Prismatic Effects in Bicentric Grinding

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Abstract

Bicentric grinding is widely used to neutralize a vertical differential prismatic effect at the near visual point. However, the prismatic effects in other portions of the reading field differ from those at the near visual point. In this study, the variations in prismatic effect throughout the entire reading field are demonstrated. It is shown that a slab-off prism is most effective in spherical anisometropic prescriptions and when the differential prismatic effects are symmetrical about the horizontal meridian.

Abrégé

Le procédé de surfaçage bicentrique est communément employé afin de neutraliser un effet prismatique au point de lecture. Toutefois les effects prismatiques diffèrent à tout autre point du champ de lecture. Ce travail étudie ces variantes dans l'effect prismatique. Le procédé bicentrique est le plus efficace quand l'anisométropie est sphérique et les effets prismatiques sont symmétriques autour du méridien horizontal.

Bicentric grinding as a correction for differential prismatic effects in the vertical meridian at the near visual point has been used for a long time.[1] The fundamental principles of its application are well known. In bifocals, the biprism allows the patient to look through the segment without having to contend with an unduly large difference in vertical prismatic effects between the two lenses. The slab line is placed so that it coincides with the top edge of the segment, usually a straight-top type. The biprism can be incorporated also in single vision lenses, but since such prescriptions allow the patient to offset differential prismatic effects by means of head movements, it is less critical. It is therefore generally associated with bifocals or trifocals, where the patient has no choice but to look through the segment while reading.

The magnitude of the bicentric grinding can be from about 1.5^{Δ} to about 5^{Δ}, depending on the thickness of the lens blank. The slab-off is introduced on the lens with the highest minus or least plus, on the front surface, its base directed upwards. It is designed to neutralize the vertical differential prismatic effect generated by the distance portions of the lenses at or close to the near visual point (NVP), usually considered to lie about 10 mm below the major reference point (MRP) of the spectacle lenses. The slab-off prism will neutralize only the vertical component of the prismatic difference. A small horizontal prismatic effect will normally remain at the near visual point. Since the two eyes can cope relatively easily with horizontal prismatic differences if binocular vision is normal, this is not considered significant. Most often, the reading adds are similar in power and will therefore not generate a significant differential prismatic effect.

Having summarized what is generally known about bicentric grinding and its effects, we are now interested in determining how the differential prismatic effects change as the eyes look through lens regions other than the near visual point, as is bound to occur during reading. An answer to this question is of considerable practical and theoretical interest. In this article, we present relatively simple examples to derive some general answers to this question.

Change in vertical differential prism through the slab-off field

First, consider a pair of spectacle lenses that embody a spherical anisometropic correction of 3.00 D, the right eye having the higher minus or lesser plus power. For example, this amount of anisometropia would be produced by the prescription:

O.D. – 6.00 D
O.S. – 3.00 D

According to Prentice's rule, which states that the prismatic effect is equal to 1^{Δ} per D per cm from the optical center of a lens, we see that the prismatic difference between the two lenses increases by 3^{Δ} per cm. We emphasize that we are interested in prismatic differences rather than absolute prismatic effects, since it is the differences which give rise to problems. If a slab-off prism of 3^{DT} is incorporated in the right lens in the above correction, the prismatic difference will be neutralized 10 mm below the optical centre of the lenses. If the eyes converge, a slight horizontal base-in effect will be produced.

Before we consider the changes in prismatic effect as the eyes look right and left through the reading field, let us simplify our task by introducing the principle of iso-prism lines.[3,4,5] An iso-prism line is a line locus in the spectacle field along which the same prismatic effect is generated. Iso-prism lines can be applied to a single spectacle lens, or it can be applied to the differential prismatic effects between left and right lenses. In the latter case, the lines are often referred to an imaginary right eye lens embodying all the differential prismatic effects. It is in the latter context that we shall use the concept in this article. This method of mapping differential prismatic effects can be elaborated on further by applying it to vertical prismatic effects only. Such loci are called iso-V-prism lines[3]. These are the loci we are most interested in at the moment.

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Figure 1 shows iso-V-prism lines for the above prescription, the lines representing loci of prismatic differences transferred to an imaginary right eye lens. When the eyes look obliquely through points corresponding to A at a distance OA from the optical center, 0, an oblique prismatic difference is generated, as shown by the prism vector. By Prentice's rule, $\Delta = cF$, this vector is proportional to the distance OA. Because the right angle triangle formed by the vertical component and the oblique resultant is similar to triangle OAB, the vertical vector is also proportional to the distance AB. Therefore, points that produce the same vertical prismatic effect lie on a line through A parallel to the horizontal axis. For example, the vertical component at A' is identical to that at A, the oblique resultant and the horizontal component being, of course, larger. This demonstrates that the iso-V-prism lines in the above type of correction are oriented horizontally. Thus, the differential prismatic effect is neutralized 7 mm below the slab line throughout the entire near field, which allows the eyes to move unrestricted from side to side at this level.

