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Review Article

A Practical Guide to Measuring Optic Disc Size and its Clinical Correlation in Diagnosing Glaucoma for the Eye Care Professional

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Abstract

This study examines the connection between glaucoma and the optic disc, cup, and neuroretinal rim size. The use of a slit-lamp and funduscopy lens as a technique for determining and estimating the optic disc size is particularly emphasized. Through this study, a clinical manual for working clinicians will be developed by summarizing this information and making it easily accessible for in-office use. PubMed, Science Direct, Ovid, Medline journals, and inter-library journals were used to find papers and abstracts of relevant studies for this review. The most common search terms were: procedures for assessing optic disc size, variance in optic disc size between populations, and ophthalmoscopic methods for measuring optic discs. The search period spanned 2020 to 2022. The following criteria were used to determine whether an article should be included or excluded: a critical evaluation of the various methods used to measure the optic disc, the significance of including population-specific variations in the size of the optic disc, and justifications for the relative risk of glaucoma associated with the size of both the optic disc and the optic cup. According to numerous studies, a slit lamp and funduscopy lens can be used to estimate the size of the optic disc. Additionally, this review discovered a weak association between measures taken at a slit lamp and those taken with more exact office tools, including fundus photography. Using fundoscopic technologies is an effective and affordable method for measuring the optic nerve head while retaining a high level of accuracy. These dimensions can be used to divide the sizes of optic discs into three groups: small, average, and large.

Introduction

Primary open-angle glaucoma is a progressive optic neuropathy. It is linked to partial or extensive thinning of the neuroretinal rim and retinal nerve fiber layer within the optic nerve head. The optic cup thus extends in size as a result of the thinning of the retinal nerve fiber layer. Neuroretinal rim loss and cup enlargement patterns might be focused or diffuse changes or both alone and together [9]. Cupping is a precursor to impairment of the visual field, and advancement of cupping has been seen in glaucoma and ocular hypertension individuals. Routine automated perimetry can identify glaucomatous visual field abnormalities when 20–40% of retinal ganglion cells are destroyed [13]. Due to this threshold, functional vision loss frequently happens before morphological alterations to the peripapillary retinal nerve fiber layer and optic nerve head. In order to diagnose and treat glaucoma, a detailed structural examination of the optic nerve head is a crucial clinical tool. When a clinician notices substantial cupping in the optic nerve head, they should be on the lookout for glaucomatous optic neuropathy. Evaluation of glaucoma risk and advancement can be done in several ways. Ocular coherence tomography, automated perimetry testing, and Intraocular Pressure (IOP) measuring are a few of these [6]. Direct examination with a slit-lamp biomicroscope and condensing lens is one of the easiest and most effective techniques a doctor has at their disposal to evaluate the optic nerve. The clinician can determine the optic nerve's Cup-to-Disc Ratio (CDR) and measure the optic nerve's head using these techniques.

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The CDR evaluates the optic cup's size about the optic nerve head's overall size. The ratio of the optic nerve head made up of the optic cup is indicated by this measurement, which is frequently given as a decimal. The CDR is frequently evaluated further by independently measuring the cup's horizontal and vertical dimensions. Clinically, the CDR, in relation to disc size, helps diagnose tiny glaucomatous discs. To better understand the presence or risk of glaucoma, it is crucial to consider the size of the entire optic nerve head when measuring the CDR [6]. This is because disc and cup size both have a high degree of variability, and a large cup does not necessarily mean that there has been glaucomatous damage. For a more well-informed choice, the relative size of the disc must be compared to the cup.

Glaucoma and Optic Disc Size

The neuroretinal rim can be indirectly measured using the Cup-to-Disc Ratio (CDR), which strongly correlates with visual field loss in glaucoma patients. Therefore, larger optic cupping raises questions about how glaucoma presents and progresses. However, the size of the optic disc and the size of the cup varies significantly between individuals. The average person has a wide range of optic disc and cup diameters. When large optic discs with large cups have the same neuroretinal rim area as a smaller disc with a smaller cup, they may appear to have glaucoma [9]. This shows that the disc size should be considered while evaluating the optic nerve. Small discs may be mistakenly categorized as usual when measuring cup size or CDR, whereas large discs may be incorrectly categorized as glaucomatous.

