Progressive lenses Part 1

How progressive power is obtained

Thirty years ago, if a subject required a correction for distance, intermediate and near vision, it might have been provided in the form of trifocal lenses.

The drawbacks of trifocals are much the same as with bifocal lenses. They have zones of fixed power, which provide the wearer with a limited focusing range through each zone, there is jump at the dividing lines unless visible, no-jump designs are used, and the presence of the segment dividing lines detracts from the appearance of the lenses. These drawbacks are eliminated by dispensing progressive power lenses, the use of which has expanded rapidly in the last few years. Without doubt, progressive lenses have become the first choice of multifocal design for the correction of presbyopia.

Progressive power lens design

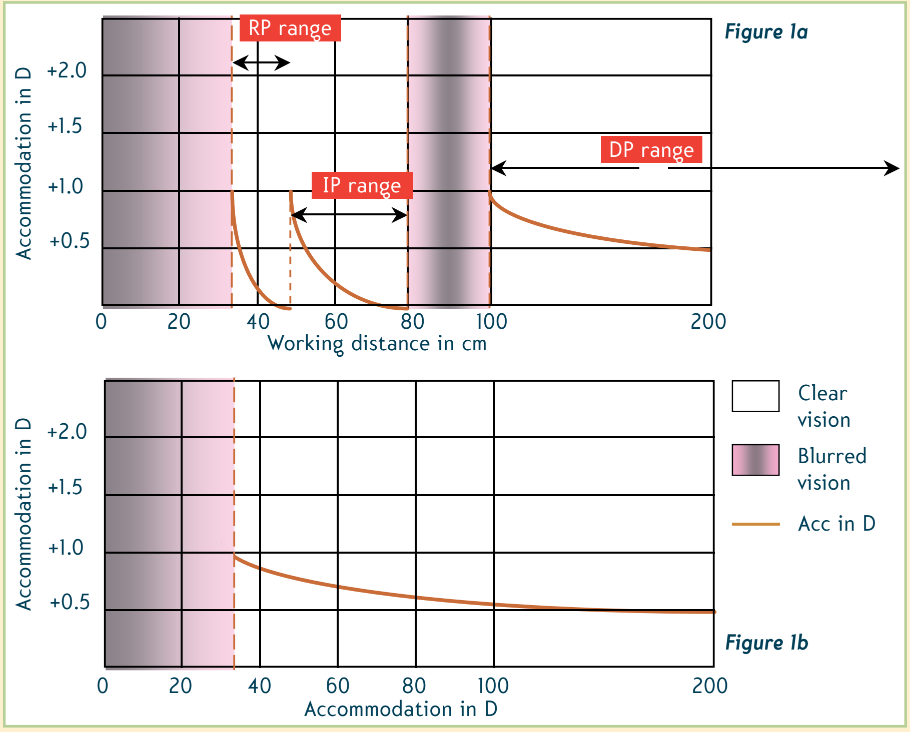
A progressive power lens is designed to provide continuous vision at all distances instead of the predetermined working distances of bifocal and trifocal lenses. The lens can be considered to have three distinct zones just like a trifocal design – a distance zone, a progression zone, or simply, the progression, and a near zone. Unlike a trifocal lens, the progression provides an increase in reading addition from the distance portion to the near portion. The rate at which the power increases in the progression zone is governed by the power law for the design. The power law may be linear, or may be more complex to provide a greater or lesser increase in power at the start of the progression.

Compared with bifocal and trifocal designs, the progressive power lens offers:

- Vision at all distances – since the addition increases over the progression zone
- More natural use of accommodation – accommodation does not need to fluctuate when vision is transferred from one zone to another
- Absence of image jump – there is no abrupt change in power
- The appearance of a single vision lens – there are no dividing lines on the lens

The second of these benefits is immediately apparent when the accommodative demands and ranges of vision through a trifocal lens and a progressive power lens are compared. Consider a subject who has an amplitude of accommodation of +1.00D and who is prescribed a correction of +3.00, Add +2.25 for near. The accommodative demands and ranges of vision, which are obtained when this specification is dispensed in trifocal form and progressive power form, are illustrated in **Figure 1**.

Figure 1 Comparison of accommodative demands and ranges of vision through trifocals and progressive power lenses



Module 2 Part 5
Lens Dispensing Today

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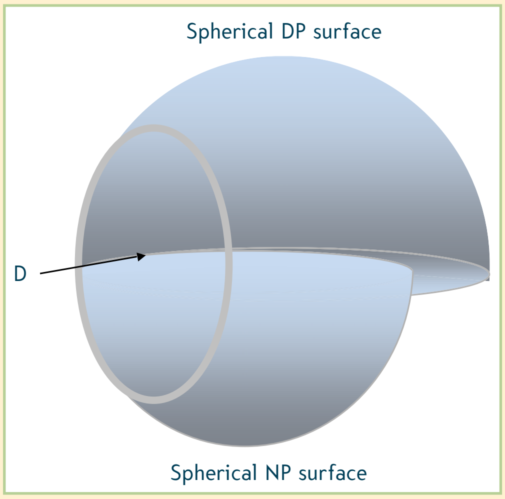

Figure 2
E-style bifocal made by placing together two spherical surfaces with a common tangent at D

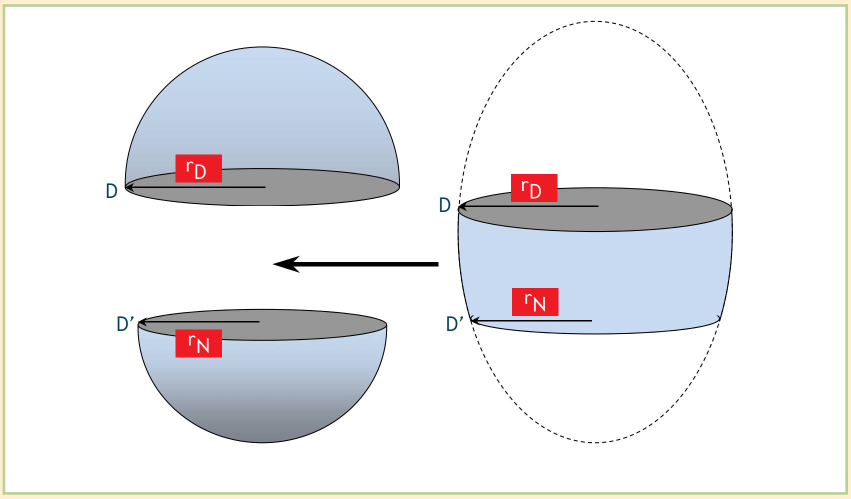

Figure 3
Concept of a progressive surface. Section of an oblate ellipsoid is inserted between two hemispheres of radius of curvature r_D for the distance portion and r_N for the near position

Figure 1a assumes that a trifocal correction with an intermediate addition of +1.25 has been provided. This intermediate addition would provide continuous vision from 80cm, down to the near point at 31cm through the intermediate and near portions of the lens. **Figure 1b** assumes that the correction has been dispensed in progressive power form and it is seen that the accommodative demand is of the same form as that enjoyed by the subject before the onset of presbyopia. Naturally, the actual position of the curve depends upon which zone of the lens the subject happens to be using.

