

SIZE MATTERS: A PRACTICAL GUIDE TO MEASURING OPTIC DISC SIZE AND  
ITS IMPORTANCE IN DIAGNOSING GLAUCOMA FOR THE EYE CARE  
PROFESSIONAL

by

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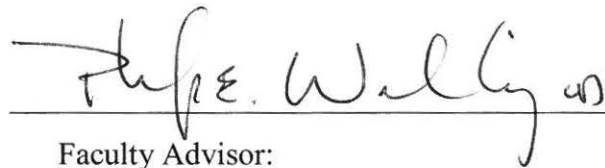
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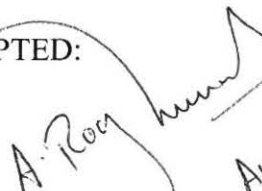
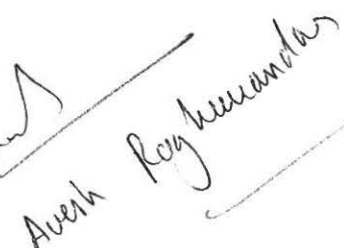
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## ABSTRACT

*Background:* This research study explores the relationship between optic disc, cup, and neuroretinal rim size and its correlation with glaucoma. There is a specific focus on the use of a slit-lamp and condensing lens as a method for the measurement and estimation of the size of the optic disc. Through this research a clinical guide for practicing clinicians will be made summarizing this information and making it available in a format that can be quickly consulted in-office. *Methods:* Papers and abstracts of relevant studies for this review were obtained from PubMed, Science Direct, Ovid, Medline journals, as well as through interlibrary loans through Ferris State University and Wayne State University. The primary search terms used were: *Optic disc size and relation to glaucoma, Techniques for measuring optic disc size, Optic disc size variation among populations, and Ophthalmoscopic techniques for measuring optic discs.* The search covered the years from 1988 to 2017. The criteria for inclusion or exclusion of articles were: the critical judgment of comparing different optic disc measurement techniques, the importance for the inclusion of optic disc variation among populations, and explanations for the relative risk of glaucoma related to the size of both the optic disc and the optic cup. *Results:* Various studies have found that estimations of the optic disc size can be made using a slit-lamp and condensing lens. These studies have also found moderate correlation between measurements made at the slit-lamp, and those made with more precise office equipment such as the Heidelberg Retina Tomograph, and fundus photo

planimetry. *Conclusion:* The use of fundoscopic techniques is an efficient and cost-effective option to perform measurements of the optic nerve head while maintaining a high degree of accuracy. These measurements can be used to classify optic disc sizes into small, average, and large categories.

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## CHAPTER 1

### INTRODUCTION

Primary open angle glaucoma is a progressive optic neuropathy, and its development is associated with regional or diffuse thinning of the retinal nerve fiber layer and of the neuroretinal rim within the optic nerve head. This results in a consequent increase in the size of the optic cup.<sup>1,2</sup> The pattern of neuroretinal rim loss and cup enlargement can take the form of focal or diffuse changes, or both in combination. Cupping is an early sign and progression of cupping has been observed in ocular hypertensive patients and in glaucoma patients, before the onset of visual field damage.<sup>3</sup> Glaucomatous visual field defects can be detected on standard automated perimetry when 20-40% of retinal ganglion cells are lost.<sup>4</sup> Because of this threshold, morphological changes of the optic nerve head and peripapillary retinal nerve fiber layer often occur before functional vision loss.<sup>5,6</sup> Therefore a precise structural evaluation of the optic nerve head is an essential clinical tool in the diagnosis and management of glaucoma.<sup>7,8,9,10</sup> A clinician observing an optic nerve head with significant cupping should be suspicious for the presence of glaucomatous optic neuropathy. Several methods exist for evaluation of risk and progression of glaucoma. Some of these include: measurement of the intraocular pressure (IOP), automated perimetry testing, and ocular coherence tomography. One of the simplest and most efficient methods a clinician has available to assess the optic nerve is through direct observation utilizing a slit-lamp biomicroscope and condensing lens. Using these tools it is possible for the clinician to measure the optic nerve head and estimate the cup-to-disc ratio (CDR) of the optic nerve.



