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A NEW CHART FOR PLANNING RETINAL SURGERY

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Purpose: To design a chart for drawing retinal detachments that minimizes the circumferential distortion that occurs with the current chart.

Methods: After trying several standard map projections, a hybrid chart was created. It retains the radial equidistant projection of the current chart from the posterior pole to the equator, but superimposes stereographic projection anterior to the equator. The hybrid chart was put on trial for drawing retinal lesions and planning retinal detachment surgery at the New York Hospital and at the University Eye Clinic in Tübingen in May 1992.

Results: The stereographic projection anterior to the equator has minimized the distortion of retinal breaks and other pathology in the anterior retina when drawn on the chart. Retinal breaks can be drawn as they are seen ophthalmoscopically and estimates of their real dimensions derived from the chart.

Conclusion: A new retinal chart that minimizes circumferential distortion anterior to the equator has proven advantages for planning retinal detachment surgery.

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The retinal chart in use today was designed by Amsler and Dubois in 1928[1] and adopted by Gonin.[2] Schepens modified it in 1951 by adding a third circle to portray the pars plana.[3] Cartographers call this chart an azimuthal equidistant projection; every point is in a true direction and distance (radially) from the macula. There is circumferential distortion, however, that increases exponentially as the radians diverge. The distortion is moderate up to the equator, but anterior to the equator it becomes extreme, making it impossible to draw a retinal break conformally, i.e., as it appears ophthalmoscopically, and obtain a reasonable measure of its circumferential dimensions from the chart. For example, a retinal tear that has a circumferential diameter of 3 mm would subtend a half clock-hour at the equator. If an identical tear (one with the same radial dimension) was drawn at the ora serrata, its circumferential extent would subtend less than a third of a clock-hour unless it was stretched and distorted. The conformal image suggests that the break might require a smaller buckle than would be necessary to close it (Figure 1).

Most surgeons draw conformally, but have learned to compensate intuitively or by routinely choosing large explants. Others rely on localizing and marking all the margins of the breaks on the sclera, measuring the distances between marks and selecting an explant to cover all the marks. This technique is subject to error in marking and measuring. It seemed desirable to develop a chart that would allow conformal image to be drawn preoperatively from which an estimate of dimensions could be derived that might serve to confirm the operative measurement.

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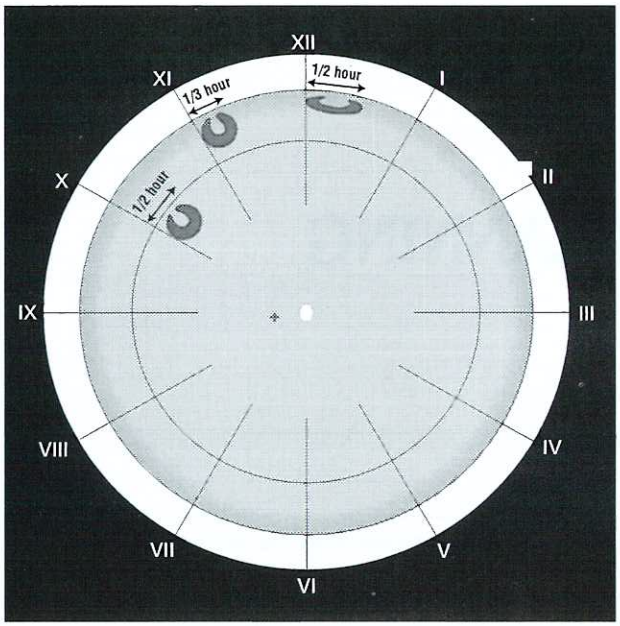

Fig. 1. The horseshoe tear at the equator at 10 o'clock drawn conformally on the Amsler-Dubois chart subtends ½ hour or 3 mm. The identical tear near the ora serrata at 11 o'clock subtends ¼ hour unless it is stretched and distorted as at 12 o'clock.

Materials and Methods

We studied a standard map-making text[4] and sought the advice of the cartography section of the National Geographic Society. They informed us that to diminish circumferential distortion between the equator and the ora would require either peeling or stretching the globe.

