Understanding Prism-Thinning

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Lens Talk
Vol. 26, No. 35 (Oct. 1998)

BACKGROUND

The curvature of a progressive addition lens surface gradually increases toward the bottom of the lens, becoming increasingly steeper as illustrated in Figure 1. This increase in curvature (and surface power) is what produces the *add power* of the progressive lens. Unfortunately, because the bottom of the lens is steeper than the top of the lens, the upper edge of a progressive lens blank is thicker than the lower edge.

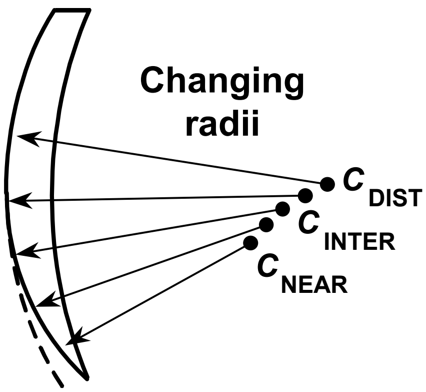

Figure 1. A conventional progressive lens steepens in curvature towards the bottom to produce the desired add power. Notice the difference in thickness between the top and bottom edges of this cross-sectional view.

If the minimum thickness of the lens blank lies at the edge of the lens, which is generally the case for plus-powered lenses or progressive lenses with a high add power, this lens geometry requires a greater center thickness in order to provide the same minimum edge thickness. (This minimum thickness occurs in the near zone at the bottom edge of the blank.) Moreover, the required center thickness of a progressive lens blank increases with add power.

Consider the following lenses, each with a +2.00 DS distance Rx and +2.50 D add power: a normal flat-top bifocal made to a minimum edge thickness of 1.5 mm, a progressive made to the same minimum edge, and a progressive made to the same center thickness as the bifocal. As Figure 2 demonstrates, the progressive lens must be made thicker at the center to maintain the same minimum edge thickness as the bifocal lens. Consequently, for plus-powered lenses—or lenses with a significant add power—a normal progressive lens blank will be thicker than a conventional flat-top lens blank of the same power.

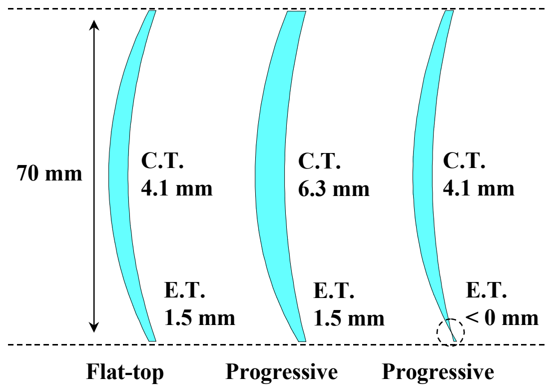

Figure 2. Many progressive lens blanks must be made thicker than conventional flat-top multifocals to maintain the same minimum edge thickness.

This increased thickness might seem a bit counter-productive for a lens designed to improve cosmetics! Many dispensers are already aware of the problems inherent with such a lens blank from past experiences with Executive-style multifocals. The steeper segment curvature of executive-style bifocals also creates a thickness differential between the upper and lower edges of the lens.

Another consideration that affects lens thickness is the fitting height of progressive lenses. In the absence of prism, the optical center of a PAL will typically be ground at the **prism reference point** (**PRP**) of the lens. The PRP is generally at the geometric center of the lens blank, about 2 to 4 mm below the fitting cross. If a pair of lenses requires an extremely high fitting height, the PRP—and optical center—of each lens needs to be decentered upwards. For high-powered lenses, this vertical decentration may also result in a noticeable thickness difference between the upper and lower edges of the finished lens. (Interestingly enough, in some cases the thickness difference produced by the fitting height can actually offset the thickness difference produced by the progressive lens geometry!)

Consider Figure 3, which illustrates the edge thickness around the perimeter of a +2.00 DS progressive lens with a +2.00 D add. The lens has a center thickness of 4.2 mm. There is also a 2-mm thickness difference between the upper and lower edges of the finished lens!

So, what can be done to ensure your progressive lens patients receive the superior cosmetics they expect?

How can the excess thickness and weight of progressive lenses be minimized? The answer: *prism-thinning*. **Prism-thinning** (also called **equi-thinning**) is the process of grinding prism into a progressive lens blank to reduce the thickness difference between the upper and lower edges.