In order to obtain an idea of the geometry of a progressive surface consider, first, an E-style bifocal whose bifocal surface is made from two different spherical surfaces placed together so that their poles share a common tangent at point D (**Figure 2**). Needless to say, the two surfaces are continuous only at point D. At all other points, there is a step between the two surfaces whose depth increases as the distance from D increases. If we wished to produce a truly invisible bifocal design, that is one whose dividing line cannot be detected, the two surfaces need to be made continuous by blending the two surfaces together making the DP surface and NP surfaces continuous at all points.

Figure 4
Schneider Opticmachines ALG 100-4 CNC
(by courtesy of Schneider Opticmachines)

In principle, a progressive lens may be considered to have spherical DP and NP surfaces connected by a surface whose tangential and sagittal radii of curvature decrease according to a specific power law between the distance and near zones of the lens.

In theory, to make a surface where the curvature increases at the correct rate to satisfy whatever power law it is required to adopt, we need to be able to combine small segments of spheres of ever-decreasing radii, all tangential to one another in a continuous curve. It will be understood that these sections will only be continuous along a single, so-called, meridian or umbilical line and that at all other points on the surface the sections must be blended to form a smooth surface.

The simplest concept of this latter surface is a section taken from an oblate ellipsoid, as illustrated in **Figure 3** where the radii of curvature of the spherical surfaces which represent the distance and near portions are shown as r_D and r_N respectively. It can be seen that the solid ovoid, which is obtained by inserting the ellipsoidal section between the two hemispheres shown in the figure, will result in a surface which has no discontinuities. Along the meridian line, DD', a cross section through the surface would be circular and the radii of the circles in a plane parallel with either the distance or near portion circles do indeed decrease from r_D to r_N continuously.

The ability to mass-produce surfaces of such complex nature was made possible by the introduction of computer numerically controlled (CNC) grinding machines. CNC machining methods have enabled the design and production of both progressive and aspheric lens designs in the last 30 years. Basically, the CNC cutter, which is often a single point diamond tool, cuts a surface under computer control, the cutter sweeping in an arc over the workpiece with the program positioning the cutter in exactly the right place as the cutter traverses the workpiece.

The drawback to the direct machining method is that no matter how accurately the surface is generated, it must still be smoothed and polished. These final stages used to be accomplished by means of a floating pad system and it was essential to ensure that the pads did not remove any more glass than intended thereby maintaining the correct surface geometry. In recent years, CNC polishing has been developed where the blocked lens may be transferred directly from the generator to the polishing cycle without de-blocking to ensure that the path of the polishing tool follows that of the generator precisely (**Figure 4**).

Slumping consists of using ceramic slumping moulds which are themselves produced by CNC cutting, upon which the glass blanks with carefully polished convex spherical surfaces are placed (**Figure 5**). The assembly is then heated to a high temperature at which the glass starts to flow. The back surface of the blank then conforms in shape with that of the ceramic mould and the convex surface of the blank, which is the progressive surface, slumps to the required geometry. The initial shape of the mould must be very carefully calculated and highly sophisticated temperature control is necessary to ensure that the glass

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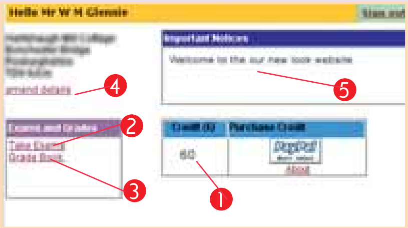

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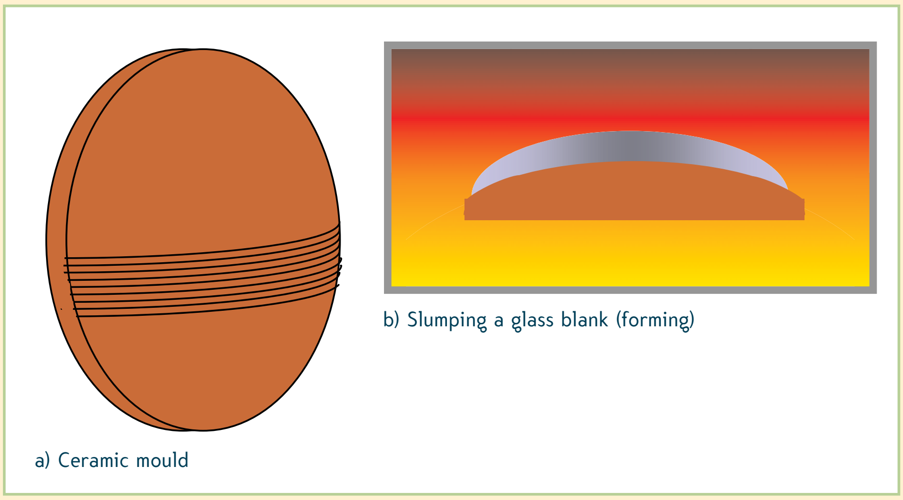

a) Ceramic mould

b) Slumping a glass blank (forming)

Figure 5
Slumping a glass blank to the required geometry

flows correctly.

Usually, the slumping is assisted by vacuum forming, where the glass is heated to just beyond its softening point at which temperature it is incapable of flowing by gravity alone, when a vacuum is applied to the interface between the forming block and the concave surface of the blank, effectively, sucking the surface into shape.

The actual geometry of a given progressive surface, naturally, is regarded as proprietary information by lens manufacturers but some insight into how the design of a surface might proceed can be obtained by developing the concept illustrated in **Figure 3**.

The CNC cutter can be programmed to cut a series of arcs, each one of which is independently controlled, but which will result in a continuous surface of any geometrical configuration. For example, it is possible to cut a conicoidal surface such as the oblate ellipsoid which, in fact, looks promising at first sight for a progressive power surface since both tangential and sagittal surface powers increase quite rapidly as the distance from the pole of the surface increases. The rate of increase in curvature can be controlled by altering the asphericity of this conicoid, and the change can be determined as follows. If an oblique pencil of rays is traced through a spherical lens there is likely to be an error, δT, in the tangential oblique vertex sphere power of the lens. Of course, in the case of a minimum tangential error lens form, the error, δT, may be zero. The ray-trace also yields the incidence height, y_1, on the front surface of the lens, the radius of curvature of the front surface, F_1, being denoted by r_1.

