Prism-thinning progressive lenses

Darryl Meister explains the concept of prism-thinning and its consequences in practice

Competencies covered: optical appliances
Target group: dispensing opticians, optometrists
Keywords: progressive lenses, prism, prism-thinning, yoked prism, equi-thinning

A progressive lens produces a smooth increase in positive foca–or addition–power from distance to near without any lines of demarcation. In order to provide this gradual change in power, the curvature of a convex progressive lens surface must become increasingly steeper toward the bottom of the lens (Figure 1). The addition power of a convex progressive lens surface is simply the result of the difference between the higher surface curvature in the lower region–or near zone–of the lens and the lower surface curvature in the upper region–or distance zone–of the lens. A concave progressive lens surface, on the other hand, must become increasingly flatter toward the bottom of the lens in order to produce an increase in addition power; this type of surface is often encountered with modern 'free-form' progressive lenses.

For instance, a progressive lens surface that measures +6.00 D in the distance zone with a lens measure and +8.00 D in the near zone (Figure 2) produces an addition power of roughly +8.00 - (+6.00) = +2.00 D. An inspection of a vertical cross-section of a typical uncut (not yet edged to shape or glazed) progressive lens blank reveals that the steeper curvature of the near zone results in a thicker upper edge and a thinner lower edge because the thickness over the entire lens blank becomes limited by the lower edge thickness of the steeper near zone (Figure 2). This surface geometry, which is analogous to the thickness constraints of plus-powered lenses, has several important consequences for a progressive lens blank:

- The upper edge is thicker than the lower edge.
- The overall thickness of the lens blank is greater.
- The weight of the lens blank is also greater due to this increased thickness.

Of course, this increased thickness might seem counter-productive for a lens designed to improve cosmesis. Many DOs are already aware of the problems inherent with such a lens blank geometry from past experiences with Executive-style bifocals. The steeper segment curvature of an Executive-style bifocal also creates a thickness differential between the upper and lower edges of the lens.

The thinnest point, or minimum thickness, along the perimeter of a progressive lens blank with no (or plano) prescription power or prism is located at the bottom edge of the lens blank below the near zone. The minimum thickness limits the overall thickness of the lens blank. If the minimum thickness of the finished progressive lens remains at the edge of the lens blank, which is typically the case for hyperopic prescriptions or prescriptions with high addition powers, the entire lens blank will be thicker than a comparable single-vision lens or flat-top bifocal lens of the same power (Figure 3). The minimum thickness of progressive lenses with strong myopic prescriptions and weak addition powers, on the other hand, is located nearer the centre of the lens blank.

Fortunately, it is possible to ensure that spectacle wearers enjoy the superior

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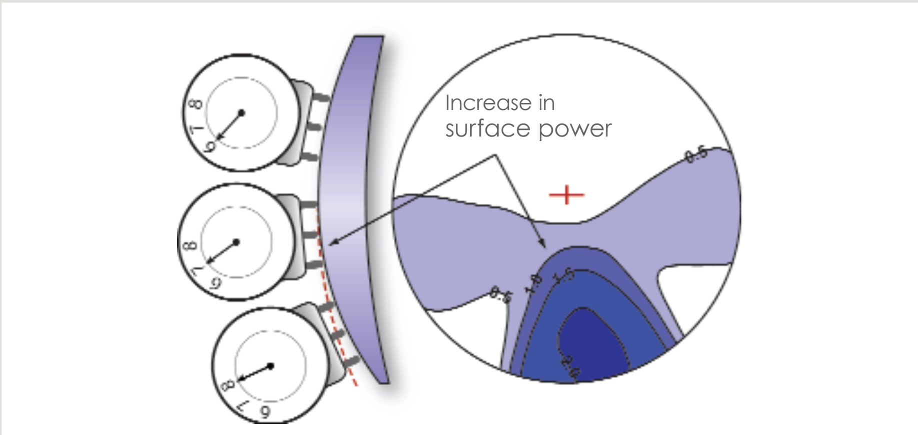