If we are dealing with a combination of right and left lenses where cylindrical components produce a differential prismatic effect that is symmetrical about an oblique meridian, the case is more complicated. Fig. 2 shows such a situation, where the diagram again represents an imaginary right eye lens onto which all the differential prismatic effects have been transferred. Points A and A' are equidistant from the "axis" of the differential prism effects. At these points, equal prism differences will be generated. Therefore, the vertical prism components will also be identical. Thus, the iso-V-prism lines will run parallel to the "axis" of the differential prismatic effect. In a manner similar to that presented above for spherical anisometropia, it can be shown that this is the case also when the iso-prism lines, representing the total

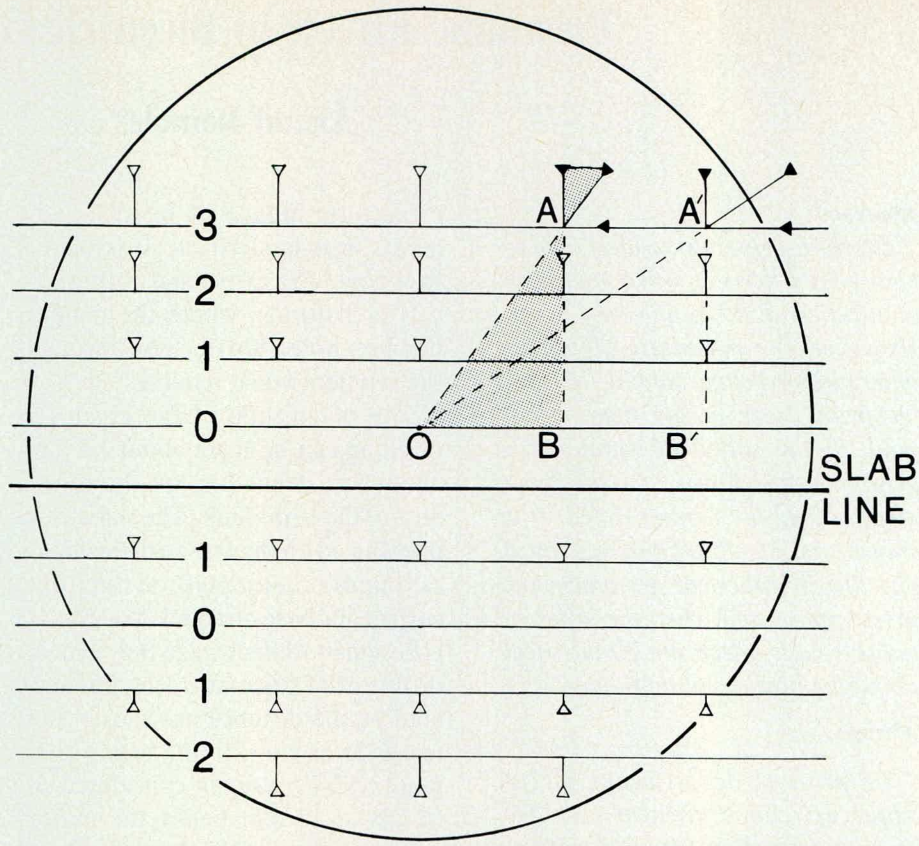
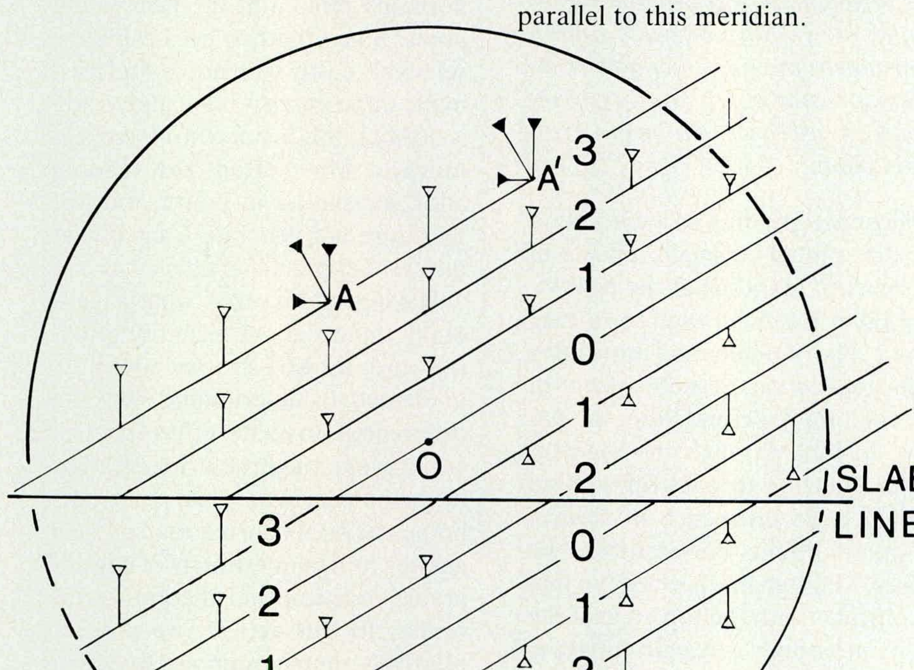