It is possible to show[1] that for any given tangential error, there must be a conicoid which will eliminate the error. If the error is positive, a conicoid whose *p*-value is less than one must be employed, whereas, if the error is negative, a conicoid whose *p*-value is greater than one would be employed.

If the tangential error is known for a given incidence height on the front surface, then the asphericity can be found from the equation:

$$p = 1 + (r_1/y_1)^2.(1 - (F_1 / (F_1 + \delta T))^{2/3})$$

This relationship provides some of the preliminary information that is needed to design a progressive power surface. In progressive power surface design, we want a tangential error to occur, the error being the magnitude of the required reading addition. If we substitute the addition for the tangential error in the above formula, it will give us the required asphericity to reach the value of the addition in the tangential meridian at a given distance below the optical axis of the surface.

For example, in the case of a +6.00D surface worked on a material of refractive index 1.50, to obtain a near addition of +1.00D at 14mm below the pole of the surface would require an asphericity of +4.5. For an addition of +2.00D, we would need an asphericity of +7.2 and for an add of +3.00D, an asphericity of +9.4. These *p*-values describe oblate ellipsoidal surfaces.

Lenses which employ oblate ellipsoidal surfaces are relatively easy to analyse using ordinary trigonometric ray-tracing techniques and in the case of a plano distance lens which employs a convex oblate ellipsoid whose *p*-value is +7.2 (which is designed to produce an Add of +2.00D), we obtain the field diagram depicted in **Figure 6**. It can be seen that for about a 25° rotation of the eye, which corresponds with a point about 14mm from the pole of the surface, the tangential oblique vertex sphere power is indeed +2.00D, the value which it was set out to achieve.

The ellipsoid alone, however, will not produce a good progressive power surface. The conicoidal surface is astigmatic, the surface astigmatism is normally chosen to eliminate the aberrational astigmatism of oblique incidence.

The field diagram depicted in **Figure 6** indicates the oblique astigmatism in the refracted pencil and it is seen that the astigmatism almost matches the increase in mean oblique power of the surface. Since the field diagram indicates the amount of oblique astigmatic error in the refracted pencil, it actually gives us the amount by which the sagittal curvature must be increased in order to eliminate the astigmatism. For example, at 25° where the astigmatism is -1.50D, if the sagittal power of the surface is increased by +1.50D, it will eliminate the astigmatism for this zone. The field diagram gives a first indication of the path that the CNC cutter must take, as it traverses the progression zone to eliminate the increasing surface astigmatism of the simple ellipsoid.

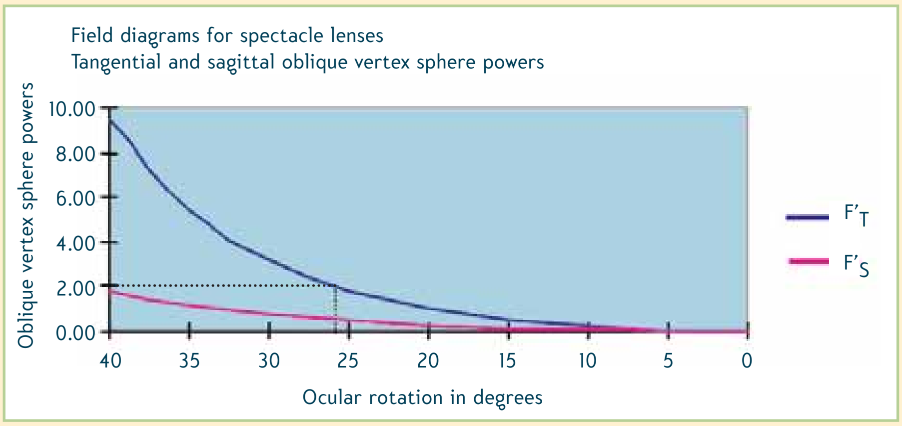


Figure 6
Field diagram for plano lens made with a convex oblate ellipsoidal surface

Figure 7 illustrates the power variation along the meridian line, AD, for progressive lenses which are assumed to have spherical distance and near portions. The separate plots shown in **Figure 7a** indicate that the tangential and sagittal powers differ, as is shown in the field diagram in **Figure 6**. Whereas the tangential power along the meridian line has reached the near portion power of +4.00D, the sagittal power only reaches +2.62D at the bottom of the progression zone. When the sagittal curvatures are increased point by point along the meridian line, however, the sagittal powers can be increased to match the tangential powers in the progression zone resulting in the power variation illustrated in **Figure 7b**.

Note that this description of the correction for astigmatism only applies to points, which lie along the meridian line itself. As the cutter moves away from the meridian line, the form of the surface becomes more complicated depending upon the performance, which the designer wants to achieve in the periphery of the progression zone.

It will be understood that the image formation within the progression zone does not depend only upon the astigmatism at single points on the surface, for the power of the progressive surface changes across the refracted pencil, which is admitted by the eye.

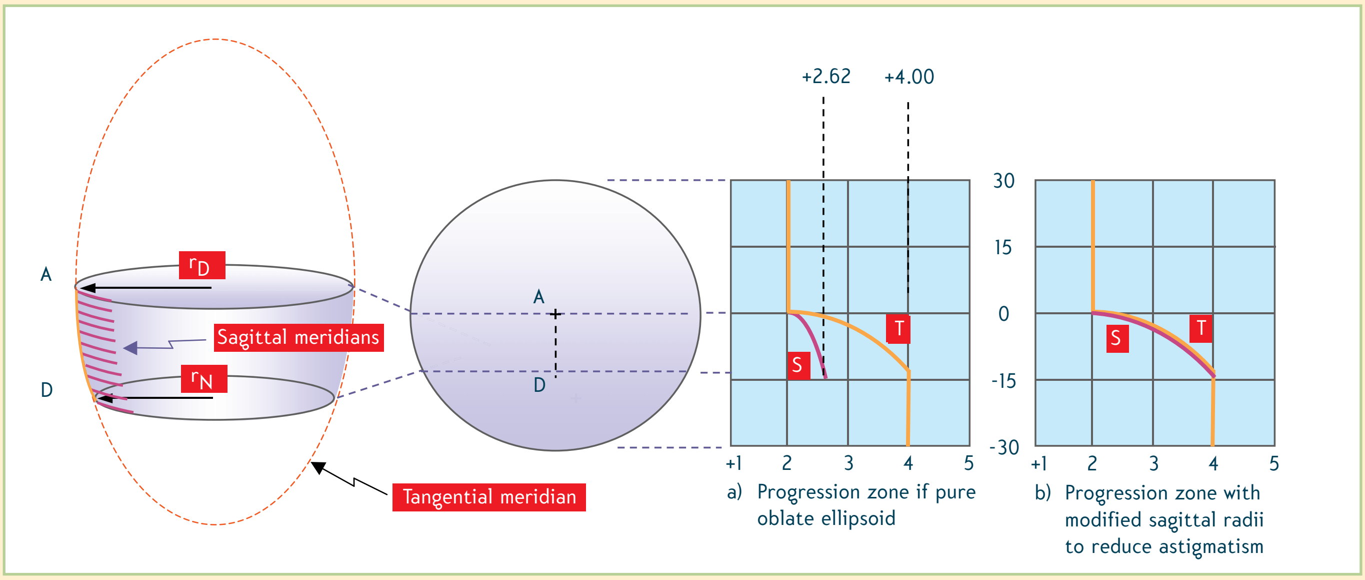
If the power law through the progression zone is linear then the change in power depends upon the near addition, *A*, and the length of the progression zone, *h*. For each 1mm of progression zone the increase in power, δF, through the zone is given by:

$$\delta F = A/h$$

Thus, if the reading addition is +2.00D and the length of the progression zone is 10mm, the surface power through the progression zone must be changing at the rate of 0.20D per millimetre.

When the eye uses the progression zone, the refracted pencil which fills the pupil must exhibit a skewed form of astigmatism, even along the meridian line. The astigmatic nature of the pencil is illustrated in **Figure 8**, which depicts the tangential and sagittal fans of a narrow circular pencil of light, which is limited by the eye's pupil, emanating from a region of the progression zone, which is bisected by the meridian line.

Assuming that the diameter of the beam of light traversing the progression zone is 4mm, with a surface that provides a near addition of +2.00D over a progression length of 10mm, there will be a difference in the tangential and sagittal surface powers across the zone of 0.40D. If the astigmatism across the pupil is defined as the difference in vergence between the tangential and sagittal fans across the pupil, then the astigmatism is $-2A/h$ D. This approximate, but important, rule tells us



a) Progression zone if pure oblate ellipsoid

b) Progression zone with modified sagittal radii to reduce astigmatism

Figure 7
Power variation for progressive power lenses with ellipsoidal progression surface of depth 14mm Rx +2.00 Add +2.00, before and after adjustment to sagittal curvatures in progression zone

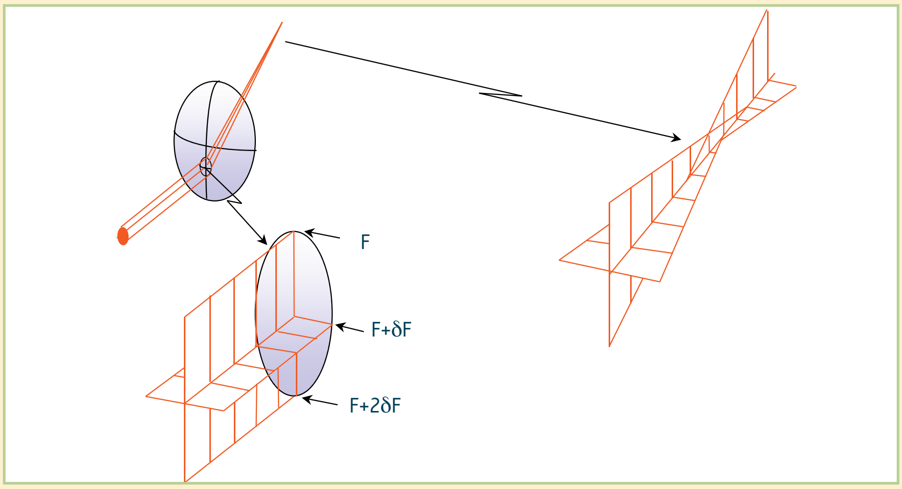


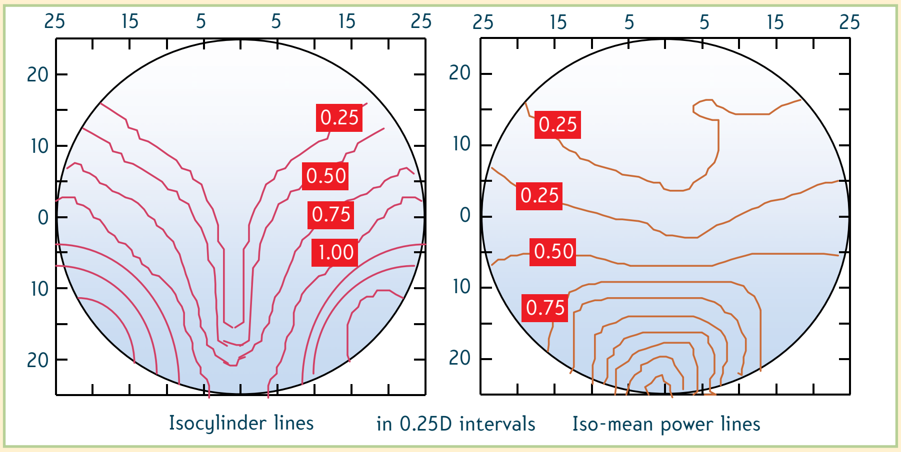
Figure 8
Astigmatic nature of the progression zone

that the astigmatism across the pupil is proportional to the addition, but inversely proportional to the length of the progression zone. In other words, the smaller the addition and the longer the progression zone, the smaller the astigmatism becomes.

As the eye moves away from the meridian line, the total astigmatism increases, approximately linearly but, of course, dependent upon the exact nature of the cross-section of the lens.