Parameters of an Average Optic Nerve Head

The average optical disc measures 1.88 mm in height and 1.77 mm in width. The innermost boundary of the reflective tissue, internal to any pigmented tissue and containing just neuroretinal tissue, is referred to as the disc's borders. The optic disc's size depends on the size of the scleral canal [6]. Although the disc might be round, it usually has an oval shape that is vertically oriented, with the vertical diameter being approximately 9–10% bigger than the horizontal diameter. Different studies have shown that for optic disc diameters, the giant measured disc was roughly 6.5 times larger than the smallest disc, with an area ranging from 0.86 mm^2 to 5.39 mm^2. The average optical disc has a horizontal diameter of 1.76 mm and a vertical of 1.92 mm in diameter. Larger discs are defined as >2.20 mm, while small discs are classified as 1.50 mm [6].

The size of the optic cup is 0.00 to 3.41 mm^2. The average horizontal and vertical diameters are 0.83 mm and 0.58 mm, respectively. This demonstrates that the optic cup is 8% longer on the horizontal than on the vertical in normal eyes, making it horizontally oval. Three types of optic cups can be identified: those with deep, punched-out cups, those with relatively flat slopes, and those without any cupping at all. In comparison to discs with temporal slopes or discs without cupping, it was discovered that the optic disc area was substantially bigger in discs with punched-out cups. Punched-out cups are also noticeably rounder than cups with flat temporal slopes.

Cup-to-Disc Ratio (CDR) runs from 0.00 to 0.87 horizontally and from 0.00 to 0.85 vertically. There are a lot of interindividual variabilities, and the horizontal value is substantially more significant than the vertical value. Normal CDRs have an average size of 0.4 and range in size from 0.3 to more than 0.5.

The neuroretinal rim area varies and averages 1.97 0.50 mm^2. The nasal region, superior region, inferior disc region, and temporal disc region are typically where the rim is the widest. The ISNT rule is a typical name for this. Age-related retinal nerve fiber count reductions range from 750,000 to 1,500,000 in normal eyes. Studies have shown a clear correlation between the quantity of nerve fibers and disc size. Because the fibers have a larger area to cross, a larger optic disc is related to a drop in nerve fiber density per area. A greater anatomic reserve capacity in eyes with large discs than in eyes with small optic discs might exist, possibly providing some protection from glaucomatous vision field alterations, assuming there are more retinal nerve fibers in large discs.

Disc Size with Respect to Other Optic Nerve Parameters

It is becoming more widely acknowledged that other disc parameters, such as neuroretinal rim area, cup area, or volume, are significantly influenced by disc size. Studies have shown that CDR grows linearly as disc size increases. Therefore, a CDR that is unusually high in eyes with large optic nerve heads may be physiological.

The average disc and those discs with temporal flat slopes tend to be substantially smaller than the optic nerve heads with steep, punched-out cups. The size of discs with cups with relatively flat slopes is normally average, but they are much bigger than discs without cups. Discs without cupping are typically smaller than the typical disc and smaller than any other disc variations.

Increasing disc size is consistently shown to increase rim area, regardless of the measurement method. It has been demonstrated that the neuroretinal rim's width is more consistent and essentially unrelated to disc size [4]. Additionally, there is a correlation between cup size and disc size; large optic discs typically have large cups, whereas small discs typically have little or no cups.

The optic disc's size must be considered to accurately determine the quantity of neuroretinal rim tissue present because cup size and disc size are correlated. According to several researchers, cupping alone should not be used to diagnose glaucoma because the size of the neuroretinal rim is proportional to the number of ganglion cell axons present [4]. A large optic disc with a 0.8 cup has a similar quantity of neuroretinal rim tissue as an average-sized optic disc with a 0.5 cup; thus, it is particularly crucial to keep this in mind.

When making a glaucoma diagnosis, a practitioner may consider the size of the optic disc. Lee claims that falsely low cup-to-disc ratios in glaucomatous eyes with short optic nerve heads make it more challenging to detect glaucomatous optic neuropathy. Additionally, when large optic discs with large cups have the same neuroretinal rim area as a smaller disc with a smaller cup, they may appear to have glaucoma [4]. The CDR may be deceptive when the rim loss is restricted to a single sector, as with a focal notch, even though it is helpful in patients with concentric cupping. The disc and visual field may be severely damaged even though the CDR was recorded as small.

Disc Size as a Risk to Glaucoma

Participants in the ocular hypertension therapy research found no correlation between disc size and the onset of primary open-angle glaucoma. The CDR is more affected by the loss of neuroretinal rim tissue when the optic disc is small instead of large. When a patient has a large cup, the doctor must decide if it is physiologically large in a large disc or glaucomatous large in a small or normal-sized optic disc [12]. The significant degree of overlap between the optic cup diameter and, hence, the CDR between acquired expanded cups and physiologically large cups further complicates the approach in diagnosis.