The CDR is the estimation of the size of the optic cup relative to the size of the entire optic nerve head.<sup>3</sup> This measurement is often expressed as a decimal denoting the percentage of the total optic nerve head consisting of the optic cup. For example a cup that comprises approximately 50% of the total area of the optic disc is designated as being a 0.5 cup. The CDR is often further assessed by separately measuring both the vertical and the horizontal dimensions of the cup. The CDR, relative to disc size, is useful clinically, especially to assist in identifying small glaucomatous discs.<sup>3</sup> When measuring the CDR, it is important to take into account the size of the entire optic nerve head to facilitate a better understanding of the presence or risk of glaucoma, as disc and cup size both have a high interindividual variability, and a large cup does not in itself indicate the presence of glaucomatous damage. The cup must be compared to the relative size of the disc for a more informed decision to be made.<sup>5</sup>

## CHAPTER 2

### RELATIONSHIP OF OPTIC DISC SIZE TO GLAUCOMA

Cup-to-disc ratio (CDR) is often used as an indirect measure of the neuroretinal rim, which has been shown to correlate well with visual field loss in glaucoma patients.<sup>8</sup> Larger optic cupping is therefore suspicious for the presentation and progression of glaucoma. However, there is great interindividual variability in both optic disc size and cup size.<sup>4</sup>

Optic disc and optic cup sizes vary widely in the general population.<sup>5</sup> Large optic discs with large cups can appear glaucomatous when they have the same neuroretinal rim

area as a smaller disc with a smaller cup.<sup>4</sup> This in turn suggests that when assessing the optic nerve, the disc size needs to be taken into account. When calculating cup size or CDR, small discs may be classified as normal despite the presence of glaucoma, while large discs may be falsely labelled as glaucomatous.<sup>5,11</sup>

Average optic nerve head parameters:

The average optic disc is 1.88 mm vertically and 1.77 mm horizontally.<sup>13,18</sup> The borders of the disc are defined as the innermost border of the reflective tissue that is internal to any pigmented tissue and within which only neuroretinal tissue is present. The size of the scleral canal determines the size of the optic disc.<sup>4</sup> The disc can be round, but is typically vertically oval in shape, with the vertical diameter being about 9-10% larger than the horizontal diameter.<sup>13,15,17</sup> Jonas has done much research on optic disc sizes and found that optic disc area ranges from 0.86 mm<sup>2</sup> to 5.39 mm<sup>2</sup>, and that the largest disc measured was about 6.5 times larger than the smallest disc.<sup>14</sup> Mean optic disc diameter is horizontally 1.76 ± 0.31 mm, and vertically 1.92 ± 0.29 mm. Small discs are defined as <1.50 mm and large discs as >2.20 mm.<sup>4</sup> According to the Blue Mountains Eye Study 25% of the 6678 eyes studied were within the category of small (1.1-1.3 mm) or large (1.8-2.0 mm) optic disc size.<sup>16</sup>

The optic cup area ranges from 0.00 to 3.41 mm<sup>2</sup> (mean 0.72 ± 0.70 mm<sup>2</sup>). The mean horizontal diameter is 0.83 ± 0.58 mm, and vertical is 0.77 ± 0.55 mm.<sup>8</sup> This shows that the optic cup is horizontally oval in normal eyes, with the horizontal diameter about 8% longer than the vertical diameter.<sup>17</sup> Optic cups can be classified into three categories: those with deep, punched-out cups; those with temporal flat slopes; and those that lack any cupping. Optic disc area was found to be significantly larger in discs with

punched-out cups than in discs with temporal slopes or discs without cupping. Punched-out cups are also significantly more circular than cups with flat temporal slopes.<sup>15</sup>