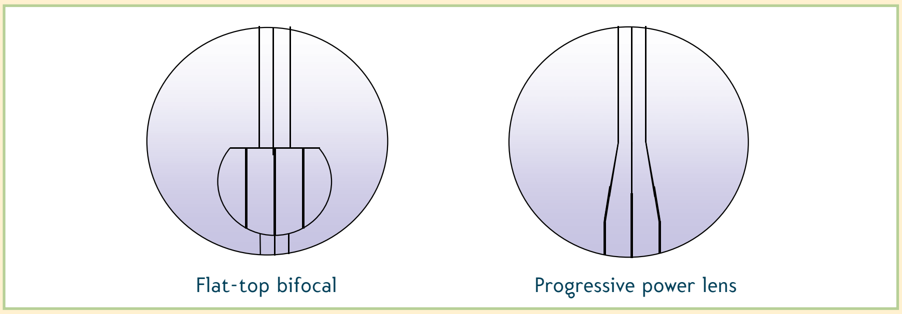
The corridor of clear vision through the progression zone is often described as the region in the zone where the astigmatism does not exceed +1.00D. It is conventional for manufacturers of progressive designs to compare the width of the corridor of clear vision, either as a stated number of millimetres or by an isocylinder diagram where the contours illustrate the change in surface astigmatism in different zones of the lens. Such a diagram is illustrated in **Figure 9**, together with an iso-mean power diagram, which shows how the power varies across the lens. On the basis of a 1.00D limit on surface astigmatism, the lens illustrated would be described as having a corridor width of nearly 20mm at 10mm below the geometric centre of the lens.

Figure 9
Isocylinder and iso-mean power lines for progressive power lens, plano add +2.00D



Isocylinder lines in 0.25D intervals Iso-mean power lines

Figure 10
Skew distortion in a progressive power lens



Flat-top bifocal Progressive power lens

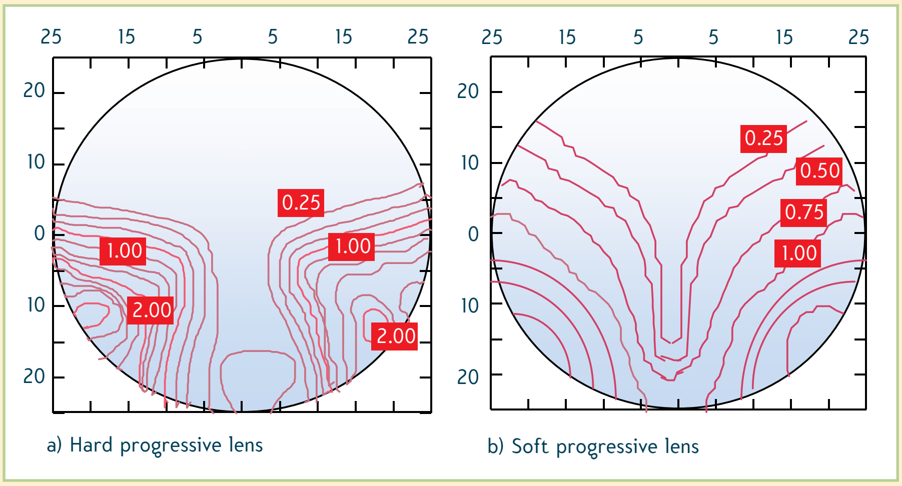
The iso-mean power diagram illustrates that the surface increases in power slightly as the eye rotates upwards from the geometric centre of the lens, which is due to the method chosen to blend the surface between the distance and near portions. Also the full reading addition of +2.00D is seen to have been reached at a point 20mm below the geometric centre of the lens.

A second consequence of the progressive surface is depicted in **Figure 10**, which compares the appearance of three vertical lines viewed through a bifocal lens and a progressive power lens. Since an increase in power is inevitably accompanied by an increase in magnification, and it is inevitable that if there is one then there must also be the other, vertical lines viewed through the progression zone exhibit skew distortion.

The directions of the lines can be illustrated by means of a vector plot, which shows how their orientation can be expected to vary in a real image of the lines. The skew effect can be minimised by decreasing the surface curvature as the eye moves away from the meridian line. The lower down the surface, the greater the reduction in curvature needs to become.

The development of progressive lenses over the last 40 years can be discussed in terms of the way in which the CNC cutter has been employed to blend the DP surface with the NP surface. In the first commercially successful lens, the Varilux 1 design from Essel Optical Company (now part of Essilor International), the DP and NP surfaces were virtually spherical and the CNC followed a path, which described circles of ever-decreasing radius as it traversed from the spherical distance portion to the spherical near portion. This necessitated very severe blending of the distance and near portions with large amounts of surface astigmatism at the peripheries of the progression. However, the distance portion was almost completely free from surface astigmatism. The second generation Varilux 2 design used a series of conic sections of varying asphericity to reduce the astigmatic nature of the earlier design and, at the same time, used aspherical DP and NP surfaces to further reduce the severity of the blend. Without doubt, the Varilux 2 design pointed the way for later generations of progressive power designs.

Third generation designs, such as the Truvision OMNI design, combined aspherical DP and NP surfaces, which spread the blending further into the distance portion, softening the definition in the distance portion but considerably reducing the astigmatism in the lateral portions of the lens. The power profile of lenses, such as the OMNI, can be compared with that of an up and down curve trifocal design, with the full distance prescription



a) Hard progressive lens

b) Soft progressive lens

Figure 11

Comparison of isocylinder lines for hard and soft progressive lens designs of power, plano add +2.00D

obtained near the top of the lens and the near prescription at the bottom. Such a long progression, of course, enabled the lens to exhibit remarkably low levels of surface astigmatism in the 'intermediate' peripheral zones.

The latest generation of designs has combined the features of low-power aspheric lenses with a progressive surface design, and also adopted different power laws for different near additions.

This feature of progressive lens design, the ability to control in which areas of the lens the blending between the DP surface and the NP surface occurs, has enabled manufacturers to decide which areas they should prioritise for optimum vision. If the designer requires a large distance portion with the surface astigmatism confined to the lower portion of the lens, rather like the earliest progressive lens designs, the result is a hard progressive design. The arrangement of the surface astigmatism in a hard design is shown in **Figure 11a**. It is seen that this design enables a large DP area and a relatively large NP area to be obtained, but there are rapid discontinuities in the astigmatism in the lower portion of the lens.

If the designer wishes to reduce the amount of astigmatism which occurs in the lower portion of the lens, to speed the patient's adaptation to progressive lens wear, it can be spread into the distance portion as indicated in **Figure 11b**. This arrangement results in a soft progressive design, and there can be no doubt that when the addition is low and, hence, the surface astigmatism is low, the soft progressive design has proved to be the most successful in enabling rapid wearer acceptance of progressive design.

Some manufacturers produce progressive lens series that are deliberately soft in design for the low addition lenses in the series, the design tending to become harder as the additions increase. These are known as multi-design series. **Figure 12** illustrates how the power law differs with a multi-design series for the additions, +1.00D, +2.00D and +3.00D. It can be seen how the length of the progression zone reduces as the addition increases for these series.