FIGURE 1: INCREASING CURVATURE OF A PROGRESSIVE LENS SURFACE

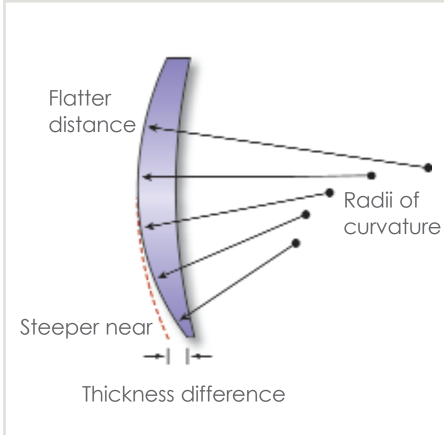

FIGURE 2: EDGE THICKNESS DIFFERENCE DUE TO INCREASING SURFACE CURVATURE

cosmetics that they expect with their progressive lenses. The excess thickness and weight of progressive lenses can be significantly minimized using a surfacing technique known as prism-thinning. Prism-thinning (also called equi-thinning) is the process of grinding vertical prism into a progressive lens blank in order to minimise the thickness difference between the top and bottom edges of the lens as well as to reduce the overall thickness of the lens.

Most commonly, prism-thinning involves grinding base down prism into a progressive lens. In some cases, however, base up prism may be appropriate. Although base down prism is 'added' to the lens, the real objective is to remove base up prism from the lens in order to eliminate the excess thickness from the upper edge of the lens blank. Consider a block of glass with parallel sides (that is, no prism). If a wedge of base up prism is removed from the block, the bottom is left thicker. Consequently, the block now has base down prism (Figure 4).

Moreover, by removing this 'wedge' of prism, the thickness across the entire block is reduced. At the geometric centre of the block, for instance, the reduction in thickness is equal to one-half of the maximum edge thickness of the wedge. Now consider an actual uncut progressive lens blank. If a wedge of base up prism is removed to balance the thickness of the upper and lower edges, the thickness of the entire lens blank is reduced (Figure 5). The finished lens is left with base down prism, however, since the lens blank initially had no prism at the geometric centre.

In addition to balancing the thickness difference between the top and bottom of the lens blank, prism-thinning also reduces the centre thickness of progressive lenses with relatively high hyperopic prescriptions or high addition powers. This overall reduction in lens thickness also makes the lens lighter in weight. In summary, these physical characteristics of prism-thinning offer two important benefits to the spectacle wearer:

- Thinner lenses with a more consistent edge profile offer better cosmetics
- Lighter weight lenses are more comfortable to wear

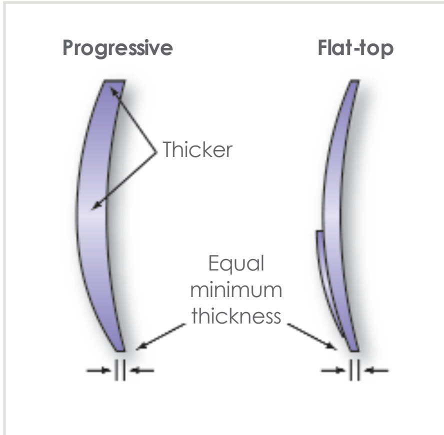

FIGURE 3: THICKNESS COMPARISON BETWEEN A PROGRESSIVE LENS AND A FLAT-TOP BIFOCAL FOR A +2.00 D PRESCRIPTION WITH A +3.00 D ADDITION