Cup-to-disc ratio (CDR) ranges horizontally from 0.00 to 0.87 (mean  $0.39 \pm 0.28$ ) and vertically from 0.00 to 0.85 (mean  $0.34 \pm 0.25$ ). The horizontal value is significantly larger than the vertical value and there is a high degree of interindividual variability. Normal CDRs range from 0.3 (66% of normal individuals) to greater than 0.5 (only 6-10% of normal individuals) with an average size of 0.4.<sup>4,15,17</sup>

The neuroretinal rim area averages  $1.97 \pm 0.50 \text{ mm}^2$  and is not interindividually constant. The rim is usually broadest in the inferior disc region, followed by the superior region, the nasal region, and finally the temporal disc region. This is commonly referred to as the ISNT rule, first termed by Werner.<sup>15,17,18</sup> Retinal nerve fibers in normal eyes varies from 750,000 to 1,500,000.<sup>4,19</sup> This number declines with age.<sup>13</sup> Some studies have demonstrated a positive correlation between disc size and number of nerve fibers, however other studies have not shown this same correlation.<sup>15,19</sup> A larger optic disc is associated with a decrease in nerve fiber density per area, because the fibers have a larger area through which to cross.<sup>2</sup> Assuming there are a greater number of retinal nerve fibers in large discs, one could conclude that there exists a greater anatomic reserve capacity in eyes with large discs than in eyes with small optic discs, possibly offering some protection from glaucomatous visual field changes.<sup>17</sup>

*Relationship of disc size to other optic nerve parameters:*

It is increasingly recognized that the disc size is a major determinant of other disc parameters such as neuroretinal rim area or cup area or volume.<sup>20</sup> CDR has been shown

to increase linearly with increasing disc size.<sup>2,8,9,19,21</sup> An unusually high CDR, therefore, can be physiologic in eyes with large optic nerve heads.<sup>17</sup> According to the Blue Mountains Eye Study, the median CDR increased from 0.35 to 0.55 from small (1.1-1.3 mm) to large (1.8-2.0 mm) discs.<sup>16</sup>

Optic nerve heads with steep, punched-out cups tend to be significantly larger than the average disc, and those discs with temporal flat slopes. Discs having cups with temporal flat slopes are typically average in size, but are significantly larger than in discs without cupping. Discs that lack cupping tend to be significantly smaller than the average disc, and also smaller than all other disc types.<sup>15</sup>

There is consistent evidence, regardless of measurement technique, that rim area increases with increasing disc size.<sup>15,19</sup> The width of the neuroretinal rim has been shown to be more constant and largely independent of disc size.<sup>10</sup> Cup size also relates to disc size; large optic discs tend to have large cups, while small discs tend to have small, or absent, cups.<sup>3,17</sup>

Due to the correlation of cup size to disc size, the size of the optic disc must be taken into account in order to appropriately estimate the amount of neuroretinal rim tissue present.<sup>9</sup> Various researchers have asserted that the size of the neuroretinal rim is proportional to the amount of ganglion cell axons present, so labeling a disc as glaucomatous should not be based on cupping alone. This is especially important to remember, as an average size optic disc with a 0.5 cup has a similar amount of neuroretinal rim tissue as a large optic disc with a 0.8 cup.<sup>5</sup>

The optic disc size may influence a clinician's decision to assign a diagnosis of glaucoma. According to Lee, glaucomatous optic neuropathy is more often missed in glaucomatous eyes with small optic nerve heads due to misleadingly low cup-to-disc ratios.<sup>21</sup> Furthermore, large optic discs with large cups can appear glaucomatous when they have the same neuroretinal rim area as a smaller disc with a smaller cup.<sup>4</sup> While the CDR is of value in patients with concentric cupping, it may be misleading when the loss of rim is limited to a single sector, as with a focal notch. In this situation the CDR may be recorded as small, and yet the disc and visual field may be badly damaged.<sup>22</sup>

*Disc size as a risk factor for optic nerve pathology:*

Disc size was not associated with the development of primary open-angle glaucoma in participants of the ocular hypertension treatment study.<sup>19</sup> Jonas found that the shape of the optic disc is independent of glaucoma susceptibility as well.<sup>17</sup>