For other optic nerve disorders, smaller optic nerve heads develop nonarteritic anterior ischemic optic neuropathy, pseudo papilledema, and optic disc drusen more commonly than large optic discs. Large optic nerve heads are more prone to disc pits and morning glory syndrome. Retinal vascular occlusions and arteritic anterior ischemic optic neuropathy are more frequent in normal-sized optic discs.

Other Diagnostic Criteria for Glaucoma

The size, color, and integrity of the optic nerve head, the size, and shape of the optic cup, the shape and configuration of the blood vessels overlying the optic nerve head, the presence of the laminar dot sign, the progression of peripapillary atrophy, and the loss of retinal nerve fibers in red-free illumination are additional important aspects of the optic nerve head to be examined during fundoscopy [12]. As it has been demonstrated that there is a link between the presence of hemorrhage and a worse prognosis in individuals with glaucoma, the presence of a hemorrhage on or near the optic nerve head is also a significant finding that should not be disregarded. Of course, continued monitoring over time without change aids in confirming the diagnosis that a patient does not have glaucoma.

Knowing the size of the optic disc will significantly boost confidence that the optic cup may be standard in clinical practice when evaluating a glaucoma suspect with large optic cups but no risk factors in glaucoma. Knowing that the disc is large in suspects with risk factors may warn the physician to proceed with care when making a diagnosis based only on the size of the cup [8]. In contrast, knowing that the disc size is small will allow the clinician to infer glaucomatous damage in suspects with risk factors and moderate cupping.

Optic Disc Size Variations

The optic disc size varies between individuals, ranging from roughly 0.80 mm^2 to 6.00 mm^2. Furthermore, there is a strong correlation between the area of the neuroretinal rim and the general area of the optic disc: the larger the optic disc, the larger the rim area. Furthermore, the optic cup itself exhibits significant interindividual variation. Studies discovered that CDR ratios in a typical population ranged from 0.0 to about 0.9 [4].

Race

The size of the optic disc is independently determined by ethnicity. According to race, the size of the optic disc ranges from large to small, as follows: Asians, Hispanics, African-Americans, and Caucasians [11]. While Caucasians range from 1.73mm^2 to 2.63 mm^2, Hispanics range from 2.46 mm^2 to 2.67 mm^2, and Asians range from 2.47 mm^2 to 3.22 mm^2, the mean disc area of African-Americans ranges from 2.14 mm^2 to 3.75 mm^2 [11]. The same neuroretinal rim area across races demonstrates that any variation in topographic parameters can be best explained by the size variations in the optic disc areas in the various populations. Regarding white patients, disc size did not affect glaucoma risk. There was also no statistically significant increase in the risk of glaucoma among African-Americans after correcting for other characteristics like age, sex, central corneal thickness, systemic illnesses, and IOP [11].

Sex

Sex has not been proven to be a substantial risk factor for glaucoma or to significantly affect the size of the optic disc in either males or females [7]. Men's eyes were longer than women's in axial length, which was the sole variation between the sexes.

Refractive Error

Compared to emmetropes, people with refractive error +5 D have much smaller discs. A refractive error of -8 D is associated with considerably bigger discs than emmetropia. After removing participants with high myopia from the study, [5] discovered no association between the size of the optic nerves, the optic cups, and the CDR between the various refractive errors. Numerous other studies on the optic disc size also need to include people with significant refractive problems.

Age

The age-optic disc size association is not statistically significant. Additionally, there is no connection between age and rim size. However, there is a clear link between glaucoma risk and age, with glaucoma risk being 1% at age 50 and 4% by age 80 [2].

Further research reveals no relationship between the right eye, left eye, body weight, or height. In those with myopia higher than -12 D, increased corneal astigmatism, or amblyopia, there is an association between the form of the anterior optic disc and these conditions. Based on the results mentioned above, only ethnicity and refractive error affect the optic disc size [2]. It is vital to keep in mind that while ethnicity and refractive error may have an impact on the disc size, these various populations also exhibit significant interindividual variation.