In order to avoid creating a vertical prismatic imbalance, equal vertical

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FIGURE 4: REMOVING BASE UP PRISM BY GRINDING BASE DOWN PRISM

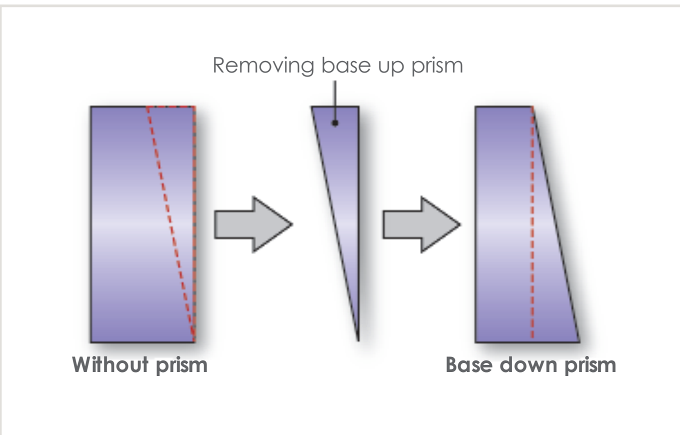
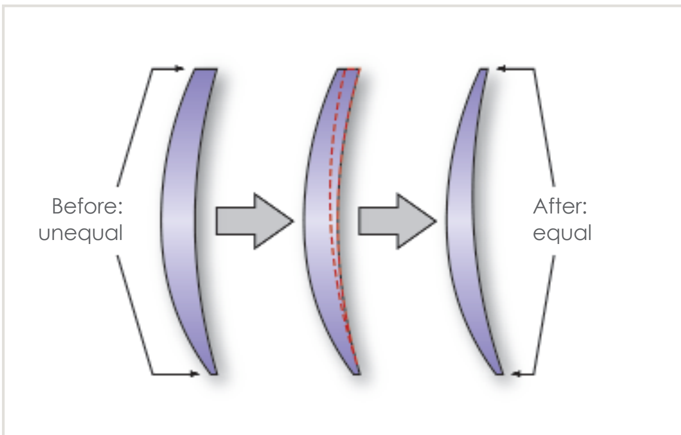


FIGURE 5: ELIMINATING THE EDGE THICKNESS DIFFERENCE OF A PROGRESSIVE LENS WITH BASE DOWN PRISM



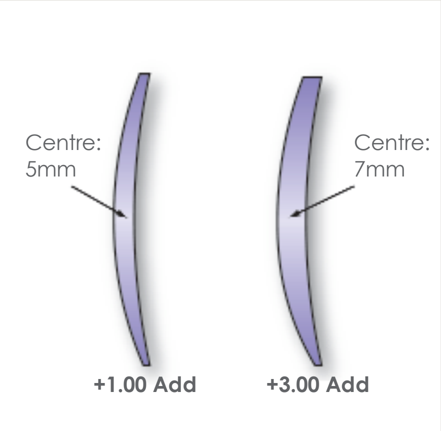


FIGURE 6: THICKNESS COMPARISON BETWEEN TWO ADDITION POWERS FOR A +2.00 D PRESCRIPTION

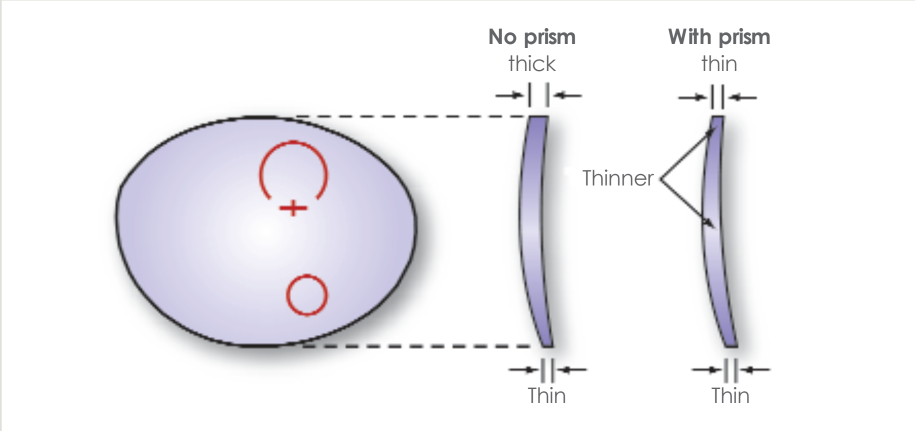


FIGURE 7: PRISM-THINNING COMPARISON WITH A +2.00 D PRESCRIPTION WITH A +2.50 D ADDITION POWER

prism is ground into both lenses with the same magnitude and orientation. This type of prism is often referred to as yoked prism, since no net prismatic effect is produced between the two eyes when the vertical prisms are equal. The wearer will therefore experience a version (conjugate) movement instead of a vergence (disjunctive) movement with no demand on fusional reserves.

The exact amount of vertical prism to use varies with a number of factors. Nevertheless, a common rule-of-thumb formula provided by some manufacturers to minimise the thickness difference at the top and bottom edges of an uncut progressive lens blank is:

Prism = 0.6 × Add

This shows that a quantity of base down prism equal to 60% of the addition power should be used to slim the lens blank down. Some manufacturers may recommend using two-thirds of the addition power (67%), instead. For modern progressive lenses used in smaller frame styles, a prism quantity equal to one-half (50%) of the addition power will often suffice. These rule-of-thumb approaches are often recommended when the combined distance and addition power through the vertical meridian of the lens exceeds +1.50 dioptres or so.

