Determination of the Location of the Fovea on the Fundus

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Purpose. To evaluate whether the distance between optic nerve head and fovea in healthy eyes determined by scanning laser ophthalmoscope may facilitate estimation of the location of the fovea relative to the optic disc in patients with macular disease.

Methods. The angular distance was measured, in horizontal and vertical directions, between the center of the optic nerve head and the fovea in 104 eyes of 104 healthy probands. For additional evaluation of intraindividual variation in 70 of these persons the contralateral eye was measured as well.

Results. The distance between the optic disc and the fovea differed vertically more than horizontally (−1.5 ± 0.9° [−3.65 to +0.65°] vs. 15.5 ± 1.1° [13.0–17.9°]). There was a mean angle between the fovea and the center of the optic disc versus the horizon of −5.6 ± 3.3°. The intraindividual difference between right and left eyes was markedly lower, with average angles being 0.2 ± 1.3° vertically and 0.0 ± 1.1° horizontally.

Conclusions. The distance between the optic nerve head and the fovea does not allow for a meaningful determination of the location of the fovea in eyes in which morphologic changes have occurred. The angle of rotation of the fovea relatively to the center of the optic nerve head is relatively stable. Therefore, the size of a central scotoma can be determined by movement of the blind spot according to the change of the preferred retinal locus (PRL). In addition, the knowledge of the location of the fovea enables determination of the position in the contralateral eye of the same patient. (*Invest Ophthalmol Vis Sci.* 2004;45:3257–3258) DOI:10.1167/iovs.03-1157

Precise definition of the location of the fovea is often difficult in patients with macular disease, especially in the presence of advanced fundus changes in age-related macular degeneration (AMD). The foveal avascular zone surrounding the fovea is not located symmetrically around the fovea. Therefore, exact determination of the location of the fovea at the fundus might be difficult.

Earlier investigations studying changes of fixation have mostly taken the movement of the location of the blind spot into account.[1,2] The knowledge of the distance between the blind spot and the fovea indirectly allows determination of the location of the fovea by measurement of the blind spot.

With the development of the scanning laser ophthalmoscope an exact function testing with simultaneous illumination of the fundus has become possible.[2–5] This technique permits fundus perimetry and testing of the behavior of fixation.[6]

The purpose of this study was to evaluate whether the distance between the center of the optic nerve head and the fovea in healthy eyes is a stable parameter in order to determine the location of the fovea and whether the angle between optic nerve head and fovea against the horizon provides additional information.

Patients and Methods

One hundred seventy-eight eyes of 178 healthy volunteers with visual acuity of 20/25 or better were included in the study. They were examined with our static threshold perimetry using the scanning laser ophthalmoscope (SLO 101; Rodenstock, Munich, Germany) as described earlier.[6–8] Before examination, informed consent was obtained after explanation of the nature and possible consequences of the study, according to the tenets of the Declaration of Helsinki. Either the right or left eye was randomly selected, providing 98 right and 80 left eyes for study. The examination was performed with a modulated HeNe laser used for stimulus presentation and an infrared laser for fundus visualization. During the examination, the location of the actual point of fixation was stored during each stimulus presentation.[7,8] From all these loci, the mean point of fixation was calculated as the center of gravity leading to the center of fixation. We included only examinations with a minimum of 200 stimulus presentations and stable central fixation (i.e., the location of fixation exactly determines the fovea). The examinations lasted between 8 and 23 minutes. Exact coincidence of this point with the fovea was confirmed by the location of the foveal reflex. Therefore only 104 of these 178 eyes with central foveal fixation—that is, location of the center of fixation at the fovea—were included in the calculations (52 right and 52 left eyes).

During a previous study we confirmed that the Rodenstock SLO has a telecentric optical pathway.[9]

We determined the center of the optic disc on the fundus image according to the inferior and nasal margin. These two points were defined manually on each single optic nerve head at the middle of the inferior and nasal margin (Fig. 1). After this, the software automatically calculated the location of the center of the disc as well as the horizontal and vertical distance between the fovea and the center of the disc (Fig. 1).

For calculation of intra- and interindividual deviation we included the second eye of 70 of the volunteers and compared the values in the right and left eyes. In these probands the first eye was randomly selected. All eyes fulfilled the criteria concerning fixation as defined earlier.

We also correlated our results to the age and the refractive power, because ametropia, especially when caused by axial length differences, can lead to different angular distances between macula and optic disc, due to magnification.

Results

The mean horizontal angular distance between fovea and the center of the optic disc was 15.5 ± 1.1°, and the mean vertical angular distance was −1.5 ± 0.9° (i.e., the fovea was below the center of the disc in most eyes). The horizontal distances ranged from 13.0° to 17.9°, and the vertical distance ranged from −3.65° to 0.65°. From these values, the angle between

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optic disc and fovea (α) was calculated to be $-5.6 \pm 3.3°$ versus the horizon.

