consistency of head movement
    c. Predominantly, ‘head movers’ require a ‘harder’ design to prevent sway
    d. ‘Eye movers’ require wide clear visual fields

11. How many combinations of lifestyle types and progression lengths are available for the Seiko Super P1 lens?
    a. Fifteen
    b. Five
    c. Eighteen
    d. Ten

12. Which statement regarding the SOLAOne Ego lens is not true?
    a. The progressive surface is on the back of the lens
    b. There is no surface astigmatism in the distance periphery
    c. It is optimised for ‘as worn’ position
    d. Orders for the SOLAOne Ego include lifestyle information