The loss of neuroretinal rim tissue has a greater impact on the CDR when the optic disc is small than when it is large.<sup>3</sup> The challenge that the clinician faces when seeing a patient with a large cup is to differentiate a physiologically large cup in a large disc from a glaucomatous large cup in a small or normal sized optic disc.<sup>9</sup> This is further confounded by the considerable amount of overlap of the optic cup diameter, and thus the CDR between acquired enlarged cups and physiologically large cups.<sup>10</sup>

With regards to other optic nerve pathology, nonarteritic anterior ischemic optic neuropathy, pseudopapilledema, and optic disc drusen occur more frequently in small optic nerve heads than in large optic discs. Pits of the disc and the morning-glory syndrome are more common in large optic nerve heads. Retinal vessel occlusions and

arteritic anterior ischemic optic neuropathy are more common in normal sized optic discs.<sup>17</sup>

*Other diagnostic criteria for glaucoma:*

Other important aspects of the optic nerve head to examine during fundoscopy include: size, color and integrity of the optic nerve head, size and shape of the optic cup, shape and configuration of blood vessels overlying the optic nerve head, presence of lamellar dot sign, progression of peripapillary atrophy, and loss of retinal nerve fibers in red-free illumination.<sup>4,6,12</sup> The presence of a hemorrhage on or near the optic nerve head is also an important findings that should not be ignored, as it has been shown that there is an association between the presence of hemorrhage and a worse prognosis in patients with glaucoma.<sup>22</sup> Of course, long term follow-up without change helps confirm the assessment that a patient does not have glaucoma.<sup>5</sup>

In clinical practice, when assessing a glaucoma suspect with large optic cups but no risk factors in glaucoma, confidence that the optic cup may be normal will be greatly increased by a knowledge of the optic disc size. In suspects with risk factors, knowledge that the disc is large should alert the clinician to exercise caution in placing too much reliance on the size of the cup alone when determining a diagnosis. Conversely, in suspects with risk factors and moderate cupping, knowing that the disc size is small will enable the clinician to suspect glaucomatous damage.<sup>3</sup>

## CHAPTER 3

### OPTIC DISC VARIATION AMONG POPULATIONS

Optic disc size is not constant among individuals, it shows an interindividual variability of about  $0.80\text{mm}^2$  to  $6.00\text{mm}^2$ .<sup>2</sup> Additionally, the neuroretinal rim also shows high interindividual variability and is correlated to the total area of the optic disc – the larger the optic disc, the larger the rim area. The optic cup itself also shows high interindividual variability. Jonas found in a normal population CDR ratios varied from 0.0 to almost 0.9.<sup>17</sup>

#### Race:

Ethnicity is an independent determinant of optic disc size<sup>21</sup>. Optic disc size varies from large to small according to race as follows: African-Americans, Asians, Hispanics, Caucasians.<sup>4,17</sup> African-American mean disc area ranges from  $2.14\text{mm}^2$  to  $3.75\text{mm}^2$ , while Caucasians range from  $1.73\text{mm}^2$  to  $2.63\text{mm}^2$ , Hispanics range from  $2.46\text{mm}^2$  to  $2.67\text{mm}^2$ , and Asians range from  $2.47\text{mm}^2$  to  $3.22\text{mm}^2$ .<sup>19</sup> According to Hancox, the vertical disc diameter in normal eyes is (in mm)  $1.96 \pm 0.16$  for African-Americans, and  $1.82 \pm 0.15$  for Caucasians.<sup>5</sup> Statistically speaking, only Caucasian disc sizes were significantly different from other races. Since glaucoma specialists are more likely referred patients with larger optic disc sizes and more suspicious CDRs, the comparatively small optic disc sizes of Caucasians suggest that there may be a tendency for under-diagnosis and under-referral of Caucasian glaucoma suspects.<sup>21</sup> Neuroretinal rim area was equal between races, showing that any difference in topographic parameters

can best be explained by the size differences between optic disc areas in the different populations.<sup>5,19</sup>

Glaucoma risk was independent of disc size in white patients. When adjusting for other factors, including: age, sex, central corneal thickness, systemic diseases, and IOP; there was no statistically significant increased risk of developing glaucoma in African-Americans either.<sup>19</sup>