Clinical Evaluation of Optic Disc Size

Only through histology or intraocular procedures like vitreoretinal surgery is it possible to directly assess the size of the optic disc. The optic disc can be measured in a clinical environment using various techniques. These include spectral-domain optical coherence tomography, fundus photography with planimetry, and scanning laser ophthalmoscopy [8]. The preceding procedures are frequently too expensive for physicians to utilize regularly because of time restrictions and equipment costs. Fundoscopy with contact and non-contact condensing lenses is a more straightforward and more effective procedure to estimate the size of the optic disc. This method entails changing the slit lamp beam to match the optic disc's vertical or horizontal diameter. The measurement is then obtained from the slit lamp's beam height indicator. Although this measurement does not always reveal the exact size of the optic disc, it does offer the doctor a general idea of how big the disc is. The size of the slit-lamp beam needs to be verified before the measurements are carried out [8]. To do this, measure the beam's length on a millimeter scale and then compare your results to the reading on the slit lamp itself. Setting the slit-beam lamp's height to 1mm as an example, you can use a millimeter ruler to measure the beam height while ensuring the ruler is in sharp focus through the slit-lamp to ensure the accuracy of the beam height indication. If not, another computation must account for the discrepancy [12]. By using this method, it is possible to measure intraocular structure sizes to within 0.05 mm, negating the need for additional, pricey equipment.

The instrument's and the eye's magnification impact the size of the optic disc as it is measured. Ametropia, axial length, and corneal curvature could affect how well the eye magnifies objects [12]. The estimate of the optic disc is possible thanks to the creation of many lens-specific correction factors. These correction factors are partially caused by the fact that 60-D lenses magnify the image while 78-D and 90-D lenses reduce it. A slit lamp's beam height indication usually is only calibrated in stages of 0.1 mm down to 1 mm [8]. It is not possible to utilize the beam height indication to measure tiny discs, especially when using the previously stated lenses that produce minified images. The measurement could be made by directly measuring the height of the slit-lamp beam using an accurate ruler that indicated 0.1 mm steps from 0 to 1 mm.

Correlation between Measurement Techniques

Due to the eye's optical system's variable magnification that depends on the eye's dimensions, it is difficult to determine the disc size accurately in vivo [12]. Stereo fundus photography is currently accepted to record and track changes in the optic nerve head impartially. The main drawback of this method is that measurements require a lot of time and have a large inter-observer variability [12]. Due to the reliability of the data, the Heidelberg Retina Tomograph (HRT) is regarded as the reference standard for optic disc measurements [3]. Due to the results' moderate agreement with planimetry, Neubauer discovered that Optical Coherence Tomography (OCT) could also be used to estimate the borders of the optic disc. The clinical appearance of the optic nerve is measured by fundus photographs and slit lamp measurements, while the scleral canal is measured by HRT utilizing variations in the laser's reflectivity. Lim discovered a strong association between the two measuring methods when he compared fundus lens readings to HRT measurements [1]. According to studies, mean vertical diameter measurements taken with a non-contact fundus lens and slit lamp were equivalent to those taken with fundus photography and HRT [10]. Furthermore, it has been demonstrated that these measurements closely match the in-vivo measurements of the optic discs taken during vitrectomy.

Table 1: compares HRT's vertical optic disc diameter measurement to those of many widely used condensing lenses using Lim's data [4]. The data acquired by the HRT were found to best correlate with the 60D lens.

Technique	Average Diameter
Heidelberg Retinal Tomograph	1.81 ± 0.18
Volk 60D	2.06 ± 0.17
Volk 78D	1.63 ± 0.16
Volk 90D	1.36 ± 0.12
Nikon 60D	1.75 ± 0.09
Nikon 90D	1.11 ± 0.10

As long as the ametropia of the eye does not exceed 5D, the distance at which the condensing lens is held does not statistically significantly affect the measurements of the optic disc. While some studies indicate that ametropia does not exceed 3 D, others have found a good association for myopia up to -8D [1]. The slit lamp condensing lens system's high magnification reduces the field depth, lowering measurement errors.

Even though this method can be used with or without pupillary dilation, estimation of disc size was found to be more straightforward, more precise, and more interobserver agreement when used in conjunction with stereoscopic seeing through dilated pupils [3]. Additionally, the larger the disc, the less error in the measurements made using fundoscopic methods. This is most likely because larger structures are simpler to measure [4]. No of the measurement method, it is crucial to account for the entire peripapillary scleral ring when measuring the optic disc. However, the actual scleral ring should be disregarded because it is not a part of the optic disc.

