CHAPTER 8

THE OPTIC DISC IN GLAUCOMA:
PARAMETER MODIFICATIONS

8.1 Bibliography by contemporary authors

Chapter 1, section 1.1 dealt with the literature on the general aspects of the optic nerve, when it referred to the history of optic nerve evaluation. We will now refer to three modern day authors, who worked extensively on this subject: Burk, Airaksinen and Schwartz.

Burk and his collaborators in 1994 [1], published their studies of the three-dimensional optic disc topography by means of the laser scanning tomography: "Clinical correlation in an analysis of clusters". They analyzed different HRT parameters in 337 optic discs belonging to 3 groups of patients: 99 of them with glaucomatous optic nerve damage, 159 with suspected glaucoma, and 79 were normal. They also correlated their results, with a perimetry study performed with static perimetry (Octopus) based on the mean defect. All the data, HRT parameters and visual field results, were analyzed with the ELM statistical method, according to Simons (39 Zass procedure cluster). The optic nerve was measured with the following parameters:

1. Optic disc area
2. Neuroretinal rim area
3. Cup area / optic disc area
4. Maximum cup depth
5. Cup shape measure of the superior temporal octant minus cup shape measure of the temporal quadrant
6. Cup shape measure of the inferior temporal octant minus cup shape measure of the temporal quadrant
7. Difference between the mean height of the contour line in the superior temporal octant and the temporal quadrant
8. Difference between the mean height of the contour line in the inferior temporal octant and temporal quadrant
9. Difference between the mean height of the contour line in the nasal quadrant and the temporal quadrant

Six types of optic discs resulted from the study:
Figure 8.1 shows the nine parameters described before in the abscissa, in the same order from left to right; in the ordinate variable, $z$ represents the standard deviation of each parameter, which is positive towards the top: 0.5, 1, 1.5, 2.0, and negative towards the bottom: -0.5, -1, -1.5, -2.0. The curves in the graph represent each of these optic discs. Normal, normal large and supernormal optic discs are easy to understand, as well as the flat glaucomatous and steep glaucomatous ones. The most interesting type of optic disc is the pseudonormal one, since it looks normal but actually is glaucomatous. In the line representing this optic disc in the graph, parameters 1, 2, 3, 4, 5 and 6 are normal, but parameters 7, 8, and 9 are pathological. That is, there is a decrease of fibers in the superior temporal octant, in the temporal quadrant and finally in the inferior temporal octant. This means that in the temporal area the damage begins before it does on the other six parameters, which would make us think that the optic nerve is normal.

According to these authors we have found the six types of optic discs, which are described in figures 8.2 to 8.7.

As a final conclusion, these authors assert that the clinical morphology of the optic disc is a decisive criterion for the diagnosis of open angle primary glaucoma, regardless of the presence or absence of visual field defects.

Optic disc morphometry and perimetry are two methods for the diagnosis of glaucoma that complement each other.
In 1994, at the Glaucoma Society Meeting held in Quebec [2], Dr. Airaksinen determined, for the first time, a reference plane at the level of the temporal part of the optic disc between -4 and -10 degrees, where the retina is thinner. This is the reason why this plane is near the scleral level. Moreover, since the papillomacular bundle containing the fibers that deteriorate only in the final stage of the evolution of glaucoma, goes through this plane, he asserts that the increase of the cup volume in the onsetting glaucoma is due to the amplification and deepening of the cup. Instead, in advanced glaucoma, a decrease of the retinal nerve fiber layer (RNFL) causes a posterior shift of the level of the reference plane, which, in turn, leads to a cup volume decrease. For him, the cup volume is not a useful parameter for distinguishing normal from glaucomatous patients. For this author, the rim volume parameter is of great importance.
We agree with him, except in congenital glaucoma (chapter 12) where the increase of the cup volume is very valuable, since congenital glaucoma usually starts at the moment of birth.

Drs. Schwartz and Takamoto with their method of photogrammetric measurement have obtained results similar to those of the HRT. For them, the study of the optic disc pallor with a computerized image analysis [3, 4, 5] is very useful.

### 8.2 Parameter modification

From all of the structures that make up the optic disc there is only one that is stable and that does not change, not even with aging or by different pathological processes: Elschnig’s Ring. This structure loses its elasticity between 5 and 6 years of age. An ex-
ception to this is congenital glaucoma, where the ring distends as we showed for the first time [6, 7] (chapter 12).

All the structures inside and outside Elschnig's Ring change due to intraocular pressure and other factors. These changes are mainly a decrease in the number of optic nerve fibers due to the damage of the axons of the ganglion cells which in turn manifests as a decrease in the neuroretinal rim surface and volume, an increase of the cup in an anterio-posterior and transversal direction, and consequently, as a change in the macroscopic optic disc morphology (cup shape measure).

We have just referred to the modifications the optic nerve undergoes in glaucoma, but it should be kept in mind that a defect in the retinal fiber layer [8] may be the first sign of glaucoma, and in this case it precedes the characteristic alterations of the optic nerve itself as well as the alterations of the visual field (see chapter 9).
The first parameter that starts to change with the decrease of the optic nerve is the volume of the neuroretinal rim. This is due to a decrease in the thickness of the nerve fiber layer. While this happens the area of the neuroretinal rim starts to decrease. (Volume is a variable raised to the third power, and area is a variable raised to the second power).

Later on, and due to the decrease of the neuroretinal rim volume, the cup volume as well as its area, start to increase, at the expense of the destruction of the rim (figure 8.8).

As the retinal thickness decreases, first the tilted neuroretinal rim and then the flat neuroretinal rim starts to decrease. Their areas are occupied by the cup surface.

As seen in figure 8.8, once the retinal thickness starts to decrease, the intersection between the oblique line representing the fall of fibers and the reference plane, begins to move from the center of the optic disc towards the periphery. This happens at the expense of a decrease of the volume previously occupied by the neuroretinal rim fibers. This affects the increase of the volume and area of the cup (in red), due to a decrease of both neuroretinal rim parts (blue and green).

The different alterations in each parameter throughout the evolution of glaucoma will be presented in chapter 10 (evolution phases).

8.3 Diffuse and localized optic nerve damage

Diffuse damage is usually the most common damage of the optic nerve. Localized damage which becomes manifest by a notch in the optic disc, occurs only in 30% of cases [9]. Sometimes, in the area of the notch, a deep canal reaching the deepest part of the optic disc, can be seen in the summation image. Two examples of these types of damage and a comparison with normal optic discs, are shown below (figures 8.9, 8.10, 8.11).
**Fig. 8.9: Normal optic disc.** Both humps are normal, as they represent the fiber bundles of the superior and inferior poles. The mean retinal thickness is maintained, with no localized depressions.

**Fig. 8.10: Optic disc with a diffuse defect.** Note the absence of both humps due to the loss of fiber bundles at the poles. The mean retinal thickness has decreased. No localized depressions are found.

**Fig. 8.11: Optic disc with a localized defect.** There is a partial loss of the second hump where a localized defect at the inferior pole has started. The mean retinal thickness is still preserved.
Bibliography