Sex:

Optic disc size does not vary significantly between males and females and sex as a risk factor for glaucoma is inconclusive.<sup>15,19</sup> The only difference between men and women was that of axial length, in which male eyes were found to be slightly longer.<sup>10</sup>

Refractive error:

Individuals with refractive error +5 D have significantly smaller discs than emmetropes. Individuals with refractive error -8 D have significantly larger discs when compared to those who are emmetropic.<sup>4,17</sup> Jonas found no correlation between the size of optic nerves, optic cups, and CDR between different refractive errors, after excluding individuals with high myopia from the study.<sup>15</sup> Several other studies on optic disc size exclude individuals with high refractive errors as well.<sup>23</sup>

Age:

There is no statistically significant relationship between age and optic disc size.<sup>15,17,19</sup> Nor is there any correlation between age and rim area.<sup>10</sup> There is a



significant correlation between age and glaucoma, however, with the risk of developing glaucoma being 1% at age 50, and 4% by age 80.<sup>19</sup>

Additionally Jonas found that there was no correlation between right eye, left eye, body weight, or height. There is a correlation between abnormal optic disc shape and the presence of increased corneal astigmatism or amblyopia, or in individuals with myopia greater than -12 D.<sup>17</sup> Given the above findings, only ethnicity and refractive error appear to have an impact on optic disc size. It is important to remember that even though ethnicity and refractive error may influence the disc size, there is also great interindividual variability inside these different populations as well.

## CHAPTER 4

### CLINICAL TECHNIQUES FOR MEASURING OPTIC DISC SIZE

Direct measurement of the optic disc size is only possible histologically, or during intraocular procedures such as vitreoretinal surgery.<sup>19,21</sup> Several methods exist for measuring the optic disc in a clinical setting. These include scanning laser ophthalmoscopy, fundus photography with planimetry, and spectral-domain optical coherence tomography.<sup>5</sup> Due to time constraints and equipment costs the above methods are often prohibitive for clinicians to regularly use. Instead, funduscopy using contact and non-contact condensing lenses is an easier and more efficient method to measure the size of the optic disc.<sup>9,24</sup> This technique involves adjusting the slit lamp beam to the size of the vertical or horizontal diameter of the optic disc. The measurement is then read off of the beam height indicator located on the slit lamp. While this measurement does not

necessarily give the true size of the optic disc, it does allow the clinician to approximate the relative disc size.<sup>5</sup> Before performing the measurements, the scale of the slit-lamp beam must be checked. This is accomplished by measuring the length of the beam using a millimeter scale, and comparing that to the measurement displayed on the slit-lamp itself.<sup>9</sup> An example would be to set the beam height on the slit-lamp to 1mm, and then measure the beam height using a millimeter ruler by placing the ruler such that it is in good focus through the slit-lamp to confirm that the beam height indicator is accurate. If it is not, an additional calculation must be made to adjust for this discrepancy.<sup>13</sup> With this technique, it is possible to measure the size of intraocular structures to the nearest 0.05 mm, eliminating the need for additional and expensive equipment.<sup>8</sup>

The measured size of the optic disc is dependent on the magnification of the instrument used as well as the magnification of the eye. Corneal curvature, axial length, and ametropia may all affect the magnification properties of the eye. The development of several lens-specific correction factors allow for estimation of the optic disc.<sup>19</sup> These correction factors are partly due to 78 D and 90 D lenses resulting in minification of the image, while 60 D lenses result in magnification. The beam height indicator on a slit-lamp is typically only calibrated in 0.1 mm steps down to 1 mm. For smaller discs, and particularly with the lenses described previously that give minified images, it may not be possible to use the beam height indicator to make the measurement.<sup>8</sup> In theory if a clinician had an accurate ruler that displayed 0.1 mm steps from 0 to 1 mm the measurement could still be taken by directly measuring the height of the slit-lamp beam with said ruler.