For instance, a progressive lens with an addition power of +3.00 D might require roughly 2/3 × 3.00 = 2.0Δ of base down prism. Note that these rule-of-thumb formulae do not consider factors like the fitting height and the distance power, but still produce satisfactory results in many cases. Ideally, the amount of prism-thinning used should be based upon the following factors:

- addition power
- distance prescription
- fitting cross height
- fitting cross decentration
- frame shape

Progressive lenses with greater magnitudes of combined plus power through the vertical meridian generally require more prism-thinning. This is true for strong plus-powered progressive lenses, progressive lenses with higher addition powers, and even weak minus-powered progressive lenses with a high addition power. The fitting height is another important factor that should be considered in order to take into account the thickness difference produced by vertical decentration. Lenses with lower fitting heights, for instance, will generally require less prism-thinning in plus-powered lenses.

Instead of using simple rule-of-thumb formulae, many laboratories utilise complex computer programs to determine the exact amount of prism-thinning required in order to minimise overall lens thickness. When the prism-thinning is computed in this fashion, the exact amount of prism is determined based upon all of the factors described earlier, including the prescription, frame shape, and fitting information. This method will produce the thinnest and lightest possible lens configuration. Laboratories using this type of software may apply prism-thinning to any progressive lens job, not just jobs with a certain amount of plus power.

The addition power of the lens is a major factor in determining the amount of prism-thinning required. As the addition power increases, the amount of prism-thinning necessary to equalise the thickness difference and slim the lens blank also increases. Because the near zone becomes increasingly steeper with increasing addition power, the thickness differential between the upper and lower edges also increases as well as the overall thickness of the lens blank (Figure 6).

Now that the applications of prism-thinning and the techniques used to compute the optimum amount of prism-thinning have been explored, an actual example can be evaluated. Consider a typical progressive lens with a +2.00 D distance prescription and a +2.50 D addition power, in a frame with an eyesize of 55 mm. After performing the necessary computations, a laboratory program might recommend 1.8Δ of base down prism for this particular job (Figure 7).

Without prism-thinning, this progressive lens has a centre thickness of 4.0 mm, a maximum edge thickness of 3.4 mm, and an overall weight of 7.5 grams. With the application of 1.8Δ of base down prism-thinning, the same lens now has a 3.3 mm centre thickness, a 2.2 mm maximum edge thickness, and a weight of 6.2 grams. Consequently, with the addition of prism-thinning, this progressive lens has become 16% thinner at its centre, 34% thinner at its maximum edge, and 17% lighter in weight. The lens is now thinner and

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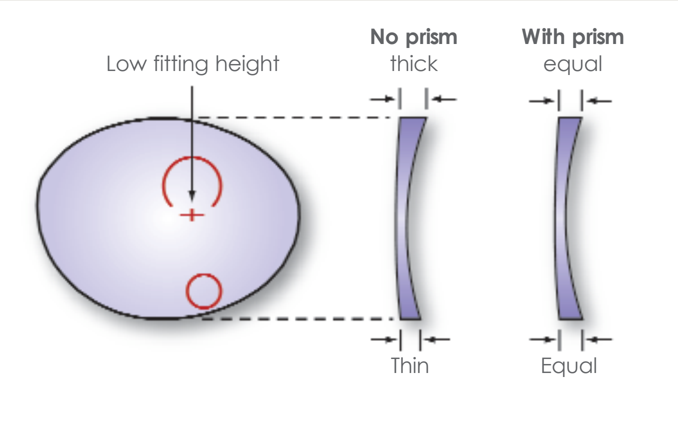