From the peeling solutions suggested, we selected a 12-segment rosette. Cartographers use the rosette to portray conformal images of the earth from the pole to beyond the equator. The rosette eliminates circumferential distortion by segmenting the globe as one might peel the skin of an orange. A problem is the discontinuity between segments. To reduce the sense of discontinuity our artist filled in the intervals with shading that suggested the folds of a continuous paper rosette (Figure 2). The rosette was printed and put on trial at retinal services in New York and Tübingen in May 1991.

From the stretching solutions we assembled a hybrid chart that retained the azimuthal equidistant projection from the posterior pole to the equator, but substituted stereographic projection from the equator to the ora. This stretched the anterior-posterior dimensions of the segment between the equator and the ora to equal and thus minimized circumferential distortion.

To add dimensions to the segment anterior to the equator, we drew upon the retinal topography that Straatsma et al[5] derived from autopsy eyes and the computer model of Borodkin and Thompson.[6] Our model eye has an equatorial (scleral) diameter of 24 mm and a diameter at the ora of 20 mm. Each 30° segment subtends 6.28 mm at the equator and 5.23 mm at the ora. The distance from the equator to the ora is 6 mm. The difference between arc length on the retina (3 vertical disc diameters) and chord length on the sclera (6 mm) is not of clinical significance. For clinical purposes, each 30° segment may be regarded as 6 mm square (Figure 3).

To provide a unit for measuring, we added a reference cross at the posterior pole. The vertical and horizontal members represent the diameters of the average disc.[7] On the chart the vertical member is proportional to 2 mm on the retina posterior to the equator. Anterior to the equator it represents 1 mm because of the magnification induced anteriorly by the stereographic projection. The hybrid chart was printed and put on trial in New York and Tübingen in May 1992.

Results

The 12-segment rosette was discarded after a year's trial. Although it provided an accurate representation of breaks within a segment, the discontinuity that occurred when a break extended beyond the edge of a segment was difficult to portray.

The hybrid chart is still in use. It has succeeded in minimizing circumferential distortion anterior to the

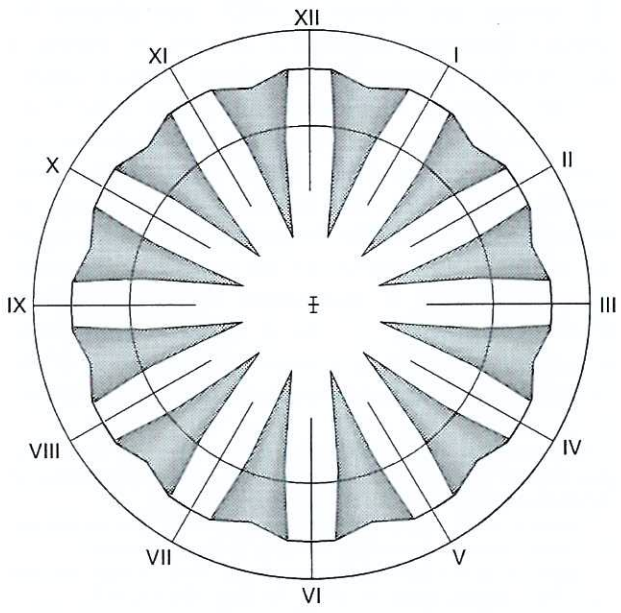

Fig. 2. The 12-segment rosette with artistic rendering between segments to suggest the folds of a continuous paper rosette.