### Correlation between measurement techniques:

Accurate measurement of the disc size in vivo is challenging due to the magnification of the eye's optical system, which varies depending on the dimensions of the eye.<sup>20</sup> Currently, the standard method to objectively document and follow changes of the optic nerve head is stereo fundus photography. The primary disadvantage of this method is that the measurements are highly subjective, time-consuming, and have a broad inter-observer variability.<sup>12</sup> The Heidelberg Retina Tomograph (HRT) is considered the reference standard for optic disc measurements due to the reproducibility of the data.<sup>21,25</sup> Neubauer found that optical coherence tomography (OCT) can also be used to determine optic disc margins due to the measurements being in moderate agreement with planimetry.<sup>12</sup> Fundus photos and slit lamp measurements measure the clinical appearance of the optic nerve, while HRT measures the scleral canal using changes in reflectivity of the laser.<sup>25</sup> Lim compared fundus lens measurements to HRT measurements and found a high correlation between the two measurement techniques.<sup>8</sup> Rao found that mean vertical diameter measured using a non-contact fundus lens and slit-lamp was comparable to that of measurements made using fundus photography and HRT as well.<sup>24</sup> Furthermore these measurements have been shown to correlate well with in-vivo measurements of optic discs obtained during vitrectomy.<sup>25</sup> Table 1 shows Lim's data on the comparison of HRT to several commonly used condensing lenses in their ability to measure vertical optic disc diameter. The 60 D lens (Volk or Nikon) was found to best correlate to measurements obtained by the HRT.<sup>8</sup>

TABLE 1: Comparison of vertical optic disc diameters using aspheric lenses and HRT<sup>8</sup>

Measurement Technique	Mean $\pm$ SD (mm)
Heidelberg Retinal Tomograph	1.81 $\pm$ 0.18
Volk 60 D	2.06 $\pm$ 0.17
Volk 78 D	1.63 $\pm$ 0.16
Volk 90 D	1.36 $\pm$ 0.12
Nikon 60 D	1.75 $\pm$ 0.09
Nikon 90 D	1.11 $\pm$ 0.10

When using condensing lenses to measure optic disc size, the distance the lens is held at does not show a statistically significant difference in the optic disc measurements so long as the ametropia of the eye does not exceed  $\pm 5$  D.<sup>3,25,26</sup> Other studies have found good correlation for myopia up to  $-8$  D,<sup>9,23</sup> while still others recommend the ametropia not exceed  $\sim 3$  D.<sup>8</sup> The high magnification of the slit lamp condensing lens system limits depth of field which also helps to reduce errors in measurement.<sup>19</sup>

While this method is possible with and without pupillary dilation,<sup>8</sup> estimation of disc size was found to be easier, more accurate, and having greater interobserver agreement under stereoscopic viewing through a dilated pupil.<sup>3,19</sup> Additionally the larger the disc the less error was present in the measurements using fundoscopic techniques. This is likely due to the simple fact that larger structures are easier to measure.<sup>9</sup> Regardless of the technique used, it is important when measuring the optic disc to include all of the area inside of the peripapillary scleral ring. The scleral ring itself, however, does not belong to the optic disc and should be excluded. This is important because for any disc measurement, inclusion of the peripapillary scleral ring will give a falsely large neuroretinal rim and consequently a falsely small CDR.<sup>17</sup>

Accuracy vs estimation for disc measurement:

While the use of fundus lenses does give an exact measurement of the optic disc size, it does allow an estimation of disc size to be made. For clinical purposes it is not necessary to perfectly measure the disc size but it is usually sufficient to categorize the optic disc as either abnormally large, average, or abnormally small.<sup>9</sup> While Rao found that there was no validated method to distinguish discs into small, average, or large categories,<sup>10</sup> Jonas described small discs as being defined as the mean disc size ( $2.69\text{mm}^2$ ) minus two standard deviations and large being the mean plus two standard deviations. Statistically only 2.3% of a standard population is expected to fall outside these limits ( $<1.29\text{mm}^2$  and  $>4.06\text{mm}^2$  respectively).<sup>17</sup> Jonas defined the mean optic disc diameter as being horizontally  $1.76 \pm 0.31$  mm and vertically  $1.92 \pm 0.29$ mm.<sup>15</sup> Browne concluded that in general, an optic nerve can be considered small if vertically  $\leq 1.20$ mm and large if  $\geq 1.80$ mm.<sup>13</sup> Additionally, cup-to-disc ratios are independent of the magnification of the examined eye, and also of any fundus camera or other instrument used. Due to this, one does not need to correct for the ocular and camera magnification when determining CDR.<sup>17</sup>