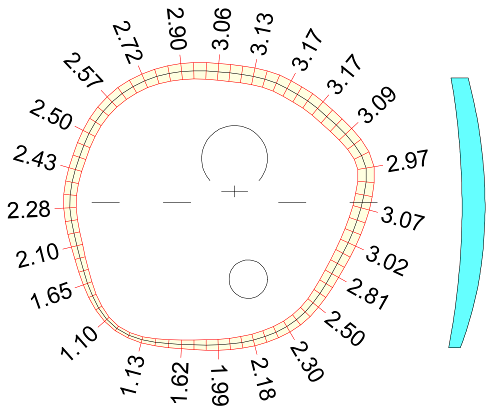

Figure 3. Front and cross-sectional view of a progressive lens with a +2.00 DS distance Rx and a +2.00 D add. The center thickness is 4.2 mm, and the weight is 9.4 g.

Prism-thinning typically involves grinding *base down* prism into progressive lenses. (Though, in some instances, *base up* prism may be appropriate.) In addition to balancing the thickness difference between the top and bottom of the lens blank, prism-thinning can also reduce the center thickness of progressive lenses with plus power and/or higher add powers. This overall reduction in thickness also makes the lenses lighter in weight. To avoiding creating a vertical prismatic imbalance, the same quantity of vertical prism is ground in both lenses. This prism is often referred to as *yoked prism*, since no *net* (or binocular) prismatic effect is produced.

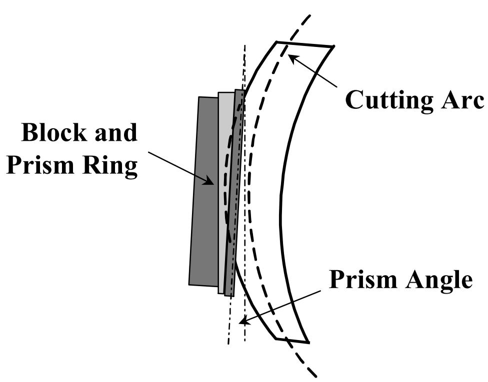

Figure 4. Base down prism is ground into the lens blank using a prism-ring (with its base positioned up) with conventional generators.

Prism-thinning is accomplished during the generating process by literally tilting the front surface of the lens on the chuck of conventional generators, using a *prism ring*. When the back surface is ground normally, the surfaced lens is left with a prismatic effect at the center. This process is illustrated in Figure 4. Newer, three-axis generators produce this prismatic effect without the use of prism rings by grinding the back curve with a tilt. The end result in either case is a reduction of unwanted thickness, as shown in Figure 5.

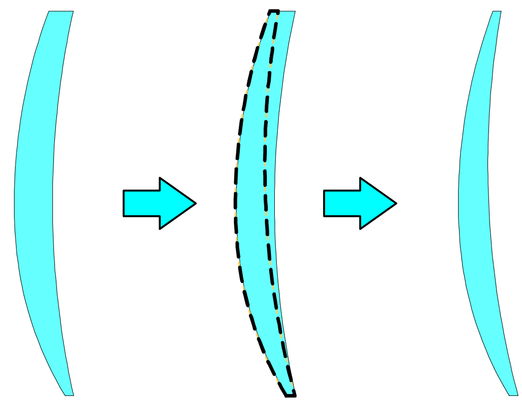

Figure 5. Grinding base down prism into a progressive lens reduces the thickness difference between the top and bottom of the lens blank, as well as some of the center thickness.

So how much prism-thinning should be used? Ideally, the amount of prism-thinning used should be based upon the following factors:

- Distance power (in the vertical meridian)
- Add power
- Fitting cross height
- Fitting cross decentration
- Frame shape

For instance, lenses with higher plus powers in the distance portion require more prism-thinning. This is also true for progressive lenses with higher add powers. The fitting height needs to be considered to take into account the thickness difference produced by vertical decentration, as described earlier.

A common rule-of-thumb formula provided in some progressive lens processing guides is:

$$Prism = 0.6 \times Add$$

This shows that a quantity of base down prism equal to roughly 2/3rd of the add power should be used. This is often recommended when the power through the vertical meridian of the lens exceeds +1.50 D or so. This formula does not consider factors like the fitting height and the distance power, but still produces satisfactory results in most cases.

Consider the prism-thinned lens in Figure 6; this is the same lens used earlier (in Figure 3). With 1.33$^{\Delta}$ of base down prism-thinning ground in—which is 2/3 the add power—the finished lens now has a center thickness of only 3.5 mm. This is a 16% reduction in thickness from the previous example, which had no prism-thinning. The thickness differential has also been reduced. Moreover, the lens is also significantly lighter in weight (by 19%). Clearly, the prism-thinning has made this progressive lens both thinner and lighter; and by no small amount!