Fig. 1. Iso-V-prism lines generated in a correction of spherical anisometropia. The loci run parallel to the horizontal meridian.

Fig. 2. Iso-V-prism lines generated by a prescription for meridional anisometropia, where the differential prism is symmetrical to an oblique meridian. All the loci are parallel to this meridian.



prismatic differences, are elliptical. The corresponding iso-V-prism lines are then parallel to the axis of the ellipse that is closest to the horizontal meridian.

In this study, we are chiefly interested in the effect of the slab-off prism in the reading field. From Fig. 2, it will be seen that the vertical prismatic effect will change as the eyes sweep from side to side during reading. There is one point at which the prismatic effect is zero, but to one side of this point the effect becomes increasingly base-up, and to the other side, increasingly base down. The reading field is therefore restricted in the horizontal meridian by the vertical prismatic effect. The patient will have to rely more on head movements from side to side.

Figure 3 is a graphical representation of the changes in differential prismatic effect as the eyes rotate vertically behind a pair of spectacles provided with a slab-off correction. The differential prismatic effect is minimal at two points, the optical center of the major lens, and at 10 mm below the major reference point. The graph also illustrates the sudden change in prismatic effect at the slab line, the "jump" due to the slab-off portion. By interpolation from the graph, it can be seen that the prismatic effect is kept to a prismatic difference of 2^{Δ} or less through a vertical range of 22 mm. Without the slab-off, this range would have been only 14 mm. The dashed line shows the prismatic the prismatic difference that would have been generated had the slab-off not been present.

If the anisometropia is spherical or symmetrical about a horizontal axis, the graph describes the change in prismatic difference in the vertical meridian through the entire field of the prescription. However, if the prismatic difference is symmetrical about an oblique meridian, the graph is descriptive only of the vertical meridian through the optical center. In other vertical meridians, the positions of the points of zero prismatic effect would change, as discussed above.