Studies have shown that the use of a single correction factor for each fundus lens may not be appropriate,<sup>26</sup> and multiple studies have found conflicting values to use for correction values of the various lenses. Several examples are listed below in table 2. Additionally, there has been found a difference between correction factors for lenses of equal dioptric power but from different manufacturers. This can be attributed to their particular aspheric specifications.<sup>8</sup> Most studies excluded eyes with ametropia greater than  $\pm 5$  D.<sup>17,19,25,26</sup>

TABLE 2: Correction factors for fundoscopic lenses by researcher<sup>4,5,8,13</sup>

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

\*Where X is the measured size of the optic disc as given by height beam indicator

\*\*Note Browne makes no distinction between Volk and Nikon lenses

\*\*\*Assuming X=1

As can be seen above, when averaging the correction factor value for each of the lenses, there is a high correlation with the data given by the manufacturer of the lenses. Only the Nikon 60 D lens had a difference in average value greater than 0.02 from the data given by the manufacturer. Given the above findings, a clinician in practice may find it more efficient to use the manufacturer given correction factor for each lens as opposed to separately calculating each value or researching the correction values others have found. Furthermore, the correction factor for the Volk 78 D lens has the highest correlation between all of the other lenses and may provide greater accuracy when taking measurements of intraocular structures.

This measurement method can be used for other structures in the posterior pole as well, such as malignant choroidal melanomas, age-related maculopathies, or retinal tumors. This is possible because the ocular magnification factor is relatively constant for the central 30° of the fundus. This method of measurement is better than describing the size using disc diameters because of the great interindividual variability of the optic disc size.<sup>9,23</sup>

Additional techniques for estimating optic disc size:

Using a direct ophthalmoscope, the small light spot, which is 5 degrees in size, is approximately the size of an average optic disc. If the ophthalmoscope has three spot

sizes, the middle spot may be used. Most published data refers to the Welch-Allen 5-degree aperture (the middle setting) when using this technique.<sup>4,13</sup> Therefore if the optic disc appears larger than the spot size, one can classify the disc as large, and if smaller than the spot size the disc can be classified as small.

One can also estimate disc size using the central retinal vein. The average thickness or diameter of this vein is approximately 125µm at the area where the vessel crosses the inferior neuroretinal rim. Using the approximate value for the thickness of the vessel, the average optic disc should be 12-14 vessel diameters across.<sup>4,13</sup> If the disc comprises more than 14 diameters then it can be classified as large, and if it comprises less than 12 diameters it can be classified as small.

Another technique is to use the distance between the optic disc and the fovea. The distance from the temporal edge of the optic disc to the fovea is approximately two to three disc diameters in eyes with normal size and axial length.<sup>4,13</sup> Therefore if the distance between the temporal rim and the fovea is greater than three disc diameters, the disc can be classified as small, and if the distance is smaller than two disc diameters the disc can be classified as large.

Useful equations for disc and cup calculations:

$$\text{Optic nerve head diameter (mm)} = \left(\frac{X}{H}\right) \times D \times C$$

Where X =beam height(mm), H=height setting on beam height indicator(mm),

D=diameter of the disc measured by the beam height indicator, C=correction factor.

\*Note X/H will be 1 if the beam height indicator is properly calibrated and accurate.