Another important feature of progressive power lens design relates to the symmetry of the power distribution across the lens. In **Figure 13**, the eyes are supposed to be viewing an object at B, the visual axes intersecting the lenses at P in the right eye and P' in the left eye. If the surface power at point P were to differ much in magnitude or orientation from the surface power at P', there will be different prismatic effects at the two points. For ease of fusion in all directions of gaze, the vertical prismatic effects at corresponding points must be approximately equal. This is more likely to be the case if each lens is individually designed for the right and left eyes, rather than producing a single design that is rotated inwards, in opposite directions for the two eyes. Progressive lens designs that exhibit approximately equal vertical prismatic effects at corresponding points, are said to possess horizontal symmetry.

Although isocylinder and vector diagrams are informative, it is foolhardy to suppose that they can be used to predict wearer adaptation and acceptance of the lens.

Despite the consequences of the progressive surface, the brain quickly adapts to the effects of surface astigmatism and skew distortion. The adaptation required of the visual system is probably no greater when patients wear their first pair of progressive lenses than that required when given their first pair of bifocals. Indeed, if progressive power lenses are introduced at the onset of presbyopia, when the reading addition is low, the adaptation period is probably less than it would be for the first pair of bifocal lenses. In an attempt to evaluate the performance of new progressive designs, most manufacturers submit the lenses to clinical trials, the information that the wearers report being fed back into the design loop.

Patients who, typically, find it difficult to adapt to progressive lenses are those with high reading additions who have successfully worn bifocal lenses in the past and have become accustomed to a wide reading field of view through a large segment. Problems with adaptation to progressive lenses are almost always due to either an incorrect prescription for distance, too high or low a near addition or poorly fitted lenses[2,3].

Figure 12

Power laws for +1.00, +2.00 and +3.00 additions for a multi-design series of progressive power lenses. Note the designs tend to become harder as the reading addition increases

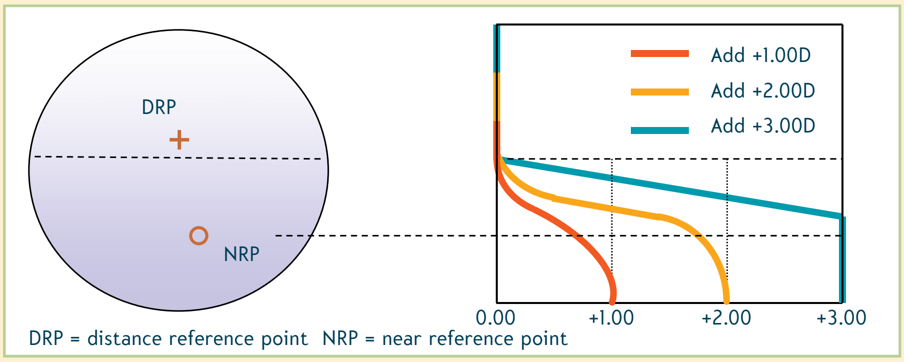
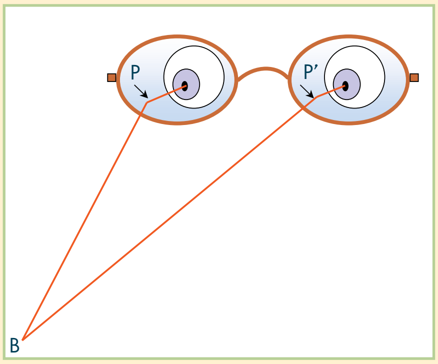
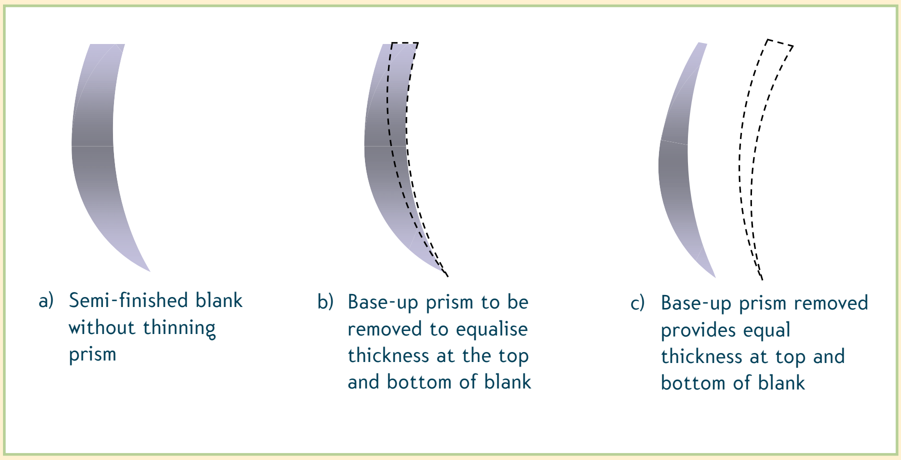


Figure 13

Horizontal symmetry at corresponding point on the lens

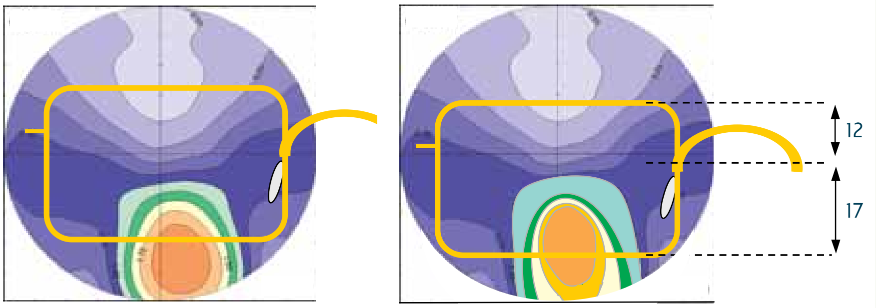



a) Semi-finished blank without thinning prism

b) Base-up prism to be removed to equalise thickness at the top and bottom of blank

c) Base-up prism removed provides equal thickness at top and bottom of blank

Figure 14
Thinning prism



Mean power plot add +2.00D for a progressive design with a corridor length of 18mm does not provide an adequate near portion in a shallow frame

Mean power plot add +2.00D for a progressive design with a corridor length of 14mm shows that the lens may be mounted in a shallow frame. Note the recommended frame depth below the pupil is 17mm, with a minimum overall frame depth of 29mm

Figure 15
Minimum requirements for frame depth

Thinning prism

When a progressive lens is worked to individual prescription by surfacing the concave surface of the blank, it is usual to incorporate a thinning prism in the specification of the back surface. The purpose of the thinning prism is to equalise the edge thickness of the finished lens, usually at the top and bottom edges of the lens, and its magnitude depends upon the power of the lens, the cylinder axis direction if the lens is astigmatic, and the position of the distance reference point with respect to the box centre of the lens (**Figure 14**). Typically for plus spherical lenses, the magnitude of the thinning prism is about two-thirds of the reading addition and its base usually lies at 270°. As with all ordered prisms, the magnitude and direction of the prism incorporated in the lens must be measured at the prism reference point, which is normally the geometric centre of the original blank.