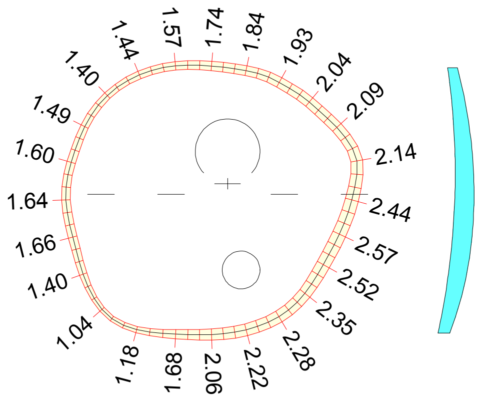

Figure 6. Progressive lens with a +2.00 DS distance Rx and a +2.00 D add. Now, 1.33^{Δ} of base down prism-thinning has been used—which is 2/3 the add power. The center thickness is 3.5 mm, and the weight is 7.6 g.

Instead of rule-of-thumb formulas, many laboratories use complex computer programs to determine the correct amount of prism-thinning. The more sophisticated laboratory software packages, for instance, give the laboratory several prism-thinning options to choose from. These options include using either a set value or calculating the exact amount of prism thinning-required. When the prism-thinning is computed in this fashion, the exact amount of prism is determined based upon all of the factors described earlier. This method will produce the thinnest possible lens configuration.

Consider the prism-thinned lens in Figure 7; this is also the same lens used earlier (in Figure 3). In this case, the *exact* amount of prism-thinning has been computed. With 1.76^{Δ} of base down prism-thinning ground in the finished lens, the finished lens now has a center thickness of only 3.3 mm. This represents a 21% reduction in thickness over the original example, which had no prism-thinning! The thickness differential has been virtually eliminated. Further, this lens is also 25% lighter in weight!

It is possible to prism-thin minus-powered lenses, as well. Depending upon the fitting height, either *base down* or *base up* prism may be required to balance the thickness difference. Although the minimum (or *center*) thickness of higher-powered minus lenses is not necessarily reduced by prism-thinning, the thickness differential can be. Consider the lenses in Figure 8; these -5.00 DS progressive lenses have a +2.00 D add and a high fitting height. One lens has no prism-thinning, while the other has 1.50^{Δ} of *base up* prism-thinning to balance the vertical thickness differential. This keeps the lower edge of the lens from looking noticeably thicker than the upper edge.

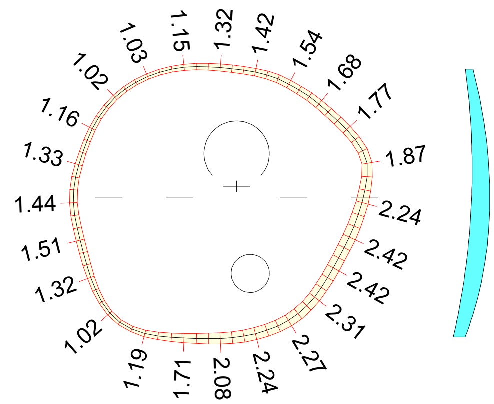

Figure 7. Progressive lens with a +2.00 DS distance Rx and a +2.00 D add. Now, 1.76^{Δ} of base down prism-thinning has been used. The center thickness is only 3.3 mm, and the weight is 7.1 g.

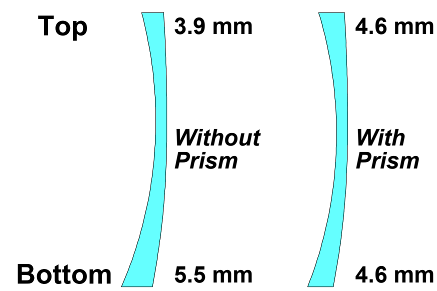

Figure 8. Progressive lens cross-sections, each with -5.00 DS distance Rx, with and without prism-thinning.

You have seen some pretty big figures used for prism-thinning in these examples. So just how much yoked vertical prism is acceptable? Is there a limit to the amount of prism-thinning that a patient can tolerate? A study was performed a few years ago exploring the effects of vertical yoked prism on wearer acceptance. This study showed that a group of test subjects was not significantly affected by 2.00^{Δ} of vertical prism (and no significant postural adjustments were made). However, 4.00^{Δ} of vertical prism was rejected by almost all of the test subjects. Consequently, the limit of prism-thinning for most wearers will probably lie between 2^{Δ} to 4^{Δ}.*

* Sheedy, J. and S. Parsons. "Vertical yoked prism—Patient acceptance and postural adjustment." *Journal of Ophthal. Physiol. Opt.* Vol. 7 (1987), pp.: 255-257.