X is found by measuring the height of the beam using a ruler, and H is the height of the beam as indicated by the slit lamp itself.<sup>4,13</sup>

**Optic disc area (mm<sup>2</sup>) = ( $\pi r^2/4$ ) x Horizontal disc diameter (mm) x Vertical disc diameter (mm)<sup>9,13</sup>**

Therefore it follows that to determine the rim tissue area, one can use the equation for optic disc area above and subtract the cup area from the total disc area:

**Rim area (mm<sup>2</sup>) = Disc area (mm<sup>2</sup>) – Cup area (mm<sup>2</sup>)**

## CHAPTER 5

### DISCUSSION

Direct assessment of the optic nerve head and the changes of the cup-to-disc (CDR) ratio is a critical component in the determination of a diagnosis of glaucoma. The CDR alone is not enough information for the clinician to use in this determination, however. The overall size of the optic disc plays a role in whether an optic cup is deemed to be abnormal or not. Large optic cups in physiologically large discs should not immediately be suspect for glaucoma if there are no other risk factors present. Similarly, a moderate cup size in a small optic disc may still be glaucomatous, even with a smaller CDR. While there are many techniques and various equipment available that are all capable of giving estimations of the size of the optic nerve, the easiest and most cost efficient method is simply using a slit lamp and condensing lens. Simply get the optic nerve in good focus, then adjust the beam height until it coincides with the size of the



disc itself. One can then simply read the measurement on the beam height indicator and multiply that number by the correction factor for the lens they are using. If the slit lamp does not have a beam height indicator, the clinician can lock the slit-lamp in place, have the patient sit back, and using a ruler at the plane of where the lens was being held measure the height of the beam directly. This measurement can then be used to classify the optic disc into the category of large, average, or small. Combining the information gained from measuring the optic disc size, cup size, and CDR with the patient's risk factors, a clinician can make a much more informed decision regarding diagnosis and treatment.

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APPENDIX A  
PRACTITIONER'S GUIDE FOR MEASURING OPTIC DISCS

## PRACTICIONER'S GUIDE FOR MEASURING OPTIC DISCS

Optic disc size (mm) for commonly used non-contact fundus lenses

Measured vertical disc size (mm)	Volk 60 D 0.93 X	Volk 78 D 1.15 X	Volk 90 D 1.38 X	Nikon 60 D 1.08 X	Nikon 90 D 1.56 X
1.0	0.93	1.15	1.38	1.08	1.56
1.2	1.12	1.38	1.66	1.30	1.87
1.4	1.30	1.61	1.93	1.51	2.18
1.6	1.49	1.84	2.21	1.73	2.50
1.8	1.67	2.07	2.48	1.94	2.81
2.0	1.86	2.30	2.76	2.16	3.12
2.2	2.05	2.53	3.04	2.38	3.43

Optic nerve rim tissue area (mm<sup>2</sup>) in small, average, and large optic discs for varying cup-to-disc ratios

Cup-to-Disc Ratio	Small disc 1.29 mm <sup>2</sup>	Average disc 2.69 mm <sup>2</sup>	Large disc 4.06 mm <sup>2</sup>
0.10	1.16	2.42	3.65
0.20	1.03	2.15	3.25
0.30	0.90	1.88	2.84
0.40	0.77	1.61	2.44
0.50	0.65	1.35	2.03
0.60	0.52	1.08	1.62
0.70	0.39	0.81	1.22
0.80	0.26	0.54	0.81
0.90	0.13	0.27	0.41

Green = within or greater than 1 SD of the mean = >1.47

Yellow = between 1 and 2 SD below the mean = 0.97 – 1.47

Red = greater than 3 SD below the mean = <0.97

### *Other techniques for estimating disc size:*

- Using a direct ophthalmoscope with two light spot settings, the small dot is 5 degrees in size and is approximately the size of an average optic disc. If there are three spot sizes, use the middle spot. If the disc is larger than the spot, it can be classified as large, if it is smaller, it can be classified as small.
- The average optic disc is approximately 12-14 central retinal vein diameters across. If the disc comprises more than 14 it can be considered large, and if it comprises less than 12 it can be considered small.
- The temporal edge of the average optic disc is approximately 2-3 disc diameters from the fovea. If it is less than 2 it can be considered large and if it is greater than 3 it can be considered small