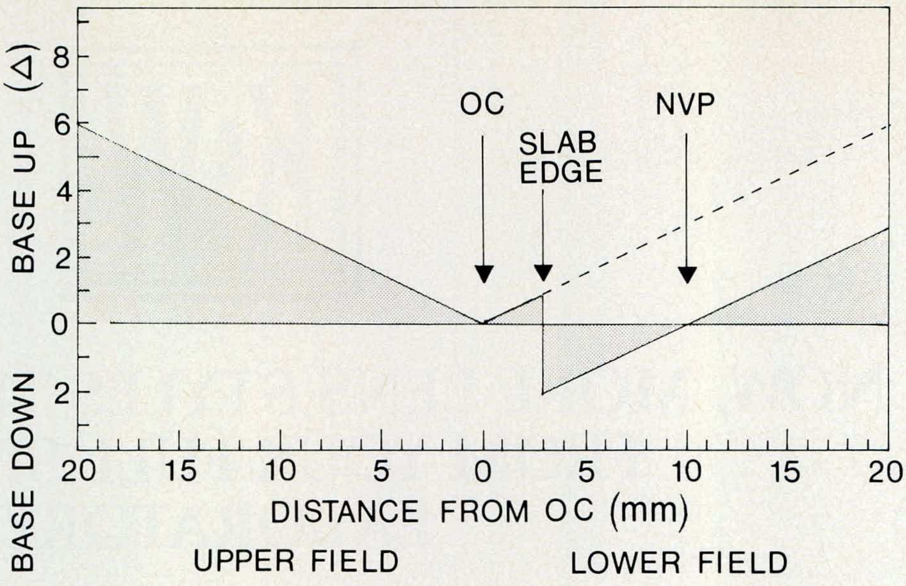
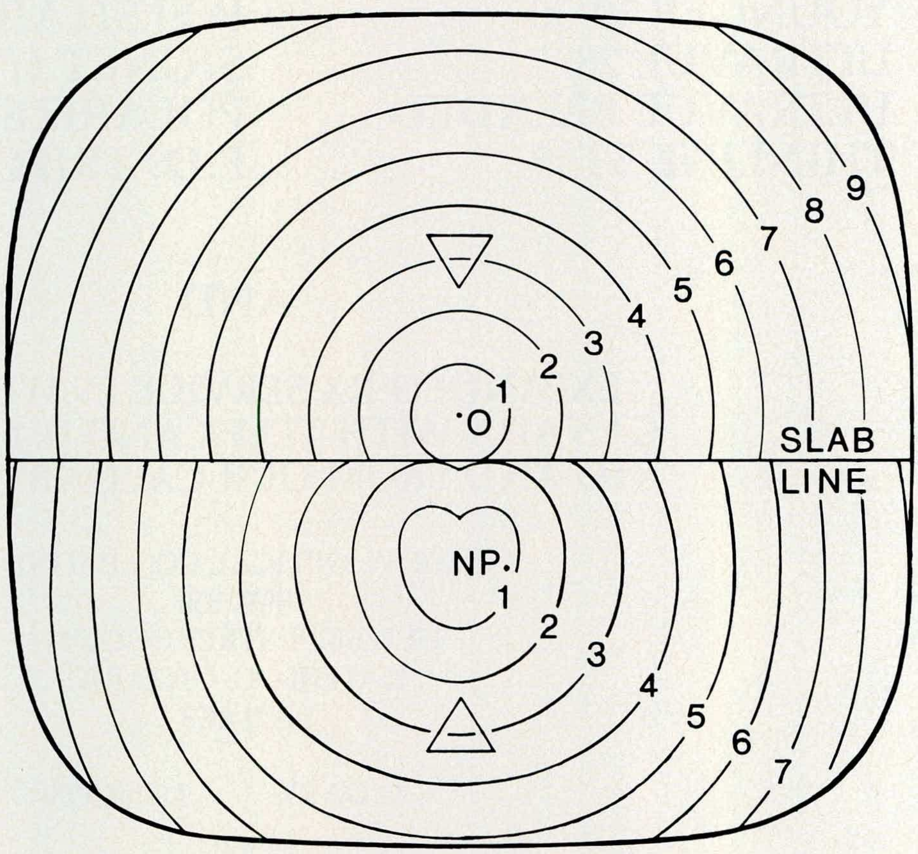


Fig. 3. Graphical illustrationof changes in differential prismatic effect in the vertical meridian as the eyes move vertically through the major portion of the lens and into the slab-off field.

Fig. 4. Iso-prism lines of a spherical anisometropic correction supplied with a biprism 3 mm below the optical centre. The loci show the changes in total differential prismatic effect as the eyes move behind the lenses, but not the changes in direction of the prism.



Total differential prismatic effect of a biprism

We have discussed the effect of the biprism on the vertical differential prismatic effect, using the principle of iso-V-prism lines. However, we must remember that the changes in vertical prism do not give the entire picture, since there is also a horizontal prism component present. When the lines of sight travel into the slab-off-prism field, there is a total change in differential prismatic effect both in direction and magnitude. Obviously, the vertical prismatic effect is the most important because of the relatively restricted fusional amplitudes in the vertical meridian, but it is nevertheless of some interest to formulate a more complete picture of the total changes in differential prism. For this purpose, we again present the relatively simple case used above, where 3.00 D of spherical anisometropia is incorporated in the prescription, the right lens being the higher in minus power. Again, a slab-off prism of 3^{Δ} has been placed on the right lens, 3 mm below the optical centre.

If the anisometropia is spherical or symmetrical about a horizontal axis, the graph describes the change in prismatic difference in the vertical meridian through the entire field of the prescription. However, if the prismatic difference is symmetrical about an oblique meridian, the graph is descriptive only of the vertical meridian, through the optical center. In other vertical meridians, the positions of the points of zero prismatic effect would change, as discussed above.

In Fig. 4, the iso-prism lines generated by such a prescription have been calculated. The lines are circular in the major field but deviate from a circle in the slab-off field. They define a region of relatively low prismatic effect surrounding the near visual point. Along the slab-line, the iso-prism loci change abruptly in location, the change being greatest towards the central portion of the lens.