The is periodically an additional consideration for the wearer using lenses with prism-thinning: **ghost images**. The *reflected* (or "ghost") images created by lenses with prism power are deviated more than the actual *refracted* image of the object. This means that lenses with prism power will produce reflected ghost images that may be noticeably offset from the original object, as illustrated in Figure 9. What does this mean to the wearer? Certain specular reflections may become more noticeable in some circumstances. Of course, these reflections will be eliminated with an antireflective coating—a popular option for any premium lens.

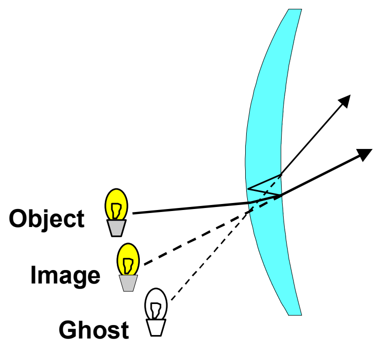

Figure 9. Because of the presence of prism, the *reflected* ghost image (Ghost) is deviated significantly more than the *refracted* image (Image) of the object.

Wearers of high-powered lenses—which naturally induce a prismatic effect as the wearer looks away from the center—are already used to this phenomenon. Wearers of low-powered lenses, on the other hand, may not notice these offset ghost images unless they have prism ground into their lenses. The reflected ghost images may also be slightly clearer (or more in focus) in low-powered lenses. Under these circumstances, prism-thinning might produce ghost images that are distracting enough to be an annoyance. Fortunately, this is a rare occurrence.

Certain highly aspherical progressive lenses may not need to be ground with prism-thinning because of the geometry of the surface. Some lenses, like the American Optical *Omni*, are surfaced with 'shims' on the front surface, which keep the lens from rocking on the block. Between the aspherical nature of the distance portion and the tilt produced by the shims, the thickness differential is minimized without the need for grinding additional prism. The lenses are automatically produced with prism-thinning.

We can now address how to verify lenses with prism-thinning. In terms of vertical prism, you are primarily concerned with the *net* vertical prismatic imbalance between the two lenses. Begin by placing the PRP of the first lens in front of the center of the lens stop of your focimeter. The PRP is illustrated in Figure 10.

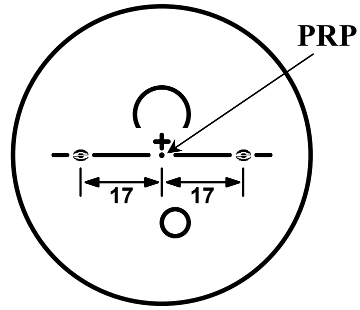

Figure 10. Prism should be verified at the prism reference point (PRP) of a progressive lens, which is centered between the alignment markings (or logos).

Next, note the amount of *vertical* prism in the lens. Repeat the procedure for the other lens. Lastly, compare the net *difference* in vertical prism measurements between the two lenses—i.e., the prismatic *imbalance*—as illustrated in Figure 11. This is then compared to the desired prism, if any.

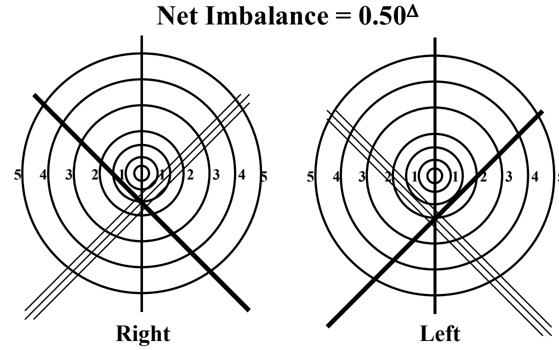

Figure 11. Note the amount of vertical prism at the PRP of each lens. The difference is the amount of vertical prismatic imbalance (or net vertical prism). In this example, the net imbalance is 0.50$^{\Delta}$.

Verifying the amount of prism-thinning in a lens is especially important when you are replacing only one of the lenses. If the previous lens had not been prism-thinned and the new one was—or vice versa—an unwanted vertical prism imbalance will be induced.

In summary, prism-thinning is a useful technique that improves both the finished cosmetics and comfort of many progressive addition lenses—with little (if any) visual impact to the wearer. Prism-thinning reduces the vertical thickness difference produced by the geometry of progressive lenses and also minimizes the overall thickness of many progressive lenses with plus power or high add powers. Although the focus of this article has been on the thickness reduction of progressive lenses, it is equally possible to use prism-thinning for Executive-style multifocals. Be sure to contact your processing laboratory if you have questions about the criteria they use to apply prism-thinning (e.g. which lenses, how much, etc.).