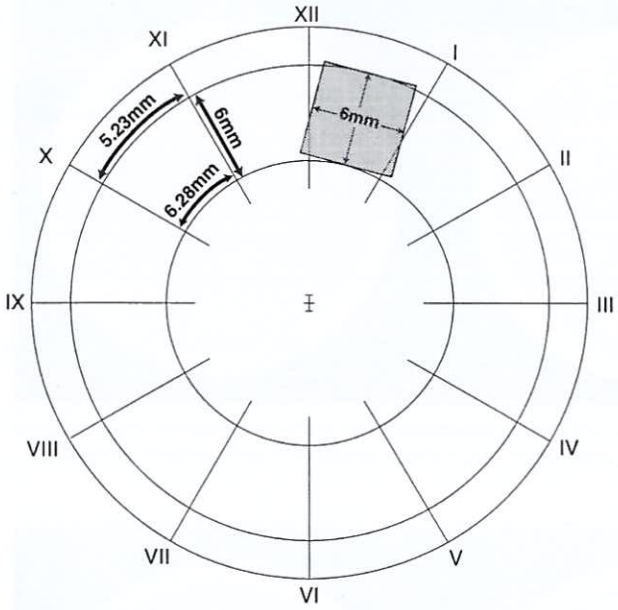

Fig. 3. The hybrid chart combines an azimuthal equidistant projection from the posterior pole to the equator and a stereographic projection anterior to the equator. Each anterior segment of 30° approximates a 6 mm square. The vertical member of the central cross = 2 mm posterior and 1 mm anterior to the equator.

equator. Breaks can be drawn as they are seen ophthalmoscopically and approximate dimensions in millimeters derived from the chart. Several examples illustrate the advantage of the hybrid projection:

(1) A retinal dialysis subtending 2¼ clock hours when drawn on the Amsler-Dubois chart portrayed the posterior margin of the break posterior to the equator. The same dialysis drawn on the hybrid chart portrayed the posterior margin anterior to the equator at 12 mm from the limbus. At the operation, a cryopexy mark on the edge of the retinal dialysis could not be obtained because of its elevation, but the estimate from scleral depression was 12 mm in agreement with the charted position. A 3 × 5 mm circumferential sponge centered 12 mm from the limbus attached the retina (Figure 4).

(2) A detachment secondary to a long circumferential tear combined with a horseshoe tear, when plotted on the Amsler-Dubois chart, appears as if it would require the combination of a circumferential and radial element to buckle it. When drawn on the hybrid chart, all of the edges of the break appeared anterior to the equator. This conformed to the localization at the operation. A 5-mm sponge, circumferentially oriented and centered at 11 mm, reattached the retina (Figure 5).

(3) A horseshoe tear on the nasal edge of the 12 o'clock radian drawn on the Amsler-Dubois chart subtended a half clock hour or 3 mm, suggesting that it could be buckled effectively with a 5-mm radial explant. The same tear drawn on the hybrid projection subtended 5 mm, indicating the need for a wider buckle. An episcleral balloon buckle with an expanded diameter of 10 mm reattached the retina (Figure 6).

Discussion

The retinal drawing chart proposed by Amsler and Dubois in 1928 and in use today is an approximate azimuthal equidistant projection. The projection represents every point plotted in a true direction and distance from the fovea to the ora. The chart is advantageous for plotting the anterior or posterior margins of a retinal break. These were the measures essential for Gonin to place igni punctures (later diathermy) at a calculated distance from the limbus. Gonin estimated horizontal disc diameters from the ora serrata ophthalmoscopically, multiplied by 1.5