Accuracy vs. Estimation for Disc Measurement

Although fundus lenses cannot accurately measure the size of the optic disc, they can provide an estimate. To classify the optic disc as abnormally large, average, or abnormally small is typically sufficient for therapeutic purposes rather than requiring exact measurement of the disc size [3]. The magnification of the examined eye and any fundus camera or other tool utilized has no bearing on cup-to-disc ratios. As a result, when calculating CDR, one does not need to account for the ocular and camera magnification.

Multiple studies have discovered inconsistent values for the correction values of the various lenses, indicating that using a single correction factor for each fundus lens may not be appropriate [10]. (Table 2) provides several examples. Additionally, it has been discovered that lenses with the same dioptric power made by various manufacturers have varying correction factors. Their unique aspheric characteristics explain this. Studies generally did not include eyes with ametropia greater than 5 D.

Table 2: Different studies' findings

Lens	Hancox	Turgut	Browne	Lim	Manufacturer	Average
Volk 60D	0.85X +0.06	0.94	1.0	0.88	0.92	0.93
Volk 78D	0.84X +0.41	1.13	1.11	1.11	1.15	1.15
Volk 90D	0.89X +0.59	1.36	1.33	1.33	1.39	1.38
Nikon 60D	0.74X +0.51	1.03	1.0	1.03	1.02	1.08
Nikon 90D	0.98X +0.73	1.59	1.33	1.63	1.54	1.56

As seen above, there is a strong correlation between the data provided by the lens manufacturer and the average correction factor value for each lens. Only the Nikon 60 D lens deviated from the manufacturer's data by an average value of more than 0.02 points [3]. Given the previous results, a clinician may find it more practical to use the manufacturer-provided correction factor for each lens rather than calculating each number independently or looking for the correction values others have discovered [10]. Additionally, the Volk 78D lens' correction factor has the best correlation of any of the other lenses, suggesting that it could offer more precise measurements of intraocular structures.

Other structures in the posterior pole, such as malignant choroidal melanomas, age-related maculopathies, or retinal malignancies, can also be measured using this technique. The center 30° of the fundus has a relatively constant ocular magnification factor, making this conceivable [1]. Due to the high interindividual variability of the optic disc size, this method of measuring is preferable to defining the size using disc diameters.

Additional Techniques for Estimating Optic Disc Size

The 5-degree little light spot is about the size of a typical optic disc when viewed through a direct ophthalmoscope. The middle spot may be used if the ophthalmoscope has three different spot sizes. When employing this method, the majority of published data makes use of the Welch-Allen 5-degree aperture. As a result, the optic disc can be categorized as large if it seems larger than the spot size and as tiny if it appears less than the spot size [9].

The central retinal vein can also determine the disc's size. At the point where the vein crosses the inferior neuroretinal rim, the vein's typical thickness or diameter is 125 ums. The typical optic disc should be 12 to 14 vessel diameters across using the rough estimate for the vessel thickness [3]. The disc can be divided into two categories: large and tiny, depending on how many diameters it has—more than 14 for large and less than 12 for small.

Utilizing the distance between the optic disc and the fovea is another method. In the eyes of normal size and axial length, the distance from the temporal margin of the optic disc to the fovea is roughly two to three-disc diameters [1]. The disc can be categorized as tiny or large depending on how many disc diameters there are between the temporal rim and the fovea. The disc can be categorized as large if there are less than two-disc diameters.

Discussion

An essential step in making a glaucoma diagnosis is a direct examination of the optic nerve head and changes in the Cup-to-Disc Ratio (CDR). However, the clinician cannot make this decision only based on the CDR. Whether or not an optic cup is considered abnormal depends on the total size of the optic disc [9]. If no other risk indicators are present, large optic cups in physiologically large discs should not be immediately suspected of having glaucoma. Similar to this, even with a lower CDR, a moderate cup size in a small optic disc may still have glaucoma. While numerous methods and equipment may be used to estimate the size of the optic nerve, the most straightforward and economical approach is to use a slit lamp and condensing lens. Get the optic nerve in sharp focus and adjust the beam height to match the disc's size [10]. The reading on the beam height indicator may then be read, and the user can multiply that amount by the lens correction factor. If the slit lamp lacks a beam height indicator, the clinician can lock it in place, have the patient recline, and measure the height of the beam directly with a ruler at the plane where the lens was held [3]. Based on this measurement, the optic disc can then be categorized as large, average, or small. A clinician can make a far more informed choice regarding diagnosis and therapy when they consider the patient's risk factors in addition to the data obtained from measuring the optic disc size, cup size, and CDR.

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