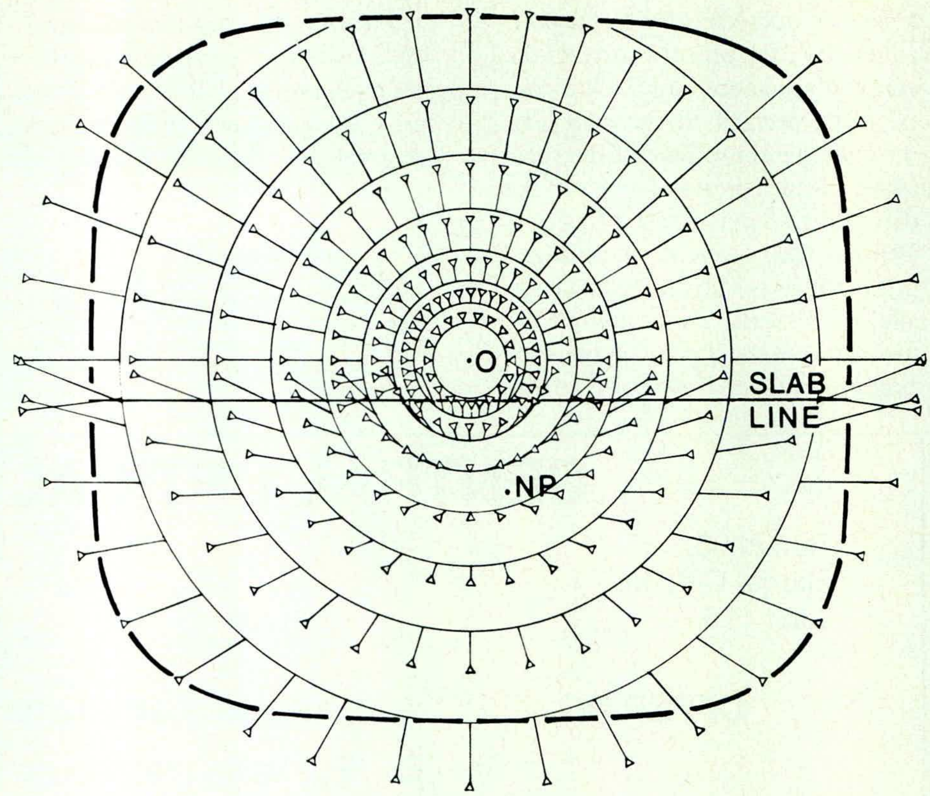


Fig. 5. Graphical illustration showing changes both in magnitude and direction of the differential prism as the eyes move behind the above prescription. The reference loci are concentric about the optical centre of the lenses.

Fig. 5 shows the directions as well as magnitudes of the prismatic effects generated by the above prescription. In this scheme, not previously presented in the literature, prism vectors are drawn from reference loci concentric about the optical centre of the major lens. Again, a region of relatively small differential prismatic effect surrounds the near visual point. The change in direction as well as magnitude of differential prismatic effect along the slab line is illustrated.

In both Figures, it can be assumed, for simplicity, that the lines of sight remain parallel as the eyes make conjunctive excursions behind the lenses. If the convergence for near is taken into account, a slight change in the horizontal component will be introduced. In this prescription, a combined convergence for the two eyes equal to 3 mm along the lens plane would result in an additional base-in prism of 0.9^{Δ} throughout the slab-off field. This adjustment can be made by a 3 mm lateral displacement of the near visual point in the imaginary right eye lens, as has been shown in the Figures. The exact differential prismatic effect at the reading level can then be interpolated with this position of the near visual point as reference. On the other hand, to adjust the entire prism field for this purpose would be awkward, for the eyes do not converge fully until the lines of sight have descended to the level of the near visual point.

Figs. 4 and 5 present a more complete picture of the differential prismatic effects generated as the eyes move behind a prescription incorporating a slab-off prism. More complicated prescriptions could be analyzed in the same manner, but since the vertical prismatic effect is the more important from a clinical point of view, the above illustrations will suffice. Their chief purpose is to add perspective to our knowledge of the vertical prismatic effects.

Conclusions

In a simple anisometripic correction, or in a correction where the differential prism induced by the anisometropia is parallel to the horizontal axis, the biprism corrects the vertical imbalance along a horizontal locus parallel to the slab line, through the entire field of the spectacles. If the axis of symmetry of the differential prismatic effects is oblique, the locus of neutralized prism effects is also oblique and parallel to this axis. This will limit the usefulness of the biprism in the horizontal meridian. If we consider the total prismatic effects produced by the biprism, it is seen that the direction as well as the magnitude of the prism changes as the eyes move across the slab-line. These changes are greatest in the central field.

References

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