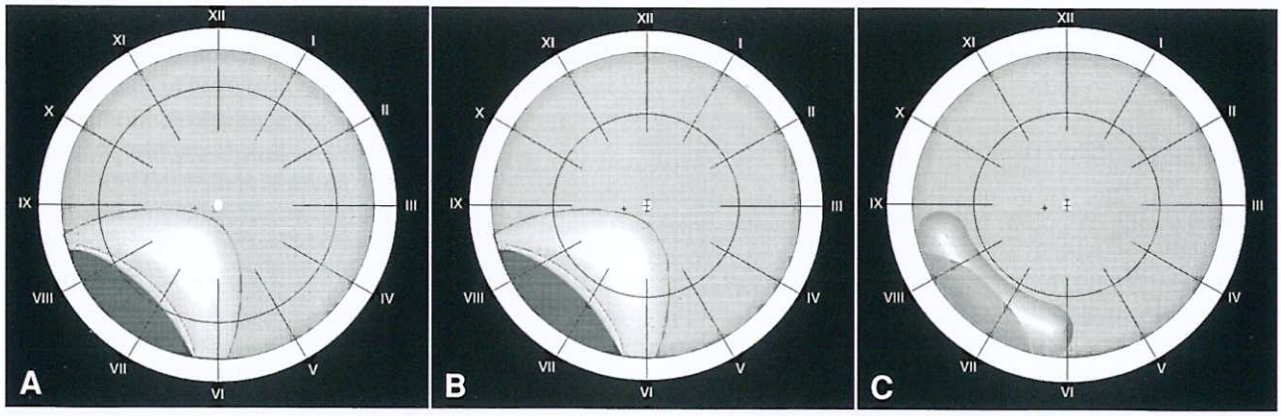

Fig. 4. A, A retinal dialysis drawn conformally on the Amsler-Dubois projection indicates that the posterior edge of the tear extends posterior to the equator. **B,** On the hybrid chart the posterior edge appears anterior to the equator at 11 mm. **C,** A 3 × 5 mm sponge centered at 11 mm attached the retina.

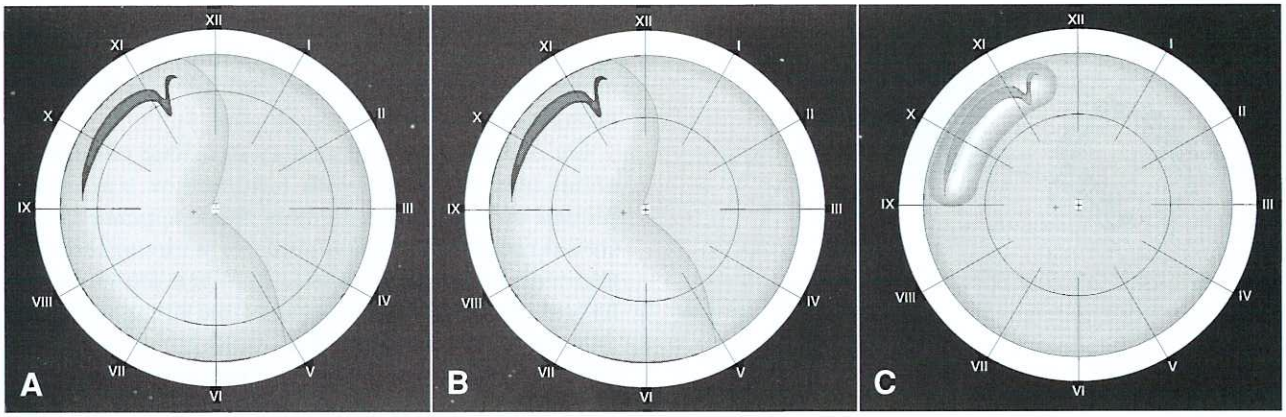

Fig. 5. A, A long circumferential tear with a radial extension drawn on the Amsler-Dubois projection appears to require a circumferential and radial buckle. **B,** On the hybrid chart all of the edges of the break appear anterior to the equator. **C,** A 5-mm sponge at 11 mm attached the retina.