FIGURE 8: PRISM-THINNING COMPARISON WITH A -6.00 D PRESCRIPTION AND A +2.50 D ADDITION AT A LOW FITTING HEIGHT

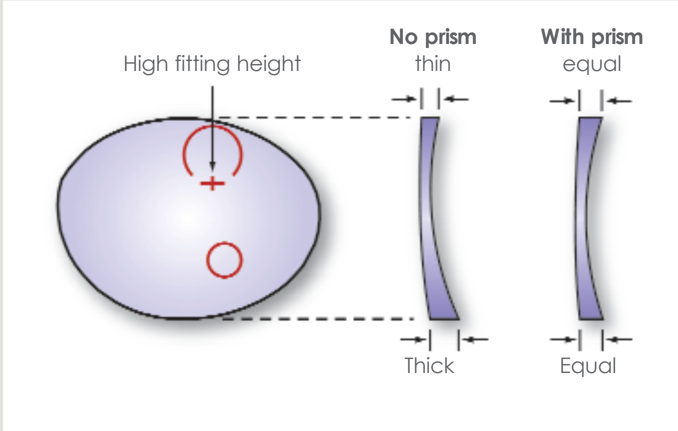

FIGURE 9: PRISM-THINNING COMPARISON WITH A -6.00 D PRESCRIPTION AND A +2.50 D ADDITION AT A HIGH FITTING HEIGHT

lighter in weight, with a more consistent edge profile.

While prism-thinning often provides substantial benefits for plus-powered lenses, it is possible to prism-thin minus-powered lenses as well. Depending upon the fitting height and the prescription, either base down or base up prism may be required to balance the thickness difference. Although the minimum (or centre) thickness of higher-powered minus lenses is not necessarily reduced by prism-thinning, the thickness differential between the upper and lower edges will be, resulting in a more cosmetically balanced edge profile. If the fitting height of a strong minus-powered lens is especially low, for instance, the upper edge of the lens is noticeably thicker than the lower edge (Figure 8).

With the use of a small amount of base down prism-thinning, however, the edges are made equal and the lens is more cosmetically and physically balanced. If the fitting height of a strong minus-powered lens is especially high, on the other hand, the lower edge of the lens is noticeably thicker than the upper edge. Without prism-thinning, the upper edge of the lens is noticeably thinner than the lower edge. With the use of a small amount of base up prism-thinning, however, the edges are again made equal and more cosmetically balanced (Figure 9).

Although yoked prism produces no vergence (disjunctive) movement, there is nonetheless a limit on the amount of vertical yoked prism that a typical spectacle wearer can tolerate comfortably. A study was conducted exploring the effects of vertical yoked prism on wearer acceptance[1]. This study demonstrated that test subjects were not significantly affected by 2.0Δ of vertical prism and no significant postural adjustments were observed; however, 4.0Δ of vertical prism was rejected by almost all of the test subjects. Consequently, most spectacle wearers should readily accept up to 2.0Δ or so of prism-thinning.

While not pertinent to dispensing, it should be noted that certain highly aspheric progressive lenses may not need to be ground with as much–if any–prism-thinning because of the geometry of the progressive surface. The asphericity in the distance zone of such progressive lenses causes the front surface to tilt slightly inside the surfacing blocks used for generating the lens blank, which reduces some of the thickness difference. Some lenses, like the American Optical Omni, are also blocked with shims on the front surface in order to keep the asphericity of the lens surface from causing the lens to rock unpredictably in the surfacing block. Although these lenses are produced with a certain amount of inherent prism-thinning, laboratory processing software may still be used to compute the precise amount of additional prism required to achieve optimum results.

Verification of lenses with prism-thinning is relatively straightforward. Generally, eye care professionals should only concern themselves with the net vertical prismatic imbalance between the two lenses at each prism reference point (PRP), which is the point on a progressive lens utilized for prism verification (Figure 10). The prism reference point is centred directly between the two horizontal alignment engravings (or ink markings), usually about 2 to 6 mm below the fitting cross of the lens. In the absence of prescribed prism and prism-thinning, progressive lenses are often surfaced so that the optical centre coincides with this point.

In order to calculate the net vertical prism imbalance, begin by placing the prism reference point of the first lens in front of the centre of the lens stop of the focimeter. Next, note the amount of vertical prism in the lens. Repeat the procedure for the other lens. In the presence of prism-thinning, significant vertical prism may be present in each lens. Lastly, compare the net difference in vertical prism measurements between the two lenses–that is, the prism imbalance. The vertical prism imbalance can be calculated as follows:

- Subtract the smaller prism from the larger prism if the prism bases are the same (for example, both base down)
- Add both prisms together if the bases are different (for example, base up and base down)

Any vertical prism imbalance should be compared to the prescribed net vertical prism, if any. Consider a typical prescription with 1.0Δ of prescribed base down prism in the left eye that has been fabricated in a progressive lens with an additional 1.0Δ of prism-thinning. In a focimeter, this particular job would most likely exhibit 1.0Δ of base down prism in