It is sensible to apply an anti-reflection coating to any lens that incorporates prism in order to eliminate the possibility of the ghost image, which is formed by total internal reflection at the lens surfaces annoying the wearer.

Fitting progressive power lenses

A suggested fitting routine for progressive power lenses is as follows:

1. Select the final frame that the patient is to wear and adjust it to fit properly. As a general guide, the frame should be closely fitting with the smallest possible vertex distance and the correct pantoscopic angle, and should provide adequate depth beneath the centre of the pupil to accommodate the reading zone of the lens. A minimum depth of 22mm is usually suggested for designs with corridor lengths of 18mm, or a minimum depth of 14mm for compact designs. Manufacturers usually give a recommendation upon both the required minimum depth of lens below the pupil centre, and the required height of lens above the pupil centre in order to ensure that the subject has an adequate field with the design (**Figure 15**).
2. If the frame is empty, attach vertical strips of transparent adhesive tape to each eye to enable reference points to be marked. Otherwise, the fitting cross positions can be marked on the existing lenses.
3. With the correctly adjusted frame in position, ask the patient to look straight into your eyes. If necessary, adjust the height of your stool to ensure that your eyes are on exactly the same level as that of the patient. Some manufacturers now recommend that measurements for the height of the fitting cross should be taken with the patient standing when it is easier to judge whether their normal head position is more or less upright than when they are seated.
4. Direct the patient to look straight into your open left eye and using a fine-tip marking pen and, preferably, a light coloured ink, place a dot in front of the centre of the patient's right pupil.
5. Direct the patient, without moving their head, to look straight into your right eye and place a second dot in front of the centre of their left pupil.
6. Remove and replace the frame on the patient's face and repeat the above procedure, this time without making any marks, to ensure that the dots which you have marked do lie in front of the centres of the pupils.

Record the fitting point positions and check by means of an appropriate blank sizing chart that the lenses can be obtained from the available blank diameters. When ordering the lenses, it is necessary to give the fitting point positions (the vertical and horizontal fitting distances and directions of the fitting points from the boxed centres of the lens shapes). The horizontal fitting point positions are deduced from the difference between the monocular CDs measured from the centre of the bridge of the frame, and half the horizontal box centre distance of the frame. It is very common for the monocular CDs to differ between the right and left eyes. The specification should be written, for example, as 34/32, which indicates that the right eye monocular CD is 34 and the left eye monocular CD is 32. The heights of the pupil centres may also differ for the right and left eyes.

It is sensible, whenever possible, to dispense a frame that allows some vertical adjustment of the height of the distance reference point at, or subsequent to, the final fitting. This enables the lenses to be raised or lowered, if this is found to be necessary, to aid adaptation.

Of equal importance to the success of dispensing progressive power lenses to new wearers is the confidence shown by the practitioner when prescribing this design for the correction of presbyopia, and especially what advice is given in the wearing and use of the lenses at final fitting. Needless to say, the advantages of progressive designs over other forms of multifocal correction should be spelt out in simple terms at the time of dispensing:

- "These lenses will enable you to focus at all distances"
- To first time young presbyopes: "They will be easier to get used to than bifocal lenses"
- "In wear, the lenses will restore the vision of youth"
- "There are no tell-tale dividing lines on the lenses"

At final collection, it is important to re-emphasise these advantages and demonstrate the use of the lenses. A suggested routine for the final delivery of progressive lenses to patients when they come to collect their new spectacles is as follows.

1. Firstly, make sure when checking the lenses that not only the powers at their recommended measuring points and the prism at the prism reference point are all as ordered, but also that the horizontal painted lines are parallel to the line joining the centres of the engraved circles. Also ensure that the position of the fitting cross on each lens has been restored so that it is clearly visible.
2. The frame into which the lenses are mounted should have been set up to fit the patient properly at the time of dispensing. However, the lens mounting process may have disturbed the initial set-up of the frame, so it is important to ensure that the frame is returned to the adjustment that was made when the lens measurements were taken. Any small final adjustments that may be needed at the time of final fitting should be undertaken first.
3. Verify that the positions of the fitting crosses do coincide with the centres of the patient's pupils. The same procedure which was used for dotting the desired fitting point positions should be adopted.
4. Clean off the painted marks and ensure that the lenses and frame are completely clean and look like new.
5. Ask the patient to look at a distant object directly in front and verify that the anticipated visual acuity is obtained for distance vision.
6. Ask them to look at a laterally placed object at the same height as the straight-ahead distance target, and point out if necessary that it might be necessary to turn the head to obtain optimum acuity for this object.
7. Ask them to look at a test chart at near, which you should guide into their hands so that it is held directly in front of the subject in the usual reading position, and verify that the anticipated acuity for near vision is obtained.
8. Ask them to move the near chart to one side and, again, ensure that the patient understands that they may need to turn their head and point their nose in the direction of view in order to see the near target clearly.
9. Move the near test target to a position where it is about 40cm to 50cm directly in front of the patient, and just below the original object chosen to verify the distance acuity. Point out that they can also see clearly at the intermediate distance, if necessary by a slight adjustment of the visual axes in the vertical meridian. In particular, allow the patient to confirm that the gaze can be transferred from the distant target to the intermediate target without moving the head, simply by adjusting the direction of gaze of the eyes.
10. Point out the visual tasks which are not easy with progressive power lenses, such as reading a notice with small print which is above head height, reading when lying down or trying to watch television when lying down in bed, and looking over their shoulder as they might when reversing a car.

Most important of all is to reassure the patient that these visual tasks are well understood, as is the optical performance of their progressive lenses, and that most people need no more than a short period to get used to this state-of-the-art correction for presbyopia.

Insetting progressive power lenses

When single vision lenses are dispensed for near vision, they are decentred inwards so that the visual axes pass through the optical centres of the lenses. This enables the centres of the near fields of view to coincide and avoids the introduction of unwanted horizontal prismatic effect for near. In the case of multifocal lenses whose distance portions have been properly centred for distance vision, the main lens exerts prismatic effect at the near visual points, which alters the convergence requirements for objects viewed through the near portion. The purpose of insetting the near portion is to bring the near fields into coincidence[4] and in order to achieve the desired effect, it is necessary to take the prismatic effect of the distance portion into account (**Figure 16**).