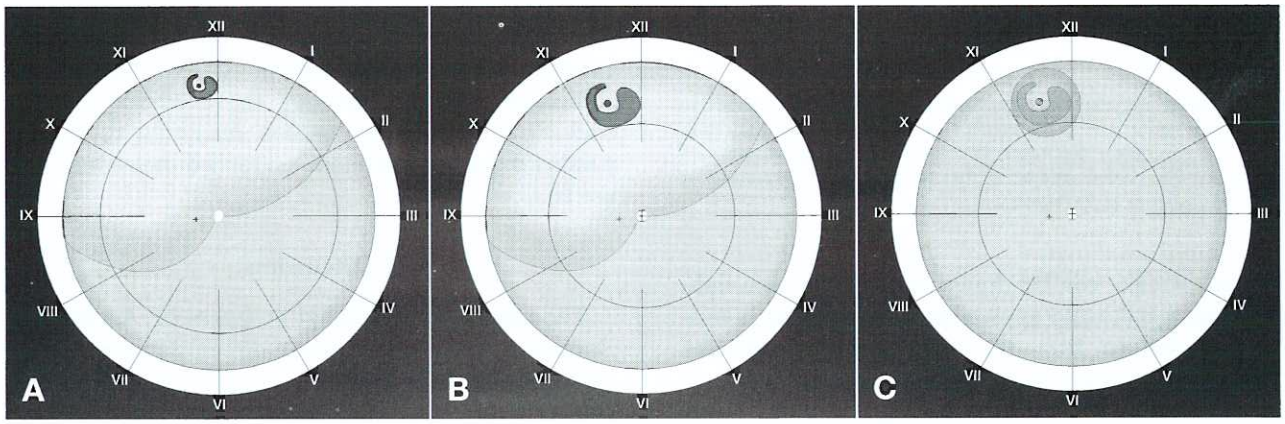

Fig. 6. A, A horseshoe tear on the nasal side of 12 o'clock, when drawn conformally on the Amsler-Dubois projection, appears to subtend ½ hour or 3 mm. **B,** On the hybrid chart it subtends 5 mm. **C,** A 10-mm balloon buckled the break and attached the retina.

mm and added 8 mm for the distance from limbus to ora, to localize on the sclera. The azimuthal equidistant projection was equally useful for Schepens, for whom localization of the posterior edge of the break was paramount because the surgical intent was to place the posterior edge on the anterior slope of a circumferential buckle.

Many retinal surgeons no longer rely on extensive circumferential buckles to attach the retina. Instead, local explants, radially or circumferentially oriented, that buckle all of the edges of the breaks are preferred. For this purpose, a circumferential as well as a radial measure of the break is required. In portraying the circumferential dimension, the Amsler-Dubois chart fails, and stereographic projection is of value. For the many breaks that are smaller than 1 mm in their longest dimension, the chart is of little value because a single localizing mark may be sufficient to orient a buckle. For very small breaks, found by biomicroscopy and at the limit of resolution by indirect ophthalmoscopy, the conformal representation of the surrounding vasculature and other landmarks can help to localize the retinal break ophthalmoscopically at the operating table.

We considered and tested a complete stereographic projection from the macula to the ora. Although it maintained conformality, it minified the posterior pole to such an extent as to make it impossible to draw details of macular disease. The hybrid chart retains the azimuthal projection for the posterior retina, which is optimal for portraying macular disease and other disorders of the posterior pole. Stereographic projection anterior to the equator enables conformal representation of the pathology of retinal detachment that is, for the most part, anterior to the equator. The magnification of pathology drawn anteriorly, which is approximately 2 times, has not proven to be a handicap. Breaks that straddle the equator are drawn conformally and measured with the units that pertain to that side of the equator where the largest part of the lesion appears. The chart fails in plotting a very large lesion, e.g., a tumor that might extend equally anterior and

posterior to the equator. Such a lesion requires other measuring techniques, such as an ophthalmoscopic approximation in disc diameters. For drawing retinal detachments, as has been pointed out before, it is useful to draw the disc at the center of the chart, because a vertical line from the disc to the ora defines a controlling factor for the distribution of a detachment and the location of the primary retinal break.[8] For portraying pathology of the posterior retina, e.g., macular disease and diabetic retinopathy, the center of the chart should represent the macula.

Few attempts have been made during the last 70 years to improve on Amsler and Dubois' original design.[9–13] Some may have had some theoretical advantages for charting anterior and posterior measurements, but none foresaw the advent of radial buckling and so made no attempts to compensate for circumferential distortion. An exception is the three-dimensional computer model that Borodkin and Thompson described in 1992.[6] With training and the appropriate software, their model is likely to replace charting on flat paper for a coming generation of retinal surgeons. In the interim, the hybrid chart may be a useful substitute.

Key words: retinal chart, retinal detachment, scleral buckle, stereographic projection.

Acknowledgments

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