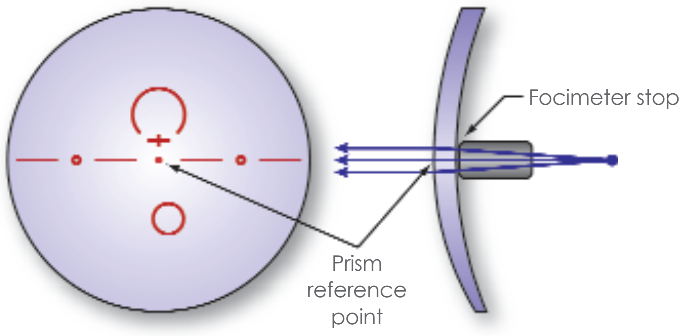

FIGURE 10: MEASURING PRISM IN A PROGRESSIVE LENS

the right lens and 2.0Δ of base down prism in the left lens (Figure 11). Regardless of the individual values, however, the vertical prism in the right lens at the prism reference point should differ in magnitude and orientation from the vertical prism in the left lens by an amount equal to the net vertical prism of the prescription.

If the unwanted vertical prism imbalance exceeds the prism tolerance specified within the relevant optical standards, the vertical separation of either the actual optical centres or the prism reference points should also be evaluated, depending upon local practice. Verifying the amount of prism-thinning in a lens is especially important when replacing only one lens of a pair. If the amount of prism-thinning utilised for the replacement lens–if any–differs from the original lens, an unwanted vertical prism imbalance will be induced.

Prism-thinning can often improve the overall cosmesis of virtually any progressive lens design. This includes modern, 'free-form' progressive lenses. In fact, sufficiently advanced free-form progressive lenses can actually have the lens design optically fine-tuned to account for the effects of prism-thinning upon optical performance. Prism-thinning represents a relatively simple and inexpensive way to maximise the cosmetic appearance and comfort of many progressive lenses with minimal visual impact for the wearer.

References

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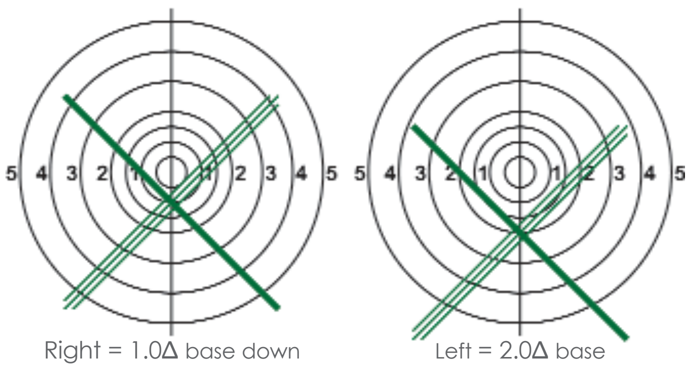

FIGURE 11: MEASURING VERTICAL PRISM IMBALANCE WITH 1.0Δ OF PRESCRIBED VERTICAL PRISM

Multiple choice questions (MCQs)

1. Which of these statements is true regarding the process of prism-thinning?

a. Vertical or horizontal prism is ground into the lens blank
b. The amount of prism-thinning is determined only by the near addition
c. Vertical prism is ground into the lens blank
d. It cannot be measured at the prism reference point

2. For which types of progressive lens prescriptions will the maximum benefits of prism-thinning be seen?

a. High positive distance powers with high additions
b. Low negative distance powers with high additions
c. High positive distance powers with low additions
d. Plano prescriptions with high additions

3. Prism-thinning most commonly introduces:

a. Prism from the near zone only
b. Base up prism across the whole lens
c. Prism from the distance zone only
d. Base down prism across the whole lens

4. Where should prism be measured on a progressive power lens?

a. Midway between the horizontal alignment engravings
b. 1.5 mm below the fitting cross
c. At the fitting cross
d. Where the add is engraved

5. What is 'yoked prism'?

a. The combination of prism-thinning and prescribed prism
b. Prism which produces no disjunctive ocular movement
c. Horizontal prism
d. Total prism applied to one lens only

6. Which type of bifocal is often prism-thinned?

a. Flat-top bifocal
b. Round segment bifocal
c. Executive bifocal
d. All of the above

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