It can be seen from **Figure16** that, in order to place the centre of the near aperture in the correct position (i.e. the centre of the segment in the case of bifocal lenses, or the centre of the near zone in the case of progressive power lenses), the insetting must be greater in the case of plus, and less in the case of minus distance portions when compared with the inward decentration of single vision lenses designed for near vision. Thus, for each combination of base curve and reading addition, the designer must calculate a different inset for the progression corridor on the lens to ensure that the wearer enjoys the widest possible widths for the progressive corridor and the near vision zone.

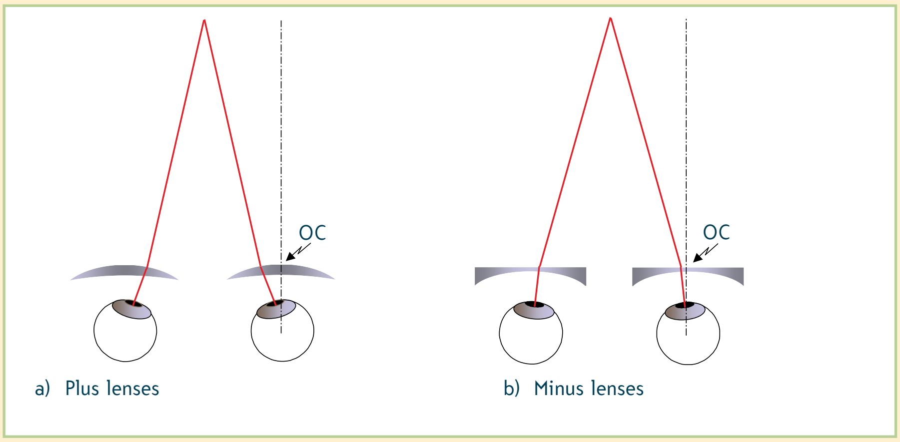
With most modern progressive designs, the inset is individually calculated taking into account both the working distance and the distance and near prescriptions, in addition to the monocular centration distances.

Part 2 of Progressive power lenses on June 17 will look at the latest generation of progressive lens designs.

References

1. Davis JK and Fernald HG (1976) US Patent 3960442. Ophthalmic Lens Series
2. Essilor International (1997) Personal communication. In-house analysis of wearer rejection of progressive lenses.
3. Sullivan CM and Fowler CW (1990) Investigation of progressive addition lens patient tolerance to dispensing anomalies. *Ophthal. Physiol. Opt.* 10: 16.
4. Jalie M (2003) Ophthalmic Lenses & Dispensing. Second edition. Butterworth Heinemann, Oxford.

Figure 16
Insetting progressive power lenses



a) Plus lenses
b) Minus lenses

MCQs

Module 2 Part 5 of Lens Dispensing Today

Progressive lenses Part 1 – How progressive power is obtained

Please note there is only ONE correct answer

1. What jump is exerted by a progressive lens made to the prescription, +1.00D add +2.50D?
a. 1.00D
b. 2.50D
c. 3.50D
d. None

2. A progressive power lens with an addition of +3.00D has a progression zone 15mm in length. Assuming a linear power law through the progression, what addition would you expect the wearer to obtain 10mm below the start of the progression?
a. +1.00D
b. +1.50D
c. +2.00D
d. +2.50D

3. Why does a section taken from a simple oblate ellipsoid not form a useful progressive surface?
a. The sagittal curvature is insufficient to provide no astigmatism along the meridian line
b. It does not join the distance and near areas without a discontinuity in the surface
c. It does not provide sufficient near addition in the tangential meridian of the meridian line
d. It provides too great an addition along the sagittal meridians of the meridian line

4. Why does skew distortion occur in a progressive power lens?
a. Because all lenses exhibit distortion
b. Because the power becomes more plus as the eye moves down through the progression zone
c. Because the power becomes less plus as the eye moves down through the progression zone
d. Because the magnification becomes less as the eye moves down through the progression zone

5. What are the characteristics of a soft progressive design?
a. No astigmatism in the distance area of the lens
b. No astigmatism in the lower half of the lens
c. Astigmatism is allowed to spread into the distance portion of the lens
d. Astigmatism is confined to the peripheral portions of the lens

6. What is the main characteristic of a multi-design series of progressive lenses?
a. The power law varies with the reading addition
b. The design becomes softer as the addition increases
c. The design varies with the distance prescription
d. The length of the progression zone increases with the near addition

7. What is meant by the term 'horizontal symmetry' when applied to a progressive power lens?
a. The horizontal power of the lens is the same at corresponding points in a pair of lenses
b. The horizontal prismatic effect is the same at corresponding points in a pair of lenses
c. The vertical prismatic effect is the same at corresponding points in a pair of lenses
d. The thinning prism which has been incorporated is the same for each eye

8. Which of the following does not usually hinder adaptation to a pair of progressive lenses?
a. Too high a reading addition
b. A low reading addition
c. An incorrect distance prescription
d. Poorly fitted lenses

9. If a standard prism thinning is applied to a progressive power lens whose power is plano / +1.00 x 90 add +1.50, how much prism would you expect to find at the distance reference point of the lens assuming this to lie 5mm above the prism reference point?
a. 1.00D base down
b. 1.50D base up
c. 1.50D base down
d. None

10. If no prism thinning is applied to a progressive power lens whose power is -5.00 add +2.50D, how much prism would you expect to find at the distance reference point of the lens assuming this to lie 4mm above the prism reference point?
a. None
b. 1.00D base up
c. 2.00D base down
d. 2.00D base up

11. On verification of a progressive power uncut lens the power at the distance reference point, 4mm above the geometrical centre of the uncut, is found to be +4.00D and it is noted that the prismatic effect at this point is 2.6D base down. What thinning prism has been incorporated in the lens?
a. None
b. 1.00D base down
c. 1.60D base down
d. 1.60D base up

12. Minus power progressive lenses should be inset in which one of the following ways?
a. The same as plus lenses
b. More than plus lenses
c. Less than plus lenses
d. The same for all minus powers

An answer return form is included in this issue. Paper entries ONLY should be completed and returned by June 15 to: CET initiatives (c-144), *OT*, Victoria House, 178-180 Fleet Road, Fleet, Hampshire, GU51 4DA.

Please note that model answers for this *Pay-As-You-Learn* series will not be available until July 15, 2005. This is so that readers submitting answers online can join at any time from now until July 12, 2005 and take part in any or all of the six articles as they are published. Paper entries will be marked on the normal monthly basis. CET points awarded will be uploaded to the Vantage website by July 23, 2005. All participants must confirm these results on

www.cetoptics.com.