When comparing right and left eyes of the same individual, there was higher concordance—that is, the horizontal and vertical differences between the fovea and optic disc were $0.0 \pm 1.1°$ and $0.2 \pm 1.3°$, respectively (range, $-2.2°$ to $+2.1°$ and $-2.8°$ to $3.5°$, respectively).

There was no significant relationship between this distances and the amount of myopia ($r^2 = 0.028$, $P > 0.1$). In addition, the angular distance between fovea and optic disc did not change with age ($r^2 = 0.0012$, $P > 0.1$; Fig. 2).

Discussion

The knowledge of the exact location of the fovea is important, especially in low-vision patients with changes of the area of fixation. Because most of those patients have morphologic alterations of the macular area, it may be helpful to know the location of the fovea in relation to the optic disc. Our findings indicate that there are interindividual differences in the distance between the center of the optic disc and the fovea and those differences are larger as assumed by others.[10,11] We chose the center of the optic disc instead of the temporal and inferior margins as the reference, because the size of the disc itself varies between different persons.[12] Otherwise, in myopic eyes with tilted nerve heads, additional corrections would be necessary. Nevertheless, the intraindividual differences between right and left eyes are small, especially for the horizontal distance. The effect of rotation may cause greater variation in the vertical distance. Recently, Keilhauer et al.[13] have reported a significant increasing distance between optic disc and fovea with age in 28 subjects caused by an increasing vertical distance. Our results in a higher number of eyes did not show any change correlated with age (Fig. 2) and especially no increasing tilt of the eye with age. When there is normal visual acuity and stable central fixation, it is even unlikely that the position of the eye would change during lifespan.

From the data for horizontal and vertical distance between fovea and optic disc, it is possible to calculate the angle between the horizontal through the center of the disc and the line connecting the center of the disc to the fovea. Our mean angle α of $-5.6 \pm 3.3°$ shows a smaller tilt than reported in the small study of Keilhauer et al.[13]

The determination of the location of the fovea may be possible by use of the perimacular vessels and the center of the avascular zone, even in patients who have macular disease.

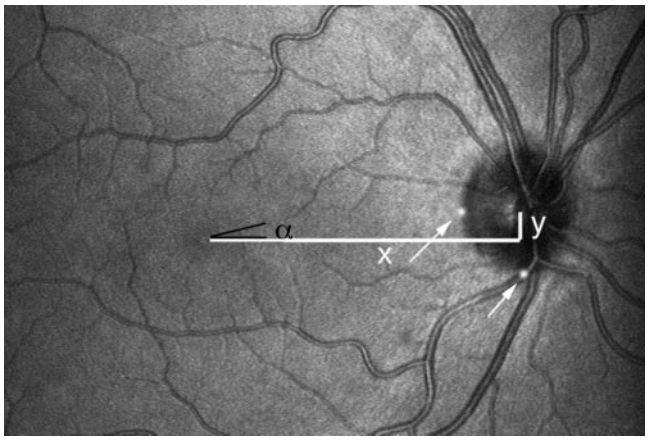

Figure 1. After determination of the temporal and inferior margin of the optic disc by the investigator (*white spots*, *arrows*) the software computes the horizontal (x) and vertical (y) distance between the fovea and the center of the optic disc, thus allowing calculation of the angle (α).

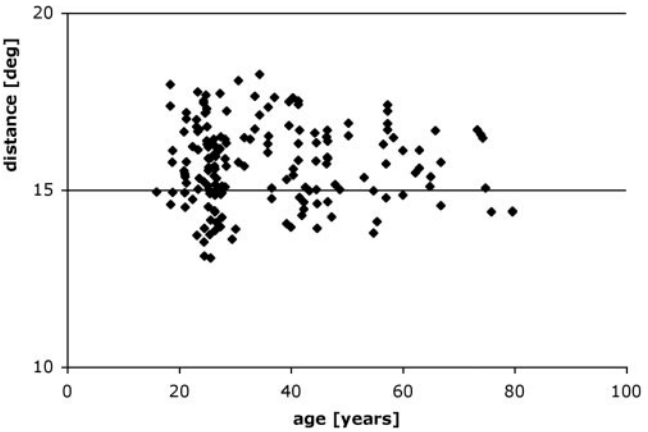

Figure 2. Correlation between age and distance between center of the optic disc and fovea (not significant).

However, in advanced stages, when central fixation is lost due to pathologic alteration, the avascular zone as well may no longer exist. Therefore, the theoretical option of a more precise definition of the former location of the fovea using the perimacular vessels often is no longer possible. The indirect definition of the location of the fovea according to the distance to the optic nerve head as given in this study may be helpful in such patients, although accuracy is limited.

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